# Project Report - Challenge: Urban Mobility

## *kemptAInability* - An interactive traffic flow simulation focusing on the city of Kempten

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# 1 Introduction

Urban areas are facing increasing pressure due to rising traffic volumes, noise levels, and greenhouse gas emissions, increased by a limited amount of green spaces to balance the urban environment. According to the European Parliament [8], urban mobility is responsible for around 70% of air pollutants and 40% of $CO_2$ emissions in cities. Such air and noise pollution can weaken residents' physical health.

In Kempten (Allgäu), the B19 highway running through the city centre is a major cause of high traffic volume and will not be rerouted due to its importance to commuters and residents. However, Kempten expects an upcoming infrastructural shift due to reconstruction work. The St. Mang bridge which carries traffic via the B19 highway, is planned to be closed for two years [5]. This change leads to concerns among frequently dependants such as residents that are afraid of increased traffic jams and stress during their rides, while the city's mobility management sees the potential for urban city planning by rerouting traffic more sustainably and reducing inner-city pollution and noise [15].

In response, our team has developed an interactive traffic simulation to be presented at the city's Future Lab [14]. This tool aims to inform citizens and encourage them to make sustainable choices about how they travel, while enabling them to experiment with real-world traffic scenarios in a visual and intuitive way. Furthermore, the aim is to convince political decision-makers to recognise the impact of traffic on the city and to integrate greener alternatives into their decision-making processes.

By incorporating low- and peak-hour traffic data, the simulation provides users with clear visualisations of not only traffic jams, such as reductions in $CO_2$ emissions and traffic noise.

# 2 Urban Mobility Transformation in Kempten

## 2.1 Challenge

Kempten is a city where tradition shapes many aspects of residents' lives, including how they move around urban areas. For a large part of the population, the private car remains the standard and preferred mode of transport and is deeply integrated into daily routines. The environmental consequences such as too much air and noise pollution and a lack of green areas in the inner-city, are often overlooked. This is not primarily due to indifference, but rather because alternatives have rarely been offered in recent years. Recognising this challenge, Kempten's Mobility Management department has invested in improving the public transport infrastructure (ÖPNV) [4]. However, Stefan Sommerfeld who is a member of this department, mentioned that these developments alone will not be sufficient about a significant shift in public behavior. [15].

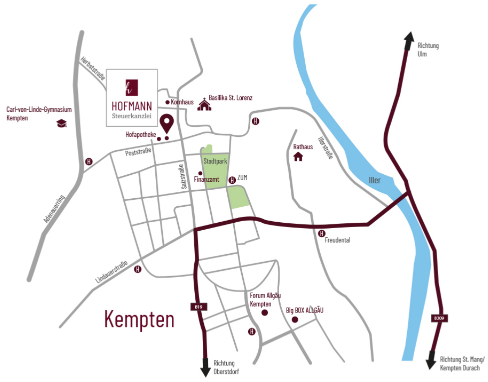


Figure 1: City Center of Kempten

This is an unintended consequence of the two-year reconstruction of the St. Mang Bridge. The central bridge, which is currently part of the B19 highway running directly through the city centre (see Figure 1), is scheduled for a complete closure [5]. This requires us to rethink how traffic can circulate around the city centre. Furthermore, inner-city residents will experience reduced air and noise pollution and traffic, leading to a healthier, quieter, more liveable city. However, the planned closure poses logistical difficulties for many residents and commuters. They are concerned about increased traffic and longer journey times[15].

Therefore, the remaining question is:
How can residents be encouraged to consider the environmental, physical health and everyday life impacts of their mobility choices?

A digital tool is the most pleasing way to inform the residents about the impact as it makes complex issues more relatable. Traditional applications, such as SUMO (Simulation of MObility) [9] or Vissim and Visum (developed by PTV GROUP) [13], have been used to create traffic simulations that can be used to model route finding and the expansion or reconstruction of transportation systems. Therefore, they can measure traffic volumes and emissions under different circumstances. Unfortunately, these applications are too technical for users and require expert knowledge to interact with [9, 13]. A promising innovation for traffic simulation is digital twin technology. This involves creating a personalised copy of a city to optimise traffic efficiency and support sustainable urban mobility. It can visualise predictive analytics and simulate the performance of the transport network. However, due to the costly and time-consuming development process, it

Figure 2: Planned Reconstruction Design of St.-Mang-Brücke

is not yet an option for Kempten [10].

