Parking space analysis for the Berlin district of Neukölln - method and result report

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Authors and Background

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This parking space analysis was created as part of a mobility and traffic turnaround initiative by the Berlin OpenStreetMap Community (OSM) and was carried out as a voluntary project. A large part of the data analysis and data collection goes back to Alexander Seidel, social and urban geographer and OSM contributor, and together with the contributions of many other OSM contributors, resulted in the results presented here.

1. Introduction

Data on the number and distribution of car parking spaces in urban areas are a valuable resource. In the course of the traffic turnaround, the traffic area is increasingly being redistributed or at least politically disputed and the reduction of stationary traffic is identified as an important starting point for more space . At the same time, traffic and mobility are taking place in an increasingly targeted manner with the inclusion of geographic data, so that, for example, unnecessary journeys or inner-city traffic can be prevented - parking lot and parking space data can also make a contribution here.

In many places, however, there is still no systematic knowledge of where and how many parking spaces are available. If necessary, this data has to be recorded in complex studies - and this data is usually not accessible to the public afterwards. In contrast to this, the free geodatabase OpenStreetMap

(OSM) represents an optimal environment in which such data can be freely recorded and analyzed.

Using the example of the Berlin district of Neukölln, this parking space analysis demonstrates how urban parking space can be systematically mapped on an OSM basis and evaluated in high resolution using geographic information systems (GIS) and other open data. The aim of the project is

- to demonstrate a method for the collection and processing of parking space-related geodata,
- Determine the locations and number of parking spaces of all parking options - both in public street space and in private space,
- Calculate parking space densities taking into account vehicle and population data,
- To provide information on land use by parked vehicles,
- to provide the data for the study area for free use.

The present report presents the approach and methodology of the parking space analysis and briefly discusses key results.

2. Methodology

2.1. General approach

The parking lot **data** on which this evaluation is based were systematically stored in the **OSM database** for this projectrecorded or completed, enriched with open data from other sources and evaluated with the QGIS software. Although OSM encompasses ever more extensive and increasingly highly specialized geographic information and, especially in Central Europe, offers an almost complete data set on the road network, the level of detail of the information differs from region to region and depends on the activities and interests of local communities and their contributors. For example, data on on-street parking is not yet part of the “standard information” and is only rudimentarily recorded in many places. A transfer of the analysis demonstrated here to other locations will therefore currently be tied to the condition that the necessary data have to be collected or completed beforehand. In addition, the methodology used places high

demands on the precision and positional accuracy of the data, as further values such as parking space capacities or no-stopping restrictions are

derived from these geometries. The more precise and complete the data are, the more precise the results can then be determined from them.[1]

The evaluation takes into account different types of parking spaces and parking spaces, which are recorded and interpreted in different ways. **Street** parking makes up the majority of the car parking spaces in downtown Berlinrepresents, i.e. parking in the public street on a parking lane at the edge of the lane. The basis of the data model of this parking space analysis is to derive the number and location of these parking spaces from the information (geometrically recorded linearly) on which sections and with which orientation (longitudinal, oblique, transverse) along a street can be parked. Sections of the route where you are not allowed to park (driveways, lowered curbs, intersections, sidewalks, parking and stopping bans, etc.) are automatically determined and excluded from the analysis. Comparisons between calculated / interpolated and real / counted values show that this method delivers precise results if the data basis is of sufficient quality (see Chapter 3).

In addition, information on (mostly private) **parking spaces away from the street space was** collected and included, which is geometrically available in planar form. These include:

- general, mostly at ground level parking spaces and parking spaces,
- Underground garages,
- Garages and carports,
- Parking garages.

These objects are more often recorded with an exact number of parking spaces, as these are often marked and countable. The parking space capacity can also be estimated from its floor space (and, in the case of multi-storey objects, possibly taking into account their horizontal extent).

The parking space data contain additional attributes such as restrictions on use or accessibility (public / private / customers, etc., fees, time restrictions) and can be specifically evaluated on this basis.

2.2. Study area

The present parking space analysis relates to the Berlin district of Neukölln. The entire study area for which parking lot data was collected includes the area within the Neukölln district boundaries and a buffer area of 500 meters outside the district boundary, in order to avoid distortions at the edge areas, especially when making statements on the density of parking spaces. The district of Neukölln covers an area of 11.7 km² (entire study area: 20.6 km²).

The district of Neukölln is a predominantly residential area, densely populated and densely built-up urban area with 165,000 inhabitants. It is characterized by a comparatively low motorization rate: 219 vehicles are registered here per 1,000 people. [2] The area of the district comprises two commercial areas that were not taken into account in some evaluations. The residential quarters considered in this case extend over an area of 7.4 km² (motor vehicle rate: 206 per 1,000 people) and can be subdivided into 16 sub-areas for more precise data analysis, which correspond to the local "Kiezen" or living-world-oriented areas (see Appendix A).

