European Innovations and Cycle Design Guidelines

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ABSTRACT

The purpose of this paper is twofold: (A) to detail the major changes to the most recent update of the UK-wide cycle design guidelines, and (B) to describe some innovations to have recently emanated from Europe and the UK (hereafter collectively known as "Europe.")

The purpose of guidelines is to consolidate the best available information on effective cycle-facility design into a single resource as well as giving cyclists consistency and a level of expectation of facilities as they cross from one jurisdiction to another. Recent decades have witnessed an unprecedented increase in demand for the design and construction of cycle-specific infrastructure, but published guidelines have not always kept pace with the rate of innovation. With renewed interest in encouraging bicycling as well as bicycling facilities, have emerged new guidelines, improving on the AASHTO design guidelines that are already used in the USA. Certainly AASHTO's *Guide for the Development of Bicycle Facilities* could be updated and improved upon. But where to begin?

Historically guidance has originated from mainland Europe as planners and engineers have looked to copy European models that appear to be effective in encouraging people to cycle safely and efficiently. But where does one start? Which model should they follow? And can European designs be effectively applied to car-centric communities that are so ubiquitous in the United States? Few people will agree on all these questions, but this paper attempts to shed some light on the path that the UK has chosen in setting guidelines for cycle-facility design.

INTRODUCTION

"Holland is the biking Mecca." That is the mantra so often overheard by bicycle professionals. But is it? And more importantly, if it is, can the "Dutch cycling model" be effectively emulated in America? (Note that although often used interchangeable, Holland is just a part of the Netherlands in a similar way that Scotland is part of the UK.)

Dutch cities are well-known for being cycle-friendly and transport data collected tend to confirm that prevalent perception. In 1995, 46% of all trips in the Netherlands were made by biking or walking, more than any other country in Europe. (*Indicators of Transport Efficiency in 37 Global Cities* Kenworthy 1997) Those are certainly some impressive numbers. But are cycle facilities the panacea that resulted in such an impressive modal split?

It is not the purpose of this paper to delve into the cultural, historical, and legal rationale for the high levels of cycling in the Netherlands. However, this paper will aim to explain that not all Dutch models can be applied to other countries, given the unique characteristics of Dutch traffic law, geography, town planning, and traffic management. The Netherlands is a small, flat, dense country that has been planned and built around sustainable forms of transport. Moreover, they have more rigorous cyclist education programs and Dutch law has been amended to make motorists fully liable in the events of crashes between cars and bicycles. (*Better protection for pedestrians, cyclists* Netherlands Ministry of Justice 1997)

In updating our national guidelines, after an exhaustive literature review, the UK has taken the most suitable components of international guidance and then applied context-sensitive elements. This is an especially appropriate document for the United States to take note of as the US tends to have more in common with the UK that with western European countries such as the Netherlands when it comes to town planning and road infrastructure. Similar to the US, the UK is rife with sprawl, with high-speed motorways criss-crossing the country and many city centres inhospitable to the non-motorised user.

Perhaps the most important difference between many western European cities and their counterparts in the UK and the US is the number of driveways and side road crossings that exist. In Copenhagen, for example, you commonly park your car on the street and then walk into a new-car dealership as opposed to pulling into a driveway and parking in an oversized parking lot. In Geneva, even the gas stations often have gas pumps where on-street parking normally would be located, so there is no driveway for the motorist to pull into. In Amsterdam, DHL delivers mail and packages with boats navigating the canals. Funnily enough, boat-bike crashes are rare indeed in Amsterdam. All of these examples tend to mitigate the

dangers of segregated facilities. It is the high amount of side-road crossings and driveways, above all, which make segregated facilities a potentially dangerous place in car-centric environments, leading the UK to develop their own guidelines.

