I IBERIAN CONFERENCE ON MCDM/A (IMCDM/A)
Universidade de Coimbra, 2025

A Multicriteria Methodology for Maintenance Planning of Cycling Infrastructure

Filipe Pais[1]; João Monteiro[1,2]; Nuno Sousa[1,3]; Eduardo Natividade-Jesus[1,4]; João Coutinho-Rodrigues[1,5]

[1] Institute for Systems Engineering and Computers of Coimbra (INESCC), Coimbra, Portugal

[2] Research Centre for Territory, Transports and Environment (CITTA), Porto, Portugal

[3] Department of Sciences and Technology, Universidade Aberta, Lisbon, Portugal

[4] Department of Civil Engineering, Polytechnic Institute of Coimbra, Coimbra, Portugal

[5] Department of Civil Engineering, University of Coimbra, Coimbra, Portugal

Motivation

- **Cycling** helps build a sustainable future by cutting emissions, reducing traffic, and improving public health
- There is a growing recognition among decision makers of cycling's importance for **sustainable transport**
- This work focuses on assessing the condition of Coimbra's **cycling infrastructure.** A better condition increases the likelihood of using this mode

Criteria set

Table 1 – Criteria/subcriteria and evaluation values.

Criteria	Description	Value/Type	Subcriteria	Value/Type
Comfort	Cycling rolling comfort	0 – 4 Benefit	Type of pavement	0 – 4 (discrete) Benefit
			Conservation defects	0 – 4 (discrete) Cost
Safety	Safety from motorised traffic	0 – 4 Benefit	Motorised traffic volume	0 – 4 (discrete) Cost
			Heavy vehicle traffic volume	0, 0.5 or 1 Cost
			Separation	0 – 4 (discrete) Benefit
Conflicts	Frequency and extension of roadside conflicts	0 – 3 Cost	N/A	
Width	Cycling space width	0 – 4 Benefit (One of…)	Shared space (speed limit 50 km/h)	0, 1 or 3
			Shared space (speed limit 30 km/h)	0, 1 or 3
			Cycle lane/track (one-way)	1, 3 or 4
			Cycle lane/track (two-way)	1, 3 or 4
Intersections	Existence of adequate intersection facilities	0 -3 Benefit	N/A	
Lighting	Cycling space lighting	0 – 3 Benefit	N/A	

N/A, not applicable

Case study

- Central area of Coimbra, Portugal
- Arcs (alternatives) selected for analysis: 1,704
- Total arc length: 250 km
- Data collection period: 4 months

ELECTRE Tri parameterisation

Reference classes

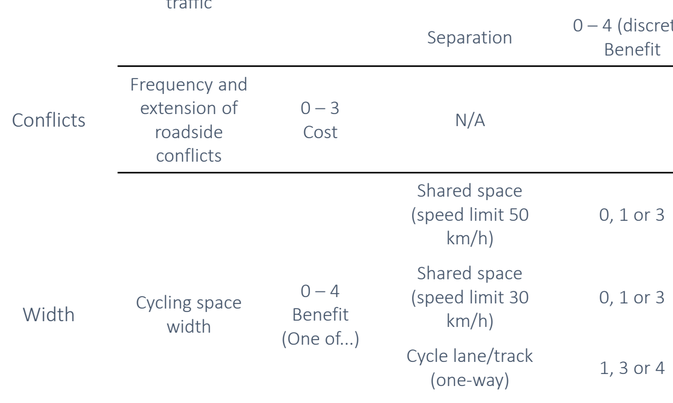

Figure 1 – Reference alternatives A1, A2, and A3.

Weights

W1 = (2, 9, 4, 3, 2, 2) (focus on safety) (1)

W2 = (9, 2, 4, 2, 2, 3) (focus on comfort) (2)

Thresholds

indifference = (0.1, 0.1, 0.1, 0.1, 0.1, 0.1) (3)

preference = (0.4, 0.4, 0.4, 0.9, 0.4, 0.4) (4)

veto = (1.1, 1.1, 1.6, 2.1, 1.6, 1.6) (5)

