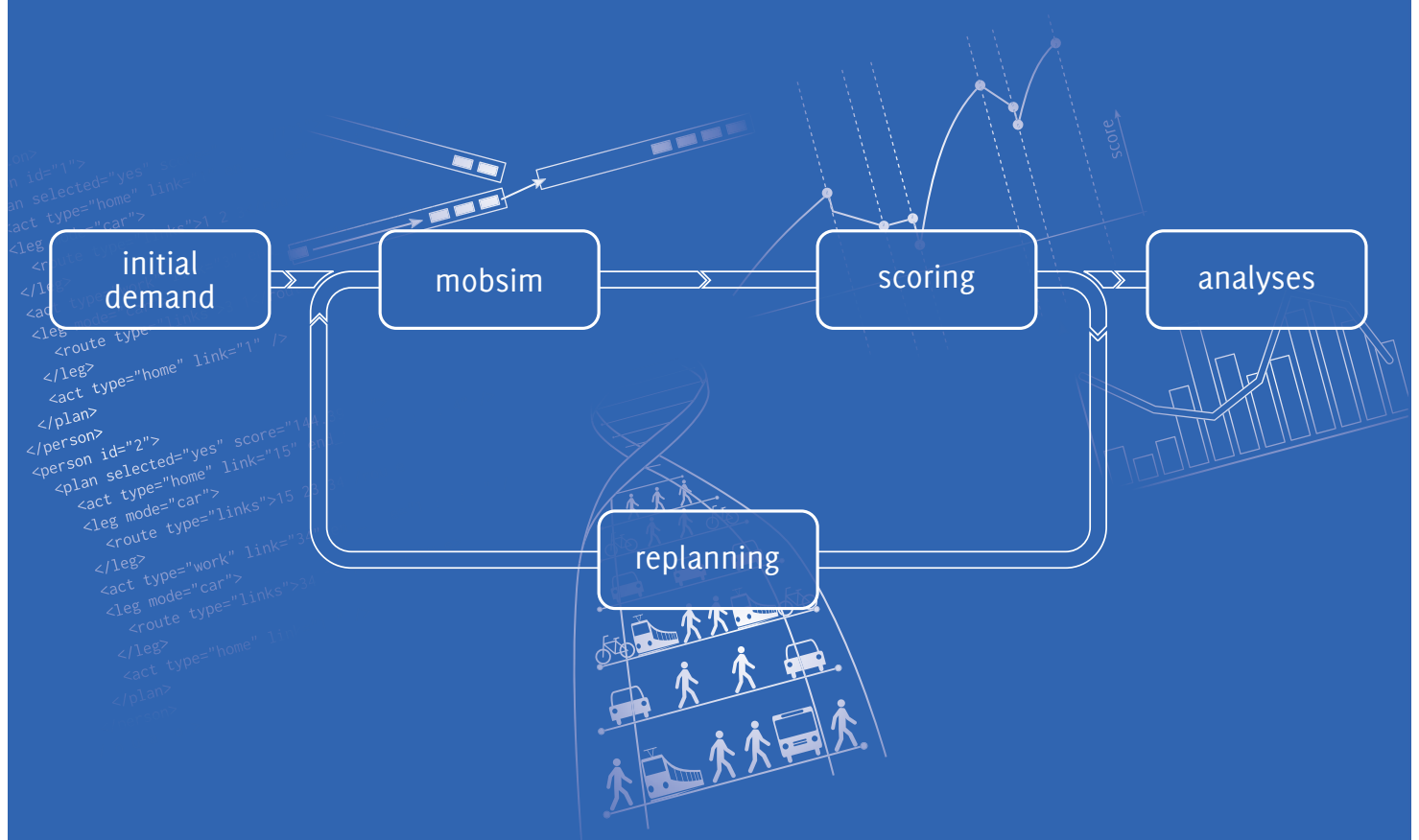# The Multi-Agent Transport Simulation MATSim

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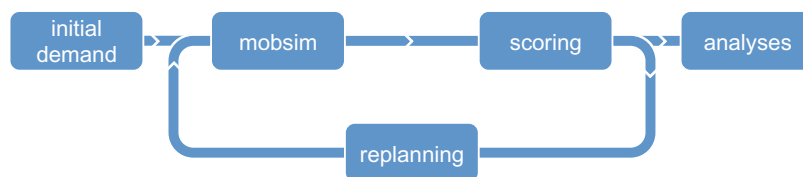
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MATSim
Multi-Agent Transport Simulation

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Hamburg Wilhelmsburg

Hubert Klüpfel and Gregor Lämmel

The following describes the evacuation of Hamburg-Wilhelmsburg as a case study. The scenario has been created using MATSim's evacuation contribution. Technical details about the evacuation contribution are given in Chapter 41.