With regard to the parking space situation, delivery traffic and short-term parking play a central role in many places during the day, especially along the main streets, but in the neighborhoods (and outside business hours) the local parking space situation is determined by the parking behavior of the residents. In order to evaluate the parking space situation, parking facilities that are suitable for permanent parking are particularly relevant. Customer or employee parking spaces are included in the data set, but were excluded from the determination of the regular available parking spaces and the density of parking spaces. Due to their sometimes large capacities (especially of supermarket parking lots), they are nevertheless an important factor,

Commercially used parking spaces (e.g. for transport vehicles used by the trades) are included in the evaluations, since the comparative data used for the actual vehicle population also include commercial vehicles. Overall, parking spaces of this type in the residential areas - i.e. outside the commercial areas - only play a minor role.

2.3. Data collection, data sources and data sets

2.3. Data collection, data sources and data sets

The majority of the parking and parking space data was recorded through systematic inspections of the study area between spring and autumn 2020. The main object of this mapping was the survey of street parking in the course of the approximately 170 km road network (104 km of which in the Neukölln district) and the completion of around 2,200 building and property entrances (of which around 1,400 in the Neukölln district), as there is no parking in front of them may be. [3] In addition, data was collected on other parking options such as garages and parking spaces, insofar as these were accessible or visible.

The on-site surveys were supplemented by further evaluations and research:

- Evaluation of aerial photos in order to determine parking spaces in areas not accessible to the public, especially backyards. In the Berlin Geoportal, orthophotos generated annually, mostly taken in spring, are available; Recordings from 2016 to 2019 were included.

- Determination of underground parking spaces on the basis of the official real estate cadastre information system (ALKIS) and plausibility check with map data and aerial photographs as well as on site. [4th]

- Checking of buildings that are categorized as garages in ALKIS for their actual status as a garage or their suitability for parking vehicles (on site as well as on aerial and oblique aerial photographs).

- Research of parking space capacities of multi-storey car parks and underground garages from documents accessible online (websites, reports and planning documents for construction projects, development plans ...) or occasionally through inquiries from landlords and owners.

For the subsequent analysis, additional data was processed and included:

- Vehicle inventory at the level of the LOR planning spaces (lifeworld-oriented spaces) to determine the parking space density: "Registration law residents at the location of the main residence in Berlin on June 30, 2020 according to planning spaces and vehicle inventory", made available on request by the Office for Statistics Berlin-Brandenburg.

Population density at the level of the block and sub-block areas (as of December 31, 2019, available in the Berlin Geoportal / Environmental Atlas) and building data set (ALKIS) to generate a building-related population model (see Chapter 2.6).

The block areas were also used to determine the area of public traffic areas using OSM data as a basis for calculating space consumption (public road and sidewalk areas, i.e. the space between the building facades and property boundaries).

Generation of a curb or lane data set from OSM and ALKIS data (data set “Buildings, systems and facilities in settlement areas and for traffic”) in order to achieve an exact positional accuracy of the parking lanes. This curb or lane data set also forms a basis for the visualization of the road and parking area map.

2.4. Data processing for modeling street parking

The OSM data scheme for recording parking lanes (“parking: lane” scheme) provides that information on parking on the left and right edge of the lane can be assigned to a street segment. These primarily include:

Type of parking: Either no parking or stopping, or the arrangement / orientation of the parked vehicles (especially lengthways, diagonally, transversely).

Parking position: The vehicles can be parked on the lane, in a parking bay, on the sidewalk, halfway on the sidewalk or on the hard shoulder.

Conditions and restrictions: Parking spaces can be reserved for certain user groups, can be used for a limited period of time or are subject to a fee.

The road segments are geometrically in the form of line objects that can be divided when attributes change along the road. If there is a parking ban along a section of a street, for example, this can be differentiated directly using a separate street segment. Small-scale restrictions such as driveways or sidewalk crossings do not (and should) not be segmented separately, as

they can be derived from the corresponding data later. Deviations of

significant length, such as in the area of longer sidewalk extensions, were taken into account in the data acquisition by dividing the street segments.

The actual data processing was largely automated using Python scripts [5] and geoprocessing tools in QGIS, with these work steps being broadly based :

(1.) Depending on the lane width, which is either stored directly on the street object or can be estimated from its attributes, the spatial courses of the left and right parking lanes can be derived.

(2.) Areas in which the road traffic regulations (StVO) result in a parking or stopping ban or which are not suitable for parking according to their structural system and which are not already represented by signposted parking and stopping bans can then be removed the data can be excluded by cutting off sections with a predetermined length. The length results from the road traffic regulations, guide values or the typical structure in the investigation area:

Table 1: Distance definitions for parking at various structures.