UPDATED GUIDELINES

In 1996, the UK's *Institute of Highways and Transportation* and the *Cyclists Touring Club* jointly produced the *Cycle Friendly Infrastructure (CFI)* guidelines. It was based to a great extent around "Sign up for the Bike," the Dutch design guidelines that were published in English in 1993 (note: new guidelines from the Netherlands are to be published in English in June 2007). The UK guidelines certainly adopted the Dutch ethos of providing facilities that are "safe, comfortable, attractive, coherent, and direct for cyclists." But they also recognize that Dutch guidelines should be modified to meet the unique infrastructure characteristics that we find here in the UK. This paper will further elaborate on those modifications.

Cycle design has moved on to such an extent that ten years on, CFI is outdated and does not fully comply with current thinking among planners and engineers. This need precipitated the process of updating the CFI guidelines, leading to "CFI 2," as well as revaluating any controversial issues that rage among cycling professionals.

On-road cycling or segregated bike paths?

Few debates in the cycle design world are more contentious that whether the focus should be on on-road cycling or segregated bike paths. Segregated facilities are commonly viewed as the ideal solution, even the only solution, for cycle travel. At the other end of the spectrum, there are those that always advocate on-road cycling with no segregation at all (*The Bikeway Controversy* Forester 2001) Although most local authorities opt for somewhere in the middle of this spectrum, it is clear that successful provision for cyclists involves the consideration of cycling at every step of the planning, engineering, and construction process. Before deciding on a facility, it is important to consider who the facility is being built for (novice cyclists? advanced?) and what type of trip is it for (utility? leisure? shopping?). At the same time, it is equally important to consider desire lines between origins and generators. Too often a facility will be built only to be unused by cyclists due lack of consideration for the most appropriate location.

Taking the aforementioned into consideration, CFI 2 stipulates a "Hierarchy of Provision" (Note that this hierarchy is often known as the "Hierarchy of Solutions" which was the old name from the 1996 CFI guide). The Hierarchy is

used as a guide to determine the best design solution for cyclists at any given location, and is as follows, from highest to lowest priority:

(1) Traffic Reduction
(2) Traffic Calming
(3) Junction Treatment and Problem Areas
(4) Carriageway Redistribution
(5) Segregated Facilities (Cycle Lanes and Cycle Paths)

Fundamental philosophy behind the hierarchy

The key concept of the philosophy behind the hierarchy, is that measures at the top of the hierarchy have the greatest benefits for all road users and the environment and should therefore be considered before those measures, such as segregated facilities, that have fewer benefits. This is not to say that segregated facilities should not be used. They are generally recommended for high-volume roads with speeds above 40 mph, and to encourage new users it is certainly prudent to build segregated facilities for children and novice cyclists. But this hierarchy simply states that segregated facilities should not be the first and only consideration. It recognises that most cyclists use the existing road network, and consequently it is often most beneficial to improve the existing network to meet the needs of cyclists before using other solutions. (The hierarchy has even been unwittingly used in places like Delft, The Netherlands, who in 1970 undertook an ambitious traffic reduction and traffic calming program as a means of increasing their cycling modal split.)

Moreover, once the higher level measures have been carried out, it is easier to implement the lower level ones. It is therefore logical to try to reduce traffic flows first because this has benefits of improving safety plus reducing congestion, noise, as well as particulate and greenhouse gas emissions. Once traffic reduction is realised, speed reduction and intersection improvements will be easier to implement because there will be fewer motor vehicles to deal with. As environmental concerns climb even higher on the political agenda, it will become easier to carry out these traffic reductions measures.

Incidentally, traffic reduction could be something as simple as local measures to remove centrelines, increase car parking charges, or install a choker-bollard combination, which prevents motor vehicles from passing while allowing cyclists through. Or it could be something more ambitious, strategic measures such as London's "Congestion Charge," Munich's widespread removal of car parking spaces, or Nottingham's reconfiguration of the streets in the city centre, reducing traffic volumes by 30% and turning a once auto-centric, pedestrian-unfriendly city centre into a lively, walkable, breathable, bikable, economically thriving area.

