

### 4.3 Bad Birnbach Autonomous Shuttle (DE)

**Autonomous shuttle service** operated in the rural area of Bad Birnbach in Bavaria federal state (Germany), operated by two autonomous vehicles. The service acts as **feeder between the railway station and the main points of interest** in Bad Birnbach

<p>Integration with Public Transport</p>	<p>Innovative technology</p>	<p>Long-term durability</p>
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#### 4.3.1 About Landshut Area, Germany

<u>Country</u>	<u>Region</u>	<u>Target Area</u>	<u>Population</u>	<u>Population density</u>	<u>Visitors/year</u>
Germany	Landshut area	68,81 Km <sup>2</sup>	5.803 inh (2021).	84 inh./Km <sup>2</sup>	591.358 overnight stays (2019)

Bad Birnbach is a small municipality about 43 km south-west from Passau in the district of Rottal-Inn and located in a rural area of Landshut (one of the 18 regions of Bavaria federal State in Germany), became famous with the opening of the Rottal Terme in 1976. This also led to the construction of numerous hotel complexes and flats. As a result, tourism became the largest economic factor in the town.

From an economic perspective, the topic of autonomous driving is of the utmost importance. Autonomous driving makes it possible to connect rural areas to public transport, which often could not be realised in the past for cost reasons. In this way, autonomous public transport not only enables young people or older people to have more personal mobility, but also contributes to provide a concrete mobility option in rural areas.



Figure 65 – Bad Birnbach site

The aim is to open up routes that have not yet been profitable for public transport and where there are therefore only a few connections a day, if any.

#### 4.3.2 Description of the Mobility Solution

The implemented sustainable mobility solution is an autonomous shuttle service operated in the rural area of Bad Birnbach. The service was started as a pilot project in October 2017 with one electric minibus of the start-up EasyMile on a 700-meter-long route from the local market square to the Rottal Terme. After the first year, the service was extended with the addition of another stop and another electric vehicle. The services carried out with the two autonomous vehicles act as feeder services between the railway station and the main points of interest in Bad Birnbach. Since May 2022, two autonomous shuttles drive additionally to 20

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stops on demand. The project was developed as a cooperation of Deutsche Bahn and DB Regio Bus Ostbayern with the district of Rottal-Inn and the municipality of Bad Birnbach. The shuttle service is now under the responsibility of the new DB business unit named “ioki” and is operated by the DB subsidiary DB Regio Bus Ostbayern.

The practical objective of the good practice is to offer a safe, affordable and innovative transport service between the railway station, the thermal baths and the local market square and overcome the problems linked to the last mile connections. The high-level objective consists in testing the potential of an autonomous shuttle service for the first/last mile operation in a small rural area.

Target user groups and needs

The autonomous shuttle improves mobility between the train station and the city centre, brings tourists and locals to health facilities as well as to shops for daily needs. The vehicles are equipped with a mini ramp. Target users are mostly elderly people (residents or tourists).

In the first project phase, an average of only 60 passengers used the shuttle per day. Among them were many tourists who naturally just wanted to try out the service. The shuttle only became an attraction for locals when the train station was also served in 2019.

Involved Bodies

The project was developed by the Deutsche Bahn in collaboration with the district of Rottal-Inn and the small municipality of Bad Birnbach, and in close cooperation with the company EasyMile and TÜV Süd, a company specialised in technology testing and certification. In addition, scientific support for the project was provided by various Bavarian colleges and universities as well as by DB Regio. Bodies involved under State level are the government of Lower Bavaria, the government of Upper Palatinate, the Bavarian State Ministry of the Interior and for Integration as well as the Bavarian State Ministry of Housing, Construction and Transport.

Mobility services provided/addressed

The service was firstly launched with one electric minibus. The shuttle route was approximately 700 m long from the local market square to the thermal bath, with only two stops. In mid-March 2018, another vehicle was added; in August 2018, the distance was doubled from 700 meters to 1,400 meters with a new stop, close to the rail station. Currently two vehicles are traveling alternately on the route where four stops are available: Neuer Marktplatz, Artrium, Rottal Terme and Badstraße.

