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RELATING ACTIVE TRAVELLER EXPECTATIONS TO SURFACE CONDITION MANAGEMENT OF CYCLE FACILITIES

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Abstract

In recent years active mobility is promoted as one of the levers for mobility changes away from the use of motorised vehicles. Road authorities at all levels invest in new cycle facilities. But active travellers only stay keen on using this infrastructure if it is maintained and kept at a sufficient quality level. This contribution discusses the prerequisites for a cycle facility management system (CFMS): the link between the quality requirements, the surface condition of the cycle facilities, and the decisions cycle facility managers can make. It is shown that the combination of criteria related to mobility and criteria related to surface condition enhance manager's understanding. It is widely accepted that there are five quality requirements for cycle facilities: Coherence and Readability, Directness, Attractiveness, Safety, and Comfort. These are discussed in the paper, identifying their link either to surface characteristics or to field situations. The paper lists different maintenance actions that can help improving on the quality requirements. Comfort and safety aspects are strongly linked with surface characteristics of the cycle facility and can be inspected or measured with methods studied in the frame of the Belgian pre-normative project SuChar-BiLan. Other quality requirements may ask for regular clearing of fallen tree leaves and dirt, or small adjustments to the environment. Hence, to determine the needs of maintenance actions, inspections, condition measurements, inventory data analysis, user's feedback and the evaluation of situations are needed, combining mobility measures and surface condition maintenance. The paper discusses several cycle facility management practices reported in the literature. It is argued that strategic decision with a CFMS needs to be based on the evaluation of all five quality requirements. It is concluded that a CFMS should provide a strategy of investment in condition maintenance, modifications in design, simple resolutions of situations, and routine measures.

Keywords: cycle facilities, expectations, design, maintenance

1 Introduction

Active mobility gains in importance [1-4] and is being promoted as one of the levers for mobility changes away from the use of motorised vehicles. Investments in cycle facilities are welcomed by mobility managers and road authorities at all levels. It is widely accepted [5-12] that there are five quality requirements for cycle facilities: Coherence and Readability, Directness, Attractiveness, Safety, and Comfort. In Section 2 these five requirements are discussed, including how they can be monitored or evaluated, and if and which indicators are in use.

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Management of cycle facilities can be oriented to the promotion of active mobility modes, for instance with the use of an "urban bikeability index" [13-15], including a tool for decision-makers to prioritise investments in bicycle infrastructure in function of bicycle travel demand. However, once investments in new cycle facilities are made, also the maintenance of this network needs attention. Numerous surveys (e.g. [16-18]) show that users of cycle facilities are expecting safe and comfortable infrastructure and that road managers are aware of this and act accordingly. Comfort and some safety aspects are strongly linked with surface characteristics of the cycle facility. Hence, road managers tend to collect data to evaluate and improve comfort and respond to complaints or observed safety issues. Beyond Safety and Comfort, the requirements Coherence and Readability, Directness, and Attractiveness are of particular importance for travellers to decide making use of the cycle facilities. These three contribute to mobility management and issues with them are often "situations" rather than "surface conditions". This is addressed in Section 3.
Unlike traffic loads affecting the condition of road pavements, the degradation of the quality of cycle facilities over time is not due to their use. For instance, one source of degradation in cities is imperfect repairs by utility companies. Therefore, a cycle facility management system (CFMS) cannot reasonably make use of any prediction of the evolution of condition in time. In Section 4 examples of cycle facility management, and simple maintenance measures to improve situations and surface conditions are discussed. It is argued that a CFMS should be based on the evaluation and improvement of the five quality requirements cited above.

