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Condition Assessment of Cycling Infrastructure – A Step towards a Systematised Approach in Austria

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1 ABSTRACT

In Austria, regular condition assessments of roads and civil engineering structures have long been established, while cycling infrastructure has often been neglected. However, an efficient, safe, and continuous cycling infrastructure is an essential prerequisite for promoting cycling and shifting journeys to this mode of transport. There are currently considerable differences between the responsible local authorities in terms of the regularity of condition surveys, the parameters recorded, their level of detail, and the survey methods used. While regular condition assessments are planned for tourist cycle routes, such as EuroVelo routes, there is a lack of uniform and binding specifications for everyday cycling infrastructure.

Regardless of the type of cycling facility, a reliable, up-to-date, and comparable database is essential for planning, maintenance, and quality assurance. It enables the early identification of gaps in the network, infrastructural deficits, and deviations from applicable safety and design guidelines. In addition, continuous updating of the Graph Integration Platform (GIP) as the central reference system for public administration for transport infrastructure data is necessary, which requires structured and regular feedback from the responsible authorities.

Against this backdrop, a research project funded by the Austrian Road Safety Fund (VSF) investigates the development of an efficient, objective, and comparable methodology for recording cycling infrastructure. To this end, online surveys were conducted among cycling officials and GIP representatives in the federal states, and supplementary expert discussions were held. Based on 27 relevant quality and safety parameters identified in the specialist literature, ten key parameters were defined in consultation with an interdisciplinary advisory board. In addition, a concept was developed for uninterrupted, sensor-based condition surveys using a cargo bike, and criteria for a continuous cycling infrastructure were defined. Pilot applications in 2026 will serve to evaluate and further develop the methodology in terms of its practical applicability and significance.

Keywords: cycling infrastructure , condition assessment , Graph Integration Platform (GIP), Austria, mobility

2 PROBLEM STATEMENT

Recording the structural condition of roads and engineering structures on a regular basis is common practice in Austria. The approach being pursued is to use a measurement vehicle to provide a comprehensive and objective assessment of the condition of the road network. The vehicle's sensory system records the roads in flowing traffic without any traffic-restricting measures (AIT 2026). Subsequently, the various road sections are categorized based on current guidelines (IÖB 2023). This approach aims to support administrative and political decision-makers in prioritizing future road maintenance and renewal measures throughout the country. Based on the available data and its classification, it is possible to develop a program for road construction and renovation measures can be scheduled.

In contrast, this approach is only being pursued for motorized transport areas and not for cycling infrastructure. Although the importance of increased bicycle traffic for the mobility transition is recognized, the necessary bicycle infrastructure is often neglected and its condition overlooked. Despite the fact that studies on single-vehicle accidents involving cyclists related to infrastructure in Austria and Germany (Zuser et al. 2023, Francke et al. 2024, Borsellino 2024) and experiences from Denmark show that "Surfaces for cyclists require high quality maintenance, higher than the road surface, as even a small crack or pot hole can have very serious consequences" (Eriksson 2013: 165). A study by the Transport Research Laboratory shows that infrastructural factors such as limited visibility or insufficient road grip are responsible for 26.3% of traffic accidents, while only 6.7% are attributable to vehicle-related causes (e.g. faulty braking systems) (Eriksson 2013). The vast majority of accidents (91.5%) are attributable to human factors, including excessive speed, the influence of alcohol or drugs, attention deficits and orientation problems (Eriksson 2013).

There are significant differences in terms of the regularity of condition assessment of bicycle infrastructure, the parameters measured, the level of detail of the parameters, and the survey procedure itself (with or without technical assistance) in Austria. The quality of bicycle infrastructure surveys therefore varies depending on the authority responsible and the importance given to the network section of the cycling infrastructure. For tourist cycle routes of European significance (EuroVelo), for example, regular condition assessments are necessary, but there are no generally applicable requirements for the subordinate cycling network or everyday cycling infrastructure.

Regardless of the type of cycling infrastructure, a reliable data basis for planning and maintenance is essential to identify gaps and poor-quality infrastructure (e.g., non-compliance with current road safety guidelines) at an early stage and to be able to take appropriate action. In addition, it is necessary to keep the Graph Integration Platform (GIP), the official reference system for authorities and public administrations for transport infrastructure based on a common data standard, up to date. That also means supporting local authorities in regularly reporting to the GIP officers on changes and innovations in cycling infrastructure.