Wilhelmsburg was severely flooded in 1962. Since then, many structural and operational improvements have been implemented. Back then, the housing situation was rather bad, many people lived in provisional housing due to destruction in World War II. Additionally to the by far more stable buildings, precautions for flooding have been taken and the walls have been heightened. Evacuation is nevertheless necessary under certain circumstances. The relocation of one of the major roads in Wilhelmsburg, the B75, will also influence the evacuation traffic, since it is one of the major north-south arterial roads. In this case study, the consequences of this relocation on the evacuation of Hamburg-Wilhelmsburg is investigated.

71.1   Brief Description

The scenario investigated here is the relocation of highway B75 in Wilhelmsburg. Two cases are investigated, as summarized in the following table. The investigation highlights differences in the evacuation traffic for both variants of the B75 trail. As seen in Figure 71.1, the new trail "B75 new" is located generally next to the existing railway track. In the south, the new variant is connected to the existing highway at the junction "Hamburg Wilhelmsburg Süd" (just north of the bridge across the river Elbe); in the north, it is connected to the existing highway just before the junction

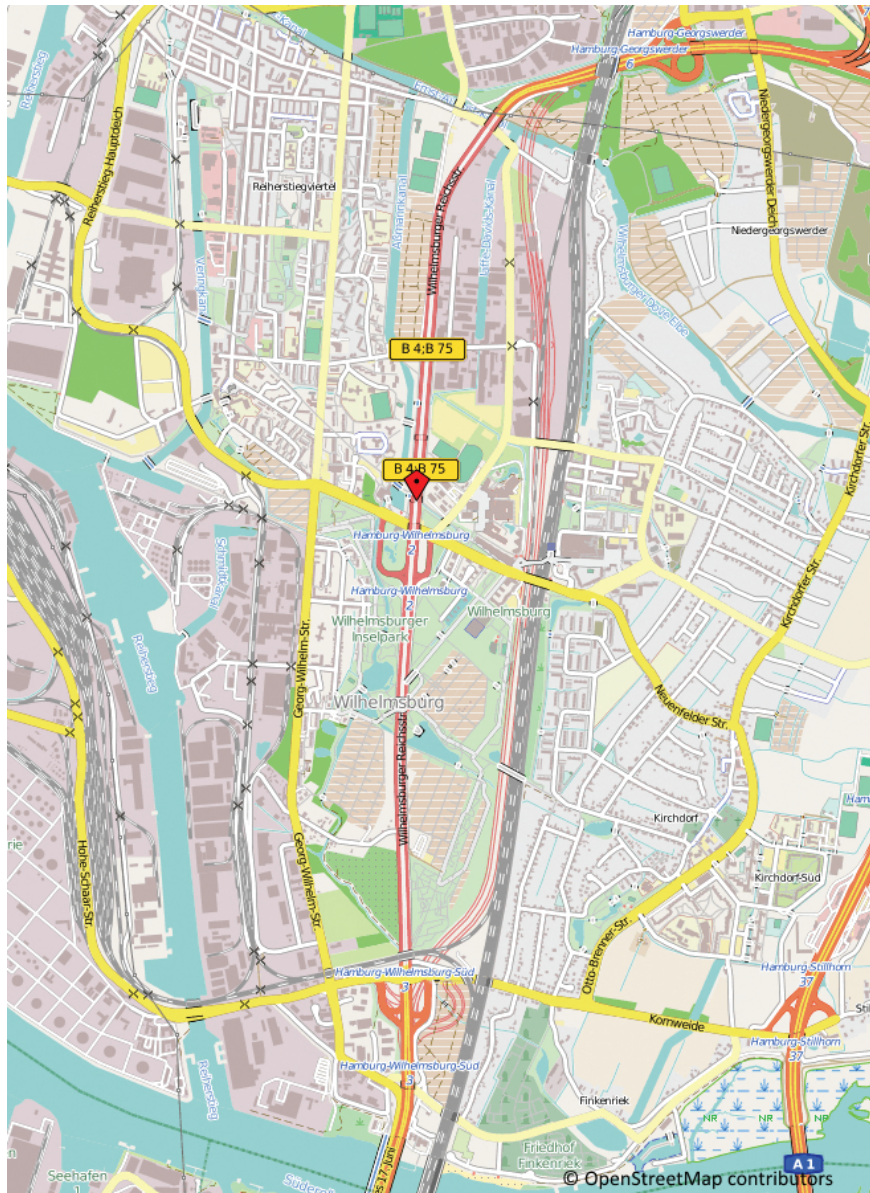| 1	Current location of B75 with restricted directional choice
2	New location of B75 with restricted locational choice

Table 71.1: Scenarios.

