CLEAN AIR IN THE CITY

Mainz Mobility, the mobility brand of Mainz's Public Utility Company, has procured DIVA as a planning system for timetable, vehicle, and duty scheduling.

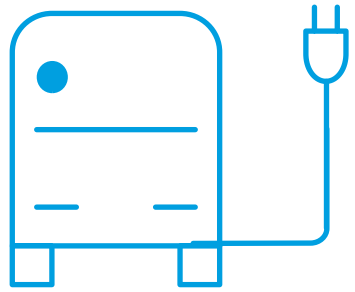
DIVA as a planning system for emission reduction and new drives.

Topic
The latest in planning systems for sustainability and pollution control.

Customer
Mainz Public Utilities

Products
DIVA R19 for timetable planning, vehicle, duty and roster scheduling, DIVA for passenger information, GENIOUS Optimization

Contact
Manuel Fritsch
Jens Krotwaart



Beyond procuring a modern system to aid transport planning, the main reason for the company's interest in DIVA was the various tools that can be used for optimization.
In a first step, MENTZ had to prove that DIVA could be used to perform automated and optimized vehicle and duty scheduling while accounting for various measures that would reduce emissions.

If emissions are to be reduced by using low-emission vehicles, the DIVA vehicle schedule optimization module can be parameterized to favor electric buses or hydrogen vehicles over their diesel counterparts. Parameters can be set for the vehicle's charging capacities and the management of charging options in depots or enroute in the optimization's background system.
The occupancy of charging stations and required reserves are taken into account, along with the non-linear charging of vehicles.

Various charging scenarios can be calculated to reduce NOx exhaust by adding or removing charging options at final stops. "Classic block optimization" seeks to maximize productive kilometers and reduce vehicle use. In contrast, this new type of optimization finds the optimal solution for the part of the electric fleet of the overall operation from the scheduled workload. Currently, the resulting workload may require a higher frequency of empty runs when compared to conventional drives. That said, the lowest possible frequency of empty runs still remains a partial aim of the calculation.

Based on this parameterization, the DIVA system and its optimization framework GENiOS help directly limit release of nitrogen oxides. This is mainly due to the fact the resulting schedules are realistic and drivable. But it is also because they can be implemented on short notice through direct integration into the planning cycle.

In the long term, DIVA's version management also helps prevent nitrogen oxides from entering the atmosphere.
Network versioning technology allows for independent planning statuses to be created in which basic network architectures can be modified. This feature also comes in handy when additional low-emission vehicles are commissioned, such as trams, or when different vehicle sizes need to be simulated.

The complete range of operational planning products, including optimization, is available for these kinds of planning network versions. Even the general costs of planning based on comprehensive vehicle and duty scheduling for the network can be determined. This is all offered in addition to the options to reduce pollutants.
Mainz Mobility was faced with the immediate task of integrating the first 4 electric vehicles into its fleet and using them in their daily operations. The baselines for range, battery capacities, and charging infrastructure (depot charging) were known. Not only did the new vehicles have to be scheduled, but vehicle scheduling for the entire fleet needed to be optimized, as did the duty schedule.

This particular challenge was solved using DIVA software and the GENiOS optimization module.

We proceeded as follows:
The route options and possible empty runs of the routes tagged to be served by electric buses were routed along actual roads using a route network graph (imported from OSM data). Lengths and trip times thus refer to routed (georeferenced)

segments and not to linear distances. The WGS 84 coordinates were converted to a Web Mercator projection (MRCV = EPSG:3857) for display on an OSM background map in the DIVA journey planning modules.

On this basis, optimization was parameterized for the different tasks.

A 3-step optimization was performed to account for different priorities. This involved solving the scheduling of e-buses first and the rest of the vehicle scheduling second. Based on these two results, we performed the duty schedule optimization last.
In addition to the input data provided by the Transport Authority of Mainz, DIVA had to calculate the number of empty runs required to consistently schedule all vehicles.

The system is able to calculate the empty runs in terms of distance and time routed, and thus to provide precise, but realistic results.

The importance of precisely calculating the number of required empty runs is clearly visible in a city like Mainz that has a river running through it, especially when compared to pure linear distances, and should achieve the closest possible approximation to reality using a specified factor. In addition, we modeled the indicated charging stations and made the following technical assumptions.

Charging will only occur at the depot, with a handling of one minute, meaning the time lost during the whole procedure in addition to the actual charging of the vehicle. We have assumed the charging speed to be consistent based on the specifications.
A vehicle's minimum remaining range is ensured before charging is initiated. When checking a vehicle's range, it is important to not only consider the specific operating day. E-buses also need to operate on their routes the following day.

In order to achieve the highest possible productive kilometer performance for e-buses, the variant is used where the vehicles operate an identical route on the following day, but do not have to guarantee being 100% fully charged at the beginning of the day.

DIVA supports several variants, including a requirement in which e-buses must be fully charged at the end of each operating day, or at the beginning of the same route on the following day.

