INFORMING WILDFIRE EVACUATION GUIDELINES IN TOURISTIC AREAS

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Abstract

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This thesis aims to address this problem and minimize the research gap related to this area by defining the key variables influencing the decision-making process of tourists during wildfire evacuation. This is done by performing a scoping review using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews approach. Subsequently, these variables were used to create archetypes related to tourists in wildfire evacuation.

Following this, a simulation model of a case study involving tourists evacuating from a campsite was developed. This modelling part aims to evaluate the effectiveness of available modelling approaches in representing tourist evacuations during wildfires and to pinpoint the stages of the evacuation process that have the greatest impact on total evacuation time. Within the modelling part, various evacuation strategies are discussed, along with the factors that influence them.

The analysis findings presented in this thesis offer recommendations for best practices that stakeholders can implement during wildfire evacuations in tourist areas.

This study identifies various insights related to tourists' evacuation during a wildfire event: Property attachment, past experience, preparedness, safety culture, risk perception, socio-demographics, interaction with authorities, place of residence, length of stay, transportation mode, information, and group dynamics.

Furthermore, the selection of the appropriate evacuation strategy needs to be made wisely, as it depends on various factors. To reduce both pre-movement and movement times, it is essential to address specific actions related to human behaviour and spatial planning such as the location of assembly points and the number of exits available.

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ملخص (Arabic)

تتزايد حرائق الغابات في جميع أنحاء العالم، وعلى عكس عمليات إخلاء المباني، فإن عمليات إخلاء Wildland-Urban-Interface (WUI) تأخذ في عين الاعتبار حركة المركبات جنبًا إلى جنب مع ديناميكية حرائق الغابات. يعتبر السياح مجموعة غير متجانسة من الناس، وهذا ما يزيد من تعقيد عمليات إخلاء WUI. يزداد هذا التعقيد بوجود عوامل متغيرة مثل حاجز اللغة، وعدم الإلمام بالمنطقة، وتفاوت مستويات الوعي بمخاطر حرائق الغابات. ومع ذلك، حتى الآن، لا توجد دراسة توفر فهما كاملا لكيفية تصرف السياح أثناء عمليات الإخلاء بسبب حرائق الغابات.

تهدف هذه الأطروحة إلى معالجة هذه المشكلة وتقليل الفجوة البحثية المتعلقة بهذا المجال من خلال تحديد المتغيرات الرئيسية التي تؤثر في عملية اتخاذ القرار لدى السياح أثناء إخلاء حرائق الغابات. يتم ذلك من خلال إجراء مراجعة شاملة باستخدام نهج Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for Scoping Reviews (PRISMA).
بعد ذلك، تم استخدام هذه المتغيرات لإنشاء نماذج أولية تتعلق بالسياح أثناء إخلاء حرائق الغابات.

تم تطوير نموذج محاكاة لدراسة حالة تشمل السياح الذين يتم إخلاؤهم من موقع للتخييم .يهدف هذا الجزء من النمذجة إلى تقييم فعالية أساليب المحاكاة المتاحة في تمثيل عمليات الإخلاء السياحية أثناء حرائق الغابات .زيادة عن هذا، يهدف هذا الجزء أيضا إلى تحديد مراحل عملية الإخلاء التي لها أكبر تأثير على إجمالي وقت الإخلاء .في قسم النمذجة، تتم مناقشة استراتيجيات الإخلاء المختلفة إلى جانب العوامل التي تؤثر عليها .تقدم نتائج المحاكاة في هذا البحث توصيات لأفضل الممارسات التي يمكن أن إعتمادها أثناء عمليات إخلاء المناطق السياحية بسبب حرائق الغابات .وبعد ذلك، تم تطوير نموذج محاكاة لدراسة حالة تشمل السياح الذين يتم إخلاؤهم من موقع للتخييم .يهدف هذا الجزء من النمذجة إلى تقييم فعالية أساليب المحاكاة المتاحة في تمثيل عمليات الإخلاء السياحية أثناء حرائق الغابات .زيادة عن هذا، يهدف هذا الجزء أيضا إلى تحديد مراحل عملية الإخلاء التي لها أكبر تأثير على إجمالي وقت الإخلاء .في قسم النمذجة، تتم مناقشة استراتيجيات الإخلاء المختلفة إلى جانب العوامل التي تؤثر عليها .تقدم نتائج المحاكاة في هذا البحث توصيات لأفضل الممارسات التي يمكن أن إعتمادها أثناء عمليات إخلاء المناطق .السياحية بسبب حرائق الغابات

تحدد هذه الدراسة رؤى متنوعة تتعلق بإخلاء السياح أثناء حرائق الغابات، مثل :الارتباط بالممتلكات، التجارب السابقة ، الاستعداد، ثقافة السلامة، إدراك المخاطر، العوامل السكانية والاجتماعية، التجاوب مع السلطات، مكان .النشئة، مدة الإقامة، وسيلة النقل، المعلومات، وديناميكية المجموعة

علاوة على ذلك، يجب اختيار استراتيجية الإخلاء المناسبة بحكمة لأنها تعتمد على عوامل مختلفة .ولتقليل أوقات ما قبل الحركة والحركة، من الضروري معالجة العوامل المتعلقة بسلوك الإنسان إضافة إلى تحسين التخطيط المكاني .للموقع السياحي مثل موقع نقاط التجمع وعدد المخارج المتاحة

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1 Introduction

1.1 Background

According to the National Fire Protection Association, 2013, a wildland fire is defined as "*an unplanned and uncontrolled fire spreading through vegetative fuels, including any structures or other improvements thereon*".

"*The wildland–urban interface (WUI) is the area where human-built structures and infrastructure about or mix with naturally occurring vegetation types*" (Platt, 2010).

The severity and frequency of fires affecting Wildland-Urban Interface (WUI) communities have increased rapidly over the past few decades worldwide. This increase has resulted in greater loss of human lives and destruction of structures (Haynes et al., 2020). In fact, changes in major driving factors have contributed to this escalation (Huang et al., 2015). Factors such as the climate crisis (Jolly et al., 2015), which leads to hotter and drier seasons, along with increased urbanization and more ignition sources, have intensified these fires as well. From this perspective, emergency managers are responsible for protecting people and ensuring safe evacuations when necessary. To achieve this goal, emergency managers prepare comprehensive plans and implement strategies designed to effectively manage such an event. Those strategies include different protective actions such as stay-and-defend, shelter-in-place, and leave early (Cova et al., 2009; Strahan, 2020). However, it is important to consider the potential delays in people taking proactive actions, which may result in negative consequences.

The reason behind this delay was explored by (Strahan et al., 2018), where they shed light on the diverse attitudes and behaviours of typical groupings of householders faced with making a protective decision during a wildfire. This finding reinforces the need for communication strategies that address the diverse attitudes of people which will enhance the evacuation and safety measures.

In WUI areas, fire risk management becomes crucial, and the traditional method of fire suppression, using a reactive approach, is now ineffective. The implementation of an integrated fire management approach can be more effective in terms of wildfire risk management as it accounts for socioeconomic, climate, and environmental roots of wildfires (Pandey et al., 2023). Nevertheless, WUI fire risk management can be very different according to the type and location.

In this context, the WUI in touristic areas presents a real challenge compared to the other areas. This challenge arises because tourists are heterogeneous and the impacts of wildfires on tourism can cause economic losses and require specific recovery strategies (Otrachshenko & Nunes, 2022). Several wildfires have occurred in touristic areas, such as the 2016 Cadiz fire in Spain (Ronchi et al., 2021), the 2023 Rhodes Fire in Greece (Bubola & Kitsantonis, 2023) and the 2023 Hawaii wildfires which were described as being more deadly than Hawaii's 1960 tsunami (Gupta, 2023). Tourists may exhibit behaviours different from those of local residents, as they may be unfamiliar with the area, speak different languages, or have different levels of risk awareness (Arce et al., 2017). These factors are crucial in defining how tourists will respond to a wildfire event and the protective actions they are likely to take.

Modelling the wildfire evacuation in Wildland-Urban Interface (WUI) areas can be challenging not only due to the complex nature of wildfires themselves which is influenced by multiple factors affecting wildfire spread behaviour (Sun et al., 2023) but also due to the research gap in terms of human behaviour response in case of wildfire scenario (Haghani et al., 2022).

Evacuation models can be used to assess the safety of individuals in wildland-urban interface fires. The evacuation modelling helps to determine the evacuation time needed to reach a safe area known as evacuation time curves. The different modelling layers depend on the evacuation mode (on foot, via private vehicles, via public transport or via alternative means) which is related to the required covered travel distance during the evacuation process (Ronchi, E. (2023)).

The integrated approach in evacuation modelling allows for a deeper understanding of how different factors interact with each other where the evacuation model calibration depends on human behaviour -related inputs (Ronchi et al., 2019). Similarly, the existence of integrated building fire evacuation models highlights the parallelism between Wildland-Urban Interface (WUI) wildfire evacuation and building evacuation, indicating the need for integrated modeling approaches in both contexts.

Pedestrian modelling represents a key element in evacuation modelling as it provides insight into the two major phases of evacuation which are the pre-movement process and the movement process (Purser & Bensilum, 2001), where the pre-movement time can also be referred to as pre-travel time or pre-evacuation time. Multiple traffic modelling approaches can be used to model the wildfire traffic evacuation where the choice can be dependent on WUI fire-related factors (fire spread and size of the affected area) and non-fire-related factors (population, density, and percentage of WUI area) (Intini et al., 2019).

1.2 Problem statement

In the case of a Wildland-Urban Interface (WUI) in a touristic area, assessing the evacuation of individuals (whether this occurs on foot or via vehicles) to estimate their time of arrival at a safe destination necessitates the consideration of the various elements mentioned previously in the background. Specifically, calibrating both the pedestrian and traffic models of the WUI evacuation system requires inputs related to human behaviour. In this scenario, the behaviour of tourists during a wildfire is particularly significant. Since they are a diverse group, they should not be treated simply as ‘tourists’. Instead, it would be more effective to group them into categories based on similar characteristics. This method will ensure a better understanding and implementation of the most effective evacuation strategies and policy.

Nevertheless, while the scientific literature has explored wildfire evacuation behaviour in general (Kuligowski et al., 2020; Rohaert, Kuligowski, et al., 2023) there has been less focus on the specific behaviours of tourists. Furthermore, there is no publicly available research that details the critical factors influencing the evacuation decision-making of tourists during a wildfire evacuation. This gap extends to specific scenarios such as the evacuation of tourist campsites, a context where the dynamics can significantly differ from other environments due to the unique layout and temporary nature of these accommodations as well as the high number of tourists during peak seasons. The absence of detailed studies in this area can introduce gaps in WUI fire risk management, which often relies on integrated fire management (IFM) strategies.

In order to address this problem and to reduce this knowledge gap, this work attempts to identify the different variables impacting tourists' decision-making which will also help to define a set of archetypes that represent the collective behaviour or pattern of typical groups. This information will be used to be included in an evacuation model. A set of evacuation simulations will be performed for a specific set of scenarios to investigate the impact of the archetypes as well as the impact of groups. Other factors such as time of the day (i.e., day vs night), and modes of evacuation (on foot vs by vehicle) are also examined. Evacuation model is performed for a camping site (Punta Milà in Spain) through conventional means of egress which are pedestrian and traffic movement.

1.3 Research question and objectives

The main research question of this thesis is: "**What are the main variables influencing the evacuation decision-making of tourists during a wildfire evacuation in a Wildland-Urban Interface (WUI), and to what extent can the available simulation tools be used to investigate the evacuation of tourists?**"

To adequately address this question, a set of objectives must be established and met sequentially. These objectives are designed to systematically explain the factors affecting tourists' decision-making during evacuations and evaluate the effectiveness of simulation tools in capturing these dynamics.

1- Identify key variables: Identify all key variables affecting tourist decision-making during wildfire evacuations and group them to maintain a manageable number for analysis.

2- Develop the archetypes: Define a set of archetypes based on the identified variables, which will help predicting the likely evacuation behaviours of tourists during a wildfire evacuation.

3- Identify the key modelling input: Design specific scenarios to simulate various conditions and factors that impact the evacuation of tourists and identify the input of the model based on that.

4- Assess the capability of the current evacuation models to simulate tourists' evacuation in WUI: Evaluate the results from the different scenarios, and investigate the limitations of exemplary models and identify future improvements.

5- Evaluation and Recommendations: Provide recommendations to develop evacuation strategies for tourists in the event of a wildfire.

This thesis aims to address the problem highlighted in the previous section and to help provide recommendations on the improvement of evacuation models in the context of the wildland-urban interface in touristic areas and ultimately inform guidelines for evacuation planning.

1.4 Methodology

This thesis aims to answer the main research question and then to inform guidelines in touristic areas about the best practices to use in case of wildfire evacuation. To achieve this, it is necessary to fulfill the objectives outlined previously and to employ a specific methodology designed for this purpose.

1- Conduct a literature review to gather information on the factors influencing the evacuation behaviour of tourists in wildfire scenarios. This has been done by performing a scoping review using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for the Scoping Reviews (PRISMA-ScR) approach (Tricco et al., 2018). This work facilitates the identification of the key variables and their impact on tourists' decision-making during wildfire evacuation events.

2- Consolidate the variables from the initial literature review and systematically reduce their number to achieve a manageable and coherent dataset. This process involves merging similar variables into single categories and eliminating those that have a marginal effect or are not well-explained in the literature.

3- Use the major key variables to adapt the archetypes originally presented by Strahan et al., 2018 to the case of tourists evacuation.

4- Introduce wildfire evacuation modelling and its key modelling layers and approaches

5- Identification of a suitable case study to model the evacuation of tourists in wildfire evacuation.

6- Definition of a set of scenarios that simulate various wildfire evacuation conditions specific to the case study of the campsite. Configuration of the simulation models to accurately reflect these scenarios. It is important to establish a method for incorporating the archetypes developed from earlier research into the model and assess their impact on evacuation results compared to alternative modelling approaches.

7- Simulate the movement of tourists inside the campsite using the pedestrian model. Ultimately use the outputs from the pedestrian model to configure the traffic model where tourists will need to use their vehicles to reach a safe destination.

8- Compare the results from different scenarios (time to reach a safe place for different scenarios, the impact of groups, the impact of including archetype profiles, the number of vehicles in the area over time, and the evacuation time curves).

9- Investigate the gaps and the limitations of the models and provide recommendations based on these findings. These suggestions will help refine and inform guidelines for wildfire evacuation in touristic areas, by improving the effectiveness and reliability of evacuation strategies.

1.5 Scope and limitations

The scope of this thesis is limited by the available data and time. There is limited publicly available information about tourist evacuation during wildfires.

The evacuation of tourists with functional limitations is not covered in this study as it is assumed that the campsite has no dedicated provisions to accommodate them. While previous studies have highlighted the impact of functional limitations (Bukvic et al., 2021)on evacuation performance, there is a significant research gap in this specific area. Therefore, this limitation extends not only to this work but also to most evacuation models available on the market. Additionally, there is a lack of comprehensive information on how functional limitations affect evacuation performance. This population will need future dedicated studies.

For the modelling part, the pre-movement time is a crucial input in the pedestrian model, yet no sources provide insights into pre-movement times at camping sites in case of wildfire evacuation. Therefore, those inputs had to be defined based on existing alternative data sources.

Furthermore, the model is calibrated based on a real case study (the Punta Milà camp in Spain). While the case study has been selected to be representative of other campsites, some of its results are contingent on the specifics of the case study. A comprehensive assessment of evacuation model usage for campsites with tourists is beyond the scope of this work as it would require data from a real-world scenario, which is currently not available.

The application of models for unconventional evacuation methods like sea, air, or public transport is out of the scope of this project (Ronchi, 2023).

The scope of this thesis focuses only on the two modelling layers, namely pedestrian response/movement and traffic evacuation. It neglects explicit wildfire spread and trigger buffers modelling (Ronchi et al., (2023), Kalogeropoulos et al., (2023)). Hypothetical wildfire conditions are assumed implicitly. This implies that the impact of smoke on the evacuation process is not explicitly included.

2 Literature review

2.1 Overview of the review methodology

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA) is a method consisting of a checklist and a flow diagram that provides a structured framework for conducting and reporting scoping reviews (Tricco et al., 2018). This method was used to select the relevant papers that would help in identifying the different variables affecting the evacuation decisions of tourists in wildfire scenarios.

Two scientific literature databases were selected to conduct the scoping review, which are Scopus and Web of Science databases as they are primary repositories for research papers within the research domain of interest. The scoping review included three stages, namely identification, screening, and inclusion. In the first stage, different search strings were employed (see Appendix A) and Records were removed based on duplicates. However, given the limited number of papers discussing the behaviour of tourists in wildfire scenarios, additional consideration was given to papers providing insights into tourists' behaviour during emergency conditions. Additionally, studies on the evacuation behaviour of people in general, were also included. In the second stage of the scooping review, a screening was applied to the papers based on the title and the abstract. Papers were selected based on four inclusion criteria: 1) Insights into tourists' behaviour in emergency context. 2) Insights into human behaviour in wildfires. 3) Insights into disaster communication or management. 4) Discussion about archetypes in the context of wildfires. Next, a full examination of the records was conducted to exclude the papers lacking full English text, includes only modelling content, or serving as review articles with no insights into tourist behaviour. Ultimately, the remaining papers were included in the review if their content is related to tourists and wildfire evacuation, tourist behaviour in other hazard evacuation, human behaviour in wildfire, and/or tourist behaviour in a general decision-making context.

Besides the two selected databases, a snowball approach was used to select relevant papers by screening the citations within references. Moreover, more papers were included to the review from consulting researchers in the field of human behaviour in wildfire. The additional papers have been also subject to the inclusion/exclusion criteria mentioned previously.

A total number of 23 papers were considered relevant to the objective of this study. The extraction of the pertinent information from the selected papers was performed using a consistent template (see Appendix C). This template is designed to summarize the content of the papers through 25 specific questions. Consequently, employing this method facilitates a comprehensive understanding of the collected data and information.

2.2 The concept of archetypes

The aim of this literature review is to define the primary variables influencing the decision-making of tourists in case of wildfire evacuation. Understanding the relationship between those variables is crucial in building a set of archetypes related to tourists. An archetype is a concept found in areas relating to behaviour and modern psychological theory. The concept of archetype was first initiated by the Swiss psychiatrist and psychoanalyst Carl Gustav Jung, called also Jungian archetypes (Weiner & Gallo-Silver, 2019).

The concept of archetype was born when Carl Jung rejected the theory of “tabula rasa” which suggests that people are born as a "blank slate" and their thoughts, actions, and emotions are shaped solely by their experiences. In other words, he rejected the idea that when we are born, we are like blank sheets of paper waiting to be written on by our experiences. Instead, he believed that right from the start, we all have some basic feelings, for instance, love and fear (Weiner & Gallo-Silver, 2019). These common experiences are part of who we are from the beginning, and they affect how we think and behave. Therefore, these experiences, shape various models with shared mental concepts and are expressed in what he called "archetypes".

However, the discussion of nature vs nurture is also more nuanced than in the times of Jung now. Therefore, it is important to acknowledge that individuals, initially classified into a certain archetype, can evolve and transition into different archetypes over time as nature and nurture are shaping human development.

2.3 Archetypes in the context of wildfire evacuation

In their paper, (Strahan et al., 2018) explore the diversity of human responses to wildfire in Australia by employing cluster and discriminant function analysis of data from 457 householders who experienced a wildfire evacuation. The study collected data on various factors influencing residents' responses, such as proximity to bushland, threat perceptions, hazard adjustments, sources of information, decision-making processes, and demographics. The measurement was conducted using The Protective Action Decision Model (PADM) (Lindell & Perry, 2012) which explains the protective action decisions taken by residents during the wildfire evacuation. The results of this study revealed seven types of archetypes that present specific attitudes and behaviours of typical groupings of householders during wildfire evacuations (Strahan et al., 2018). In other words, these archetypes represent the collective behaviour of typical groupings rather than perceiving evacuees as individuals with distinct behaviours.

The seven archetypes as defined by (Strahan et al., 2018) are:

1- *Responsibility deniers* who believe they are not responsible for their personal safety or for their property.
2- *Dependent evacuators* who expect the emergency services to protect them and their property because they are incapable of taking responsibility for themselves.
3- *Considered evacuators* who are carefully considering evacuation and are committed to it as soon as they are aware of a wildfire threat.
4- *Community guided* that seek guidance from neighbours, media, and members of the community who they see as knowledgeable, well informed and providing reliable advice.
5- *Worried waverers* who prepare, equip their property and train to defend it but worry they lack practical experience to fight a wildfire (potentially putting their personal safety at risk).
6- *Threat deniers* who do not believe that their personal safety or property is threatened by a wildfire.

7- *Experienced independents* who are highly knowledgeable, competent, and experienced and perceive themselves as responsible and self-reliant when fighting wildfire.

2.4 Key variables affecting tourist evacuation behaviour in wildfires

Tourists can be more vulnerable in case of wildfire evacuation scenario, as their decision-making process can be impacted by various factors. Therefore, it is crucial to define those factors which we will refer to as "variables". A well-considered selection of variables is essential for gaining a clear understanding of tourists' vulnerabilities. For this reason, a methodology was employed to refine the variables by iteratively refining them at various levels. This process involves merging similar variables into single categories and eliminating those that have a marginal effect or are not well-explained in the literature. After the identification of the important information from the selected papers using the template, a spreadsheet was used to extract the list of variables from each paper. Subsequently, identical variables, along with those with broader scopes, were grouped together, and a name was assigned to each category. An analysis of the scope of each variable was then conducted to assess the possibility to group some into one category. This systematic process aimed to refine and reduce the number of variables, thereby enhancing clarity and effectiveness when defining the archetypes.

Table 1 shows the ten variables that were identified from the selected papers.

Table 1: Key variables influencing tourists' decision-making in case of wildfire evacuation.

Variables	Property attachment	Past experience and preparedness	Safety culture	Risk perception	Socio-demographics
	Interaction with authorities	Place of residence and length of stay	Transportation mode	Information	Group dynamics variable

2.4.1 Property attachment

This variable refers to the fact of having emotional connection to an object or a place.

In their paper, Huang et al., 2016 and McLennan et al., 2019, show that property attachment may have a negative correlation with the evacuation. Moreover, it is noted that international tourists typically demonstrate lower levels of property attachment when compared to local residents (S.-K. Huang et al., 2016) which may increase the evacuation likelihood of international tourists in case of evacuation. The fact that local residents have higher property attachment is connected to the fact of being more cautious about the economic value of the property and safeguarding it from looters (S.-K. Huang et al., 2016). This suggests that, in contrast to local residents, those without property may be more likely to carry out an evacuation (i.e., to comply with an evacuation order) (McLennan et al., 2019).

2.4.2 Past experience and preparedness

Past experience and preparedness variable reflect the fact that the evacuation decision-making may be influenced by the knowledge gained from previous wildfire incidents as well as by one's degree of preparedness.

This can be explained by two factors. The first factor is the evacuation training, which can have a positive impact on evacuation decisions. The second factor is the "cry wolf effect," which refers to the decrease in compliance with evacuation orders in situations where the previous evacuations were judged unnecessary (Matyas et al., 2011) (McLennan et al., 2019). Nevertheless, it should be noted that, the 'cry wolf' factor may have different effects depending on the considered evacuation phase (e.g. alarm phase, actual evacuation phase). Moreover, the preparedness includes the awareness of any precautions taken to increase the safety against the hazard, such as being aware of evacuation routes and/or protocols that are meant to make evacuation more efficient. According to a research based on hurricanes, visitors who had prior experience and which did not result in negative outcomes are less likely to evacuate since they perceive less risk (Matyas et al., 2011). This result remains valid for people who have indirectly experienced fires, such as when friends or relatives have previously been affected by the hazard (Matyas et al., 2011). Nevertheless, a cyclone study shows that due to the curiosity to see an event never seen before, visitors without past experience would be less likely to evacuate(Banerjee et al., 2023). For instance, tourists without past wildfire experience paused along the evacuation route to capture photographs (Vaiciulyte et al., 2019). Moreover, the influence of past experience and preparedness on the likelihood of tourist evacuation may vary depending on the place of residence. This was demonstrated through a comparison of French and Australian populations(Vaiciulyte et al., 2022). Additionally, tourists who are familiar with the area where a wildfire occurs are more likely to take a route that is familiar to them rather than the quickest or shortest one (Limanond et al., 2011). Research about hurricanes has indicated a relationship between the past experience and the perceived credibility of specific information sources like local tourism offices and hotel staff(Cahyanto & Pennington-Gray, 2015). This may hold true in the context of wildfire as well, since previous experience can shape tourists' judgment on the information they receive from a particular source, subsequently influencing their decision-making regarding evacuation.

2.4.3 Safety culture

In this context, "safety culture" refers to how tourists see and use safety information, as well as their level of awareness of the wildfire hazard.

In a study about Hurricanes, it was indicated that tourists who did not check for the possibility of this hazard prior to their travel, were less likely to evacuate (Matyas et al., 2011). This may be related to the fact that visitors who did not investigate the hazards before travelling have a limited awareness of the hazard and its implications. Additionally, a research on wildfires on the island of Corsica demonstrated that the safety cultures of the locals, whose safety culture had been acquired from school, and the tourists, who had a limited awareness of fire hazards, may be diverge (Vaiciulyte et al., 2019)

2.4.4 Risk perception

This variable reflects the individuals' perception of the hazard and how it is likely to personally affect them or their loved ones (e.g., via injury or even death) (Kinateder et al., 2015).

Risk perception usually serves as a mediator variable where higher levels of risk perception are strongly linked to evacuation likelihood (Folk et al., 2019, 2019; S.-K. Huang et al., 2016; Katzilieris et al., 2022; Kuligowski et al., 2020; McLennan et al., 2019). The decision to evacuate is shaped by a number of factors, including past experiences, access to information sources, preparedness levels, and socio-demographic. Research shows that tourists who are visiting the area for the first time exhibit high-risk perception and may be more likely to evacuate (Cahyanto et al., 2014; Matyas et al., 2011). Moreover, tourists who have not previously been affected by hurricanes (either directly or indirectly), had a short trip duration, or had checked for the possibility of hurricanes prior to their trip had higher levels of risk perception (Matyas et al., 2011). Tourist who are travelling with children may have higher levels of risk perception (Cahyanto et al., 2014; Villegas et al., 2013). A research about cyclones shows a positive relationship between the risk awareness level and risk perception where tourists risk perception was not sufficiently high to encourage them to evacuate (Banerjee et al., 2023). Nevertheless, it is possible that this can be improved by the dissemination of the warning message in multiple languages. In fact, there is a positive relationship between warnings dissemination in multiple languages and the risk perception of a group of tourists from different countries (Banerjee et al., 2023).

2.4.5 Socio-demographics

This variable refers to the number of socio-demographic elements such as education, race and ethnicity, functional limitations, gender, age, and income which may have an impact on the level of risk perception and subsequently their decision-making to evacuate.

Income is considered as one of the important factors to have an effect on the evacuation likelihood of tourists where tourists with lower income levels are less likely to evacuate(Cahyanto et al., 2014; Katzilieris et al., 2022). In the same context, low income may be a contributing factor that leads international tourists to opt for shelter accommodations rather than staying in hotels (Cohn et al., 2006).

Research has found that there is a positive relationship between age and willingness to evacuate (Matyas et al., 2011). Nevertheless, compared to other age groups, senior tourists may have limited access to evacuation warning messages due to the language barriers (although not in all situations) (Christianson et al., 2019).

Female tourists may be more likely to evacuate than men, as they may be more likely to perceive higher levels of risk (Cahyanto et al., 2014; Cahyanto & Pennington-Gray, 2015). In addition, female tourists perceive information sources as more credible and may be more likely to use information from the following sources: family, locals, the local tourism office and local authority, when compared with male tourists (Cahyanto & Pennington-Gray, 2015). However, in the case of families of tourists, the impact of gender may be less prominent since (Litvin et al., 2004) showed that they generally make most decisions jointly.