Figure 71.1: The current trail of highway B75 is shown in the center of the image. The new trail is east of it next to the railroad.

"Hamburg Georgswerder". The main differences between the two variants are the location of the access routes to highway B75 in the center of Wilhelmsburg.

71.2   Road Network

The MATSim road network is generated ("imported") from the Hamburg OSM file, downloaded from http://www.geofabrik.de. Fortunately, the OSM file already contains the new B75 highway track, marked by an attributed "open 2016". Therefore, the two networks for the "B75 old" and "B75 new" variants could be derived from the same OSM file. For the variant "B75 old", this file could be directly imported. For the variant "B75 new", the section of B75 to be relocated has been removed in a first step. In a second step, the new B75 track has been connected to the existing road network, i.e., the B75 north at junction "Georgswerder" in the north and junction "Hamburg Wilhelmsburg Süd" in the south.

Figure 71.2: Comparison between network for the old and new track of the B75.

Figure 71.3: Roads closed during evacuation.

Additionally, the on and off-ramps to the B75 have been added. The two variants of the resulting road network, i.e., "B75 old" and "B75 new" are shown in Figure 71.2.

In an evacuation, some roads would be blocked to avoid intersecting and inbound traffic. The following streets were thus deleted in the OSM file:

- Neuenfelder Str.
- Im Schönenfelde
- Elsterweide
- Kirchdorfer Str.

An illustration is given in Figure 71.3.

71.3   Evacuation Scenario

The comparison of the two variants is based on overall evacuation time, clearing time of different cells (squares in the area that had to be evacuated) and the number of cars using the road network (utilization).

As described in Section 41.4, the input files for the network (OSM), the area (ESRI shp), and the population (ESRI shp), as well as the parameters for sample size and departure time distribution, have been specified and assessed via a GUI. The scenario XML file for the existing (or "old", in German "alt") track of highway B75 is shown in the following listing.

