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CONNECTING THE DOTS

SMART CITY ANALYTICS
Whitepaper Findings

May 2025

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1 Introduction: Opportunities and challenges of the Smart City ICT infrastructure

$12B
2023

↓

$53B
2032

The digital transformation of urban spaces is progressing at an unprecedented pace, driven by the growing need for sustainable, efficient and connected urban infrastructures. Smart cities are at the heart of this development and promise to revolutionize life in cities through the use of intelligent technologies. In 2023, the global market for smart city ICT infrastructure reached an impressive USD 12 trillion. This market is forecast to grow to USD 53 trillion by 2032, which corresponds to a compound annual growth rate (CAGR) of 17.7 %.

Several key factors are driving this growth: increasing urbanization, government support and initiatives and the growing acceptance of digital solutions. However, despite these positive developments, there are also challenges that need to be overcome.

Source: Figures from the report "Smart City ICT Infrastructure Market, 2024-2032" by Allied Market Research, with a focus on global and regional markets, particularly North America.

Image source: www.shutterstock.com

1.1 MARKET GROWTH IN EUROPE AND GERMANY

The market for smart cities in Europe is growing rapidly and is expected to reach an annual growth rate of around 13.95% by 2032. Germany is a leading player in this area with a forecast market volume of 847 billion euros in 2026.

Source: eco, IMARC

Bildquelle: www.shutterstock.com

In May 2024, for example, around 3.24 million visitor arrivals were registered in Germany, which represents a significant increase compared to the previous month. These figures are crucial for the planning and optimization of urban services.

Source: Global Economic Data

Note

The recorded visitor numbers include both domestic and international tourists. This data is particularly relevant as it reflects seasonal fluctuations and the impact of major events and vacation periods. The continuous monitoring and analysis of these visitor flows is essential for the further development of smart cities. It enables cities to act more efficiently and respond better to the needs of their citizens and visitors.

Image source: www.shutterstock.com

1.2 TECHNOLOGICAL PRIORITIES

5G and IoT-Integration: The expansion of 5G networks will accelerate the spread of the Internet of Things (IoT) in cities. This enables real-time data transmission and promotes data-based decision-making processes in areas such as traffic management and environmental monitoring.

Artificial intelligence (AI) for urban planning: AI is increasingly being used to analyze large amounts of data in order to optimize urban planning processes, traffic management and resource allocation. This contributes to the creation of more efficient and sustainable cities.

Focus on sustainability: Smart cities are increasingly focusing on sustainable transportation solutions and the integration of renewable energies. Technologies such as solar panels and wind turbines are being integrated into urban infrastructures to reduce the carbon footprint.

1.3 VISITOR FREQUENCY AND ITS APPLICATIONS

The measurement of visitor frequency plays a central role in the development and operation of smart cities. This data is used to monitor the flow of people in urban areas, which is important for traffic management as well as for planning public facilities and services.

Traffic managemen
Visitor frequency data is used in real-time systems to optimize traffic flow and avoid congestion.

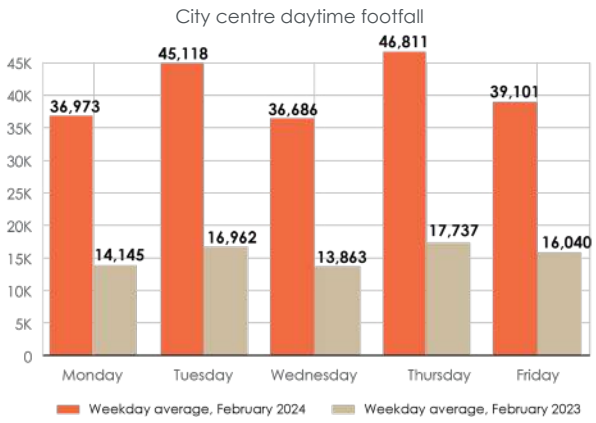
Retail analytics
Companies use this data to analyze customer flows and optimize their offers accordingly.

Urban planning
This data helps urban planners to better understand which areas are most frequented and to plan infrastructure projects accordingly.

Image source: www.shutterstock.com

1.4 CONCLUSION

The European Union and its member states continue to invest more in visitor frequency measurement technologies. These investments will increase in the coming years as cities optimize their services and infrastructure based on this data. By combining modern technologies and accurate analytics, cities can increase their efficiency and improve their service offerings.



2 Challenges in the urban environment

The complexity of urban structures requires advanced analytical tools to effectively manage and interpret data. This applies to public institutions as well as to the retail and real estate sectors, where optimizing the use of space and understanding customer flows are crucial.

2.1 MAIN PROBLEMS OR CHALLENGES

Cities around the world are facing various challenges that are intensified by increasing urbanization and the complex needs of modern societies:

Urbanization: The growing population density in urban areas places enormous demands on infrastructure and resource management. Cities need to work more efficiently to meet rising demand without harming the environment.

Functional change: The social and economic changes that have become even more dynamic in recent years. This requires local authorities to develop adaptation strategies in order to prevent vacancies and to secure or increase the attractiveness of the area. These changes also depend on local and specific framework conditions.

Traffic management: Congestion and inefficient traffic flows are the order of the day in many cities. This leads to increased CO2 emissions and reduces the quality of life for residents.

Security aspects: Monitoring and controlling crowds, especially at large events, is a major challenge for urban security.

Sustainability: The pressure to create environmentally friendly and resource-saving infrastructures is increasing. Cities need to find innovative approaches to reduce their ecological footprint.

2.2 RELEVANCE AND IMPACT OF THE CHALLENGE

These challenges have a direct impact on the quality of life in cities. Inefficient traffic management leads to congestion and increased emissions, while poor urban planning impairs the use of public spaces and resources. Security gaps can lead to dangerous situations at major events, and inadequate sustainability measures exacerbate environmental problems. It is therefore essential to find innovative solutions that specifically address these problems and support urban development in the long term.

3 Solution approach: Visitor frequency measurement and city analytics

Footfall measurement is a central component of Smart City Analytics. It enables the systematic recording and analysis of movement patterns in urban areas. Technologies such as Wi-Fi tracking, GPS data, and IoT devices can collect precise data that provides valuable insights for urban planners and decision-makers. This data is essential for planning and optimizing urban infrastructure, building management, traffic control, and the planning of major events.

Image source: www.westfalen-blatt.de/owl/bielefeld/stadt-analysiert-wie-sich-besucher-durch-die-innenstadt-bewegen-digitalisierungsbuero-cityteam-3098282?pid=true&ueg=default

3.1 TECHNOLOGICAL BASICS

Various technologies are used to carry out frequency measurements, including:

WiFi-Tracking: This technology uses the signals from mobile devices that log into a store's WiFi network to record the movements and locations of customers.

Camera systems: Cameras with image recognition software can count the number of visitors and track their movements.

Beacons and RFID technology: These systems detect signals from special tags that are either worn by customers or attached to their shopping carts.

LiDAR (Light Detection and Ranging): This technology uses laser pulses to capture three-dimensional spatial data. It enables anonymous counting and tracking of visitor flows without the use of camera images.

3.2 ARIADNE TECHNOLOGY AND METHODS

Ariadne offers an innovative technology for the detailed analysis and visualization of movement data in urban environments. The technology uses advanced algorithms and machine learning to anonymously capture the movement patterns of people and display them in precise heatmaps, dashboards and interactive maps. These analyses help cities, retailers and real estate developers to make informed decisions and use their resources efficiently.

