Proceedings of ICE
Civil Engineering 158 May 2005
Pages 39–47 Paper 14014

Keywords
roads and highways; town and city planning; traffic engineering

Improving traffic behaviour and safety through urban design

Ben Hamilton-Baillie
MA, Dipl Arch, DMS, FRSA
is an urban design consultant with an interest in traffic

Phil Jones
BSc, CEng, MICE, MIHT
is a traffic consultant with an interest in urban design

Recent experiments in mainland Europe and more recently the UK have found that removing the traditional separation between traffic and people in urban areas can make streets safer and less congested. Removing standard kerbs, barriers, highway signs and road markings forces motorists to use eye contact with other road users and pedestrians, for which they need to be travelling at less than around 30 km/h. As this paper reports, the result is slower, more careful traffic, increased safety for cyclists and pedestrians and a more attractive urban environment overall—in which local architecture and culture prevails over standard traffic infrastructure.

On arrival in any town or city, the backdrop to your first impressions will be determined by the history, landscape, topography and architecture of place. We know we are in Bath, Bolton or Birmingham by a unique mixture of natural and artificial landmarks and symbols that provide the data for our mental maps. Yet the foreground to our experience is very different. The immediate environment of our urban areas is dominated by kerbs, road markings, bollards, traffic signals, barriers and signs. We negotiate our journey through a city landscape fashioned by traffic engineering. The rules that govern this landscape have little in common with the special cultural history and values that have shaped the architecture and the unique signature of the place. Indeed, the overarching principle governing the foreground has its roots in the desire for consistency, conformity and predictability. Traffic engineering seeks uniformity and unambiguous clarity, demanding the same standards, whether the backdrop is Fort William or St Austell.

We have learnt to accept and blank out the foreground; to allow the presence of traffic-engineering paraphernalia as a tiresome but necessary part of modern life. A change in level at the kerb will divide the space for pedestrian activity and social interaction from the carriageway. The carriageway will be marked by a central white dividing line, and painted lines and coloured lights will define priorities at intersections. Road lighting will provide a predetermined level of background illumination. More lights and markings will indicate where pedestrians should cross the road. We know where we should drive, where we should walk, and where we should cross the road. It is difficult to

Fig. 1. Houston, Texas is typical of the many US cities that devote over 70% of urban space to streets and car parks (courtesy USICE)

imagine that these rules could be different.

This paper reflects on how the relationship between traffic, people and places might be otherwise. We hope to suggest that a new set of principles to define the relationship of traffic engineering and urban design might offer possibilities for reconciling the competing and conflicting demands for safe, efficient movement with the quality and legibility of the built environment.

The effect of traffic engineering on the public realm is difficult to overstate. In many cities in the USA, over 70% of the urban space is made up of streets and car parks (Fig. 1). Even in the UK, 30–40% of public space lies in the realm of the traffic engineer. Yet these professionals receive no training in urban design and usually (unsurprisingly) place little value in achieving good-quality places, preferring instead to focus on optimising traffic capacity and safety. It is encouraging that the Department for Transport, in its guidance to local authorities for the second round of local transport plans,[1] is encouraging highway authorities to place greater

