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Examination of the Professional Support for a Major Public Event

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Bachelorthesis

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Abstract

The author of this thesis organizes major open air events since five years. After the Love Parade disaster in 2010, the research of pedestrian crowds got more and more to the attention of scientists. Therefore, a lot of basic research has been conducted. Pedestrian simulation constitutes a large part of it. Various new approaches and software packages have been developed. Basic terms and models are described and two software packages are presented and compared in this thesis; the black box solution AnyLogic and the multiscale framework TransiTUM. Both are used to simulate five different scenarios. Furthermore, other assistance systems are introduced and examined for their practical benefit in the context of open air events: the Building Information Modelling method and Oppilatio. The former is a new planning method of the building sector. With its new publisher-independent data format, it helps connecting the different parties. Furthermore, the visualizing of the event design is examined by realizing various changes in the site layout with Autodesk's BIM software Revit. Oppilatio is a software to identify the paths visitors have chosen to get to the event site. Through the use of different algorithms, it is capable to calculate the used paths with little input data. Just the timestamped entrance data and the public transportation timetable are necessary to receive the according densities. Therefore, it is a cheap alternative to the usual monitoring. In the final chapter a professional safety concept is summarized and commented. Furthermore, a list is created to help novices organizing a small open air event. Important information is provided and exemplary numbers are presented.

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Chapter 1

Introduction

Every person shall have the right to life and physical integrity.¹

On 24 July 2010 the Love Parade took place in Duisburg. The Love Parade was an annual electronic dance music street parade with up to 500,000 visitors (Hitzler *et al.*, 2011). Initially it started in 1989 in Berlin, but after some cancellations it moved to different cities from 2007 to 2010. The last Love Parade ended in a tragically catastrophe. Because of design errors and misdirected pedestrian flows, 21 people died and more than 500 were injured. Incorrect planning and poor decisions lead to a congestion in a tunnel, where visitors were crushed to death by a forward pushing crowd (Helbing & Mukerji, 2012).

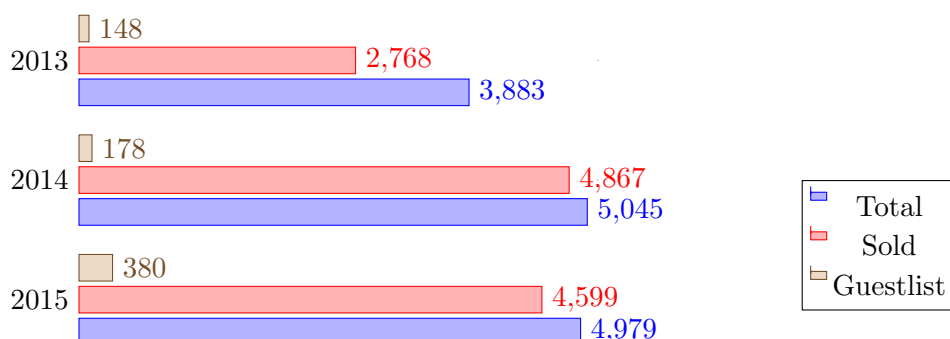
Since that disaster the legal restrictions for events have increased more and more (Oehlhorn, 2014). Event organizers even notice the impact when they try to hold a small event.

The author is part of a group called “Kellerkind”. They are 10 young people who started to organize techno open airs in 2011. As they just used their own assets, they started with a really small event. Their open air “Schall im Schilf” was well received and the number of visitors increased each year. Because of a limitation of the available area, they are stuck at roughly 3000.

In 2013 “Kellerkind” launched a second event named “Back to the Woods Open Air”. The venue, located at the site of the Technische Universität München in Garching, has a larger capacity with a maximum of 5000 people.

¹http://www.gesetze-im-internet.de/englisch_gg/englisch_gg.html#p0019

Here is a short table summarizing the progress:



Since the beginning of 2014 the “Back to the Woods” festival is part of the MultikOSi research project. Their task is to develop assistance methods for urban events. It is a joint project of the Technische Universität München, the Hochschule München, the Technische Universität Kaiserslautern, the Universität Koblenz, the Bavarian police department and different companies specializing in event organization and security.²

It was the first time the “Kellerkind” team received professional support in the form of detailed concepts, weather observation, emergency strategies and many more themes that an amateur usually does not consider. Previously, the made experience had been quite the contrary; there exists a lack of information and knowledge in most of the responsible administrations. Especially outdoor events, which do not take place in designated sites, are regulated rather poorly. As there are almost no federal laws, the legal restraints depends on the responsible official.

In 2014, the first year of the MultikOSi observation, it started to rain at 8pm and after one hour a powerful thunderstorm approached. The team turned off the music at 8.44pm and evacuated the area. Because of the rain, people had already been leaving the site continuously since the rain came up. However, the remaining 3.500 visitors were enough to show up the core issues emerging in such an emergency case.

This thesis presents different methods to assist an event team and examines carefully if it is worth putting them into practice based upon an event like “Back to the Woods”. After the 2014 storm, the emergency exits and evacuation routes were moved more to the center of attention. Therefore, that topic will constitute a large part in this thesis. Furthermore, we will review more support options in term of 3D modelling and the analysis of the access routes. Concluding, we discuss the recent “Back to the Woods” safety concept and create a short checklist, which can be helpful to other organizers of public events.

²<http://multikosi.de/>



Figure 1.1: Event site after the evacuation

The author takes no responsibility for the given information. The information and tips do not replace established law, like the “Versammlungsstättenverordnung”. Moreover, the legal requirements vary between each federal state and each country. The laws and numbers used in this thesis are taken from Bavarian and especially Munich related regulations.

Chapter 2

Pedestrian Simulation Software

With the increased gathering of large crowds (Betz *et al.*, 2011), the safety of such major events was brought to the focus of public attention and science. The numbers of scientists increased rapidly and research was driven forward (Helbing *et al.*, 2002). An important section of that research is the simulation of various pedestrian scenarios.

A simulation is an imitation of the operation of a real-world process or system over time. It is used to describe and examine the behavior of a system, to run through different changes, or to help creating completely new systems (Banks *et al.*, 1999). Simulations are often cheaper than real experiments. Especially in the pedestrian flow sector, experiments involve high costs. As large crowds are needed, the personnel costs are immense. In addition, ethical concerns make some of them even impossible. For example, investigations with marginal densities are hard to realize with real people. Moreover, scenarios with fire or other critical causes are too dangerous. Therefore, simulations are used to gain information in a safe, fast and cheap way.

Pedestrian simulations can not only be used to identify threats in the planning of mass events, but also within live software that helps the responsible crowd-manager to react in the correct way.

The following chapters will introduce some basic terms and concepts of the pedestrian flow simulation research. Afterwards two different simulator software packages are presented and compared, and their practical benefit will be evaluated by the author.

2.1 Basic Terms

2.1.1 Scales

Pedestrian simulations are usually divided into macroscopic, mesoscopic and microscopic scales.

Macroscopic models have an over-all perspective at the scenario, which is reduced to nodes and edges (Kneidl, 2013). Pedestrians are not considered as discrete objects; rather the evolving densities are examined. Not the behavior of each individual pedestrian is calculated, but aggregated parameters. For the cost of low spatial resolution, macroscopic models are fast and do not need much computer resources (Biedermann *et al.*, 2016).

There are two major kind of macroscopic models; the network and the system dynamic models. The network models are divided into different approaches: many of them work with an adapted theory of fluid mechanics (Biedermann *et al.*, 2014). An important example are the continuity models that are based on the continuity equation of fluid dynamics; like the LWR model (Lighthill & Whitam, 1955; Richards, 1956). To lower the complexity, the system is often reduced to one spatial dimension (Hartmann & Sivers, 2013; Colombo & Rosini, 2005). The second approach are the network flow models. They are mostly used to determine the fastest time a pedestrian needs to exit a given network scenario (Burkard, Dlaska & Klinz, Burkard *et al.*)

A further important macroscopic approach are the System Dynamics models. Thereby the chronological behavior of dynamic systems is described with causal loop, stock and flow diagrams. Thus, dependencies and feedbacks are simulated (Handel *et al.*, 2014).

With regard to urban events, macroscopic models are often used to simulate the arrival and departure of the visitors.

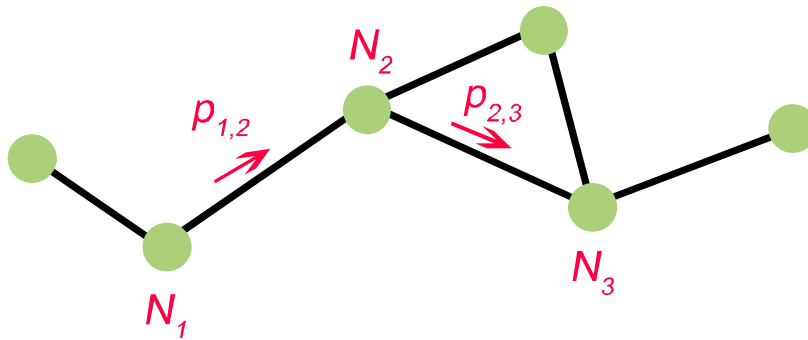


Figure 2.1: Pedestrian flow from node 1 to node 2 and from node 2 to node 3

Mesoscopic models are the link between macroscopic and mesoscopic models. The scenario is split up into a regular grid with a cell size of one person (Schadschneider *et al.*, 2008). Each pedestrian is simulated as an discrete object.

The use of cellular automaton (Blue & Adler, 2001) increases the simulation speed compared to microscopic models. The routing of the pedestrians happens according to certain defined rules that can be changed and adopted depending on the situation (Schadschneider, 2001). As the movement is cell-wise, the possibility that artefacts occur exists (Köster *et al.*, 2011).

Mesoscopic models are more realistic than macroscopic models and have a lower computational effort than microscopic models. They are used to simulate a large number of pedestrians without the necessity of knowing the exact position. Due to the artefacts and the accuracy that is limited by the cell-size, it is not recommended to inspect critical areas like certain emergency exits and other bottlenecks (Biedermann *et al.*, 2014). The maximal possible density per square meter is calculated by dividing one person through the area of a cell:

$$D = \frac{1}{A_{cell}} \quad (2.1)$$

The result is approximately 4.7 pedestrian per square meter for quadratic cells and 5.5 pedestrian per square meter for hexagonal cells (Biedermann *et al.*, 2016). Those numbers are based on the assumption that the pedestrians are circular formed bodies with a radius of 0.23 m (Weidmann, 1993).

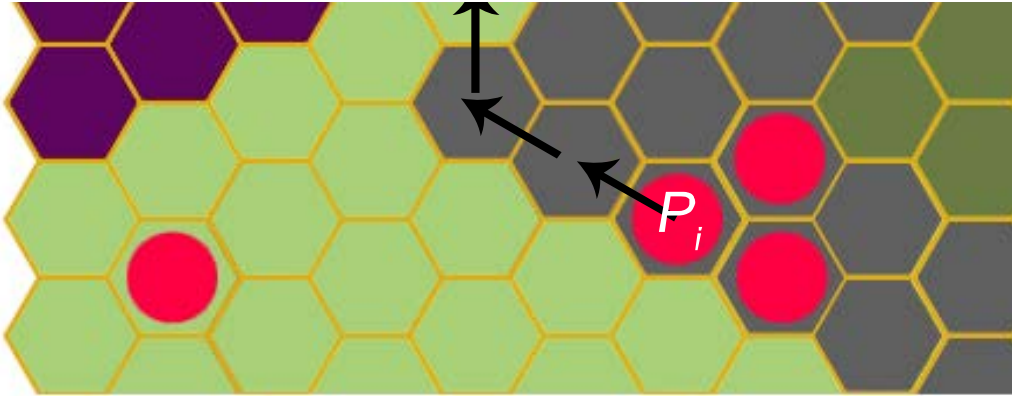


Figure 2.2: Mesoscopic model with a cellular grid

Microscopic models also calculate the pedestrians as discrete objects, but instead of using a grid, the area is considered as continuous space (Biedermann *et al.*, 2014). There are different groups of microscopic models. The force models, e.g. the social force (Schadschneider *et al.*, 2008) or the centrifugal model (Yu *et al.*, 2005) are based on physical laws. Each pedestrian is simulated with its own potential and the superposition of all forces derived from these potentials determines the movement of the individual agent. Furthermore, there are models

working with a mathematic optimization approach, which use a given function to calculate the movement of each automaton (Hoogendoorn & Bovy, 2004).

Microscopic models show their advantage when small changes are considered. They can be used for every kind of pedestrian simulation, but are especially useful for analyzing critical and well-visited areas like entrances, exits or bars. As the computational effort is very high, it is not advisable to simulate scenarios with large crowds.

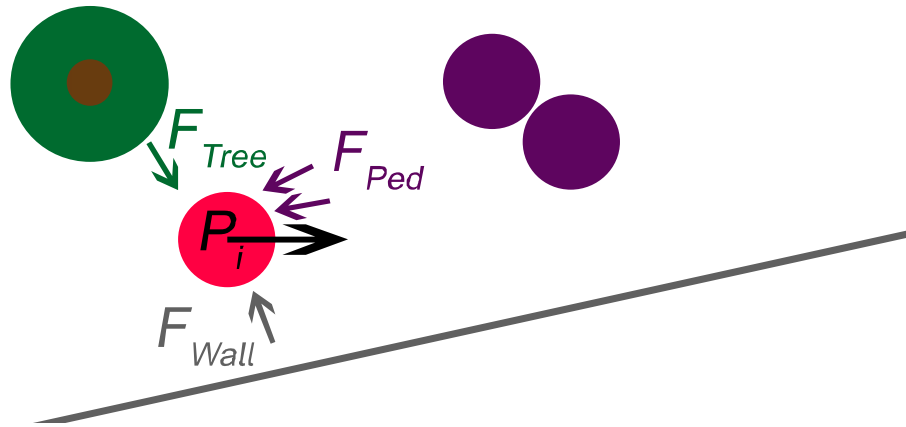


Figure 2.3: Microscopic model: superposition of all forces

In addition, several hybrid approaches allow the use of different pedestrian dynamic models in the same simulation. Thus, you can simulate different areas of the scenario with different models and get an accuracy tailored to your needs. The difficulty is to get a smooth transition between the different sections. In the current situation, the transition is limited to certain regions of the boundary (Ijaz *et al.*, 2015). Nevertheless, for an outdoor event simulation it is necessary to enter from any direction.

Therefore the new transition framework TransiTUM was developed at the Technische Universität München (Biedermann *et al.*, 2014). This framework was used to couple the mesoscopic simulator MomenTUM(v1)¹ from Technische Universität München with the microscopic simulator VADERE from the Hochschule München². The newly hybrid-framework will be presented and compared to AnyLogic, another pedestrian simulation software, in the next chapter.

¹<https://www.cms.bgu.tum.de/de/team/kielar/31-forschung/projekte/456-momentum>

²<http://www.multikosi.de/teilverhaben-der-hm>

2.1.2 Three Layer Model

The three layer model represents the logical architecture of agent-based simulations. It divides the pedestrian behavior into three different levels (Biedermann *et al.*, 2016).

The first level assigns a target to each pedestrian, for example a toilet or food stand in terms of an open-air event. The second level calculates the route from the current position to the target. The last level ensures, that a pedestrian walks with an appropriated velocity and without any collision to the target. The scales mentioned in the section before are implemented within the last level. The different layer are independent, but interact with each other (Handel, 2016).

Several scientists have proposed similar three layer approaches, each of them with an own nomenclature:

	Hoogendorn and Bovy	Blumberg	Reynolds
Level	(Hoogendoorn & Bovy, 2004)	(Blumberg & Galyean, 1995)	(Reynolds, 1999)
1	Strategic Level	Motivation Layer	Action Selection,Layer
2	Tactical Level	Task Layer	Navigation Layer
3	Operational Level	Motor Layer	Locomotion Layer

Table 2.1: The different Three Layer Model nomenclatures

2.2 Software Solutions

There are several pedestrian simulation software packages available. Two of them are presented in the next chapter. On the one hand, there is AnyLogic, a commercial black box solution and on the other hand, the mentioned research framework TransiTUM. Furthermore, they are used to calculate five “Back to the Woods” related scenarios.

2.2.1 AnyLogic

AnyLogic is a Java-based simulation tool developed by The AnyLogic Company. Originally it was not developed as a pedestrian simulation but as a tool for various economic simulations. Thus, the pedestrian simulation is just a small part of the much broader capabilities of this software. AnyLogic supports three simulation technologies: System Dynamics, Discrete Event and Agent Based (Emrich *et al.*, 2007).

The Agent Based Modeling can be used for micro- and macroscopic simulation. In the case of a pedestrian flow simulation, a microscopic model is used. The second layer is realized with a social force model (Handel, 2016). Since AnyLogic is a black box solution, it is difficult to get all the specific information on how the different layers and models are implemented.