To collect infrastructure information in Austria efficiently, objectively, and in a comparable manner, the requirements for an efficient infrastructure condition assessment methodology must be determined.

3 METHODOLOGICAL APPROACH AND PRELIMINARY WORK

A three-stage methodological approach was chosen to identify key quality parameters for cycling infrastructure (see Fig. 1). First, preparatory work involved conducting a comprehensive literature review and systematizing relevant quality criteria and characteristics of reported problem areas. Building on this, qualitative data was collected through discussions with stakeholders from various federal states, analysis of measurement methods used, and the involvement of an advisory board. In a third step, the results were quantitatively validated and prioritized using an online survey of 29 experts and used to derive requirements for sensor instruments. The result is a survey catalog with the ten key parameters.

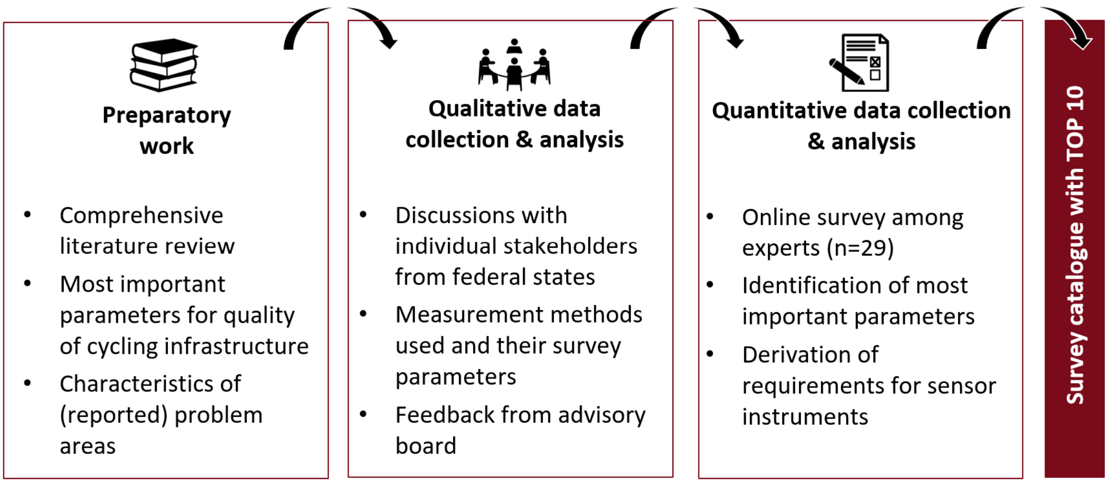

Fig. 1: Methodological approach.

To outline the initial situation, the following paragraphs briefly discuss relevant national and European preparatory work.

In Austria, several studies on the systematic evaluation of cycling infrastructure were carried out at the Institute of Transportation Sciences at the University of Natural Resources and Life Sciences in Vienna. This resulted in standardized survey and evaluation approaches using checklists (Ferstner 2020, Schnauderer/Vavti 2022), including classification systems and analyses of administrative requirements for app-based reporting systems (Zorzi 2014). The BikeQuality app from Salzburg Research assesses cycling infrastructure based on vibrations, stopping times, and speeds during the ride (Salzburg Research 2021) without providing details on the surface characteristics, signage, markings or clearance.

At the European level, the SABRINA project (Safer Bicycle Routes in the Danube Area) investigated the safety of cycling infrastructure in the Danube region. The results show deficits compared to motorized traffic standards, particularly in terms of equipment and maintenance, and emphasize the added value of bicycle-based inspections (Fischer et al. 2022).

4 STATE-OF-THE ART OF CONDITION ASSESSMENT OF BICYCLE INFRASTRUCTURE

In February 2025, AustriaTech conducted an evaluation of safe cycling networks[1] based on data from the GIP. At the time of the analysis, the cycling network recorded in the GIP covered a total length of 18,724 km. The distribution of lane types by kilometre and federal state shows a clear dominance of roads with a maximum speed limit of ≤ 30 km/h (around 41%), followed by mixed footpaths and cycle paths (around 40%) and roads with access restrictions, except for cycle traffic (around 9.5%) (AustriaTech 2024).