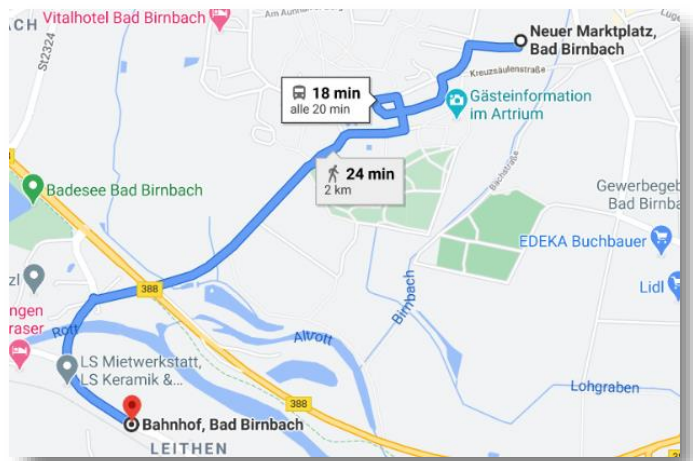


Figure 66 - Route covered by the service

Each vehicle has six seats and six standing places and is equipped with mini-ramps for people in wheelchairs. The maximum speed is limited to 18 km/h in Bad Birnbach. The service is available all weekdays from 8:00 am till 6:00 pm. An onboard assistant is always available who can intervene in an emergency case (for legal reasons).

The service is free of charge for residents and tourists. For safety reasons, the bus does not operate in extreme weather conditions, for example during storms or heavy rain. EasyMile offers an autonomous means

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of transport which includes the driverless vehicle, autonomous driving software, fleet management system as well as remote control centre. The solution implemented in Bad Birnbach is innovative in the fact that the vehicles are not in a controlled environment but in an open public area. Before the pandemic, an average of 120 people a day travelled autonomously on the approximately 2.6-kilometre route. More than 65,000 passengers have travelled the route so far. Since then, the buses have covered around 60,000 kilometres.

Ridership and other key metrics/results

The service is used by tourists and residents between the train station and the city centre. The service has been commonly recognised as green and safe from the residents of Bad Birnbach. Local interviews showed that the bus service has become part of everyday mobility. Users can pre-order the on-demand service by phone or app. They are therefore dependent on a mobile phone or telephone. The app is constantly being improved to make it even more user-friendly.

An acceptance study among the local population concludes that curiosity was named as the main reason for using the shuttle bus, followed by interest in the technology and the correspondence of the route with one's own destination. The bus was appreciated for its positive contribution to the preservation of the environment, its flexibility of use in public transport and the creation of "borderless" access to mobility, also for senior citizens and the disabled. The low range and speed were decisive for people not (yet) to use the bus. The respondents are skeptical that autonomous shuttle buses can replace conventional public transport systems or that autonomously controlled vehicles can increase safety.

Supporting technologies

The vehicles are fully electric, with 8 kWh Lithium ion 48V tension battery, an autonomy of around 14 hours and with 7-hour charging time on average. The shuttle follows automatically a predefined fixed route. The lidars (technology to assess distance to objects) connected to the on-board computer analyse the effective path and allow the electric vehicle to locate precisely and move without a driver.

The vehicles used are bi-directional driverless shuttles equipped with a set of sensors for detecting and avoiding potential obstacles on the route. There is always a safety operator onboard who can intervene if necessary. The management operations are carried out with EasyMile's fleet, a set of software and mobile apps that supervise multiple vehicles at once. They use an operating system for digital mobility, which transmits the orders to the autonomous bus and the autonomous on-demand shuttles.

Engagement aspects

The fact that Deutsche Bahn was already in regular contact with the spa administration in the run-up to the project, both through Südostbayernbahn and Regionalbus Ostbayern, made it easier to agree on the idea of a pilot project. On the initiative of the spa administration, local authorities and the responsible mayor were involved in the next step, and in the second step the district development department of the Rottal-Inn district office, the local member of the state parliament and other regional bodies were involved.