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<grips_config
 xsi:schemaLocation="http://www.matsim.org/files/dtd
 http://matsim.org/files/dtd/grips_config_v0.1.xsd"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <networkFile>
        <inputFile>osm/hamburgB75_alt.osm</inputFile>
    </networkFile>
    <mainTrafficType>vehicular</mainTrafficType>
    <evacuationAreaFile>
        <inputFile>area/area.shp</inputFile>
    </evacuationAreaFile>
    <populationFile>
        <inputFile>population/population.shp</inputFile>
    </populationFile>
    <outputDir>
        <inputFile>matsim_output_B75alt</inputFile>
    </outputDir>
    <sampleSize>0.1</sampleSize>
    <departureTimeDistribution>
        <distribution>normal</distribution>
        <sigma>1800.0</sigma>
        <mu>1800.0</mu>
        <earliest>0.0</earliest>
        <latest>3600.0</latest>
    </departureTimeDistribution>
</grips_config>
```

71.3.1   Departure Time Distribution

The departure time distribution is specified in the file scenario.xml. The values were in seconds, i.e., a normal distribution with a mean value (mu) and a standard deviation (sigma) of 30 minutes in the range of zero (earliest) to one hour (latest) was chosen. More details about time distributions are discussed in Section 41.4. This distribution reflected certain assumptions made about evacuation procedure. The overall time frame, based on the warning time, is minimum 7 hours. The preparation phase is projected with three hours. Available time for the evacuation is three hours, with a one-hour buffer. The warning via radio will start at t=0 hours and local warning (e.g., by police cars, sirens, and via short messages) at t=1 hours; simulation reference point was set to t=3 hours. The overall time acceptance criterion for the simulation is the a required safe evacuation time (for simulation by car) of less than three hours (including reaction time). The reaction time set in the simulation could be interpreted as decision-making time after readying personal belongings. In short: ASET (Available Safe Evacuation Time) determined by flooding is 3 hours and the RSET (Required Safe Egress Time) is estimated by the simulation. The criterion for a successful evacuation is ASET > RSET.

71.3.2   Population Size