2 Five quality requirements for cycle facilities

2.1 Comfort

Comfort is strongly related with the evenness of the cycle surface. Waviness with short wavelengths is considered as uncomfortable. So are local defects that can be avoided by the users by steering their bicycle (or another vehicle) alongside, as well as uneven transitions, for instance at road crossings. Examples of very short wavelengths, sometimes also representing a safety hazard, are the vertical deformations due to tree roots, and potholes. Measurement devices exist for the evaluation of comfort (see [19] for a review). Their measurement results are reported in "comfort indicators" or in "estimated IRI". These devices usually make use of an accelerometer, and they measure the vertical accelerations due to unevenness of the cycle surface. Comfort indicators derived from such measurements are used for the evaluation of the quality of cycle facilities on a network level. In Belgium, the "Fietsersbond" combines their comfort measurements with a thorough visual quality inspection, addressing all kinds of other potential issues beyond evenness. Other measurement devices allow the determination of the evenness of the cycle surface [19]. The Cycle Path Profiler is used in Belgium and reports evenness coefficients. These are used for the evaluation and acceptance of newly built cycle facilities. When combined in a quality indicator the allow the analysis of the current condition of a whole network, as done by the Flemish NRA [20]. The Cycle Path Comfort Measurement Device is used in The Netherlands, measures the evenness of the cycle surface, and then reports the comfort index [19]. The device measures the surface profile accurately. The result is translated into a comprehensive indicator for the consequences of the measured unevenness on the comfort for the users. This transformation function is the result of extensive research reported in [21]. Other profilers exist in Germany, Sweden, and USA [19]. There is also a lidar system in use in Belgium [22].

2.2 Safety

A high percentage of accidents with cycle facility users do not involve other users [23]. The safety expectations of cycle facility users are very broad and should be subdivided in safety hazards caused by the surface condition of the cycle facility, safety issues due to the presence of obstacles, safety issues related to the design of the cycle facility, objective unsafety and subjective feelings of unsafety related to the relationship with other types of transport modes and the sharing of space with them, and the subjective feeling of safety related to the conditions under which the user is making use of the facility. Positive safety perception does impact route choice [24]. Surface characteristics do influence safety. Very local unevenness by pushing up tree roots as well as potholes can be a safety hazard. The skid resistance of the surface is particularly important in curves and for users of faster and heavier vehicles such as e-Bikes and cargo bikes. Evenness indicators and skid resistance indicators [18] can thus be used in management.

2.3 Attractiveness

A cycle facility is attractive when it is integrated into the environment and the environment gives the user a positive experience. A good choice of route, design and layout of the cycle facility ensure a social environment, create social safety and a safe situation under all circumstances. Research shows that generally spoken cyclists find green, open spaces, water, and aesthetic quality of the built environment attractive. Elements that are considered unattractive are congestion, exhaust fumes, subjective risk on accidents and personal safety.

2.4 Directness

Directness means offering the user of cycle facilities as direct a route as possible with detours kept to a minimum. More direct routes also increase the reach for cycle facility users. Directness can be expressed by measuring the ratio L/D between the length L of the trajectory and the distance as the crow flies D between two locations. A minimal number of places along the route with potential delays, and the design speed of the cycle facility contribute to good flow, which is another aspect of directness since it has an impact on the time needed for travel between two locations. Flow, traffic jams on cycle paths, and traffic counting can be studied with crowdsource data. Prioritisation and separation from other type of road infrastructure users can improve fluidity. Users may prefer a longer trajectory avoiding a section in bad condition, which reduces directness. Hence, directness is not only influenced by the lack of completeness of the cycle facility network. While directness is a result of design, it usually also reduces maintenance costs (shorter infrastructure, less signs, etc.) and improves readability (straight sections). Rolling resistance is a surface characteristic that has influence on the action radius of electric vehicles on the cycle facility. Measuring rolling resistance is non-trivial and a topic of research.

2.5 Coherence and Readability

Readability contributes to the recognisability of cycle facilities. It can be achieved by consistency in the quality of the infrastructure and the use of same materials and sizes, and by uniform and clear signing. It also increases route predictability. The network must form a coherent whole. It must provide connections that connect to the places of origin and destination of the users. Coherence is achieved by completeness of the network and cohesion between different transport modes allows the traveller to reach a destination.

