Evacuation in the Classroom

A workbook

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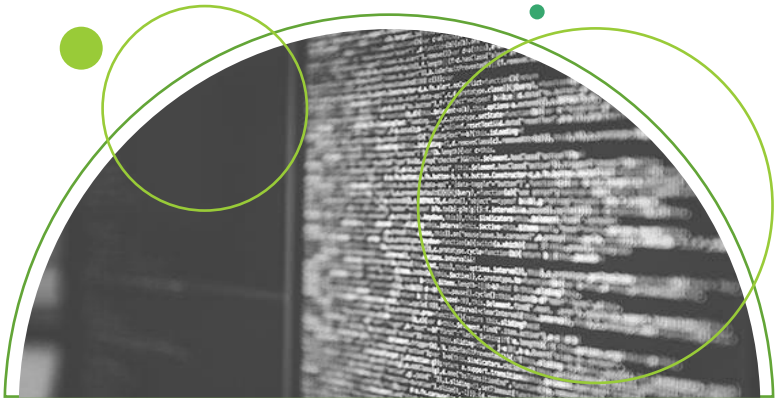


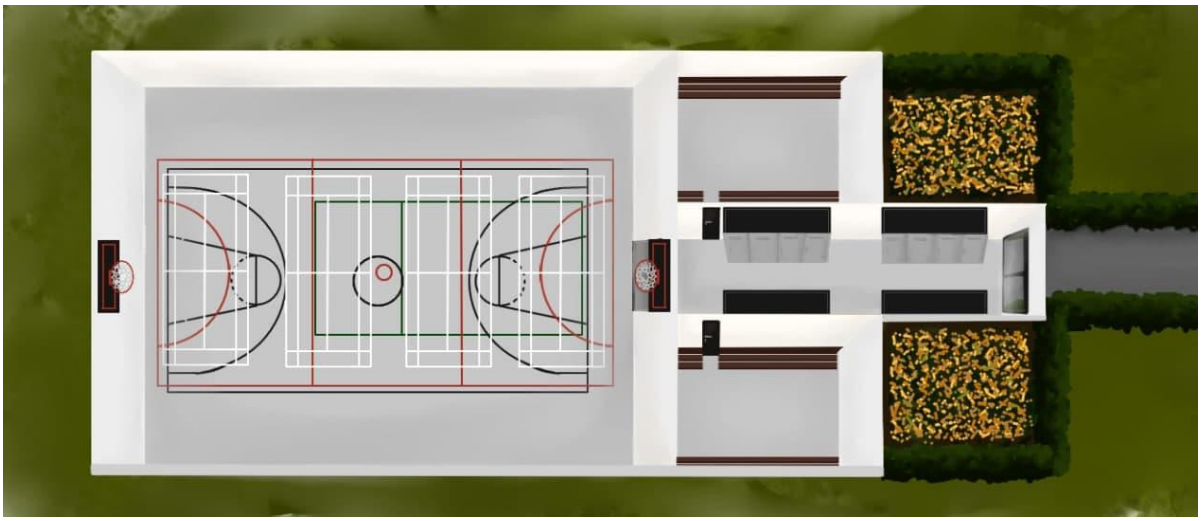
PREFACE

Dear pupils,
Dear teachers!

In this exercise booklet you will dive into the fascinating world of evacuation. In doing so, you will find out on which factors a successful evacuation depends and develop your own suggestions for improvement on this basis.
The "Gitterautomat" software is available to support you in this process.
However, like any programme, this simulation can only represent a small part of reality.
Therefore, the central focus of this book is to provide you with tools to decide how realistic a simulation actually is.

In today's world, more and more decisions are made based on complex software simulations. It is therefore increasingly important to be able to reflect critically on programmes.

Just as media literacy protects you from fake news and the like, we hope that this exercise book will help you to debunk simulations that are far removed from reality.



MOTIVATION

Yesterday there was an accident at your school. Hence the headmaster has excused all pupils from lessons today, so you have time to read the newspaper while having breakfast.

Monday, 19. April 2025

NEWS OF THE DAY

Latest news and bulletin updates

Edition #10

Brian Greer

Modelling Reality in Mathematics Classrooms

Bavarian pupils have great difficulties with mathematics

This paper serves as a general introduction to the set of papers which follows, representing
a closely-knit and ongoing collaboration.