Cyclist's dynamic envelope

The new guidance still subscribes to the original Dutch ethos, which also aims for more livable, bikable communities, but also includes elements that change the way that designers think about cycle provision. The cornerstone of these changes is research in the Netherlands that developed a concept known as the "cyclist's dynamic envelope". (*Sign Up For the Bike* CROW 1993)

This refers to the minimum profile required for the safe movement of the cyclist on the carriageway given a certain design speed and design vehicle size. For example, with a standard sized design vehicle, a comfortable passing distance was measured to be .85 metres at 20mph, which increases to 1.05 metres at 30mph. What is significant about the cyclist's dynamic envelope is the change in envelope with a change in motor vehicle speed. It indicates that speed reduction measures may be necessary to accommodate cyclists safely and comfortably on certain carriageways.

At locations where there are pinch points in the carriageway, such as at central refuge locations, the cyclist's dynamic envelope is quite revealing in determining when the cyclist will feel "squeezed" off the carriageway and when they will not. Empirical research carried out in the Netherlands has shown, as a general rule of thumb, lane widths above 4 metres tend to be sufficient for cyclists and motor vehicles to travel side by side, while widths under 3 metres are also satisfactory as the cyclist tends to travel in the centre of the lane and the motor vehicle is not encouraged to overtake them.

However, lane widths (especially at pinch points) between 3 and 4 metres should be avoided as often the motor vehicle will attempt to pass the cyclist at unsafe distance. Note that these widths do not take into account carriageways with significant numbers of HGV's (Heavy Goods Vehicles.) The guidelines give comprehensive figures for carriageways at various design speeds and various vehicle sizes (including HGV's.)

Maintenance

One of the prime causes of consternation for UK cyclists is the maintenance of facilities, or lack thereof. Maintenance of both cycle paths and cycle lanes, from sunken gullies to accumulation of debris, has proved to be a serious problem for cycle facilities in the last decade. In the 80's labour was inexpensive but capital was difficult to obtain so there was a movement towards increasing resources for capital budgets. However, since then, labour has become increasing expensive and even cost-prohibitive at times for local authorities meaning that many cycle facilities have fallen into disrepair.

One major obstacle, certainly, is lack of knowledge on what should be included in a maintenance regime. An important addition to CFI 2, therefore, is the section on maintenance, which includes a maintenance checklist to be used by local authorities to set up a maintenance system. A few of the maintenance related recommendations to emerge from CFI 2 are:

(1) Set up a maintenance hotline;
(2) Trim shrubbery regularly;
(3) Inspect by bicycle;
(4) Use volunteers (such as Sustrans Rangers); and
(5) Budget early for maintenance – probably the most crucial of the recommendations.

Advanced Stop Lines (ASLs)

Advanced Stop Lines are not a new idea and have been widely used in cities throughout the UK. "Bike Boxes," as they are known in America, have been lauded both for their low cost as well as their ability to facilitate safe cycle movement. However they vary significantly in quality, a problem the new guidelines seek to address by setting out new recommended dimensions for ASLs, including a 30 metre lead in lane, a 5 metre reservoir depth, and a 1.5 metre entry cycle lane width, or a 2 metre cycle lane width (if possible) when motor vehicle lanes are on both sides of the cycle lane.

Tactile Paving

Guidance on the use of tactile paving is a further supplement to the new document. In this age of DDA (UK equivalent for ADA) rules and regulations, it has become not just a moral but a legal obligation to accommodate those with disabilities. It is necessary to alert visually-impaired pedestrians to the presence of a cycle path, and CFI 2 details various options for corduroy tactile paving placed on the footpath immediately before the cycle path crossing. However, use of tactile paving should not be the default option – it should be recognised that it is not only unsightly and expensive, but can present difficulties for wheelchair users. Therefore a balance must be struck between the needs of different users, and it is especially important that comprehensive consultation with local stakeholders is carried out before tactile paving is used.