Object / structure	Length / distance
crossing	5 meters before the intersection of the curbs Since the StVO amendment from 2020, this distance has increased to 8 meters if there is a built cycle path next to the road, which is not yet taken into account in the data model - in the study area, however, it is only the case at a comparatively few intersections.
Property and building entrances, lowered curbs	Width of the entrance, if known, but at least 4 meters
Crossings for other road users:	
Pedestrian crossings	4 meters and 5 meters in front of it

Object / structure	Length / distance
Edge markings or sidewalk projections	6 meters
Pedestrian crossings and other markings	4 meters and possibly traffic lights
Traffic lights (not clearly regulated, in fact hardly observed)	10 meters in front of it
Bus stops	15 meters in front of and behind

(3.) Objects that prevent parking in the parking lane area were systematically recorded or completed before the evaluation and deducted from the parking areas in a separate work step with safety clearances. This includes bicycle parking facilities, street trees, lanterns, bollards, curb structures, street signs and, especially when parking (half) on sidewalks, street furniture and sidewalk fixtures (e.g. distribution boxes). Overall, however, this only affects a small proportion of all roads.

(4.) The calculated parking lane segments were then subjected to a (partly manually controlled) post-processing: Short segments and artifacts were removed and error and plausibility checks were carried out (e.g. correction of overlapping or adjacent but not connected segments).

(5.) For the present parking space analysis, complex manual post-processing was also carried out, in particular to adapt the parking lanes to the exact, real curb edges. [6] The precision was thereby increased considerably, since this step enables precise statements to be made, but the general meaningfulness of the results would hardly be impaired without such post-

processing and can therefore be dispensed with when the parking space analysis is transferred to other locations. [7th]

(6.) Finally, parking space capacities for connected parking lane segments were calculated (quotient of the length of a segment and the distance between the vehicles parked there, see the following section).

2.5. Interpolation of parking space capacities

2.5.1. Street parking

For 5.5 percent of all parking spaces in the street area of the study area, capacity information was already available in the OSM data, especially for marked parking spaces and parking bays. The missing values had to be derived from the length of the parking lane segments.

In the case of parallel parking, individual parking spaces are usually not marked; the number of vehicles that can be parked along a route section depends on the length of the vehicle and a maneuvering / safety distance. In the traffic planning literature, an average distance of 5.2 meters between the vehicles is assumed, which can be largely confirmed in counts in the study area (see also Appendix B). With diagonal and perpendicular parking, the arrangement of the individual parking spaces is usually based on the recommendations for systems for stationary traffic (EAR). [8th]When parking at an angle, different angles are possible, which result in different parking widths - here a constant angle of 60 gon (54 degrees) was assumed. [9] This results in the following distances between two parked vehicles:

Parallel parking: 5.2 meters,

Diagonal parking: 3.1 meters,

Cross parking: 2.5 meters.

The parking space capacity results from the quotient of the length of a parking lane segment and the corresponding distance, rounded down to a whole number.

Result:
For the district of Neukölln there are a total of 27,335 parking spaces in the public street space. In the residential areas of the district, minus the industrial areas Ederstraße and Köllnische Heide, there are 24,403 (see

industrial areas Luerstraße and Kollmische Heide, there are 24,403 (See detailed Appendix A).

The parking space map shows the parking spaces in different zoom levels in different forms - from street counting to individual parking spaces.

2.5.2. Parking and parking spaces away from the street area

For the geometrically extensive parking spaces and parking spaces away from the public street space, precise parking space information is often available, as these are often marked and countable. However, no information is available for around half of the parking spaces (cf. 2); These parking space capacities are derived from the base area of the geometric objects (and in the case of multi-storey objects in some cases from the number of parking levels). This applies above all to underground garages: Due to the restricted accessibility, exact parking spaces were only available for 36 of the 221 objects included. [10] Since the data or interpolation model could only be validated in the few real, known cases, these data are also subject to greater uncertainty (see Chapter 3).

The median of the average area per parking space was determined from the objects with known parking space information - differentiated for different types of parking space and taking into account any multi-storey parking space objects (floor space). The estimated capacity of a parking space object results from the quotient of the floor area of the object geometry and this median value. It is necessary to differentiate between types of parking spaces, as these differ in terms of the space required per vehicle and the structural design: For example, garage geometries usually do not contain access routes, while underground garages, like support elements, exits, etc., contain these in the floor space. Ground-level parking spaces and parking spaces have been divided into a smaller and a larger category, as smaller parking spaces usually do not have,[11th]

Table 2: Calculation basis for the interpolation of parking space capacities of geometrically extensive parking space objects.

	Number of objects in the data record *

Shelf type	Area per parking space [m²]	Number of objects in the data record *		Share of estimated parking spaces
		total	with a known number of parking spaces	
Shelf type	**Area per parking space [m²]**	**total**	**with a known number of parking spaces**	**Share of estimated parking spaces**
Carports	14.9	46	38	14%
Garages	16.8	789	578	34%
Parking garages	28.2	9	5	8th %
Parking spaces (small) **	14.5	537	327	42%
Parking spaces (large)	21.7	472	247	48%
Underground garages	31.3	221	36	81%
total	**-**	**2074**	**1231**	**47%**

* The *number* refers to the total number of objects of one type of storage space in the investigation area, i.e. in the Berlin district of Neukölln and a buffer zone of 500 meters around its district boundaries.

** The *“parking spaces”* category mainly comprises classic ground-level parking spaces (N = 994), but also occasional roof-top parking (N = 6) and parking decks / parking spaces on the ground floor under buildings (N = 9).