There are 125 sheep and 5 dogs in a flock. How old is the shepherd?
Most of the children tested were prepared to offer an answer to such questions.
One student's protocol went like this: 125+5=130... this is too big, and 125-5=120 is still too big... while... 125+5=25... that works... I think the
shepherd is 25 years old.

Bild: Word-

Bild: dpa

Mirjam Nilsson

Alarm at secondary school in Würzburg

Explosion in chemistry reveals deficiencies in evacuation plan

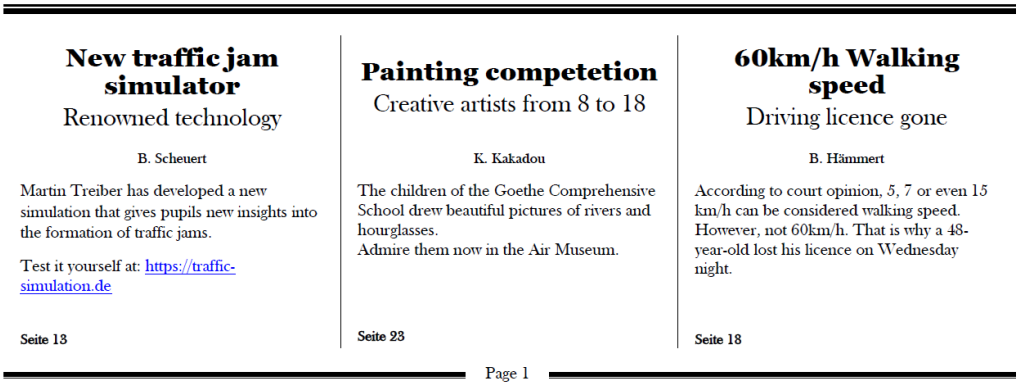
Würzburg - An NBC alarm was triggered in Fantasy High on Friday morning, 6 April 2021. The building was evacuated as a result.

The school's fire alarm system had sounded at 9.23 am. When the fire brigade and police arrived on the scene, the emergency services were informed by caretakers and teachers about a hissing 10-litre hydrogen bottle that was standing in the area of the chemistry laboratory. They had apparently tried to close the bottle themselves, but were unable to do so.

Due to the heavy smoke and loud bang, many students panicked and as a result, there were blockages in the corridors.

Fantasy High thus clearly failed to comply with the official guidelines of the Ministry of Civil Protection and Disaster Relief. According to these, a building must be evacuated within a maximum of 10 minutes.

Many parents and students are appalled by the current situation and are clamouring for improvements.



New traffic jam simulator

Renowned technology

B. Scheuert

Martin Treiber has developed a new simulation that gives pupils new insights into the formation of traffic jams.

Test it yourself at: https://traffic-simulation.de

Seite 13

Painting competetion

Creative artists from 8 to 18

K. Kakadou

The children of the Goethe Comprehensive School drew beautiful pictures of rivers and hourglasses.
Admire them now in the Air Museum.

Seite 23

60km/h Walking speed

Driving licence gone

B. Hämmert

According to court opinion, 5, 7 or even 15 km/h can be considered walking speed. However, not 60km/h. That is why a 48-year-old lost his licence on Wednesday night.

Seite 18

Page 1

You spontaneously decide to deal with the problem in more detail!
The exercises in this exercise booklet will help you to do so!

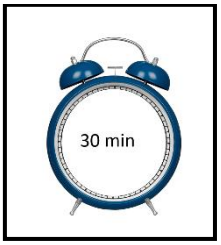
First, of course, you read the newspaper article carefully to familiarise yourself with the situation.

While you are still eating the last bites of your croissant, you start thinking about evacuation.

You want to find out what factors determine the evacuation time, where evacuation time here means the time from the sounding of the alarm to the arrival of the last person at one of the assembly points.

Let's go!!

1: DRY RUNS



I) Imagine the evacuation of your school in case of a fire alarm.
How does this regulated procedure differ from a flight-like evacuation?

- ❖ _____
- ❖ _____
- ❖ _____
- ❖ _____

II) In the following, we assume a regulated evacuation.

Tick the factors that have a noticeable effect on the evacuation time and then add at least 3 more!