Race and Ethnicity show how tourists who share a common cultural background or descent may behave in case of evacuation and this variable is often understudied. However, in research that is limited to American population, it was indicated that race and ethnicity play a role in risk perception. In particular, certain minority population groups perceive lower levels of risk perception compared with other majority populations (Perry & Green, 1982). In addition, the membership in an ethnic minority group increases the chances that an individual will perceive an external locus of control, i.e., a belief that what happens is the result of external factors outside of their control – e.g., due to luck or fate (Perry & Green, 1982). In the same context, membership in an ethnic minority group is positively linked with a higher level of community involvement and lower levels of perceived credibility of authorities (Perry & Green, 1982). These variables may therefore have an impact on the information obtained during the hazard and the decision-making process of tourists.

The education level is also considered relevant in the decision-making process of tourists in case of wildfire evacuation. In research on Tsunami evacuation, it was found that international tourists who completed high school or a bachelor's degree were more likely to follow the crowd in their evacuation route choice when compared with those with higher education levels. In fact, those with higher education (Master/Ph.D.) tended to rely primarily on signage than on surrounding crowd behaviour (Limanond et al., 2011).

During a wildfire evacuation, people with functional limitations (e.g., those related to movement, sight, hearing, or cognition) may be at high risk compared to others. This is because the majority of visitors might be able to evacuate by using their own resources, while people with functional limitations may face difficulties and require help. These difficulties may arise from physical or cognitive impairments, or from the absence of a suitable mode of transportation (Kuligowski et al., 2020; McLennan et al., 2019)

2.4.6 Group dynamics

The group dynamics encompass the number of characteristics shared by a group of individuals and their interactions with one another, potentially influencing the evacuation process.

In a study conducted on Hurricanes, it was shown that families with children generally perceive higher risk, (Cahyanto et al., 2014; Villegas et al., 2013) which increases the evacuation likelihood (Cahyanto et al., 2014). Nevertheless, this may not be always the case as some families with children may choose to remain if they lack knowledge about what actions to take, and where to seek refuge. Besides the fact of having children in the family, the number of minors may also influence the decision-making process of the evacuation as it was indicated to be negatively correlated to the evacuation likelihood (Katzilieris et al., 2022). A possible reason for that could be that large families may need more time to gather family members and get ready and this could in a delay to decide or evacuate. Nevertheless, it was also shown that larger travel groups are more likely to evacuate than those with smaller travel groups (Cahyanto et al., 2014). Yet, the interaction between emerging groups of tourists may lead to evacuation delays due to debates about the preferred actions to pursue (Drabek, 1999). Travelling with old people may also reduce the evacuation likelihood, due to their health issues that could worsen during the evacuation process (Cahyanto et al., 2014). Furthermore, residents generally prefer to stay with friends instead of evacuation shelters, while people without a personal network who cannot afford to stay in hotels tend to choose shelters (Cohn et al., 2006). This case can be applied to tourists who in most cases don't have personal network in the place they visit.

2.4.7 Interaction with authorities

The interaction with authority's variable primarily examines how visitors and authorities interact in term of communication and compliance with evacuation orders. WUI resident archetypes may exhibit various levels of distrust in government and emergency instructions (Paveglio et al., 2015). Moreover, while tourists may be more rule-obedient compared to local residents in the presence of authority, some tourists may display disregard for authorities' orders and delay their evacuation to capture footage of the wildfire (Vaiciulyte et al., 2019). The interdependence between the members of a tourist group can affect evacuation decisions where certain individuals within the group may exhibit resistance to evacuation policies (Banerjee et al., 2023).

2.4.8 Place of residence and length of stay

The place of residence denotes the initial location from which the tourists originated.

The place of residence may provide insights into the evacuation likelihood of local residents (Vaiciulyte et al., 2022), but it can also have an impact on tourists especially when considering factors such as language and cultural differences. In the case of international tourists and national tourists, studies found that international tourists are more likely to evacuate compared to national tourists (Cahyanto et al., 2014; Matyas et al., 2011). The dependence on the place of residence can also have an influence on the relationship between tourists' information needs and the resulting intention to seek information(Aliperti & Cruz, 2019). One possible explanation is that tourists from a collectivist country, for example, which often prioritizes the group over the individual tend to be influenced by social norms and act in a socially appropriate manner which may lead them to seeking more information (Quintal et al., 2010). In other words, it is possible to say that tourists coming from collectivist countries may be more likely to comply with evacuation order.

The length of stay of tourists is crucial in defining their evacuation likelihood as they may become more familiar with the area and the routes. In a study related to Hurricanes, it was shown that a shorter length of stay and/or visiting for the first time may lead to a higher likelihood of evacuation given their unfamiliarity with the area (Matyas et al., 2011). The length of stay does not only impact the evacuation likelihood but also it has an impact on the route choice during the evacuation. For instance, a study about a tsunami event indicated that international tourists who stayed in the area for less than six months were more likely to follow the crowd, while most international tourists who stayed longer than six months took a an evacuation route that was more familiar to them (Limanond et al., 2011). While tourists who stayed for a long duration of stay (6 months to more than one year) at the destination are more likely to choose a familiar route (Limanond et al., 2011).

2.4.9 Transportation mode

This variable is related to the relationship between the tourists’ means of transportation and their resulting evacuation behaviour.

The mode of transportation may have an impact on the level of risk perception (Villegas et al., 2013). Moreover, it was found that tourists with personal vehicle may be more likely to evacuate compared to the ones with rented vehicles (Cahyanto et al., 2014). The choice that people make about the type of transportation mode during an evacuation (e.g., on foot or using a vehicle) may depend on the type of hazard and its location (Arce et al., 2017). (Limanond et al., 2011) showed that in case of a tsunami, international tourists who use public transport in the area are more likely to follow the crowd when making decisions about evacuation routes. In the same context, international tourists who drive private or rented vehicles are more likely to follow evacuation instructions (Limanond et al., 2011).

2.4.10 Information

This variable refers to the way in which tourists receive, understand, and access information during an emergency.

While it is possible that tourists may be notified about the hazard from temporary neighbours or from others they met informally (Drabek, 1999), Tourists expect to receive evacuation warnings through official channels or the media, the internet, and the news rather than unofficial sources (Arce et al., 2017). However, specifically, international tourists demonstrate a greater willingness to approach hotel staff for information as compared to national tourists and use social networks more than them as well (Cahyanto & Pennington-Gray, 2015). Moreover, international tourists are also more likely to seek information (Cahyanto & Pennington-Gray, 2015). It should be noted that the fact of seeking more information may cause evacuation delays. The way people receive information cues about the hazard may have an impact on their decision making process, for instance, the presence of environmental cues, either alone or in combination with social cues, could decrease individuals wait-and-see attitude (Vaiciulyte et al., 2022).

Additionally, international tourists may see local tourism offices as highly credible (Cahyanto & Pennington-Gray, 2015), one possible explanation is that tourists are used to use their services during the vacation. Furthermore, Compared to national tourists international tourists may be more likely to use local authorities as an information source (Cahyanto & Pennington-Gray, 2015). A study about tsunami revealed that the access to information through signage may be dependent on language, visibility, location, relevance of information, size, and materials of the signage (Arce et al., 2017). This indicates that the way the information is presented has to be consistent to effectively encourage tourists to evacuate. This also includes the dissemination of warnings in multiple languages (Banerjee et al., 2023).

2.5 Summary of the variables

The following table presents the summary of the variables and their link to the evacuation likelihood of tourists in case of a wildfire scenario. Each variable reflects a specific aspect that could influence tourists' decisions regarding evacuation. This summary serves as an informative resource that offers valuable insights into the factors influencing tourists' evacuation behaviour during wildfire emergencies, facilitating a quick understanding of the key variable involved. To examine those variables in depth, it is necessary to refer to the previous description.

Table 2: Summary of the variables and their link to the evacuation likelihood of tourists in case of a wildfire scenario.

Variables	Likely impact on evacuation decisions
Property attachment	- Tourists have less property attachment. - People who do not own a property may be more likely to proceed with an evacuation.
Past experience and preparedness	- "Cry wolf effect" negatively affects evacuation decisions. - Evacuation training positively affects evacuation decisions. - The influence of preparedness and experience on evacuation likelihood may be dependent on the place of residence. - Past experiences with hurricanes may be linked to the perceived credibility of particular information sources.
Safety culture	- Tourists' safety culture may be different from residents. - Tourists are less likely to understand consequences of fire.
Risk Perception	- Mediator variable. - Higher levels of risk perception are strongly associated with the likelihood of evacuation. - Tourists with children generally exhibit higher levels of risk perception. - There is a positive relationship between warnings dissemination in multiple languages and risk perception.
Socio-demographics	- Tourists with lower income are less likely to evacuate than high income tourists. - Female tourists are more likely to evacuate than men.

	- Minority groups perceive an external locus of control. - Tourist with higher education (Master/Ph.D.) Tend to rely primarily on signage than on surrounding crowd behaviour.
Group dynamics	- The number of minors is negatively related to the decision to evacuate. - Tourists travelling with older individuals are less likely to evacuate. - Larger travel groups may be more likely to evacuate than smaller groups.
Interaction with authorities	- Tourists may be more rule-obedient when compared to residents. - Some tourists may disregard authorities' orders. - The inter-dependence between the members of a tourist group can affect evacuation decisions.
Place of residence and length of stay	- International tourists are more likely to evacuate when compared to national tourists. - Intention to seek information may be dependent on the place of residence. - Shorter length of stay and/or visiting for the first time may lead to a higher likelihood of evacuation. - Tourists with a long duration of stay at the destination are more likely to choose a familiar route.
Transportation mode	- Tourists with a personal vehicle may be more likely to evacuate compared to the ones with rented vehicles.
Information	- Tourists expect to receive evacuation warnings through official channels. - International tourists are more likely to approach hotel staff for information as compared to national tourists. - International tourists are also more likely to seek information. - Language use affects evacuation decisions.

2.6 Archetypes of tourists in wildfire evacuation

In this section, we combined findings from our literature review with the seven archetypes of Strahan et al., 2018. The goal is to see how Strahan et al.'s original work can fit tourists. This was performed by comparing Strahan et al.'s archetypes with the likely impact about on tourist evacuation decisions obtained in our review (see Table 2). When no specific information is found about tourists (i.e. how their behaviour would differ from residents in terms of their evacuation decisions), the archetype from Strahan et al. (or the portion of it related to a given variable) is kept as is. If a variable or information related to the original resident archetypes is not relevant to tourists (e.g. preparatory actions for property protection), this has been removed from the archetype description.

Therefore, the updated description of the tourist archetypes considering the findings of our review is as follows:

Archetype 1: Threat Deniers (Tourist denying the threat)
This type of archetype can be referred to the tourists who do not believe that the wildfire will impact their safety. This will result in them disregarding the information received about the incoming wildfire threat received from emergency services, media, residents, or other tourists. This type of tourist has very little experience with wildfires, limited safety culture, and low risk perception. They are not familiar with the area and the wildfire safety procedure.
Outcome: The archetype of *Tourists denying the threat* is committed to remain in case of evacuation.

Archetype 2: Responsibility Deniers (Tourist denying responsibility)
As for the case of residents, this type of tourist does not believe they are responsible for their own safety. They do not feel that they need to rely on themselves, and therefore expect that others (e.g., authorities or tourist managers) take care of their safety. They have limited experience with wildfires, no training, limited safety culture, and limited preparedness. They are not influenced by media, residents, or other tourists.
Outcome: The archetype of *Tourists denying responsibility* will stay as long as others will take care of their evacuation. This may imply long evacuation delay, depending on the actions of others. They are neither aware of the best route nor are familiar with the area and procedures.

Archetype 3: Experienced Independent (Experienced Tourist)
This type of tourist has experienced wildfires before and has a good level of preparedness, safety culture, and training. They are familiar with the protective actions to be taken when a wildfire is in the area, having extensive knowledge of wildfire safety from their place of residence or previous travels to the area. They rely mostly on themselves and are strategically prepared for what actions to take. They are not largely affected by the decisions of others. They consider themselves more knowledgeable about wildfires than emergency services, media, residents, or other tourists.
Outcome: The archetype of *Experienced Tourist* will decide to evacuate quickly, are aware of the best route/procedures and are familiar with the area.

Archetype 4: Community Guided (Community Guided Tourist)

This archetype refers to tourists that are strongly affected in their decisions by their positive perceptions of the knowledge of emergency services, media, residents, and other tourists. They have limited wildfire experience and are not self-reliant despite being aware of the situation.
Outcome: The archetype of *Community Guided Tourist* is fully reliant on the evacuation decisions on the community.

Archetype 5: Worried Waverer (Worried Tourist)
This archetype refers to tourists that are concerned about the wildfire threat and its impact on their safety. These tourists are knowledgeable about wildfires and informed/prepared about the event. They consider information from emergency services, media, residents or other tourists as useful.
Outcome: The archetype of *Worried Tourist* is committed to evacuating as they consider this as the best option for their personal safety.

Archetype 6: Dependent Evacuator (Dependent Tourist)
This archetype refers to tourists who rely on emergency services to protect their personal safety. The largely rely on emergency services rather than media, residents, or other tourists. This group of tourists had no previous experience with the wildfire threat, lacked knowledge and information about wildfires and had no training.
Outcome: The archetype of *Dependent Tourist* is committed to evacuating and relies extensively on emergency services in their decisions.

Archetype 7: Considered Evacuator (Considered Tourist)
This archetype refers to tourists who perceive wildfires as a current and future threats since they have them extensively into their lives from their place of residence or previous travels to the area. They had experience of evacuation in the past and had some limited training. They are influenced by information in the media but to a smaller extent by emergency services, residents, or other tourists.
Outcome: The archetype of *Considered Tourist* is strongly committed to evacuation as soon as they become aware of the threat.

2.7 Wildfire evacuation modelling

Modelling the wildfire evacuation in the WUI communities presents a unique challenge compared to the building evacuation modelling. This is due to several reasons. The first reason is that modelling the wildfire evacuation requires two evacuation modes which are pedestrian mode and traffic mode. Another reason is that wildland fire is seen as an event that triggers human responses at various scales, for instance, the temporal scale and the social-organizational (McCool et al., 2006). This is because the WUI communities differ from one another in terms of social, political, and environmental context (McCool et al., 2006). Overall, this was summarized by Ronchi et al., 2017 in one sentence "The multi-dimensional nature of a WUI incident that further differentiates it from most building fires: spatial dynamism, temporal iterations, the range of influential factors and the multi-level organisational involvement." (page 41)

Using evacuation models in WUI helps to provide an estimation of the time needed to leave the threatened area and reach a safe destination. Those tools help as well to evaluate the impact of various evacuation strategies in response to changing fire conditions (Ronchi & Gwynne, 2020). Different approaches can be used to represent different modelling components of evacuation modelling where three modelling layers exist, namely, people response modelling layer, people movement modelling layer, and traffic movement modelling layer (Ronchi & Gwynne, 2020) . The first approach consists of modelling all three layers explicitly, the second is to include implicitly the representation of people's response and the third is to include an implicit representation of people's response and movement (Ronchi & Gwynne, 2020). The selection of the approach usually depends on modeler preferences as well as the computational resources, time and data needed for calibration, and the level of detail needed to be captured.

2.8 Traffic simulation

The traffic model is one of the key modelling layers in the wildfire evacuation scenario. It consists of four-step structure: 1) Travel Demand, 2) Trip Distribution, 3) Modal Split and 4) Traffic Assignment (Intini et al., 2019).

Travel demand involves trip generation, which, in the context of touristic areas, refers to the number of tourists departing from their original location.

The trip distribution links origins and destinations. This can be presented by adopting either a trip-based or an activity-based modelling approach (Ronchi et al., 2017) where the difference between the two is the capability of the activity-based modelling to count for the individual activities of each person. In other words, the trip-based modelling approach ignores the intermediate trips (Ronchi et al., 2017).

Modal split specifies the types of transportation chosen for travel (Ronchi et al., 2017). In the context of wildfire evacuations in tourist areas, especially in campsites, the modes of transportation can include either private vehicles or transportation arranged by authorities.

Traffic assignment involves distributing a specified set of origin-destination pairs across an appropriate road network, according to criteria chosen by travellers (Saw et al., 2015). Depending on the project goals and time variability, traffic assignment can either be static or dynamic. In static assignment, the traffic demand is assumed to remain constant over time where the traffic on the network is in a 'steady-state' (Ronchi et al., 2017). In contrast, the dynamic assignment implies that traffic loading and route choices change over time.

For a traffic model, the key outputs include the elements that describe the network's traffic conditions (i.e., flows, travel times, delays) and the total evacuation time (Ronchi & Gwynne, 2020). It also assesses strategies to enhance evacuation efficiency, like reducing congestion. In the case of a wildfire evacuation scenario in WUI, the resolution of the results depends mainly on the scale of the traffic modelling (i.e., microscopic, mesoscopic, macroscopic)

The macroscopic model describes a low level of detail where the traffic flow is presented as a combination, measured in terms of characteristics such as speed (km/h), flow (veh/km/lane), and density (veh/h/lane) (Rohaert, Janfeshanaraghi, et al., 2023). The goals addressed in macroscopic modelling encompass the assessment of the level of congestion of a city and road traffic conditions (Dorokhin et al., 2020) where it is possible to represent the large road networks with a possible computational demand.

In contrast, the microscopic model allows a detailed description of the traffic flow by capturing the interactions between vehicles and the road (Ferrara et al., 2018). It uses time as an independent variable, calculating each vehicle's position, speed, and acceleration at each simulation step (Tapani, 2008). Nevertheless, this model requires a proper calibration of a high number of parameters to accurately simulate the scenario (Ferrara et al., 2018).

Mesoscopic models occupy an intermediate position between the microscopic model and the macroscopic model (Ferrara et al., 2018). Mesoscopic models describe traffic flow dynamics using aggregate probability distributions influenced by individual driver behaviours. These models balance the simplicity of macroscopic models and the detail of microscopic models. It combines the modelling of large road networks with a reasonable representation of individual behaviours and traffic dynamics using a probabilistic term (Ferrara et al., 2018).

3 Case study description

3.1 Why Spain?

According to the Joint Research Centre, (2024), the Mediterranean region of Europe experienced a surge in the number of wildfires, making 2023 the fourth worst year since 2000 in terms of total burned surface area. In Europe, the years 2018 and 2019 were among the most severe on record for wildfires, in Portugal, Italy, and Spain alone, nearly 800,000 hectares of land were burned (Alló & Loureiro, 2020). Therefore, numerous regions in Europe (and worldwide) could have been relevant to this study. In this work, the case study was selected as a representative of an area with high wildfire risk and a significant presence of tourists.

A megafire is a fire that has burned more than 500 hectares of forest (Alló & Loureiro, 2020). In this context, Spain is entering a new era of mega wildfires, with a record of 306,555 hectares (0.306555 Mha) burned by wildfires in the year 2022 (Salas, 2024).

This sharp increase in wildfires in Spain is driven by changes in the fire regime. Fire regime encompasses a variety of fire-related factors, which can be combined and used in various way (Krebs et al., 2010).

The dynamics of the fire regime have been shown to have a direct link with demographic factors and climate trends (Rodrigues et al., 2020). The demographic factor, particularly the growth of Wildland-Urban Interface (WUI) communities, has been associated with increased fire activity, as demonstrated in a study on fire regime dynamics in Spain (Rodrigues et al., 2020). This also includes the fact that fire regimes have changed as a result of human modifications to fuel availability and its quantity in the landscapes. Besides the demographic factor, fire regimes are driven by environmental conditions (ignitions, vegetation, climate, weather, and topography) that influence both fire behaviour and effects.

In the context of wildfire spread, fuels are a crucial element but very unique as they are biomass and remain constantly changing (Finney et al., 2021). For instance, the fuel flammability is very dependent on its moisture content which can be reduced due to the precipitation deficits (Pausas & Fernández-Muñoz, 2012). Thus, the weather and climate influence wildfire activity. Due to the climate crisis, even though the plants are alive, they become flammable in case of fire because their roots are dry.

Nevertheless, the link between drought and wildfire propagation may be dependent on the ecosystem itself. For instance, in savanna ecosystems, dryness during the wet season results in a fuel-limited environment, whereas drought in forest ecosystems is associated with increased wildfire activity due to the decrease in fuel moisture content. Based on the data from the state meteorological agency, the northeastern part of Spain can show a combination of high temperatures, and dry weather which increase wildfire propagation.

3.2 Punta Milà campsite

3.2.1 Background

Punta Milà campsite is a major tourist destination in the northeastern part of Spain. This campsite features the typical infrastructure found in many other campsites across Southern Europe.

A study trip was undertaken to the regions of Catalonia and southern France in September 2023, during which we visited several campsites. Conversations with campsite managers, who had previously experienced wildfire evacuations, as well as discussions with firefighters and municipality managers, provided insights into the tourism activity in the area, the types of visitors, specific weather conditions, and the fire management strategies implemented there.

It is located in the heart of the Natural Park of Montgrí between the municipalities of l'Escala and Torroella de Montgrí. The discussion with the fire manager in the region indicated that those municipalities receive a high number of tourists mainly during the summer season with tourism services serving as the main economic activity. According to campsites managers, this region is attractive to tourists because of its proximity to beaches and forests, offering numerous activities to do.

However, the area where the Punta Milà campsite is located can present a real danger for tourists in case of a wildfire event. Based on the discussion with the fire managers, the wind behaviour in this region can be driven by the wind coming from the north known also as northern wind (Tramontana). This wind accelerates the spread of the fire as it is a very strong wind blowing from north to south, directly towards the Natural Park of Montgrí, where there is plenty of fuel. Moreover, the final stage of these wildfires remains challenging even after the general northern wind disappears because the local winds which are influenced by the terrain (topographic winds) can still be active and may increase the fire activity in the flanks and back.

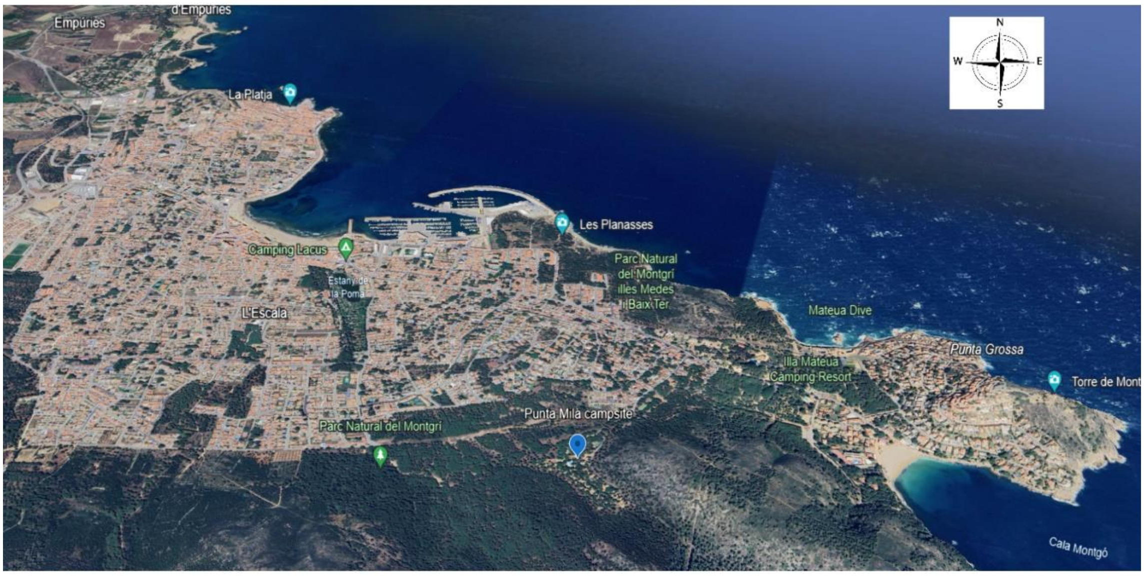

Figure 1: Map of L'Escala region (Image: Google Earth).

3.2.2 Campsite layout

Punta Milà camping site is a popular destination for tourists from the Netherlands, Belgium, and France because of its proximity to beaches (850 meters from Cala Montgó beach), natural park, and its Mediterranean climate. The total area of the camp is approximately 51 810 m² and it provides various accommodation options including pitches for tents and caravans. The total number of parcels is 160 fully equipped for 5 persons. The camp also includes several buildings to ensure that guests have access to essential services. The reception is located near the camp entrance where the staff assist tourists in obtaining essential information. Moreover, there is a building that houses the supermarket, bar, and restaurant.

Inside the camp, all surfaces are designed to be easy to walk. A concrete path runs through the camp, providing a well-defined route for vehicles and pedestrians to navigate. The width of the main paths within the camping site is 5 m. Besides that, the camp has only one entrance/exit (permanently open exit door with a total width equal to 10 meters). Moreover, the vegetation within the camping includes tall, pruned pine trees and low scattered bushes, all of which are well maintained.

The yellow region in Figure 2 shows the campsite boundary from a satellite view (Google Maps).

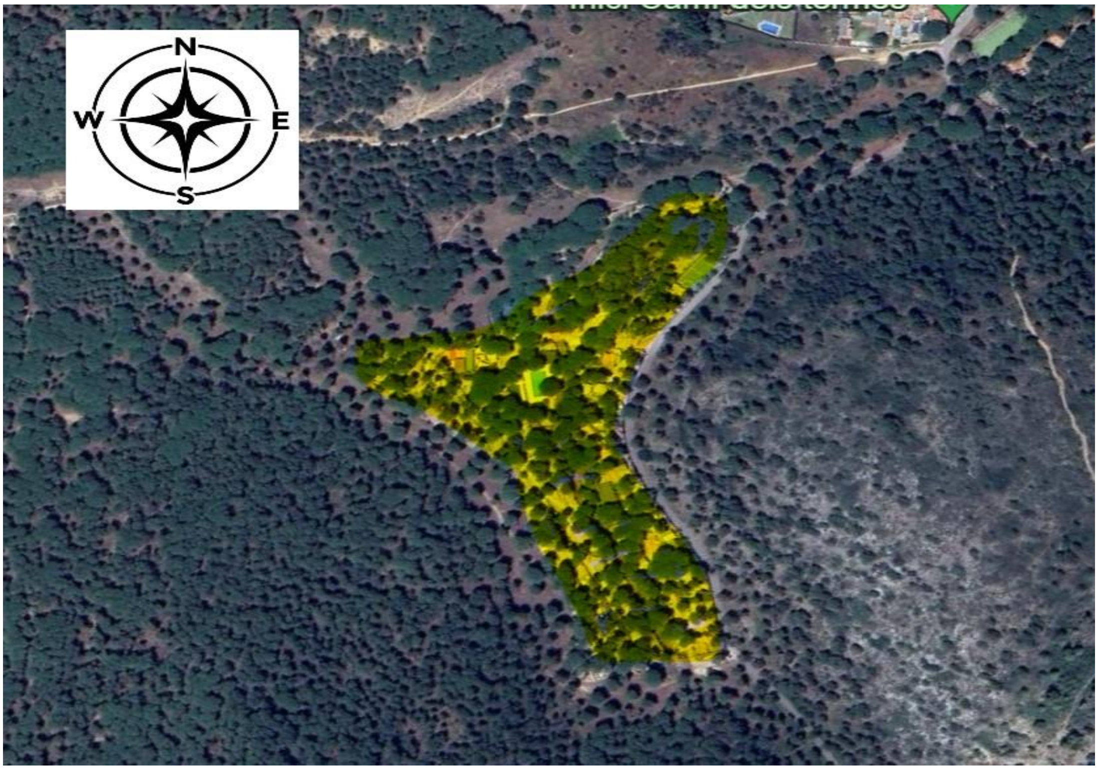

Figure 2: Satellite view of Punta Milà campsite, with the yellow region indicating the campsite boundary area (Image: Google Maps).

3.2.3 Campsite Occupancy

During the peak season, Camping Punta Milà can host a maximum of 900 tourists with a staff of 14 individuals during the day and 10 individuals during the night.

A typical tourist population in the campsite includes families from the Netherlands with 2-3 children aged 10-15 years old. This is alongside a number of older couples who also frequent the camp. While the majority of the tourists are from the Netherlands, there is also a considerable number of tourists coming from Belgium and France.