As explained previously, the population is not stored in the scenario file, but in the population shape file, possibly consisting of several polygons. The number of persons is stored as an attribute for each polygon. Here, one must assume that only part of the population would have to evacuate; for many, escape to higher ground might be sufficient. Detailed information on the different procedures can be found at http://www.hamburg.de/sturmflut/3425646/sturmflut-download-1/ (in German).
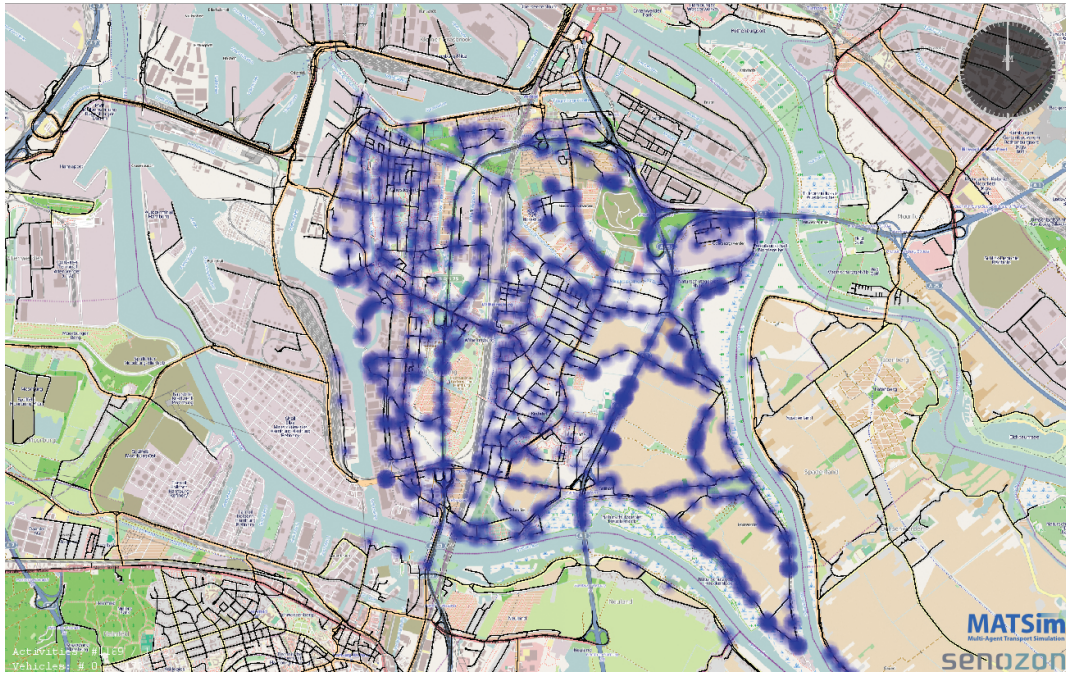
Figure 71.4: The initial distribution of the agents for the evacuation of Wilhelmsburg (for both cases, B75 new and old).

Each agent represented one evacuee traveling by car. To independently check the number of agents based on the simulation files, one could open the file `population.dbf` with a database or spreadsheet editor. Note that the number specified in the `population.shp` (resp. `population.dbf`) is multiplied with the `sampleSize` when converting the files to MATSim input, i.e., in this case, the `population.xml.gz` located in the output directory.

The population is initially distributed as shown in Figure 71.4. The algorithm that converted the area and population (i.e., `area.shp` and `population.shp`) is described in Section 41.2. It assigns agents to the edges of the network. In the case study, harbor areas are left out and agents are equally distributed to streets in the housing (and agricultural) areas of Wilhelmsburg (Figure 71.4). Of course, this could have been further refined by going to a block, or even house level and assigning the population according to detailed statistical housing data. This has not been undertaken for this simulation, for two reasons. First, many assumptions are made about behavior, initial location, and share of population that had to evacuate. Therefore, the level of detail seemed to be sufficient. Second, each agent represented a car driver, i.e., in the simulation, all cars registered in Wilhelmsburg left the area. Considering that inbound, as well as through traffic would be prohibited when flooding level exceeded a certain threshold, this is a "worst case" assumption resulting in a heavy traffic load. To summarize, the overall approach is justified to assess highway B75 relocation based on heavy traffic load with a reaction time span between 0 and 1 hour.

71.4   Simulation Results