□ Average walking speed

□ Fastest walking speed

□ Slowest walking speed

□ Width of the walkways

□ Width and length of the bottlenecks

□ Number of bottlenecks

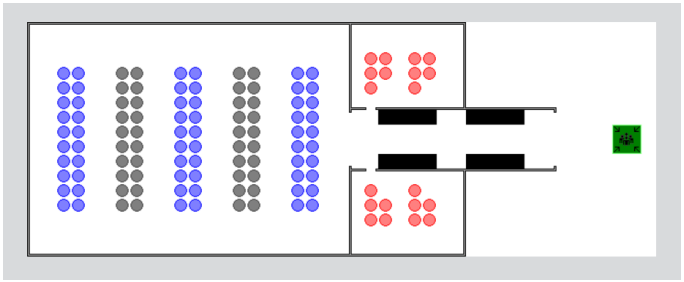
□ _____

□ _____

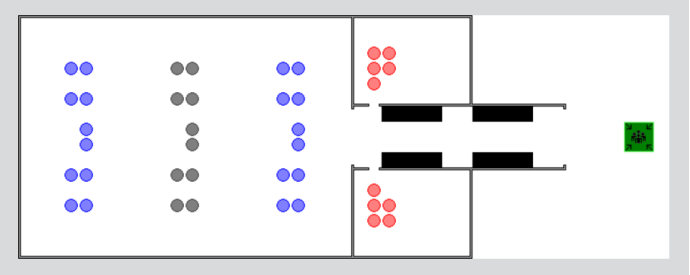
□ _____

□ _____

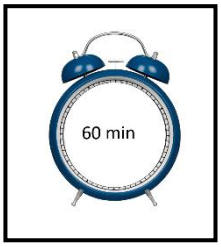
III) In the list above, circle in green up to three factors which (in your opinion) will be most influential in the following situation:



IV) In the list above, circle in blue up to three factors which (in your opinion) will be most influential in the following situation:



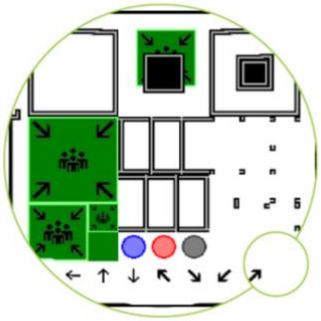
2: FIRST STEPS



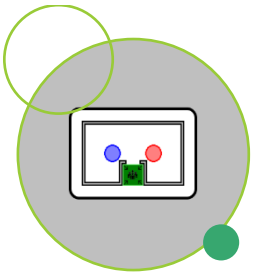
Click on the following link: https://evadid.it/eva2

Now you have time to discover the programme.

If you can't make sense of the symbols or don't know how to use them, you can always ask your supervisor!



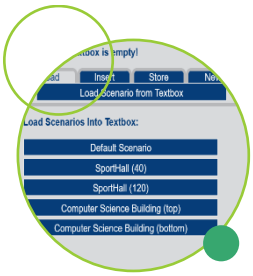
I) Simulating your classroom



Go to the tab "Scenario Editor". There you can recreate any environment of your choice. To begin with, try to imitate your classroom.

To do this, simply click on the desired symbol in the right side margin and then on any position of the building environment. Additional help can be found in the manual.

II) Loading the sports hall



Now we want to load a prefabricated scenario. To do this, click on the button "Scenario Manager" and then select SportHall (40) from "Load Scenarios Into Textbox:".

Confirm your selection with "Load Scenario from Textbox".

III) Running the simulation

Now go to the tab "Simulation Player" and play the simulation using the arrow keys.

Describe what you observe:

_____
_____
_____
_____
_____
_____

Explain what "Simulation Steps" might mean.

_____
_____

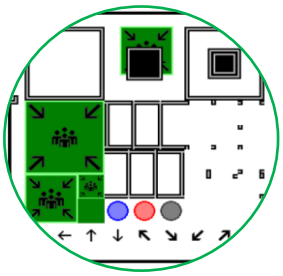
Write down the evacuation time in steps:

Number of „Simulation Steps “= _____

Now switch to the Scenario Editor and run the simulation again by clicking on the Simulation Player. What do you notice?

_____
_____
_____
_____
_____

IV) From simulation to reality



You have a rough idea of what will happen during a simulation step, but to be sure you write an e-mail to the developer.

He tells you that the gym consists of many small boxes (50cmx50cm) into which exactly one person fits. This is the reason why this software is called a grid machine.

In a simulation step, each person either moves exactly one box forward with the speed x m/s or does not move at all.

If you move the mouse over a person, the path this person is taking is shown.

Now you have all the information together to create a formula describing the duration of a step as a function of speed.