The maximum number of vehicles during peak season is 300 vehicles where 1/3 are caravans and 2/3 are passenger vehicles. Although parking spaces are limited both inside and outside the campsite, tourists have the option to park their vans and cars in their parcels or in a parking area near the entrance.

4 Evacuation Scenarios

In this section, a series of evacuation scenarios is presented to assess the influence of various factors on the overall evacuation time. The evacuation scenarios include two types of evacuation strategies: one in which tourists evacuate on foot, and the other in which tourists use their private vehicles.

Figure 3 illustrates the first evacuation strategy (Evacuation on foot), tourists are initially located either in their accommodation or somewhere around the camp (starting point). They are then required to go to the meeting point on foot to receive evacuation instructions. After that, they are supposed to return to their accommodation to prepare for the evacuation. Finally, they evacuate on foot to the campsite's designated exit point before boarding buses arranged by authorities for further transport. This strategy requires good coordination and management between authorities to ensure the safe evacuation of all individuals.

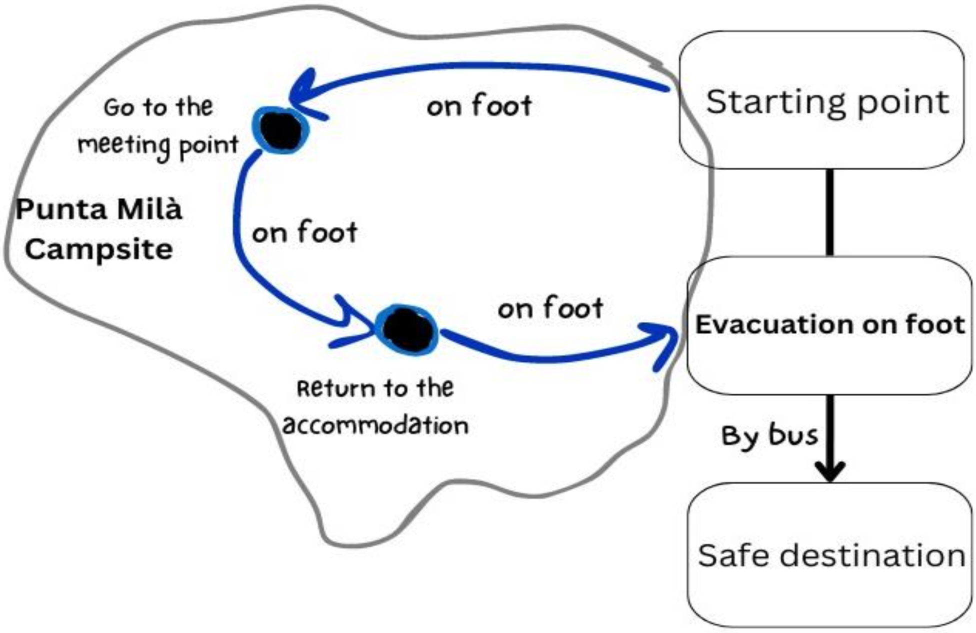

Figure 3: Evacuation on foot strategy process.

Figure 4 shows the second evacuation strategy (Traffic evacuation), tourists are initially located either in their accommodation or somewhere around the camp (starting point). They are then required to go to the meeting point by foot to receive evacuation instructions. Following instructions, they are supposed to return to their accommodation to prepare for the evacuation. Finally, they are required to drive by private vehicle to a dedicated safe area, specifically the area near the beach 'Platja de Montgó'. This evacuation strategy considers traffic congestion and good coordination to facilitate the safe departure of tourists from the campsite.

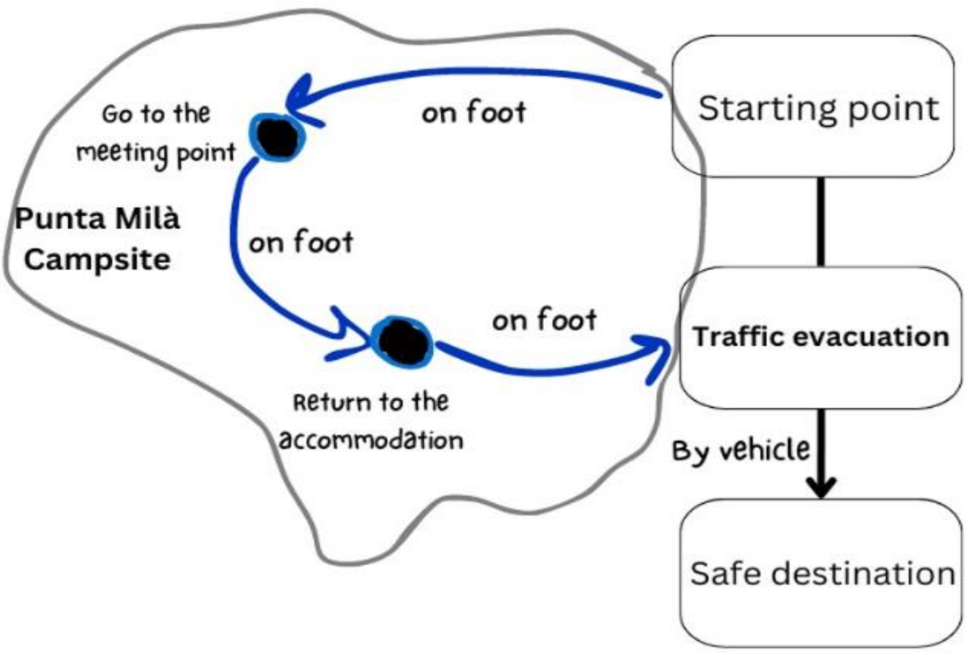

Figure 4: Evacuation by vehicle strategy process.

By evaluating these two evacuation strategies and their respective implications, it is possible to decide on the most effective approach for ensuring a secure evacuation of tourists from the campsite in case of a wildfire evacuation.

The evacuation scenarios involve using Pathfinder software to simulate pedestrian movement and SUMO software to simulate vehicular traffic.

Table 3 outlines the total number of scenarios performed during the modelling, where in all scenarios the camp is operating at full occupancy. The moment of the day column indicates the time of the day when the evacuation occurs (Day or night). The evacuation type column describes the mode of evacuation used to evacuate to the exit of the campsite (Vehicle or foot). The groups column specifies whether the model involves the gathering of groups of tourists during the evacuation, such as groups of families and friends (Yes or No). The archetypes column indicates whether the tourists' profiles in the model include tourist archetypes defined in the literature review (Yes or No).

Table 3: Description of the study scenarios.

Scenario	Description	Moment of the day	Evacuation type	Groups	Archetypes
1	Traffic day evacuation	Day	Vehicles	No	No

2	Day evacuation on foot	Day	Foot	No	No
3	Day evacuation on foot with groups	Day	Foot	Yes	No
4	Day evacuation on foot with archetypes	Day	Foot	No	Yes
5	Traffic night evacuation	Night	Vehicles	No	No
6	Night evacuation on foot	Night	Foot	No	No
7	Night evacuation on foot with groups	Night	Foot	Yes	No

In scenario 1, which is the traffic day evacuation, tourists are randomly distributed around the campsite. Tourists will receive the evacuation notification from the staff or other tourists as there is no centralized alarm, then they need to go to the assembly point on foot to receive the instruction, and then return to their accommodation, take the car/van, and then evacuate via their private vehicle.

In scenario 2, which is a day evacuation on foot, tourists go to the assembly point on foot, receive instructions, and then return to their lot and evacuate on foot to the outside of the camping to be taken by buses arranged by authorities.

In scenario 3, which is a day evacuation on foot with groups, tourists engage in the same process as in scenario 2. However, in this scenario, the fact of having group movement is introduced to evaluate its impact on evacuation time.

In scenario 4, which is a day evacuation on foot with archetypes, tourists follow the same process as in scenario 2. Nevertheless, the concept of archetypes, as mentioned earlier, is introduced to examine how the added complexity in defining profiles can influence evacuation time.

Scenarios 5, 6, and 7 respectively represent traffic night evacuation, night evacuation on foot, and night evacuation on foot with groups. These scenarios aim to capture the influence of night time conditions on the evacuation process.

5 Pathfinder model configuration

5.1 What is a model?

Understanding the concept of a model is crucial as it offers a foundation for a better output analysis. The common scientific approach used to describe a complex phenomenon is the system approach, which views the system in a holistic way. In other words, the components of that system interact and act together toward the accomplishment of some logical end (Barceló, 2010). This definition shows clearly that a system is not just about assembling parts together. Instead, it describes how those components are interdependent and aim for the same goal. Therefore, we need a formal tool that can represent our real system, describe it, and show how it develops over time. Such a mechanism is known as a model. There are many definitions of the word model, in most basic forms, a model is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process (Friedenthal & Dori, 2023).

5.2 Introduction to Pathfinder Software

Pathfinder is an agent-based egress simulator released by Thunderhead Engineering (2022). Widely adopted in both academic and industrial settings, Pathfinder is a commonly used pedestrian evacuation model (Lovreglio et al., 2020). It allows the use of two movement simulation modes. The first one is the steering mode where occupants use a steering mechanism to interact with others (Reynolds & others, 1999). The second one is the Society of Fire Protection Engineering mode which is based on a set of hand calculations and assumptions where agents do not avoid each other (Gwynne & Rosenbaum, 2016). The default configuration in Pathfinder is a continuous movement based on steering behaviours a characteristic that closely mirrors real-world evacuation scenarios. The model representation of Pathfinder is a 3D triangulated mesh providing a detailed and realistic presentation of the environment and occupants' interactions within it.

In this case study it is important to use a model that is based on realistic assumptions. Therefore, Pathfinder has been selected because it employs a steering model to represent movement within space. Moreover, the structure of the grid is continuous where the occupants can move in a continuous space and incorporate the element of time. Besides that, Pathfinder provides a fast model input set-up and a friendly user interface.

5.3 Input data for Pathfinder simulation

The Pathfinder model configuration is based on the available data as well as a number of assumptions made. The model configuration includes the occupant's characteristics, occupants’ distribution, the pre-movement time, the waiting time at the meeting point, the preparation time, and the effect of the topography on the walking speed.

Overall assumptions:

- Full occupancy of the campsite.
- The impact of potential obstacles on the road that might obstruct or impede movement is disregarded. The reason is based on the observations from a visit to

the campsite, where all surfaces appeared easily navigable. There is a concrete path for vehicles and people to go through. Moreover, vegetation within the camping is very well maintained. Tall, pruned pine trees, and low scattered bushes (See Figure 5)

- Fire detection and alarm notification times are omitted as RSET calculations will start directly after the evacuation order is given.
- The area on the top left of the camp is excluded from the study as it was a renting area from the municipality (on the other side of the river, parcels 60-77 and 98-103).
- The toxic effect of smoke is not considered as we are assuming that the fire is happening far away from the campsite.
- Staff members are distributed randomly around the campsite.
- The campsite terrain is predominantly flat, but in an area where a moderate incline (*Google Earth*, 2023) was observed. In that area the slope increases by 3% (Elevation changes from 14m to 17 m for a distance of 100 m) (*Google Earth*, 2023). Assuming that the speed will decrease by 0.01 for every 1% change in the slope, then a speed reduction factor equal to 1-0.03 = 0.97 was included.
- It is assumed that all vehicles are parked near the accommodation.

Figure 5: Punta Milà campsite (8 February 2024).

5.4 Occupants' characteristics

The total number of tourists at full occupancy is 900 tourists. As mentioned previously, the majority of the visitors are families with 2-3 children aged 10-15 years. Additionally, older visitors are also accounted for in the demographic makeup of the campsite.

Table 4 and Table 5 present the occupant's number distribution as well as their walking speed for the different scenarios and the body size (Korhonen et al., 2008). The speed is given as uniform distribution to capture variability and the influence of factors such as congestion, density, and obstacles on pedestrian movement. The speed during night time is reduced due to the reduced visibility at night.

For scenarios 1,2 and 3:

Table 4: Profile's characteristics for day scenarios.

Profile	Number	Speed in m/s (uniform distribution)	Body size in m (uniform distribution)
Adult	450	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Child	360	Min= 0.6; Max= 1.2	Min= 0.39; Max= 0.45
Elderly	90	Min= 0.5; Max= 1.1	Min= 0.46; Max= 0.54

For scenarios 5,6 and 7:

Table 5: Profile's characteristics for night scenarios.

Profile	Number	Speed in m/s (uniform distribution)	Body size in m (uniform distribution)
Adult	450	Min= 0.71; Max= 0.88	Min= 0.44; Max= 0.58
Child	360	Min= 0.46; Max= 0.91	Min= 0.39; Max= 0.45
Elderly	90	Min= 0.38; Max= 0.84	Min= 0.46; Max= 0.54

5.5 Pre-movement time

The pre-movement time is also referred to as pre-travel time, represents how long it will take for the occupants to recognise the alarm and respond to it. This time varies depending on several factors, including the area purpose, the occupants' familiarity with the physical environment, their state of alertness (i.e., sleeping or awake), the type of alarm employed, and the level of management in place.

In the case of the campsite and tourists, specific pre-movement times were not readily available. As a result, estimates were made considering the existing literature. These estimates were done to consider a credible pre-movement time for the campsite evacuation scenarios.

The pre-movement time was defined using Table E.2 from PD 7974-6:2019 standard (PD, 2019). For day scenarios the scenario category is B: awake and unfamiliar, while for night scenarios the scenario category is Ciii: Sleeping and unfamiliar.

Management level M2 consists of having occupants and staff trained for fire safety management but has a lower staff ratio whereas management level M3, represents standard facilities with basic minimum fire safety management. However, in the case of Punta milà campsite, still maintains a higher level of fire safety management compared to M3. Additionally, it is not possible to assume that all tourists are trained or have knowledge about fire safety procedures because tourists may have different levels of preparedness and risk awareness. Therefore, the camping site cannot be classified as level M2 as well.

Consequently, the suggested pre-movement time for day scenarios estimates 10 minutes for $\Delta t_{pre(1st\ percentile)}$ and 20 minutes for $\Delta t_{pre(99th\ percentile)}$ as reasonable mid-way between management level M2 and management level M3.

The suggested pre-movement time for night scenarios estimates 20 minutes for $\Delta t_{pre(1st\ percentile)}$ and 40 minutes for $\Delta t_{pre(99th\ percentile)}$.

$\Delta t_{pre(1st\ percentile)}$: pre-evacuation time of the first few occupants.

$\Delta t_{pre(99th\ percentile)}$: pre-evacuation time of the last few occupants.

The pre-movement time is typically represented by a log-normal distribution. This choice is based on the fact that variables like social influence or delayed responses can impact pre-evacuation intervals, leading to non-symmetrical distribution shapes (Ronchi, E., & La Mendola, S. 2016). Unlike the normal distribution, the log-normal distribution offers realistic scenarios.

The log-normal distribution of the pre-movement time for daytime is estimated based on a set of calculations (See appendix I). For log-normal distribution, Pathfinder software requires location and scale as inputs instead of the mean value and standard deviation.

For day-time scenarios, the parameters of the pre-movement time are:

Table 6: Pre-movement for day scenarios.

Min (s)	600
Max (s)	1200

Location (s)	159
Scale (s)	9

For night-time scenarios, the parameters of the pre-movement time are:

Table 7: Pre-movement for night scenarios.

Min (s)	1200
Max (s)	2400
Location (s)	201
Scale (s)	9

In scenario 4, where evacuation on foot with various archetypes is involved, accounting for different pre-movement times is crucial. The *Responsibility Deniers* tourists may experience prolonged delays, expecting authorities or camp managers to handle their safety. The *Experienced Independent* tourists may show a quick response and decide to evacuate as soon as possible. The *Worried Wavers* tourists can show a quick commitment to the evacuation order as well by using information from emergency services. The *Dependent tourists* can exhibit a slight delay as they are committed to evacuating but rely extensively on emergency services in their decisions. The *Considered tourists* are strongly committed to evacuating as soon as they become aware of the risk. The *Threat Deniers tourists* may show a very long delay before they evacuate as they may disregard the information or the evacuation order. The *Community Guided* tourists present moderate behaviour as they fully rely on the community evacuation decisions.

In the absence of specific data for pre-movement times of archetypes in wildfire evacuations, a systematic approach is adopted to incorporate the archetype concept into the model. This involves classifying archetypes based on their evacuation likelihood and quantifying pre-movement times accordingly. The subsequent step consists of assigning the previously determined pre-movement time to archetypes exhibiting moderate behaviour. Adjustments are made by modifying the mean for archetypes showing delays and deducting time from the value of the location (μ) for those with shorter pre-movement times (see Table 8 for the resulting chosen values). Only the value of the location (μ) is changed while the scale (σ), minimum, and maximum values remain consistent across all archetypes as we do not have data to support more detailed assumptions.

It should be noted that the pre-evacuation times for all archetypes have been accounted for in the simulations that did not consider archetypes explicitly, where the entire range of behaviours is captured. Nevertheless, adding a scenario with archetypes and comparing the two approaches can offer insights into the extent to which added complexity impacts the total evacuation time. Furthermore, this comparison helps in understanding the model's sensitivity to variations in pre-movement times across different archetypes.

The process followed to include the archetypes in the model involved first defining the profiles in the Pathfinder software. The profile of adults was replaced with the profiles of the archetypes, while the profiles of children and older people were kept as they were, as there is no data or information available to support more detailed assumptions. As the total number of adults (450) was not possible to distribute exactly equally between the 7 archetypes, the Community guided archetype has 66 persons out of a total of 450, as it's the archetype presenting a moderate level of pre-movement time. It should be noted that this is a hypothesis we aim to test, as no previous work has included archetypes in a simulation model.

The following table summarizes the profiles used to model scenario 4 (Day evacuation on foot with archetypes):

Table 8: Description of the profiles used in the model.

Profile	Number	Speed in m/s (uniform distribution)	Body size in m (uniform distribution)
Experienced Independents tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Worried Waverers tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Considered tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Community Guided tourists	66	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Dependent tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58

Responsibility Deniers tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Threat Deniers tourists	64	Min= 0.95; Max= 1.55	Min= 0.44; Max= 0.58
Child	360	Min= 0.6; Max= 1.2	Min= 0.39; Max= 0.45
Elderly	90	Min= 0.5; Max= 1.1	Min= 0.46; Max= 0.54

Following this step, pre-movement needed to be defined for the archetype's profiles based on their characteristics. For instance, Experienced Independents tourists may show a short pre-movement time as they are familiar with wildfire evacuation, while Threat Deniers tourists may exhibit a long pre-movement time as they may ignore warnings.

To include this feature in the pre-movement time, the archetypes were first classified based on who we expected to leave first and then who would leave last. The pre-movement time that was defined in the previous scenarios was attributed to the archetype showing moderate behavior (Community Guided tourists).

For the rest of the archetypes, 0.8 seconds was added or reduced from the location parameter depending on the type of archetype to maintain a log-normal distribution where the mean value is skewed towards the minimum (it should be less than 15 min, which is the mean). It should be noted that Pathfinder software requires location (μ) and scale (σ) as inputs for a log-normal distribution.

The following table shows the values for the location and its equivalent mean value.

Table 9: Values of the location and equivalent mean value for each archetype.

Archetype profile	Value of the location (s)	Equivalent mean time (min)
Experienced Independents	156,6	13,753
Worried Waverers	157,4	13,938
Considered Evacuators	158,2	14,125
Community Guided	159	14,314
Dependent Evacuators	159,8	14,506
Responsibility Deniers	160,6	14,7
Threat Deniers	161,4	14,898

Table 10 summarize this approach.

Table 10: Classification of archetypes

Archetypes	Pre-evacuation time in a qualitative way	Reason	Quantification of the Pre-movement time
Experienced Independents tourists	Shortest	They are aware of the best route/procedures and are familiar with the area and with the protective actions to be taken in case of wildfire in the area.	Log normal distribution (μ= 156.6 s; σ = 9 s; minimum=600 s; max=1200 s)
Worried Waverers tourists	Shorter	They are knowledgeable about wildfires and well-prepared and well-informed.	Log normal distribution (μ= 157.4 s; σ = 9 s; minimum=600 s; max=1200 s)
Considered tourists	Short	They are prepared as they perceive wildfires as a possible risk.	Log normal distribution (μ=158.2 s; σ = 9 s; minimum=600 s; max=1200 s)
Community Guided tourists	Moderate	They are reliant on the evacuation decisions of the community.	Log normal distribution (μ= 159 s; σ = 9 s; minimum=600 s; max=1200 s)
Dependent tourists	Long	They heavily rely on emergency services in their decisions.	Log normal distribution (μ= 159.8 s; σ = 9 s; minimum=600 s; max=1200 s)

Responsibility Deniers tourists	Longer	They will stay as long as others will take care of their evacuation as they are neither aware of the best route nor familiar with the area and procedures.	Log normal distribution (μ= 160.6 s; σ = 9 s; minimum=600 s; max=1200 s)
Threat Deniers tourists	Longest	Do not believe the threat will affect them, ignore warnings until the last moment. They are not familiar with the area and the wildfire safety procedure.	Log normal distribution (μ= 161.4 s; σ = 9 s; minimum=600 s; max=1200 s)

5.6 Waiting time at the meeting point

Once tourists start their movement, they will be required to gather at the designated meeting point to receive instructions on the evacuation process (See Figure 6). It is assumed that the waiting time will differ from one individual to another, influenced by a variety of factors including the language of the instructions, the speed at which people comprehend the guidance, and possible congestion at the meeting point. In the absence of relevant data, a normal distribution has been assumed for a rough estimation.

For day-time scenarios:

Table 11: Normal distribution for the waiting time for day-time scenario.

Min (s)	60
Max (s)	600
Mean (s)	300
Standard deviation (s)	96

For night-time scenarios:

Table 12: Normal distribution for the waiting time for night-time scenario.

Min (s)	60
Max (s)	900
Mean (s)	480
Standard deviation (s)	138

Figure 6: The meeting point location (Image: Punta Milà Self-protetcion plan).

5.7 Preparation time in the accommodation

It is expected that tourists will perform a number of actions before their evacuation. In their paper (Shi et al., 2009) cited pre-movement times according to influencing factors. The preparation action time was included in the model as a normal distribution. Assuming that each tourist will perform each delay action once, then the mean delay time would be the sum of the mean times for each delay action. Similarly, the variance of the delay time would be the sum of the variances of each delay action's time, assuming the actions are independent of each other. (ignoring the action of calling the fire brigade, rescuing, and notifying others).

Based on Shi et al., (2009), the delay time will be then:

Table 13: Preparation time.

Delay Action	Mean Time (s)	Standard Deviation (s)
Inaction	60	18
Collect belongings	30	9

Telephoned others	30	9
Close/open doors/windows	5	1.5
Shut down equipment	20	6
Get dressed	60	18
Total	205	-

Therefore, the input data for the delay time due to the performed preparation activities are:

Table 14: Preparation time normal distribution.

Mean (s)	205
Standard deviation (s)	30
Min (s)	120
Max (s)	290

6 Building Microscopic Traffic Simulation using SUMO model

6.1 Introduction to Microscopic Traffic Simulation using SUMO model

SUMO (Simulation of Urban Mobility) is a free and open-source traffic simulation suite. It is created by The Institute of Transportation Systems in Berlin, Germany, and was released on the year 2001 (Lopez et al., 2018). Sumo is a multi-modal model which means that it integrates the movement of cars as well as the other transport systems and supports traffic lights. Moreover, the simulation in SUMO is space-continuous, and time-discrete traffic flow simulation (Lopez et al., 2018). The traffic flow is microscopic which means that each vehicle within the road network is represented individually by providing its specific position and speed through the network. Modelling vehicles at this granular level is important to get insights into the time when the last vehicle reached the safe zone as well as the speed distribution of the vehicles travelling to the safe destination.

The SUMO package includes a variety of tools, the main modules of the package are:

- SUMO GUI which is the graphical user interface that helps to visualize vehicles dynamics. It reads the input data, conducts the simulation, collects results, and generates output files.
- OsmWebWizard is a tool that allows to extract the road network from OpenStreetMaps (a free, open geographic database). After the configuration of randomized traffic demand, it is possible to run and visualize the scenario in the SUMO-GUI.
- For a visual network editor, Netedit or a command line can be used to modify the network or to create new features within the road (Lopez et al., 2018). It processes the input data, generates the input for SUMO, and saves the outcomes in different output formats, including XML.

The car-following model defines the speed of a vehicle in relation to the vehicle ahead of it (Song et al., 2014). This is an important feature as it illustrates that vehicle speeds influence overall traffic flow and can significantly impact evacuation times. The default model used by SUMO is Krauß model (Krauß, 1998) which consists of selecting the maximum speed that allows one to stop at any time without any collision with the following vehicle (Lopez et al., 2018). The speed is referred to as the safe velocity (v_{safe}) (Krajzewicz et al., 2002). The car-following model is influenced by multiple factors such as individual characteristics (age, gender, risk-taking propensity, driving skills) but also by situational factors (time of day, road conditions, impairment due to alcohol, fatigue, trip purpose, driving length) (Ranney, 1999).

In terms of input, SUMO relies on two main files to initiate simulations. The first file, known as the routes file, serves a dual purpose. Firstly, it defines the traffic demand by specifying the routes that vehicles will take within the simulated network. Additionally, this file includes details about the characteristics of the vehicles involved, such as their type, acceleration, deceleration, length, and maximum speed. The second essential file is the net-file, which represents the network topology of the network. This file illustrates the spatial layout of roads, intersections, lanes, traffic lights, and other relevant infrastructure elements. Together, these two files provide SUMO with the necessary information to simulate the scenario.

As for output data, SUMO can generate several files for the simulated scenario. One of the key outputs is the XML file from the virtual induction loops (in case it was added to the network) which records detailed information about the movement of each vehicle in a specific lane. Another key output is the trip output which provides a table with all information about every vehicle including depart time, arrival time, arrival speed, duration, route length, and waiting time (queuing).

SUMO (Simulation of Urban Mobility) is very useful in this study as it provides a microscopic analysis which is important in this case study. Moreover, it allows the importation of realistic maps, provides an adaptation to behaviours on the roads, and supports a large amount of traffic (Haliti, 2018) which allows an accurate simulation of vehicle movement within a specified road network.

SUMO version 1.19.0 was used for building the model and an example of the working interface of SUMO-GUI is shown in Figure 7.

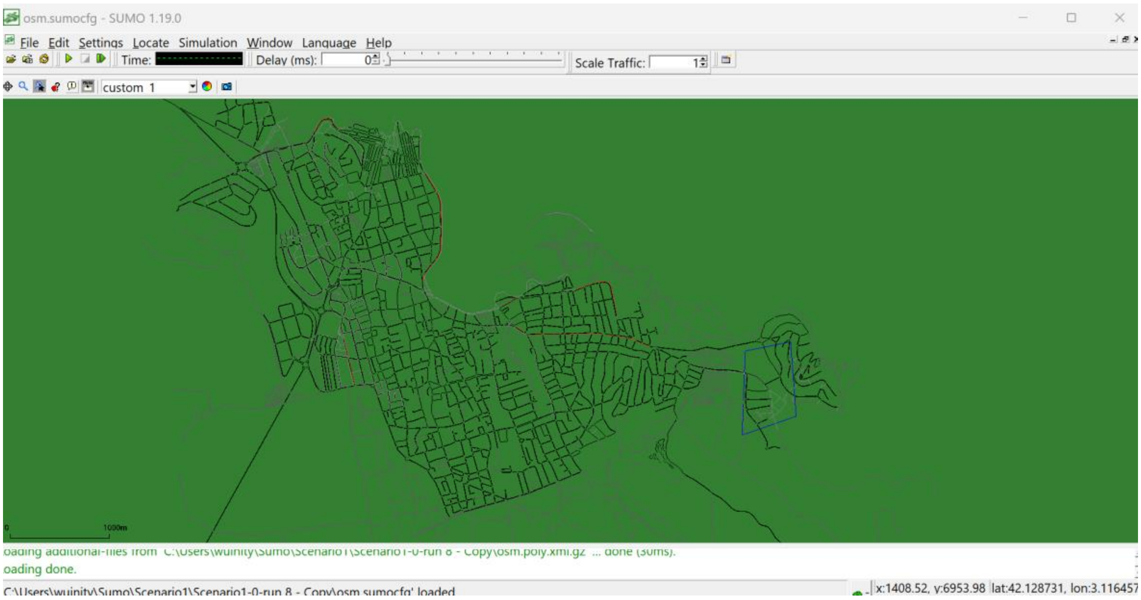

Figure 7: SUMO-GUI interface.