ARIADNE'S SENSORS	EASELINK
	

Image source: www.shutterstock.com

3.3 ARIADNE'S SUCCESS IS BASED ON FOUR MAIN FACTORS

GDPR compliance / anonymous solution:

Ariadne offers a technical solution that complies with data protection regulations. Not only compliant. Anonymous solution and therefore outside GDPR.

Cost-effective solutions:

The hardware is inexpensive to purchase and easy to install. This means that even large-scale measurements are cost-effective.

High measuring accuracy:

The technology measures very accurately and avoids double measurements.

Real-time data visualization:

Real-time analysis enables cities and companies to react quickly to changes and adapt their strategies.

Image source: www.shutterstock.com

"We use advanced algorithms to precisely and anonymously research customer behavior."

Georgios Pipelidis, PhD
CEO and co-founder of Ariadne

4 Application examples in general

The integration of city analytics tools offers cities, retail companies and real estate developers numerous advantages in various areas:

Traffic management: Optimization of traffic flows and reduction of congestion through precise data analysis, particularly important during high traffic volumes and major events.

Real estate management and city marketing: Anonymized data optimizes real estate values and urban development strategies, maximizes event utilization and increases economic benefits.

- **More efficient personnel planning:**
  Frequency data enables targeted personnel planning, improves customer service and visitor satisfaction.
- **Marketing and sales strategies:**
  Analysis of frequency data optimizes advertising campaigns, increases profit through targeted measures such as push messages and the sale of movement data.

Optimization in retail: Customer flow analyses optimize the store structure, promote cross-sales and improve the customer experience.

Infrastructure planning: City Analytics supports well-founded decisions on the efficient use of resources and long-term urban development.

Security monitoring: Real-time monitoring enables rapid responses to risks and increases security in busy city centers and at major events.

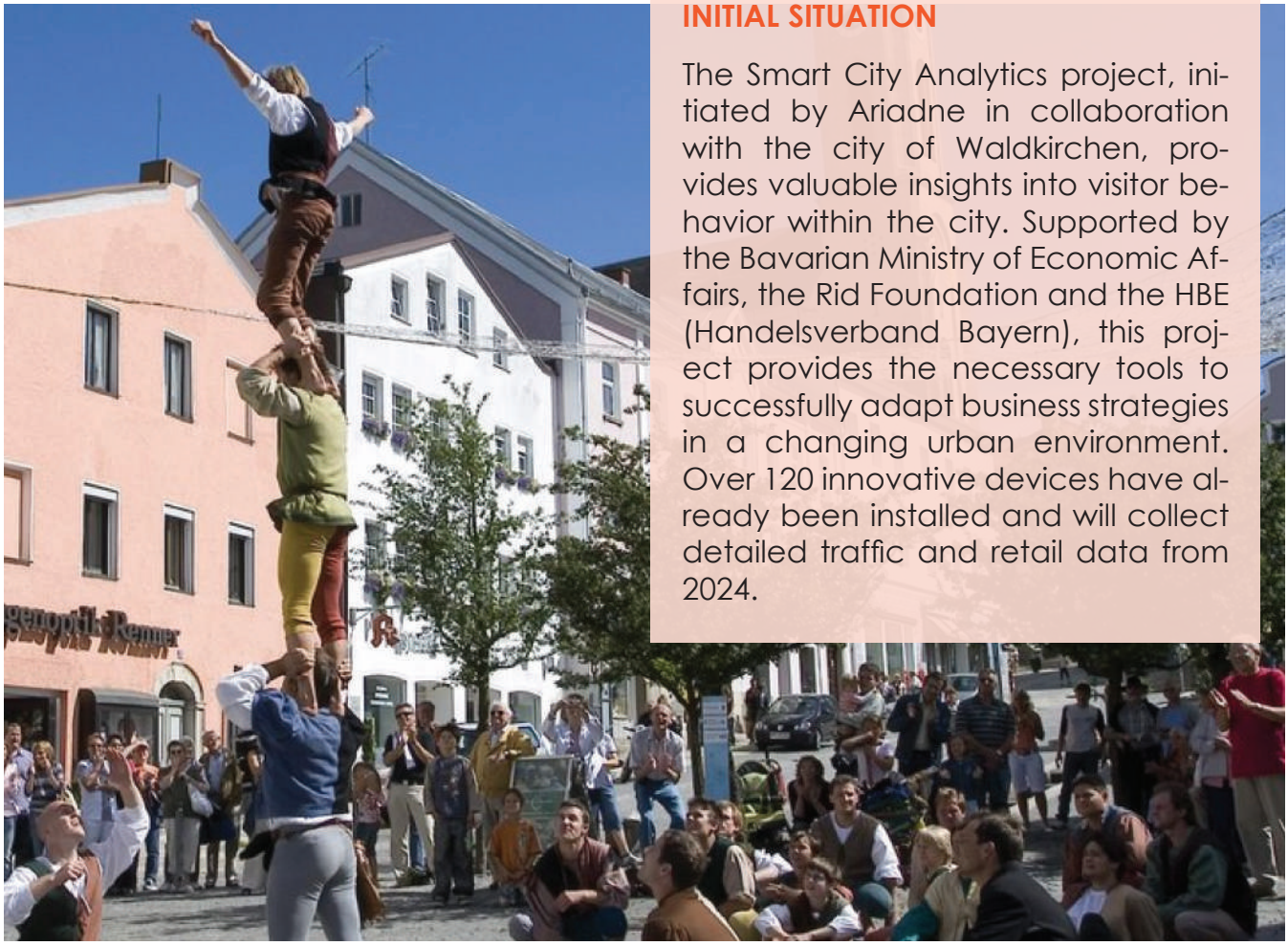
Energy and resource management: Adapting air conditioning and lighting to visitor frequency leads to energy savings and reduces operating costs, relevant for sustainable cities and companies.

5 Ariadne and partners present various application scenarios and case studies

These application scenarios examine the use of modern data analysis technologies to optimize urban planning and marketing strategies. Using case studies in cities of different sizes - from small towns such as Waldkirchen, Traunstein to major events in Frankfurt during UEFA 2024 and Madrid, Bielefeld - it shows how data-driven solutions improve visitor flows, purchasing power and economic activity. The examples illustrate the potential of these technologies to make cities smarter, safer and more economically successful.

5.1 APPLICATION EXAMPLE: SMALL TOWN OF WALDKIRCHEN

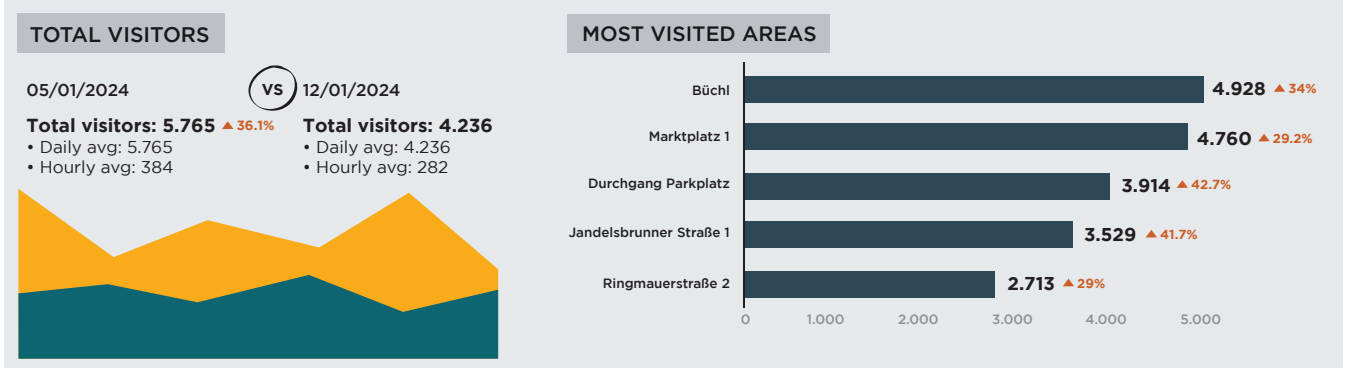
Imagine you are a retailer in the center of Waldkirchen. In recent years, you have noticed that customer frequency in your street has decreased. Thanks to the Smart City Analytics pilot project of the Bavarian Ministry of Economic Affairs, you now have valuable data on how visitors move through the town center and where they spend the most time.