Although AnyLogic is capable of handling complex simulations, the structure used in this thesis is implemented very simple. Since the evacuation is in the center of attention, the three layer model is reduced to the last two layers. The target is instead determined manually. The Agents just idle around and wait that the user pushes the evacuation button. In that case, all pedestrians are going to a target area on the lower left corner. They are not influenced by any human needs, like thirst, hunger and the urge to go to the toilet. The escape route is modified manually, based on the experience of the evacuation in 2014. Thus, a part of the pedestrians is guided to the main emergency exit. Those specifications and interventions were realized with a small chart.

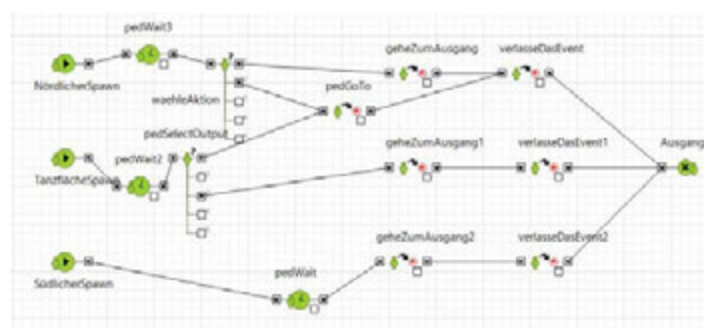


Figure 2.4: Process chart of the evacuation in AnyLogic

The AnyLogic framework contains a graphical interface and different libraries to easily create the needed environment. After loading a background map, the individual elements are created by just clicking on the map. All steps are done in the same window, which leads to a smooth workflow. For more difficult changes a little bit of Java is required. Some one-liner have to be written to start a special event or to connect different functions. For example, an implemented function automatically shows the evacuation times and the amount of people who reached the target.

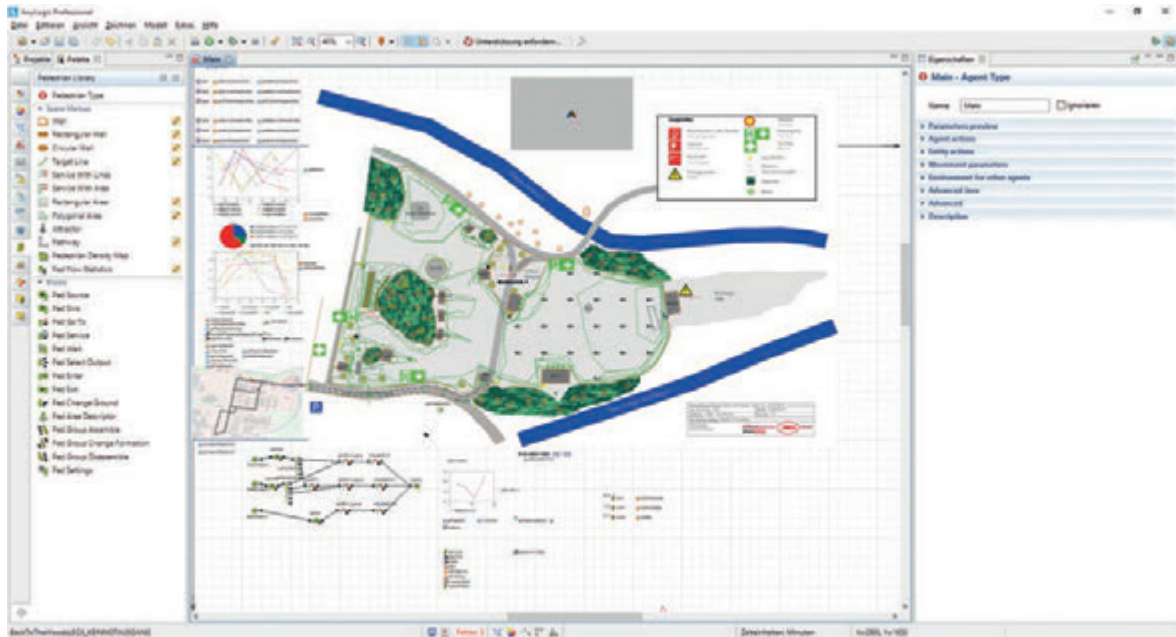


Figure 2.5: AnyLogic interface with the “Back to the Woods” scenario

2.2.2 Multiscale Simulation: TransiTUM with VADERE and MomenTUM

TransiTUM is a multiscale research framework that is able to connect different simulation models. The version used in this thesis connects a mesoscopic simulator with a microscopic simulator. The mesoscopic simulator is the MomenTUM(v1) research simulator developed at the Technische Universität München (Kielar *et al.*, 2014). The microscopic simulator VADERE is developed at the Munich University of Applied Sciences (Dietrich & von Sivers, 2014). It performs on the self-developed Optimal Step Model (Seitz & Köster, 2012; von Sivers & Köster, 2015). The data exchange between the simulators was executed by an interoperability protocol (Kielar *et al.*, 2014).

The event site is divided into two areas of different scales. Both simulators just have information on their sector. TransiTUM whereas knows about all parts of the scenario. If an agent gets to the border of a scale, TransiTUM transfers him to the neighboring model. To complete this process, information like the current velocity, current position, the diameter and the next target of the transmitted pedestrian are necessary.

In contrast to other hybrid pedestrian simulators, TransiTUM allows pedestrians to cross the border of the two models on any point and not only at specific entry points. This is realized with a special transition zone:

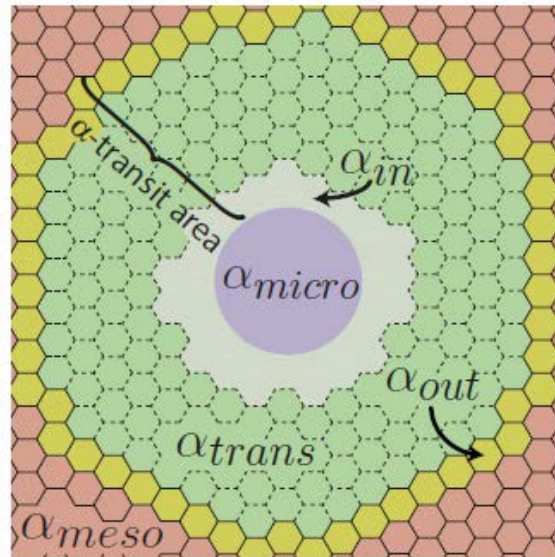


Figure 2.6: Transit area of TransiTUM - (Biedermann *et al.*, 2014)

Figure 2.6 shows a transit area with its various parts. α_{meso} , α_{out} and α_{trans} are calculated by the mesoscopic model and α_{micro} , α_{in} and α_{trans} belong to the microscopic. α_{trans} is the connection between both scales and the pedestrian has to be inside for being transformed (Biedermann *et al.*, 2014).

Like AnyLogic, the TransiTUM framework works with Java. All necessary options for the transformation (e.g. location of microscopic areas, width of the transition area) are defined within a configuration file. The layout coordinates are integrated through an .xml file.

```

55 <object name="-3" type="origin">
56 <point x="29.0507893818389" y="50.6516094979027"/>
57 <point x="32.2509015249725" y="67.0248453157453"/>
58 <point x="36.5177167190377" y="66.3394544007003"/>
59 <point x="33.0890259914913" y="48.5192814735145"/>
60 <point x="39.7940217236421" y="47.2050277181514"/>
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69 </object>
70 <object name="1" type="destination">
71 <point x="0.124404880601217" y="8.00407370833599"/>
72 <point x="2.03116998367443" y="8.00532305844112"/>
73 <point x="1.88965799195023" y="16.283466175596"/>
74 <point x="0.124404880601219" y="16.2080786594952"/>
75 </object>

```

Figure 2.7: .xml layout file

After running the combined simulation of MomentUM(v1) and VADERE, a new output .xml file is generated. The graphical presentation is handled by a tool called SiNewVis, which is able to visualize this file.

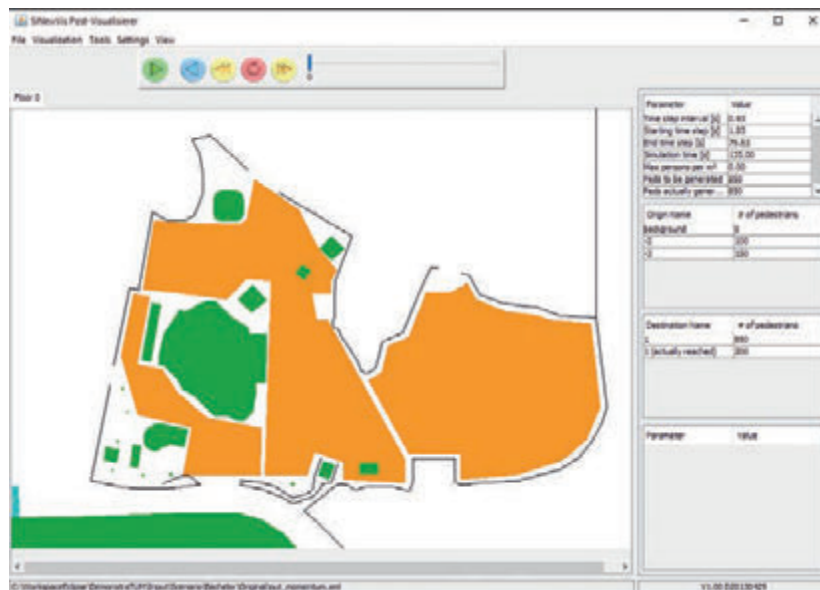


Figure 2.8: SiNewVis - visualization tool

The possibility to track individual pedestrians exists as well as different visualization modes, like displaying the density or velocity. Furthermore, there is a lot of information about the running scenario, e.g. the amount of pedestrians and the simulation time.

2.3 Five Simulation Samples

In the following chapter different setups of the “Back to the Woods” open air are simulated with both software solutions. Not just the resulting times are compared but also the handling and the adaptations that needed to be made to achieve a reliable outcome.

Both software simulations run with 850 agents. The used pedestrian velocity is 2.17 m/s. The usual average walking speed is 1.34 m/s (Weidmann, 1993) but since an emergency situation is simulated, the velocity is increased. The pedestrian radius is assumed as 0.3m. Since this radius was the source of some problems in AnyLogic, it got decreased to 0.2m. The explanation thereof can be found in the last section of this chapter.

The event site is 8926 m² with an accessible area of 6389 m². The area can easily be divided into two parts by the centered track: the dancing area on the right with 2949.2 m² and the quieter area on the left with 3440 m². The maximum distance to the next emergency entrance is 50 m.



Figure 2.9: ©VABEG map of the event site

In 2014, most of the visitors used the main emergency exit near the entrance. If people are not in panic, they tend to leave an area the same way they came in. Furthermore, it is the only way to the public transportation service and the parking lot. Therefore, the upper emergency exits are irrelevant in a thunderstorm scenario. They are more important if a sudden event,

like a carbon dioxide explosion, causing damage. However, in real panic situations, people are reducing their attention in situations of fear and therefore alternative exits are often ignored (Helbing *et al.*, 2002). Those experiences are included in the different scenario settings.

The aim of the simulations is to calculate the times of each scenario until more than 50, 75 and 95 percentage of the visitors reached the target area. The listed results are the mean values of 10 runs (RIMEA, 2009).

Thereby weak points or possible improvements are pointed out and discussed. The difference between the two software solutions is worked out and the author comments each scenario and compares it to the made experiences.

2.3.1 Back to the Woods 2014

The first simulation matches with the real setup from 2014. As it was the first year of the MultikOSi observation, there are no external influences and modifications. The setup was adopted from 2013 without any big changes. The layout serves as initial scenario for the following simulations.



Figure 2.10: “Back to the Woods” 2014 from a lifting platform

TransiTUM scenario and sequence:

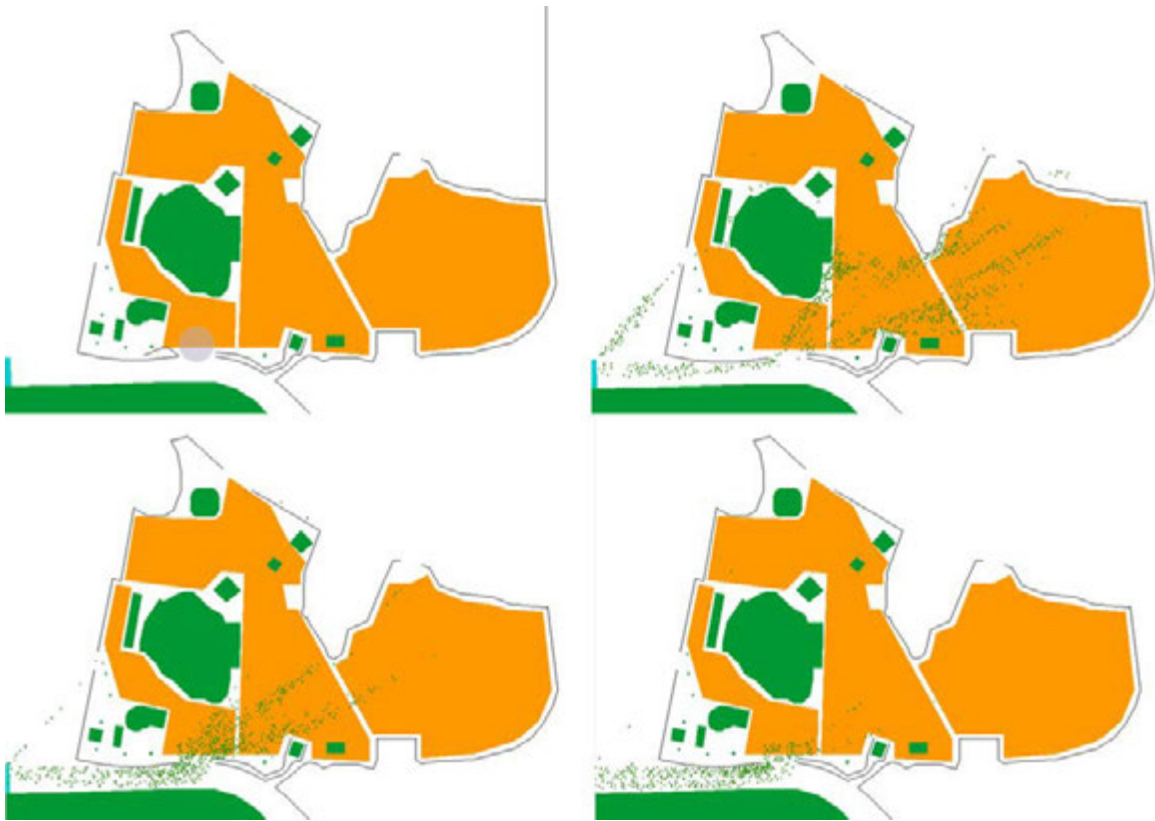


Figure 2.11: TransiTUM scenario with the microscopic area at (50,20)

AnyLogic scenario and sequence:

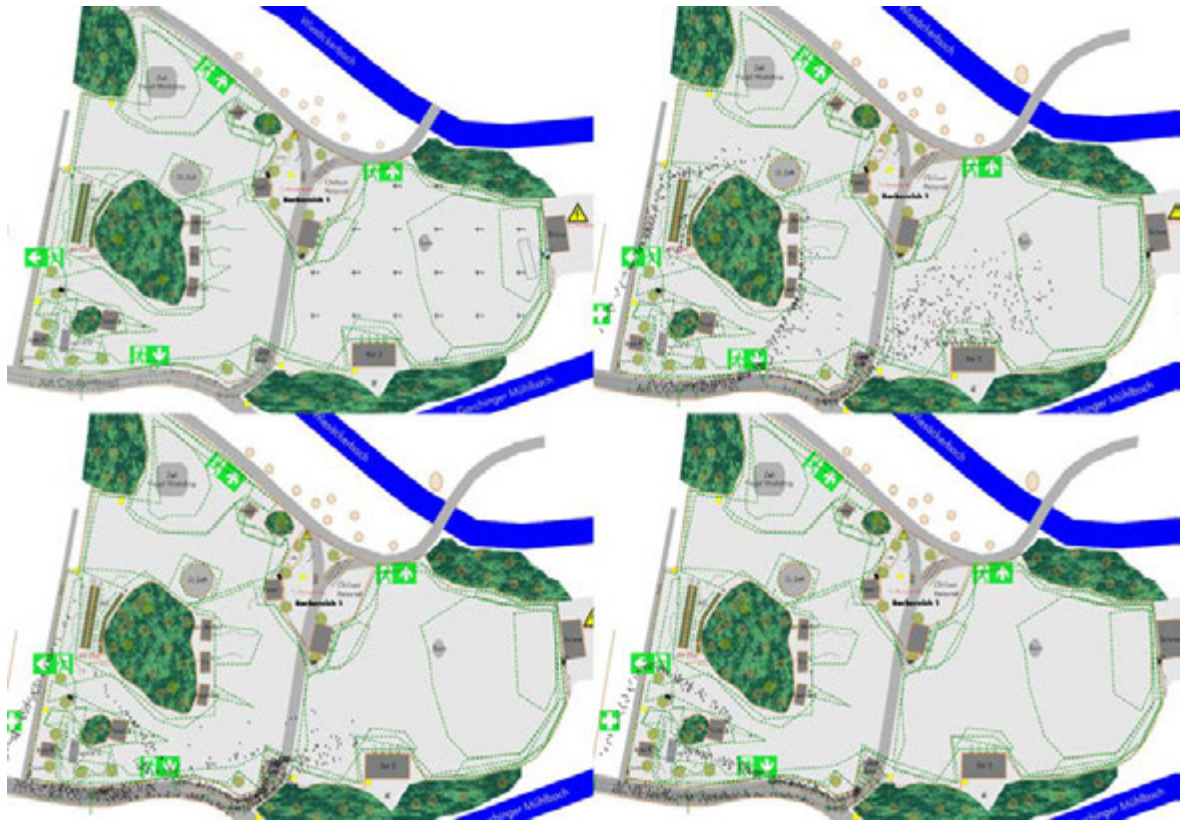
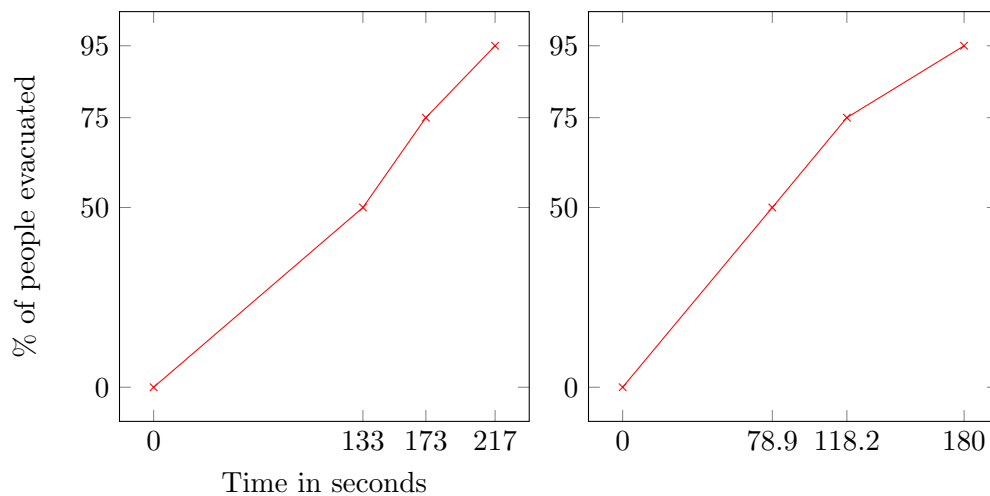