Side Road Crossings

CFI 2 also includes new guidance on the design of side road crossings for segregated cycle paths, which, according to research carried out in the Netherlands, is where the cyclist is most at risk of being involved in an accident (*The Dutch Experience* Wegman and Dijkstra 1998). This research validates the emphasis in the Hierarchy of Provision on on-road facilities, as it shows that cyclists on roadways tend to have less accidents. Furthermore, it points to the importance of good design to mitigate against the safety issues that surround side road crossings.

Several alternatives are recognised in CFI 2, the best of which is a bent-out with raised crossing, which the guidelines describe in detail. This design brings cyclists away from the major road while slowing the motor vehicles turning onto the minor road. However, solutions are always site specific, and a bent-out crossing only operates effectively when it is well designed and where sight distances are sufficient.

It is valuable to note that there is a tendency to utilise foreign guidelines but then fail to include critical design elements. Case in point: in Ireland the highway authority imported Dutch design guidance on side-road crossings, but then in the final document, all four of the raised adjacent side path crossing designs had been changed to remove priority from cycle traffic and give it to motorised traffic. (*Irish Cycle Facilities Design* Foran 2005). It is critical that if foreign guidance is used, the design should be looked at holistically and the context should be fully understood before any attempt is made to replicate it.

Access Control

The issue of controlling access to segregated facilities is a long-standing concern for many local authorities and CFI 2 includes significant changes in the guidance on this. Access control measures tend to be symbolic rather than functional. That is, a single bollard will often be placed at the entrance to a shared use path to let road users know it is a non-motorised facility rather than effectively preventing any determined motor vehicle drivers from going places they shouldn't. Indeed, several options currently being used for access control tend to be more of a hindrance to cyclists than a help in keeping out undesirable users. Consequently, CFI 2 recommends that access control measures are only used "when there is a proven need."

Invisible Infrastructure

What is quite often not recognised by professionals and decision-makers, is that simply concentrating on building facilities for cycles is quite often not the most appropriate course of action. Transport policy requires joined-up thinking, and measures that have wider benefits are quite often the most appropriate for cyclists.

Recognising this, the concept of "Invisible Infrastructure" is introduced in CFI 2 to highlight that cycle-specific infrastructure alone does not increase cycle usage. CFI 2 makes the point that if one is to design for cyclists and simply "open the book of cycle infrastructure design," then one is opening the wrong book. Taking a cue from the aforementioned Hierarchy of Provision, one should "open the book of traffic reduction/traffic calming" first.

The Invisible Infrastructure "toolbox" contains a broad range of options, including, but not limited to:

(1) Land Use Policies
(2) Parking Meters
(3) Travel Plans
(4) Individualised Marketing
(5) Congestion Charging

EUROPEAN INNOVATIONS

Despite the many additions to the new guidelines, and perhaps indicating the difficulty of the task of keeping pace with the changes in infrastructure design, ,there are many European innovations that have yet to be included in full detail. Some examples of these are:

- Centreline removal;
- Door opening strips;
- Logo-only Routes; and
- Innovative roundabout mitigation measures.

Centreline Removal

Ben Hamilton-Baillie of Hamilton-Baillie Associates, an Urban Design firm based in Bristol, once said that "centrelines do three things: Increase speeds, decrease separation between vehicles, and reduce peripheral acuity." As one of the foremost European consultants in his field, he has advocated widespread removal of centrelines from roadways.

Centreline removal schemes are certainly becoming more common. A 4-year study of before and after data of 12 roads in Wiltshire County, England showed that centreline removal resulted in a remarkable 33% reduction in motor vehicle crashes. (*White Line Carriageway Markings Report* A Wyatt, 2004) One centreline removal case study from Suffolk, England showed that car volumes reduced from 5500 per day to 4500 per day while bike volumes increased from 150 to 183 per day in a one-year period.

