CRUSE to Safe Cycling in Ireland

An Open Source Methodology to Support Active Travel

Robin Lovelace

Joey Talbot

Eugeni Vidal Tortosa

Hussein Mahfouz

Elaine Brick

Peter Wright

Gary O’Tool

Dan Brennan

Suzanne Meade

2023-09-21

Under the EU Road infrastructure safety management (RISM) directive, the National Road Safety Strategy (RSS), and the Climate Action Plan Transport Infrastructure Ireland (TII) has a remit for road safety and decarbonizing a predominantly road-based network in Ireland.

To address data needs for both safety and project evaluation on the National Road Network (NRN), the Cycle Route Uptake and Scenario Estimation (CRUSE) Tool was developed. While cycling in Ireland represents only 3% of total modal share, with higher intensities in urban areas, the levels of cycling collisions are disproportionately high at 20% of all serious injuries and 7% of all fatalities. If Ireland is to meet its climate and safety targets, data to establish baseline cycling levels and future cycling levels is needed.

Due to an absence of reliable data, particularly rural cycling levels, TII commissioned the Institute for Transport Studies (ITS) at the University of Leeds and AECOM to develop a new tool for this purpose. ITS Leeds led the development of the PCT for England and Wales, which has “revolutionized the practice of strategic cycle planning nationally”. The tool is an open-source approach using recognized open-source methodology to enable planners, engineers, and other stakeholders to make evidence-based decisions for the NRN. CRUSE is available at <https://cruse.bike/> and builds on the Propensity to Cycle Tool (PCT) for England and Wales. CRUSE goes beyond the PCT in several important ways, higher resolution data, more trip types, including estimates for education, inter-urban, and recreational trips. In addition to understanding cycling intensity, for asset planning and management purposes, the tool provides essential road safety information to enable reporting of disaggregate collision rates.

CRUSE is structured in a similar way to the traditional four-stage transport model, but its use of Open Street Map (OSM) data, used by [Cyclestreets.net](https://www.cyclestreets.net/) for routing, enables network quality to be assessed without costly surveys to record new infrastructure. OSM tags generate “cycle friendliness” estimates of all links on the network, based on existing recorded infrastructure. A range of networks is provided, highlighting routes for directness (Fastest) and “cycle friendliness” (Quietest). It uses origin and destination data from the 2016 Census in combination with modeled demand data to estimate cycling levels and potential at the area, route, and network levels for each county in Ireland and offers estimates of the baseline level of cycling and several future scenario-based levels of cycling.

As countries, like Ireland, invest in cycling, the number of killed and seriously injured cyclists must reduce too. The CRUSE Tool provides estimates of cycling potential and routing for each county in Ireland, and works in both urban and rural settings, to enable monitoring of cycling safety. With growth in the E-bike market, the tool will help inform inter-urban and rural networks to support the transfer of trips to sustainable modes for longer journeys. The CRUSE Tool methodology and findings are directly relevant to addressing the challenges and opportunities faced by other NRAs. The datasets resulting from the project are open access and can be used by both non-experts and professionals.

# 1. Introduction

Mobility kills. High energy transport systems are a major contributor to climate change, a leading cause of premature death and injury due to road traffic collisions, and a cause of disease due to airborne pollutants. Conversely, evidence-based and effective transport *policies* have great potential to decarbonize economies, improve public health, and save lives.

Transport is responsible for 23% of global emissions, 70% of which is from road transport, nearly half of which (around 10% of global emissions) is from passenger cars (Jaramillo et al., 2022). The transport system encourages, enables and in some cases enforces unsustainable lifestyles, including over-consumption of goods due to excessive mobile storage space and dependency on services that are only accessible by car due to land use plans that have built up around roads (Gray et al., 2001; Motte-baumvol et al., 2010; Shergold et al., 2012).

Recognizing the growing evidence of such impacts of poorly designed and performing transport systems, governments in many countries have set targets and taken actions. In the context of climate, road safety and physicial inactivity crises, policies to improve transport systems can be classified according to the ‘Avoid-Shift-Improve’ (ASI) framework (Jaramillo et al., 2022). The framework highlights the importance of demand reduction (*avoid*ing unnecessary trips), in addition to mode *shift* and *improvement* of existing energy converters, in that order.