### 2.2 Policy and Regulations

As previously mentioned, there are currently no plans to reroute the B19 highway. Instead, the city intends to rebuild the St. Mang bridge with the same number of lanes for cars to maintain the central route through the city. As can be seen in Figure 2,the planned design continues to prioritise inner-city traffic over structural transformation. This is because the B19 highway belongs to the federal state of Bavaria, not the city of Kempten [15]. However, Kempten's urban mobility and infrastructure planning for mobility management is still in the process of becoming sustainable. This is influenced by policy frameworks such as the *Sustainable Development Goal* (SDG) from the *United Nations*(UN) [17]. Specifically, it aligns with the *SDG 11: Sustainable Cities and Communities*, which emphasizes the need for safe, resilient, inclusive, and sustainable urban planning [17]. Additionally, the *European Green Deal* aims to substantially reduce $CO_2$ emissions, with traffic being a significant contributor to this issue. It also promotes climate-resilient infrastructure and resident involvement in urban transformation processes [7]. These policies and regulations demonstrate the importance of resident information and integration in the planning process, as well as the need to transform Kempten into a more sustainable, green city.

### 2.3 Solution

The challenge lies in transforming the planned closure of the St. Mang bridge from a logistical task into an opportunity to encourage sustainable behavioral change among residents through information provision. This requires the development of an accessible, data-driven tool that empowers residents to understand and engage with the environmental and health impacts of their transport choices, and influences policymakers to support greener alternatives.

In summary, the following core objectives must guide the development process:

- Usage of real-world data in low and peak hours to simulate different traffic times.
- Accessibility for non-experts, with a focus on user-centred design, to be monitored in Kempten's Future Lab.
- Affordable application (not a full digital twin) with limited scope to the most relevant facts, such as the impact of reduced inner-city traffic.
- Visualisation of structural impacts, such as traffic delays and traffic jams, as well as environmental impacts, such as $CO_2$ emissions and noise heat maps.
- Gamification features, such as interactions with road closures.
- Inform residents of upcoming infrastructural changes, such as bridge closures.
- Foster active decision-making among residents to encourage more conscious and sustainable transportation choices.
- Convince political stakeholders to proactively contribute to improving the quality of life in Kempten.

## 3 Concept

While developing our concept, we initiated primary research and talked to our contact persons, among others, to find out specific requirements and design an optimal project for the city, factoring in the diverse needs of all stakeholders alongside our insights into effective and enjoyable development practices. Following the idea generation phase, as elaborated in preceding sections, our project is centered around the creation of an innovative application aimed at two primary target groups: **Political stakeholders and residents of Kempten**. This application will demonstrate how alternative transport routes can enhance the city's quality of life while enhancing a more sustainable environment. To emphasize traffic scenarios from the residents' perspective and identify their most significant pain points, we developed two personas: Hanna and Claire. Hanna is concerned about the implications of the bridge closure and is the niece of Claire, who serves on the city council. Together, we analyzed potential scenarios that might encourage Hanna to collaborate with the city council, while also considering the inquiries a Kempten resident, like Claire, might pose to a city council member like Hanna. This process, along with discussions with our contact person, facilitated the simulation of two critical scenarios that could significantly influence political opinion leaders.

### 3.1 Scenarios

The first scenario focused on the closure of the St.-Mang-Bridge, a decision that initially encountered resistance from various interest groups. However, we quickly recognized the viability of the ring road as an alternative. Our visualizations illustrated a reduction in both noise pollution and emissions, highlighting the feasibility of this option. Furthermore, redirecting traffic from the city center to the ring road may result in an increase in travel time of only 1 to 2 minutes. This minor delay is a negligible trade-off for the substantial benefits of a greener urban environment characterized by significant reductions in noise and emissions in the inner-city. Additionally, we propose conducting individual interactive experiments with our system, such as a second scenario. The closure of Residenzplatz is to evaluate the subsequent alterations in traffic dynamics and environmental parameters. This interactive approach to traffic investigation employs storytelling techniques to effectively convey planning insights, highlighting their potential positive impact on the community.