Door Opening Strips

Cyclists in bike lanes or in wide kerb lanes often risk being struck by a suddenly open car door. Research done by the London Accident Analysis Unit has shown that 10% of cycle crashes in 2002 were due to cyclist hitting the open door of a vehicle. (*Analysis and Use of Cycle Crash Data* TfL 2002)

One potential mitigation measure is painting a buffer zone known as a door opening strip between a cycle lane and a row of parked cars. The City of Glasgow in Scotland has miles of door opening strips with no adverse accident issues reported to date. City of Edinburgh Guidelines due to be published in 2007 will provide specific recommendations on the dimensions of door opening strips.

Logo-only Routes

Another improvement that is increasingly popular is logo-only routes. Several cities in the USA already have logo-only routes, with popular variations including "Chevrons" and "Sharrows." Indeed, a study produced for the City of San Francisco (*San Francisco's Shared Lane Pavement Markings* Alta Planning + Design 2004) on "Shared Lane Markings" (logos, but no lane lines) concluded that they have a "positive impact" on motorist and cyclist behaviour, positions, and safety.

In the UK, logo-only routes have gone a step further and are being implemented on routes with higher speeds that found in the US. In one case study in Shropshire, in the Midlands of England, the volumes on the roadway have been found to be 4,000 cars per day with the 85th %ile speed at 48 miles per hour. Cycle logos were placed at 100 metres on centre, staggered every 50 metres on each side of the road, and were found to be successful in raising awareness of cycling and giving cyclists on the roadway an increased sense of comfort.

Logo-only routes in London have gone as far as marking the number of the route (such as route 45 in one famous example) alongside the cycle logo. These provide way-finding guidance along with a providing a visual cue to drivers that cyclists are present on the roadway.

Innovative Roundabout Mitigation Measures

One has only to mention the word roundabout to compel cyclists young and old to cringe in unison. Despite all their benefits of increased capacity and decreased energy consumption, roundabouts can often be intimidating for cyclists to use.

Historically, crash records of roundabouts have not painted them in the greatest light. A New Zealand study (*The ins and outs of roundabouts* Transfund New Zealand, 2000) found cyclist injuries make up 29% of all serious and 22% of slight injuries at roundabouts compared to 12% and 12% respectively for serious and slight injuries at priority controlled intersections, 7% and 0% at traffic signals and 5% and 6% at uncontrolled intersections. Moreover, a British study (*Crashes at four-arm roundabouts*, G Maycock and RD Hall, 1984) found that accident rates involving cyclists at roundabouts are up to 15 times greater than those involving cars and 2 to 3 times greater than bicycle accident rates at signalised intersections.

Nonetheless, roundabout designs have evolved considerably in the last couple decades. With geometric design modifications that have included high deflections and negative superelevations, roundabout speeds have been reduced and many are now easily navigable by bicycle. Although not ideal for ever situation, roundabouts are now considered to be a valuable addition to the Urban Designer's toolbox.

In the United States, roundabouts of some form or another have been around for over 100 years. The last 15 years have witnessed the emergence of so-called "Modern Roundabouts" (known as "Continental Roundabouts" in Europe) which are known to be innovative as their small size, high deflections, and low speeds often provide an amenable environment for bicycles and pedestrians. However, although speeds can be easily reduced on single-lane roundabouts with simple geometric design measures, reducing speeds on multi-lane roundabouts to the speed of bicycles remains a significant challenge. Furthermore, guidelines are generally focused on providing new facilities, overlooking the critical issue that first we should "fix what we have." Existing facilities need to be modified to better accommodate non-motorised users. The following are examples that can be used as modifications to existing roundabouts.

Cycle Logos in the Roundabout

One case study in Brent (northwest London) has logos in the centre of the circulatory roadway, conveying to both the cyclist and the car driver that the cyclist is to take the lane in the roundabout, thereby minimising conflicts during the turning movements and raising the profile of bicycle as a mode of transport.

The vandal-proof logos are thermoplastic (rather than paint) for longevity and are imbedded with small aggregate to minimise cyclists' slippage. In Brent the on-road logos have lasted two years with minimal wear.