Uptake of cycling, the main topic of this paper, should be seen in this broader context of transport decarbonisation (Brand et al., 2020) and sustainable mobility (Burns, 2013). Although cycling uptake appears on the surface to only relate to the ‘shift’ part of the ASI framework, closer consideration of the knock-on impacts of cycling uptake shows that it can also help avoid unnecessary trips (Nello-Deakin, 2020). The rapid uptake of highly efficient e-bikes can also be seen as an improvement on most electric vehicles, which are too heavy and expensive to be a sustainable alternative and could in fact delay the transition away from car dependency and inadvertently enable “high travel lock-in” (Anable & Goodwin, 2019). At the European level, the European Union has a target of reducing greenhouse gas emissions by 55% by 2030, compared to 1990 levels, and to achieve ‘net-zero’ by 2050.[^1]

Regarding road traffic casualties, another deadly consequence of inefficient transport systems, the Road Infrastructure Safety Management (RISM) directive (2008/96/EC) requires member states to implement a road safety management system (RSMS) for all public roads. Specifically, “Member States shall ensure that the ranking of high accident concentration sections and the network safety ranking are carried out”.[[1]](#footnote-22) Given that ‘safety’ in this context is usefully quantified as the number of people killed and seriously injured (KSI) per distance travelled, the directive requires estimation of distance travelled by mode, down to the road link level. For active modes, about which there is a paucity of data compared with motorized modes, this is a major challenge. Better data to inform road safety policies and interventions is a motivation for the CRUSE tool outlined in this paper, and modeling active travel more broadly.

In Ireland, the Road Safety Authority (RSA) has set the target of halving the number of road traffic deaths and serious injuries by 2030.[^3] Doing so while simultaneously enabling rapid uptake of active modes will require key active travel routes to be identified and improved.

A proactive approach to the development of cycling policy and infrastructure is taking place in Ireland. The main framework underpinning these efforts is the Climate Action Plan[[2]](#footnote-23) and The National Development Plan[[3]](#footnote-25) . Strategic alignment is also outlined by the Phoenix Park Transport and Mobility Options Study, which highlights public support for active travel interventions: "83% of respondents supported enhanced walking and cycling facilities" .

At the regional level, the recently published Greater Dublin Area Transport Strategy[[4]](#footnote-27) reinforces these findings: "nearly a quarter of adults cycle at least once a week in the Dublin Metropolitan Area" with cycling in the Dublin area taking up to 60,000 cars off the road today. Extrapolating this on a per population basis across Ireland, with around 40% of the population living in Dublin, this suggests that around 150,000 cars could be removed nationwide just by achieving Dubline levels of cycling in all counties (notwithstanding existing cycling trips and differences in trip distances).

Further evidence of the importance of cycling in Ireland *already* is provided by the National Strategic Objective (NSO) from the National Development Plan, with €8.6 billion allocated to sustainable transport infrastructure including public transport and active travel interventions. Cycle infrastructure will be developed in synchrony with the BusConnects project, an entire redesign of the bus network in Dublin and Cork.

It was in this context that Transport Infrastructure Ireland (TII) commissioned the Cycle Route Uptake and Scenario Estimation (CRUSE) project. Based on the Propensity to Cycle Tool (PCT) for England and Wales, the CRUSE tool was developed to provide evidence on current cycling levels and future cycling potential nationwide across Ireland. A key consideration for TII is to ensure both urban and rural Ireland were targeted for cycling infrastructure. To this end, TII extensively reviewed activity on Irish Roads and how the road network was being used by commuters, cyclists, heavy goods vehicles and other road users across the Irish transport network. The aim was for the tool to provide strong, national, systematic but locally-specific evidence to monitor cycling friendliness and safety in Ireland, to ensure strategic alignment with national, regional and local policies. The open source and publicly available nature of the tool ensures more inclusive and evidence-based conversations around cycle network planning between all stakeholders in the transport planning process. Other use cases in the Irish context includes monitoring the need for existing cycling infrastructure upgrades, undertaking appraisal, as well as safety and exposure information in line with the European Cycling Federation, Dutch Cycling Embassy recommendations and the European RISM Directive, for reporting collision rates of vulnerable road users by 2024. These factors mean that the tool can be seen as an open access ‘leverage point’ in the planning system (Lovelace et al., 2020).