### 3.2 Color and Functionality Concept

Next, we present an overview of the color and interactive functionality concept that was subsequently implemented, utilizing sample images from the frontend. Different traffic states are demonstrated using certain colors.

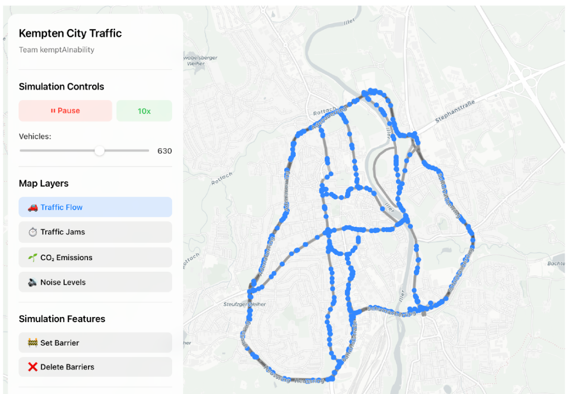


Figure 3: Traffic Flow

In the menu on the left-hand, as illustrated in Figure 3, users can initiate the traffic simulation, select the number of vehicles using a slider, and simulate a specific state within the map layers. Figure 3 displays the normal traffic flow in blue, with currently 630 cars and a certain speed, adjustable manually.

Moreover, colors such as orange and dark red are employed to represent traffic jams (see Figure 4, left), indicating areas with a high concentration of vehicles, which can be activated via the traffic jam button in the menu. The intensity of red indicates the intensity of traffic jam: the darker the red, the more intensity. By selecting the $CO_2$ emissions button, users can visualize areas with particularly high emissions (orange) versus those with lower emissions (green) see figure 4, center. The blue areas in (figure 4, right) illustrate noise intensity, correlated to their size.

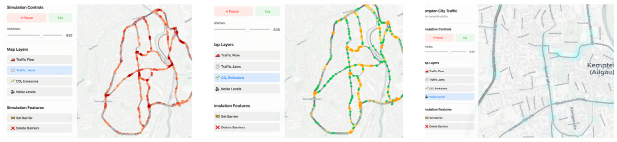

Figure 4: Left -traffic jam , center - emissions, right - noise impact

The 'Set Barrier' button allows for the placement of barriers on both sides of the roadway, enabling observation of their effects on traffic flow, noise, emissions, and traffic jams across different streets (see Figure 5). Hovering over the road segments provides detailed road information, including name, length, width, speed limit, priority, authorized vehicles, and current status regarding closures.

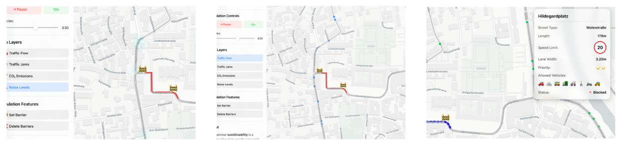

Figure 5: Demonstration of set barrier functionality

Through our project, we aim to convince both political stakeholders and citizens of Kempten to embrace a greener urban vision, featuring increased public green spaces, potential café installations, and expanded bike paths that would contribute to a more vibrant urban atmosphere. By implementing our project, we want to showcase the transformative potential of data in urban planning and its impact on community well-being.

# 4 Implementation

### 4.1 Technology and Selected Software

To extract and process urban street network data for Kempten, we utilized Overpass Turbo [2] with a custom query specifically tailored to filter OpenStreetMap (OSM) data [12] based on a targeted set of street names. This query generated XML output containing relevant ways tagged as *highway*, along with their associated nodes and complete metadata, optimized for further processing.

The raw XML data underwent an initial preprocessing stage using JOSM [1] for manual inspection and pruning. Subsequently, custom scripts were applied within a dedicated virtual environment to systematically remove unnecessary elements, including pedestrian paths, cycleways, junction nodes, and traffic signals, ensuring a clean and focused dataset.