6.2 Building Microscopic Traffic Simulation using SUMO model

SUMO (Simulation of Urban MObility) is used here to model the traffic evacuation of tourists from the campsite to the safety zone. The SUMO scenario will start after tourists reach their accommodation and pick up their private vehicles. Therefore, the model configuration of SUMO (Simulation of Urban MObility) relies on the output from Pathfinder.

The input data for SUMO (Simulation of Urban MObility) includes the road network, vehicle data, traffic demand, and configuration file data.

6.3 Road network

The first step to build the SUMO model is to import the road network that describes the lanes, intersections, distances, and road speed to have a real-world scenario. The road network can be uploaded using OSM Web Wizard map, which is a tool of the SUMO package.

In the xml file, a lane is given as follows:

```
<lane id="<ID>" index="<INDEX>" speed="<SPEED>" length="<LENGTH>" shape="<SHAPE>"/>
```

The generated road network is then edited in NETEDIT which is a graphical network editor program from the SUMO package. This step is necessary as the roads inside the campsite were not initially visible after the generation of the road network for the selected region as well as making the street outside the camp one-directional. NETEDIT allows for the creation and modification of roads within the campsite and outside of it, ensuring that the entire network accurately represents the simulation real environment.

The speed limit inside the campsite is set to 20 km/h to account for possible pedestrians walking around, which may slow down the speed of cars. Outside the camp, the speed limit is fixed at 50 km/h.

6.4 Traffic Assignment Zone (TAZ)

The traffic assignment zone TAZ defines the area where vehicles depart (Origin) or arrive (Destination). The TAZ zones typically encompass multiple network edges. In this case study, the traffic assignment zone is designated as a destination for vehicles. This decision is driven by the high number of vehicles coming from the campsite and the limited parking space, leading vehicles to park in various locations near the beach. To simplify the model, the traffic assignment zone for the destination is placed near the beach. Figure 8 shows the location of TAZ, where the beach 'Platja de Montgó' is designated as a safe destination for evacuating people.

Figure 8: Location of the TAZ (Image: Google Earth).

6.5 Traffic demand

In SUMO the traffic demand refers to the traffic that will move over the road network during the simulation. To generate the traffic demand, it is necessary first to define the type of vehicles and their characteristics in the XML file known also as the trip file, moreover, each vehicle's route in the network must be included as well.

As the tourists inside the campsite are using cars and vans, the specific type of van employed is the Class C motorhome. The vehicle characteristics were selected according to specifications outlined in the SUMO documentation (Lopez et al., 2018), where default values are provided for passenger cars. However, no specifications were mentioned in the documentation for vans, so values between those for passenger cars and trucks were used, as vans may fall somewhere in between.

and they are defined by a string of .xml code starting with vType:

<vType id="veh_passenger" vClass="passenger" accel="2.6" decel="4.5" sigma="0.5" length="5" maxSpeed="55.55" color="0,1,1"/>

<vType id="veh_van" vClass="passenger" accel="1.3" decel="4.25" sigma="0.5" length="12" maxSpeed="45.83" color="1,0,1"/>

Now that the vehicle characteristics are defined, the next step is to generate routes for the vehicles evacuating from the campsite. For this purpose, the outputs from Pathfinder are required as input for SUMO. This is because tourists will start driving their vehicles at different times. To elaborate, in Pathfinder, the movement of tourists is modelled by starting from their initial position, proceeding to the meeting point, and then returning to their accommodation. The Pathfinder simulation ended when they reached their accommodation, marking the moment when tourists would initiate driving their vehicles outside the campsite (after completing some preparation activities).

To solve this, a Python code was used to generate the trips for SUMO based on the outputs of Pathfinder simulation (See Appendix D).

At Punta Milà campsite, in full occupancy, there are a total of 300 vehicles, comprising 1/3 caravans and 2/3 passenger vehicles. The distribution of vehicles was randomly selected based on the total number of occupants in each accommodation area, ensuring that the final composition consists of 1/3 caravans and 2/3 passenger vehicles.

The suggested distribution of cars and vans is shown in Table 13.

Table 15: Vehicles distribution in the campsite.

Location	Number of people	Number of cars	Number of vans
R32	47	10	5
R34	7	2	1
R35	49	11	5
R37	41	9	5
R38	50	11	6
R39	15	3	2
R40	17	4	2
R41	16	4	2
R42	70	15	7
R43	45	10	5
R44	16	4	2
R45	34	8	4

R46	16	4	2
R47	37	8	4
R48	61	14	7
R49	36	8	4
R50	63	14	7
R54	11	2	1
R61	13	3	1
R62	30	7	3
R63	38	8	4
R64	55	12	6
R65	7	2	1
R66	28	6	3
R68	23	5	3
R85	75	16	8
Total number of vehicles		300	

An example of a SUMO trip code is:

```
<trip id="veh0" depart="1138.51" departLane="best" from="E38" toTaz="taz_0" type="veh_passenger"/>

<trip id="veh1" depart="1241.09" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
```

6.6 Random trips

In a real scenario, there can be background traffic which may have an impact on the evacuation time as it may create congestion on the road. This traffic may include emergency vehicles or vehicles headed to other destinations.

Therefore, it is crucial to take this into account when generating the traffic demand.

In SUMO, a random trip has a predefined Python script that helps create vehicles with random routes. The Python script ‘randomTrips.py’ generates a set of random trips for a specific road network. The resulting trips are provided as an XML file. The trips are distributed evenly based on a started time (option -b, default 0) and end time (option -e, default 3600) in seconds. The number of trips is defined by the repetition rate (option -p, default 1) in seconds (Lopez et al., 2018)

The command used to generate vehicles with the random trips script is:

```
python randomTrips.py -n osm.net.xml -r test.rou.xml -e 3600 -p 1 -l
```

7 Results

This section presents the results from a series of simulation studies based on the various scenarios described earlier. The primary objective of these simulations is to evaluate the model's effectiveness in simulating tourist evacuations from the campsite and to assess how different factors influence the evacuation process. The assessment of those factors will help to gain a deeper understanding of how each factor contributes to the overall evacuation time. This will help the tourism managers implement the appropriate strategies and improve evacuation procedures.

7.1 Scenario 1 (Traffic day evacuation)

In this scenario, the objective is to test the capability of integrating two distinct software programs (Pedestrian software and traffic software), previously unlinked, to simulate the entire evacuation process.

Although it is possible to model vehicles in Pathfinder and to use a pedestrian model called JuPedsim (Wagoum et al., 2015)integrated within SUMO, it was chosen to not use those models together, as the JuPedSim integration within SUMO is not yet fully documented. The vehicle mode in Pathfinder is not meant for cars but rather for assisted evacuation. In our model application, the foundational assumptions of each model are specifically adapted to their primary functions, therefore, employing them beyond these intended uses may not provide realistic or reliable results.

Another objective is to evaluate the total evacuation time for tourists leaving the campsite in private vehicles, compared to scenarios where tourists evacuate on foot and are subsequently transported by pre-arranged buses.

7.1.1 Pathfinder

To reduce the variability in the simulation, it is necessary to run the model multiple times (Ronchi et al., 2014). Probabilistic approach (Zhang et al., 2013) is used in Pathfinder to randomise occupants' positions and run the model (Ronchi et al., 2014). This approach helps in assessing simulation variability, with various methods available for this purpose (e.g., convergence method). Nevertheless, in this case study, only 10 simulation runs were used, assuming that the variability between the runs should be less than 5%, as more runs would require a longer simulation time.

Figure 11 shows the total pedestrian evacuation time for every simulation run. For this scenario, the average total pedestrian evacuation time is 3094 seconds (52 minutes).

The total pedestrian evacuation time which in this case refers to the time at which tourists arrive at their accommodation is a result of a series of intervals. The time interval is illustrated in Figure 9. It includes the pre-movement time, active time, and waiting time at the meeting point.

The active time here refers to the duration during which the agent is actively moving towards a goal. It indicates the time when an agent starts moving until they reach their goal or become inactive due to encountering an obstruction or reaching a temporary waiting point. This metric helps in understanding how long each tourist is actively involved in the evacuation process.

Moreover, on one hand, the pedestrian evacuation time includes pre-movement time, active time, and waiting time at the meeting point. On the other hand, the pedestrian movement time comprises the sum of active time and waiting time at the meeting point.

Nevertheless, it should be noted that the concept of pre-movement time was explicitly included in the model to represent agents in the simulation, even though it is not directly observable in reality.

Table 16: Average and standard deviation of the pedestrian evacuation time for scenario 1.

Scenario	Average pedestrian evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
1 (Traffic day evacuation)	3094	51:33	126	02:06

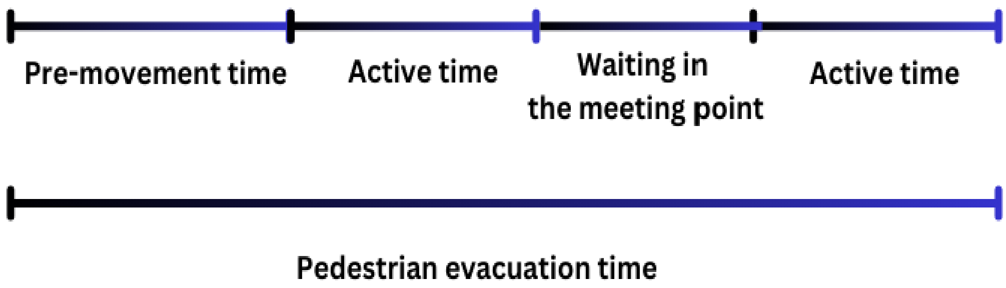

Figure 9: Timeline interval for pedestrian evacuation time.

Active time is defined as "*the amount of time the occupant is actively seeking a location in the model*" (Thunderhead Engineering, 2021). The avearge minimum active time is 27 seconds, while the average maximum active time is 1772 seconds (29 minutes). The difference between the minimum and maximum active time is around 30 minutes.

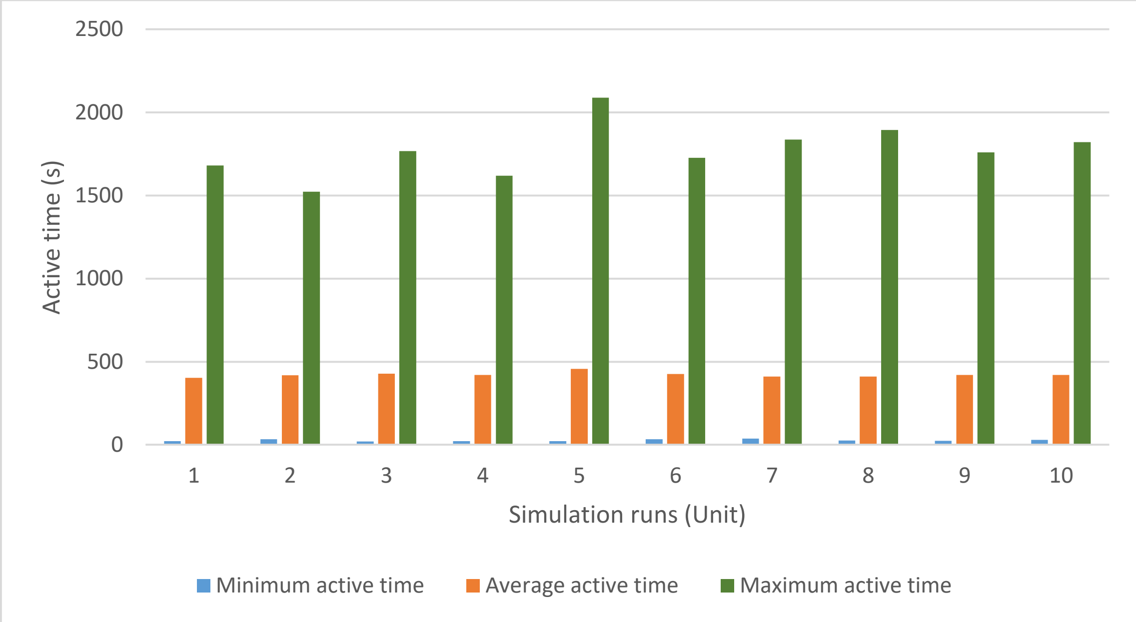

Figure 10: Active time analysis.

The average active time is around 422 seconds (7 minutes), providing a baseline for expected movement duration. However, understanding the reasons behind the extended or short active time is more important than focusing solely on the average. In other words, analyzing the factors influencing active time will help to capture the key elements impacting the total evacuation time as active time takes a considerable part in the time interval.

However, Figure 11 illustrates that the shortest and longest total pedestrian evacuation times do not correspond with the shortest and longest active times. This indicates that other factors are at play, such as pre-movement time, which can have a wide distribution and significantly impact the total evacuation time. Furthermore, the time spent at the meeting point follows a normal distribution, impacting the overall evacuation time.

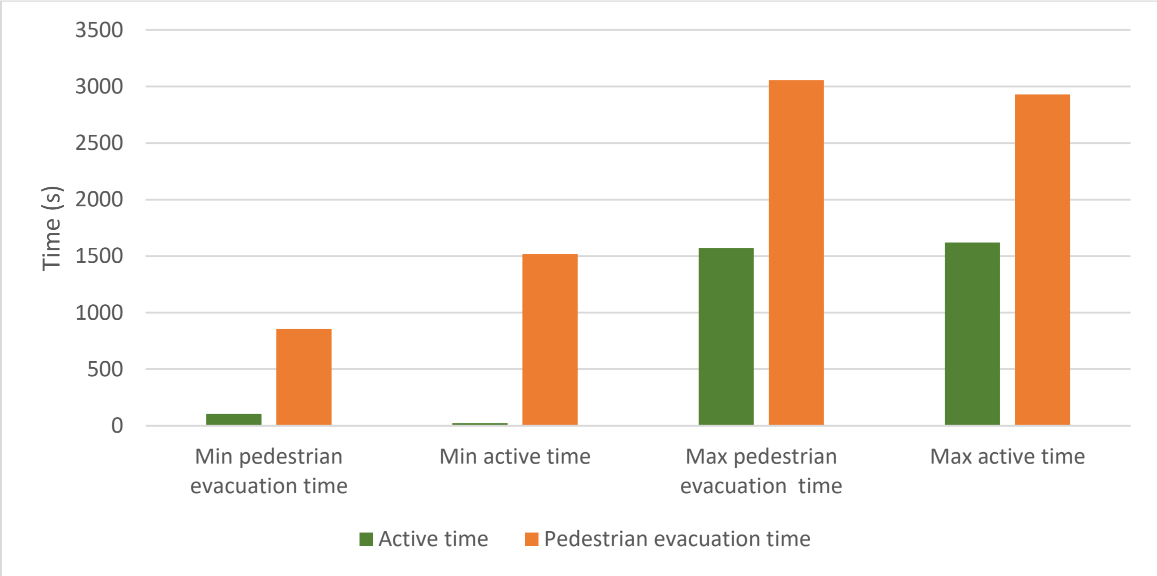

Figure 11: Active time vs total pedestrian evacuation time.

7.1.2 Microscopic Traffic Simulation using SUMO

The starting time of the vehicle movement from a specific lane in the campsite corresponds to the time tourists reach their accommodation and perform a couple of preparation activities. As mentioned previously, one of the key inputs in SUMO is the traffic demand. This key input is extracted from output results of Pathfinder. The Python code that is used to extract the necessary information requires a set of files from Pathfinder simulation:

- 'Scenario_occupants.csv' file from which the Python code extracts the value of the 'last_goal_started time(s)' and the agent ID number to determine the time an agent reaches its accommodation.
- 'Scenario_occupant_params.csv' file is used to know the accommodation location of each agent.

Besides the files extracted from Pathfinder simulation, additional documents are needed:

- 'From_To.csv' file where the distribution of the vehicles around the campsite accommodation is defined as well as the ID of the starting lane and the ID of the destination which is in this case TAZ.

Figure 12 shows a view from SUMO-GUI. In this visualization, cyan vehicles represent the passenger cars of tourists, fuchsia vehicles are camper vans, and yellow vehicles indicate background traffic.

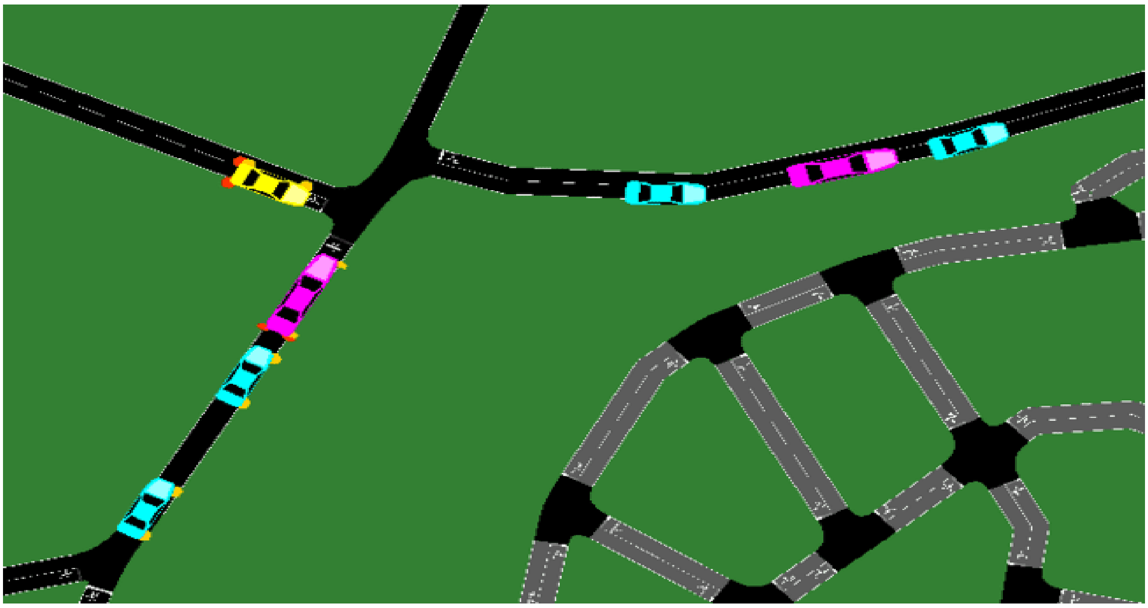

Figure 12: SUMO-GUI simulation interface (yellow vehicles represent background traffic, cyan represents the evacuating passenger cars and fuchsia the camper vans).

One of the key elements in traffic simulation is the background traffic. Figure 13 shows the location of the campsite Punta Milà as well as the location of the TAZ.

Figure 13: View of the simulation in SUMO.

In this case study, a number of simulations were performed to assess the sensitivity of the SUMO model to the background traffic on the traffic evacuation of the vehicles coming from the campsite. The first case consists of running the SUMO simulation without background traffic. The second case includes a background traffic which consists of injecting 1 car per second during the total simulation time. The third case is more conservative in which more vehicles were introduced (1 vehicle per 0.7 second). According to Europe. Cataluña (Spain): Municipalities in Provinces-Population

Statistics, Charts and Map (2024), the number of vehicles introduced is selected by taking into account the total population in L'Escala region which is around 10 676.

from an evaluation performed on 01-01-2023. While this statistic may not include visitors and temporary tourists, the number of vehicles in the background traffic was conservative.

Table 15 summarizes the sensitivity analysis conducted for background traffic. Changes in the number of vehicles in the background traffic did not affect the time it took for the last tourists to drive and reach the safe zone (i.e. TAZ). This might be attributed to the short driving distance and the location of the safe zone. Congestion caused by background traffic has a greater impact within the city of L'Escala, rather than on the evacuation route.

Table 17: Sensitivity analysis of the background traffic on the traffic evacuation time.

Case	Background traffic	Number of cars in the background traffic	Time to reach TAZ for the last vehicle	
			(s)	(hh: mm: ss)
0	No	0	3388	56:27
1	Yes	3600	3424	57:03
2	Yes	5143	3401	56:40

As background traffic did not affect the travel time of vehicles to the safe zone (TAZ), the simulation of tourist traffic evacuation was conducted without considering background traffic. The table 16 displays the duration of the traffic evacuation process, starting from the fastest tourists to begin driving their vehicle and ending with the slowest tourists arriving at the safety zone. The average duration of the traffic evacuation process may take 2214 seconds (36 minutes).

Table 18: Average duration and standard deviation of the evacuation process for scenario 1.

Scenario	Average duration of the evacuation process		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
1 (Traffic day evacuation)	2214	36:54	125	02:04

The trip duration of each vehicle is presented in Figure 14 where more than 194 vehicles take only between 120 seconds (2 minutes) and 140 (2 minutes and 21 seconds) to reach the safe zone TAZ. However, the histogram also highlights outliers, notably the vehicle with the longest trip duration, which extends up to approximately 1009 seconds (16 minutes and 48 seconds). This considerable deviation from the typical trip duration is attributed to congestion within the campsite. The congestion likely slows down the progress of vehicles, leading to longer travel times for some.

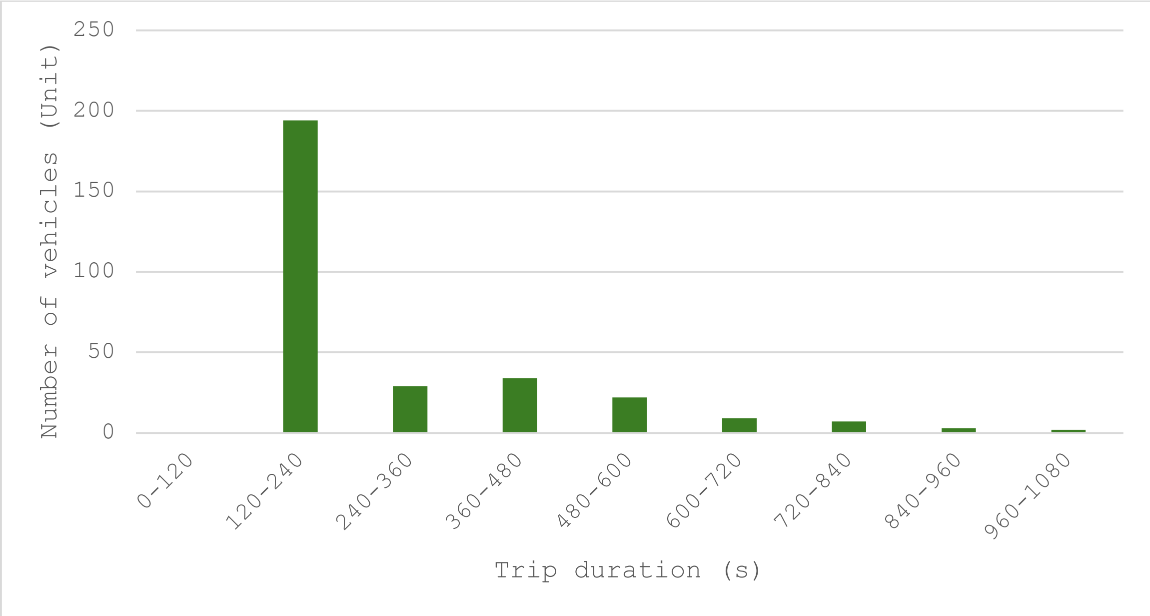

Figure 14: Trip duration.

Figure 15 describes the number of vehicles passing by the detector placed at the entrance of the safety zone. The first vehicle reaches the safety zone at around 1200 seconds (20 minutes) after the evacuation order was issued, while the last one at around 3388 seconds (56 minutes and 27 seconds).

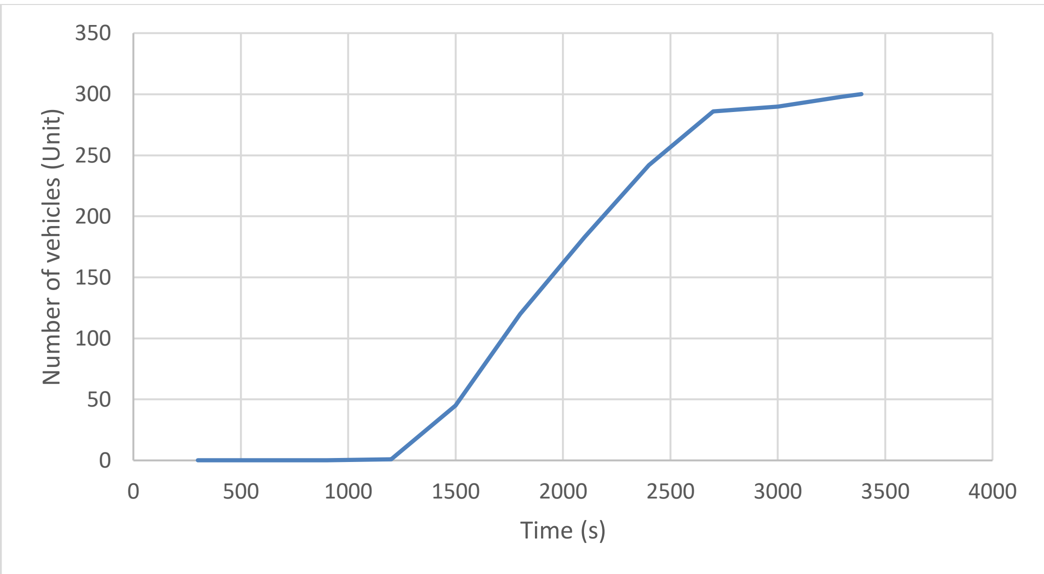

Figure 15: Number of vehicles passing by the loop detector.

7.1.3 Combination of the two models

The total evacuation time for Scenario 1 is the sum of the time when the last person arrived by foot (value from Pathfinder model) and the traffic evacuation time of the last person arriving by vehicle (value from Sumo model) which is in the case of the first run. The average total evacuation time for scenario 1 is 3234 seconds (53 minutes).

Table 19: Average total evacuation time and standard deviation for scenario 1.

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
1 (Traffic day evacuation)	3234	53: 54	124	02:03

The timeline interval for the overall evacuation process of tourists from the campsite is as follows:

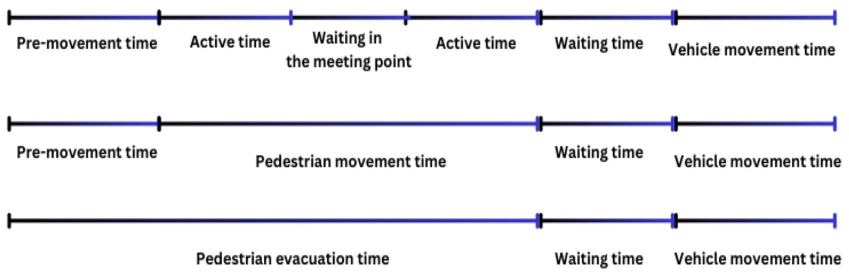

Figure 16: Traffic Evacuation-Timeline interval.

As simulation run number eight shows the highest evacuation time, it was used as a base case to outline the duration of each part of the evacuation time interval.

Figure 17 illustrates the total evacuation time for both the fastest tourist as well as the slowest one. After the evacuation order was issued, the fastest tourist arrived at the safe zone in 1191 seconds (19 minutes), while the slowest tourist took about 3388 seconds (56 minutes). As grouping is ignored in this scenario, the fastest tourist's profile is classified as an adult, while the slowest profile belongs to a child. The fastest tourist's profile is classified as an adult, while the slowest profile belongs to a child, as grouping is not considered in this scenario. Notably, the tourists who arrived at the safety zone first were not necessarily the ones who reached the accommodation first. They had to wait for other members to join them before departing in the vehicle. This delay allowed another group, who gathered quickly, to arrive first.