Cut-off and assignment rule

- Cut-off level: λ = 0.50
- Pessimistic assignment rule

Results

Focus on safety

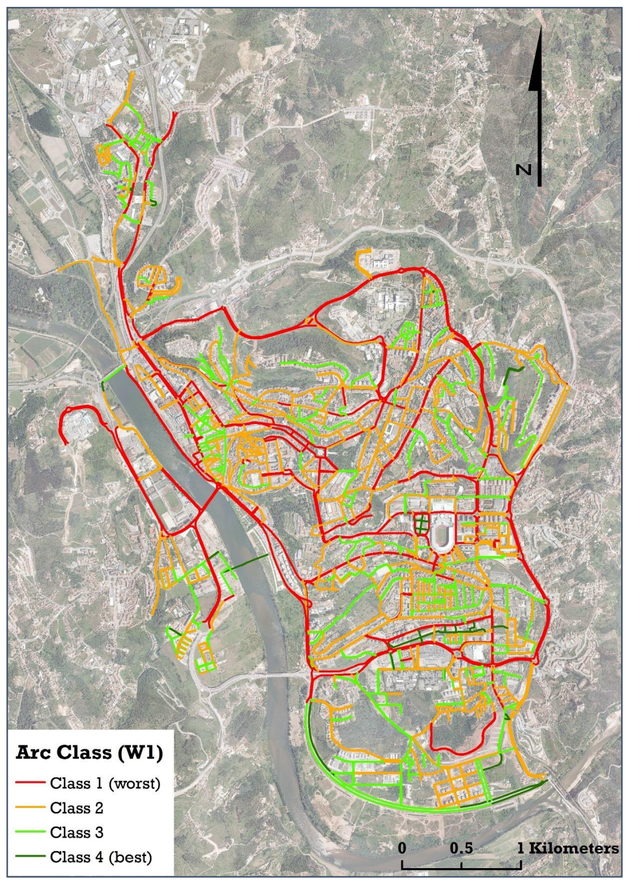

Figure 2 – Classification of arcs (set of criterion weights W1) – focus on safety.

Focus on comfort

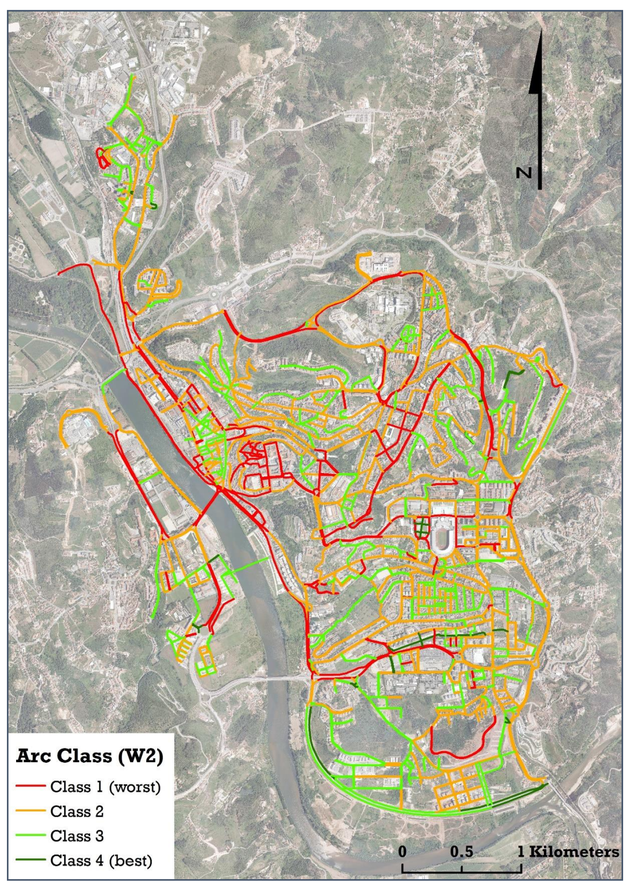

Figure 3 – Classification of arcs (set of criterion weights W2) – focus on comfort.

Table 2 – ELECTRE Tri result statistics.

	Safety (W1)	Length span. (W1)	Comfort (W2)	Length span. (W2)
Class 1	368 (21%)	72.0 km	268 (16%)	47.4 km
Class 2	795 (47%)	108.8 km	860 (50%)	126.0 km
Class 3	511 (30%)	62.6 km	549 (32%)	70.7 km
Class 4	30 (2%)	5.9 km	27 (2%)	5.2 km

Main findings

- **Coimbra's cycling network infrastructure**: overall poor performance
- **Main distributor roads**: worst scores, mostly due to inadequate safety provisions for cyclists
- **Applied methodology**: a valuable decision-aid tool for prioritising maintenance and upgrade works – all criteria can be intervened by municipal authorities and are easy to survey

Field examples

Examples of arcs with final classifications of **1** and **4**, and their respective criteria scores

Focus on safety

Figure 4 – Class 1 arc (W1).

Figure 5 – Class 4 arc (W1).

Table 3 – Figure 4 score breakdown.

Criteria	Score
Comfort	4
Safety	0.5
Conflicts	0
Width	0
Intersections	0
Lighting	3

Table 4 – Figure 5 score breakdown.

Criteria	Score
Comfort	2
Safety	4
Conflicts	0
Width	3
Intersections	3
Lighting	2

Focus on comfort

Figure 6 – Class 1 arc (W2).

Figure 7 – Class 4 arc (W2).

Table 5 – Figure 6 score breakdown.

Criteria	Score
Comfort	0
Safety	3
Conflicts	2
Width	3
Intersections	2
Lighting	2

Table 6 – Figure 7 score breakdown.

Criteria	Score
Comfort	3
Safety	2
Conflicts	0
Width	3
Intersections	1
Lighting	3

Research dissemination

- Pais, F.; Monteiro, J.; Sousa, N.; Coutinho-Rodrigues, J.; Natividade-Jesus, E. **A Multicriteria Methodology for Maintenance Planning of Cycling Infrastructure**. *Proceedings of the Institution of Civil Engineers – Engineering Sustainability* **2022**, *175*, 248-264, https://doi.org/10.1680/jensu.21.00088

- Sousa, N.; Coutinho-Rodrigues, J.; Natividade-Jesus, E. **Sidewalk Infrastructure Assessment Using a Multicriteria Methodology for Maintenance Planning**. *Journal of Infrastructure Systems* **2017**, *23(4)*, https://doi.org/10.1061/(ASCE)IS.1943-555X.0000362 - similar work for the pedestrian mode