This refined dataset was converted into a SUMO [9] compatible format utilizing SUMO's `netconvert` tool, enabling the creation of a valid `.net.xml` file. Additional network simplification and manual refinements were performed using SUMO's built-in editor, `netedit`, further optimizing the network structure.

In preparation for advanced traffic modeling integration, we experimented with TSMM [16], thereby establishing groundwork for future application of reinforcement learning (RL) and machine learning (ML) techniques.

For frontend visualization and simulation, the SUMO-generated network data was transformed into GeoJSON format [6], enriched with additional lane-level attributes through customized scripts adapted from SUMO's `net2geojson`. The data was then visualized using a React [11] and Vite [3]-powered frontend application, featuring dynamic simulation of traffic flow, the application of traffic barriers, and visual representations of congestion, noise pollution, and $CO_2$ emissions through interactive heatmaps and color-coded map layers. The frontend also provides real-time vehicle counts, speed limits and more relevant metadata, and supports animated time controls.

While this prototype was developed as a proof of concept within a limited timeframe, the overall methodology is structured to be easily adaptable for diverse urban planning scenarios and scalable to additional cities beyond Kempten.

### 4.2 Features and Insights

Throughout the project, we implemented a modular, reproducible pipeline leveraging widely adopted open-source tools and libraries such as `osmnx`, `geopandas`, and `pyproj`, all documented within a public GitHub repository containing a detailed README for setup and extensibility. The frontend supports features like interactive simulation control, heatmap overlays, traffic manipulation (e.g., barrier placement), and real-time monitoring. Tangible interaction mechanisms allow users to apply touch-based input to simulate real policy changes directly on the map. This includes scenario customization tools enabling participants to close roads, test configurations, and instantly observe impacts on traffic flow and environmental indicators.

Unlike comprehensive digital twins, our interface deliberately simplifies data representation by focusing only on key indicators, avoiding overwhelming complexity while still supporting meaningful analysis, while being way more cost-effective than developing a digital twin from scratch.

During development, it became clear that OSM data, when enriched with real-time or domain-specific traffic data, offers significant potential for scalable urban mobility applications. The ability to dynamically select and process relevant OSM subsets enables tailored simulations for specific cities, districts, or even intersections, making this approach suitable for both generalized urban planning and specialized traffic engineering use cases. This insight underscores OSM's value as a foundational data source for future smart mobility systems augmented by AI-driven optimization strategies.

## 6 Business Perspective

*KemptAInability* therefore serves as a shared "decision theatre" for every stakeholder:

- **Employees of the City** can receive instant, scenario-ready graphics for grant proposals.
- **Political stakeholders** and decision-makers can weigh the modest increase in travel time against sizable cuts in noise and emissions.
- **Residents and commuters** close streets virtually and watch live updates of $CO_2$, noise and delays.
- **Mobility planners** export the most promising configurations to SUMO or Visum for detailed study.
- **Local businesses** see evidence that a calmer city-center can co-exist with dependable ring-road access.

Against this backdrop, the platform's *unique selling points* are fourfold:

### 6.1 Unique Selling Points (USP)

- **Cost-efficient**: Delivers the essential insight of a full digital twin at a fraction of the time and budget.
- **Low threshold**: Intuitive, touch-first interface, colour-coded layers, no specialist jargon.
- **Focused**: Displays only decision-critical indicators, preventing information overload.
- **Engaging**: Storytelling and optional gamification sustain public interest.
- **Open data**: Built on OSM and publicly available counts; no vendor lock-in.

### 6.2 Cost Structure vs. Digital Twin

A lean web simulator and one multi-touch station can be built with off-the-shelf hardware and open-source software; most effort goes into data cleaning and UI design. Custom city-wide digital twins, by contrast, require detailed 3D geometry, live IoT feeds and extensive calibration, driving up timelines, team size and budget.

*KemptAInability* follows a "good-enough digital twin" philosophy:

- **Lean data**: Relies on open traffic counts and OSM; no LiDAR or 24/7 sensors needed at launch.
- **Rapid deployment**: A small interdisciplinary team can deliver a usable version within weeks.
- **Lower overhead & easy upkeep**: No 3D engine, no HPC cluster; periodic data refreshes suffice.
- **Scalable template**: Loading a new OSM network plus a few parameters ports the tool to another mid-size city.