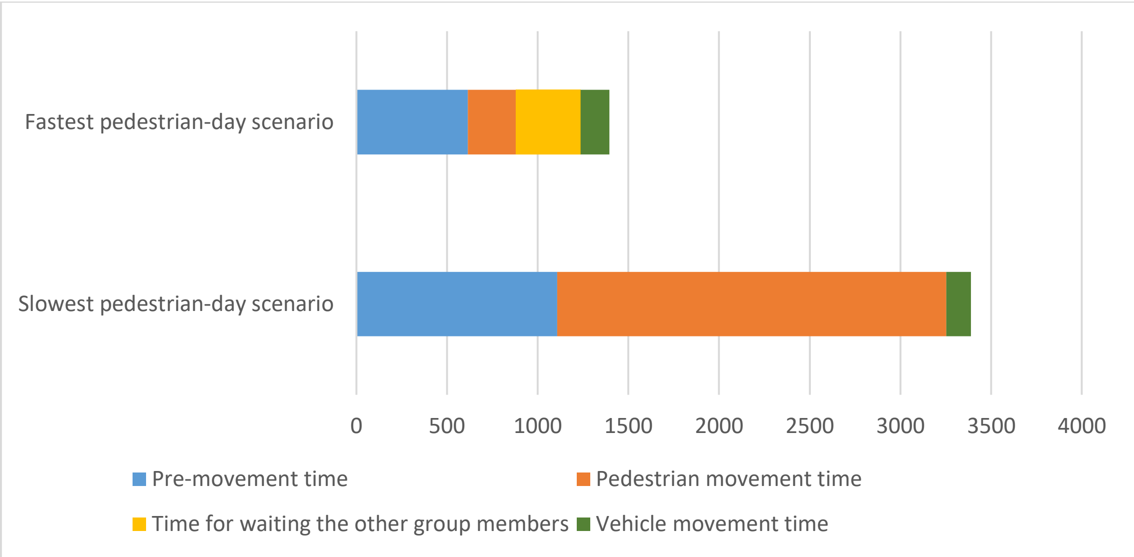

Figure 17: Slowest pedestrian vs fastest pedestrian comparison.

7.2 Results of Scenario 5 (traffic night evacuation)

- Average total pedestrian evacuation time 5115 seconds (1 hour and 25 minutes).
- The average duration of the traffic evacuation process may take 3413 seconds (56 minutes and 48 seconds).
- The average total evacuation time for scenario 5 is 5242 seconds (1 hour and 27 minutes).
- By using the simulation run number 9 as a base case, the fastest tourist to reach the accommodation arrived at the safe zone at time 1991 seconds (33 minutes) after the evacuation order was issued while the slowest tourist took about 5385 seconds (1 hour and 29 minutes) to arrive at the safety zone. The fastest tourist's profile is classified as elderly, whereas the slowest profile belongs to an adult.

7.3 Day vs night comparison

7.3.1 Traffic day evacuation vs traffic night evacuation

Table 18 and Table 19 illustrate the impact of the night-time on both the pedestrian evacuation time and the total evacuation time. The average total evacuation time for the scenario 1 (traffic day evacuation) is 3234 seconds (53 minutes) while for the scenario 5 (traffic night evacuation) 5242 seconds (1 hour and 27 minutes). Table 18 shows that the traffic night evacuation takes approximately 2,008 seconds (33 minutes and 40 seconds) longer compared to the traffic day evacuation. It can also be seen from Table 19 that the pedestrian evacuation time is nearly equal to the total evacuation time, suggesting that vehicle movement time does not have a significant impact on the total evacuation time.

The Mann-Whitney U Test was employed to statistically compare the total evacuation times between scenario 1 (traffic day evacuation) and scenario 5 (traffic night evacuation). This test is used when the data are not normally distributed (McKnight & Najab, 2010).

The results from the Mann-Whitney U Test indicate a significant difference in total evacuation time between scenario 1 (traffic day evacuation) and scenario 5 (traffic night evacuation). The U-Value is 0, which is less than the critical value (U, $p < 0.05$) of 23. Additionally, the Z-score is equal to -3.74185 and the p-value is equal to 0.00018. Thus, the test result is significant ($p < .05$).

Figure 18 clearly illustrates the significant difference in total evacuation time between the two scenarios.

Table 20: Average and standard deviation of the total evacuation time (Scenario 1 vs scenario 5).

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
1 (Traffic day evacuation)	3234	53: 54	124	02:03
5 (Traffic night evacuation)	5242	01:27:00	104	01:43

Table 21: Average and standard deviation of the pedestrian evacuation time (Scenario 1 vs scenario 5).

Scenario	Average pedestrian evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
1 (Traffic day evacuation)	3094	51:33	126	02:06
5 (Traffic night evacuation)	5115	01:25:12	101	01:40

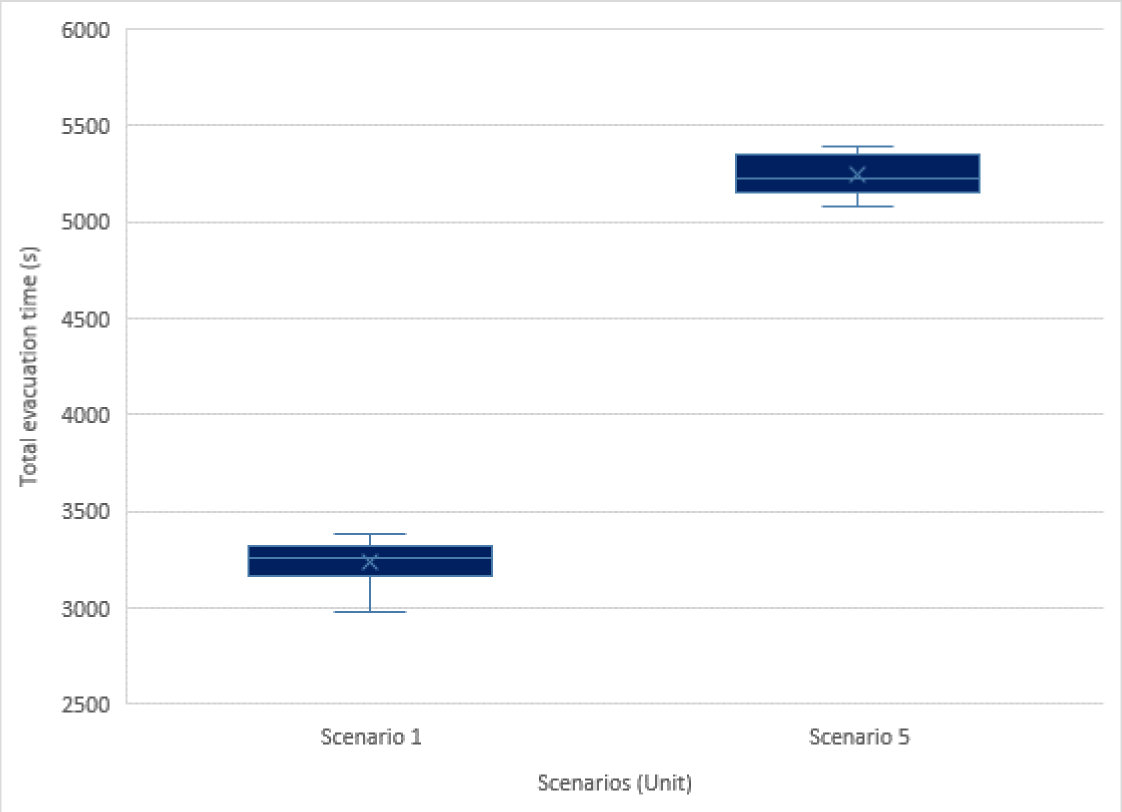

Figure 18: Statistical testing using Mann-Whitney U test (Scenario 1 vs scenario 5).

Figure 19 aims to compare the total evacuation time as well as its components between the fastest pedestrian who reach their accommodation and the slowest ones. The comparison also includes the night-time vs day-time. This will help to illustrate which part of the interval mentioned previously has a more pronounced impact on the total evacuation time of tourists in the campsite. The first two bars indicate that the pre-movement time is the primary contributing factor to the total evacuation time for the fastest pedestrians, regardless of whether it is daytime or night-time. However, the two last bars indicate that, when comparing daytime and night-time evacuations for the slowest pedestrians, the extended total evacuation time can be attributed to both the pre-movement time and the pedestrian movement time. Here, the pedestrian movement time covers the majority of the interval.

Figure 19 demonstrates that vehicle movement time has the least impact on the total evacuation time. Additionally, waiting time is only visible in the case of the fastest pedestrians, as the last person to join the accommodation does not need to wait for anyone before leaving with the vehicle.

Figure 19: Fastest pedestrian vs slowest pedestrian total evacuation time.

7.3.2 Day evacuation on foot vs night evacuation on foot

Table 20 shows the average total evacuation time for scenario 2 (Day evacuation on foot) and scenario 6 (Night evacuation on foot). The average total evacuation time for scenario 2 (Day evacuation on foot) is 3249 seconds (54 minutes), while for scenario 6 (Night evacuation on foot) is 5098 seconds (1 hour and 24 minutes). The time difference in total evacuation time between day-time and night-time evacuation on foot is approximately half an hour.

The results from the Mann-Whitney U Test indicate a significant difference in total evacuation time between scenario 2 (Day evacuation on foot) and scenario 6 (Night evacuation on foot). The U-value is 0, which is less than the critical value (U, $p < 0.05$) of 23. Additionally, the Z-score is equal to -3.74185 and the p-value is equal to 0.00018. Thus, the test result is significant ($p < .05$).

Figure 20 clearly illustrates the significant difference in the total evacuation time between the two scenarios.

The total evacuation time on foot does not account for the time it takes for the arranged bus to reach the safety zone, which may take around 4 minutes. Additionally, it does not include the time needed to board tourists onto the bus.

Figure 21 represents the number of evacuees leaving the campsite through the exit, termed 'unsafe evacuees' because this scenario only accounts for evacuation to the exit without considering the process of boarding the arranged bus. Evacuees are considered safe only when the bus reaches the safety zone.

Figure 21 illustrates the impact of night-time on the total evacuation time, with its main effect being a shift without altering the curve's shape. This shift is primarily due to the initially extended pre-movement time, the decrease in speed due to reduced visibility, and the prolonged waiting time at the meeting point.

Table 22: Average and standard deviation of the total evacuation time (Scenario 2 vs scenario 6).

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
2 (Day evacuation on foot)	3249	54:09	101	01:40
6 (Night evacuation on foot)	5098	01:24:36	106	01:45

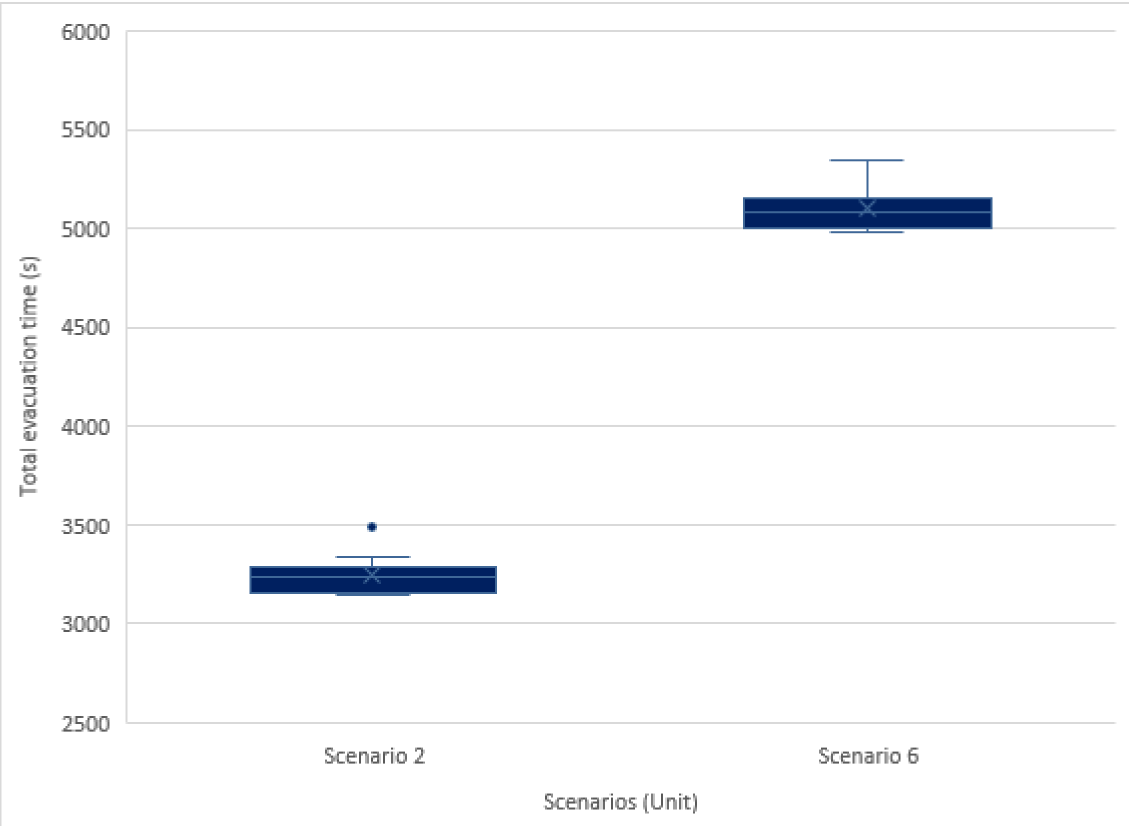

Figure 20: Statistical testing using Mann-Whitney U test (Scenario 2 vs scenario 6).

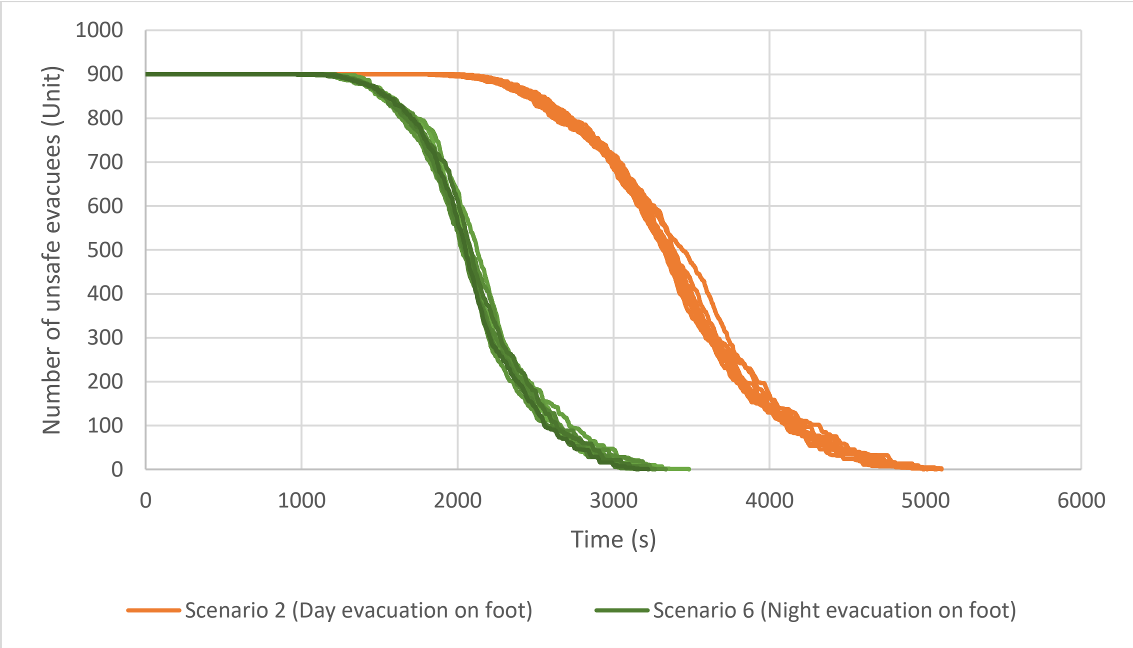

Figure 21: Evacuation time curve (Scenario 2 vs Scenario 6).

7.3.3 Day evacuation on foot with groups vs night evacuation on foot with groups

Table 21 presents the average total evacuation time for day and night evacuation on foot with groups.

For a day scenario, the average total evacuation time of tourists for 3 (Day evacuation on foot with groups) is 3528 seconds (58 minutes), while for scenario 7 (Night evacuation on foot with groups) is 5640 seconds (1 hour and 33 minutes).

The results from the Mann-Whitney U Test indicate a significant difference in total evacuation time between scenario 3 (Day evacuation on foot with groups) and scenario 7 (Night evacuation on foot with groups). The U-value is 0, which is less than the critical value (U, $p < 0.05$) of 23. Additionally, the Z-score is equal to -3.74185 and the p-value is equal to 0.00018. Thus, the test result is significant ($p < .05$).

Figure 22 highlights the difference in the total evacuation time between the two scenarios.

Figure 23 clearly demonstrates the difference in evacuation time curves, showing that scenario 7 (Night evacuation on foot with groups) is shifted compared to scenario 3 (Day evacuation on foot with groups).

Table 23: Average and standard deviation of the total evacuation time (Scenario 3 vs scenario 7).

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
3 (Day evacuation on foot with groups)	3528	58:48	93	01:33
7 (Night evacuation on foot with groups)	5640	01:33:36	97	01:36

Figure 22: Statistical testing using Mann-Whitney U test (Scenario 3 vs scenario 7).

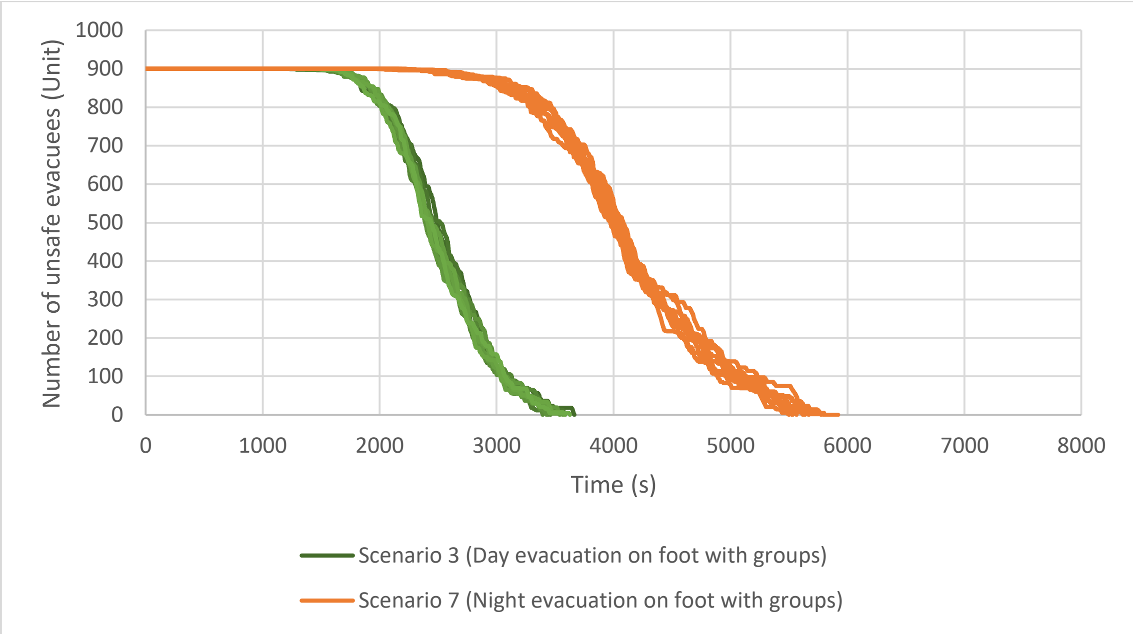

Figure 23: Evacuation time curve (Scenario 3 vs Scenario 7).

7.4 The impact of groups

This part aims to investigate the impact of adding a grouping feature to the model. In reality, tourists are more likely to walk in groups which may reduce the total evacuation time.

Table 22 presents the average total evacuation time for scenario 2 (Day evacuation on foot) and scenario 3 (Day evacuation on foot with groups). The average total evacuation time for the scenario scenario 2 (Day evacuation on foot) which did not consider the grouping feature is 3249 seconds (54 minutes) while for scenario 3 (Day evacuation on foot with groups) is 3528 seconds (58 minutes). The results show a 4-minute difference, which is not as significant as the difference found in the day and night comparison.

The results from the Mann-Whitney U Test indicate a significant difference in total evacuation time between the scenario 2 (Day evacuation on foot) and scenario 3 (Day evacuation on foot with groups). The U-value is 4, which is less than the critical value (U, $p < 0.05$) of 23. Additionally, the Z-score is equal to -3.43948 and the p-value is equal to 0.00058. Thus, the test result is significant ($p < .05$).

Figure 24 illustrates the difference in the total evacuation time between the two scenarios.

Compared to the previous tests where the U-Value was 0, the difference in the total evacuation time is slightly less pronounced in this case, as reflected by a higher U-Value of 4. Nonetheless, the test still indicates a significant difference between the scenarios.

Figure 25 clearly illustrates the effect of incorporating a group feature into the model. The curve is slightly shifted compared to the effect of night-time, where the curve is more pronounced. This slight shift occurs because group members have to wait for each other, and they also need to synchronize their walking speeds.

Table 24: Average and standard deviation of the total evacuation time (Scenario 2 vs scenario 3).

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
2 (Day evacuation on foot)	3249	54:09	101	01:40
3 (Day evacuation on foot with groups)	3528	58:48	93	01:33

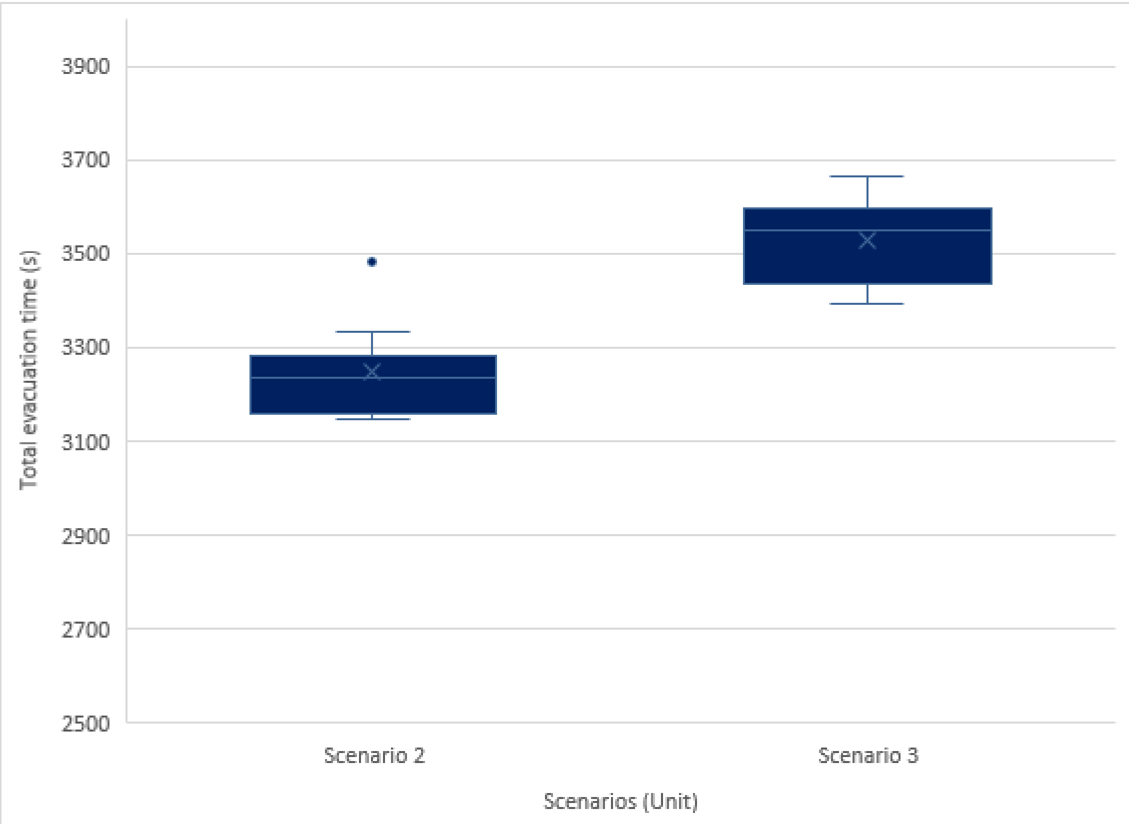

Figure 24: Statistical testing using Mann-Whitney U test (Scenario 2 vs scenario 3).

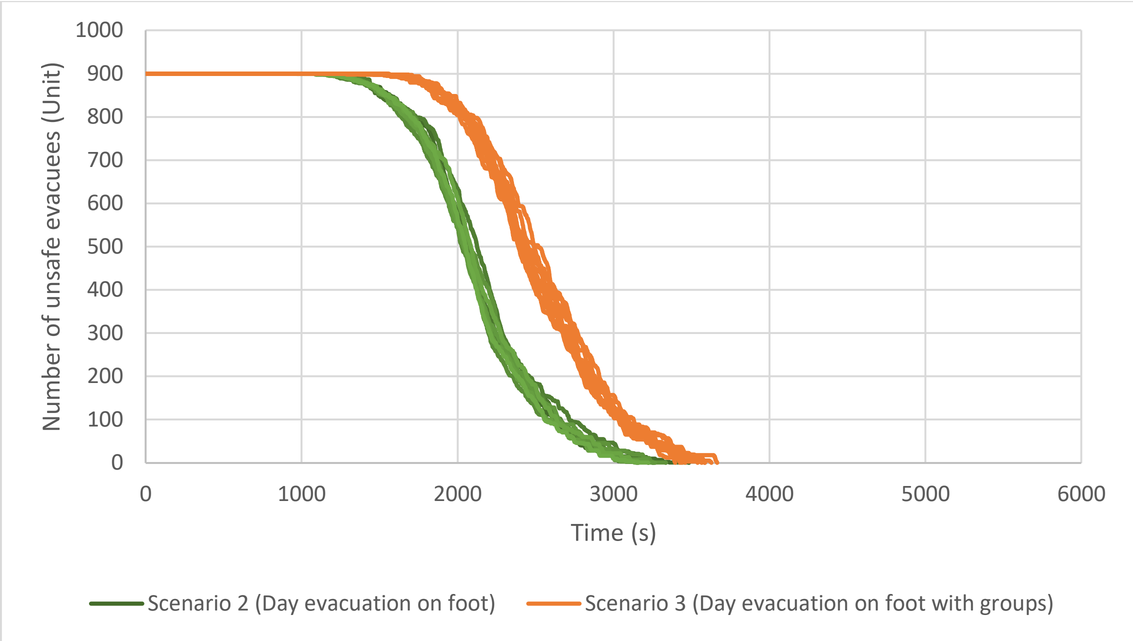

Figure 25: Evacuation time curve (Scenario 3 vs Scenario 2).

7.5 The impact of archetypes

As mentioned in Chapter 4, archetype profiles were introduced to the model to investigate how added details can influence the model results.

Table 23 demonstrates the average total evacuation time for scenario 2 (day evacuation on foot without archetypes) and for scenario 4 (day evacuation with archetypes). The average total evacuation time for scenario 2 (day evacuation on foot without archetypes) is approximately 3249 seconds (54 minutes), while for scenario 4 (day evacuation with archetypes) it increases to approximately 3894 seconds (1 hour and 4 minutes).

One observation is that the difference in total evacuation time between the two scenarios is about 10 minutes.

Figure 26 illustrates this difference in the total evacuation time between the two scenarios.

The results from the Mann-Whitney U Test indicate a significant difference in total evacuation time between scenario 2 (Day evacuation on foot) and scenario 4 (day evacuation with archetypes). The U-value is 0, which is less than the critical value (U, $p < 0.05$) of 23. Additionally, the Z-score is equal to -3.74185 and the p-value is equal to 0.00018. Thus, the test result is significant ($p < 0.05$).

The effects of this added complexity are observable in Figure 27, where the curve for the scenario with archetype profiles differs noticeably from the curve for the scenario without them. This difference arises from the increased heterogeneity in tourists' profiles introduced by the archetype-based model.