In terms of the percentage distribution of cycling infrastructure across the federal states, Lower Austria leads the way with a share of 18%, followed by Styria and Vienna with 14% each. Vorarlberg is close behind with 13%, followed by Tyrol with 10% and Salzburg and Upper Austria with 9% each. Carinthia and Burgenland have the lowest share with 7% and 6% (AustriaTech 2024). Apart from the high network density in Vienna, which is due in particular to the intensive expansion of inner-city transport connections, Vorarlberg stands out as the second smallest federal state (Statistik Austria 2025) with a comparatively small area, but an above-average level of development of its cycle network.

Although these official figures and a definition of safe cycling infrastructure exist, discussions with the federal states have revealed that the term “cycling infrastructure” is not understood uniformly by the stakeholders. From a legal perspective, the different types of facilities are defined in the Road Traffic Regulations (StVO) and the Road Marking Regulations (BmVO). The guidelines and regulations for road construction (RVS) contain further conceptual distinctions: while cycle facilities comprise all areas where cycling is permitted, cycle lanes refer to those areas for which special usage regulations apply, such as multi-purpose lanes (Radlobby 2024).

It should also be noted that the importance of various cycling facilities varies from one federal state to another. In Tyrol, for example, the focus is on leisure and tourism (see Fig. 2). Accordingly, the characteristics and requirements of cyclists vary depending on whether they are using their bikes for everyday or leisure purposes, as explained in RVS 03.02.13 “Cycling”.

The federal states pursue different approaches to the assessment, expansion, financing and maintenance of cycling infrastructure. While Burgenland, Lower Austria and Tyrol carry out regular condition assessments and inspections, there is no systematic assessment in Upper Austria. Lower Austria, Carinthia and Upper Austria have clear regulations on the distribution of costs between the state and municipalities, especially for supra-regional main routes. Carinthia and Vorarlberg have established supra-regional cycle paths legally and strategically, with Vorarlberg prioritising everyday cycling and using data-based condition assessments. Salzburg and Vorarlberg also focus on everyday traffic, while Tyrol prioritises recreational cycling. Vienna records its cycling infrastructure digitally across the board using its own survey system (Kappazunder). Overall, there are significant differences in terms of responsibilities, quality standards, data bases and the strategic orientation of cycling in the federal states.

[1] A safe cycling network includes the following (cycling) infrastructure: Structured bike paths, bike paths without mandatory use, separate sidewalks and bike paths with and without mandatory use, mixed sidewalks and bike paths with and without mandatory use, bike lanes, bike crossings, multi-purpose lanes, residential streets, shared zones, cycling in pedestrian zones, cycling against one-way traffic ≤ 30 km/h, roads ≤ 30 km/h, driving ban except for bikes ≤ 50 km/h.