Result:
For the district of Neukölln, this results in 12,226 (in the residential areas: 11,044) off-street parking spaces that are suitable for permanent or overnight parking for residents. Together with street parking, a total of 39,561 (residential areas: 35,447) parking spaces are available, compared to 36,266 (33,513) registered vehicles, which corresponds to a theoretical space utilization of 91.7 percent (94.5 percent).
In addition, in the Neukölln district there are 8,105 (residential areas:

1,940) spaces not suitable for permanent parking (especially employee and customer parking spaces), as well as 428 (219) unused spaces, for example in empty underground garages.
The parking map also shows these parking spaces away from street parking, differentiated according to the type of parking space and suitability for long-term parking.

2.6. Determination of parking space densities with a building-specific population model

One aim of the evaluation is to calculate small-scale parking space density distributions, i.e. to compare the number of parking spaces in an area with the number of residents or the number of registered vehicles. It is assumed that the number of vehicles registered at a location is an indicator of vehicles actually parked at a location, which is at least obvious for residential areas (see Chapter 3). The ratio of available parking spaces to the number of registered vehicles is referred to below as the “parking space density”.

For small-scale statements, for example to determine the parking space density for a certain street or in the vicinity of a certain place, correspondingly high-resolution, address-precise vehicle data are necessary, which were not available in the context of this project. This can be remedied by a separate data model based on population data at block level (323 sub-areas in the Neukölln district alone with an average of around 500 inhabitants each) and vehicle data at the LOR planning area level (18 sub-areas in the Neukölln district with an average of almost 10,000 residents each; for the data sets see chapter 2.3).

For the population model, the statistically expected number of residents was initially assigned to each building. For this purpose, residential buildings must first be distinguished from other buildings [12] and the building floors used for living must be determined. [13] The total population of a block area was finally distributed proportionally to this “residential floor area number” among the buildings. In this way, each resident can be represented statistically individually at the place of residence and can be classified as a vehicle owner with a corresponding probability on the basis of the vehicle registration data.

The resulting vehicle owner data can in this way - as well as the available

parking spaces - be mapped in the form of point clouds, with each point corresponding to a parking space or an approved vehicle. In this way, the ratio of available parking spaces and registered vehicles can easily be determined for a specific area. The parking space map shows this parking space density at lower zoom levels for the vicinity of a residential area, based on a walking distance of 350 meters (3 minutes on foot at a speed of 7 km / h or just over 4 minutes at 5 km / h). The parking space density for this distance was calculated for the grid center of a 25 meter hexagonal grid on the basis of isochrones [14] .

Result:
On average (median) there is a number of 835 parking spaces, a number of 759 registered vehicles and a theoretical availability of 1.08 parking spaces per vehicle for the Neukölln residential areas within a 350-meter walking distance of a location. If only street parking is taken into account, there are 604 parking spaces available in this area (median: 0.81 per vehicle).
How many can find a parking space in the vicinity, how many have to drive on on average?
When interpreting this representation, it must be taken into account that rooms and objects with a large excess of parking spaces - such as sparsely populated areas or parking garages, which can make an important contribution to the provision of parking spaces in a larger area - only affect the result within this close distance.

2.7. Land consumption

From the position and length of the parking lanes in the street space, depending on the orientation of the vehicles parked there, conclusions can be drawn about the area that is directly used by stationary or parked vehicles. The width of a parking lane corresponds to:

- 2 meters for parallel parking,
- 4.5 meters for diagonal parking,
- 5 meters when parking across the street.

This area can be set in relation to the area of the public road or traffic area, i.e. the area between the building facades or property boundaries including

all road components such as lanes, median strips or sidewalks and bike paths. The calculation basis for this is the division of the block areas, as used

in the Berlin Geoportal, for example, to reflect the population density (see Chapter 2.3). In uninhabited rooms, this block area division has gaps that were filled on the basis of OSM data.

> **Result:**
> For the Neukölln residential areas alone, this means that parking lanes in the public street space take up a total of 327,000 m², which corresponds to 19 percent of the public traffic area and 4.4 percent of the total area. Parking spaces and parking spaces away from the street space also take up an additional 171,000 m², a total area share of 2.3 percent.

3. Assessment of uncertainty factors

The presented parking space analysis is based on an interpolative data model, i.e. statements and simplifications derived from geographical data and empirical assumptions in order to model (complex) reality and make it “calculable”. Many of the underlying assumptions and results can be checked, counted or measured in actual reality, others are subject to certain uncertainties that can hardly be quantified or only with considerable empirical effort. For example, how many garages are actually used to park vehicles, how many illegal parkers are there, or how many company and rental cars are not included in the vehicle statistics for the study area? And especially: How precise is the reproduction of the number of parking spaces at the roadside? Uncertainty factors like these are to be subjected to a rough estimate in this section.