INITIAL SITUATION

The Smart City Analytics project, initiated by Ariadne in collaboration with the city of Waldkirchen, provides valuable insights into visitor behavior within the city. Supported by the Bavarian Ministry of Economic Affairs, the Rid Foundation and the HBE (Handelsverband Bayern), this project provides the necessary tools to successfully adapt business strategies in a changing urban environment. Over 120 innovative devices have already been installed and will collect detailed traffic and retail data from 2024.

Image source: www.bauernhofurlaub-bayerischerwald.de/bayerischer-wald/der-bayerische-wald/attraktive-staedte-und-ortschaften/waldkirchen/



PERSPECTIVES

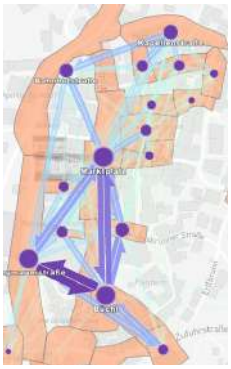
This analysis shows that most visitors prefer certain main routes and spend less time in the adjacent side streets. Based on this information, you can:

1. **Plan targeted promotions:** Knowing that most visitors prefer the high street, you could place special promotions and advertising along this main route to draw more attention to your business.
2. **Optimize product placement:** If you know that people stop at certain points more often, you could place special products or offers there to increase the length of stay and boost sales.
3. **Identify new locations:** The data could reveal that certain areas that previously received little attention are suddenly becoming more attractive. This would give you the opportunity to open new retail spaces or pop-up stores in these up-and-coming areas.

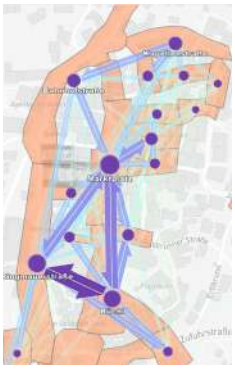
CONCLUSION

Participation in the Smart City Analytics project in Waldkirchen makes it possible to increase the attractiveness of the store and optimally adapt to the changing routes taken by visitors to the town center.

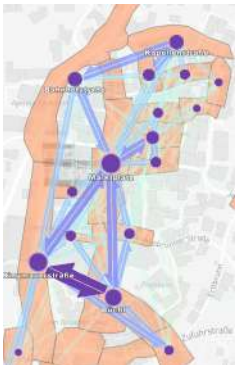
Transitions of pedestrians 09/24

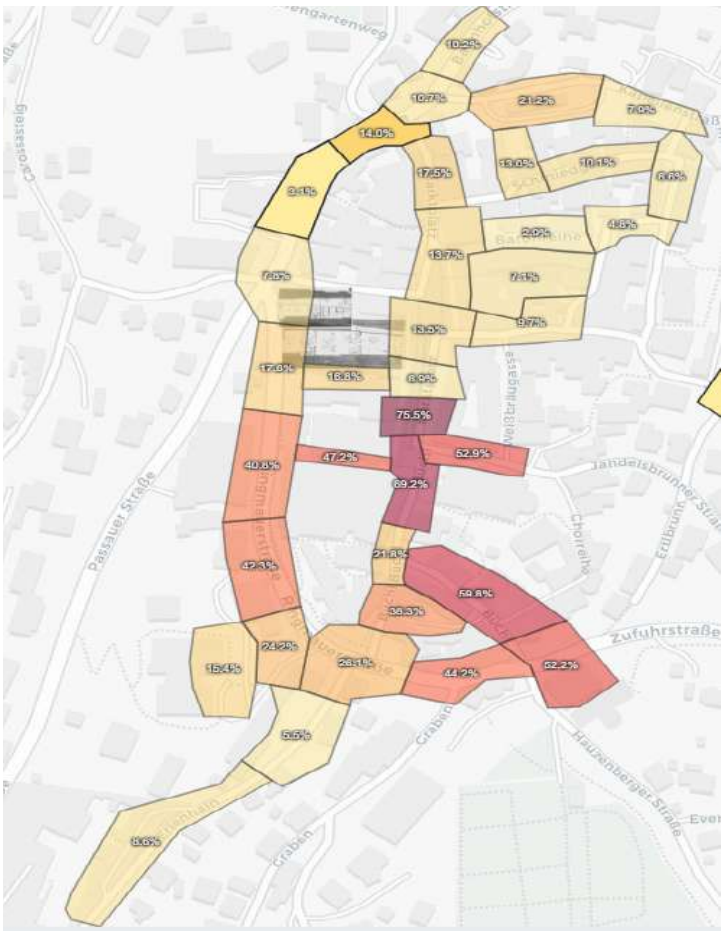


Transitions of pedestrians 10/24



Transitions of pedestrians 11/24





"The results should not only remain in Waldkirchen, but also enable a Bavaria-wide knowledge network by setting up a public project platform with exchange opportunities for all interested parties"

Michael Seidel
Partner of CIMA Beratung, Management GmbH

5.2 APPLICATION EXAMPLE: OPTIMIZATION OF URBAN EVENTS - TRAUNSTEIN, SINGEN, LEVERKUSEN

Carnival and carnival parades in cities such as Traunstein, Singen and Leverkusen are popular major events that attract thousands of visitors. To ensure safety, make optimum use of resources and fully exploit the economic potential, cities and municipalities need precise data on visitor flows, dwell times and hotspots.

COMPARATIVE ANALYSIS

On 10.02.2024, a record 42,682 visitors were recorded in Traunstein during the carnival parade, which is 5% above the January average. Maxplatz proved to be a hotspot and the length of stay increased by 14%. In Singen, the carnival parade was extremely popular with almost 93,000 visitors, especially in August-Ruf Straße. Leverkusen found that both the carnival and a Bundesliga match attracted many people, resulting in an increased number of visitors of almost 10,000 people on 10.02.2024.

SOLUTION:

Smart City Analytics from Ariadne provides comprehensive data analysis that enables cities to make informed decisions and plan events efficiently.

Image source: www.ovb-online.de/rosenheim/chiemgau/traunstein-weit-ueber-10-000-besucher-beim-faschingszug-2023-92096155.html
Image source: poppele-zunft.de/event/fasnetsumzug-in-singen/
Image source: https://rp-online.de/info/consent/

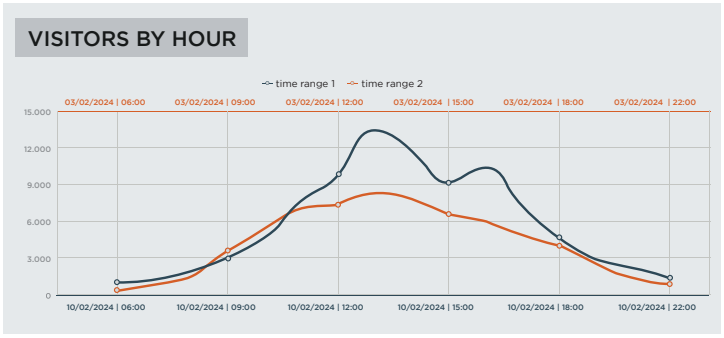
ADVANTAGES

1. **Targeted marketing strategies:** With the knowledge gained, particularly frequented areas can be specifically advertised in order to increase sales per person.