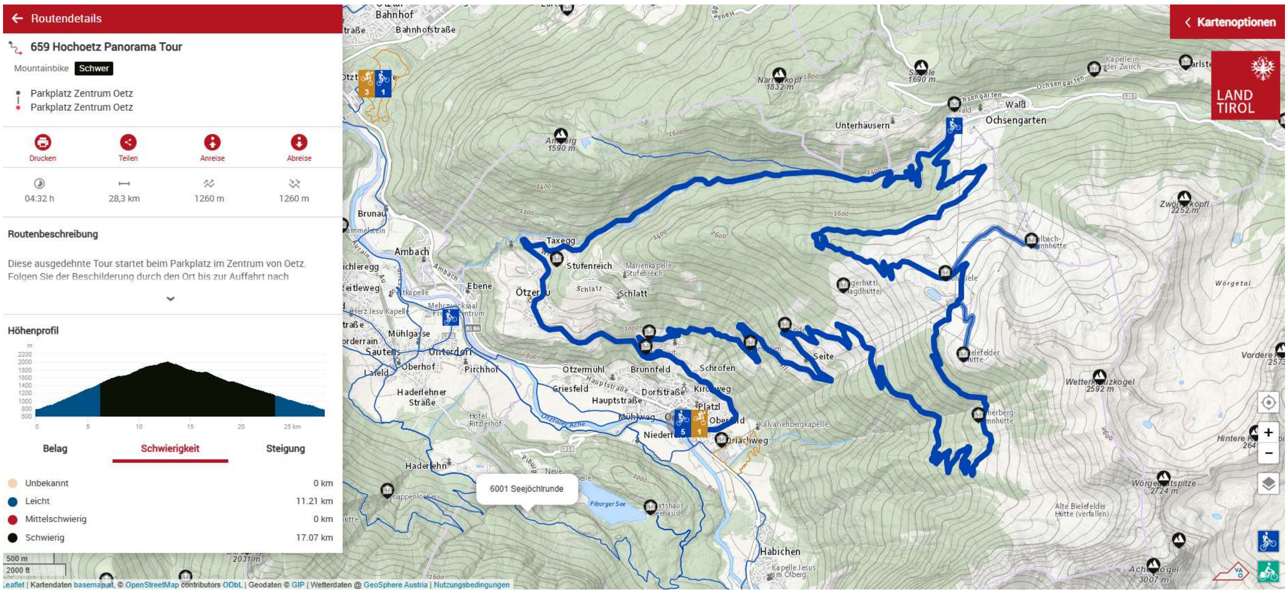

Fig. 2: Tyrol’s bike route planner based on GIP data (https://radrouting.tirol/) provides a route description, an elevation profile with information on the surface type and difficulty level as well as travel time and route length.

5 DEVELOPMENT OF A SURVEY CATALOG USING EXPERT FEEDBACK

In addition to discussions with stakeholders, an online survey among experts has been conducted (16 September 2025 to 9 October 2025) to ascertain current access to status surveys of cycling infrastructure and the implementation of data in the GIP. The aim was to identify the most important parameters for condition assessment and to create a survey catalog that allows for systematic inspection of the cycling infrastructure based on these.

A total of 29 questionnaires were evaluated, 22 of which were complete and the remaining six participants answered at least half of the questions. Different questions were asked depending on the job profile, as GIP experts have a different focus than those who collect status data. The complete questionnaire consists of 13 questions. The survey reached experts from all federal states with the following distribution: Vienna – 5 persons, Burgenland – 5 persons, Tyrol – 5 persons, Upper Austria – 4 persons, Lower Austria – 3 persons, Carinthia – 2 persons, Vorarlberg – 2 persons, Styria – 2 persons, Salzburg – 1 person. In terms of the professional orientation of the survey participants, the field of geoinformation (18 mentions) leads the way, followed by bicycle traffic coordination and bicycle traffic planning (with five mentions each). Three respondents mentioned the signage of bicycle facilities, two mentioned the construction of physical facilities, and one mentioned the maintenance of physical facilities.

The survey participants responsible for cycling infrastructure were asked about the current practices for assessing the condition of cycling facilities. The most common response was an inspection without a standardised checklist followed by assessing the condition of cycle facilities by driving along them in a vehicle using a checklist. The evaluation of planning documents, driving along the route in a measuring vehicle, cycling along the route using a checklist and an inspection with a checklist are hardly according to the survey participants. Cycle paths primarily used by tourists are inspected at regular intervals in Austria (every year up to every three years). For everyday cycle paths, the frequency of inspections depends heavily on the responsible authorities and the available budget. However, problem areas are often known and are sometimes reported by the citizens. Responsibilities vary greatly between the federal states. In Vorarlberg, for example, the road maintenance authority is responsible, while in Lower Austria it is the state employees. In some federal states (e.g., Salzburg, Burgenland), it even concerns different stakeholders.

The survey of regularly recorded parameters on the condition of cycle facilities (24 answers) shows a strong focus on basic infrastructural features. A total of 27 parameters from the literature were provided for selection, and the option of entering free text was also offered (Miscellaneous). The most frequently documented aspects are surface type, signage and facility width, while structural condition, road markings and separation from other traffic areas are only taken into account by a small proportion of respondents. Numerous parameters relevant to safety and riding comfort, including gradients, obstacles, drainage, grip and distances to parked vehicles, are not systematically recorded. In addition, other aspects such as the mere presence of cycle facilities and vegetation in the clearance profile were mentioned in isolated cases. Overall, the evaluation indicates limited and heterogeneous data collection, in which key qualitative and safety-related features are often not taken into account.