The simulation results are summarized in Table 71.2. The 0th iteration is based on shortest distance only. This might have resulted in "strange" behavior, as illustrated in the following Figure 71.5 (south of the bridge across the Elbe river, near the junction "Großmoordamm"). The road network had a circular shape; it was cut out from the OSM road network according to the `area.shp`, which is, in this case, just a circle. Since all the agents are taking the shortest path in iteration 0, they headed to the nearest road out of the evacuation area. Technically, the boundary links in the network are connected to a super link when creating the MATSim network from the OSM file and the
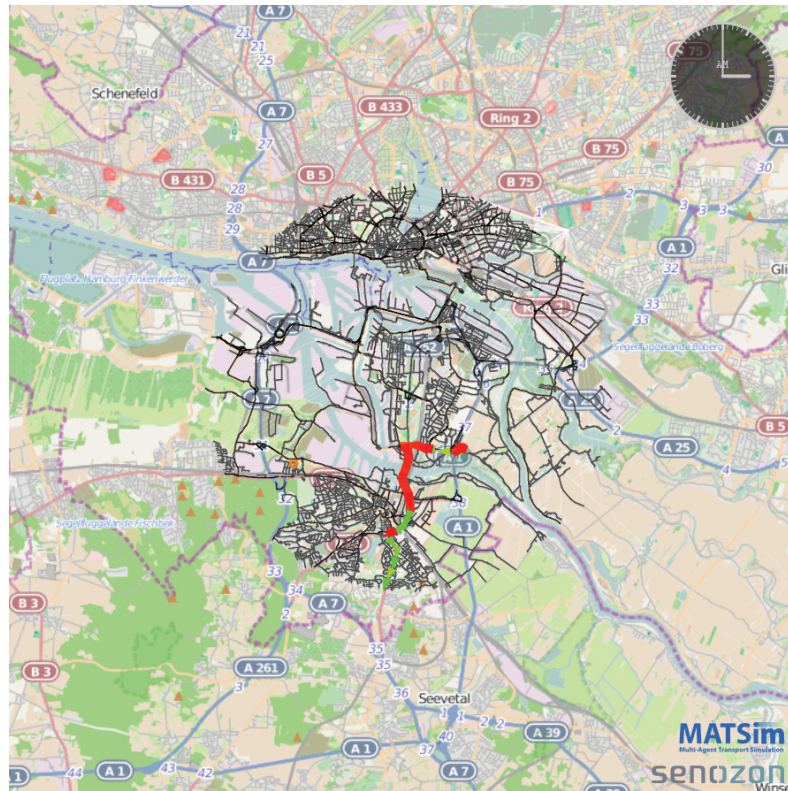
Figure 71.5: Results for B75 old, iteration 0.

|	B75 old	B75 new
Iteration	Time	(hh:mm)
00	04:45	05:00
10	01:52	01:58
20	01:42	01:46
30	01:40	01:42

Table 71.2: Results.

area.shp. This super-link is the destination in all evacuees' plans. A second factor that contributes to congestion in iteration 0 is a short cut via an on- and off-ramp of Autobahn A253 at "Großmoordamm". Capacity of the on- and off-ramp is 1 500 cars per hour, compared to 4 000 cars per hour on the highway. Thus, the short cut (which is shorter in distance, the reason agents chose it) was a bottleneck, resulting in artificial congestion in iteration 0. Therefore, the 0th iteration was unsuitable for assessing the overall evacuation time. As can be seen from Table 71.2 above, for both cases, from iteration 10 on, time presumably converges to some realistic value. This was also illustrated in Figure 71.6 where the situation at t=1:30 hours was shown for iteration 20.

In summary, relocation of highway B75 had no major influence on the overall evacuation time. The evacuation time of about two hours was also within the available safe egress time, as described in the previous section.

It would certainly have been possible to analyze the results further. The two screenshots above, for the situation in iteration 0 at t=3 hours and for iteration 20 at t=1.5 hours, were created with Senozon AG Via (the visualizer presented in Chapter 33). As a conclusion to this chapter and an illustration for the built-in capabilities of the evacuation contribution for analyzing simulation results, road utilizations of the two variants are shown in Figure 71.7.
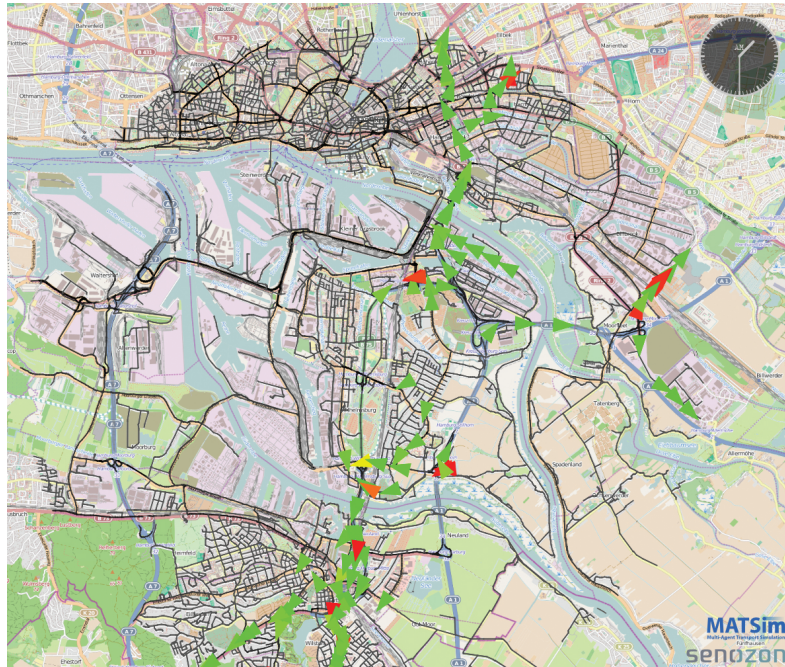
Figure 71.6: Results for B75 old, iteration 20.

(a)	(b)
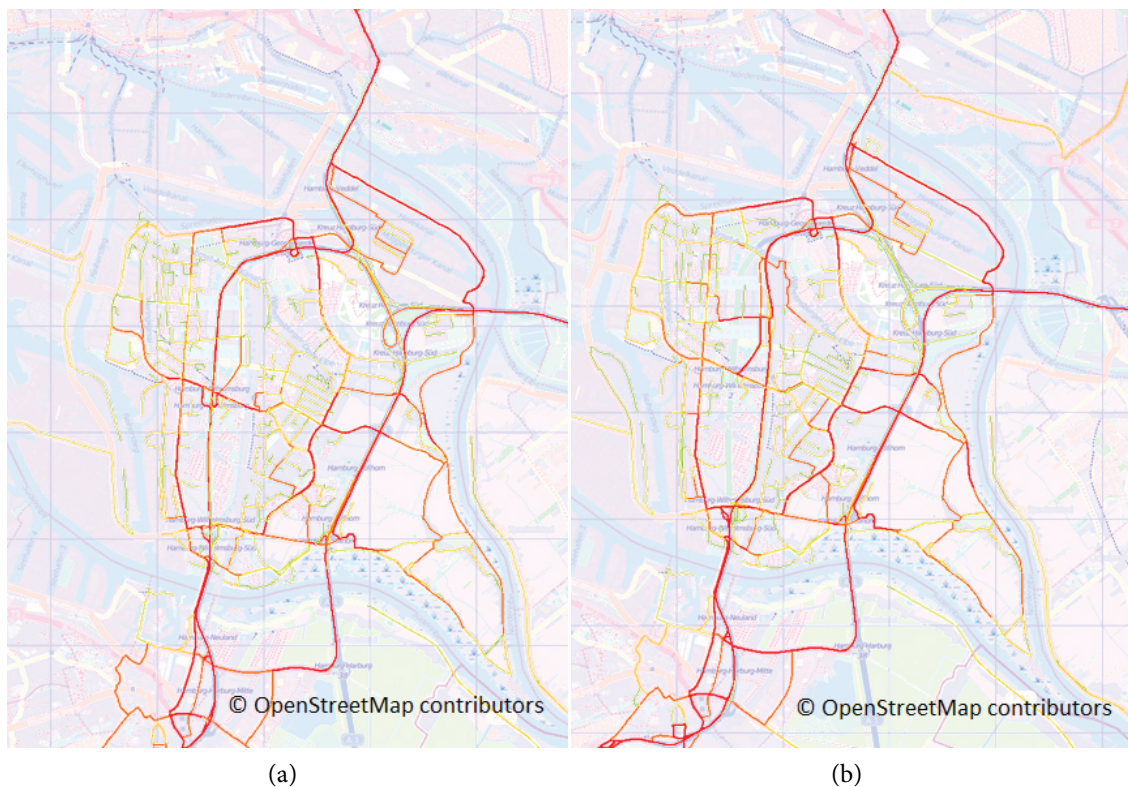
Figure 71.7: Comparison between network utilization for the old and new track of the B75.