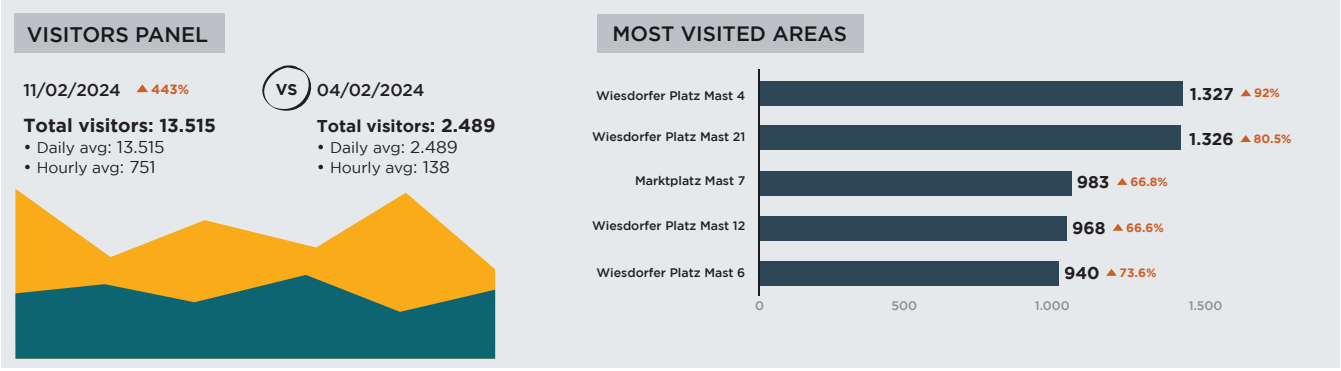
2. **Efficient use of resources:** Precise visitor counting enables the optimal allocation of staff and security personnel, which increases safety and efficiency.

3. **Improved traffic planning:** The precise analysis of visitor numbers supports cities in planning local public transport in order to better manage peak times and direct visitor flows.

Traunstein: Maxplatz as a heavily frequented square on February 10, 2024



Comparison between February 10, 2024 and February 3, 2024



Leverkusen: Comparison between February 11, 2024, and February 4, 2024. High visitor numbers due to the carnival parade

CONCLUSION

By using technology from Ariadne, Traunstein, Singen and Leverkusen were able to make their major events not only safer, but also more economically successful. This data-based decision-making demonstrates the potential of Smart City Analytics to transform the urban events of the future and promote sustainable urban development.

5.3 APPLICATION EXAMPLE: PURCHASING POWER AND ECONOMIC ANALYSES - TRAUNSTEIN AND WALDKIRCHEN

Traunstein is a large district town in the administrative district of Upper Bavaria, located about ten kilometers east of Lake Chiemsee and 15 kilometers north of the Chiemgau Alps. With an area of 48.57 km² and a population of 21,551 (as of December 31, 2023), Traunstein has developed into an important regional center. A regional center offers highly qualified and specialized services as well as high-end goods, such as universities and specialist clinics.

Image source: www.chiemsee-chiemgau.info/en/traunstein

5.3.1 RETAIL AND PURCHASING POWER ANALYSIS IN TRAUNSTEIN

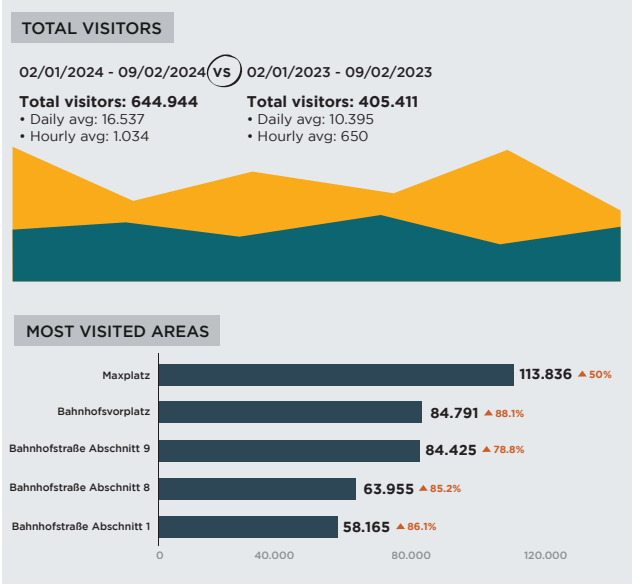
Purchasing power in Traunstein is growing continuously in line with the rising population. In 2023, retail sales reached 338.33 million euros, while retail purchasing power rose to 156.47 million euros. This corresponds to a purchasing power of 7,680 euros per inhabitant, result retail figures resulted in higher revenues for the city through taxes and duties, which increased the administrative budget to 69.3 million euros and the capital budget to 27.72 million euros in 2023.

Image source: www.treffpunktdeutschland.de/events-item/bayern-traunstein-kultsommer

SOLUTION USE

By using Ariadne's technology, it is possible for the first time to analyze, based on data, where people spend time in the city and which areas are most frequented. These insights are particularly valuable for city marketing, as they help to understand precisely where most visitors spend their time as retail sales increase.

One example of the use of this technology is the creation of heat maps that show where most potential customers are located. This data enables the city to target its marketing strategies to the most frequented areas. Another useful tool is the Sankey diagram, which shows the flow of visitors from the city center (Maxplatz) and allows conclusions to be drawn about retail sales.



Traunstein 10.02.2025

Image source: www.treffpunktdeutschland.de/events-item/bayern-traunstein-kultsommer

5.3.2 EVENT ANALYSIS IN WALDKIRCHEN

Waldkirchen, a town in south-eastern Bavaria near the border with the Czech Republic, is the youngest town in the Lower Bavarian district of Freyung-Grafenau. With an area of 48.57 km² and around 11,221 inhabitants, Waldkirchen has seen a steady population growth of 2.2% compared to the previous year.

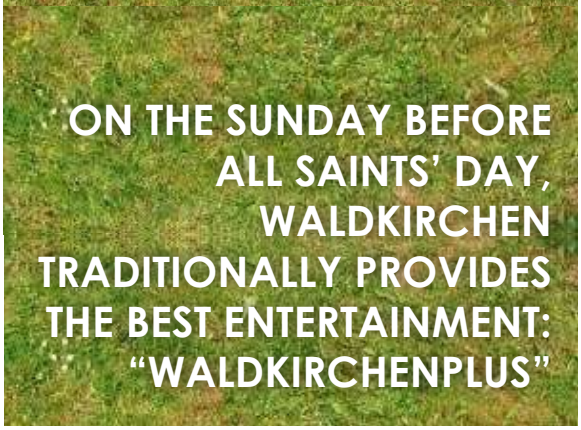


Image source: www.pnp.de/lokales/landkreis-freyung-grafenau/waldkirchen-laedt-zum-action-triathlon-14648823