A noticeable feature of GENIOS' solutions for the 4 electric blocks are the long depot exit trips. Based on the goal of scheduling "as many productive kilometers as possible," the algorithm selects the longest routes options that run from the countryside into the city, and which make for the shortest possible distance to the depot when a capacity limit has been reached.
As described above, the parameterization of the e-bus block was optimized in a manner that allows them to get to a depot for intermediate charging and then to charge their batteries accordingly.

This scenario can be set for linear or staggered charging.

Using this technology, not only can e-buses be used multiple times a day, but simulations can be performed in which charging devices are installed at end points. The occupancy of charging stations is taken into account when creating vehicle blocks. Double occupancy of a charging station is not permitted.

DIVA's optimization module also accounts for timetables and does not maintain set charging times or specific charging states that need to be achieved. It calculates the charge required at this station based on the timetable and the distance to the next charging station.

The Mainz Public Utility Company successfully introduced the DIVA planning system in 2022. Currently, multiple GENIOS configurations are being jointly created by MENTZ and Mainz Mobility, and tested in live operation.

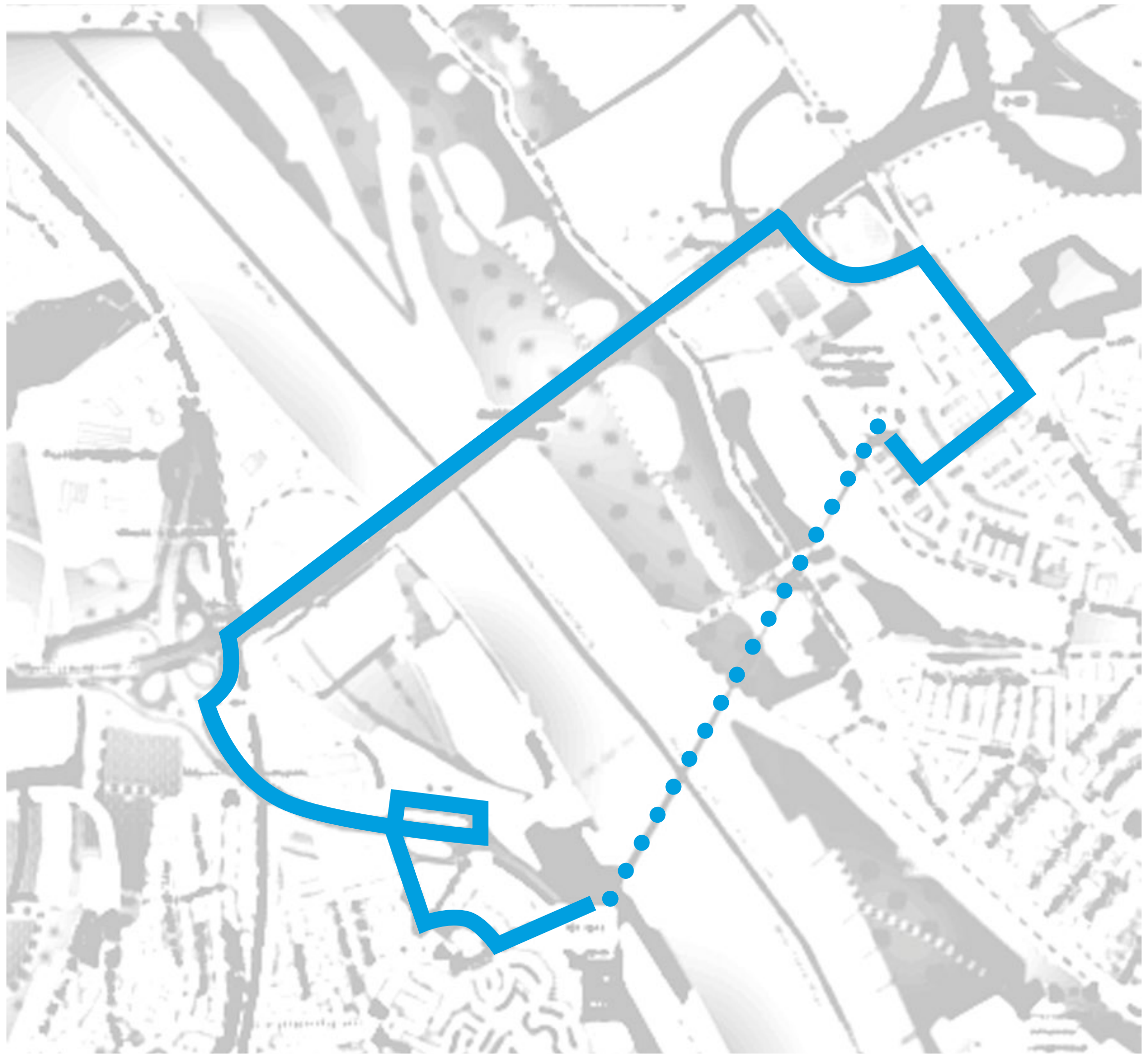


Figure 1 DIVA Web routed empty trip (solid, 4.7km) between Rüsselsheimer Allee and IGS Mainspitze compared to the linear distance (dotted, 1.4km)

Figure 2 Map display of an e-bus block on the DIVA Client map