From Figure 27 it can be seen that in the archetype-based model, tourists start their evacuation at slightly different times due to variations in mean pre-movement times. The curve of scenario 2 (day evacuation on foot without archetypes) reflects a more uniform evacuation process, while for scenario 4 (day evacuation with archetypes), the curve changes notably throughout the evacuation process. It begins with a gradual descent, followed by a steeper decline, and accelerates as the process progresses.

It should be noted that these outcomes are based on the initial input assumptions and may vary depending on the initial model configurations.

Table 25: Average and standard deviation of the total evacuation time (Scenario 2 vs scenario 4).

Scenario	Average total evacuation time		Standard deviation	
	(s)	(hh: mm: ss)	(s)	(hh: mm: ss)
2 (Day evacuation on foot)	3249	54:09	101	01:40
4 (Day evacuation on foot with archetypes)	3894	01:04:48	126	02:06

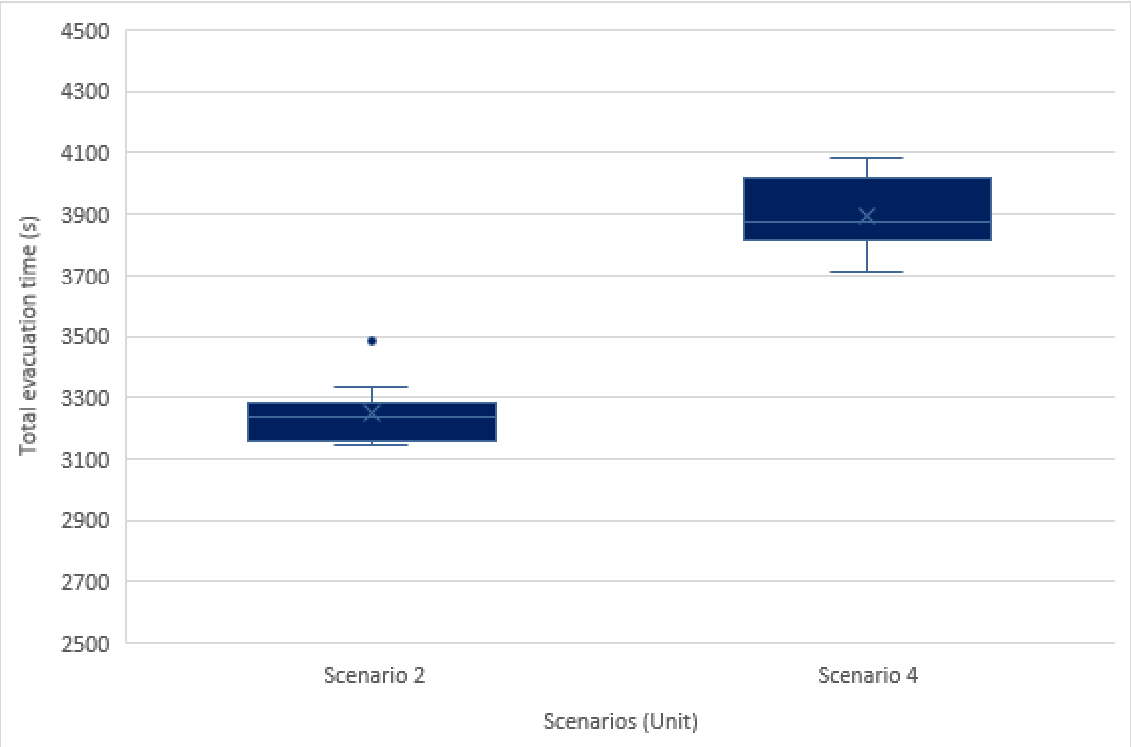

Figure 26: Statistical testing using Mann-Whitney U test (Scenario 2 vs scenario 4).

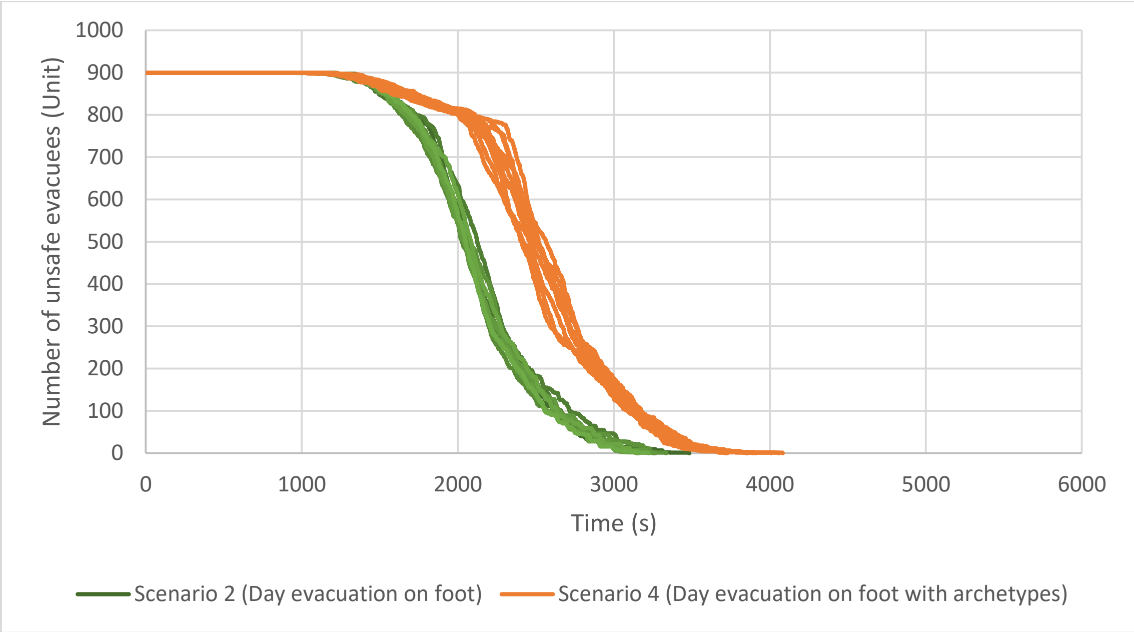

Figure 27: Evacuation time curve (Scenario 2 vs Scenario 4).

7.6 Results summary

Table 24 summarizes the total evacuation time for all the scenarios. The total evacuation time for all scenarios is long due to different factors such as the pre-movement time, the number of tourists, and the travel distance inside the campsite. However, the vehicle movement time did not show a significant impact on the total evacuation time. Scenario 7 (night evacuation on foot with groups) shows the longest evacuation time (5640 seconds) due to the extended pre-movement time at night and the grouping feature.

Table 26: Summary of the total evacuation time for all scenarios.

Scenario	Average total evacuation time	
	(s)	(hh: mm: ss)
Scenario 1 (traffic day evacuation)	3234 seconds	53:54
Scenario 2 (day evacuation on foot)	3249 seconds	54:09
Scenario 3 (day evacuation on foot with groups)	3528 seconds	58:48
Scenario 4 (day evacuation on foot with archetypes)	3894 seconds	01:04:48
Scenario 5 (traffic night evacuation)	5242 seconds	01:27:00
Scenario 6 (night evacuation on foot)	5098 seconds	01:24:36
Scenario 7 (night evacuation on foot with groups)	5640 seconds	01:33:36

8 Discussion

8.1 Review of the results

This section summarizes the key findings from the literature review and the case study modelling. It provides a basic analysis of wildfire evacuation in tourist areas, covering both the theoretical side (key variables influencing tourists' decision-making during evacuation) and the practical side (modelling analyses of camping sites). Both of these perspectives aim to establish a foundation and pave the way for future studies in this area.

8.1.1 Literature review

The first part of this work explored tourists as a unique individual profile. It uncovered the key elements that make tourists show different behaviour compared to residents in case of wildfire evacuation. For instance, safety culture, place of residence, length of stay, and transportation mode were some of those key elements that can be different from one tourist to another, therefore, it may lead to a various degree of evacuation likelihood among tourists. The risk perception variable is a very important factor as it was as it has been shown to act as a mediator variable. Therefore, increasing the risk perception of tourists upon arrival by informing them about the potential risk of wildfires may be helpful.

It is possible that in the case of tourists, place of residence can also act as a mediator variable. This may be due to the fact that the place of residence of tourists can be related to their preparedness and experience (Vaiciulyte et al., 2022), the way they perceive the credibility of information sources (Aliperti & Cruz, 2019), safety culture, transportation mode, and income. However, this aspect has not yet been extensively explored even though it is a key factor element in the decision-making process of tourists in wildfire evacuation. In the same context, future studies should explore also how the cultural differences between tourists influence the group dynamics during the evacuation process. In the simulation part, the group dynamics were explored but without considering the cultural differences impact on it.

Furthermore, language has been shown to have an impact on the access to evacuation information for tourists (Arce et al., 2017), and previous case studies exploring wildfire evacuation have mentioned the language barrier as a key factor (Ronchi et al., 2021). Nevertheless, studies in this area are limited and not widely discussed, especially regarding the behavior of tourists whose first language is not English. Thus, to ensure that all tourists receive the evacuation order, it would be helpful to have information about the languages spoken by tourists upon their arrival at the destination.

Moreover, the impact of tourists’ functional limitations on the evacuation process is not explored yet as well. The functional limitation can be related to limited mobility, hearing, vision or cognitive abilities. For instance, individuals with mobility impairments may face challenges in navigating routes or accessing vehicles, while those with hearing or vision impairments may struggle to perceive visual evacuation cues and receive evacuation instructions. Additionally, tourists with cognitive limitations may find it difficult to understand and follow evacuation instructions or make decisions. Addressing the needs of tourists with functional limitations during evacuation is very important to ensure an efficient evacuation process for all tourists.

Drawing parallelism with hurricanes, the length of stay of tourists has been shown to influence their evacuation likelihood (Matyas et al., 2011) as well as their evacuation route (Limanond et al., 2011). However, this aspect has not yet been widely addressed, especially in the context of wildfire evacuation. In this context, the route choice of tourists while driving may be different from that of residents due to factors such as unfamiliarity with local roads and reliance on GPS navigation systems. Therefore, during tourist evacuations, tourists may exhibit different driving behaviours compared to residents, which can impact the evacuation process, particularly if it is conducted on a large scale.

8.1.2 Impacts of each component of the timeline interval on the total evacuation time

The modelling work aimed to explore the impact of each component of the timeline interval on the total evacuation time. The components are the pre-movement time, pedestrian movement time, waiting time, and vehicle movement time.

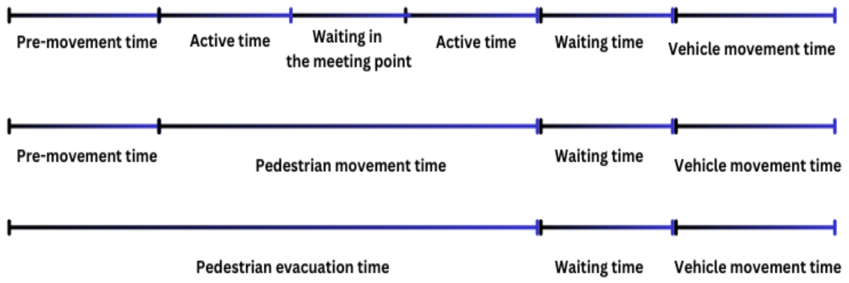

Figure 28: Traffic Evacuation timeline interval.

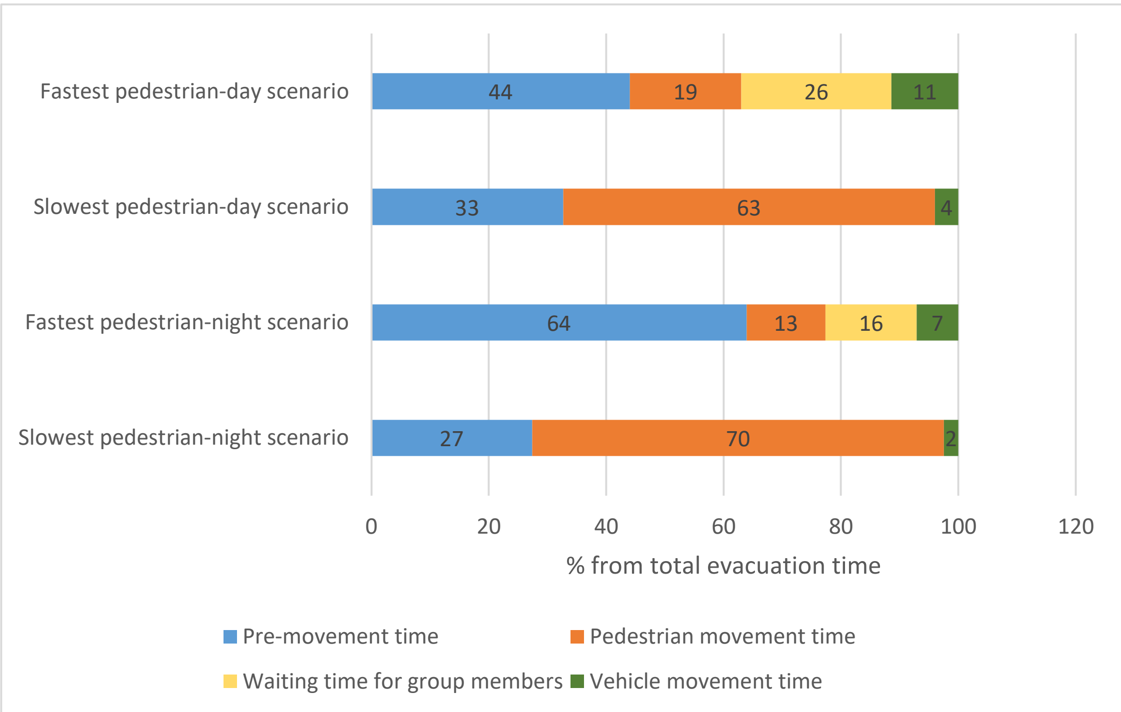

Figure 29: Percentage of each timeline interval component.

Figure 28 shows the vehicle movement time as a component of the timeline interval. It is evident from Figure 29 that this component occupies a smaller percentage of the total evacuation time in the Punta Milà case study. In this case study, vehicle movement time did not significantly impact the total evacuation time, as most vehicles took approximately 3 minutes to reach the safety zone. This is attributed to the campsite's proximity to the safe zone and the fact that the background traffic did not have an impact on the evacuation process of vehicles from the campsite. This is in contrast with other wildfire events, for which vehicle movement time is very important in the case of wildfire evacuation, often serving as the primary contributor to the time required to reach safety zones, given the considerable distances that need to be covered (Ronchi et al., 2017). For instance, a study examining traffic dynamics during the 2019 Kincade wildfire evacuation reported a 5% reduction in road capacity during the event due to changes in driving behaviour (Rohaert, Kuligowski, et al., 2023). The study suggested that one reason for this change in driving behaviour could be drivers opting for unfamiliar routes (Rohaert, Kuligowski, et al., 2023). Therefore, this situation may also apply to tourists as they are typically unfamiliar with the area. This unfamiliarity with roads can result in different driving behaviours compared to residents, leading to reduced speeds and flow, ultimately resulting in longer evacuation times. Thus, it would be helpful to account for parameters in the traffic model that capture differences in driving styles influenced by tourists' home countries, as well as changes in driving behavior while using unfamiliar roads. The congestion inside the campsite is also a driving factor for the vehicle movement time as this will contribute to the speed reduction inside the camp caused by pedestrians walking around. Therefore the evacuation time is extended.

In this context, the absence of incorporation of interaction between pedestrians and vehicles in the model represents a limitation of this study. However, it also highlights a broader limitation within the field, as there is currently no model that provides a fully coupled pedestrian/traffic interaction. Although there is the WUI-NITY modeling platform (Wahlqvist et al., 2021), this platform has limited capacity to model this integration at a microscopic pedestrian level.

Besides the vehicle movement time, the evacuation time interval includes other components. The first component of the timeline interval is the pre-movement time, which significantly delays the evacuation process. Figure 29 shows that the pre-movement time is one of the predominant components for the case of the. This finding provides insights into what can influence the evacuation dynamics of tourists slowest pedestrians. Therefore, it is of key importance to act to reduce pre-movement time by using human behavior theories to trigger the movement of tourists. This can be achieved by implementing strategies based on key variables defined in the literature review, such as increasing risk perception, disseminating information in multiple languages, providing detailed information about potential wildfire events in the area upon arrival, and issuing the evacuation order from an official source.

The second component of the timeline interval is the pedestrian movement time. Figure 29 demonstrates that this component is a major contributor to the total evacuation time in the case of the slowest pedestrian. This could be attributed to the sub-elements within this component. Those sub-elements are the activities individuals undertake before returning to their accommodation, in this case study, the sub-elements of the pedestrian movement time are active time and waiting time at the meeting point.

One possible factor that can increase the active time is the initial location of the tourist which may lead to a longer travel distance if the meeting point is located far from the initial location. Therefore, the location of the meeting point is very important and should be established in various places away from the exit door. Congestion, particularly at gathering points, is another contributing factor that can prolong active time as it causes tourists to navigate through dense crowds, slowing their pace. Additionally, demographic factors like age can influence active time, with age groups such as children and the elderly having less movement speed compared to adults. The campsite layout and design of the environment, including its topography, can also extend active time, as varying elevations and terrain can reduce the walking speed. Besides that, route choice can have an influence on the active time especially if it is the first day of the tourist in the campsite and the tourist is till unfamiliar with the campsite layout and route.

Waiting time at the meeting point can be extended if the process of delivering the instructions is not well managed. In the case of tourists, this sub-element may be influenced by several factors. The language and clarity of instruction delivery can present a key element for making the waiting time less. Moreover, the location, as well as the number of meeting points, are important as they influence travel distance and congestion.

It is noteworthy that these sub-elements may vary in different case studies. Nevertheless, active time persists across all case studies.

The third component of the timeline interval involves waiting for other group members to join at the accommodation, and then boarding the vehicle to leave to the the safe zone. It could potentially delay the evacuation process for tourists, as they may need to wait for other group members before departure.

In the case of scenario 2 (Day evacuation on foot), tourists take more time to reach the campsite exit on foot (54:09) compared to scenario 1 (Traffic day evacuation) where tourists use their vehicles to reach the safety zone (53:54). This can be attributed to several factors reflected in the modelling assumptions adopted, including variation in walking speeds among tourists, the distance they must walk, and the fact that using vehicles for evacuation enables faster movement. Additionally, the proximity of the safe zone to the campsite contributes to reduced driving time. Nevertheless, it is important to note that drivers would likely need to be more cautious at night and reduce their driving speed, a factor that is not fully accounted for in the model.

8.1.3 Impact of different factors on the total evacuation time

Different factors were introduced to the model to assess their impact on the total evacuation time. The results indicate that the evacuation process is prolonged during night-time for all scenarios mainly due to the longer pre-movement time as well as the reduced walking speed. Therfore, it is very important to account for the visibility of the roads in the campsite at night-time, install clear signage and keep the roads clear of any obstacles that may reduce the walking speed. The impact of grouping on the evacuation process has also resulted in an extended evacuation time. In scenarios involving groups, individuals tend to move together, requiring group members to wait for each other and adjust their speed to match the group's pace.

From scenario 4 (Day evacuation time with archetypes), the added complexity of defining profiles as archetypes resulted in an increase in total evacuation time (10 minutes) compared to scenario 2 (Day evacuation on foot) where the standard population was used. This occurred even though the only changes were in the number of profiles included in the model and the pre-movement time for the archetypes, which varied only by a few seconds in the value of the location (μ). One possible explanation can be related to the log-normal distribution input parameter and the way the archetypes have been implemented. In other words, the key aspect to consider here is how small changes in the scale parameter of a log-normal distribution can have an impact when converted to a mean value for the pre-movement time. This means that the small changes in the value of the location parameter that was used as input to the model can have more effect when those changes are applied to the mean value instead. Moreover, in scenario 4 (Day evacuation on foot with archetypes), the definition of the profiles was more detailed as we replaced the profile of adults with 7 archetype profiles. This added complexity to the profiles may have had a cumulative effect on the values of pre-movement time, especially when multiplied by the number of evacuees.

Nevertheless, the standard population model (Scenario 2), which uses the same pre-movement time distribution for all occupants, results in a more predictable and smoother curve. In contrast, in the archetype-based model, the heterogeneity in occupants' mean pre-movement times leads to a distinctly different curve shape. It is worth noting that, those results are based on the current assumptions, therefore, while the models provide valuable insights, they should be interpreted within the context of their limitations and assumptions.

8.1.4 Analysis of the Evacuation Strategies

In this case study, the model suggests two strategies for the evacuation process. The first strategy is the arranged evacuation process using private vehicles. The second evacuation process strategy is the evacuation on foot of tourists to the campsite exit followed by arranging a bus to transport them further. In Chapter 2, the transportation mode was identified as a key variable in the decision-making process of tourists in case of wildfire evacuation. Therefore, it is important to see how this can be linked to the evacuation strategy.

On one hand, the evacuation planning for such a large number of tourists from the campsite using authority-arranged buses presents several challenges. One significant issue is logistical, especially considering the need for six buses to evacuate the 900 tourists safely. Additionally, the narrow road outside the campsite, allowing movement for only one vehicle, may obstruct access for emergency authorities to the Parc del Montgrí in the wildfire event. Furthermore, compared to individual vehicles, buses may take longer to load, depart, and arrive, leading to delays in the evacuation timeline. Another challenge is managing the tourists' luggage inside the buses, which can further complicate the evacuation process. Waiting for all tourists to board the buses before departure can also prolong the evacuation time. In other words, evacuating tourists via buses does not guarantee their safety until they reach a safe location. As defined in Chapter 2, two of the key variables influencing tourists' evacuation behaviour, are property attachment, which may have a significant negative relationship with evacuation (S.-K. Huang et al., 2016), and transportation mode. Therefore, an evacuation strategy using buses may affect tourists' decision-making regarding evacuation, as they may have a property attachment to their vehicles.

On the other hand, other challenges can also be associated with evacuation using private vehicles. One key challenge is the availability of private vehicles at the campsite to evacuate all tourists. Furthermore, research studies have explored the willingness to share resources during the evacuation (Wong et al., 2023), which may be necessary if not all tourists have access to private vehicles. Nevertheless, in their paper, Wong et al., 2023 did not specifically explore the willingness of tourists to share resources. However, they demonstrated that trust in strangers and neighbors significantly increases the willingness to share transportation among residents. From an overall perspective, future studies could investigate the key factors influencing tourists' willingness to share resources, such as transportation, and examine whether the place of residence plays a role. Therefore, it would be possible to identify the elements that can trigger the sharing of private vehicles and use them to facilitate the evacuation process. Furthermore, travel distance in case of wildfire evacuation of tourists can present a key challenge as tourists may be unfamiliar with routes which can lead to a different driving behaviour and an extended evacuation time.

8.2 Answer to the Research Question

In this part, an answer to the research question is provided based on the findings from both the literature review and the modelling of the case study.

In Chapter 1, a research question was introduced:

"**What are the main variables influencing the evacuation decision-making of tourists during a wildfire evacuation in a Wildland-Urban Interface (WUI), and to what extent can the available simulation tools be used to investigate the evacuation of tourists?**"

The answer to the research question includes a description of the variables influencing the decision-making of tourists in wildfire evacuation, as well as the limitations of the current simulation tools in modelling the evacuation of tourists.

1- Different key variables affecting the evacuation decision-making of tourists during wildfire evacuation were identified. These include:

- Property attachment.
- Past-experience and preparedness.
- Safety culture.
- Risk perception.
- Socio-demographics.
- Interaction with authorities.
- Place of residence and length of stay.
- Transportation mode.

- Information.
- Group dynamics variable.

2- The available simulation tools are useful to some extent in modelling the evacuation of tourists during wildfires:
   - The validity of those simulation tools in case of tourist evacuation primarily relies on the input data and data from real scenarios, which are not yet available for tourists and campsites.
   - Unlike the pedestrian simulation tool, the traffic simulation tool lacks explicit inputs related to evacuation behaviour. This limitation may affect the driving behaviour responses of tourists in case of a wildfire evacuation such as route choice.
   - The two simulation tools used to model the evacuation of tourists are currently not integrated. The output generated by the pedestrian simulation model needed to be converted into a format suitable for input into the traffic simulation model. This conversion was necessary due to the different formats and requirements of each simulation tool. Therefore, it was necessary to use a Python code to solve this.
   - The pedestrian/traffic simulation tools do not explicitly account for interactions between tourists and vehicles within the campsite. This could occur when the vehicles are evacuating outside the campsite while pedestrians are moving inside the campsite.
   - The outputs from the pedestrian simulation tool were used as inputs for the traffic simulation tool, which may introduce additional uncertainties in the final results.
   - The transition between the pedestrian model and traffic model during the simulation, specifically the time tourists spend waiting at their accommodation for others to join them before leaving by car, is not very clear in the model.

9 Conclusion

This work aims to investigate a topic that is not widely investigated in the evacuation sector. This work defined the key variables influencing the decision-making of tourists which can be used for human vulnerabilities assessment of tourists' populations by the community stakeholders. It can be also considered as a starting point for defining the characteristics of tourists' archetypes that integrate the likely impact of the key variables with the existing archetypes defined by Strahan et al. (2018). Besides this, this work uncovered several research gaps in this sector and concludes that the field of wildfire evacuation in touristic areas requires further research, both in theoretical aspects and in modelling aspects.

Simulation models were used to assess the capability of current simulation tools in modelling the wildfire evacuation of tourists at campsites. This included evaluating various evacuation strategies and optimizing total evacuation time. This was achieved by comparing a set of scenarios and examining the impact of different factors on the total evacuation time.

A timeline interval was established in this case study to explore which part of the interval contributes most significantly to the overall total evacuation time. Thus, it will be possible to identify the key elements to focus on to efficiently trigger the evacuation process.

In this case study, both pre-movement time and pedestrian movement time emerged as significant contributors to the total evacuation duration. Addressing the pre-movement phase requires actions that stimulate tourists' decision-making processes, particularly by improving their risk perception and awareness, especially if they originate from regions where wildfire occurrences are rare. Meanwhile, to reduce pedestrian movement time, enhancements to signage, route visibility, travel distance, number of meeting points, instructional delivery methods, and other factors associated with the campsite layout could be helpful.

Based on the findings from the literature review as well as the simulation model, possible recommendations can be given.

1- One general set of recommendations about tourists in wildfire evacuation:

- Establish assembly points at various locations around the campsite to minimize travel distances and reduce congestion.
- Relocate meeting points away from areas near the exit, to limit the obstruction of the vehicle traffic.
- Consider various factors in choosing an evacuation strategy, such as the number of tourists, their willingness to leave their cars or to share transportation, and the travel distance to the safety zone.
- Provide assistance for tourists with functional limitations to ensure their safe evacuation.
- Inform tourists about the potential risk of wildfires to increase their risk perception.

- Ensure that tourists receive evacuation orders from an official source as it was found in the literature review that tourists generally expect to receive evacuation order from an official source.

- Encourage tourists to fill in a document upon arrival that includes their contact information and spoken languages so that evacuation orders can be issued in multiple languages.

- Increase the visibility of roads within the campsites at night to facilitate navigation in case of emergency.

- Install clear signage throughout the campsite to guide tourists effectively,

- Ensure that roads within the campsites are kept clear of any obstacles to avoid a reduction in the walking speed.

2- One specific set of recommendations on how future evacuation models should be improved to better represent the tourist's evacuation in wildfire event:

  - Future evacuation models should explicitly incorporate the interaction between tourists moving on foot and vehicle movement to yield more realistic results. Existing tools exist that do this at the macroscopic level such as WUI-NITY platform (Wahlqvist et al., 2021), but limited capabilities exist for modelling this integration at microscopic level of pedestrian modelling.

  - Integration of pedestrian modelling and traffic modelling into a single, cohesive model can help reduce uncertainties in evacuation predictions.

  - Human behaviour inputs specific to tourists should be accounted for in the traffic modelling component of future models. This could involve integrating parameters that capture differences in driving styles influenced by tourists' home countries, such as safety distance and driver-yielding behaviour. Another example is the identification of unfamiliar routes on the map and considers changes in driving behaviour when vehicles traverse them. This approach would reflect the findings of studies examining traffic dynamics during events like the 2019 Kincade wildfire evacuation (Rohaert, Kuligowski, et al., 2023).