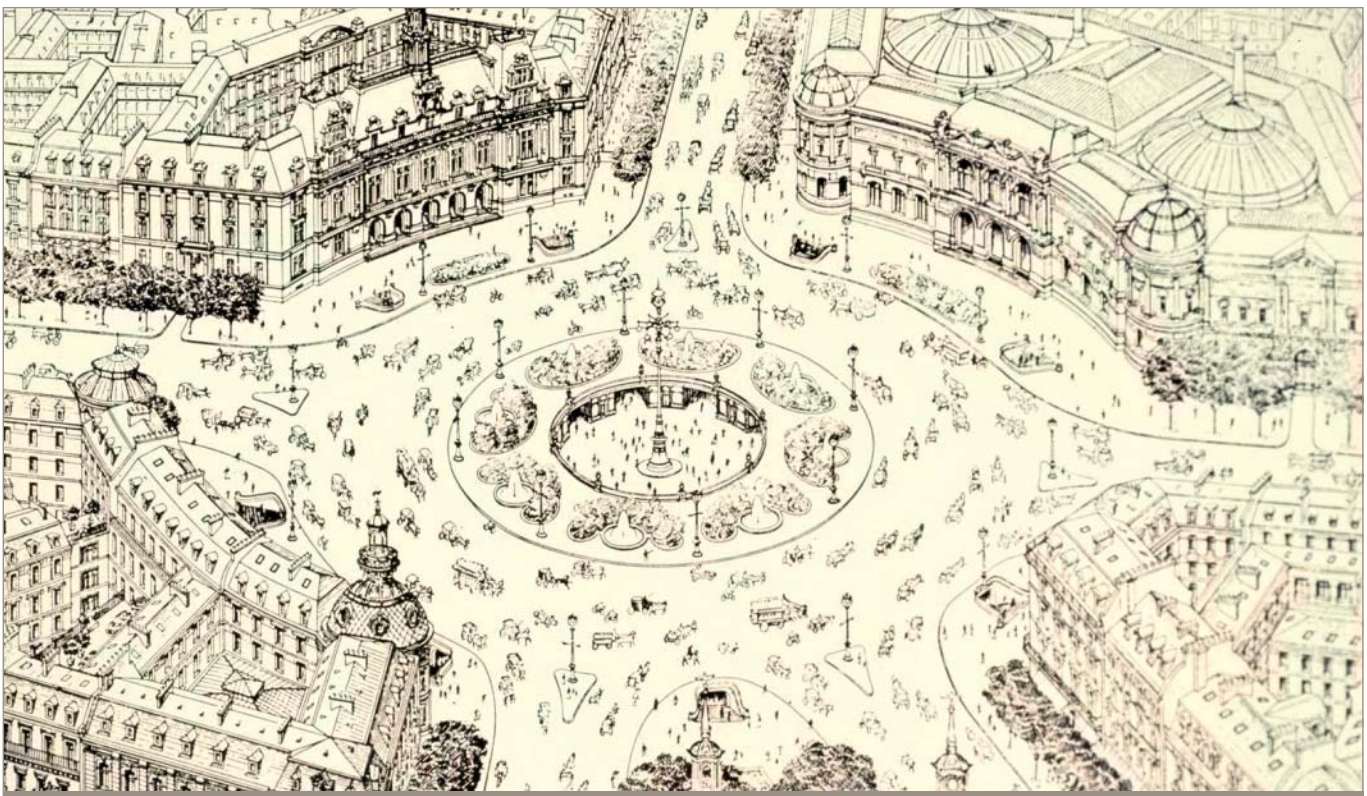

Fig. 2. Eugene Henard's 1895 proposal for a roundabout in Paris would not look out of place in a modern traffic-engineering handbook, but few of his designs were implemented

emphasis on the quality of public spaces, but this is only a small step forward.

If we wish to understand how cities might become more legible, coherent and liveable, it would seem sensible to understand how the dichotomy between the design professions and traffic engineering has arisen.

The historical background

Eugene Henard, as the father of modern traffic engineering, could be said to have had more influence on modern cities than many of the great architects and planners. Working in Paris at the end of the nineteenth century, Henard drew some remarkable sketches for traffic circulation. He is credited with the invention of the traffic roundabout in 1877[2] and his proposals for junction designs would not look out of place in the modern traffic-engineering handbook (Fig. 2).

Few of Henard's ideas were implemented during his lifetime, but his work was taken up by a new generation of traffic engineers. In the USA, William Phelps Eno adapted many of the principles for the earliest set of US traffic-engineering guidelines, later codified by Arthur Tuttle and Edward Holmes in 1932. Although some traffic devices had appeared in Britain before the turn of the century, it was Holroyd Smith who is generally credited with the introduction of Henard's ideas to this country in the 1920s.[3]

The planning of a new settlement in Radburn, New Jersey, introduced the concept of segregation between the traffic and pedestrian networks. Radburn's principles greatly influenced new town developments in the UK, and the separation of vehicles from people remains a persuasive model for many to this day. Unfortunately many of the UK estates that were developed on Radburn lines have become places with severe social problems. Houten, a recent new town in the Netherlands for 35 000 inhabitants, adapts the segregated model with greater success (Fig. 3).