3 Surface conditions and situations

From the descriptions of the 5 requirements, it becomes clear that good surface conditions of the cycle facilities will only partially respond to the expectations of the users. Other aspects that influence the 5 requirements – here called "situations" - have to do with the design of the cycle facilities and the implementation of the design. Surface defects such as potholes, cracks, subsidence, etc., can be detected by visual inspection. Some propose collecting images and automated image detection using Artificial Intelligence. Surface conditions such as longitudinal evenness, transverse evenness, cross-fall, macro-texture, skid resistance, and rolling resistance can be measured with dedicated measurement devices [18]. A Finish company [25] proposes crowdsourcing data from the cycle facilities network. With a mobile game app on a phone, images are collected and with AI technology some surface defects are detected in the images. Situations can be non-optimal geometrical design: connection to existing infrastructure, constraints in the environment such as entrances and road crossings, badly designed curbs and gutters, an axis shift at a bus stop, and sewer cover and other disturbing elements integrated in the cycle facility, tree, lamppost, or small delineator posts in the middle of the track. Situations can also suddenly appear: overgrowth, fallen leaves, waste and dirt, obstructed water drainage, winter conditions (ice and snow), and temporary obstacles (waste bins, parked vehicles). Some situations should already be contained in the inventory database. Routine inspections and complaint management can help detecting the other situations.

4 CFMS: Management and maintenance measures

In a course text [26], typical maintenance concerns of cycle facilities are listed with possible maintenance measures. The concerns are grouped in surface problems, encroaching vegetation, and signing and marking. In guide [27] the objectives of maintenance are twofold: offering safe and comfortable cycle facilities and maintaining the infrastructure in good condition to optimise its lifetime. The interventions concern signage, surface condition and surface water management, and operational management including cleaning debris, controlling vegetation, correcting markings and winter maintenance. Doing so makes the infrastructure more attractive and efficient. The guide then enumerates possible interventions. The document also addresses inventory, the division of the network in manageable sections, hierarchies in the network and its influence on priority setting of maintenance, inspections, and related condition indicators. Small interventions can resolve "situations". Surface treatments such as filling joints and cracks, and local repairs improve surface conditions. Planning these interventions however askes for a preventative maintenance strategy and priority setting.
A management system for bike paths in operation in Bogota is described in [28]. The paper lists what should be contained in an inventory: surface type, surface width, type of facility, bordering zone (waterproof or permeable), layer thicknesses, joint spacing (for rigid pavements), material of (sub-)base course, presence of trees (distance to cycle facility, species of tree), longitudinal slope length. A "Bike-path Condition Index" is used and is defined as a function of the International Roughness Index (IRI) and a distress index. The distress index is a weighted combination of surface defects, the IRI is measured. The authors of the paper point out that the causes of deterioration of cycle facilities are different from the causes of deterioration of road pavements. The main cause of distress of cycle paths in Bogota are climate effects. Therefore, they insist on the importance of texture measurements. It is also possible to predict evolution over time when only climate effects on some specific asphalt type surfaces are to be considered. It is also pointed out that the IRI model for a car driving at 80km/h is not adequate for cycle facilities and hence they propose to recalibrate the IRI model. The authors state that precautionary thresholds should allow maintenance actions to

preserve serviceability, and remind that social assessment is a key element to be considered at the stage of prioritizing interventions and their impact on target community in a bike-path network. Hence, they list the indicators to be associated to the sections in the inventory: bike-path condition index, boundary marking condition index, bike-path user volume, and socio-economic level in the zone.
A system was developed for the network of a university campus [29], making an inventory and a condition survey based on surface defects, large vertical displacements, condition of markings, geometrics, rideability, and transitions. The paper mentions suggested maintenance procedures. The database is destined for better estimating current and future maintenance, but in a first instance maintenance is planned for the sections with medium or high distress severity level. The authors suggest repeating the condition survey every 2 years, and the future use of incremental benefit-cost analysis for optimal maintenance management.
Several indicators for the evaluation of the "bicycle suitability" of "roadways" and "side-paths" are described and compared in [30], as they are amongst the necessary tools to mainstream and bring objectivity to bicycle planning. The authors aim for comfortable, safe, and direct biking facilities to promote cycling as a form of transportation. Suitability indicators are often based on perceived safety of users and computed from road geometry and type of traffic.
The urban bikeability index in [13] is defined according to relevant expectations of the users and can be computed from openly available data (in occurrence: Open Street Map). Yet in the conclusions the absence of surface condition and the geographical distribution of parking facilities is considered as a potential weakness of the approach when it comes to management decisions.
In a PhD thesis in Canada [31] an approach was designed and showcased, concentrating on on-street bicycle lanes and roads shared by cars and bicycles and extending the pavement management system to bicycle lanes and bicycle travel demand. From network characteristics and GPS cyclist trip data the bicycle volumes along segments are estimated and these are considered in the goal optimisation that decides on the maintenance planning programme. Specific improvements of the infrastructure for cyclists are foreseen in the generic list of maintenance actions, e.g. creating a separated space for cyclists.
From these examples, it becomes clear that management decisions for a cycle facility network should be based on surface conditions and mobility criteria, on "conditions" and "situations". The 5 quality requirements represent all these criteria.