Figure 2.12: AnyLogic scenario and sequence

Evaluation:

	TransiTum	AnyLogic
50%	133	78.9
75%	173	118.2
95%	217	180

Figure 2.13: Evacuation times in seconds for 50%, 75%, 95% of the people**Figure 2.14:** Evacuation graph of TransiTUM and AnyLogic

Both software packages show a similar time process. In TransiTUM the agents do not use the entrance but split up to the two emergency exits, with a majority choosing the big one in the south. Thus, there occurred no complications.

On the contrary, most of the AnyLogic agents from the dancing area, choose the entrance as their favorite exit. This results in an increased density and even a slight congestion.

Compared to the evacuation flow in 2014, the TransiTUM simulation was more closely to the real situation. As mentioned before, most visitors used the big emergency exit instead of the entrance. Since the big emergency exit is just a few meters away and in line of sight of the entrance, most of them decided in favor of it.

2.3.2 New Postion of the Main Bar

The "Kellerkind" team thought about this change for 2015 and the considerations were very advanced. The idea behind this proposal was to clear the old bar area around the trees and open it for the visitors. Additional, some space would have been gained for a bigger bar. The idea was dropped because of lacking distance to the fence in the south. The warning came from the VABEG safety expert. To realize that change anyway, huge efforts would have been necessary.

TransiTUM scenario and sequence:

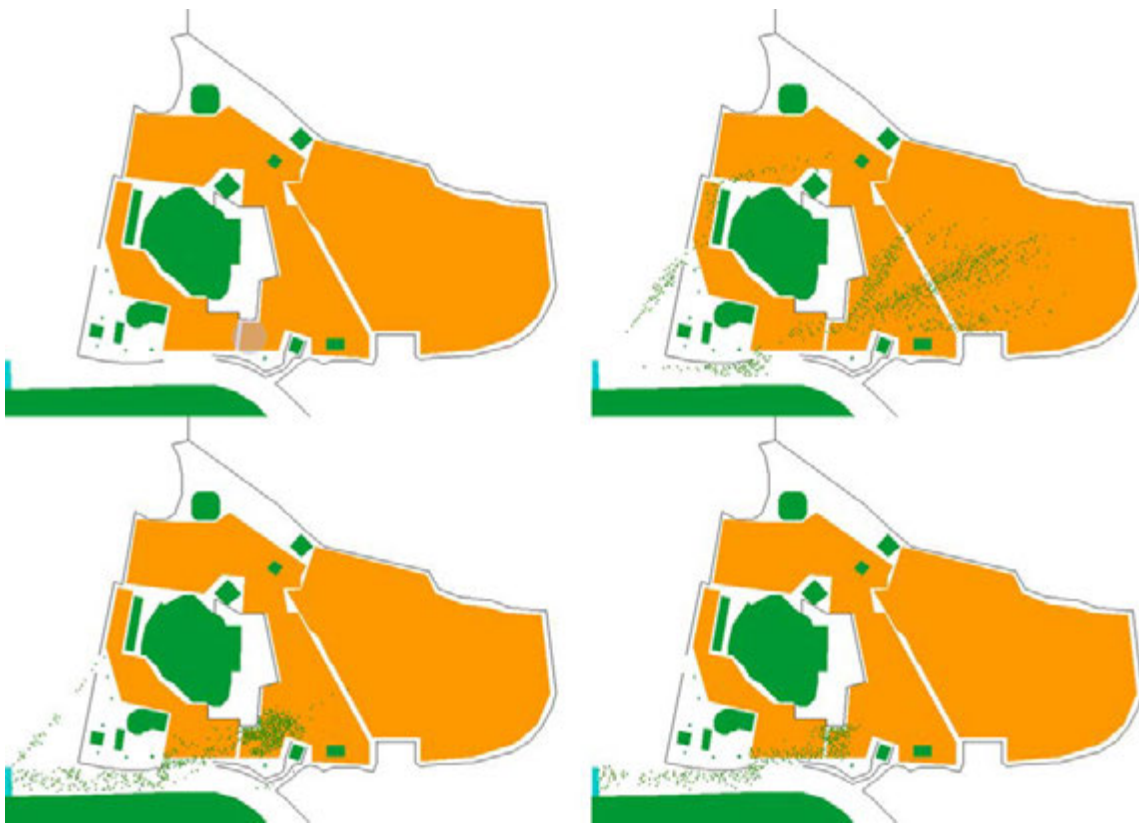


Figure 2.15: TransiTUM scenario with the microscopic area at (70,23)

AnyLogic scenario and sequence:

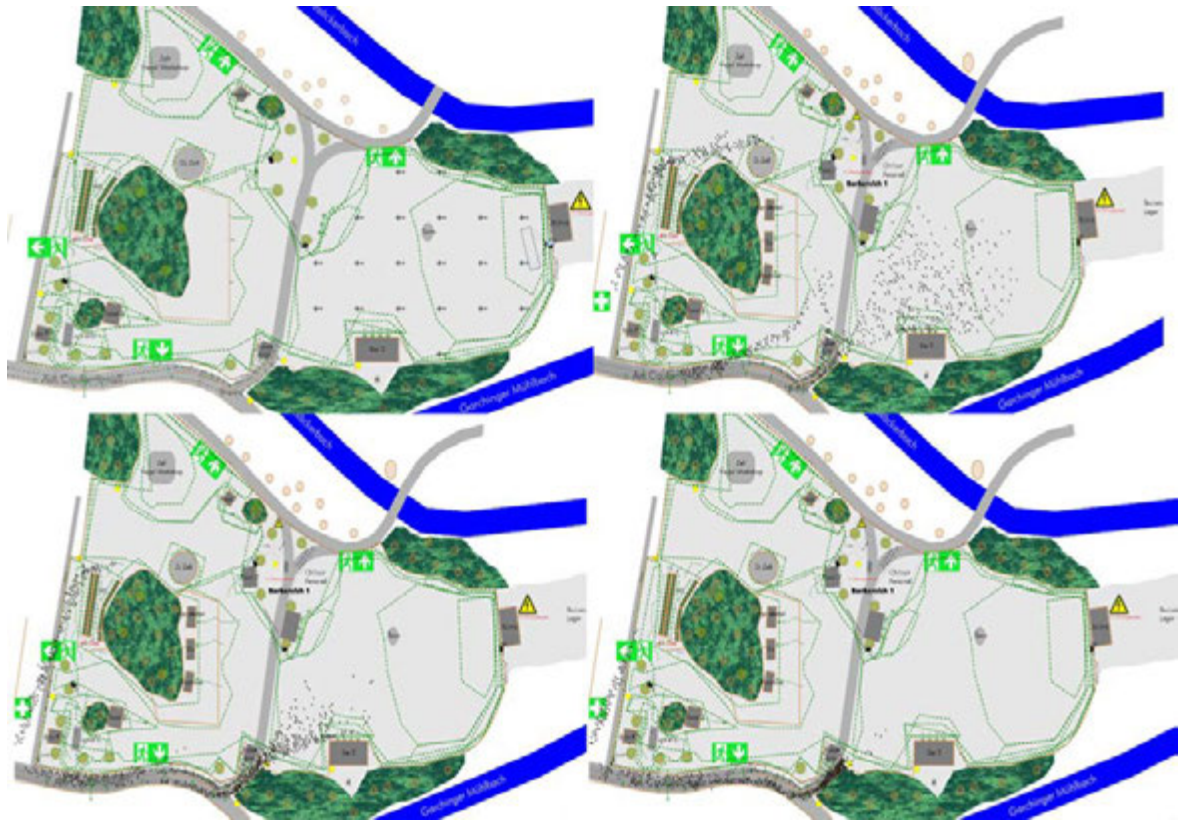
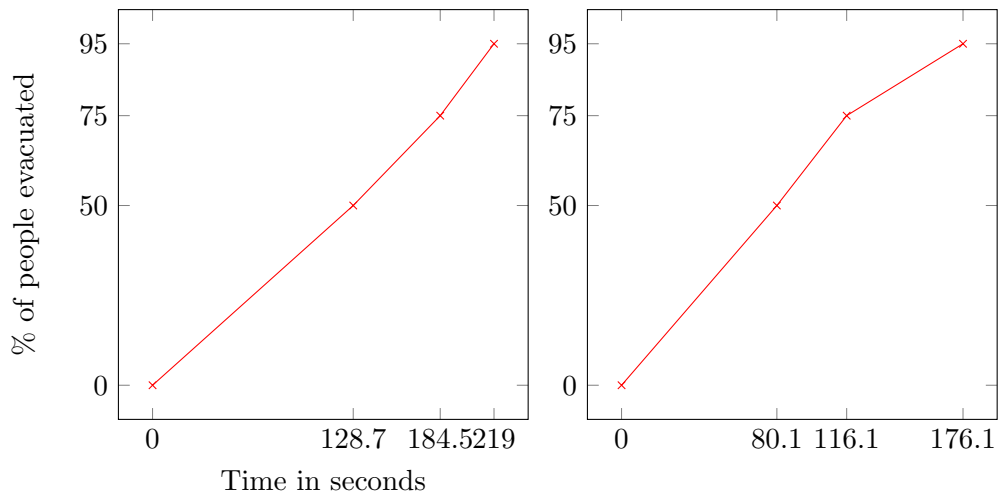


Figure 2.16: AnyLogic scenario and sequence

Evaluation:

	TransiTum	AnyLogic
50%	128.7	80.1
75%	184.5	116.1
95%	219	176.1

Figure 2.17: Evacuation times in seconds for 50%, 75%, 95% of the people**Figure 2.18:** Evacuation graph of TransiTUM and AnyLogic

This change does not have a strong impact on the simulation times. They largely correspond to the initial setup. However, the TransiTUM simulation shows a small delay till the 50% are reached. This is based on a densification in the critical area around the lower end of the bar. As this increase in density is resolved fast, there is almost no impact on the final time.

That danger is not noticeable within AnyLogic, as it once again navigates most of the pedestrians to the entrance.

The issue can get worse, if there are still people waiting in line for a drink. The distance between the lower right corner of the bar and the tree at the entrance is approximately 8.00 m. Thus, the queue at the bar can easily get in the way of the escaping people. The author knows from experience that visitors, especially drunken ones, tend to ignore the evacuation announcements to get a last drink or even try to hide under the canopy of the bar. In this case, the passage could be blocked completely and the people have to use the entrance or an alternative emergency exit.



Figure 2.19: People waiting at the bars during the evacuation

2.3.3 Smaller Main Emergency Exit

This scenario shows the course of the evacuation with a small main emergency exit in the south. The exit is just approximately 3.5 meters wide, which matches one site fence element and is often seen at events. Through the fence stones the chargeable width is reduced to 3.00 m.

TransiTUM scenario and sequence:

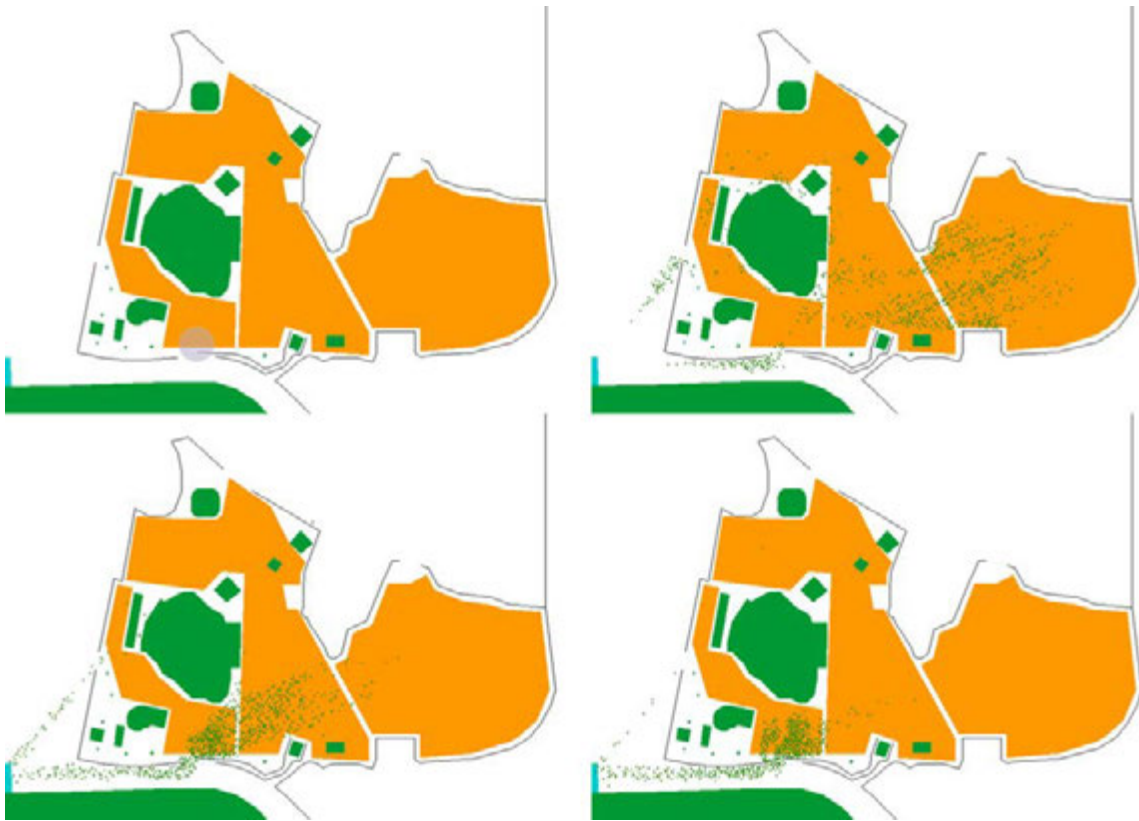


Figure 2.20: TransiTUM scenario with the microscopic area at (55,20)

AnyLogic scenario and sequence:

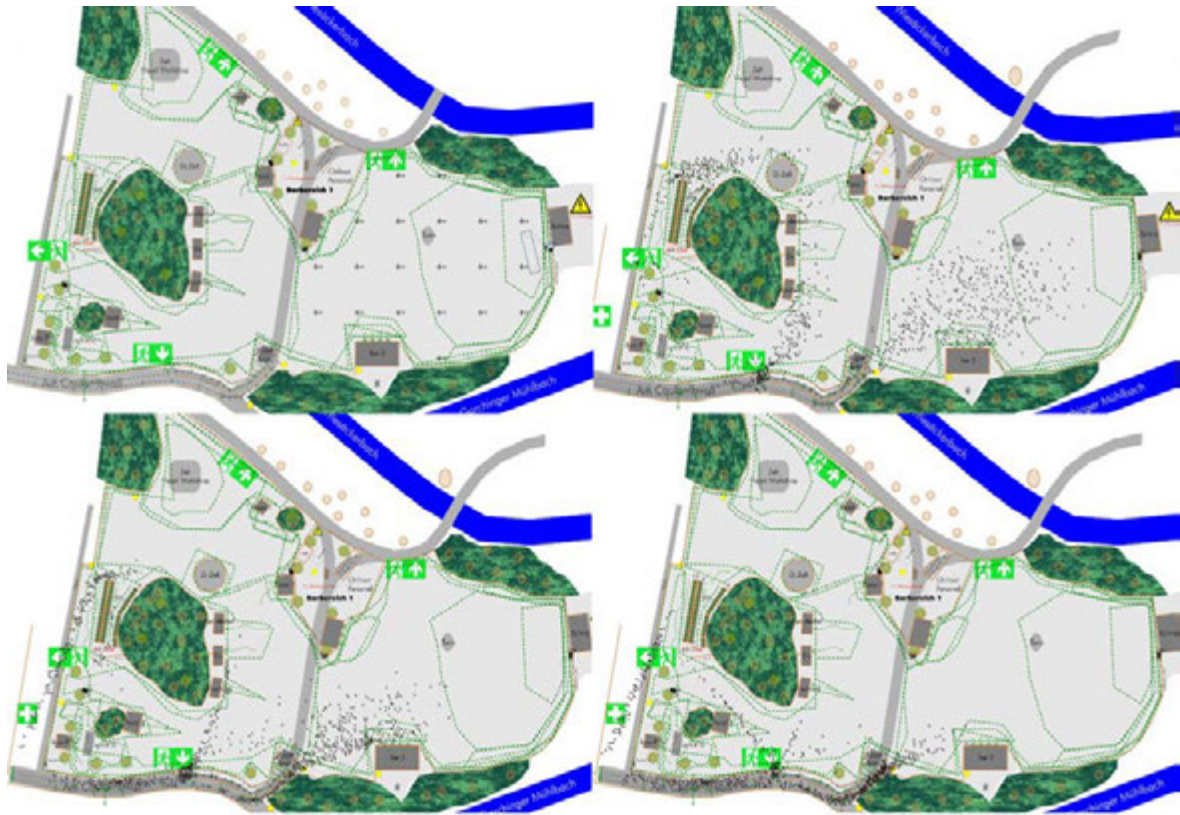
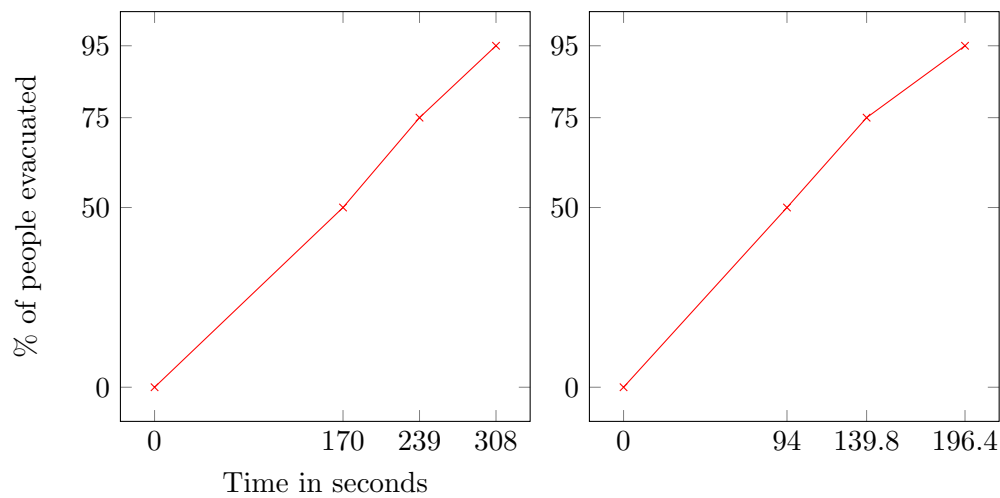


Figure 2.21: AnyLogic scenario and sequence

Evaluation:

	TransiTum	AnyLogic
50%	170	94
75%	239	139.8
95%	308.3	196.4

Figure 2.22: Evacuation times in seconds for 50%, 75%, 95% of the people**Figure 2.23:** Evacuation graph of TransiTUM and AnyLogic

The two simulators show up very unequal results. The reason is again the extensive use of the entrance in AnyLogic. Just a small amount of pedestrians is routed to the emergency exit and therefore the impact of the change is little. Whereas TransiTUM calculates a high deviation since a major part of the pedestrians is affected. Thus, a large concentration of pedestrians emerge around the exit.

AnyLogic hardly shows any effects except the usual densification at the entrance. Just a small cluster is formed around the emergency exit. This is based on the confluence of the two pedestrian flows.

This scenario is one of the more dangerous. A lot of the visitors are guided to the too small emergency exit. Since it is signposted as an emergency exit, they are not looking for any alternative solution. They recognize the congestion very late and other emergency exits are hard to see from their position. Therefore, they wait until the congestion is dissolved.

2.3.4 No Main Emergency Exit

In this case the main emergency exit is removed completely. This could theoretically happen when the exit is blocked by a car or visitors who are standing in line: the entrance queue is located in front of the exit and additionally a lot of people hanging around there. In 2013 a car passed the roadblock and parked across. It took only a minute to send him away, but what would be if an emergency occurs during this period.



Figure 2.24: The queue blocking the emergency exit in 2014

TransiTUM scenario and sequence:



Figure 2.25: TransiTUM scenario with the microscopic area at (95,20)

AnyLogic scenario and sequence:

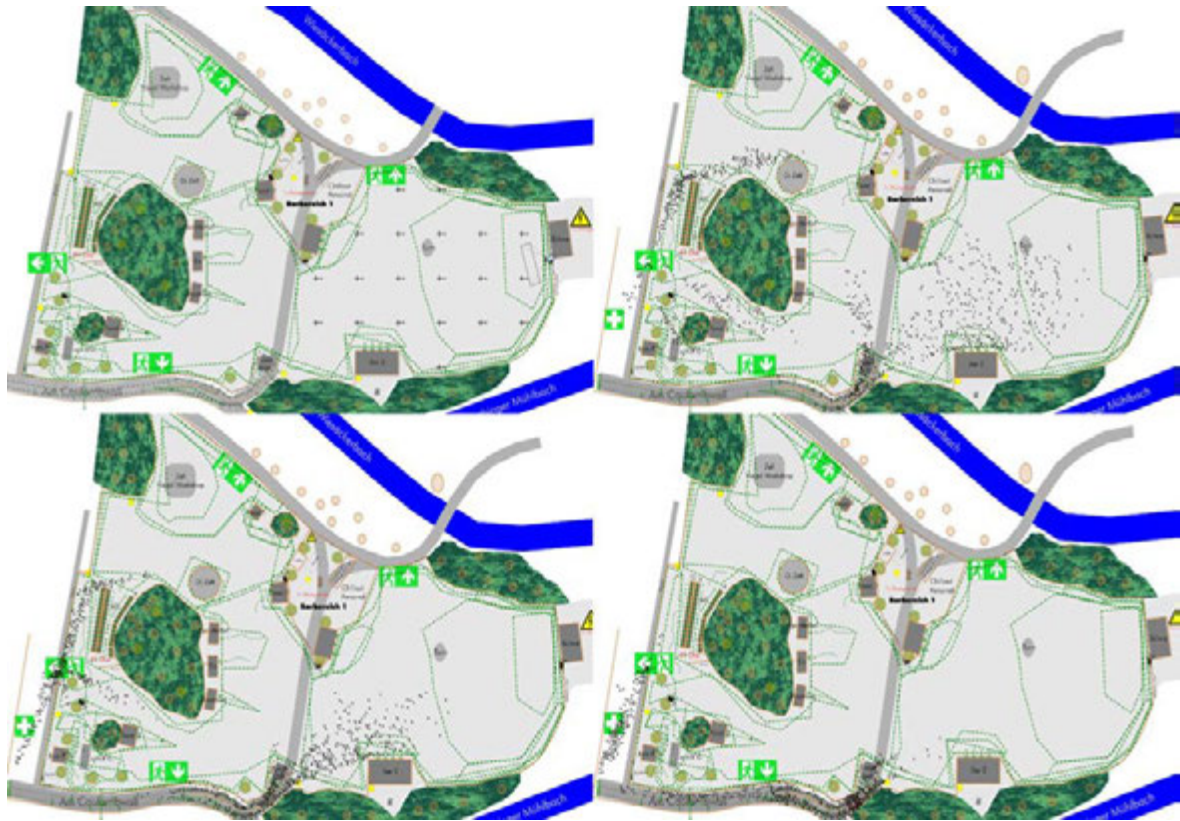
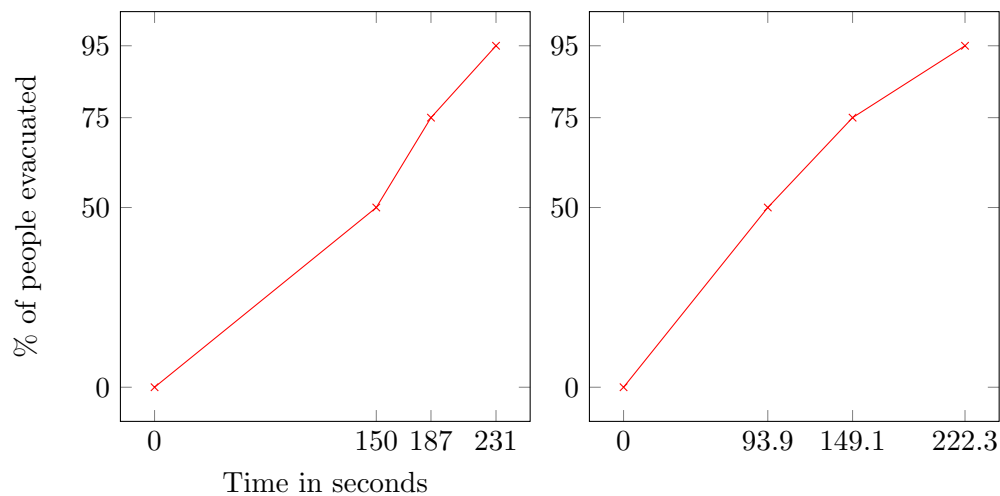


Figure 2.26: AnyLogic scenario and sequence

Evaluation:

	TransiTum	AnyLogic
50%	150	93.9
75%	187	149.1
95%	231	222.3

Figure 2.27: Evacuation times in seconds for 50%, 75%, 95% of the people**Figure 2.28:** Evacuation graph of TransiTUM and AnyLogic

The agents split up and use the main entrance and the emergency exit in the west. As the pedestrians have no choice but using the entrance, both packages simulate a similar scenario. It is the first time that the pedestrians are using the entrance in TransiTUM. The entrance has a width of 1.80m and is therefore even smaller than the reduced emergency exit in the scenario mentioned before. Thus, the evacuation times are increased. A high density and reduction of velocity is noticed at the entrance.

The author thinks it is very important to guide the visitors to one of the side exits. Instead of queuing them at the entrance, early signs should point the way to an alternative emergency exit.

2.3.5 Barrier

The “Kellerkind” team had this barrier in form of benches at the first “Back to the Woods Open Air” in 2013. It was situated directly in the route from the main stage to the exit and served as a rest area where people could sit down.

TransiTUM scenario and sequence:



Figure 2.29: TransiTUM scenario with the microscopic area at (105,35)

AnyLogic scenario and sequence:

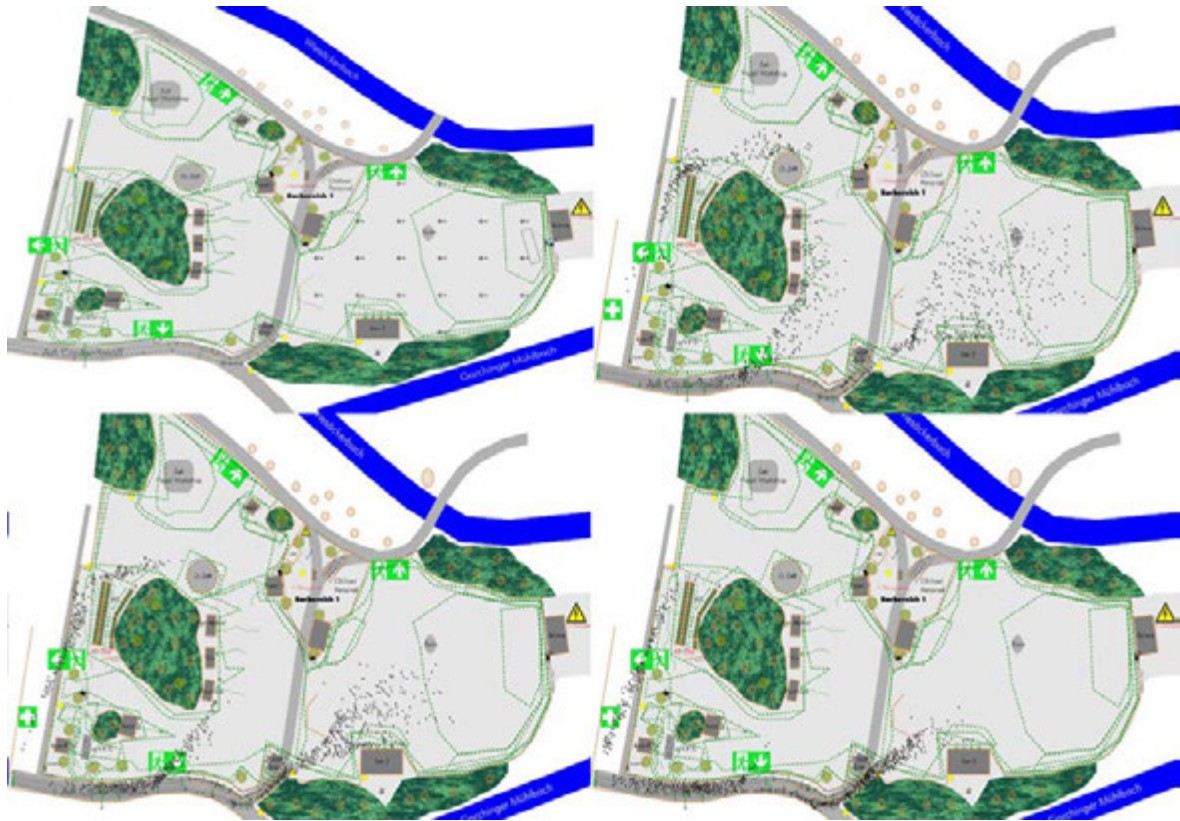
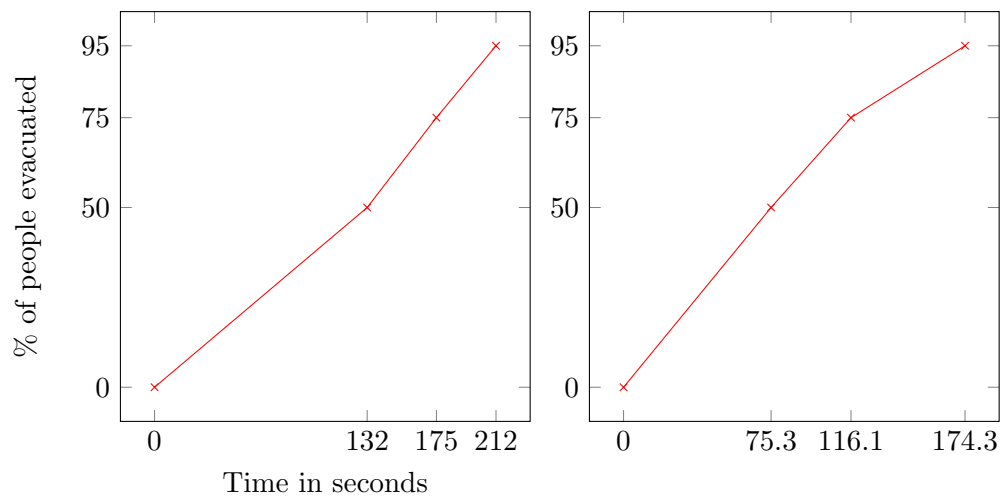


Figure 2.30: AnyLogic scenario and sequence

Evaluation:

	TransiTum	AnyLogic
50%	132	75.3
75%	175	116.1
95%	212	174.3

Figure 2.31: Evacuation times in seconds for 50%, 75%, 95% of the people**Figure 2.32:** Evacuation graph of TransiTUM and AnyLogic

Without any other critical occurrence the simulated setup does not really affect the evacuation times. There is rather a benefit: the barrier delays the pedestrians coming from the dancing area. Thus, less people are gathering at the exits at the same time. This relief provides an easier get through and therefore an overall faster evacuation time.

The only small risk is if an additionally obstacle comes up between the bars and the barrier. But since there is always an alternative route and a side exit above, this consideration can be neglected.

2.4 Conclusion and Practical Use

Both software packages were working quite well after an introduction phase. However, the results differ significantly. Although the simulation times are similar, each software calculates different paths.

We had to influence the structure of AnyLogic so that the pedestrians also use the large emergency exit. Manual target areas and paths were used for more realistic routes. For example, a small target area rerouted a percentage of pedestrians to the large exit. The other way round, the agents in TransiTUM did not use the entrance. Even though that is more closely to reality, a mixture of both would be good.