The rest of paper is structured as follows. In [Section 2](#sec-methods), we outline the methods used to generate the evidence presented in the CRUSE tool for Ireland. In [Section 3](#sec-results), we present the results of the CRUSE tool, including estimates of current cycling levels and future cycling potential at the national, regional and local levels. In [Section 4](#sec-discussion), we discuss the implications of the results for policy and practice. In [Section 5](#sec-conclusions), we conclude the paper.

# 2. Methods and data

The methods used to generate the evidence presented in the CRUSE tool for Ireland build on the Propensity to Cycle Tool (PCT), which was originally funded by the UK’s Department for Transport and developed by a multi-university team. An important feature of the PCT is that it is open source and publicly available (at [www.pct.bike](https://www.pct.bike/)), allowing its use by all stakeholders in the transport planning process (Lovelace et al., 2017). The PCT approach has had major policy impacts, as outlined in Research Excellence Framework (REF) impact case studies, which demonstrate that the tool “revolutionised strategic cycle planning in England and Wales”[[5]](#footnote-31) by overcoming the barriers to cycling investment imposed by lack of evidence on cycling potential[[6]](#footnote-33) .

The first version of the PCT was based on current and future potential uptake of cycling for single stage *travel to work* at desire line, zone, route, and route network levels (Lovelace, 2016). It was launched in April 2017 as the government-endorsed tool for strategic cycle network planning, as part of the Cycling and Walking Investment Strategy (*Cycling and Walking Investment Strategy*, 2017). Extensions of the PCT approach have included estimation of benefits at the individual level (Woodcock et al., 2018), addition of travel to school network (Goodman et al., 2019), and improved modelling of impacts on health, environmental and distributional outcomes (Woodcock et al., 2021). Initially developed just for England, the PCT was extended to cover all of Wales (for commuter data only) in 2018.

The PCT approach has been applied in other countries, including Ireland (the topic of this paper), Scotland, and Portugal. In Portugal the ‘biclaR’ project, based on methods underlying the PCT, has been developed and deployed for the Lisbon metro region. The resulting evidence is available in an interactive web application hosted at [biclar.tmlmobilidade.pt](https://biclar.tmlmobilidade.pt) (Félix et al., 2022). biclaR includes estimates of impacts, using the World Health Organisation (WHO) ‘HEAT for Cycling’ tool[[7]](#footnote-36) and an ‘intermodality’ scenario that combines cycling with currently available public transit options based on General Transit Feed Specification (GTFS) data.

The CRUSE tool seeks to overcome the following methodological limitations of the original PCT:

* Low resolution of data, with routes starting and ending in administrative zone centroids
* Limited coverage of trip purposes beyond travel to work and school
* A web interface that was not user-friendly or intuitive

Methods were developed to overcome each of these, as outlined in [Section 2.2](#sec-trip-purposes) to [Section 2.3](#sec-ui).

## 2.1 Disaggregation of origin-destination data

A feature of active travel interventions is that they require dense networks of routes to be effective (Parkin, 2018). This means that high levels of geographic resolution are needed in the data used to estimate cycling potential. However, datasets on travel patterns are often only available at the level of administrative zones. The Central Statistics Office (CSO) in Ireland provides Place of Work, School or College Census of Anonymised Records ([POWSCAR](https://www.cso.ie/en/census/census2016reports/powscar/)) data on the number of people travelling to work and school at the Electoral Division (ED) level, for example.

The method used to convert OD data to route networks used in the PCT was to calculate a single route between the population weighted centroids associated with each OD pair. This method works fine when the OD data represents movement between small areas, but was not appropriate for generating route networks from the POWSCAR data because zone centroids are so far apart that the resulting route networks would be sparse and unrealistic. To tackle this issue we developed a new method for OD data disaggregation called ‘jittering’ (Lovelace et al., 2022). The method works by first disaggregating the OD data based on a ‘disaggregation threshold’ and then assigning each disaggregated ‘sub-OD’ pair to ‘subpoints’ within each zone. As shown in [Figure 1](#fig-dublin), the resulting route networks are dense, even in rural areas.

|  |
| --- |
| Figure 1: Illustration of the density of route networks generated by the CRUSE tool for Dublin City and surroundings (top) and rural County Mayo on the West coast of Ireland. Source: CRUSE tool, available at <https://cruse.bike/>. |

## 2.2 Additional trip purposes

A limitation of the original PCT was that it only included travel to work data. This was partially addressed by the inclusion of travel to school based on data from the Department for Education in England (Goodman et al., 2019). An advantage of the POWSCAR OD data over OD datasets derived from census surveys in many countries is that it includes travel to school data. We commissioned a version of POWSCAR that included a breakdown of the total flows between OD pairs by purpose and mode, enabling a more realistic estimation of the ‘Baseline’ cycling network.