INITIAL SITUATION

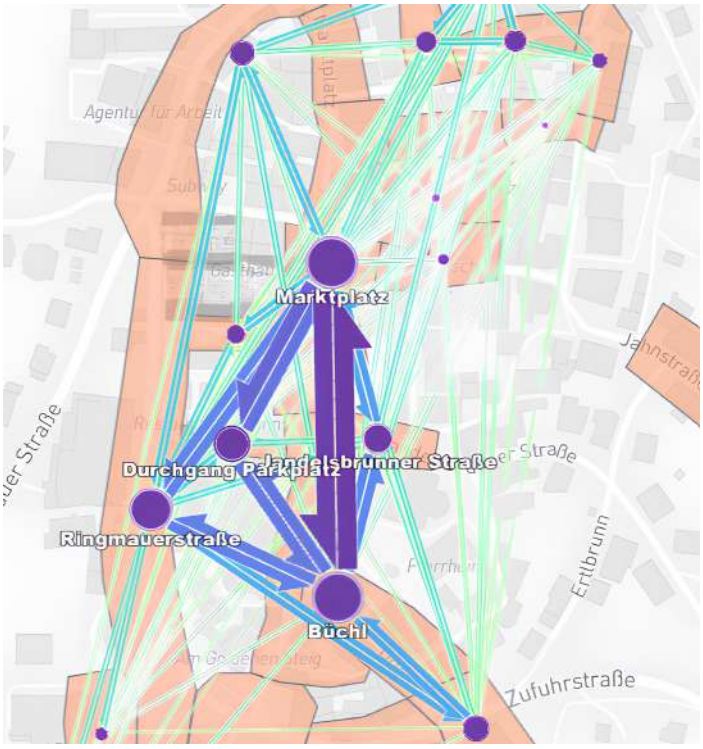
On October 29, 2023, Waldkirchen hosted a special event that began at 10 a.m. with a large market on the market square. From 12 noon to 5 p.m., numerous stores opened their doors to turn Sunday shopping into a relaxed shopping experience. In addition to the shopping experience, visitors could look forward to a varied program for the whole family. The focus was on the Waldkirchen Action Triathlon, in which participants could compete in various disciplines.

SOLUTION

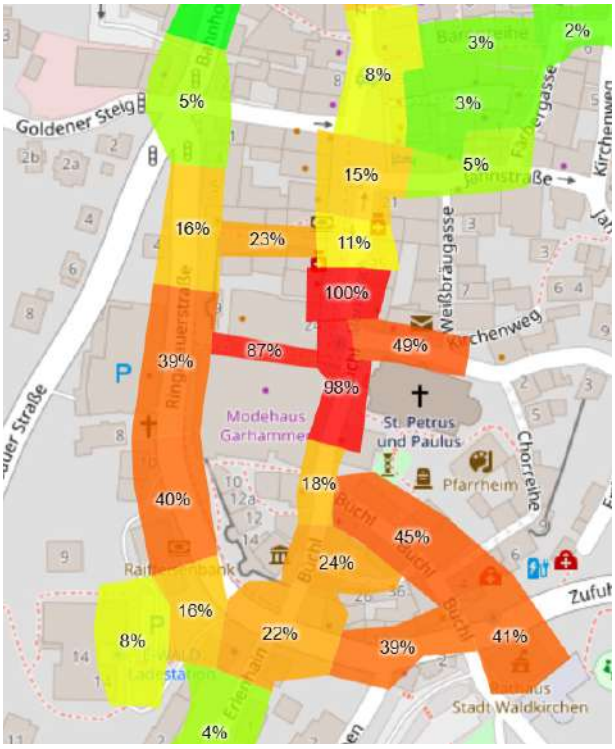
In order to measure the impact and success of this event, Ariadne carried out frequency measurements. These measurements showed that a total of 3,658 visitors came to the city on Sunday, which corresponds to an increase of 336% compared to an average Sunday.

In addition, the data collected enabled a detailed analysis of visitor flows and peak times. This made it possible to identify the times when visitor numbers were at their highest, which helped to take measures to better manage the volume of visitors, such as additional parking facilities or increased security measures.

Another interesting result of the analysis was that 43% of visitors stayed in the city for longer than 30 minutes on Sunday when it was open for business. This longer dwell time indicates that the range of activities and the shopping experience were attractive and varied enough to keep visitors for longer.



Waldkirchen Area Transitions, March 23. 2024



Areas Visitors Heatmap, March 23. 2024

CONCLUSION

A comparison of purchasing power and visitor flows shows that Traunstein benefits from steady retail sales and well thought-out urban planning, while the example of Waldkirchen shows how targeted events can provide a significant economic boost. The detailed analyses of visitor flows and the economic impact of events in Waldkirchen illustrate how important precise and data-based event planning can be for smaller towns.

5.4 APPLICATION EXAMPLE: EVENT AND VISITOR ANALYSES IN LÖRRACH

Lörrach, a town in south-western Baden-Württemberg near the border with Switzerland, is known for its lively event scene. With a population of around 50,000 people and its location in the border triangle, Lörrach regularly attracts visitors from Germany, Switzerland and France, especially during vacation periods and major events.

VACATION PERIOD COMPARISON IN LÖRRACH

The city administration of Lörrach uses detailed data analyses to assess the impact of vacation periods and events on visitor flows and the local economy. A comparison of weeks with and without vacations shows that visitor numbers increased significantly during the summer vacations (July 27, 2023 to September 10, 2023) and autumn vacations (October 28, 2023 to November 5, 2023).

Image source: www.bernerzeitung.ch/mitten-in-der-ohrenbetaeubenden-gugge-explosion-631449570013

OPTIMIZATION THROUGH DATA ANALYSIS

The analysis of visitor flows enabled the city administration to take targeted measures to better manage the infrastructure and services during peak times. This included increasing the number of security staff, additional parking facilities and improved management of public transport.

Another important aspect was the length of time visitors spent in the city center. During the carnival, particularly at the "Gugge-Explosion" event, it was found that around 43% of visitors stayed in the city center for longer than 30 minutes.

5.5 PEDESTRIAN FREQUENCY MEASUREMENT IN BIELEFELD

Cities around the world are facing the challenge of making their city centers more attractive and livable. Bielefeld has taken on this task with an innovative solution: pedestrian frequency measurement. By installing around 100 sensors in the city center and old town, the city collects valuable data that helps to understand people's movement patterns and make targeted improvements.

Image source: www.westfalen-blatt.de/owl/bielefeld/stadt-analysiert-wie-sich-besucher-durch-die-innenstadt-bewegen-digitalisierungsbuero-cityteam-3098282?pid=true&ueg=default