T_{step} = _____

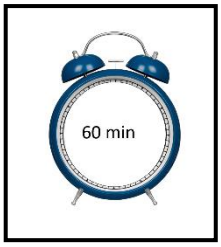
Justification for the formula:

_____
_____
_____
_____

Calculate the duration of the evacuation, assuming that people walk at an average speed of 3 m/s.

T_{evak}=_____
_____
_____
_____

3: WORKING WITH ASSUMPTIONS



I) Making assumptions

You ask your friends how fast they think people move during an evacuation.

Andre estimates that people move quickly during an evacuation, i.e. at around 5m/s. Julia reckons that running is forbidden in the school building and thinks that 1m/s is realistic.

Which assumption do you think is more realistic? Give reasons!

_____
_____
_____
_____
_____
_____
_____

II) Calculate the evacuation time, assuming a speed of 1 m/s.

T_{evak}=_____
_____

III) Calculate the evacuation time, assuming a speed of 5 m/s.

T_{evak}=_____
_____

Your friend Kaya remarks: "The results of the evacuation are totally different depending on the assumption. In addition, the results are not always the same if they are carried out several times. That means you can't do anything with the results!"

Sonja replies: "That's not true. Sometimes a result can be valuable even though it is not exact!"

These statements should now be assessed, starting with some preliminary considerations.

IV) Describe your initial thoughts on the statements:

_____
_____
_____
_____
_____

V) Describe at least two situations in which results only have value if they are exact.

_____
_____
_____
_____
_____

VI) Describe at least two situations where results have value even if they are not exact.

_____
_____
_____
_____
_____

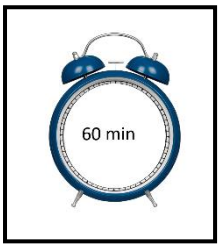
VII) Justify whether simulation results for a building evacuation are useful even if they are not exact. Use at least two different arguments.

_____
_____
_____
_____
_____
_____
_____

VIII) Describe in general terms: When do results have value, even if they are not exact?

_____
_____
_____
_____
_____
_____
_____

4: EXPERIMENTS WITH THE MODEL



Now that you have familiarised yourself a little with the grid machine you want to make some recommendations to your head teacher, to shorten the time it takes to clear the building.

You have prepared a long list of possible improvements:

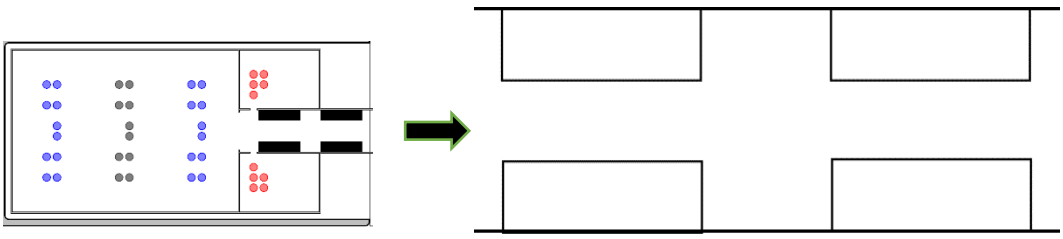
- wider doors
- wider corridors
- more assembly points
- fewer people in the rooms
- etc.

Unfortunately, your director is a tough cookie. All your suggestions cost time and money. Therefore, he is not willing to consider any changes until you provide him with hard facts in the form of simulation results.
In the following, you will look at how to evaluate the impact of such changes with the help of simulation results.

Our lockers should become fewer!

The situation in the gym is a particular big thorn in your side. Therefore, you are very happy when your headmaster agrees to remove two of the four lockers.

I) Cross out the two lockers that you hope will reduce the evacuation time the most.

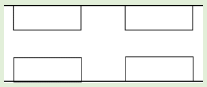
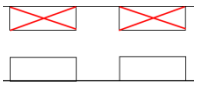
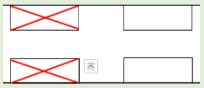
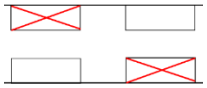


II) Explain why you expect the greatest reduction eliminating exactly these two lockers:

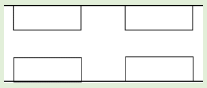
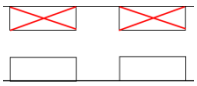
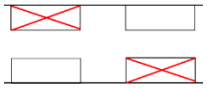
_____
_____
_____
_____
_____

Now check your assumption by simulating different situations:

III) Calculate the simulation durations in steps when there are few people (40) in the hall:

	Evacuation duration (SportHall 40)
	
	
	
	

IV) Calculate the simulation durations in steps when there are many people (120) in the hall:

	Evacuation duration (SportHall 120)
	
	
	
	

V) Reason whether the simulation results support your assumption, refute your assumption, or do not affect your assumption.