In the beginning, AnyLogic seems more user friendly than the multiscale simulation. Thanks to the graphical interface the handling is quite easy. All features are well structured and self-explanatory. But if you are focusing on pedestrian evacuations, AnyLogic has a little bit too many features. Most of them are useless in terms of pedestrian simulation.

In the process of creating an evacuation framework, you have to connect different functions and events with some programming. Therefore, some Java knowledge is required.

Furthermore, it happened that the outflow was blocked by a few pedestrian running in the opposite direction. This ended in a complete congestion which dissolved very slowly. This problem was solved by using an exit path from the entrance to the target area.

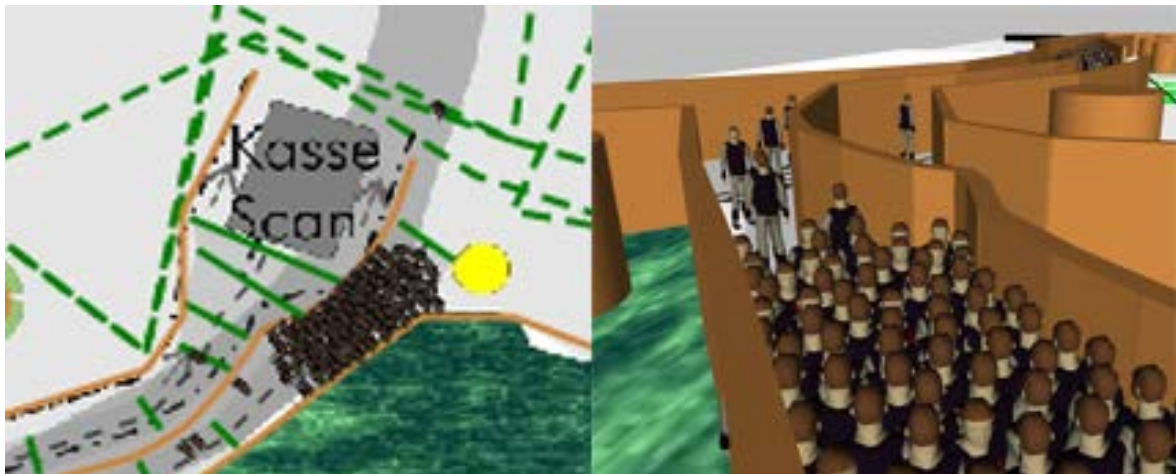


Figure 2.33: Congestion at the entrance because of wrong-way pedestrians

The same issue occurred at different edges in the scenario. The result was a cluster of agents, not moving forwards or backwards. To fix that problem, the diameter of the pedestrians was reduced.

An advantage of AnyLogic is the low calculating time. The simulation starts almost immediately and in contrast to TransiTum, there are no long waiting times.

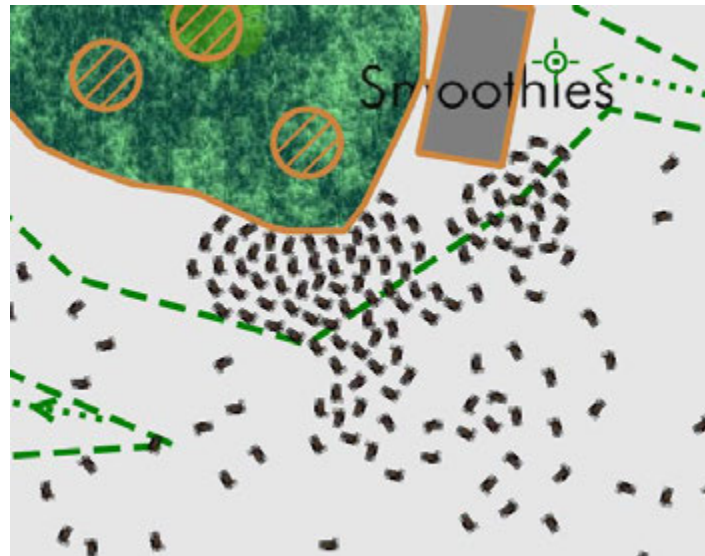


Figure 2.34: Cluster formation at a corner

On the other hand, the early TransiTum release used by the Author is starting quite inconvenient. The cumbersome creation of the scenario via the .xml file is taking a lot of time. The configuration file and the whole structure of the framework is unclear for a novice.

To get the different simulations time, the user has to follow the try and error principle. The simulation runtime is determined in the .xml file. After each simulation, the amount of successful evacuated people has to be checked and compared with the needed amount of the 50, 75 or 95 percentage. If the calculated amount is too low, the simulation time is increased. This step is repeated until the right number of evacuated pedestrians is reached for each percentage.

However, after getting used to it, the simulation runs very smooth. There are no unusual clusters or blocked paths. The evaluation via SiNewVis is working well and the different visualization possibilities are helpful.

Both software packages are missing some influences like they would appear in real life, for example that visitors do not follow the instructions, are too drunken to realize the seriousness or people falling down or getting injured. Therefore, the evaluation needs to be done by an experienced person who is able to rate and classify the results.

Overall both software solutions are very helpful to check an event site and occurring problems were recognized easy within the graphical interface. The author will use them again to check the big changes for the second open air “Schall im Schilf” coming up in 2016. The event size will be doubled, involving a lot of structural changes. Especially a bottleneck between two sections will be examined carefully.

2.5 Outlook: MomentTUMv2 and TransiTUM

TransiTUM got already developed further and is now included in the “MomentTUMv2” simulation platform.³ Thus, the framework structure was reduced and therefore just one shared configuration file remains. The external xml file to create the scenario was removed.

The simulation speed was noticeable increased and a visualization tool was included into the simulation platform.

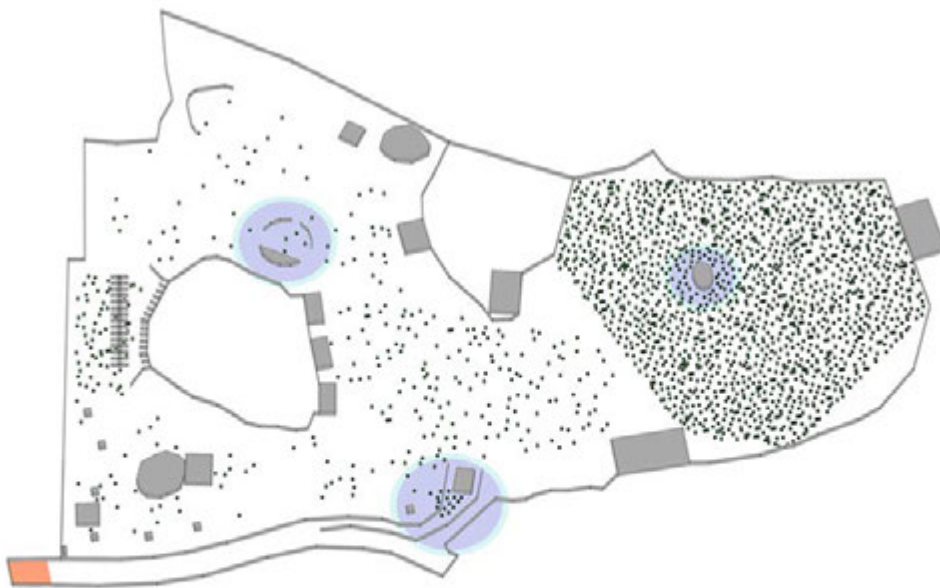


Figure 2.35: The coupled MomentTUMv2 and TransiTUM with different microscopic areas

The further developed “MomentTUMv2” simulator has a lot more features. He implements the three layer approach from Hoogendron and Bovy which divides the pedestrian behavior into three layers: strategic, tactical and operational (Hoogendoorn & Bovy, 2004).

The operational layer is capable of running one or two combined models. To safe computational costs, large scenarios are realized with two different models: a mesoscopic model for large parts of the event side and a microscopic for the more challenging. And that’s the point

³<https://www.cms.bgu.tum.de/de/team/kielar/31-forschung/projekte/456-momentum>

where TransiTum comes into play, as it is connecting those two models (Biedermann *et al.*, 2016).

Another new feature is an AutoCAD plugin which is able to create and read the layout files. Thus, creating the scenario is simplified and quickened with the help of CAD software.

Chapter 3

Building Information Modelling

3.1 Introducing BIM

Building Information Modelling (BIM) describes a software planning method of the building and facility management sector. It combines the complete life time cycle from planning and building to the execution and deconstruction of a building. Therefore a new publisher-independent data format, called Industry Foundation Classes IFC, has been developed (Borrmann *et al.*, 2015).

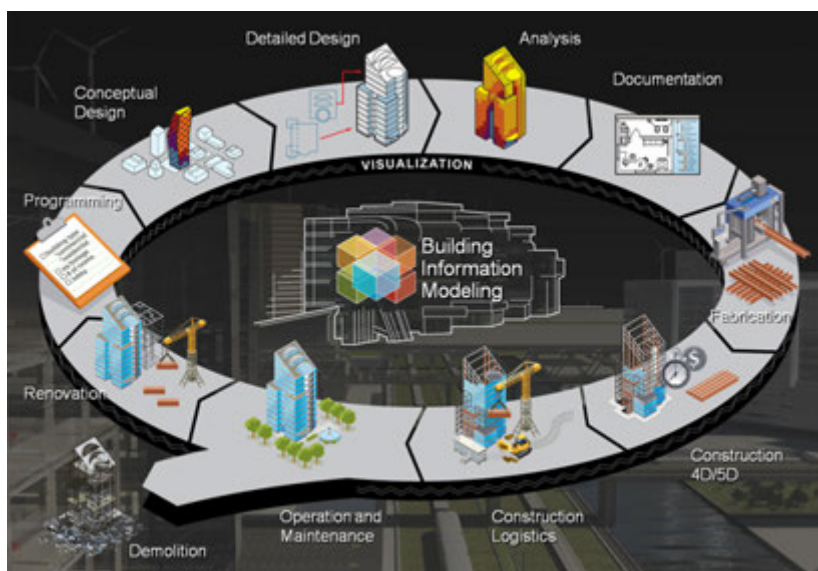


Figure 3.1: BIM life time cycle - http://nurebiz.de/wp-content/uploads/2015/11/BIM_Illustration.jpg

The involved crafts getting more connected as they are working on one shared model. This results in a fast exchange and update of information, e.g. the used material and quantities, the structural analysis and the technical configuration.



Figure 3.2: Different crafts are connected through BIM <http://bit.ly/1VV0NO7>

Everything is done in a 3D interface, which allows an easy visual presentation at all times. However, it is more than just a simple CAD application, as the model do not consists of lines or geometrical forms but of individual objects. This object-orientated working method entails a certain dependency between the different elements. If something is moved, all related objects are being changed simultaneously (Borrmann *et al.*, 2015).

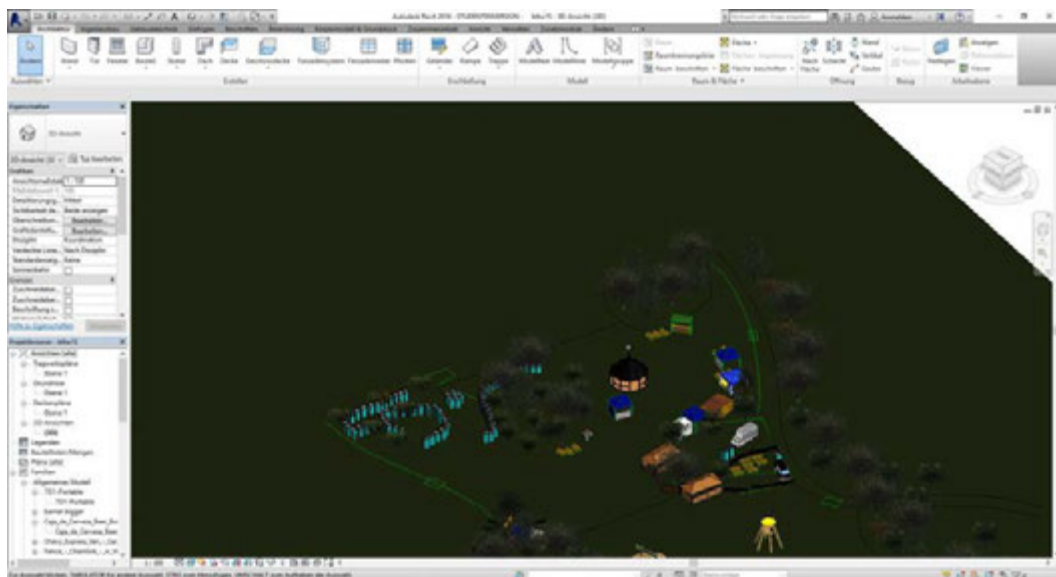


Figure 3.3: Interface of Autodesk Revit 2016

There are different producer of BIM software like Nemetschek with Allplan and Autodesk with Revit. The author is using Autodesk Revit 2016.

In the event planning many features of BIM are not important, but you can easily build a model true to scale, in which you can try out different setups, pick out distances and areas and visualize all of it to external partners.

3.2 BIM Model Back to the Woods

By order of the MultikOSi research project, a student assistant did a BIM model of the Back to the Woods Open Air 2014. Based on the VABEG site plan she used a satellite image to approve the scale. The installations, based in large parts on pictures, were constructed with Autodesk's AutoCAD software.



Figure 3.4: Rendered second stage compared to the original

After some hours of orientation, she needed 40 hours to complete the 3D draft. Each installation needs about 2 hours in AutoCAD, the easier even only 30-45 minutes.



Figure 3.5: Back to the Woods 2014 ©Andrea Mayer

The author used the model from 2014 as basis for an updated 2015 version. There were no new installations, but rather changes in the layout:

- Increased the amount of toilets from 43 to 86 and moved them to a new location
- Added a second wooden frame house to the main bar
- Moved all food trucks to the same place
- Moved Joe's pub next to the food court
- Mirrored the entrance
- Added the "Viva con aqua" booth and the pavilion of the anti-drug campaign



Figure 3.6: Back to the Woods 2015

As the student assistant already did a lot of the CAD work, the changes were accomplished very fast. There is no real need of any background knowledge. The new plan was finished after 30 minutes. It helped the "Kellerkind" team to discuss and try out possible changes internal. Where hand drawings were used in the past, are now accurate and clear 3D models.

They even handed it over to the ambulance service to clarify the situation around the emergency exit to the west. In consequence of the increased amount of toilets, concerns about blocking the exit came up. With the help of the 3D design the doubts were straightened out.

3.3 Conclusion and Practical Use

The author sees a clear advantage in using Building Information Modelling in the process of planning an event. It often happens that there are misinterpretations between the different

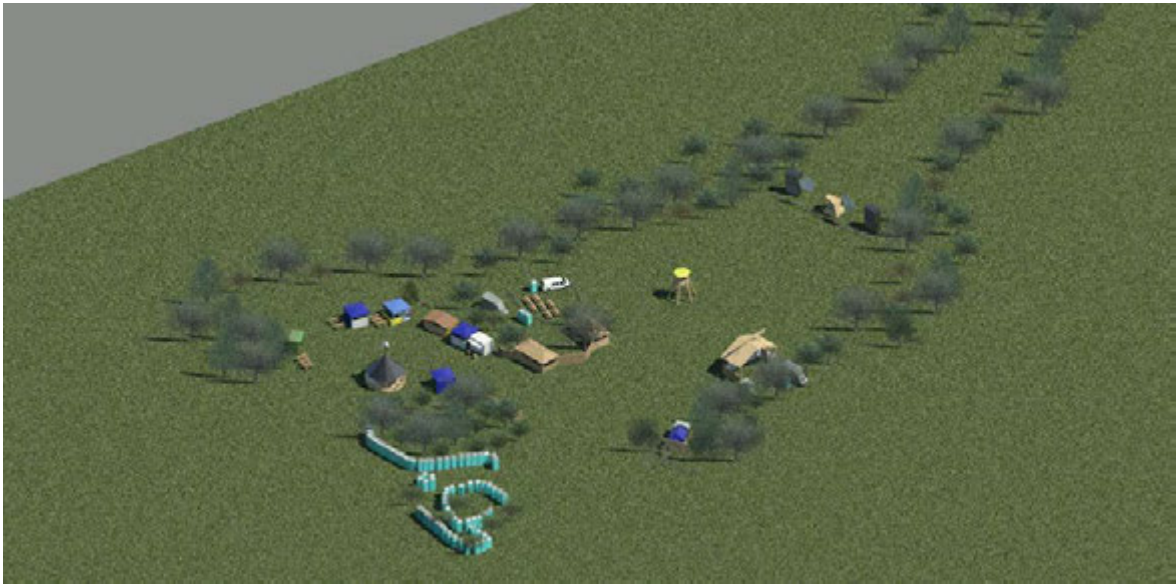


Figure 3.7: Rendered Back to the Woods 2015

trades. Even the simple 3D model facilitate the cooperation deeply, but if additionally every participant would use BIM, it lifts the communication between each other to a new level.