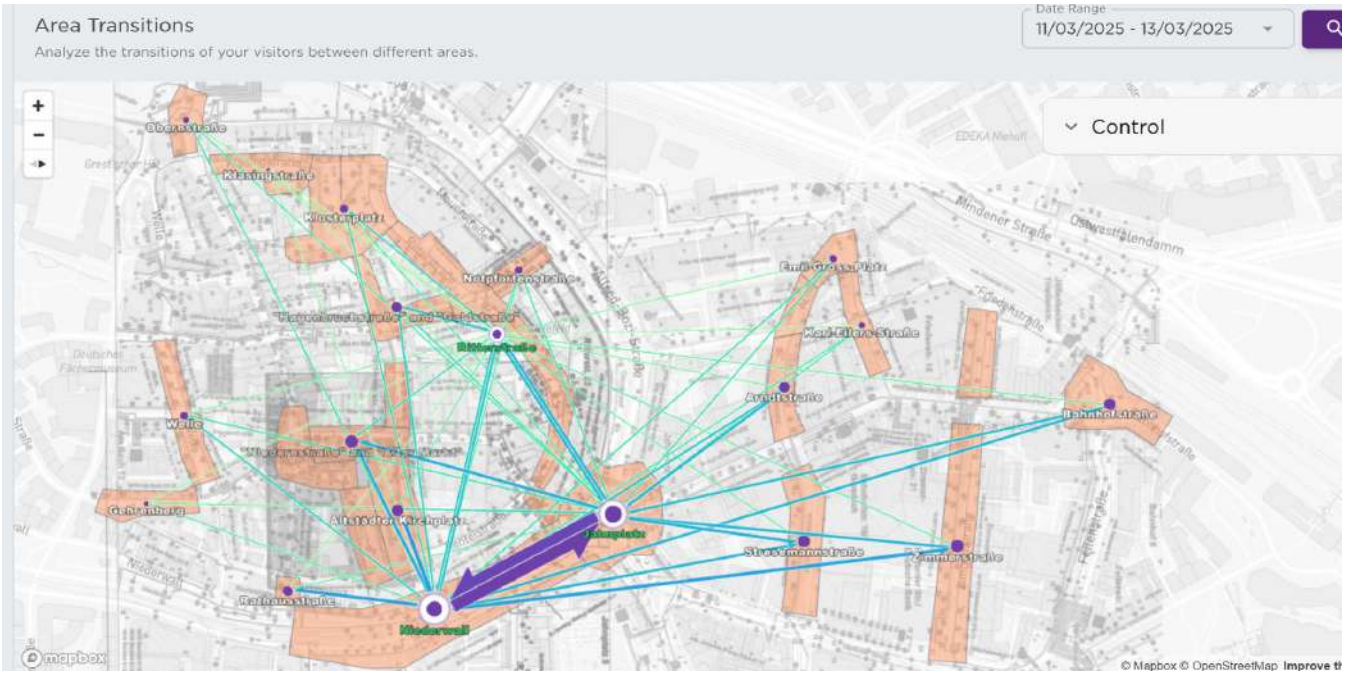
CHALLENGE

Bielefeld's city centre attracts thousands of visitors every day, but which areas are particularly popular and where is there potential for optimization? To answer these questions, it was necessary to collect accurate and comprehensive data on the behavior of passers-by. Traditional methods such as manual counts or surveys provided only limited insights and could not adequately map the dynamic movements of people.

SOLUTION

The digitalization office of the city of Bielefeld, in close cooperation with the city team and other municipal offices, decided to use a modern pedestrian frequency measurement system. Sensors were installed on lampposts in strategic areas of the city center. These sensors record anonymized cell phone signals and enable a detailed analysis of movement patterns.

Image source: www.westfalen-blatt.de/owl/bielefeld/stadt-analysiert-wie-sich-besucher-durch-die-innenstadt-bewegen-digitalisierungsbuero-cityteam-3098282?pid=true&ueg=default



"Personal data is not collected, which underscores the high priority given to data protection. The technology records which routes passersby take, where they spend longer, and which places are less frequented. This allows targeted measures to be taken to improve the quality of stay."

Desirée Lukowski
Citymanagement | WEGE Wirtschaftsförderung of Bielefeld

> "The system was installed for an 18-month test phase and has already sparked interest beyond the city limits. Cities like Munich are closely monitoring the Bielefeld initiative with a view to potentially implementing similar projects."
>
> **Tatjana Dzepina**
> Project Manager Smart City | Open Innovation City Bielefeld

RESULTS

The data collected by the sensors provides a wide range of insights:

1. **Attractiveness analysis of areas:** The data shows which places in the city centre, such as the Alter Markt or Stresemannstrasse, are particularly popular and where there is a need for optimization.

2. **Event planning:** The movement patterns during events, such as the upcoming wine market, can be analyzed to optimize the organization and placement of stands.

3. **Traffic and urban planning:** Insights into people's movements are incorporated into the planning of traffic projects to improve the flow in the city.

Image source: www.expedia.com/Bielefeld.dx6341

CONCLUSION

Bielefeld shows how modern technologies for pedestrian frequency measurement can be used to make a city center smarter, more attractive and more liveable. The results of the measurements offer valuable insights for city planners, retailers and event organizers and help to make Bielefeld's city center fit for the future.

5.6 OPTIMIZATION OF CENTER MANAGEMENT AND PROPERTY VALUATION

The real estate market is currently facing considerable challenges, which are being exacerbated by rising interest rates, high construction costs and long-term changes such as the decline in retail space. The hospitality industry is also under pressure, exacerbated by falling demand as a result of inflation. These factors are leading to a high level of uncertainty in the market. Traditionally, many decisions in center management and property valuation have been based on experience. However, in times of rapid market changes and changing consumer behavior, these empirical values are increasingly less reliable. It is clear that well-founded decisions must be based on current figures and data.

> "Ariadne's ability to provide detailed and precise data in real time has revolutionized our management and strengthened our negotiating position."
>
> **Mario Zanolli**
> CEO of Völkel Real Estate Berlin

SOLUTION APPLICATION

The innovative and patented Ariadne technology offers decisive advantages here:

- **Data protection compliance:** The anonymity of the data, which has been confirmed by German authorities, even allows the technology to be used in public spaces in German cities.
- **Comprehensive data collection in real time:** Ariadne achieves an accuracy of over 90 %, which enables a detailed analysis of visitor flows and customer behavior.
- **Cost benefits:** The simple and flexible installation of the hardware and the relatively low hardware costs make the technology particularly economical.

Image source: www.shutterstock.com

USE OF TECHNOLOGY AND EXAMPLES

Ariadne captures anonymous antenna signals from mobile devices and can track them precisely through triangulation. With user consent (opt-in), personal data can also be recorded, which enables in-depth analysis and long-term evaluation of customer loyalty (frequency of visits and occasions).

The technology offers numerous applications that significantly improve center management and property valuation:

- **Optimization of center management:** Ariadne enables dynamic reporting and the targeted development of new target groups. Event controlling and the optimization of areas such as facility management (e.g. toilet usage) are supported by precise data.
- **Location-based marketing:** By linking location data, targeted marketing campaigns can be carried out to optimize the customer approach.
- **Optimization of letting:** Ariadne supports the analysis of linkages between tenants, the evaluation of anchor tenants and the analysis of capture rates of different space concepts. This improves the negotiating position for rental agreements and facilitates the acquisition of new rental concepts as well as the better allocation of space.
- **Valuation of properties:** Comparing assets and valuing them based on the future viability of the tenant mix creates a more sound basis for decision-making.
- **Long-term strategies:** The introduction of frequency rents and the optimization of the tenant mix for existing and new business are supported by continuous data collection and analysis.

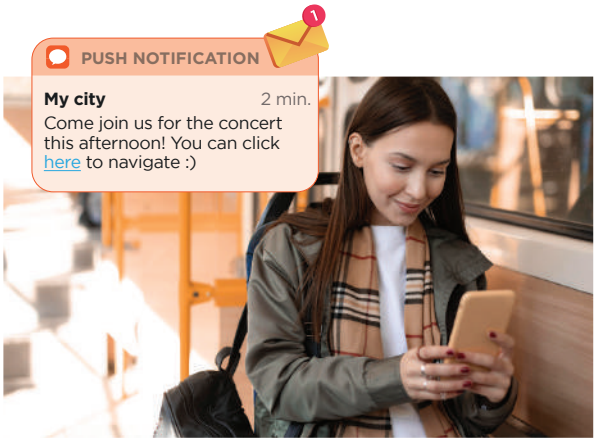


Image source: www.shutterstock.com

CONCLUSION

The implementation of Ariadne technology in urban shopping centers made it possible to record detailed movement data, which led to an optimization of rental contracts and space utilization. Despite stable visitor numbers, profitability was increased through the introduction of frequency-based rental models and targeted marketing strategies. This shows how precise data analysis can make a decisive contribution to reducing fluctuation rates and increasing efficiency in center management.