Since street parking has a significant impact on the parking situation, it is the core of the data model. In order to test this aspect of the data model, over 70 road sections with different parking arrangements (longitudinal / diagonal / transverse, lane and curb parking, straight and curved segments, blocking objects in the parking lane area, etc.) were run in two test areas and the vehicles or vehicles parked there . available parking spaces [15]compared with the data model in order to prove its informative value (see Appendix B). Overall, the comparison shows a high level of agreement between

Overall, the comparison shows a high level of agreement between interpolated and on-site counted values with a total deviation of less than one percent - however, differences can be observed between the results for parallel, oblique and perpendicular parking. While there is a slight overestimation of 1.1 percent for parallel parking, the calculated values for oblique and perpendicular parking are around 8 to 9 percent below the number of parking spaces counted (which, however, has only a minor influence on the overall result, as this is only 13 percent of all Identify the parking lane and the error is almost offset by the parallel parking result). This significant error value is mainly due to very high deviations in three individual street sections, in which the influence of entrances and objects in the parking area (trees, street lamps) was clearly overestimated, i.e. in fact significantly more vehicles can be parked than interpolated. With diagonal parking, there can also be a systematic deviation, since the real angle of the parking spaces can deviate from the fixed value in the data model.

The automatically generated parking lane data of the present parking space analysis were subjected to a complex manual post-processing, which also resulted in an error correction (quantitatively, however, also rather negligible): The number of parking spaces in the raw data record was 0.6 percent higher than in the post-processed data record (see Chapter 2.4).

In addition, there are a number of other factors that can lead to an overestimation or underestimation of the real parking space situation compared to the data model. They are difficult to measure and can therefore not or only to a limited extent be mapped in a numerical data model. For the interpretation of the results of the parking space analysis, these factors in particular must be taken into account:

> The data model of street parking depicts a legal, StVO-compliant situation; In reality, however, frequent wrong-way parking can be observed in the examination area up to actual parking lanes in traffic-calmed areas, in which parking is permanently wrong (e.g. Isar- / Neckarstrasse). In addition, there are gray areas such as diagonal and perpendicular parking, which should actually be arranged by signs or markings, which in some cases is not (no longer) recognizable on site - in this case the model reflects the situation as it is on site and in the past (aerial photographs) was permanently observable.

The influence of illegal parking behavior was quantified for two scenarios:

> If the average distance between parked vehicles and the intersection area is halved from 5 to 2.5 meters, the number of parked vehicles in the street area increases by 3.3 percent.
>
> If you park before every second entrance, the number of vehicles parked in the street area increases by 2.6 percent.

When calculating the density of parking spaces using vehicle registration data, it is assumed that the number of vehicles registered at a location is an indicator of the vehicles actually parked there (see Chapter 2.6). In residential areas in particular, there should be at least a strong correlation here - the actual number of parked vehicles could, however, be higher, especially since:

> Company / company cars are used privately by part of the population, i.e. also at their place of residence, but the vehicles are usually not registered there and therefore remain statistically invisible. This value is difficult to quantify, but is likely to be in the range of no more than four percent of all vehicles in the study area. [16]
>
> Vehicles from car sharing providers, of which around 6,000 are currently available in Berlin in the free-floating segment, are also increasingly being taken into account. The proportion of these vehicles in the study area is likely to be around one percent. [17] In addition, station-based providers occasionally claim parking spaces, for example in underground garages.

In areas with little parking pressure, there are also vehicles that are parked longer and at a greater distance from their actual reporting location due to the favorable parking space situation (e.g. sporadically used vans or mobile homes) - but which do not take up any parking space at the actual reporting location. Phenomena such as visitor traffic, on the other hand, are likely to have only a minor influence on the assessment of the permanent parking space situation.

Parking space information, which, in addition to street parking in public space, also takes into account the (mostly private) parking spaces away

space, also takes into account the (mostly private) parking spaces away from the street space, must be understood as potential statements,

since the actual occupancy of parking spaces remains unknown. For example, garages in particular are often used differently than to park a vehicle. Assuming that every second garage is not used to park a vehicle, the total available parking space in the data model is reduced by 3 percent. In neighborhoods with a high proportion of garages, especially the Rollbergkiez, this can lead to greater uncertainty in individual cases.

All car parks in the study area can also be used by residents; they contribute a total of almost 4 percent of the total storage space in the data model. In fact, however, this potential is apparently not being exhausted, as a large number of vacancies can be observed. In part, this also applies to other parking spaces, underground garages, etc. that are permanently underutilized.

Underground garages account for 7 percent of all available parking spaces, 81 percent of these underground parking spaces, however, are based on estimated values (see Chapter 2.5.2). If the actual number of estimated underground parking spaces were 10 percent above or below the determined values, the total available parking spaces in the data model would increase or decrease by 0.6 percent. This value is comparatively low; in individual cases, however, larger deviations could occur. The parking space situation around Mariendorfer Weg is dominated in the data model by two very large underground garages, which lead to a large oversupply of parking spaces. The real number of parking spaces here could possibly be considerably lower or not be available for all residents.

Construction sites and other temporary stopping and parking bans are not reflected in the data model, but in reality they permanently lead to a slight reduction in the actually usable parking space capacities.