_____
_____
_____
_____
_____

VI) Reason whether the simulation is realistic enough to assess whether the reduction of lockers actually shortens the evacuation of the gym.

_____
_____
_____
_____
_____
_____

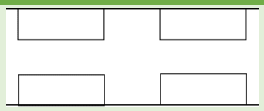
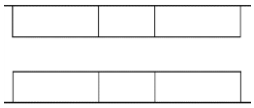
Our lockers should become more?!

Marian has the following concern: "The gaps in the lockers are dangerous: people can run in and then get stuck in the gaps. We should fill the gaps with more lockers to avoid the problem!"

VII) Do you find Marian's assumption realistic? Give reasons!

_____
_____
_____
_____
_____

VIII) Calculate the simulation time in steps with and without a full locker row.

	Evacuation duration (40)	Evacuation duration (120)
		
		

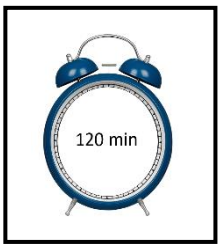
IX) Justify whether the simulation results support your assumption, refute your assumption, or do not affect your assumption.

_____
_____
_____
_____
_____
_____

X) Begründe, ob die Simulation realistisch genug ist, um diese Frage zu beantworten.

_____
_____
_____
_____
_____
_____
_____

5: EVALUATION OF THE IMPROVEMENTS



With the help of the simulation, you were able to successfully simulate potential changes to the building. This has made a big impression on your director: he is willing to invest 20,000 €. Now all that remains is to find out which measures will bring the greatest improvements.

In this task, we therefore want to analyse how we can invest the money most sensibly. Of course, you are well prepared and have already researched a list of different measures with cost estimates:

Cost estimate - Disaster management

Our family-owned company Secure & Sons specialises in all disaster prevention measures. Take advantage of one of our numerous services and increase your well-being. Whether you need help setting up a new assembly point, want a running training for your protection confidants or want to remodel your building. Secure & Sons combines everything in one service company. So what are you waiting for? The next catastrophe is sure to come, take precautions!

Services	Costs
☐ Running training	8.000€
☐ Move assembly point	1.500€
☐ Additional assembly point	2.000€
☐ Double the door width	14.000€
☐ Remove obstacles	4.000€
☐ Thanos – Snap (half as many people)	18.000€
☐ Additional obstacles	2.000€
☐ Special request	18.000€

Running training results in all people, participating in the evacuation, running 50% faster - in an orderly fashion and without tripping or bumping into each other.

Moving assembly points allows you to place the previous assembly point in front of the sports hall at a different location.

With the **additional assembly point**, new signs are ordered so that people can go to several different assembly points. But be careful: new doors will not be installed for this!

To **double the door width** or **install a new door** (of any width), the basic structure of the building can be changed. But be careful: a door cannot be wider than 3m, otherwise the building will become unstable!

Obstacles can be **removed or added** for a price. Whereas the removal of 2 lockers costs 8000€.

I) Setting priorities

Assessing all things takes time. Even if you have been quick so far, you may not have that much time left. We therefore need to determine which actions seem most promising and which we will work on first.

List the five measures you consider most important. Rank them in order of importance (descending from "very important" to "not so important"):

1	Measure:_____ Justification of importance:_____ _____
2	Measure:_____ Justification of importance:_____ _____
3	Measure:_____ Justification of importance:_____ _____
4	Measure:_____ Justification of importance:_____ _____
5	Measure:_____ Justification of importance:_____ _____

You decide to evaluate at least the most important measure. If you want to investigate other measures, you can answer them in the same way. Further templates can be found at the end of the sheet.

II) Evaluation of the most important measure

II.A) Making the assumption

If one ...

_____
_____

Then…

_____
_____

And that is because:

_____
_____

II.B) Simulating the scenarios

We have simulated the following scenarios and thereby obtained the following values:

_____
_____
_____
_____
_____
_____

II.C) The simulation results influence our assumption as follows:

_____
_____
_____
_____
_____

II.D) The question □ can be answered □ cannot be answered with the simulation, because:

_____
_____
_____
_____

II.E) In summary, it can therefore be said that:

_____
_____
_____
_____

III) Evaluation of the second most important measure

II.A) Making the assumption

If one ...