  - The time tourists spend waiting at their accommodation for others to join them can be represented more explicitly in the models. This remains a "shadow" aspect, not readily observable like the other components of the timeline interval. Consequently, assessing its reliability and understanding how this part of the process functions becomes challenging.

The insights derived from this study contribute not only to reducing the knowledge gap regarding wildfire evacuation in touristic areas but also offer practical recommendations that can be implemented by emergency planners to ensure safer and more efficient evacuations. Additionally, this work aims to highlight the limitations related to the current simulation tools in modelling tourist evacuation in a wildfire evacuation which may guide future research in this area.

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‘*Les batailles de la vie ne sont pas gagnées par les plus forts, ni par les plus rapides, mais par ceux qui n'abandonnent jamais*.’ Roi Hassan II

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Appendices

Appendix A. Search strings of the scoping review

Scopus

Date: 20/06/2023 wildfire OR bushfire OR forest fire OR campfire OR brush fire AND tourist* AND evacuation AND PUBYEAR > 1997 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE,"English"))

Date: 21/06/2023 wildfire OR bushfire OR forest AND fire OR camp AND fire OR brush AND fire OR outdoor AND fire AND tourist* OR transiant AND evacuation AND behavior OR behaviour AND decision-making AND PUBYEAR > 1997 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English"))

Date: 23/06/2023 wildfire OR bushfire OR forest AND fire OR campfire OR brush AND fire AND transien t AND evacuation AND PUBYEAR > 1997 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English"))

Web of Science

Date: 28/06/2023 (((((((((ALL=(Wildfire)) OR ALL=(forest fire)) OR ALL=(camp fire)) OR ALL=(bush fire)) AND ALL=(tourist)) OR ALL=(tourists)) OR ALL=(touristic)) OR ALL=(short term resident*)) AND ALL=(evacuation)) AND ALL=(behavior)

Date: 29/06/2023 ((((((((ALL=(Wildfire)) OR ALL=(bush fire)) OR ALL=(forest fire)) OR ALL=(camp fire)) AND ALL=(short-term resident)) OR ALL=(tourists)) OR ALL=(touristic)) AND ALL=(response)) AND ALL=(evacuation)

Appendix B. PRISMA scoping review flow chart

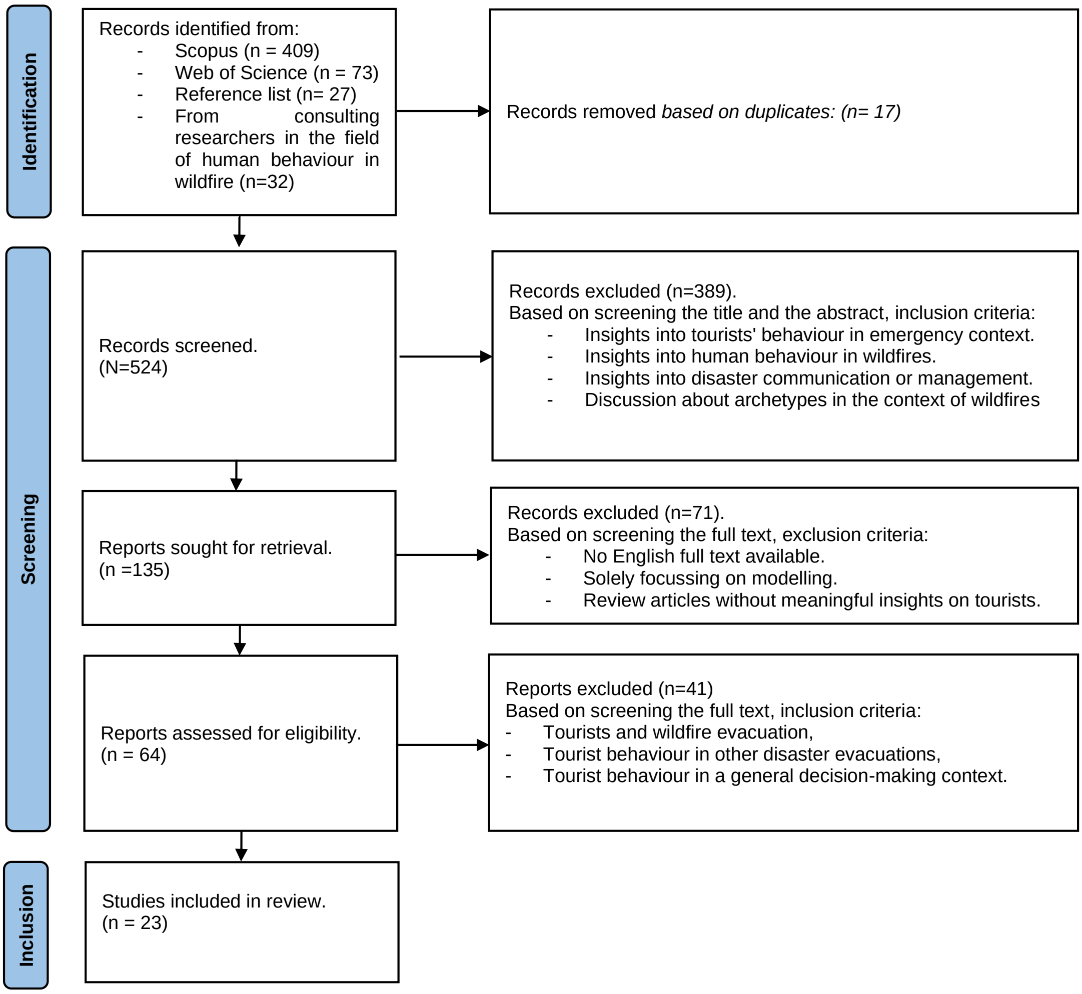

Figure 30: The process followed in PRISMA framework process

Appendix C. Review template adopted to extract information related to tourist evacuation behaviour from the selected papers.

1- Author(s)
2- Year
3- Title
4- Short description
5- Type of paper
6- Method of data collection
7- Method of data analysis
8- IF Data paper, type of data
9- IF Data paper, is data available openly / upon request?
10- IF Data paper, sample size
11- Country(ies) of study and/or region
12- Is the area of study prone to wildfires?
13- Does the peak wildfire season coincide with the peak tourism season?
14- Is the area investing in wildfire resilience*?
15- Is the study area explicitly mentioned as prone to tourism in general? High / low levels? Domestic/ international tourism?
16- Any specific mention of tourists in the paper?
17- Any information about the characteristics / demographics of the population involved (e.g., age, language, experience with wildfires, income, household types/size education, safety culture, etc.)
18- Does the study differentiate among recurrent vs seasonal** vs first-time tourists?
19- If tourists are mentioned, summarize content (including inferring type of tourists)
20- Reference to a behavioural theory(ies)?
21- Main findings of study of interest to define archetypes, such as behaviours reported, issues associated with evacuation or shelter/defend-in-place behaviour, or physical state of populations; in other words, what qualitative observations were used in the study that can help us think about the archetypes?
22- List of variables which can be identified through this study
23- Possible archetype categorizations identifiable through this study; if the study has identified archetypes, what are they?
24- Study limitations (summary) / perceived study limitations
25- Paper(s) in the reference list to be screened

Table 27: Review template adopted to extract information related to tourist evacuation behaviour from the selected papers.

Appendix D. Python code used for SUMO input

```
# -*- coding: utf-8 -*-
"""
Arthur Rohaert
2024-03-25
Update 2024-04-08
Generate Trips

A simple script that reads the excel file and generates SUMO trips
"""

#%% import the necesariy packages and load excel
import numpy as np
import pandas as pd
import random

# %% Waiting time distribution (normal, clamped), all in seconds
wait_min = 0  # Minimum value
wait_max = 0  # Maximum value
wait_mean = 0  # Mean of the normal distribution
wait_dev = 0  # Standard deviation of the normal distribution


# %% create a table of origins and destinations for all pedestrians

route = pd.read_csv("Scenario 1_occupant_params.csv",
usecols=["behavior"]).rename(columns={"behavior": "Behaviour"})
origin_per_behaviour = pd.read_csv("From-To.csv", index_col=0)["From"].to_dict()
destination_per_behaviour = pd.read_csv("From-To.csv", index_col=0)["ToTaz"].to_dict()
number_of_cars_per_behaviour = pd.read_csv("From-To.csv", index_col=0)["Number of cars"].to_dict()
number_of_vans_per_behaviour = pd.read_csv("From-To.csv", index_col=0)["Number of
vans"].to_dict()
start_time = pd.read_csv("Scenario 1_occupants.csv")["last_goal_started time(s)"]

route["Origin"] = np.nan
route["Destination"] = np.nan
route["Start"] = np.nan
for index in range(len(route)):
    route.loc[index, "Origin"] = origin_per_behaviour[route["Behaviour"].iloc[0]]
    route.loc[index, "Destination"] = destination_per_behaviour[route["Behaviour"].iloc[0]]
    waiting_time = max(wait_min, min(np.random.normal(wait_mean, wait_dev), wait_max))
    route.loc[index, "Start"] = start_time.iloc[index] + waiting_time

# %% create a table of pedestrians finished per behavior

#text = ""
#veh_ind = 0

tables_per_behaviour = []

behaviours = list(origin_per_behaviour.keys())
for behaviour in behaviours:
    # figure out when to start a car
    start_per_behaviour = list(route[route['Behaviour'] == behaviour]["Start"])
    start_per_behaviour.sort()
```

```
    total_vehicles = number_of_cars_per_behaviour[behaviour] +
number_of_vans_per_behaviour[behaviour]
    pedestrians_per_car = len(start_per_behaviour)/total_vehicles
    vehicles_left = np.floor((1+np.arange(len(start_per_behaviour)))/pedestrians_per_car)
    vehicles_left[-1] = total_vehicles
    full_vehicles = np.diff(vehicles_left, prepend=0)
    vehicle_starts = np.array(start_per_behaviour)[full_vehicles==1]

    # figure out which type
    types =
["veh_passenger"]*number_of_cars_per_behaviour[behaviour]+["veh_van"]*number_of_vans_per_beha
viour[behaviour]
    random.shuffle(types)

    # save data in a table
    table = {"Start": vehicle_starts, "Type": types}
    table = pd.DataFrame(table)
    table["origin"] = origin_per_behaviour[behaviour]
    table["destination"] = destination_per_behaviour[behaviour]
    tables_per_behaviour.append(table)

final_table = pd.concat(tables_per_behaviour, ignore_index=True)

# Sort the DataFrame by the "Start" column
final_table = final_table.sort_values(by="Start")

#%% Save the sorted DataFrame as an Excel datasheet
final_table.to_excel("start_vehicles.xlsx", index=False)

#%% Loop through all vehicles and save text
text = ""
veh_id = 0
for index, row in final_table.iterrows():
    print(f'    <trip id="veh{veh_id}" depart="{row["Start"]:.2f}" departLane="best"
from="{row["origin"]}" toTaz="{row["destination"]}" type="{row["Type"]}"/>')
    newline = f'    <trip id="veh{veh_id}" depart="{row["Start"]:.2f}" departLane="best"
from="{row["origin"]}" toTaz="{row["destination"]}" type="{row["Type"]}"/>\n'
    text += newline
    veh_id += 1

# Path to the text file
file_path = "trips.txt"

# Open the file in write mode and write the string to it
with open(file_path, 'w') as file:
    file.write(text)

print("String saved to", file_path)
```

Appendix E. SUMO input script for traffic demand - Scenario 1

```xml
<?xml version="1.0" encoding="UTF-8"?>

<!-- generated on 2024-02-26 09:48:37.826000 by osmWebWizard.py v1_19_0+0000-baa66a0f364
<configuration>
    <allow-fringe.min-length value="1000.0"/>
    <fringe-factor value="5"/>
    <fringe-start-attributes value="departSpeed=&quot;max&quot;"/>
    <insertion-density value="12.0"/>
    <lanes value="True"/>
    <min-distance.fringe value="10.0"/>
    <min-distance value="300.0"/>
    <net-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.net.xml.gz"/>
    <remove-loops value="True"/>
    <route-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.passenger.rou.xml"/>
    <trip-attributes value="departLane=&quot;best&quot;"/>
    <output-trip-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.passenger.trips.xml"/>
    <prefix value="veh"/>
    <validate value="True"/>
    <vehicle-class value="passenger"/>
    <via-edge-types
value="highway.motorway,highway.motorway_link,highway.trunk_link,highway.primary_link,highway.
secondary_link,highway.tertiary_link"/>
</configuration>
-->

<routes xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://sumo.dlr.de/xsd/routes_file.xsd"
>
        <vType id="veh_passenger" vClass="passenger" accel="2.6" decel="4.5" sigma="0.5"
length="5" maxSpeed="55.55" color="0,1,1"/>
    <vType id="veh_van" vClass="passenger" accel="1.3" decel="4.25" sigma="0.5" length="12"
maxSpeed="45.83" color="1,0,1"/>
       <trip id="veh0" depart="1043.88" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh1" depart="1079.65" departLane="best" from="E38" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh2" depart="1100.70" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh3" depart="1116.72" departLane="best" from="E16" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh4" depart="1117.22" departLane="best" from="E32" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh5" depart="1134.40" departLane="best" from="E15" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh6" depart="1135.10" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh7" depart="1137.95" departLane="best" from="E35" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh8" depart="1140.80" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh9" depart="1156.30" departLane="best" from="E4" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh10" depart="1162.10" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh11" depart="1170.10" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh12" depart="1170.40" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
```

```
  <trip id="veh13" depart="1172.00" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh14" depart="1172.08" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh15" depart="1174.40" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh16" depart="1175.08" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh17" depart="1190.42" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh18" depart="1198.35" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh19" depart="1203.15" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh20" depart="1208.53" departLane="best" from="E30" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh21" depart="1212.05" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh22" depart="1226.47" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh23" depart="1234.83" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh24" depart="1235.05" departLane="best" from="E22" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh25" depart="1236.28" departLane="best" from="E69" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh26" depart="1239.92" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh27" depart="1241.15" departLane="best" from="E56" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh28" depart="1250.05" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh29" depart="1251.78" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh30" depart="1256.12" departLane="best" from="E2" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh31" depart="1256.80" departLane="best" from="E16" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh32" depart="1260.40" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh33" depart="1263.47" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh34" depart="1267.78" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
  <trip id="veh35" depart="1268.47" departLane="best" from="E56" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh36" depart="1270.92" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
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type="veh_passenger"/>
  <trip id="veh38" depart="1272.85" departLane="best" from="E18" toTaz="taz_0"
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type="veh_van"/>
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type="veh_passenger"/>
  <trip id="veh41" depart="1289.38" departLane="best" from="E51" toTaz="taz_0"
type="veh_van"/>
  <trip id="veh42" depart="1291.75" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
```

```xml
<trip id="veh43" depart="1294.83" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
<trip id="veh44" depart="1299.80" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh45" depart="1319.45" departLane="best" from="E32" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh46" depart="1320.92" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
<trip id="veh47" depart="1321.45" departLane="best" from="E4" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh48" depart="1333.22" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh49" depart="1336.05" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh50" depart="1336.25" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh51" depart="1339.42" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh52" depart="1342.08" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh53" depart="1342.40" departLane="best" from="E42" toTaz="taz_0" type="veh_van"/>
<trip id="veh54" depart="1342.55" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
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<trip id="veh56" depart="1347.20" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
<trip id="veh57" depart="1352.03" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh58" depart="1357.35" departLane="best" from="E20" toTaz="taz_0" type="veh_passenger"/>
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<trip id="veh60" depart="1362.28" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh61" depart="1363.38" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
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<trip id="veh63" depart="1368.00" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
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<trip id="veh68" depart="1389.67" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh69" depart="1390.78" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
<trip id="veh70" depart="1402.72" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
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type="veh_van"/>
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type="veh_van"/>
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type="veh_passenger"/>
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type="veh_passenger"/>
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    <trip id="veh81" depart="1419.88" departLane="best" from="E18" toTaz="taz_0"
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    <trip id="veh84" depart="1423.20" departLane="best" from="E30" toTaz="taz_0"
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    <trip id="veh85" depart="1423.95" departLane="best" from="E2" toTaz="taz_0"
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    <trip id="veh86" depart="1425.90" departLane="best" from="E32" toTaz="taz_0"
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    <trip id="veh87" depart="1426.70" departLane="best" from="E56" toTaz="taz_0"
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    <trip id="veh91" depart="1435.60" departLane="best" from="E6" toTaz="taz_0"
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    <trip id="veh94" depart="1443.70" departLane="best" from="E15" toTaz="taz_0"
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    <trip id="veh95" depart="1447.65" departLane="best" from="E38" toTaz="taz_0"
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type="veh_passenger"/>
    <trip id="veh97" depart="1449.22" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
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type="veh_passenger"/>
    <trip id="veh100" depart="1455.40" departLane="best" from="E20" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh101" depart="1459.17" departLane="best" from="E50" toTaz="taz_0"
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    <trip id="veh102" depart="1459.25" departLane="best" from="E15" toTaz="taz_0"
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<trip id="veh105" depart="1473.15" departLane="best" from="E5" toTaz="taz_0"
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<trip id="veh157" depart="1627.28" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
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    <trip id="veh225" depart="1821.72" departLane="best" from="E53" toTaz="taz_0"
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    <trip id="veh233" depart="1868.25" departLane="best" from="E34" toTaz="taz_0"
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type="veh_passenger"/>
    <trip id="veh248" depart="1918.05" departLane="best" from="E69" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh249" depart="1967.80" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh250" depart="1987.60" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh251" depart="1989.90" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh252" depart="2001.70" departLane="best" from="E4" toTaz="taz_0"
type="veh_passenger"/>
```

<trip id="veh253" depart="2015.88" departLane="best" from="E22" toTaz="taz_0" type="veh_van"/>
<trip id="veh254" depart="2020.35" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh255" depart="2024.25" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh256" depart="2050.90" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh257" depart="2054.55" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh258" depart="2078.53" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh259" depart="2088.62" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh260" depart="2090.50" departLane="best" from="E42" toTaz="taz_0" type="veh_van"/>
<trip id="veh261" depart="2094.40" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
<trip id="veh262" depart="2099.03" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh263" depart="2126.68" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh264" depart="2138.03" departLane="best" from="E2" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh265" depart="2153.57" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh266" depart="2155.47" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh267" depart="2158.32" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh268" depart="2161.78" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh269" depart="2162.97" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh270" depart="2181.45" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
<trip id="veh271" depart="2185.18" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh272" depart="2185.60" departLane="best" from="E38" toTaz="taz_0" type="veh_van"/>
<trip id="veh273" depart="2219.65" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh274" depart="2269.88" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh275" depart="2277.78" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh276" depart="2305.65" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh277" depart="2314.88" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh278" depart="2321.07" departLane="best" from="E16" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh279" depart="2334.68" departLane="best" from="E6" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh280" depart="2352.40" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh281" depart="2385.20" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh282" depart="2424.60" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>

```
    <trip id="veh283" depart="2438.85" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh284" depart="2472.35" departLane="best" from="E18" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh285" depart="2537.95" departLane="best" from="E51" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh286" depart="2581.70" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh287" depart="2749.68" departLane="best" from="E34" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh288" depart="2758.45" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh289" depart="2832.00" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh290" depart="2879.57" departLane="best" from="E16" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh291" depart="2907.85" departLane="best" from="E32" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh292" depart="2956.70" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh293" depart="2967.32" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh294" depart="3026.78" departLane="best" from="E38" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh295" depart="3043.05" departLane="best" from="E6" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh296" depart="3069.68" departLane="best" from="E35" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh297" depart="3101.03" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh298" depart="3178.75" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
</routes>
```

Appendix F. SUMO input script for traffic demand - Scenario 5


```xml
<?xml version="1.0" encoding="UTF-8"?>

<!-- generated on 2024-02-26 09:48:37.826000 by osmWebWizard.py v1_19_0+0000-baa66a0f364
<configuration>
    <allow-fringe.min-length value="1000.0"/>
    <fringe-factor value="5"/>
    <fringe-start-attributes value="departSpeed=&quot;max&quot;"/>
    <insertion-density value="12.0"/>
    <lanes value="True"/>
    <min-distance.fringe value="10.0"/>
    <min-distance value="300.0"/>
    <net-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.net.xml.gz"/>
    <remove-loops value="True"/>
    <route-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.passenger.rou.xml"/>
    <trip-attributes value="departLane=&quot;best&quot;"/>
    <output-trip-file value="C:\Users\wuinity\Sumo\2024-02-26-09-48-13\osm.passenger.trips.xml"/>
    <prefix value="veh"/>
    <validate value="True"/>
    <vehicle-class value="passenger"/>
    <via-edge-types
value="highway.motorway,highway.motorway_link,highway.trunk_link,highway.primary_link,highway.
secondary_link,highway.tertiary_link"/>
</configuration>
-->

<routes xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://sumo.dlr.de/xsd/routes_file.xsd"
>
        <vType id="veh_passenger" vClass="passenger" accel="2.6" decel="4.5" sigma="0.5"
length="5" maxSpeed="55.55" color="0,1,1"/>
    <vType id="veh_van" vClass="passenger" accel="1.3" decel="4.25" sigma="0.5" length="12"
maxSpeed="45.83" color="1,0,1"/>
      <trip id="veh0" depart="1779.53" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh1" depart="1926.40" departLane="best" from="E38" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh2" depart="1956.05" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh3" depart="1984.05" departLane="best" from="E38" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh4" depart="1986.90" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh5" depart="2006.20" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh6" depart="2007.42" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh7" depart="2071.05" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh8" depart="2072.30" departLane="best" from="E5" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh9" depart="2087.90" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh10" depart="2089.80" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh11" depart="2108.62" departLane="best" from="E69" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh12" depart="2123.95" departLane="best" from="E35" toTaz="taz_0"
type="veh_van"/>
```

```
<trip id="veh13" depart="2140.97" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh14" depart="2144.55" departLane="best" from="E35" toTaz="taz_0"
type="veh_van"/>
<trip id="veh15" depart="2151.65" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh16" depart="2156.62" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh17" depart="2175.90" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh18" depart="2182.55" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh19" depart="2195.25" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh20" depart="2221.38" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh21" depart="2226.80" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh22" depart="2238.00" departLane="best" from="E56" toTaz="taz_0"
type="veh_van"/>
<trip id="veh23" depart="2246.07" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh24" depart="2252.62" departLane="best" from="E32" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh25" depart="2253.00" departLane="best" from="E42" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh26" depart="2255.88" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh27" depart="2258.25" departLane="best" from="E18" toTaz="taz_0"
type="veh_van"/>
<trip id="veh28" depart="2259.20" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh29" depart="2266.07" departLane="best" from="E38" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh30" depart="2268.97" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh31" depart="2306.75" departLane="best" from="E5" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh32" depart="2317.00" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh33" depart="2322.25" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh34" depart="2331.47" departLane="best" from="E51" toTaz="taz_0"
type="veh_van"/>
<trip id="veh35" depart="2358.80" departLane="best" from="E15" toTaz="taz_0"
type="veh_van"/>
<trip id="veh36" depart="2359.62" departLane="best" from="E2" toTaz="taz_0"
type="veh_van"/>
<trip id="veh37" depart="2382.70" departLane="best" from="E22" toTaz="taz_0"
type="veh_van"/>
<trip id="veh38" depart="2392.35" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh39" depart="2399.07" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh40" depart="2404.68" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
<trip id="veh41" depart="2405.38" departLane="best" from="E69" toTaz="taz_0"
type="veh_passenger"/>
<trip id="veh42" depart="2410.80" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
```

```
<trip id="veh43" depart="2426.12" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh44" depart="2439.07" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh45" depart="2440.03" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
<trip id="veh46" depart="2451.03" departLane="best" from="E35" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh47" depart="2451.28" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh48" depart="2461.22" departLane="best" from="E6" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh49" depart="2469.32" departLane="best" from="E32" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh50" depart="2490.45" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh51" depart="2493.28" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
<trip id="veh52" depart="2493.32" departLane="best" from="E5" toTaz="taz_0" type="veh_van"/>
<trip id="veh53" depart="2497.62" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh54" depart="2498.12" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh55" depart="2498.18" departLane="best" from="E6" toTaz="taz_0" type="veh_van"/>
<trip id="veh56" depart="2527.32" departLane="best" from="E50" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh57" depart="2529.03" departLane="best" from="E2" toTaz="taz_0" type="veh_van"/>
<trip id="veh58" depart="2532.45" departLane="best" from="E38" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh59" depart="2535.18" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
<trip id="veh60" depart="2549.88" departLane="best" from="E42" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh61" depart="2550.25" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh62" depart="2554.20" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh63" depart="2563.53" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh64" depart="2566.82" departLane="best" from="E35" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh65" depart="2569.70" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh66" depart="2570.03" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
<trip id="veh67" depart="2580.80" departLane="best" from="E6" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh68" depart="2581.35" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh69" depart="2583.07" departLane="best" from="E4" toTaz="taz_0" type="veh_van"/>
<trip id="veh70" depart="2590.78" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh71" depart="2602.78" departLane="best" from="E11" toTaz="taz_0" type="veh_van"/>
<trip id="veh72" depart="2617.45" departLane="best" from="E35" toTaz="taz_0" type="veh_van"/>
```

<trip id="veh73" depart="2627.30" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh74" depart="2629.90" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh75" depart="2630.40" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh76" depart="2634.00" departLane="best" from="E38" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh77" depart="2641.18" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh78" depart="2643.90" departLane="best" from="E42" toTaz="taz_0" type="veh_van"/>
<trip id="veh79" depart="2658.88" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh80" depart="2664.88" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh81" depart="2670.38" departLane="best" from="E38" toTaz="taz_0" type="veh_van"/>
<trip id="veh82" depart="2674.97" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh83" depart="2678.15" departLane="best" from="E42" toTaz="taz_0" type="veh_van"/>
<trip id="veh84" depart="2693.93" departLane="best" from="E20" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh85" depart="2696.95" departLane="best" from="E2" toTaz="taz_0" type="veh_van"/>
<trip id="veh86" depart="2711.12" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh87" depart="2715.57" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
<trip id="veh88" depart="2716.72" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh89" depart="2721.75" departLane="best" from="E35" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh90" depart="2729.05" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh91" depart="2734.40" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
<trip id="veh92" depart="2734.55" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh93" depart="2740.00" departLane="best" from="E16" toTaz="taz_0" type="veh_van"/>
<trip id="veh94" depart="2740.22" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh95" depart="2747.55" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh96" depart="2747.57" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh97" depart="2749.90" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh98" depart="2752.38" departLane="best" from="E42" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh99" depart="2754.93" departLane="best" from="E35" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh100" depart="2756.88" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh101" depart="2759.22" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh102" depart="2765.07" departLane="best" from="E69" toTaz="taz_0" type="veh_van"/>