In addition, there are other factors that can lead to uncertainties in a specific case, but only affect a very small part in relation to the totality of the data and for which a rather negligible influence on the general informative value can be assumed:

It must be assumed that not all parking-relevant objects have been mapped and that some are classified incorrectly or no longer up-to-date.

Above all, smaller parking spaces in shady backyards or parking garages on the ground floor of buildings that are difficult to access or see from public space and cannot be seen in aerial photographs are likely to be missing.

The data model only includes parking lanes as well as parking spaces and parking spaces, but neglects, for example, (sometimes illegal) parking on driveways, paths or other areas not designed for this purpose.

The parking space for parking lanes is based on a flat vehicle length or a fixed distance between two parked vehicles, based on an average vehicle length. Actual vehicle lengths are of course variable; there are also vehicles with larger (e.g. vans) or smaller (e.g. motorcycles) space requirements. The motor vehicle data set taken into account for the parking space density comprises 80 percent cars, the remainder is mainly divided equally between motorcycles and trucks (which also includes most small vans). [18th]

The demarcation of commercially used parking spaces, for example for transport vehicles (usually registered at this location), and employee or customer parking spaces that are not designed for long-term parking (and are therefore not taken into account in some evaluations), is difficult in individual cases or through mixed use impossible, so some of these can be incorrectly assigned.

Entrances or lowered curbs for which no widths are noted in the OSM data are included in the data model with a blanket width of 4 meters [19] . In individual cases, these can be narrower or wider, even if particularly wide driveways were usually provided with a width specification during the data collection phase or the parking lanes in this area were corrected in the manual post-processing of the data.

Appendix A: Available parking space capacities in different sub-areas

Anhang A: Verfügbare Stellplatzkapazitäten in verschiedenen Teilräumen

	Bevölkerung	Kfz		Verfügbare Stellplä Gesamt	
		Anzahl	% zu Bevölk.	Anzahl	% zu KfZ
Untersuchungsgebiet gesamt (a)	245.870	59.718	24,3%	64.973	108,8%
Ortsteil Neukölln	165.702	36.266	21,9%	39.561	109,1%
davon Wohnquartiere (b)	162.841	33.513	20,6%	35.447	105,8%
Bouchéstraße	3.852	1.023	26,6%	1.212	118,5%
Donaukiez	8.306	1.632	19,6%	1.015	62,2%
Flughafenkiez	9.824	1.792	18,2%	2.758	153,9%
Glasower Straße	8.570	2.066	24,1%	2.062	99,8%
Hertzbergkiez	8.894	1.845	20,7%	1.931	104,7%
Körnerkiez	12.248	2.405	19,6%	2.352	97,8%
Reuterkiez	27.355	5.426	19,8%	5.780	106,5%
Richardkiez	23.143	4.669	20,2%	4.655	99,7%
Rollbergkiez	7.397	1.497	20,2%	2.158	144,2%
Schillerkiez	15.798	2.848	18,0%	2.953	103,7%
Schulenburgpark	9.226	2.331	25,3%	2.568	110,2%
Silbersteinstraße	5.045	966	19,1%	1.298	134,4%
Treptower Straße Nord	7.073	1.544	21,8%	1.671	108,2%
Warthekiez	6.762	1.136	16,8%	1.214	106,9%
Weiße Siedlung	5.734	1.638	28,6%	1.301	79,4%
Wissmannstraße	3.614	695	19,2%	519	74,7%

a) Das gesamte Untersuchungsgebiet umfasst den Ortsteil Neukölln sowie zusätzlich eine angrer

b) Die Einteilung der Wohnquartiere entspricht den LOR-Planungsräumen, mit der Ausnahme, da

Anhang A | Diagramm 1 | Diagramm 2

Appendix B: Comparison of interpolated and counted parking spaces (street parking)

Anhang B: Vergleich interpolierter und gezählter Stellplätze (Straßenparken) : Anhang B