### 6.3 Go-to-Market Roadmap

The roll-out will proceed in three complementary streams. First, a **local launch** installs the system permanently in Kempten's new Future-Lab and pairs it with a browser-based demo so that schools and interested citizens can explore scenarios from home. Building on the local showcase, a **regional roll-out** will take the simulation on the road: a mobile touch-table and outreach team visit neighbouring towns, while ready-made lesson modules let teachers integrate the tool into STEM and geography classes. Finally, an **open-source release** on GitHub makes the complete code and documentation publicly available, allowing other mid-sized cities to fork the repository, plug in their own OpenStreetMap network and traffic counts, and extend the platform through community pull-requests.

### 6.4 Risk Analysis & Mitigation

Several potential challenges must be addressed to ensure the platform's success. First, **data gaps** may arise because Kempten currently lacks continuous traffic sensors; we could mitigate this by partnering with providers of floating-car or mobile-network data to fill temporal blind spots. Second, **political resistance** could slow adoption if stakeholders perceive the tool as an anti-car agenda; hosting co-design workshops early—inviting city councillors, business owners and community representatives to shape scenarios together—could help build trust. Third, **technical scalability** must be proven before expanding beyond Kempten; our codebase is modular and cloud-ready, and would undergo rigorous stress tests to guarantee smooth performance under heavier loads. Finally, **long-term maintenance** will depend on community engagement: if other cities adopt and customize the open-source code, or individual contributors pick up development, the platform can evolve without relying on a single municipal budget.

### 6.5 Impact Metrics & KPIs

To gauge success, several key indicators could be tracked. For instance, the share of residents who interact with the tool, whether in the Future Lab or via the online demo, and the frequency of their return visits would reflect citizen engagement. Another measure would be the number of council or planning documents that reference the simulation's outputs, indicating policy influence. Financial impact might be assessed by comparing consultancy costs avoided when the city uses *KemptAInability* instead of commissioning traditional traffic studies. Finally, the modelled emission and noise-reduction potential of any scenarios adopted for further planning would provide a clear environmental KPI, demonstrating real-world benefits.

### 6.6 Sustainability & Long-Term Vision

The codebase will migrate to an open-source licence, inviting community contributions and transparent auditability. AI modules can later automate tasks such as demand interpolation, anomaly detection and low-impact rerouting proposals. Ultimately the platform aims to become a plug-and-play toolkit for medium-sized cities, feeding community- or AI-optimised scenarios into Sustainable Urban Mobility Plans and fostering a pan-European practice of citizen-centric, data-smart traffic modelling.

## 7 Conclusion and Outlook

The two-year closure of Kempten's St. Mang bridge is not only an engineering project, it is a chance for citizen-centred mobility planning. *KemptAInability* demonstrates that lightweight data and open standards can turn abstract traffic numbers into a concrete, shared experience. City staff, councillors and residents can explore rerouting options, visualise impacts on $CO_2$ and noise, and discuss trade-offs on equal footing, laying the groundwork for smoother policy adoption and a more liveable city centre.

Next steps include:

- **Broader data streams**: Seasonal demand patterns and, where possible, real-time floating-car or mobile-network feeds.

- **AI-assistance**: Modules for gap-filling, anomaly detection and automated low-impact diversion suggestions.
- **Gamification**: Participants gain points for creating sustainable, efficient traffic configurations and are rewarded both visually and statistically for improvements in life quality.
- **Web deployment**: An online edition mirroring the Future-Lab installation for schools and neighbouring towns.
- **Participatory formats**: Workshops and hackathons that feed citizen or AI scenarios into Kempten's SUMP.
- **Open-source roadmap**: Phased publication of the code to build a pan-European community of practice.

In short, the bridge closure is not a crisis but a springboard. With modest resources and an open design philosophy, *KemptAInability* offers a replicable blueprint for cities that wish to turn disruptive infrastructure work into collective progress toward quieter, cleaner and smarter streets.

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