Parameter	**Entries**	**Parameter**	**Entries**
Signage (traffic signs in accordance with road traffic regulations and directional signage)	18	Longitudinal gradients	4
Type of surface paving	16	Lighting	4
Separation from other traffic areas (roads, pavements)	15	Clearance	4
Width of the cycle lane	14	Stopping points and stopping times	3
Road markings	11	Metal grilles	3
Changes in road surface	11	Distance to parked vehicles	3
Route images (front, rear and 360° panoramic camera)	11	Driving comfort (vibrations)	3
Obstacles	9	Kerbs lowered at entrances and exits	2
Hazardous areas	8	Cross slopes	2
Structural condition, including type and severity of damage	8	Drainage facilities	2
Uneven surfaces	8	Grip	2
Narrow sections	7	Curve radii	2
Sight lines	5	Miscellaneous	2
Longitudinal edges, kerb edges	5		

Table 1: Survey question “Which parameters are relevant to your daily work (planning, maintenance, transfer to the GIP)?”.

In contrast, respondents were asked which parameters would be relevant for their everyday work (see Table 1). This question was answered by 28 of the 29 respondents. The most frequently mentioned factors were: signage (18 entries), type of surface paving (16), separation from other traffic areas (15) and width of the cycle lane (14). The least frequently mentioned were: cross slopes, kerb ramps, drainage facilities, grip, curve radii, other (2 mentions each). The correct location (in the GIP) was mentioned under the category “Miscellaneous”.

Focussing on the GIP officers among the respondents, the entry of infrastructure data into the GIP was questioned with regard to the information collected as a priority and the frequency of reporting. The survey participants were asked about the types of infrastructure which are primarily included in the GIP (see Fig. 2) and the details on the cycling infrastructure available in the GIP (answered by 15 persons, question “What data is included in the GIP?”).

The minimum standard was mentioned most frequently (12 mentions), followed by “push bike” (8 mentions), “traffic restrictions for cyclists” (7 mentions), and cycle route status (7 mentions). Speed limits were mentioned only five times, difficulty five times, and obstacles twice. Accompanying paths were only an issue for one stakeholder, while details on the experience value and time restrictions for cyclists were each mentioned twice.

To verify the practical suitability of the condition assessment method prior to field testing, an advisory board was established. The advisory board consisted of national and international experts in the fields of cycling infrastructure, cycling safety, and infrastructure data, with national experts from six of Austria’s nine federal states. The ten most important metrics were determined in consultation with the advisory board of which five metrics are to be transferred to the GIP.

(1) Type of surface paving (→ GIP)

(2) Changes in road surface (→ GIP)

(3) Width of the cycle lane (→ GIP)

(4) Road markings quality including pictograms/sharrows or similar

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(5) Separation from other traffic areas (roads, pavements) (→ GIP)

(6) Signage (traffic signs in accordance with road traffic regulations and directional signage) (→GIP; a facility type)