Reducing Sight Distance

In another case study in Bristol in southwest England, engineers erected walls on the approach to a roundabout to reduce sight distance. This successfully slowed down approaching vehicles by hindering their visibility onto the circulating carriageway.

Geometric modifications

In York (UK) the so-called "Magic Roundabout" with inscribed painted cycle lanes did manage to reduce cycle accidents, but only in conjunction with a comprehensive range of geometric modifications to reduce vehicle speed. Reviewers of the Cycle Friendly Infrastructure guidelines concluded that the York example was a special case, with extraordinarily high cycle volumes and significant motor vehicle volumes. Consequently, inscribed cycle lanes are not be recommended, matching guidance from the newest version of the MUTCD (the Manual on Uniform Traffic Control Devices). Continental Roundabouts were recommended as the most appropriate roundabout design, as with the lower vehicle speeds, cyclists can comfortably occupy the centre of the circulating lane.

Incidentally, inscribed painted cycle lanes are often the cause of much controversy, even in mainland Europe. Although relatively common on European roundabouts, they are now not recommended as Best Practice as they force the cyclists to ride along the edge of the roundabout's travel lanes and consequently the motorists "never know whether a cyclist will go further along the circulatory roadway or use the next exit." (*Cycling and Roundabouts* Meschik 2005)

Raised Crossings

In a case study from Malmo, Sweden, a roundabout with an ADT of 22,000 had raised crossings installed at all four legs and it was found to increase safety and comfort considerably for bicycles and pedestrians. The raised crossings were put in with sinusoidal ramps for minimal impact to bicyclists riding over them.

Turbo Roundabouts

Finally, Turbo Roundabouts, which originated in Holland, are the latest innovations on roundabouts in Europe. They manage to combine the characteristics of Modern Roundabouts, including higher deflection and lower

speeds, with exceptionally high volumes. Turbo Roundabouts are multi-lane roundabouts that have high deflections on their approaches, but have raised kerbs with in the roundabouts, kerbs that separate the various lanes of traffic. They have been found to carry up to 4,800 motor vehicles per hour, a significant amount of traffic given the low speeds of the vehicles. (*Pedestrian and Bicycle-Friendly Roundabouts* Fortuijn 2003) The design of Turbo Roundabouts, however, is in its infancy and further research is recommended before application in the United States.

CONCLUSION

To be sure, updating guidelines is an iterative practice that is never perfected with the qualitative criteria that corresponds with cycle infrastructure design. Nonetheless, changes made to the *Cycle Friendly Infrastructure* guidelines are certain to facilitate the planning and design of our communities for non-motorised traffic. Guidelines are far from a panacea to increasing cycling. Planners and engineers commonly use figures from guidelines out of context and try to apply them without understanding how they were developed and how they should be used. Consequently, it can be argued that implementing extensive professional training would be more effective than creating more design guidelines. However, it is generally accepted that we need more professional training as well as high-quality design guidelines to compliment that training.

If there is one underlying theme to the UK's design guidelines, it is that the best way to improve the situation for cyclists is to constrain both the use and the speeds of motor vehicles. Cycling facilities are necessary, but facilities alone are not sufficient to "getting more people cycling, more safely, and more often." It will take multi-disciplined, joined-up thinking, utilising all the tools available in the tool box, to increase the modal split of cyclists and create a truly cycle friendly environment.

Next Steps

The CFI 2 Guidelines are scheduled to be published in 2007 (www.dft.gov.uk) as an internet-only document, joining the environmentally conscious 21st century as we try to reduce the eco-footprint of our publications. Parts of the guidelines have already been incorporated in the newly released draft Manual for Streets, which can be downloaded from www.ManualforStreets.org.uk. As more cycle-related data is being collected and more research is carried out, cycle-specific infrastructure guidelines continue to evolve, forming a valuable tool with which to create happier, healthier, and more livable communities for the future.

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