However, travel to school and work only constitute a small proportion of all trips. To overcome this issue, we developed a spatial interaction modelling methodology to estimate the number of trips between each OD pair for additional trip purposes.

The classification of trip purposes used in the CRUSE tool was guided mainly by the trip purpose classification found within the National Household Travel Survey (NHTS), but with the addition of categories based on the comprehensive POWSCAR data, and the need to include recreational trips and multi-stage trips (not yet implemented). An overview of the trip purposes used in CRUSE is presented in [Figure 2](#fig-trip-purposes).

|  |
| --- |
| Figure 2: Trip purposes used in the CRUSE tool. |

## 2.3 User interface

# 3. Results

National planning

Regional

Local

# 4. Discussion

# 5. Conclusions

# 6. List of abbreviations

CSO: Central Statistics Office

CRUSE: Cycle Route Uptake and Scenario Estimation

ED: Electoral Division

GTFS: General Transit Feed Specification

KSI: Killed and Seriously Injured

NRA: National Road Authority

NRN: National Road Network

OD: Origin-Destination, typically referring to origin-destination data which contains information on the number of people travelling between each pair of zones

OSM: Open Street Map

PCT: Propensity to Cycle Tool

POWSCAR: Place of Work, School or College Census of Anonymised Records

TII: Transport Infrastructure Ireland

# 7. Declarations

## Availability of data and material

Data was obtained from the Central Statistics Office (CSO) and Transport Infrastructure Ireland (TII) under license and cannot be shared publicly. The code used to generate the results presented in this paper is available at https://github.com/cruse-bike.

## Funding

The work was funded by Transport Infrastructure Ireland (TII).

## Acknowledgements

Thanks to Paul MacDonald and Donal Hodgins (Kildare County Council), for testing early versions of the tool and for their input into the project. Thanks to Ciaran Maguire, Catherine Swift, and others at AECOM for their input into the project.

## Competing interests

The authors declare that they have no competing interests.

## Authors’ contributions

RL led the development of the CRUSE tool, with input from JT, EV, HM, EB, PW, GOT, DB, and SM. SM instigated the project and coordinated its policy impact. PW, EB and GOT provided project management and transport engineering expertise.

Anable, J., & Goodwin, P. (2019). *Transport and mobility*. CREDS. <https://www.creds.ac.uk/publications/shifting-the-focus-4-transport-mobility/>

Brand, C., Dons, E., Anaya-Boig, E., Avila-Palencia, I., Clark, A., Nazelle, A. de, Gascon, M., Gaupp-Berghausen, M., Gerike, R., & Gotschi, T. (2020). The climate change mitigation effects of active travel. *Preprint: Researchsquare.com*.

Burns, L. D. (2013). Sustainable mobility: A vision of our transport future. *Nature*, *497*(7448), 181182. <http://dx.doi.org/10.1038/497181a 10.1038/497181a>

*Cycling and walking investment strategy*. (2017). <https://www.gov.uk/government/publications/cycling-and-walking-investment-strategy>

Félix, R., Lovelace, R., & Moura, F. (2022). *biclaR - Ferramenta de apoio ao planeamento da rede ciclável na área metropolitana de Lisboa*. CERIS - Instituto Superior Técnico and Transportes Metropolitanos de Lisboa. <https://biclar.tmlmobilidade.pt>

Goodman, A., Rojas, I. F., Woodcock, J., Aldred, R., Berkoff, N., Morgan, M., Abbas, A., & Lovelace, R. (2019). Scenarios of cycling to school in england, and associated health and carbon impacts: Application of the ‘propensity to cycle tool’. *Journal of Transport and Health*, *12*, 263–278. <https://doi.org/10.1016/j.jth.2019.01.008>

Gray, D., Farrington, J., Shaw, J., Martin, S., & Roberts, D. (2001). Car dependence in rural scotland: Transport policy, devolution and the impact of the fuel duty escalator. *Journal of Rural Studies*, *17*(1), 113125. <https://doi.org/10.1016/S0743-0167(00)00035-8>

Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O. E., Kajino, T., Lee, D. S., Nugroho, S. B., Ou, X., Hammer Strømman, A., & Whitehead, J. (2022). *Transport* (P. R. Shukla, J. Skea, R. Slade, A. A. Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, & J. Malley, Eds.). Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter10.pdf>

Lovelace, R. (2016). Mapping out the future of cycling. *Get Britain Cycling*, *5*, 2224. <http://eprints.whiterose.ac.uk/100080/>

Lovelace, R., Félix, R., & Carlino, D. (2022). Jittering: A Computationally Efficient Method for Generating Realistic Route Networks from Origin-Destination Data. *Findings*, 33873. <https://doi.org/10.32866/001c.33873>

Lovelace, R., Goodman, A., Aldred, R., Berkoff, N., Abbas, A., & Woodcock, J. (2017). The Propensity to Cycle Tool: An open source online system for sustainable transport planning. *Journal of Transport and Land Use*, *10*(1). <https://doi.org/10.5198/jtlu.2016.862>

Lovelace, R., Parkin, J., & Cohen, T. (2020). Open access transport models: A leverage point in sustainable transport planning. *Transport Policy*, *97*, 47–54. <https://doi.org/10.1016/j.tranpol.2020.06.015>

Motte-baumvol, B., Massot, M.-H. M. M.-H., & Byrd, A. M. A. A. M. (2010). Escaping car dependence in the outer suburbs of paris. *Urban Studies*, *47*(3), 604619. <https://doi.org/10.1177/0042098009349773>

Nello-Deakin, S. (2020). Environmental determinants of cycling: Not seeing the forest for the trees? *Journal of Transport Geography*, *85*, 102704. <https://doi.org/10.1016/j.jtrangeo.2020.102704>

Parkin, J. (2018). *Designing for cycle traffic: International principles and practice*. ICE Publishing. <https://www.icevirtuallibrary.com/isbn/9780727763495>

Shergold, I., Parkhurst, G., & Musselwhite, C. (2012). Rural car dependence: An emerging barrier to community activity for older people. *Transportation Planning and Technology*, *35*(1), 6985.

Woodcock, J., Abbas, A., Ullrich, A., Tainio, M., Lovelace, R., Sá, T. H., Westgate, K., & Goodman, A. (2018). Development of the Impacts of Cycling Tool (ICT): A modelling study and web tool for evaluating health and environmental impacts of cycling uptake. *PLOS Medicine*, *15*(7), e1002622. <https://doi.org/10.1371/journal.pmed.1002622>

Woodcock, J., Aldred, R., Lovelace, R., Strain, T., & Goodman, A. (2021). Health, environmental and distributional impacts of cycling uptake: The model underlying the Propensity to Cycle tool for England and Wales. *Journal of Transport and Health*, *22*, 101066. <https://doi.org/10.1016/j.jth.2021.101066>

1. https://eur-lex.europa.eu/legal-content/EN/TXT/?u ri=celex%3A32008L0096 [↑](#footnote-ref-22)
2. <https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/> [↑](#footnote-ref-23)
3. <https://www.gov.ie/en/publication/774e2-national-development-plan-2021-2030/> [↑](#footnote-ref-25)
4. <https://www.nationaltransport.ie/planning-and-investment/strategic-planning/greater-dublin-area-transport-strategy/> [↑](#footnote-ref-27)
5. See REF Impact Case Study “Cycle network policy, planning and investment transformed by the Propensity to Cycle Tool” at [results2021.ref.ac.uk](https://results2021.ref.ac.uk/impact/847d1191-7f25-46ba-a399-b481125edc8f) submitted by the University of Leeds. [↑](#footnote-ref-31)
6. See the REF Impact Case Study “Creating Step Changes in Cycling Policy and Infrastructure Planning across the UK” at [results2021.ref.ac.uk](https://results2021.ref.ac.uk/impact/4BBF3436-FD10-4C75-9791-F5E98AB4411B) submitted by the University of Westminster. [↑](#footnote-ref-33)
7. See the Health economic assessment tool for walking and cycling at [www.heatwalkingcycling.org](https://www.heatwalkingcycling.org/#homepage). [↑](#footnote-ref-36)