(7) Route images

(8) Longitudinal edges, kerb edges

(9) Structural condition including type and extent of damage

(10) Clearance including obstacles

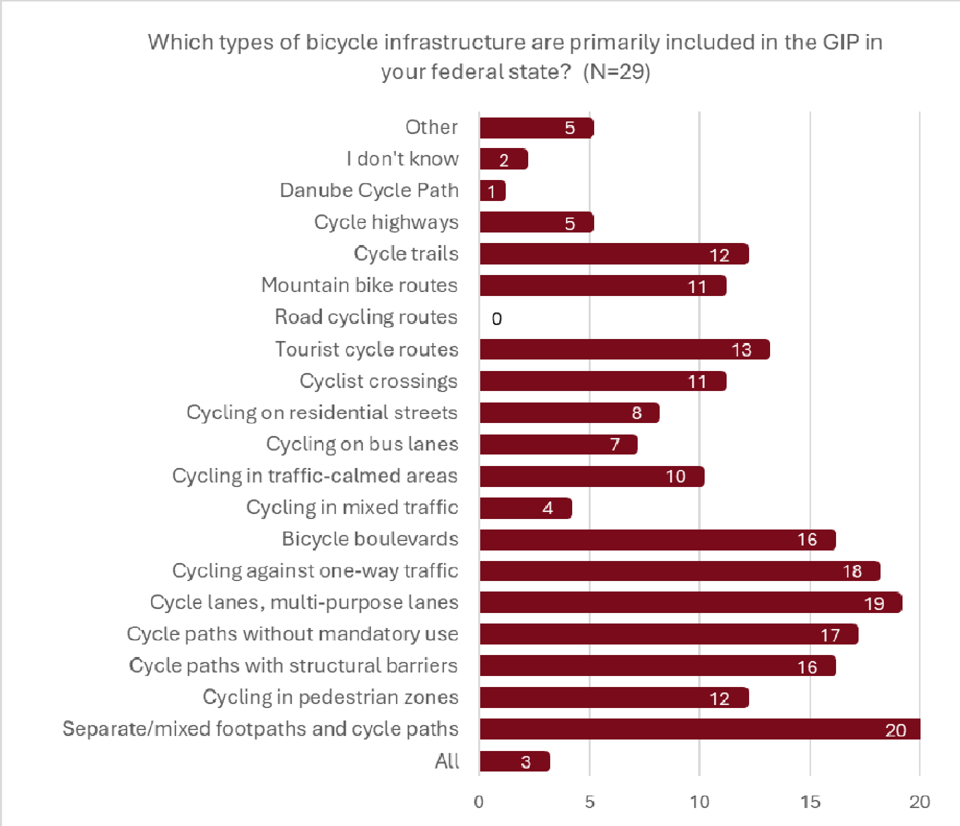

Fig. 3: Survey question “Which types of bicycle infrastructure are primarily included in the GIP in your federal state?”.

During the advisory board meeting, it was suggested that on the journey, it should be possible to record signage in both directions, and the side space would also be interesting for obtaining additional information (e.g., signage obscured by vegetation). In addition, curbs and associated vibrations should be recorded at intersections, and with regard to obstacles in urban areas, cars protruding into the bicycle lane would be of interest (percentage evaluation). All elements of the survey catalog must also be described or defined in more detail, and the level of detail of the survey data must be specified.

6 TRANSFER OF SURVEY RESULTS INTO A MEASUREMENT SYSTEM

To record the parameters in a measurement run without interruptions (performed by a cargo bike due to more points of contact with the ground), basic sensor equipment has to be assembled and the level of detail for the condition assessment of cycling infrastructure has to be defined.

A survey of currently existing digitization solutions for bicycle networks shows that camera-based detection systems in combination with GPS are predominantly used. In Germany, Steffen Knab Mobility Consulting offers image-based inventory of cycling infrastructure with a focus on signage (bildbefahrung 2025), while the R4R research project expands on this approach by using additional sensors (including LiDAR and IMU) and automatically merging multimodal data (Laghbani et al. 2025). The Holocene Bike has been developed by Boréal Bikes with the following equipment: GPS, IMU, LiDAR, cameras, on-board computer, interfaces for wireless communication, electric drive (Salzburg Research 2026).

In Denmark, the “ROAD System” has been tested as a comprehensive monitoring tool that records various infrastructure and environmental parameters and visualizes them in a GIS-based dashboard (EIT Urban Mobility 2026). A simplified version uses smartphone images taken from bicycles to automatically detect road damage with high classification and positional accuracy (ROAD SYSTEM™ 2026).

CycleRAP takes a model-based approach, calculating a risk score for cycling regardless of the type of facility by taking into account infrastructure features, accident factors, and, in particular, the distance to motorized traffic (iRAP 2024).

Investigations on sensors available to collect the ten specified parameters resulted in a limitation of basic sensor equipment to the technologies described in Table 2.

Sensors	**Possible measurement parameters**
GPS	Trajectory, curve radius
IMU	Evenness, longitudinal and transverse slope
Stereo cameras	Object positioning, carriageway width, lighting, colour, parking facilities, side distances, cracks/damage
LiDAR	Carriageway width, sight lines, clearance profile, cracks/damage, kerb height, overtaking distances, side distances, speed difference during overtaking manoeuvres
Position sensor (DMU)	Distance travelled
Temperature sensors	Air temperature, carriageway temperature

Table 2: Sensors for recording various parameters.