5 Conclusions

In this contribution, the prerequisites for a cycle facility management system (CFMS) were discussed. Active traveller expectations are best captured in the 5 quality requirements Coherence and Readability, Directness, Attractiveness, Safety, and Comfort. The condition of a cycle facility does not evolve in function of the use for which in is designed. A CFMS must help in decision-making on budget allocation to investments in new infrastructure, in modifications to existing infrastructure, and in maintenance actions. Such decisions can only be made on a combination of surface condition criteria and mobility criteria. Therefore, a CFMS should base a preventative maintenance strategy and its priority setting on an evaluation of all 5 quality requirements, based on inspections, condition measurements, and the evaluation of situations. Any management system needs an inventory of the assets to start with. Routine inspection rounds and routine maintenance should address immediate needs of improvement. The CFMS should concentrate on the strategy for condition maintenance for the improvement of comfort and safety, on priority setting for "easy" measures for improvements of situations due to design issues and/or related to coherence and readability, and for more general situation management addressing safety perception, attractiveness, and directness.

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References

[1] European Cyclists' Federation (ECF): Annual Report 2022, Publication by ECF, https://ecf.com/system/files/ECF-AR2022-online-spreads.pdf, 26.02.2024.

[2] Courbe, T.: Impact économique et potentiel de développement des usages du vélo en France, Les Dossiers de la DGE, études économiques, Bureau de la communication – DGE, April 2020 (in French)

[3] Hallisey, K.: Biking Your Way to Better Health, Article on UCLA, https://transportation.ucla.edu/blog/biking-your-way-better-health, 26.02.2024.

[4] Adriazola-Steil, C., Ohlund, H., El-Samra, S., Targa, F., Zayas, G.: Investing for Momentum in Active Mobility, Discussion Paper, Transport Decarbonization Investment (TDI) Series, World Bank Group, October 2021.

[5] CROW: Design Manual for Bicycle Traffic, The Netherlands, latest revision: CROW-publicatie 351 Ontwerpwijzer Fietsverkeer, 2016.

[6] Transport for London: London Cycling Design Standards, consultation draft, London, UK: Transport for London, Sustrans, 2014.

[7] State of Queensland Department of Transport and Main Roads: Sustrans Design Manual: Handbook for cycle-friendly design, Bristol, UK: Sustrans, 2015.

[8] State of Queensland Department of Transport and Main Roads: Selection and Design of Cycle Tracks, Technical Note 128, Brisbane, Australia

[9] European Cyclists' Federation: Fast Cycling Routes, Criteria of fast cycling routes, https://ecf.com/what-we-do/urban-mobility/fast-cycling-routes, 27.02.2024.

[10] Cahier cyclostrades, Vadémécum vélo en Région de Bruxelles-Capitale, N° 11, 2022, https://mobilite-mobiliteit.brussels/fr/professionnels-de-la-mobilite/publications-techniques-analyses-et-etudes, 27.02.2024. (in French)

[11] Service Public de Wallonie: Guide de bonnes pratiques pour les aménagements cyclables, Les manuels de la mobilité, No 2, September 2009. (in French)

[12] DTV Capacity Building: 5 design principles for successful bicycle infrastructure, https://dtvcapacitybuilding.com/blog/5-design-principles-for-successful-bicycle-infrastructure/, 27.02.2024.