5.7 REAL-TIME VISITOR FREQUENCY MEASUREMENT UEFA EURO 2024 IN FRANKFURT

UEFA EURO 2024 is not only a sporting highlight, but also an example of the use of modern technology for visitor management. In Frankfurt, one of the host cities, an advanced visitor frequency measurement solution with Ariadne technology was used during the tournament to record and display real-time data on visitor flows in the fan zone on the banks of the Main. This project was carried out by partners ekom21 and [ui!]. This case study highlights the successful implementation and benefits of this technology, which will be invaluable not only during EURO 2024 but also for future events.

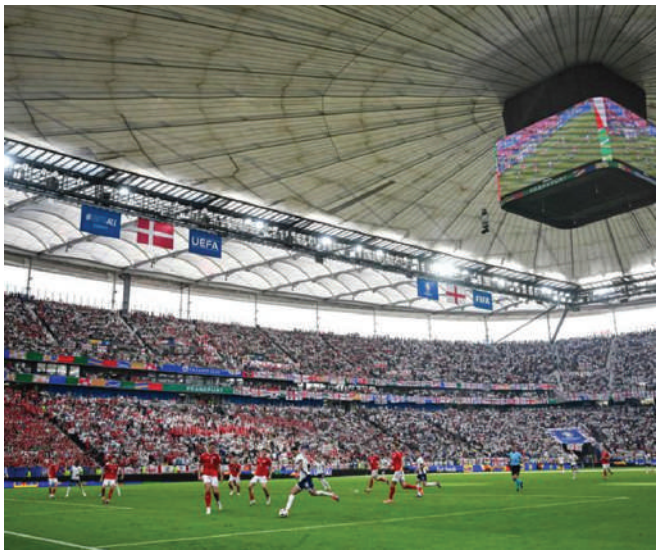


Image source: english.ahram.org.eg/News/525785.aspx

INITIAL SITUATION

Frankfurt, as one of the most internationally connected cities, attracts a large number of visitors, especially during major events such as the UEFA EURO 2024. To optimize security and the visitor experience, an effective solution was needed to monitor and control visitor flows in real time. This challenge was met by implementing a comprehensive visitor frequency measurement solution from Ariadne, supported by partners ekom21 and [ui!].

TECHNOLOGICAL APPROACH

Ariadne offers an innovative technology for visitor frequency measurement that has been integrated into Frankfurt's Urban Data Platform (UDP). This platform, which has been in operation since October 2022, acts as the digital heart of the city by collecting, processing and visualizing urban data. A new use case was added to the UDP for UEFA EURO 2024: real-time measurement of visitor flows in the Mainufer fan zone. Here, 35 sensors were installed along the 1.4-kilometer-long zone to record precise data on visitor numbers and movements. Using an intuitive traffic light system, fans were able to see at a glance how busy the respective areas were and whether they were worth a visit.

PARTNERS AND COOPERATION

- **ekom21 (www.ekom21.de):** As the largest municipal IT service provider in Hesse and one of the leading providers in Germany, ekom21 facilitated the technical implementation and integration of the solution into the existing municipal IT infrastructure. The company plays a central role in the digitalization of municipal administrative processes and makes a significant contribution to the modernization of public administration in Hesse.
- **[ui!] Urban Software Institute (www.ui.city):** [ui!] is a leading global provider of smart city solutions and has contributed its expertise in the development and implementation of the Urban Data Platform (UDP). By providing the open urban data platform [ui!] UrbanPulse, [ui!] was able to ensure that the collected data is efficiently processed and visualized. This technology is also used in other urban infrastructures such as street lighting and traffic situations.

ADVANTAGES AND ADDED VALUE:

1. **Real-time data for visitor control:** Thanks to Ariadne's solution and the support of ekom21 and [ui!], visitor flows in the fan zone could be monitored in real time. This enabled a rapid response to overcrowding and contributed to improved safety and visitor satisfaction.
2. **Optimization of future events:** In addition to real-time analysis, the solution provides valuable data for follow-up. Route analyses, dwell times and area frequencies provide important insights for planning and implementing future events more efficiently.
3. **Wide range of applications:** Ariadne's technology is not only used at major events such as the UEFA EURO 2024. It is also used in shopping centers, in retail, at airports and in several smart cities in Germany to optimize the customer journey and improve the use of urban infrastructure.

"I am pleased about the practical benefits of digitalization for citizens."

Eileen O'Sullivan
City Councillor and Head of Digitalization

"The immense relevance of UEFA EURO 2024 for Frankfurt and the region is expected to attract around one million visitors."

Thomas Feda
Managing Director of TCF

CONCLUSION

The implementation of Ariadne's visitor frequency measurement solution for the UEFA EURO 2024 in Frankfurt, supported by partners ekom21 and [ui!], is an outstanding example of how modern technology can contribute to the optimization of major events. The real-time data enables effective visitor management and at the same time provides valuable insights for future events.

5.8 PEOPLE FREQUENCY MEASUREMENT AND CAMPAIGN MANAGEMENT IN MADRID

The city of Madrid faced the challenge of efficiently managing its traffic flows and targeting advertising campaigns to improve both the infrastructure and the customer experience. In collaboration with technology partners Appcelerate and Ariadne, advanced people counting methods and digital advertising strategies are being used to achieve these goals at key transportation hubs.

INITIAL SITUATION

Madrid is a vibrant metropolis with a high volume of visitors, especially at important transportation hubs such as Plaza Elíptica or the Moncloa area. These locations are not only crucial for traffic, but also for the placement of advertising measures that need to be targeted at different demographic groups. The challenge is to effectively manage the flow of people and maximize the impact of advertising campaigns through precise data analysis.

Image source: commons.wikimedia.org/wiki/File:Plaza_Moncloa.jpg

TECHNOLOGICAL APPROACH

The technology used is based on Ariadne's real-time recording of people flows, which makes it possible to analyze detailed movement patterns and dwell times. This data is seamlessly integrated into Appcelerate's platform, which uses artificial intelligence to transform the collected information into actionable insights. This allows advertising campaigns to be adjusted in real time and maximize their effectiveness. Particularly in locations such as the Moncloa urban area, digital advertising content is targeted and continuously optimized to achieve the greatest possible reach and impact.

PARTNER

Appcelerate uses Ariadne technology to introduce campaign management in Madrid through people flow measurement. Appcelerate specializes in platforms that integrate data analytics, artificial intelligence and creative advertising solutions, while Ariadne provides high-precision people flow measurement and analysis technologies. Together, they enable real-time analysis of movement patterns and dwell times to make informed decisions for infrastructure planning and advertising campaign optimization.