In addition to selecting the sensory characteristics, the level of detail for the condition assessment had to be determined. The GIP standard description devotes a separate chapter to bicycle traffic and the associated special provisions, which is illustrated with various examples. The most important metrics recorded are the type of cycling infrastructure (cycle path, cycle lane, etc.), the average width, the surface (paved, unpaved, or specification), the type of crossing (intersection area). Apart from that, the assessment of comfort (experience value, difficulty), and regulations according to the StVO (time restrictions for cyclists, speed limits, pushing bikes, restricted through traffic for cyclists), lighting, traffic light control, cycle route status, and obstacles can be implemented in the GIP (ÖVDAT 2021).

The GIP standard description (ÖVDAT 2021) therefore offers a wealth of parameters in the category of bicycle traffic. The definition of road surface characteristics thus comprises 28 options, excluding the option “unknown”. The level of detail causes problems when analyzing the data, which is why a simplified approach to data collection is chosen in some cases (see Table 3). In addition to the aspects mentioned in the GIP standard description, other aspects such as gaps in signage and the quality of the road surface, pictograms, and the condition of signs are relevant as well.

Parameter	**Level of detail**
Type of surface paving	Gravel, asphalt, concrete, paving stones, terrain
Changes in road surface	-
Width of the cycle lane	Accurate to ≤ 10 cm
Road markings availability/quality	All markings including pictograms, sharrows; Categories: okay/monitor/replace
Separation from other traffic areas	Infrastructural separation (roads, pavements)
Signage	Existence and condition of signage compliant with traffic regulations and directional signage; Categories: okay/monitor/replace; Identification of gaps in signage
Route images	Front and rear images
Longitudinal edges, kerb edges	Existence and location
Structural condition including type and extent of damage	Identification of cracks etc.; Categories: okay/monitor/replace
Clearance including obstacles	Occurrence and location

Table 3: Level of detail in the collection of various parameters.

Furthermore, criteria were established that a “continuous cycling infrastructure” should meet. This definition incorporated aspects such as adequate directional signage, clear indication of the type of facility through road markings and traffic signage, cycle-specific routing at junctions (cycle crossings, etc.), clear separation/mixing with other road users, and passage (bottlenecks, obstacles). Furthermore, it has been solved from a technical perspective how gaps (e.g., in signage) or bottlenecks (e.g., due to vegetation) are to be dealt with during the inspection.

7 CONCLUSIONS AND OUTLOOK

Safe and attractive cycling infrastructure is a key factor in driving forward the mobility transition. Systematic assessment of the condition of cycling infrastructure is therefore essential. To assist those responsible, the parameters to be collected as standard and the intervals at which they should be collected were identified and this approach was compared with actual requirements. A literature review, an online expert survey as well as discussions with experts and the feedback of an advisory board were used to achieve a systematic approach to assessing the state of cycling infrastructure.

A total of ten parameters were identified that should be collected in order to adequately assess the condition of cycling infrastructure and five of them that provide the necessary data for the GIP implementation: type of surface paving, changes in road surface, width of the cycle lane, road markings quality including pictograms/sharrows or similar, separation from other traffic areas (roads, pavements), signage (traffic signs in accordance with road traffic regulations and directional signage), route images, longitudinal edges/kerb edges, structural condition including type and extent of damage, clearance including obstacles.

Based on the parameters to be collected, suitable sensor technologies were identified and the required level of detail for data collection was determined. As part of sample surveys of various cycling infrastructures starting in Spring 2026, potential weaknesses in the methodology for condition assessment, the sensor technology used, and data processing will be identified. The aim is to verify and ensure the practicality and robustness of the chosen approach to condition assessment.

A total of around 150 km of cycling infrastructure in Austria will be examined. The surveys will be carried out on different types of infrastructure and in several federal states. There is no minimum length for the individual sections; rather, the sections examined should be as diverse as possible in order to comprehensively evaluate the suitability of the measurement methodology and the subsequent data analysis. The collected data will be integrated into the GIP in cooperation with the respective GIP officers of the federal states concerned. The results of the survey will be presented to the advisory board and their feedback will be incorporated into the survey catalog and the list of recommendations for efficient surveying.

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