[13] Hardinghaus M., Nieland S., Lehne M., Weschke J.: More than Bike Lanes - A Multifactorial Index of Urban Bikeability, Special Issue, Transport Sustainability and Resilience in Smart Cities, MDPI – Sustainability, 13 (2021) 21, 11584, DOI: 10.3390/su132111584

[14] Arellana, J., Saltarín, M., Larrañaga, A.M., González, V.I., Henao, C.A.: Developing an urban bikeability index for different types of cyclists as a tool to prioritise bicycle infrastructure investments, Transportation Research Part A: Policy and Practice, 139 (2020), pp. 310-334

[15] Hartanto, K., Grigolon, A., van Maarseveen, M., Brussel, M.: Developing a bikeability index in the context of transit-oriented development (TOD), 15th Intl. Conf. on Computers in Urban Planning and Urban Management, Adelaide, Australia, 11-14.07.2017.

[16] Lepert, Ph., et.al.: High Level Management Indicators, PIARC report 2012R22EN (ISBN 978-2-84060-288-1), World Road Association, La Defense, France, 2012.

[17] Casse, C., Van Geem,C., Vijay Ramdas, EXPECT - Stakeholders' Expectations and Perceptions of the future Road Transport System, The 28th International Baltic Road Conference, Vilnius, Lithuania, 26-28.08.2013.

[18] Van Geem, C., Bergiers, A., Goubert, L.: Belgian Pre-Normative Research Project Suchar-Bilan on Surface Monitoring of Bicycle Lanes, 8th World Multidisciplinary Civil Engineering- Architecture – Urban Planning Symposium, Prague, Czechia, 4-8.09.2023.

[19] Van Geem, C., Massart, T.: Comfort Evaluation of New Bicycle Paths with a Laser Profilometer: 15 Years of Experience in Belgium, 8th World Multidisciplinary Civil Engineering- Architecture – Urban Planning Symposium, Prague, Czechia, 4-8.09.2023.

[20] Briessinck, M.: State of the Art in Monitoring Road and Road/Vehicle Interaction, PIARC publication 2019R14EN, World Road Association, La Defense, France, 2019.

[21] Van den Berg, N.: Onderzoek ter bepaling van comfort en vlakheidparameters en eisstelling voor fietspaden in Vlaanderen, Report of Research project nr. e0703496, KOAC-NPC, Vught, 21.01.2009. (in Dutch)

[22] De Meester; K.: Digitizing bike lanes for Bike PMS, Presentation at European Road Profile Users' Group (ERPUG), Athens, 25-27.10.2023.

[23] Bouwen, L., Nuyttens, N., Martensen, H.: Severely injured cyclists: Analysis of Belgian hospital data for 2016-2020, Transportation Research Procedia, 72 (2023), pp. 2880-2887

[24] Huber, S., Lindemann, P., Schröter, B.: Understanding the influence of accident risk and perceived safety on bicycle route choice, Transportation Research Procedia, 72 (2023), pp. 367-374

[25] Crowdsorsa, a Finish company: https://crowdsorsa.com, 27.02.2024.

[26] Federal Highway Administration: University Course on Bicycle and Pedestrian Transportation, Lesson 16: Bicycle Facility Maintenance, Publication No. FHWA-HRT-05-115, July 2006.

[27] Ambros, M., Tremblay, G.: Guide de gestion de l'entretien des voies cyclables, Centre d'expertise et de recherche en infrastructures urbaines (CERIU), Québec, 2018.

[28] Arguelles, G. M., Fuentes, L. G., and Torregroza Aldana, L. M.: Review of the pavement management system of the Bogotá bike-path network, Revista Ingeniería de Construcción, 26 (2011) 2

[29] Gharaibeh, N., Wilson, C., Darter, M., Jones, G.: Development of a Bike Path Management System for the University of Illinois at Urbana-Champaign, Transportation Research Record 1636, Paper No. 98-0331

[30] Barsotti, E., Kilgore, G., The road network is the bicycle network: Bicycle suitability measures for roadways and sidepaths, Transport Chicago conference, 2001.

[31] El Said, F.M.: Road Management Systems to Support Bicycling: A Case Study of Montreal's Bike Network, PhD Thesis, Concordia University, Montreal, Quebec, Canada, 2018.