Figure 67 - Electric bi-directional driverless vehicle used for shuttle services

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In the run-up to the project, intensive exchange took place with the authorities in the form of workshops in which the goals and the steps to be taken were discussed. From the beginning, the Bad Birnbach spa administration, the district office responsible for district development and acting as the lower road traffic authority, as well as the government of Lower Bavaria, which acts as the upper road traffic authority and public transport approval authority, were involved.

Around June/July 2017, the Bavarian Ministry of the Interior and Transport as well as the government of Upper Palatinate were brought in to constructively discuss and jointly design the approval process at an early stage.

### 4.3.3 Timelines and Milestones

**Milestone no. 1:** October 2017: Launch of the service

*The first expansion stage of the project was launched on 25 October 2017. The permit permission to participate in road traffic was granted by the Rottal-Inn district office. The original route leads from the centre of the village to the spa. Only minor infrastructural measures had to be taken in Bad Birnbach to start autonomous operation. had to be carried out in Bad Birnbach. Since its debut in Oct. 2017, the vehicle has travelled more than 15,000 km autonomously and carried more than 25,000 passengers.*



**Milestone no. 2:** August 2018: Extension of the route length

*In August 2018, a track extension followed in the second expansion stage of the project, doubling the distance travelled from 700 metres to 1400 metres. Two vehicles travel alternately on the route where the four following stops are available: Neuer Marktplatz, Artrium, Rottal Terme and Badstraße. The Badstraße stop was then connected twice a day and important findings were already being gathered for the connection of the station. Further minor infrastructural measures were carried out for the set-up of the new track. This concerned, for example, the installation of so-called localisation panels, which are used for orientation in the open field and are essential for determining the position of the autonomous bus.*



**Milestone no. 3:** October 2019: Connection between the railway station and the town centre

*In the second expansion stage, the connection to the high-performance public transport system was implemented with the development of the route to Bad Birnbach railway station, which is approx. 1.8 kilometres away from the town centre. From the project's point of view, the development of the railway station is highly complex in terms of traffic engineering, as the route of the autonomous minibus to the station leads via a country road. This involves greater interaction with other road users as well as maximum speeds of up to 60 km/h. The service became an attraction for locals since the train station is connected to the route. The number of passengers doubled in a short time as many people from Birnbach left their cars behind and chose the train as their mode of transport.*



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**Milestone no. 4:** May 2022: 2 additional shuttles drive to 20 stops in the city area on demand

*Since May 2022, there has been an "on demand" offer. Two autonomous shuttles will be deployed to take passengers from A to B and back again, exclusively on demand. The shuttle collects up to six passengers. There are 20 stops to which the shuttles can be ordered between 8 am and 6 pm. The rides are free of charge and can be booked via a dedicated app, the "Wohin-du-willst-App" (Wherever you want to go-App). The booking is possible from seven days in advance up to three minutes before the ride starts. The app is constantly being improved to make it even more user-friendly.*

#### 4.3.4 Long-term assessment

##### Success, Durability and Expansion

In May 2018, the service had carried out around 10.000 passengers covering 4.900 kilometres. On average, around 50 passengers a day used the bus service. In March 2019, the passengers transported amount at 27.218 with an average of 61 passengers a day and with 15.389 kilometres.

The minibus in Bad Birnbach is one of the first driverless electric bus that travels in public traffic in Germany and is a pioneer for mobility in the country. It is particularly relevant because it is one of the first cases in Europe which investigates the possibility of replacing conventional public transport services in a rural area with low demand with autonomous vehicles. Passengers feel comfortable with the service, and there are positive feedbacks with respect to the safety perceived, comfort during the travel and waiting time at stops.

Since the project is the first pilot in the field of autonomous mobility in public transport it acts as a benchmark for operational and approval processes in autonomous public transport mobility, which had a big impact on the creation of a working group related to autonomous mobility on a national level. So far, the service has not been replicated in another region.