For example, the drafted stage could be virtually equipped with the technical equipment and the rental company automatically knows what to provide. If there are any mistakes, they can easily correct them. Furthermore, they can read out the location of the generators and therefore the necessary length of the cables. Currently you have to make a separate plan with the needed information, hand it over and wait for the reviewed version. This process may be repeated several times until a final solution is found.

Thanks to the realistic graphical presentation, you can easily check if planned changes fit into the appearance. External booth operator can use it to get an impression and suit their design to the overall concept. The problem of inappropriate stands occurred a few times. Furthermore, it can help to ease the negotiation with them by showing their location and the benefits hereof. Better positioned vendors can be charged for more fee. Artists can also verify if their work is located in the right part of the site with suitable surroundings.

A major benefit is the opportunity to show the planned changes to the authorities. This could increase the chance of getting a permission, as they can better visualize what is requested. It happened once, that a small change was declined because the official in the public order office misunderstood it. As it happened in the short-term, there was no possibility to discuss it. Furthermore, the other authorities, e.g. the fire department or the police, can use it to orientate themselves. At remote event sites there is no compulsory knowledge of the area. If an emergency is reported, the localization can be done with the help of a 3D map.



Figure 3.8: A food stand adapted to the design concept

Another advantage is the possibility to present the area to the visitors in advance. A virtual fly through can be useful for marketing purposes or to help the people orientating: If you are able to present a good looking event site, the people tend more to buy tickets. Moreover those short video presentation can be used to help them orientating at a complicated event site.

A further big improvement is the possibility to use a BIM model for pedestrian simulation. An extension of the IFC format would made it possible to capture the required information to run a pedestrian simulation. The simulation not just analyses the imported data but also suggests certain improvements that can be transferred back to the BIM model.

The simulation can even use live information of the BIM model. In the case of an emergency, the simulation collects information from a BIM based Building Management System and calculates a safe escape route. It could easily work the same way for an urban event. If there are narrow paths and some of them are blocked, the Management System is updated automatically by camera and therefore the pedestrian simulation (Mayer *et al.*, 2014).

Chapter 4

Oppilatio

4.1 Introduction¹

Oppilatio is a software to identify the used paths chosen by the visitors to get to the event site. It is developed by Daniel Biedermann, Peter Kielar and André Borrmann from the Technische Universität München. The intention is to show the recent situation and densities of the access paths. This helps to identify problems and to initiate necessary steps to solve possible congestions.

Oppilatio is much simpler than a simulation because you do not need any background knowledge about pedestrian dynamics. Local transportation timetables, possible pathways and a timestamped counting of the arriving people at the event side are sufficient. The timetable is publicly available; the pathways can be picked out of free geodatabases and are implemented as edges and nodes.

The timestamped data can be achieved using tickets and ticket scanner with timestamps. If there are no presales tickets, somebody has to create that data manually at the entrance. But most of the major events have employees counting the people anyway, because the information of how many people are at the event site is essential to stick to the authority requirements. With this information, Oppilatio is able to show the routes, which are most likely used by the incoming visitors. Afterwards, the event organizer just have to take the necessary actions.

The framework behind consists of different algorithms that allocate the public transport arrival times and the possible paths to the event site to different visitors p_i .

The first algorithm deals with the allocation of the event arrival time t_i to the arrival times of the public transportation service. Therefore, the unknown pedestrian velocity is needed. It is assumed, based on the velocity distribution by Weidmann (Weidmann, 1993), with a

¹The following paragraph is based on (Biedermann *et al.*, 2015)

mean value of $\nu = 1.34ms^{-1}$ with a standard deviation of $\sigma_v = 0.26ms^{-1}$ and a minimal and maximal velocity of:

$$\nu_{max} = \nu + \sigma_v \quad (4.1)$$

$$\nu_{min} = \nu - 2\sigma_v \quad (4.2)$$

ν_{min} is reduced because many of the visitors take a break to communicate or drink on their way to the event site. The second needed variable is the length d_l of a route λ_l :

$$d_l = \sum_{m=1}^{M-1} |s_{l,m}| \quad (4.3)$$

with the sum of all route section lengths $s_{l,m}$ and m as classification of the edges and nodes. With d_{min} as the shortest and d_{max} as the longest route, it is possible to determine a minimal $\Delta t_{min} = d_{min}/\nu_{max}$ and maximal $\Delta t_{max} = d_{max}/\nu_{min}$ walking time. Therefore, the time a visitor left the station is in the following time interval: $\tau_i \in \Delta D_i = [t_i - \Delta t_{max}, t_i - \Delta t_{min}]$

If different transport services arrive in that time interval, an explicit assignment of starting times t_i is not possible. Therefore, the probability of each arrival time is calculated with the help of a normal distribution. The one with the highest probability is chosen as starting time. ²

The second algorithm selects the most likely route a visitor has used to get to the event site. Therefore, a rating system is introduced. It considers the deviation from the routes to the beeline. People tend to choose a route similar to the beeline (Kneidl, 2013).

A further component is the amount of direction changes. Referring to an experiment from Kneidl (Kneidl & Borrmann, 2011), routes with less turns are preferred in 73.2% of all cases.

Finally, human beings have a kind of herding instinct, thus they are influenced by the amount of surrounding people. Externals often follow other visitors instead of orientating themselves (Schadschneider *et al.*, 2003). However, if the density of people increases to a certain level, the behavior will turn around and they try to avoid those sections (Weidmann, 1993).

Combing solely the two algorithm and the mentioned information, Oppilatio is able to calculate the most likely routes for each visitor (Biedermann *et al.*, 2015).

²For more information about the calculation, see the (Biedermann *et al.*, 2015) paper

4.2 Workflow

The handling of Oppilatio is quite easy and even feasible for a beginner. After starting the MATLAB based tool, the first step is to load a map of the specific arrival area by pushing the “D” button. One can easily get an appropriate map out of free geodatabases like OpenStreetMap. Afterwards Oppilatio asks for a public transportation timetable. The timetable is imported as a csv file, containing the arrival time and the transportation type ID. The next step is loading the timestamped data from the entrance. That file contains each time and the associated entrance ID.

After finishing the loading process, the nodes and edges have to be set. With “add Vertex” one can place the nodes, with “add edge” the edges. Both operations are performed by the left mouse button. The right one is used to end the process. The button “undirected edge”

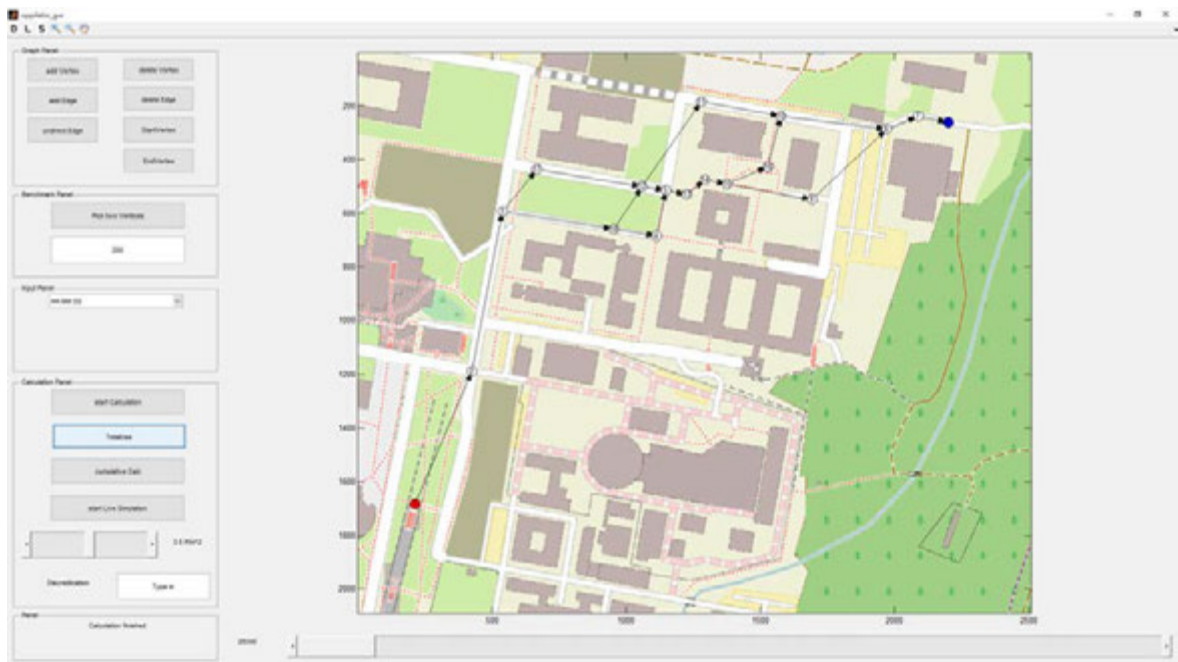


Figure 4.1: Nodes and edges in Oppilatio

makes it possible to set a two-directed edge. The Benchmark Panel is to specify the scale. After two exemplary nodes are selected and the distance between them is entered, Oppilatio is able to calculate all the other distances. The width of the street is not changeable and assumed with a default value. This should be changed in future releases.

Last but not least, the time format of the imported csv files can be changed between seconds and the usual time format HH:MM:SS. Afterwards the calculation is started with the according button. There are some more functions, like saving and loading a network mesh with the “S” and “L” button. Moreover, “TotalUse” shows the density of the various paths

and “start Live Simulation” allows the user to view a time-dependent progress of the density.

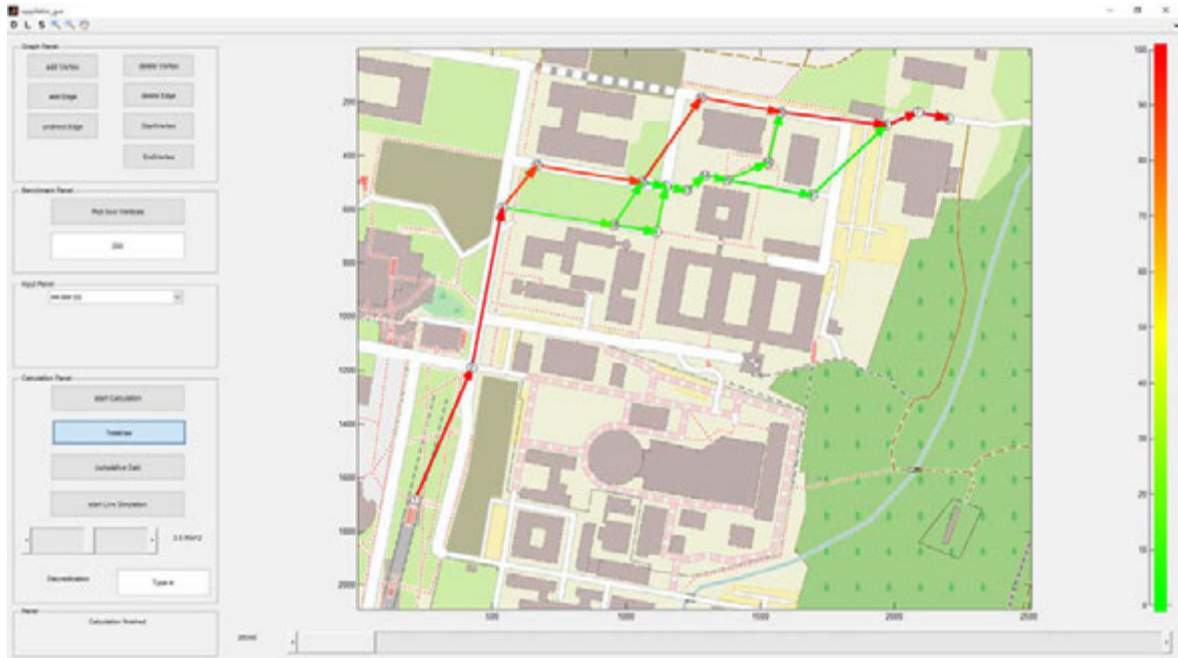


Figure 4.2: Emerging densities in Oppilatio

4.3 Case Study Back to the Woods Open Air 2015

The team of Daniel Biedermann and Peter Kielar took the 2015 edition of “Back to the Woods” to test the newly developed Oppilatio. With the help of student assistants, they tried to verify it by following the visitors from the subway station to the event site. They tracked their routes and recorded them with the help of GPS devices. Although ten student assistants were not enough to collect representative results, most of the values correspond quite well to the ones Oppilatio outputted (Biedermann *et al.*, 2015).

The timestamped data were extracted from the entry list of “Ticketscript”, the ticket provider used by the “Kellerkind” team. Combined with the arrival times of the subway line U6, Oppilatio was able to recalculate the used routes.

Based on experience and observations the calculated distributions are largely accurate although having problems with collecting the data. Those problems led to a deviation in section 02 and 04.

A higher number of tracked visitors would most likely assimilate the result more to the Oppilatio output. Many participants of this experiment have observed, that especially during the peak hours the people tended to a herding behavior in the sections 01, 03 and 06. The

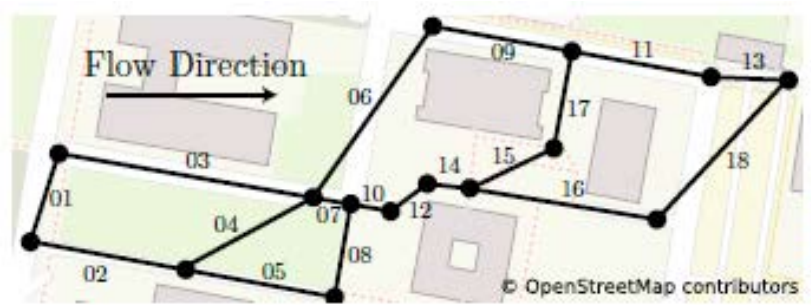


Figure 4.3: Nodes and edges of the case study (Biedermann *et al.*, 2015)

stream of visitors was concentrated almost on those sections. Also, the author passed the area almost every hour and experienced this high traffic there first-hand.

4.4 Conclusion and Practical Use

The case study showed that Oppilatio is calculating the used routes quite accurate. Despite the fact that just little information is needed, the output approximate the real behavior of the visitors. The use of Oppilatio is simple and no background knowledge is needed.

For a rather small event like “Back to the Woods” with spacious paths and no real obstacle or contraction, Oppilatio is not necessary. Whereas it could work really well for large events in narrow urban sites. Combined with practical knowledge like visitor peak times, it is a good tool to recognize emerging problems early. Thanks to the graphical interface, the handling is quite easy and even practicable for untrained staff.

The needed information is easy and cheap to collect. Thus, it is a reasonable alternative to live surveillance with cameras or employees. However, when Oppilatio gives an alarm, the spot has to be extra checked the old-fashioned way. As an event organizer the author would like to see the possibility to have various starting points and destinations. The visitors usually arrive with different means of transportation, like the subway and the bus. Furthermore, a lot of events have more than one entrance and therefore several destinations are needed.

To improve the information exchange and integration an interface between Oppilatio, the public transportation services and the ticket provider would be great. The framework could easily read out the arrival times of the public transportation. Moreover, there is no time during the event to manually load the timestamped entrance data. Thus, those times should be downloaded and integrated automatically. If the density reaches a critical limit, Oppilatio can alarm the organizer through a message on their mobile phones. This would be a step towards a more automatic observation. If there is an employed crown manager, those innovation would at least facilitate his job.

Besides the live monitoring, the software can be used to analyze a in the past recorded event and improve the routes for the next time. Even small events could use this knowledge to change the routing or to block individual routes.

Chapter 5

Creating an Open Air Event: Safety Procedure and Checklist

Although one could assume that event safety is a much-elaborated sector, the evolution of guides and laws progressed rather late. Before we getting to the current venue regulation “Versammlungsstättenverordnung VStättV(O)”¹ it was a long process, starting with first theater regulations in 1879 and followed by the “Lichtspielverordnung”, which controlled the safety in cinemas. It was only in 1970 that the VStättV(O) was introduced in the different federal states.²

Today a nationwide template exists, called ”Musterversammlungsstättenverordnung MVStättV”, which the federal states can use to compile their own version. However, since 2014 the regulation is just a requirement for venues with a permanent installed tribune. Therefore, it is rather a guideline for open-air events like “Back to the Woods” and while the actual power of decision is held by the city or district administration.

Some cities, for example Munich, published additional documents to complement and to intensify certain topics. In the case of the booklet “Veranstaltungssicherheit”, released by the Munich fire department, it is an almost 200-page paper. It outlines the different planning and approval stages and gives practical tips and figures. It even includes a numerical risk analysis to assess the event safety and to categorize the event into different risk groups (Bachmeier *et al.*, 2015).

Even though this way exists, most public order offices, according to the author’s experiences, use their own way to decide whether a safety concept is necessary or not. Most of them relate

¹All VStättV related numbers can be looked up here: <http://gesetze-bayern.de/Content/Document/BayVStaettV>

²<https://de.wikipedia.org/wiki/Versammlungsstättenverordnung>

to the VStättV(O), which says that you must have a concept when planning an event for more than 5000 visitors.