Straßenbschnitt			Seite	Ausrichtung	Stellplatzzahl	
Name	von	bis			gezählt	berechnet
Allerstr.	Lichtenrader Str.	Oderstr.	Nord	Längs	18	18
Allerstr.	Oderstr.	Lichtenrader Str.	Süd	Schräg	30	30
Allerstr.	Schillerprom.	Weisestr.	Süd	Längs	18	17
Allerstr.	Weisestr.	Schillerprom.	Nord	Schräg	33	30
Berthelsdorfer Str.	Kirchgasse	Donaustr.	Süd	Längs	11	9
Berthelsdorfer Str.	Richardstr.	Kirchgasse	Süd	Längs	18	18
Donaustr.	Geygerstr.	Innstr.	Ost	Längs	11	12
Elbingeroder Weg	(ganze Länge)	(ganze Länge)	Süd	Längs	20	21
Finowstr.	Kleine Innstr.	Wildenbruchplat	Süd	Schräg	18	20
Finowstr.	Sonnenallee	Weserstr.	Süd	Längs	26	26
Finowstr.	Weserstr.	Kleine Innstr.	Süd	Schräg	20	19
Fuldastr.	Ossastr.	Weigandufer	Süd	Längs	16	17
Geygerstr.	(Schleife)	(Schleife)	-	Längs	16	16
Geygerstr.	Donaustr.	Sonnenallee	Süd	Schräg	48	34
Geygerstr.	Sonnenallee	Donaustr.	Nord	Längs	24	22
Harzer Str.	Bouchéstr.	Wildenbruchstr.	Süd	Längs	26	25
Harzer Str.	Wildenbruchstr.	Sülzhayner Str.	Nord	Längs	11	13
Herrfurthstr.	Oderstr.	Lichtenrader Str.	Süd	Quer	34	33
Herrfurthstr.	Weisestr.	Hermannstr.	Süd	Längs	20	17
Hüttenroder Weg	(ganze Länge)	(ganze Länge)	Süd	Längs	35	33
Hüttenroder Weg	(ganze Länge)	(ganze Länge)	Nord	Längs	22	22
Hüttenroder Weg	(ganze Länge)	(ganze Länge)	Nord	Quer	21	10
Innstr.	Sonnenallee	Donaustr.	Nord	Schräg	46	41
Innstr.	Weserstr.	Sonnenallee	Nord	Längs	25	25
Innstr.	Weserstr.	Werrastr.	Süd	Schräg	40	37
Jansastr.	(ganze Länge)	(ganze Länge)	West	Schräg	26	23
Jansastr.	(ganze Länge)	(ganze Länge)	West	Längs	12	13
Kienitzer Str.	Lichtenrader Str.	Schillerprom.	Nord	Längs	20	18
Kienitzer Str.	Oderstr.	Lichtenrader Str.	Nord	Längs	17	17
Kienitzer Str.	Schillerprom.	Weisestr.	Nord	Längs	17	18
Kirchgasse	(ganze Länge)	(ganze Länge)	West	Längs	6	6
Kirchgasse	(ganze Länge)	(ganze Länge)	Ost	Quer	7	6
Leinestr.	Schillerprom.	Lichtenrader Str.	Nord	Schräg	34	34
Lichtenrader Str.	Herrfurthstr.	Kienitzer Str.	West	Längs	26	26
Lichtenrader Str.	Herrfurthstr.	Selchower Str.	Ost	Quer	62	62
Lichtenrader Str.	Kienitzer Str.	Allerstr.	Ost	Längs	15	15
Lichtenrader Str.	Kienitzer Str.	Herrfurthstr.	Ost	Schräg	44	42
Lichtenrader Str.	Leinestr.	Okerstr.	Ost	Längs	14	14
Lichtenrader Str.	Mahlower Str.	Herrfurthstr.	West	Längs	48	52
Lichtenrader Str.	Okerstr.	Allerstr.	Ost	Längs	16	14
Lichtenrader Str.	Selchower Str.	Mahlower Str.	Ost	Quer	31	32
Oderstr.	Kienitzer Str.	Allerstr.	Ost	Schräg	27	22
Oderstr.	Okerstr.	Allerstr.	Ost	Schräg	24	26
Okerstr.	Hermannstr.	Weisestr.	Nord	Längs	25	25
Okerstr.	Lichtenrader Str.	Oderstr.	Nord	Längs	15	18
Okerstr.	Lichtenrader Str.	Schillerprom.	Süd	Schräg	31	31
Okerstr.	Schillerprom.	Lichtenrader Str.	Nord	Längs	18	18
Okerstr.	Weisestr.	Schillerprom.	Nord	Längs	19	19
Ossastr.	(Wendeschleife)	Weichselstr.	Süd	Schräg	18	18
Ossastr.	Fuldastr.	Weichselstr.	Nord	Längs	32	32
Ossastr.	Weichselstr.	(Wendeschleife)	Nord	Längs	10	10
Schillerprom.	Kienitzer Str.	Allerstr.	Ost	Schräg	25	24

Schillerprom.	Okerstr.	Leinestr.	West	Längs	15	15
Sülzhayner Str.	(ganze Länge)	(ganze Länge)	Nord	Längs	23	23
Sülzhayner Str.	(ganze Länge)	(ganze Länge)	Süd	Längs	30	37
Tellstr.	(ganze Länge)	(ganze Länge)	Ost	Schräg	48	38
Weichselstr.	Ossastr.	Weserstr.	Nord	Längs	23	25
Weigandufer	Elbestr.	Wildenbruchstr.	Süd	Längs	22	22
Weigandufer	Fuldastr.	Elbestr.	Süd	Längs	21	19
Weisestr.	Allerstr.	Kienitzer Str.	West	Schräg	27	27
Weisestr.	Herrfurthstr.	Kienitzer Str.	West	Längs	27	26
Weisestr.	Kienitzer Str.	Allerstr.	Ost	Längs	16	14
Weserstr.	Elbestr.	Wildenbruchstr.	Süd	Längs	26	27
Weserstr.	Finowstr.	Wildenbruchstr.	Nord	Längs	15	17
Weserstr.	Jansastr.	Weichselstr.	Süd	Längs	12	12
Weserstr.	Tellstr.	Jansastr.	Süd	Längs	19	20
Weserstr.	Wildenbruchstr.	Finowstr.	Süd	Längs	17	17
Wildenbruchplatz	Finowstr.	Innstr.	Süd	Längs	16	16
Wildenbruchstr.	Harzer Str.	Kiehlufer	Nord	Längs	25	26
Wildenbruchstr.	Kiehlufer	Harzer Str.	Süd	Längs	17	19
			Anteil real			
			87,3%	Längs	933	943
			7,9%	Schräg	539	496
			4,8%	Quer	155	143
				gesamt		
				(gewichtet nach Anteil der jewe		