_____
_____

Then…

_____
_____

And that is because:

_____
_____

II.B) Simulating the scenarios

We have simulated the following scenarios and thereby obtained the following values:

_____
_____
_____
_____
_____
_____

II.C) The simulation results influence our assumption as follows:

_____
_____
_____
_____
_____

II.D) The question □ can be answered □ cannot be answered with the simulation, because:

_____
_____
_____
_____

II.E) In summary, it can therefore be said that:

_____
_____
_____
_____

III) Evaluation of the third most important measure

II.A) Making the assumption

If one ...

_____
_____

Then…

_____
_____

And that is because:

_____
_____

II.B) Simulating the scenarios

We have simulated the following scenarios and thereby obtained the following values:

_____
_____
_____
_____
_____
_____

II.C) The simulation results influence our assumption as follows:

_____
_____
_____
_____
_____

II.D) The question □ can be answered □ cannot be answered with the simulation, because:

_____
_____
_____
_____

II.E) In summary, it can therefore be said that:

_____
_____
_____
_____

V) Summary

The following evaluated measures help the most:

_____
_____
_____

Now you finally have the data to make a concrete proposal to your director!

VI) Deciding on a package of measures

With the 20,000 € you should implement the following measures:

_____
_____
_____

Justification:

_____
_____
_____

VII) Decision for the low-budget variant

If instead only 10,000 € were available, the following measures should be implemented:

_____
_____
_____

Justification:

_____
_____
_____

VII) Reflecting on economic efficiency

Money is always tight. It is true that one can improve the evacuation of a school. However, the money could also be used to equip a new computer room. Therefore, assess how much money should be spent to have a school that is as evacuable as possible:

One should invest the following amount: _____€

This amount should be used to implement the following measures:

_____
_____
_____

Justification:

_____
_____
_____

OUTLOOK: QUESTION EVERYTHING!

Congratulations! You have contributed to making your school safer. Your boss is proud of you, the newspaper celebrates you as an engaged citizen and you have requests from companies and other educational institutions who also want your advice.

But some questions remain: How accurately can a simulation like this actually predict reality? Is it a problem that the people in the simulation all run at the same speed and largely in an orderly fashion? What about the box structure: Does it affect the outcome? What if a fire breaks out and paths become impassable? Does the whole approach also work for other and larger buildings? In short: How realistic is the simulation actually and how can realism be assessed mathematically?

Unfortunately, we can not answer these remaining questions in today's workbook.
So today we leave, it's no end, but sure we'll return, that's grand.
Soon, a follow-up issue will answer these questions and many more.

Stay tuned!

ACKNOWLEDGEMENTS

A workbook like this is not possible without the help of many people.

Many thanks to all contributors!

Development of the simulation: André Greubel

Development of the workbook: Julia Wenkmann, André Greubel

Didactic support for the concept: Prof. Dr. Hans-Stefan Siller

Financial support: Stiftung der deutschen Telekom

Supervision of students: Dr. Angela Siller, Janina Just, Daniela Andres, Julia Wenkmann, Christian Heinze, Hannah Brandl, Julia Leisten, Dr. Sabine Büttner

Contact: andre.greubel@uni-wuerzburg.de

Kontakt: andre.greubel@uni-wuerzburg.de

And thank you for working on the tasks ☺

X) Appendix 1: Evaluation of another measure

II.A) Making the assumption

If one ...

_____
_____

Then…

_____
_____

And that is because:

_____
_____

II.B) Simulating the scenarios

We have simulated the following scenarios and thereby obtained the following values:

_____
_____
_____
_____
_____
_____

II.C) The simulation results influence our assumption as follows:

_____
_____
_____
_____
_____

II.D) The question □ can be answered □ cannot be answered with the simulation, because:

_____
_____
_____
_____

II.E) In summary, it can therefore be said that:

_____
_____
_____
_____

Y) Appendix 2: Evaluation of another measure

II.A) Making the assumption

If one ...

_____
_____

Then…

_____
_____

And that is because:

_____
_____

II.B) Simulating the scenarios

We have simulated the following scenarios and thereby obtained the following values:

_____
_____
_____
_____
_____
_____

II.C) The simulation results influence our assumption as follows:

_____
_____
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_____
_____

II.D) The question □ can be answered □ cannot be answered with the simulation, because:

_____
_____
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_____

II.E) In summary, it can therefore be said that:

_____
_____
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_____