Thanks to the MultikOSi research project, the "Kellerkind" team had the opportunity to obtain a safety concept. It was the first time that they had such professional assistance. The elaboration was done on the principle of the VABEG safety procedure. The following section will present the process of creating such a concept from the author's point of view. Furthermore, the concept will be summarized and commented.

5.1 VABEG Safety Concept Back to the Woods 2015

5.1.1 Creation Process

The creation process starts with a first meeting between the event organizer and a VABEG licensed safety expert. The goal is to estimate the necessary effort and to recognize first problems. Based on this talk, an individual offer is made. After accepting, the organizer has the task to answer different questionnaires; including contact and basic information. This leads to another meeting to discuss details and arisen issues. This process might be repeated until everything is eradicated. Afterwards the concept is presented to the public order official. If he does have any objections, it has to be discussed and eventually changed again.

Altogether, the expenditure of time must not be underestimated. It can easily take up to four months until a final version is created. The effort is obviously depending on the kind and size of the event.

VABEG offers different kinds of concepts; differentiated between a temporary event or a permanent venue. ³

5.1.2 Content⁴

The final "Back to the Woods" 2015 safety concept contains the following chapters:

- Basic information
- Structural report , fire protection, safety equipment
- Surroundings and environment
- Access, event site, stages

³<http://www.vabeg.com/loesungen/vabeg-handbuch-konzept>

⁴The following subsection is based on the "VABEG Konzept"

- Organizational
- Health, cleaning, gastronomy
- Risk management

The first chapter starts with some basic information to present the event; like the runtime, the timetable and the layout of the event site. Still there are already some details like the amount of toilets, the power supply, lightning protection and mobile constructions.

Figures 5.1 and 5.2 show a part of the emergency exit calculation. It includes a division of the area and the associated space information, the resulting number of visitors and the available and needed width of the escape routes.



Figure 5.1: VABEG map with partial surfaces

The calculation is made according to the VStättV(O): the red partial surface has a visitor space of 3440.2 m². With two visitors per square meter assumed, this leads to a possible amount of 6880 visitors. Because the red area is almost the only way to escape from the yellow area and they share three out of four escape exits, the possible amount of people has to be reduced dramatically. In this case, it is reduced by 5880 people, which results in 1000 visitors.

The VStättV(O) says that you need a width of 1.20 m per 600 people at open air events, which equals 2.40 m for 1000 visitors. There are three emergency exits; all of them are 3.50

m wide site fence gates with a chargeable width of 3m. Added up that makes 9 m, which is a plus of 6.60 m. However, you may not disregard that the calculations of the yellow area have to be included.

Ort:	Vord. Gelände bei Bühne (gelb)	max. 28 Zeltchen	ZD241
Berechnung:	stehend	im	Freien/ Stadion
Berechnung der zugelassenen Personenzahlen (Stehplätze & Sitzreihen in Gebäude & Freien (nach VStättV); in Fliegenden Bauten (Zelte))			
2 Besucher je m ²			
Fläche der Besucherplätze	Kuppel 78m ² (begehbar)		2949,0m ²
Nicht angerechnete zugängliche Besucherfläche			
Mögliche Besucherzahl (nach Fläche)			5898
Vorgeschriebene Anzahl, Plätze für Rollstuhlfahrer		Empfohlener Wert bei FIBauten	50
Nicht besucherzugängliche Fläche			
Beschreibung:	Barbereich 1 rechter Teil 239m ² ; Bar 2 26,3m ²		265,3m ²
Summe, freizuhaltende zugängliche Besucherfläche (Werden nicht als Besucherplatzfläche angerechnet)			
Summe Fläche (Netto)	(Besucherplätze)		2949,0m ²
Summe Fläche (Brutto)	(Besucherplätze + besucherzugängl. Fläche + Nichtbesucherzugängl. Flächen)		3214,3m ²
Fläche der Bühnen/ Szenenflächen			
Mögliche Besucherzahl (nach Fläche)			5898
Personal- und Darstelleranzahl			27
Mögliche Anzahl Personen nach Fläche (Besucher & Personal)			5925
Besucherzahlen Abzug oder Addition:			
Resultierende max. Besucherzahl nach Abzug			4000
Resultierende max. Personenzahl nach Abzug			4027
Genehmigte maximale Besucherzahl nach Bestuhlungsplan			
Bisher max. genehmigte Besucherzahl			40
Vorgeschriebene Anzahl, Plätze für Rollstuhlfahrer (VStättV) Empfohlener Wert bei FIBauten			
Berechnung der notwendigen Flucht- und Rettungswegbreiten			
Vorhandene Fluchtwegbreite			
Ausgang bei Kasse 1,8m; Oberer Rettungsweg 3,5m (3m); sowie Notausgänge			4,80 m
Ort, Breiten: aus Berechnung rote Fläche			
0	Sichere gegenüberliegende Ausgangssituation vorhanden	Anzahl Besucher-Notausgänge:	2
Da es sich um eine Halbinsel handelt, kann nur nach hinten, jedoch in einer großen Breite entflucht werden.			
Benötigte Fluchtwegbreite zzgl. Rettungsweg hinterer Fläche, siehe Gesamtzahlen!			8,40 m
Fluchtwegbreiten - Differenz			-3,60 m
Personenzahl - Differenz			-1627
zzgl. Kapazität der vorderen Ausgänge im vorderen Bereich! Somit nach VStättV ausreichend!			
0	Rettungsweg getrennt von Fluchtweg vorhanden	Anzahl:	
Beschreibung: Teils können die Hilfskräfte an der Seite gut nach vorne laufen.			
Bemessung der Lüftung & Rauchableitung (nach ASR; DIN 1946, VStättV, DIN EN 13779)			
Benötigte Mindestluftströme ohne Raucherlaubnis und Geruchsbelastung 20m ³ /h/Person (ASR, DIN 1946)			0 m ³ /h
Benötigte Mindestluftströme mit Raucherlaubnis oder Geruchsbelastung 40m ³ /h/Person (ASR, DIN 1946)			0 m ³ /h
Ben. Mindestluftströme mit Geruchsbelastung & vorwgd. tanzendem Publikum ca. 60m ³ /h/Person (ASR, DIN 1946)			0 m ³ /h
Maschinelle Rauchableitungsanlage mit Luftvolumenstrom von 36m ³ /h/m ² (nach VStättV)			0 m ³ /h
Vorhanden:			
FIBau: Zelt/ Räume: Benötigte Rauchabzugsfläche (oder maschinell) (Ab 1500 zugel. Besuchern)			0,0m ²
Berechnung der Löschmittleinheiten (LE); Grundschatz nach ASR A2.2 (Detailbewertung siehe D241)			
Für den Grundschatz bereitzustellende LE:			84 LE
Wandhydrant	Mögliche Anrechnung nach ASR A2.2	28 LE	Vorhanden: 0 Stk.
Durch Feuerlöscher bereitzustellende Löschmittleinheiten:			84 LE
Anrechnung der höchsten Werte an die Gesamt-Bewertung (Pluster-Berechnung wenn spätere Geäu)			

Figure 5.2: Calculation of the yellow area: amount of people, emergency exit width

There are additional 2949.2 m², which is enough for 5925 visitors. Deducting an amount of 1898 people, because of the shared escape routes, results in a permitted number of 4000 visitors. The available width of 4.80 m (main exit 1.80 m, emergency exit in the north 3.00 m) would not be enough; there is a difference of -3.60 m. However, regarding the whole area and adding the two results, there is a plus of 3.00 m.

The deducted amounts of people can not be justified exactly. Since the "Kellerkind" team applied for a permission for 5000 visitors, there was no need to cover more within the safety concept.

The next chapter expands on structural setup, fire protection and installed safety equipment. Since "Back to the Woods" is an open-air event, the constructional facilities are not important; there are no stairs, elevators or ramps. The subsection fire protection lists all kind of

possible fire sources, like pyrotechnics, cigarettes and candles; and possible countermeasures. Finally the inventory of safety installations is mentioned: emergency power, smoke extraction systems and alarm systems.

“Surroundings and environment” deals with the arrival, the traffic and the parking lot situation. An evaluation on how visitors arrive at the event site is the basis for the car and bicycle parking space calculation. Additionally the surrounding buildings and trees are checked for possible dangers.

In “Access, event site and stages” is information about the visitors: average age and sex, potential for violence, physically impaired visitors and youth protection. Hereinafter the ticket sale, scan procedure and the visitor search through is explained. A big sub chapter is the description of the stages and the different barriers and fences. However, the most important part is the security service, police and ambulance description. It contains the following information:

- Security service: amount, times and operation areas
- Police: contact, communication
- Ambulance: nearest hospital, communication, access route for ambulances, calculation of the required amount, helicopter landing site

The next two chapters are rather small, just dealing with various organizational notes like mobile phone network, instruction of the employees, liability insurance, artist associations like GEMA or KSK and hygiene regulations.

The chapter “risk management” deals with the strategy for unexpected incidents. First of all the possible risks are shown up including each likelihood of occurrence. Followed by precise instructions what to do and what to say in case of a disturbance, a serious incident or even a real catastrophe.

There are different announcement messages listed, helping the responsible persons to express themselves correctly even though they act under great stress. The bilingual messages have to be clear and explicit.

Bei Brand/ Rauch (In case of fire/ smoke) :
 Aufgrund einer **anstehenden Gefahr**, ist das Veranstaltungsgelände zu Ihrer eigenen Sicherheit unverzüglich über die gekennzeichneten Fluchtwege zu räumen. Helfen Sie Behinderten, Rollstuhlfahrern.
 Because of **upcoming dangers**, the event area has to be left over the marked escape routes. Please help **handicapped, wheelchair users**.

Figure 5.3: Announcement message in the case of a fire

A further improvement of the VABEG supervision is the establishment and operation of a permanently manned security center. Located in a building of the Technische Universität



Figure 5.4: Emergency case instructions

München, equipped with internet, a land line phone and a computer, the perfect place for the VABEG safety expert was found. He was the contact point for the organizer and authorities like the police. Additionally he was monitoring the weather conditions and, in case of an upcoming thunderstorm, able to inform the other participants. This means one burden less for the event organizer. Based on the experience from 2014, the author knows about how stressful it can be when watching the weather and caring about the normal operation of the event at the same time.

The cost vary between 5000.00 EUR to 12000.00 EUR, depending on the additional options like a fire protection concept, a security concept, a evacuation concept or a complete on-site supervision of the event. Those packages are not mandatory, but depending on the event site sometimes useful. If you do not change the event site, these are non-recurring costs. The price for changing details the following years is far off the initial costs.

5.1.3 Conclusion

To order a safety concept seems like a difficult step in the beginning. The horrendous costs along with the enormous effort have a deterrent effect on every event organizer. The creation process takes several months and comes with hundreds of questions. Some of them are easy



Figure 5.5: Security center next to the event site ©Michael Öhlhorn, VABEG

to answer but others never came up before. The questions are very extensive, for example the safety experts request the measures of indeed every construction.

Furthermore, the appearance of the event site fades into the background. The “Kellerkind” team always keeps a close eye on an appropriate design. But since the concept has been introduced, a lot of changes had to be made and new guidelines had to be followed. Compromises between appearance and safety had to be found. Decoration elements and constructions had to be removed to clear emergency routes and some of them have been strengthened to defy the weather. Overall, a lot of modifications, which do not look necessary at first glance, have been made. Therefore, a lot of time is spent, whereby part-time organizers can run into a problem. This effort can easily scare off newcomer.

Nevertheless, the realization of a safety concept has been one of the most important improvements in the past. The learning effect is great and one gets a totally new view on the various aspects an open-air event brings along. The support of the safety experts is very helpful, whether in the approval procedure or on the event day. They are always on hand to answer questions and to give advice. The contact to the authorities gets easier because professionals talk among themselves. All authorities are pleased when a professional safety concept is presented without demand.

The costs are usually non-recurring for one and the same event, they are rather a onetime investment for several dates. Small changes are not expensive. Thus, the expenses should be amortized over a longer period.

The safety concept includes all necessary information and even the smallest details are mentioned. However, the range of information can be overstraining. The table structure with all the colors and charts sometimes appears too complex. From the organizer’s point of view

there is a lack of continuous text. Some aspects, like the evacuation procedure, should be described more detailed. That increase in comprehensibility would make the discussion and the exchange with different parties easier. Furthermore, the instruction notes should be arranged more clearly. Otherwise it could be confusing in such a stressful situation.

In closing it can be stated that a safety concept is a must-have when it comes to big events. If it is not requested by the responsible authorities, it should be done anyway. There are more than 140 legal regulations that must be taken into account. Thus, a safety concept should always be done by a professional safety expert.

By experience, the author knows that there is no budget in the early stages of event organization. Therefore, the following section will present a checklist and empirical values to start a small open-air event.

5.2 Checklist for Private Events: Numbers and Costs

This section is based on experiences the author has gained over the last years. The information is probably inapplicable on different scenarios and should be used with caution.

At the end of each subsection, the costs of “Back to the Woods” 2015 are mentioned exemplary. Sometimes the listed “Back to the Woods” fees do not match with the ones mentioned in the chapter, because the “Kellerkind” team has long-standing relations to the different suppliers.

Some expenses are just mentioned in the compilation at the end. The reason is that some of them are very specific and just apply for “Back to the Woods”. For example, the disc jockey booking differs depending on the kind of event. Furthermore, some spendings like cleaners or a photo machine are not mandatory and a more luxury good. Also the bartender and entrance jobs could be staffed with friends instead of paying professionals.

5.2.1 Setup:

Toilets:

The values out of the VStättV(O)⁵ can be taken without hesitation. If you are using mobile toilet cabins, it is enough to add ladies’ toilets and urinals and ignoring the amount of mens’ rooms. This worked out perfectly for “Back to the Woods” with 80 cabins for 5000 visitors.

⁵<http://gesetze-bayern.de/Content/Document/BayVStaettV>

One mobile toilet costs about 60.00 EUR per event and there is no delivery fee. Some providers offer cabins with a washbasin – they are to be preferred. Additionally there is the opportunity to rent wheelchair suitable toilets for 190.00 EUR.

The toilets should be placed not too far away from the crowd and you have to take care that the area is accessible for the delivery truck.

Visitors	Ladies' toilets	Mens' toilets	
	Toilet bowl	Toilet bowl	Urinal
till 1000, every 100	1.2	0.8	1.2
over 10000, every further 100	0.8	0.4	0.6
over 20000, every further 100	0.4	0.3	0.6

Table 5.1: Table to calculate the amount of toilets, based on the VStättV(O)

Back to the Woods 2015: 86 toilets for 45.00 EUR each, 1 toilet for disabled people for 190.00 EUR: 5349.05 EUR

Site fence:

The fence is important to define the event site. Usually it surrounds the whole area and makes it inaccessible from outside. It is the basis to allow limitation and control of the incoming visitors. Most of the time mobile construction fence is used. The customary element is 3.50 m long, 2.00 m high and the event fee is 3.00 EUR each. They are delivered on palettes with 25 pieces.

Unlike the toilets, the delivery is quite expensive. Depending on the distance it can easily get up to 350.00 EUR one-way. As the truck is usually a 40-tonner, the surface should be solid, no grassland, and remember that the truck has a limited manoeuvring capability.

It is recommendable to rent a forklift or wheeled loader for setting up the fences, otherwise it is a time-consuming work. The costs are approximately 125.00 EUR per day and a delivery lump sum of 160.00 EUR.

Back to the Woods 2015: 100 site fence elements for 2.00 EUR each, Delivery 500.00 EUR, several road signs and 60 of the barriers mentioned in the next chapter: 1340.65 EUR, Wheeled loader for 3 days: 758.95 EUR

Entrance:

The setup of the entrance depends on whether you have a ticket office or just pre-sale tickets and a guest list. In general, it is recommended to separate each of them. The employees are much faster when concentrating on one task instead of switching between them.

It is important to have a clear barrier setup with signs to signalize people where to go. You can get those barriers with the site fence; approximated rental fee is 4.00 EUR per

unit. Furthermore, it is good to keep some distance between the scanning employee and the security. The security staff searches the arriving visitors for bottles and dangerous goods.

The way you handle your tickets differs from each ticket provider. Most of them provide digital scanners or a mobile phone app to scan the printed or digital ticket. All of them claim transaction fees depending on the contract duration and the number of tickets. These costs are passed on to the visitors and are paid during the ticket purchase.

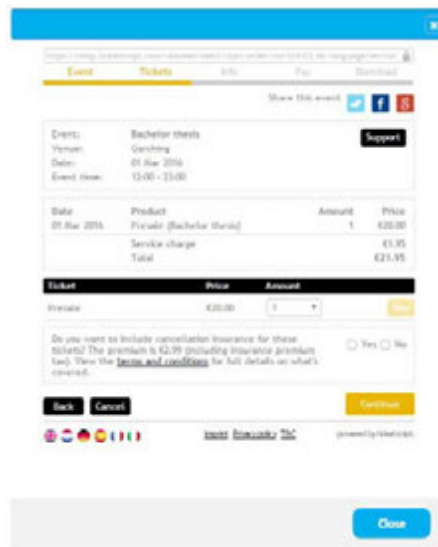


Figure 5.6: Extra charge of the transaction costs

Structures:

The structures like bars, entrances, stages and big decoration elements should be built in a robust and steadfast way. If you are not familiar with designing and constructing such structures, you should get professional help from carpenters or event technicians. People tend to underrate those activities, which results in many accidents. The safest way is to rent a stage from your event equipment rental company. They know exactly which wind force it stands. Obviously, you have to close off the structures with barriers to prevent strangers from entering. A small stage starts at 1000.00 EUR but might get a lot more expensive.