Anhang B

Footnotes

1. What influence a lower accuracy and completeness of the OSM data would have on the quality of the result, especially with regard to street parking, will be the subject of later evaluations, which will be documented on the project page in the OSM Wiki . ↩

2. Calculated according to the Berlin-Brandenburg Statistics Office: “Inhabitants registered under registration law at the location of their main residence in Berlin on June 30th, 2020 according to planning areas and vehicle inventory”, available on the data page for this parking space analysis . ↩

3. Building entrances were then included in the evaluation if they have a curb drop at the road junction and are recognizable or signposted as an entrance. This is the case in the vast majority of built-in driveways. In rarer cases, however, such driveways are obviously no longer used despite the curbs being lowered (neither for vehicles nor, for example, for garbage collection) and are also not marked as driveways, and

possibly no longer legally designated as such. ↩

4. Since the ALKIS data are obviously incorrect in some cases or parts of the underground car park are missing, some geometries were corrected on the basis of map data and aerial photographs (particularly taking into account building floor areas or structures above them such as parking lots, slopes and entrances). In addition, the access routes to the underground car parks were recorded on site and locations excluded if no access routes could be found or, in rarer cases, underground car parks with estimated floor areas were included if these were completely missing in the ALKIS data. ↩

5. Available online on the parking space analysis project page . ↩

6. For this purpose, an automated "snapping" and then a systematic error correction and follow-up control was carried out for each individual segment, partly using current street photos (mapillary) and other data such as the traffic sign and sidewalk crossing layer of the Berlin road traffic 2014 for a more precise alignment of parking spaces. and stopping bans or entrance areas. ↩

7. The deviation between the number of parking spaces determined purely automatically and the post-processed data is only 0.6 percent for on-street parking and is therefore lower than that of other uncertainty factors (see Chapter 3). ↩

8. Research Society for Roads and Transport (FGSV) (Ed.): Recommendations for systems for stationary traffic EAR 05, edition 2005. Cologne: FGSV-Verlag. ↩

9. This value corresponds to the angle that could be determined from orthophotos for most parking spaces of this type from random samples in the investigation area. In the case of angles that deviate from this, only a marginal deviation in relation to the overall result is to be expected, so this value was assumed to be constant to simplify the calculations. ↩

10. The known parking space information for underground garages is based on documents accessible online such as reports and planning documents

on documents accessible online such as reports and planning documents for construction projects or advertisements on rental portals, on-site

counts and occasional successful inquiries from landlords or owners (see also Section 2.3). ↩

11. Smaller parking spaces have fewer than eight spaces, larger ones at least eight. This limit was derived from the existing properties with precise information on the parking space capacity, since a significant jump in the quotient of the area and the number of parking spaces was observed in this area. ↩

12. The ALKIS building data contain a classification of its function for each building, so that residential buildings can be differentiated from office, commercial or industrial buildings, for example, or mixed uses can be identified. ↩

13. For pure residential buildings, all upper floors were included. For buildings in the “residential buildings with commercial use” category, it can be assumed that one floor (ground floor) is not used for living. For the rather rare category “commercial building with residential use” it was assumed that half of all floors are used as residential floors. ↩

14. Isochrones are spatial lines of the same time, so in this case they delimit a space that can be reached on foot within the specified time and that extends up to 350 meters from the starting point. The routing took place via the OSM road and path network. ↩

15. Vehicles and parking spaces of sufficient size for a car were counted, provided that proper parking is observed, i.e. in particular with compliance with the 5-meter distance to crossings and the keeping of entrances free. ↩

16. Around four percent of drivers in Germany state that their first vehicle is a company car (cf. Statista: [“Number of people in Germany whose first vehicle is a private or company car”]( ). The extent to which this information can be transferred to the socio-economic and geographical conditions of the study area and how second car etc. and other factors influence this value cannot be assessed at this point. ↩

17. Assuming that these 6,000 vehicles would all be parked within the S-Bahn ring, where there are around 350,000 registered vehicles, this would result in a share of 1.7 percent of the vehicles registered there. The business area of many providers also extends beyond that. ↩️

18. For Berlin see Statistical Office for Berlin-Brandenburg: Motor vehicle inventory in the state of Berlin, available online here. ↩️

19. In the case law, a width of 3 meters is sometimes seen as sufficient, which in the data model would result in a 0.7 percent higher number of parking spaces. The fact that individual entrances are wider, but do not flow into the model with their actual width, is not yet taken into account. ↩️