In summary, the innovation is likely to lead to new mobility concepts and business models. Although there will also be losers of the innovation, from today's perspective the benefits of the innovation seem to clearly outweigh the costs. It is not yet clear whether the offer, which has been free of charge up to now, can be maintained in this form beyond the end of the project in 2023. During the project phase, the offer should of course be kept as simple as possible and any intervention in the fare system of the railway should be prevented.

It is not yet clear what will happen after the end of the project. Conceivable for the future is a flexible mobility network with a wide range. However, a future shuttle network with many small autonomously driving shuttles in the spa town of Bad Birnbach presupposes that the autonomous buses are manufactured in such large numbers that the individual bus gets a cheaper price tag.

##### Funding and Financing

Concerning the capital costs, at the beginning, the goal of the stakeholder was to make as few adjustments to the infrastructure as possible to keep the costs of implementation low. Deutsche Bahn acquired the bus and was also able to use existing infrastructure. Due to the high costs and the administrative project effort, it makes sense for the implementation of such a project to involve large companies that have a good infrastructure and the necessary network.

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The costs were incurred primarily by Deutsche Bahn and, to a lesser extent, by the local partners involved, while the passengers and tourism and the businesses in Bad Birnbach benefited indirectly. However, if one considers the high medium and long-term economic potential, it can be expected that in the medium term the costs for the project will be offset by corresponding revenues. Deutsche Bahn is investing in a highly relevant future topic at this point.

From the operating costs point of view, the project is financed both by loki and Deutsche Bahn (project management, acquisition and operation of the bus and other vehicles, accompanying research) as well as the municipality of Bad Birnbach (public relations, structural measures for infrastructure upgrading on site). The spa administration is seeking partial reimbursement of the costs from the Bavarian state government. The financing decisions of the municipal council remain unaffected by this. Currently, the shuttle service in Bad Birnbach is depending on public funding as well as support of the project partners. A business case has not been developed yet. The service is completely free of charge for passengers since there is a strategic interest of all partners and stakeholders to learn and professionalize the service instead of creating a revenue stream. the project with the on-demand buses is fully funded by the Federal Ministry of Transport with 2.8 million euros.

Why is it considered as a Good Practice?

The solution is relevant because it is one of the first cases in Europe which investigates the possibility of replacing conventional public transport services in a rural area with low demand with autonomous vehicles. Passengers feel comfortable with the service, and there are positive feedbacks with respect to the safety perceived, comfort during the travel and waiting time at stops.

4.3.5 Transferability considerations

<b>CONTEXT PECULIARITIES</b>	<b>TRANSFERABILITY CONDITIONS</b>
<p>In general, the project seems to be well transferable as the high-level objective consists in testing the potential of an autonomous shuttle service for the first/last mile operation in a small rural area. One thing that should be considered is that many different stakeholders are involved and that many parties must have agreed by the time the project is implemented.</p>	<p>It is important to provide the autonomous vehicles including a mini-ramp to make the service accessible. In addition to the vehicle, autonomous driving software, fleet management system as well as remote control centre are also important. An operating system for digital mobility transmits the orders to the autonomous bus and the autonomous on-demand shuttles. An assistant must be on site as onboard staffing.</p>
<b>DIFFICULTIES ENCOUNTERED/WEAKNESS</b>	<b>LESSONS LEARNT</b>
<p>The advantage was that Deutsche Bahn took the project in hand. It lends itself to a large company implementing the project, which already has the relevant infrastructure and the necessary network. The costs were mainly borne by Deutsche Bahn and partly also by the local partners and from public funds, while the offer is free of charge for the users. If one considers the high medium and long-term economic potential, it can be expected that in the</p>	<p>Firstly, it has been noticed that the connection of the station to the route has brought increasing numbers of users. The acceptance study showed that passengers feel comfortable with the service, and there are positive feedbacks with respect to the safety perceived, comfort during the travel and waiting time at stops. On the other hand, many people did not use the bus because of the low range and speed.</p>

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<p>medium term the costs for the project will be offset by corresponding revenues.</p>	<p>All respondents largely agreed with the statement that the bus represents an opportunity for more mobility for older and less mobile people.</p>
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