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<trip id="veh103" depart="2766.97" departLane="best" from="E32" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh104" depart="2780.10" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh105" depart="2785.55" departLane="best" from="E38" toTaz="taz_0" type="veh_van"/>
<trip id="veh106" depart="2786.00" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh107" depart="2793.80" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh108" depart="2801.90" departLane="best" from="E42" toTaz="taz_0" type="veh_van"/>
<trip id="veh109" depart="2805.18" departLane="best" from="E4" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh110" depart="2817.50" departLane="best" from="E2" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh111" depart="2820.20" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh112" depart="2821.15" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh113" depart="2833.93" departLane="best" from="E50" toTaz="taz_0" type="veh_van"/>
<trip id="veh114" depart="2836.40" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh115" depart="2840.00" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh116" depart="2845.78" departLane="best" from="E69" toTaz="taz_0" type="veh_van"/>
<trip id="veh117" depart="2850.30" departLane="best" from="E5" toTaz="taz_0" type="veh_van"/>
<trip id="veh118" depart="2853.47" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh119" depart="2857.62" departLane="best" from="E3" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh120" depart="2867.45" departLane="best" from="E4" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh121" depart="2890.07" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh122" depart="2895.72" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh123" depart="2896.05" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh124" depart="2911.57" departLane="best" from="E4" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh125" depart="2913.82" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh126" depart="2914.32" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh127" depart="2916.15" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh128" depart="2918.22" departLane="best" from="E35" toTaz="taz_0" type="veh_van"/>
<trip id="veh129" depart="2918.90" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
<trip id="veh130" depart="2919.90" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
<trip id="veh131" depart="2923.03" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh132" depart="2923.65" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
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<trip id="veh134" depart="2925.18" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh135" depart="2927.40" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
<trip id="veh136" depart="2937.90" departLane="best" from="E2" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh137" depart="2943.12" departLane="best" from="E2" toTaz="taz_0" type="veh_van"/>
<trip id="veh138" depart="2944.00" departLane="best" from="E32" toTaz="taz_0" type="veh_van"/>
<trip id="veh139" depart="2945.60" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh140" depart="2952.18" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh141" depart="2953.20" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh142" depart="2954.28" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh143" depart="2957.18" departLane="best" from="E38" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh144" depart="2958.72" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh145" depart="2968.95" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh146" depart="2968.97" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh147" depart="2974.65" departLane="best" from="E22" toTaz="taz_0" type="veh_van"/>
<trip id="veh148" depart="2977.00" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh149" depart="2986.45" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh150" depart="2987.38" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh151" depart="2992.50" departLane="best" from="E69" toTaz="taz_0" type="veh_van"/>
<trip id="veh152" depart="2996.38" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh153" depart="3010.03" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh154" depart="3017.25" departLane="best" from="E6" toTaz="taz_0" type="veh_van"/>
<trip id="veh155" depart="3017.40" departLane="best" from="E69" toTaz="taz_0" type="veh_van"/>
<trip id="veh156" depart="3018.28" departLane="best" from="E5" toTaz="taz_0" type="veh_van"/>
<trip id="veh157" depart="3035.22" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh158" depart="3044.62" departLane="best" from="E42" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh159" depart="3046.28" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh160" depart="3053.10" departLane="best" from="E2" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh161" depart="3060.00" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh162" depart="3067.07" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>

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<trip id="veh164" depart="3078.70" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh165" depart="3081.60" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh166" depart="3082.85" departLane="best" from="E3" toTaz="taz_0" type="veh_van"/>
<trip id="veh167" depart="3085.65" departLane="best" from="E11" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh168" depart="3086.53" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh169" depart="3089.05" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
<trip id="veh170" depart="3091.38" departLane="best" from="E30" toTaz="taz_0" type="veh_van"/>
<trip id="veh171" depart="3091.40" departLane="best" from="E16" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh172" depart="3093.88" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh173" depart="3095.55" departLane="best" from="E2" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh174" depart="3102.82" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh175" depart="3104.82" departLane="best" from="E4" toTaz="taz_0" type="veh_van"/>
<trip id="veh176" depart="3105.12" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh177" depart="3109.93" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh178" depart="3110.57" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
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<trip id="veh180" depart="3113.55" departLane="best" from="E56" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh181" depart="3115.62" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh182" depart="3120.57" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh183" depart="3121.88" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh184" depart="3124.55" departLane="best" from="E42" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh185" depart="3130.80" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
<trip id="veh186" depart="3132.07" departLane="best" from="E38" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh187" depart="3137.57" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh188" depart="3139.53" departLane="best" from="E50" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh189" depart="3142.15" departLane="best" from="E22" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh190" depart="3168.18" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh191" depart="3172.80" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh192" depart="3180.50" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
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    <trip id="veh193" depart="3185.22" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh194" depart="3190.40" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh195" depart="3193.82" departLane="best" from="E6" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh196" depart="3195.15" departLane="best" from="E15" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh197" depart="3198.47" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh198" depart="3198.57" departLane="best" from="E32" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh199" depart="3201.62" departLane="best" from="E2" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh200" depart="3203.18" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh201" depart="3203.40" departLane="best" from="E51" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh202" depart="3213.57" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh203" depart="3217.70" departLane="best" from="E69" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh204" depart="3219.15" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh205" depart="3219.78" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh206" depart="3224.10" departLane="best" from="E4" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh207" depart="3224.25" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh208" depart="3225.10" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh209" depart="3227.25" departLane="best" from="E42" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh210" depart="3230.43" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh211" depart="3235.85" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh212" depart="3241.45" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh213" depart="3243.60" departLane="best" from="E18" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh214" depart="3251.45" departLane="best" from="E34" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh215" depart="3253.22" departLane="best" from="E6" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh216" depart="3255.35" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh217" depart="3257.07" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh218" depart="3261.60" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh219" depart="3269.40" departLane="best" from="E15" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh220" depart="3275.70" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh221" depart="3283.75" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
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type="veh_passenger"/>
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    <trip id="veh223" depart="3308.57" departLane="best" from="E4" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh224" depart="3329.65" departLane="best" from="E20" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh225" depart="3334.05" departLane="best" from="E56" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh226" depart="3335.43" departLane="best" from="E30" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh227" depart="3340.90" departLane="best" from="E30" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh228" depart="3349.93" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh229" depart="3352.18" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh230" depart="3364.62" departLane="best" from="E3" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh231" depart="3367.45" departLane="best" from="E42" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh232" depart="3374.32" departLane="best" from="E35" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh233" depart="3378.10" departLane="best" from="E32" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh234" depart="3387.43" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh235" depart="3388.07" departLane="best" from="E11" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh236" depart="3390.10" departLane="best" from="E34" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh237" depart="3398.60" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh238" depart="3422.07" departLane="best" from="E34" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh239" depart="3440.72" departLane="best" from="E2" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh240" depart="3464.88" departLane="best" from="E4" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh241" depart="3499.28" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh242" depart="3501.20" departLane="best" from="E30" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh243" depart="3509.88" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh244" depart="3514.45" departLane="best" from="E53" toTaz="taz_0"
type="veh_van"/>
    <trip id="veh245" depart="3524.20" departLane="best" from="E18" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh246" depart="3525.15" departLane="best" from="E16" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh247" depart="3527.65" departLane="best" from="E20" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh248" depart="3538.00" departLane="best" from="E42" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh249" depart="3542.65" departLane="best" from="E34" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh250" depart="3544.38" departLane="best" from="E53" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh251" depart="3544.72" departLane="best" from="E15" toTaz="taz_0"
type="veh_passenger"/>
    <trip id="veh252" depart="3549.62" departLane="best" from="E51" toTaz="taz_0"
type="veh_passenger"/>
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    <trip id="veh253" depart="3567.28" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh254" depart="3572.05" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
    <trip id="veh255" depart="3573.60" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh256" depart="3578.10" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh257" depart="3585.53" departLane="best" from="E6" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh258" depart="3588.85" departLane="best" from="E53" toTaz="taz_0" type="veh_van"/>
    <trip id="veh259" depart="3612.00" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh260" depart="3621.57" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh261" depart="3652.75" departLane="best" from="E22" toTaz="taz_0" type="veh_van"/>
    <trip id="veh262" depart="3668.82" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh263" depart="3672.55" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh264" depart="3699.80" departLane="best" from="E30" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh265" depart="3700.25" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh266" depart="3704.38" departLane="best" from="E6" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh267" depart="3708.50" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
    <trip id="veh268" depart="3713.68" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
    <trip id="veh269" depart="3715.68" departLane="best" from="E5" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh270" depart="3718.75" departLane="best" from="E34" toTaz="taz_0" type="veh_van"/>
    <trip id="veh271" depart="3733.65" departLane="best" from="E53" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh272" depart="3762.75" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
    <trip id="veh273" depart="3795.65" departLane="best" from="E16" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh274" depart="3796.18" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh275" depart="3811.78" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
    <trip id="veh276" depart="3827.00" departLane="best" from="E42" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh277" depart="3862.97" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh278" depart="3872.88" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh279" depart="3875.45" departLane="best" from="E56" toTaz="taz_0" type="veh_van"/>
    <trip id="veh280" depart="3896.93" departLane="best" from="E34" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh281" depart="3906.18" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
    <trip id="veh282" depart="3941.93" departLane="best" from="E18" toTaz="taz_0" type="veh_van"/>
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<trip id="veh283" depart="3957.95" departLane="best" from="E20" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh284" depart="3976.55" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh285" depart="4016.75" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh286" depart="4219.65" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh287" depart="4241.55" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh288" depart="4296.30" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh289" depart="4334.55" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh290" depart="4353.60" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh291" depart="4469.12" departLane="best" from="E51" toTaz="taz_0" type="veh_van"/>
<trip id="veh292" depart="4538.00" departLane="best" from="E69" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh293" depart="4651.15" departLane="best" from="E16" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh294" depart="4700.65" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh295" depart="4960.32" departLane="best" from="E18" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh296" depart="4966.15" departLane="best" from="E15" toTaz="taz_0" type="veh_van"/>
<trip id="veh297" depart="4980.23" departLane="best" from="E16" toTaz="taz_0" type="veh_van"/>
<trip id="veh298" depart="4984.02" departLane="best" from="E15" toTaz="taz_0" type="veh_passenger"/>
<trip id="veh299" depart="5051.27" departLane="best" from="E51" toTaz="taz_0" type="veh_passenger"/>
</routes>

Appendix G. Duration of the traffic evacuation for all runs-scenario 1 (Traffic day evacuation)

Table 28: Duration of the traffic evacuation process for Scenario 1 (Traffic day eveacuation)-All runs.

Run	Start time first driver (s)	End time last driver (s)	Duration of the traffic evacuation process	
			(s)	(hh: mm: ss)
1	971	3215	2244	37:24
2	1009	2977	1968	32:48
3	1057	3309	2252	37:31
4	1053	3194	2141	35:40
5	983	3363	2380	39:39
6	1027	3094	2067	34:27
7	1041	3282	2241	37:21
8	1044	3388	2344	39:03
9	1011	3236	2225	37:04
10	1001	3284	2283	38:03
Average			2214	36:54

Appendix H. Total evacuation time for all runs-scenario 1 (Traffic day evacuation)

Table 29: Total evacuation time for Sceanrio 1 (Traffic day evacuation)-All runs.

Run	The last person arriving by foot (s)	Total evacuation time, the last person arriving by vehicle	
		(s)	(hh: mm: ss)
1	3080	3215	53:34
2	2841	2977	49:36
3	3171	3309	55:09
4	3058	3194	53:13
5	3226	3363	56:03
6	2936	3094	51:33
7	3133	3282	54:42
8	3252	3388	56:27
9	3100	3236	53:55
10	3146	3284	54:73

Appendix I. Log-normal distribuation of the pre-movement time calculation

Assuming that the 1st percentile corresponds to the minimum value and the 99th percentile, then we have:

$$Min = 10\ minutes$$

$$Max = 20\ minutes$$

The equation that corresponds to a log-normal distributionis:

$$X = e^{\mu+\sigma z}$$

Where μ is the location and σ is the scale.

Therefore,

$$10 = e^{\mu+\sigma z}$$

$$20 = e^{\mu+\sigma z}$$

For this, a random variable X is said to follow a lognormal distribution if ln(X) follows a normal distribution.

Therefore,

$$\ln(10) = \mu + \sigma z$$

$$\ln(20) = \mu + \sigma z$$

Assuming ln(10) and ln(20) correspond to the 1st percentile and 99th percentile respectively of the normal distribution, therefore,

$$\ln(10) = \mu - 2.33 * \sigma$$

$$\ln(20) = \mu + 2.33 * \sigma$$

Based on the two equations, the location parameter μ is approximately 2.65 minutes, and the scale parameter σ is approximately 0.15 minutes. These parameters correspond to a mean value of approximately 14.30 minutes for the actual log-normal distribution, indicating a skewness towards the value of the min, which is typical for a log-normal distribution.

Appendix J. Total pedestrian evacuation time for all the runs.

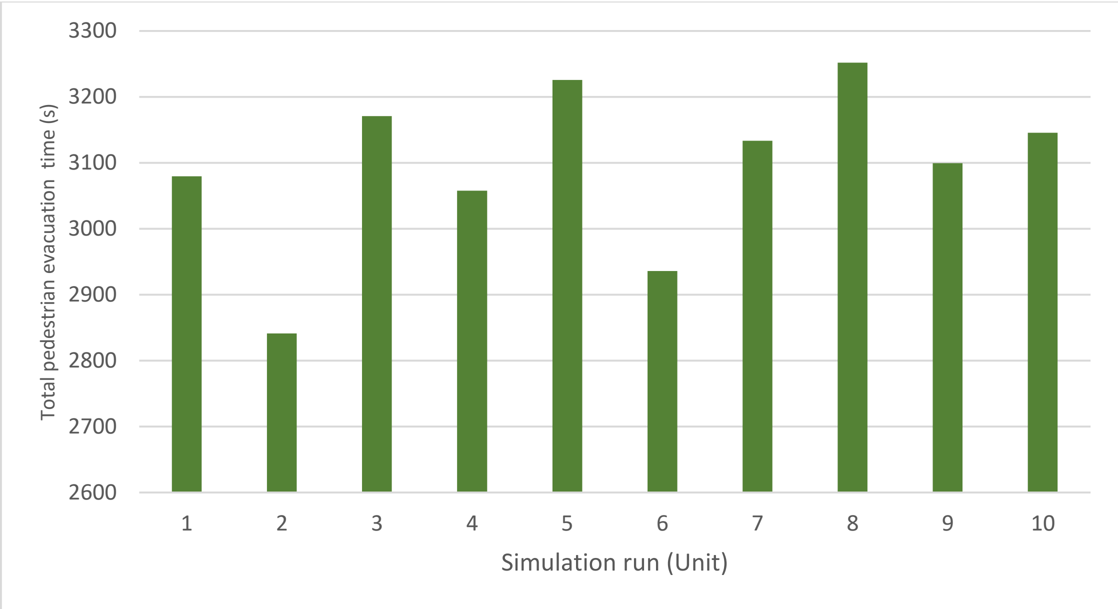

Figure 31: Total pedestrian evacuation time for scenario 1(Traffic day evacuation)- All runs.

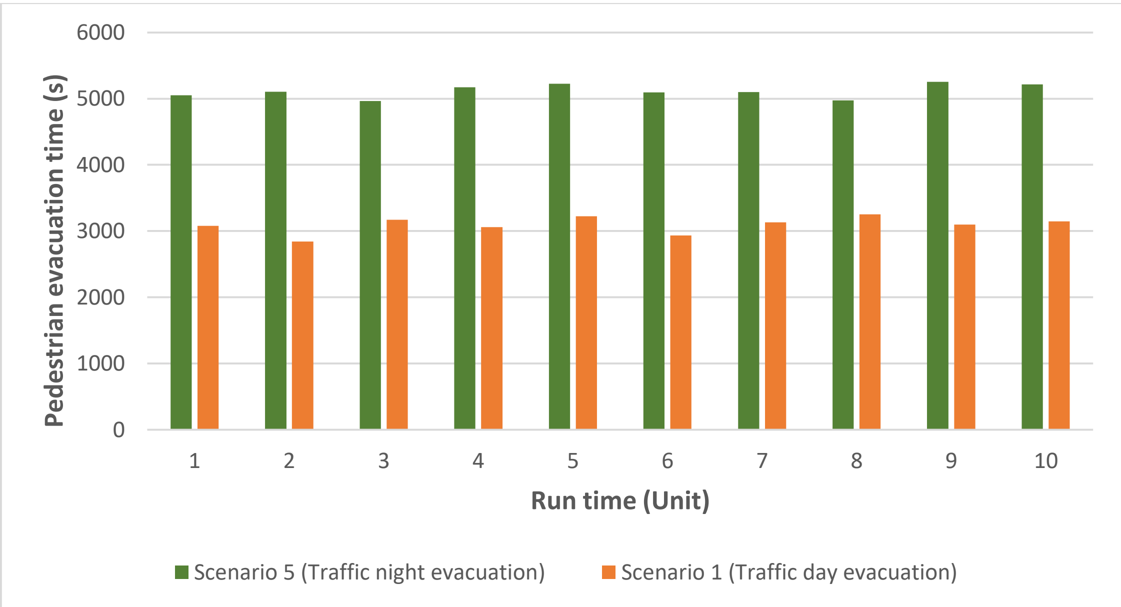

Figure 32:Total pedestrian evacuation time for scenario 1(Traffic day evacuation) vs Scenario 5 (Traffic night evacuation)- All runs.

Appendix K. Total evacuation time for all the runs.

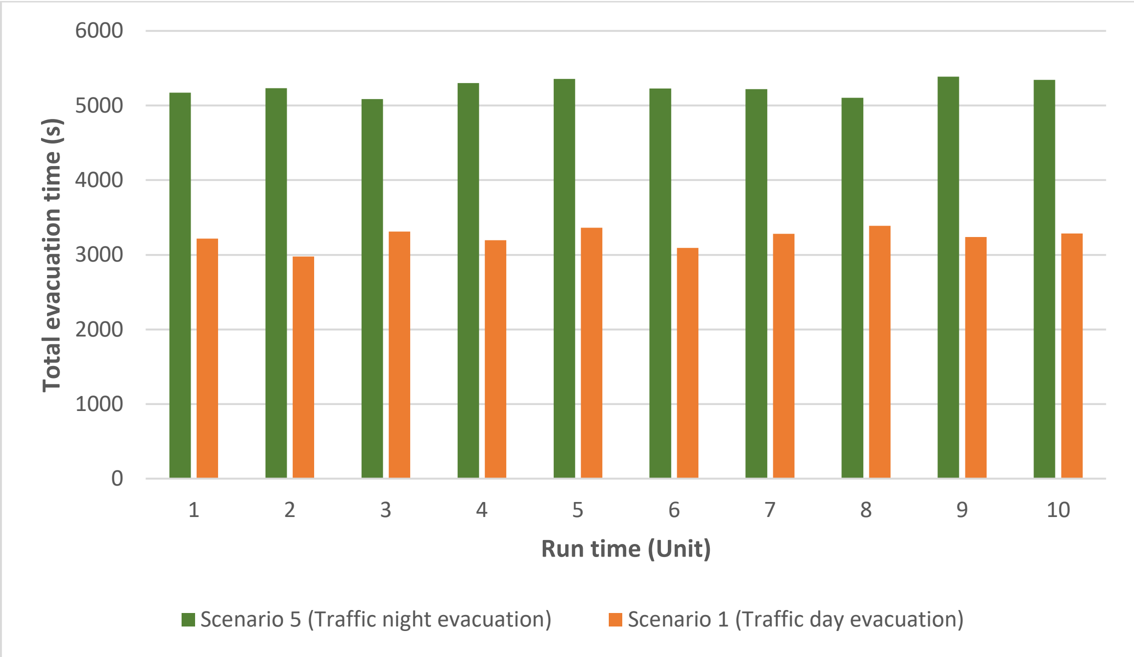

Figure 33: Total evacuation time for scenario 1 (Traffic day evacuation) vs Scenario 5 (Traffic night evacuation)-All runs.

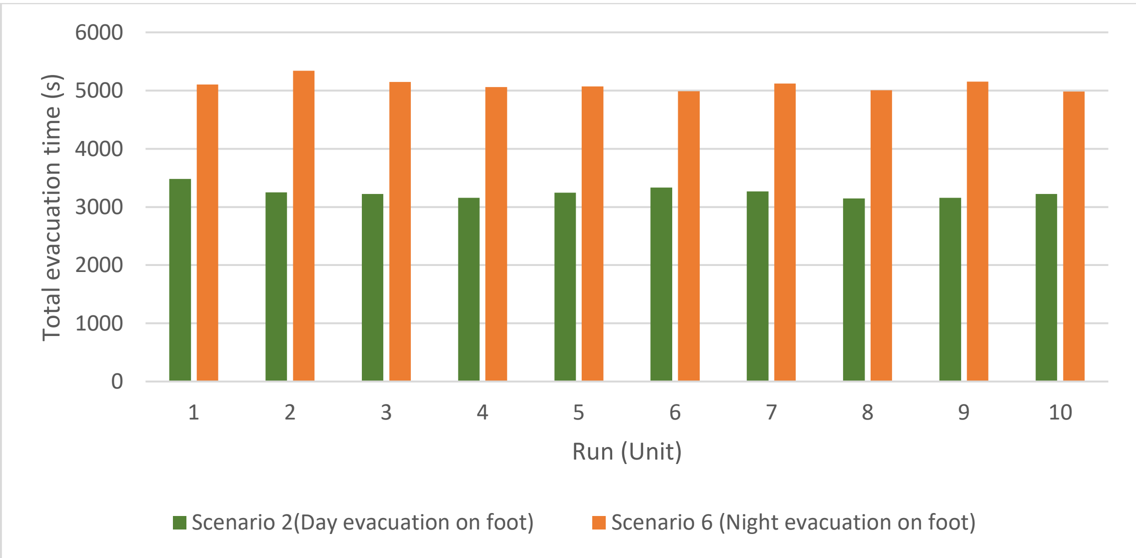

Figure 34: Total evacuation time for scenario 2 (Day evacuation on foot) vs scenario 6 (Night evacuation on foot)-All runs.

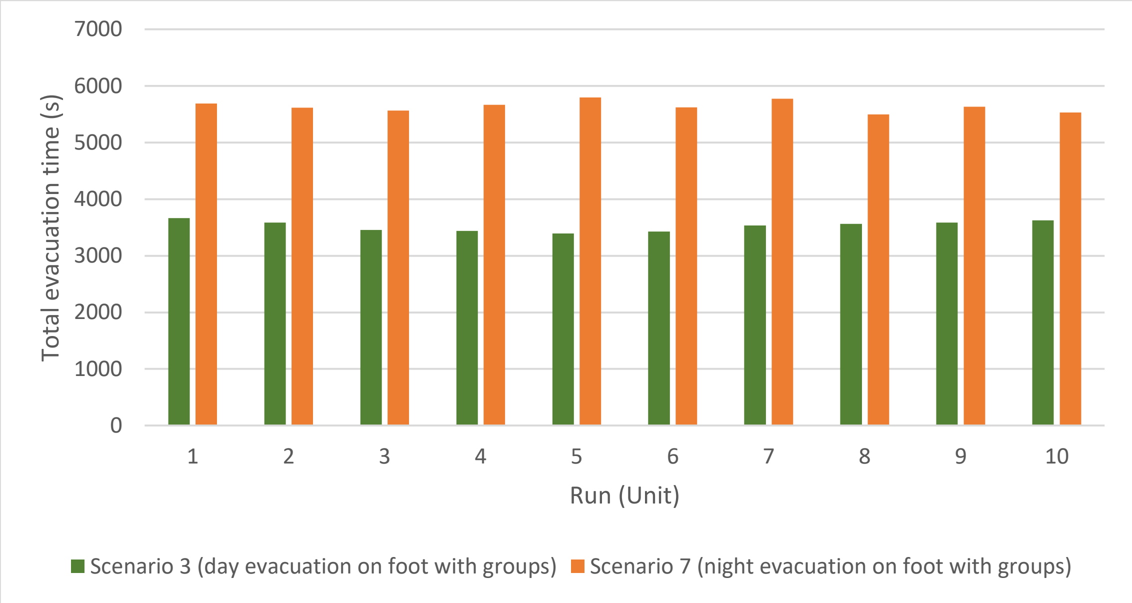

Figure 35: Total evacuation time for scenario 3 (Day evacuation on foot with groups) vs scenario 7 (Night evacuation on foot with groups)-All runs

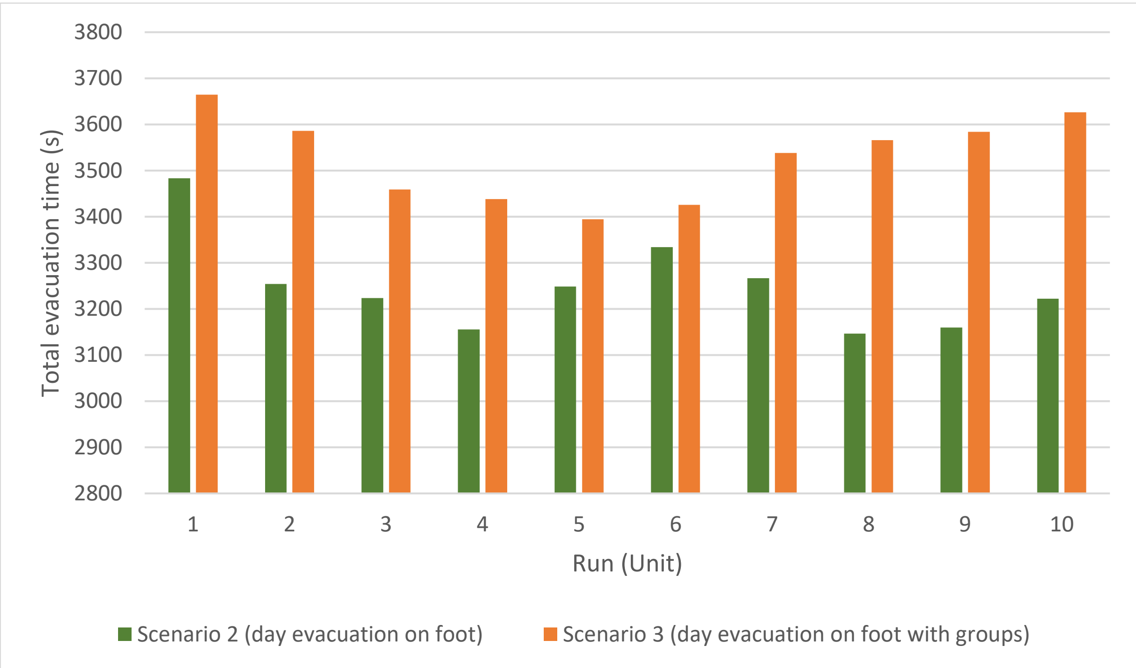

Figure 36: Total evacuation time scenario 2 (Day evacuation on foot) vs scenario 3 (Day evacuation on foot with groups)-All runs.

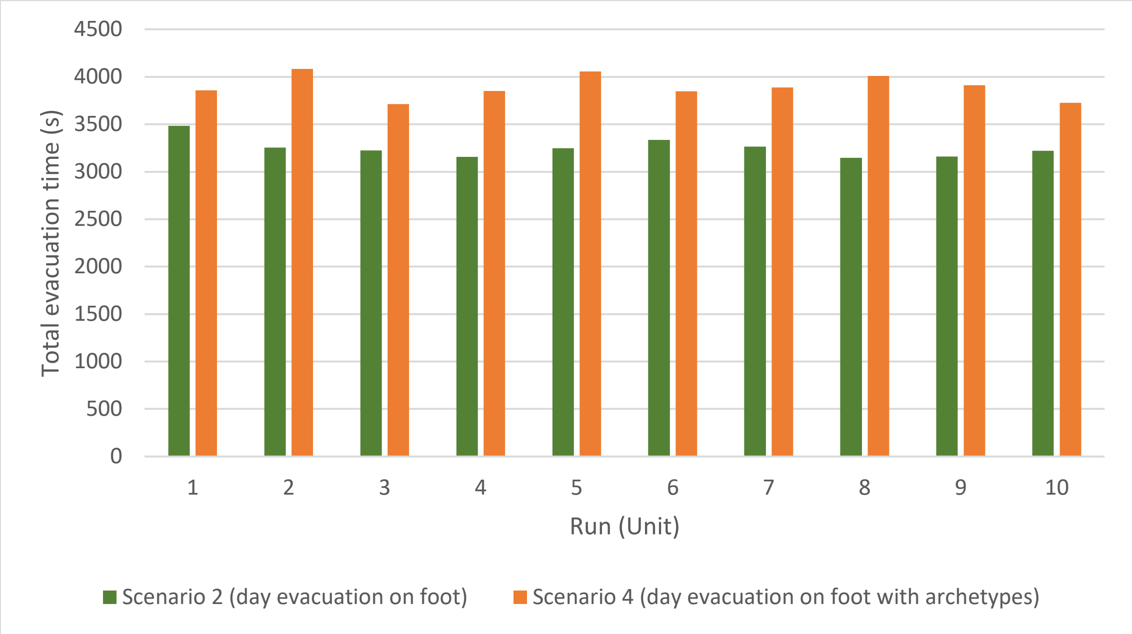

Figure 37: Total evacuation time scenario 2 (Day evacuation on foot) vs scenario 3 (Day evacuation on foot with archetypes)-All runs.