APPLICATION AND BENEFITS IN THE MONCLOA URBAN AREA

The Moncloa urban area benefited greatly from the integration of frequency measurement using Ariadne technologies. The precise recording and analysis of the flow of people made it possible to achieve several advantages:

- **Improve punctuality and efficiency:** The real-time recording of passenger flows made it possible to optimize train departures and arrival times, which led to an overall improvement in punctuality.
- **Optimization of personnel planning:** Based on the measured frequencies, peak times could be better predicted and personnel could be deployed more efficiently.
- **Targeted advertising placement:** The measured visitor numbers in outdoor and indoor areas were enriched with data on main user groups, social stratification and advertising contact rates. By analyzing daily passenger flows, the operators were not only able to optimize traffic flows and staff deployment planning, but also place advertising efficiently. Digital screens were placed in high-traffic areas to precisely reach target groups and maximize advertising exposure rates.
- **Optimization of advertising strategy:** Based on the data collected, advertising content could be adapted to achieve the highest possible impact by targeting specific demographic groups.
- **Improving the infrastructure:** Analyzing the flow of people helped to identify bottlenecks and efficiently distribute the flow of people, which improved the overall infrastructure in Moncloa.
- **Increased customer satisfaction:** The optimized routing and shorter waiting times as a result of these measures led to a better user experience for locals and tourists.

peopleMetrics
Indoor Location Analytics

granpantalla

Medición | Moncloa

Datos Outdoor

Usuarios Outdoor
2.565.709

Cobertura Outdoor
19,00 %

Usuarios Unicos Outdoor
2.565.709

Turistas Outdoor
1.303.393

Impactos OOH
32.395.813

Frecuencia Outdoor
13

Datos Indoor

Usuarios Indoor
5.282.703

Cobertura Indoor
33,00 %

Usuarios Unicos Indoor
4.477.020

Turistas Indoor
2.274.349

Impactos Indoor
36.479.887

Frecuencia Indoor
8

Moncloa

CONCLUSION

Overall, the example from Moncloa shows how the use of state-of-the-art technology has significantly increased both the efficiency of traffic management and the effectiveness of advertising campaigns. The implementation of this technology not only led to more efficient use of resources, but also to higher user satisfaction and stronger brand building for advertisers. This partnership and technology application offers significant added value for the long-term planning and optimization of traffic and advertising strategies in Madrid.

6 Ariadne technology implementation and challenges

The implementation of Smart City Analytics in these cities has led to significant improvements in urban infrastructure, increased sales in retail and hospitality, and improved the quality of life of citizens. The projects demonstrate that the use of real-time data and precise movement analytics enables cities to operate more efficiently, optimally utilize resources, and better meet the needs of their residents and businesses.

6.1 STEPS FOR IMPLEMENTING THE ARIADNE SOLUTION

The implementation of Ariadne's technologies requires seamless integration into existing urban information systems. The following steps are crucial:

1. **Inventory:** Analysis of the existing infrastructure and identification of areas that would benefit from visitor frequency measurement.
2. **Installing the hardware:** Setting up the Ariadne sensors for recording movement data.
3. **Software customization:** Creation of a new Ariadne dashboard and if required setup of API for integration of already existing software solutions
4. **Training:** Training municipal employees in the use of the new tools and data to ensure that they can use them effectively.
5. **Pilot phase:** Test run of the systems in a selected district or at an event to check the functionality and accuracy of the data.
6. **Scaling:** After a successful pilot phase, the technology is rolled out to the entire city or additional areas.

6.2 CHALLENGES AND POSSIBLE SOLUTIONS

Various challenges can arise during implementation, including:

- **Data protection:** The collection and processing of large volumes of transaction data must comply with the strict requirements of the General Data Protection Regulation (GDPR). The data collected by Ariadne is anonymized and contains no personal information. This has been confirmed by German data protection authorities.
- **Data quality:** The accuracy and reliability of the collected data is crucial for the quality of the analyses. The use of sophisticated sensors and AI-based algorithms ensures that the data collected is precise and meaningful.
- **Integration into existing systems:** Integrating new data sources into existing urban information systems can be complex. Ariadne offers flexible interfaces and APIs that enable smooth integration.
- **Costs:** The implementation of such technologies can be costly. Through targeted pilot projects and a gradual introduction, cities can spread the costs and maximize the return on investment.

PHONE
Everyone carries a smartphone.

SIGNALS
Every phone is emitting signals.
Even in airplane mode!

DEVICE
Ariadne's surveyors sense such signals.
No opt-in required!

DISTANCE
Ariadne's platform understands the distance to each signal.
Up to 30cm accuracy!

LOCATION
Ariadne's platform determines the exact location and journey of each signal, **in real-time!**

7 Future developments and trends

7.1 TECHNOLOGISCHE WEITERENTWICKLUNGEN

The continuous development of technologies, particularly in the field of artificial intelligence and big data, will open up new opportunities for optimizing urban processes in the coming years. For example, the integration of 5G networks and IoT devices could further improve the real-time processing of movement data. The development of edge computing technologies will also make it possible to process data directly at the source, which will further reduce response times.

Image source: www.shutterstock.com

7.2 POTENTIAL FOR FUTURE APPLICATIONS

Future applications could enable even more detailed analyses and an even better adaptation of urban infrastructures to the needs of citizens and their businesses. The combination of movement data with other data sources, such as weather data or socio-economic information, could provide even deeper insights into the behavior and needs of city dwellers. Integration into areas such as healthcare, environmental monitoring or education is also conceivable and offers great potential for future developments.

8 Conclusion

8.1 SUMMARY OF THE MOST IMPORTANT RESULTS

Visitor frequency measurement and Smart City Analytics are indispensable tools for modern urban development. They offer cities the opportunity to use their resources more efficiently, improve the quality of life of their residents and reduce environmental pollution at the same time. By implementing these technologies, cities can not only increase their efficiency, but also better prepare for future challenges.

8.2 OUTLOOK AND RECOMMENDATIONS FOR THE FUTURE

For successful implementation, cities should continue to invest in innovative technologies and work closely with technology partners such as Ariadne. The continuous development and adaptation of the systems used to the specific needs of cities is crucial to successfully mastering the challenges of the future. In addition, cities should promote the exchange of best practices and learn from each other in order to fully exploit the benefits of Smart City Analytics.

Image source: www.boomermagazine.com/small-town-munich-germanys-biggest-village/

9 About us

COMPANY DESCRIPTION ARIADNE

Ariadne is an innovative company that was founded in Munich, Germany, in 2019. Its origins lie in doctoral studies at the Technical University of Munich. Ariadne is dedicated to transforming the physical world of retail through advanced data and analytics solutions. Despite the boom in online retail, 80% of sales still take place offline, and this is where Ariadne comes in. We equip brick-and-mortar businesses with the same data and analytics that online businesses take for granted, enabling them to interact with their customers both online and offline at the right moment.

Using state-of-the-art AI systems and in-depth, privacy-protected analytics, we accurately assess people flows. Our solutions provide both the private and public sectors with data-driven, actionable insights and information. We track and visualize customer behavior, understand revenue drivers and take targeted actions, such as placing advertising messages, providing indoor navigation and optimizing product placement to drive cross-sales.

Our team of experts consists of executive engineers, managers and scientists. Together, we drive the digitalization of physical companies to adapt them to modern retail requirements and enable them to sustainably improve their business.

POSSIBLE FURTHER INDUSTRY APPLICATIONS

Retail and shopping centers:
By recording visitor frequencies, dwell times and customer journeys, retailers and shopping centers can optimize their use of space, improve brand positioning and develop targeted marketing measures.

Food retail and supermarkets:
Smart analytics can be used here to optimize product placements, monitor customer flows and adjust staff planning. This is also particularly useful for A/B testing layouts and promotions.

Airports and transportation hubs:
The technology can be used to analyze passenger flows, reduce waiting times and increase the efficiency of service facilities. In addition, marketing measures and special promotions can be specifically controlled and adapted.

Urban planning and public facilities:
The technology can help monitor the movement of crowds in urban areas or at large events to improve safety and comfort measures.

Amusement and theme parks:
By analyzing visitor patterns, operators can better position attractions, optimize queue management and control targeted advertising campaigns.

Bildquellen: www.shutterstock.com

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