Back to the Woods 2015: The “Kellerkind” team does not like the usual appearance of a rent-able stage. Therefore, they commissioned wooden structures by friendly carpenters and architects. Approximately costs per structure are 2000 EUR to 3500 EUR, most of it material costs.

Technical equipment:

The next important point is the technical equipment. It does not only include effect lightning and sound, but power supply, water connection and emergency power and light. All of these, excluding the water connection, should be done by a professional. Choosing the right cables,



Figure 5.7: Various structures at Back to the Woods

laying and connecting them, especially if a generator is used, has to be done by an electrician or a trained event technician.

The event organizer's task is to think about cable paths and lengths, needed power of the generators or the capacity of electrical connections and the position of light and sound. All this information should be included in a two-dimensional plan or even in a BIM model. You need the following information:

- Location of lightning, effect lights, sound, bars, entrance and food stands. Do not forget to include lights to create a minimum brightness all over the event site.
- Rough power consumption of each: get the kilowatts information out of the specification sheets or ask your renter.
- Optimal grouping of the different consumers: try to avoid long cable distances. Instead, it is sometimes cheaper to rent additional generators.
- Routing: try to avoid cables crossing emergency routes or areas with a high flow of visitors

After completing this plan, you should get back to your event technician to discuss and if necessary adapt it. Using different generators can secure the power feed although one of them is having a malfunction. The lighting of the emergency exits should be separated from the main electric circuit.

Back to the Woods 2015: effect lightning and electricity 5683.20 EUR, sound systems for two stages: 4750.00 EUR, three 80 kilowatt generators and five Powermoon lamps: 1447.40 EUR. Everything including delivery, setup and dismantling.

5.2.2 Safety:

Emergency exits:

The VStättV(O) implies that 1.20 emergency exit meters per 600 visitors are needed. Try to avoid a coincidence of emergency and escape routes. The exits have to be marked and illuminated, but take care of the often-used site fence covers: they are vulnerable to wind and easily overlooked if somebody is standing in front.



Figure 5.8: Usual emergency exit fence cover at Back to the Woods ©Michael Öhlhorn, VABEG

Thanks to VABEG there was a special setup at the main emergency exit at “Back to the Woods”: it includes a gate, which can be opened just from the inside. Generally used it has the advantage that there is no need of a guard watching the exit. With our particular kind of event, the chance that some of the visitors use it as regular exit or open it for people to come in unnoticed, is quite high. Therefore, we used it in combination with a security guard.

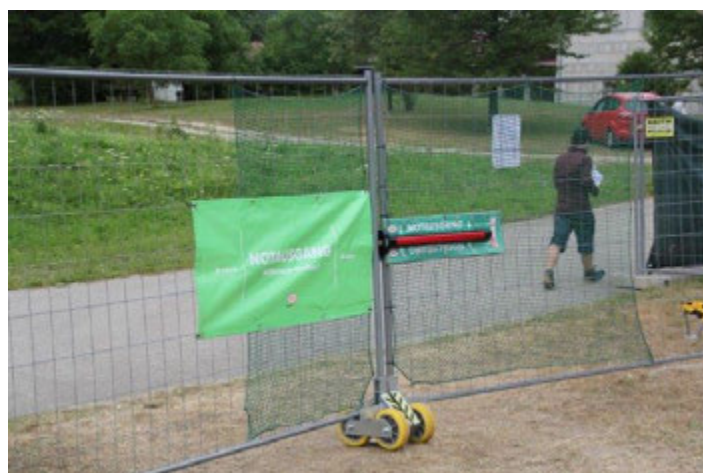


Figure 5.9: VABEG special emergency exit setup ©Michael Öhlhorn, VABEG

In addition, there was an emergency exit sign above every exit. It solved the problem of not seeing the used fence covers. To open the gate easier, rubber tires have been installed at the gate. These special ones are working much better than the simple castors you get with the construction fence. Finally, there was an extra pillar to give the fence more stability.

Altogether, this customized equipment successfully removed some weak points. The rental rate for the package per week is 393.36 EUR, but it is also possible to rent everything individually.

Back to the Woods 2015: VABEG emergency exit setup 393.36 EUR, bought three emergency exit fence covers for 69.50 EUR each

Fire protection and gas cylinders:⁶

Try to avoid highly flammable material or at least minimize it. Do not concentrate it on one point to prevent eventual fire from spreading. Fire extinguishers are necessary at every critical area; like generators, stages, bars or food stands. Keep in mind that there are different categories and sizes. Think about the use and the according category. However, the only recommendable size is 6kg or more.

Liquid gas cylinders are very risky and should be avoided. If that is not possible, the rules below should be followed:

- Have to be placed in a sheet cabinet with floor aeration
- This cabinet has to be outside of the stand, accessible and visible, Marked with a black “G” on yellow background
- Pipes have to be secured and strain-relieved. If they are longer than 40 centimeters, safety pipes are required.
- The proper condition has to be certified
- The maximum amount of liquid gas is 2x 11kg per stand

⁶(Bachmeier *et al.*, 2015)

5.2.3 Equipment

Cups: If glass bottles are forbidden you need to rent plastic cups. One 0.5l cup costs about 0.085 EUR including a final cleaning. The amount depends on the cleaning possibilities on-site. The cheapest way is to rent a dishwasher and about three to four cups per person. The dishwasher has to be staffed with employees and costs about 150.00 EUR a day. Since destroyed or lost cups have to be paid, do not forget to add a deposit on the selling price.

Back to the Woods 2015: 17720 0.5l cups, lost 1053 and 455 were destroyed: 3065.10 EUR; one dishwasher for 2 days including delivery: 487.90 EUR

Garbage container: Waste comes up in every stage of the event, from the build up to the dismantling. It is hard to separate the waste in such a stressful time. Therefore one container for all the residual waste is fine. Most companies have 10 m^3 or 25 m^3 containers. For a small open air the small one is enough. Since the fee difference is little, choose the big one if there is enough space to put it down. The rental fee is negligible and a ton of residual waste costs about 170.00 EUR

Back to the Woods 2015: we had one 25 m^3 container, two glass containers and produced 2.910 tons of rubbish: 743.39 EUR

More equipment you should think about, divided in leasable and purchasable:

Leasable:

- Transporter, about 400.00 EUR per week
- Tents, for example for the entrance or the ambulance

Purchasable:

- Laptop or tablet with a SIM card to watch the weather or to answer questions coming up online, 350.00 EUR
- Deposit tokens, depends on the amount, starting from 50.00 EUR for 500 up to 760.00 EUR for the 20000 the "Kellerkind" team bought
- Tape, tools and gloves
- Pavilions, e.g. for the backstage area
- Fence covers

5.2.4 Human Resources and Authorities

Ambulance: The amount of medics is usually calculated through different kind of algorithms. In Germany, the “Maurer Algorithm” is by far the most common. It has been developed by Klaus Maurer to rate the risk of major events and thereby get the amount of necessary medics.

See below an exemplary picture of such an algorithm. It shows an alternative developed by the Munich fire department.

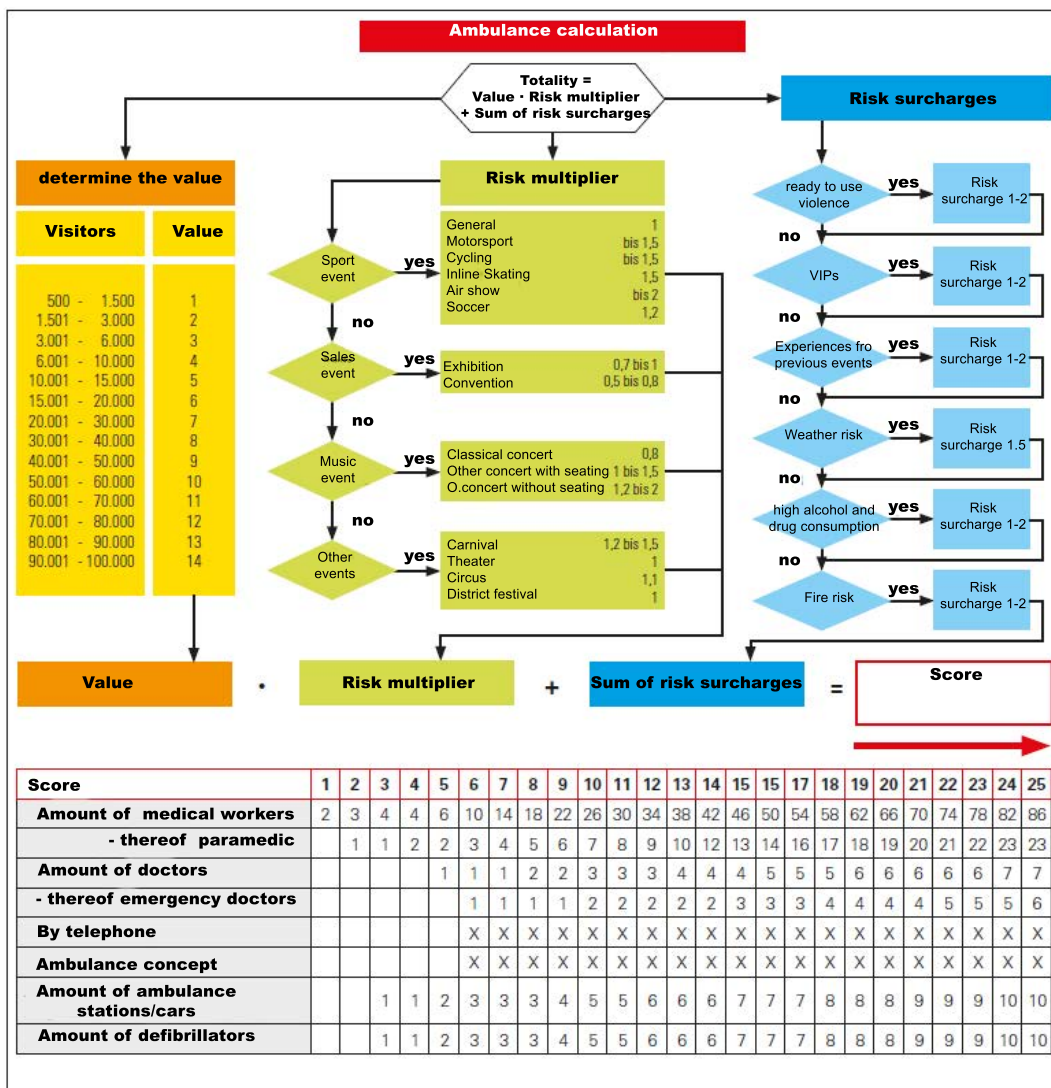


Figure 5.10: Ambulance calculation table (Bachmeier et al., 2015)

Keep in mind that the given values are specified for Munich with its developed ambulance infrastructure. The numbers should be increased if the event takes place in the countryside.

The costs start at about 25.00 EUR per hour for one paramedic. These costs vary between the different training levels. An emergency doctor charges rather 50.00 EUR. Furthermore, the used up equipment and the travel expenses have to be paid.

Back to the Woods 2015: We used the local ambulance youth group combined with some more experienced paramedics and an emergency doctor. We paid a lump sum of 1000.00 EUR.

Security staff:

Further important and expensive personnel costs arise with the engagement of a professional security staff. The number does not only depend on the amount of visitors and their inclination to aggression, but also on the different positions which need to be staffed. For example, each emergency exit must be manned permanently. Other positions are the entrance, the stage and the bars. All of those must be protected against external intrusion.

Furthermore, some have to patrol the area and look out for troubles or emergency cases. If the event site is fenced, they should pay attention to prevent people from climbing over. It is recommended to have teams of two people. Each team is assigned to a specific area of responsibility.

The ones working on the entrance are responsible for a calm procedure. They are usually searching the visitors for forbidden things like weapons, drugs and alcohol. If the event has age restrictions or personalized tickets, they are the ones verifying it. If everything is fine, the visitors can pass and proceed to the employees who scan their tickets.

Communication between different groups is guaranteed through walkie-talkies. If an incident occurs, they can easily request assistance. As the ambulance is also equipped with walkie-talkies, it is also possible to call for medical support. Usually the security company is able to bring them along. The average cost for one security guard is 17.00 EUR per hour with some surcharges for night and holiday work.

Back to the Woods 2015: The "Kellerkind" team had 30 security guards. The attendance was divided into two groups: 20 worked from 11:30 until 02:00 o'clock and the last 10 from 15:00 to 02:00 o'clock. Summed up that equals 400 man hours and an invoice of 6800.00 EUR.

Authorities

Closing, a few words concerning the interaction with the different public authorities. The first step after finding a suitable location is to contact the public order office. They are responsible for the approval procedure. They will initiate further steps and, if necessary, contact the other authorities like the police.

It is recommendable to cultivate a good relationship with them. Disagreements will come up and most of the times the official emerge victorious. It is little help when the applicant fights the decision too hard, especially when it is just about small issues. A good preparation, preferentially with professional support, helps a lot more.

5.2.5 Balance Back to the Woods 2015

Every event organizer knows from experience, that entrance fees are criticized with pleasure. The following balance sheet lists all the expenses and incomes we had for our 2015 edition of “Back to the Woods”. This could shed light on where the high entrance fees result from. All numbers are before tax.

Just the event spendings are listed, but not the recurring costs for running a company, store the equipment and other periodic purchases.

Expenses

Setup:	EUR
Toilets	5449.05
Fence & barriers	1340.65
Wheeled loader	758.95
Lifting platform	423.56
New wooden stage	2850.90
Tent for second stage including delivery	986.90
Effect lightning & power cabling	5683.20
Sound system	4750.00
Generatos & Powermoon lamps	2100.71
Fence covers	208.50
Waste container & disposal	743.39
Construction market: tools, screws etc	4389.75
Transporter: 2 for one week	832.00
Fuel	542.00
Miscellaneous	5370.00
Staff:	
Entrance	700.00
Ambulance	1000.00
Security	6800.00
Cleaners	2860.00
Dishwashers	720.00
Light jockey, visuals & laser	2800.00
Disc jockeys	8760.00
Travel and hotel for the DJs	1592.00
Bartender	8516.00
External decoration staff	1250.00
General:	
Photo machine	1000.00
Permission	520.00
GEMA	9700.00
Camera	335.00
Liability and weather insurance	2008.96
Total	84,159.52

Table 5.2: Expenses Back to the Woods 2015

Income	EUR
4599 Tickets, each 17 EUR	78,183.00
Bar revenue	86,423.60
Bar invoice	32,123.76
Bar income	54,299.84
Photo machine	931.20
Total	133,441.23

Table 5.3: Income Back to the Woods 2015

Profit	EUR
Income	133,441.23
Expenses	84,159.52
Profit before tax	49,281.71

Table 5.4: Profit Back to the Woods 2015; before tax

Chapter 6

Conclusion

The research of major events has come more and more into focus in the past years. Tragic events like the Love Parade disaster necessarily speeded up this progress. Nevertheless, the science is just at the beginning. There still has to be done a lot of fundamental research.

However, all of the presented and tested assistance methods had a positive impact on an event like “Back to the Woods”. The pedestrian simulations are a fast, cheap and safe way to verify changes in the event site or to structure a completely new one. Both software packages were working smooth and even a not trained person can use them. The MomentTUMv2 simulator has a lot of great new features. Combined with the TransiTUM framework it is a great multiscale concept.

The Building Information Modeling software entails clear advantages visualizing and presenting the event site. Thanks to the extensive capabilities, it is more than just an usual CAD software. The communication and networking between all parties involved has improved. Through the increased transparency more security in planning is provided.

Oppilatio is a great tool for major events with critical arrival routes. The opportunity to get such important information with so little data input and effort is rare.

Safety concepts are nothing new, but the most important upgrade for a major event. The concept does not just consider all legal requirements, but it even compensates lacking regulations. It handles all upcoming questions. The safety expert is available to give advice at any time and helps during the approval process.

Overall, the professional support of a major event is urgently. The “Kellerkind” team is pleased having the opportunity to gain such an experience. It has not only affected “Back to the Woods” but also the other projects. The general approach for the next events has changed significantly.

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Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die vorliegende Bachelor-Thesis selbstständig angefertigt habe. Es wurden nur die in der Arbeit ausdrücklich benannten Quellen und Hilfsmittel benutzt. Wörtlich oder sinngemäß übernommenes Gedankengut habe ich als solches kenntlich gemacht.

Ich versichere außerdem, dass die vorliegende Arbeit noch nicht einem anderen Prüfungsverfahren zugrunde gelegen hat.

Weiterhin versichere ich, dass diese Arbeit mit den eingereichten digitalen Dokumenten übereinstimmt.

Garching, 07. März 2016

Leo Ehrecke