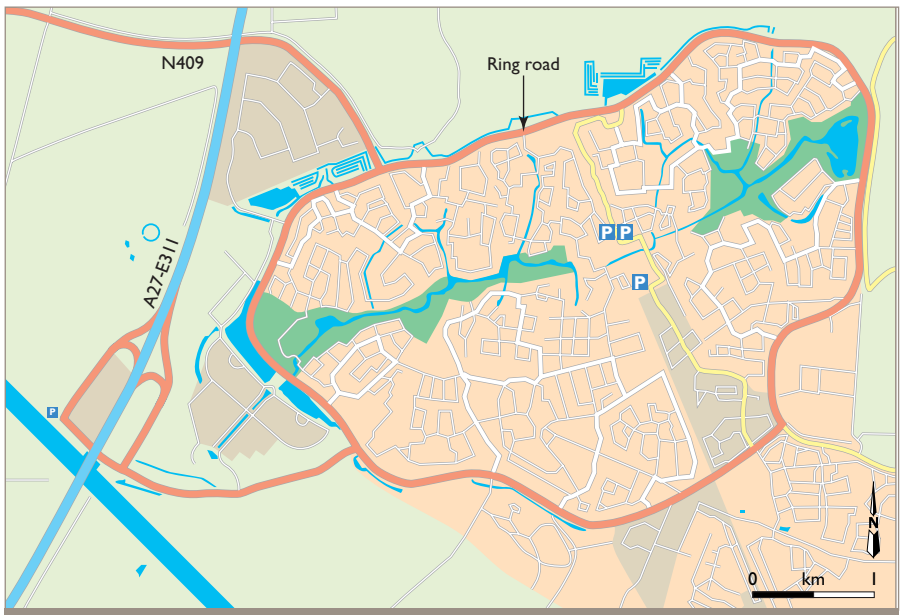

Fig. 3. Street map of Houten, a recent new town in the Netherlands in which vehicular traffic is segregated from pedestrians

Sir Colin Buchanan's 1963 report, *Traffic in Towns*,[4] took the segregation principle further. Buchanan stressed that projected increases in traffic growth presented a serious threat to the quality and efficiency of towns and cities. He concluded that vehicular traffic and pedestrian activity were fundamentally incompatible, and guided planners and traffic engineers to segregate roads designed for the movement of vehicles from spaces where pedestrian activities, children's play and public events could take place (Fig. 4).

Traffic in Towns has never been updated, but a raft of government-endorsed technical guidance has been published

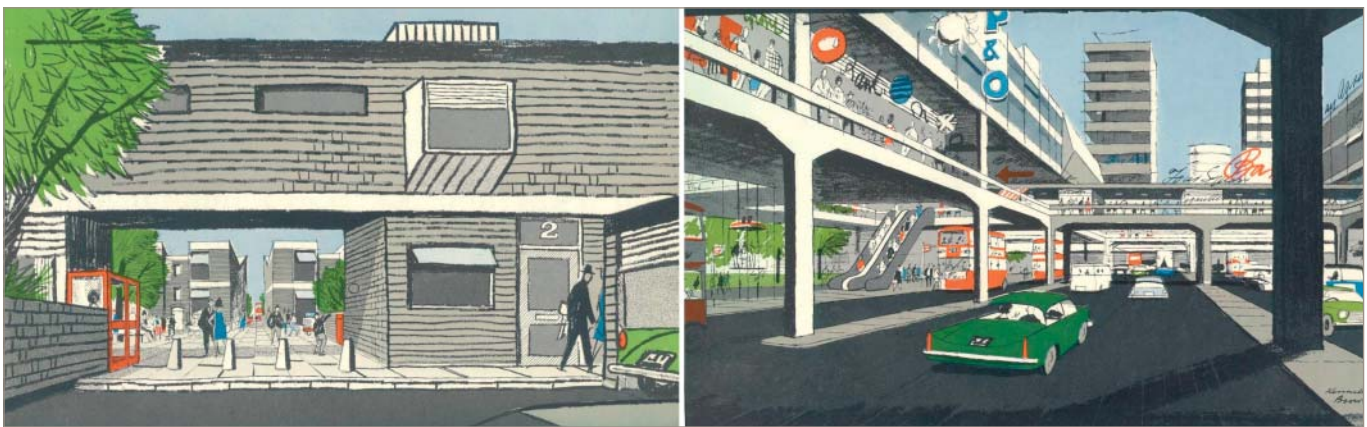

Fig. 4. Illustrations from Colin Buchanan's seminal 1963 report *Traffic in Towns*, showing vehicles segregated from pedestrians (Crown copyright)

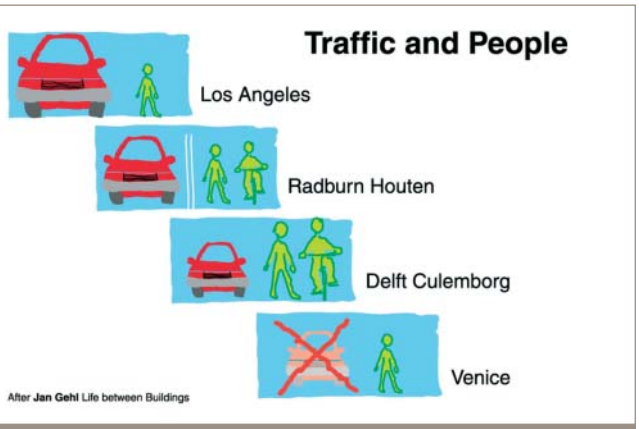

Fig. 5. Jan Gehl's four relationships between people and cars in urban areas, together with examples

Fig. 6. Morice Town Home Zone in Plymouth, one of around 60 such schemes already built or planned in the UK based on the Dutch *woonerf* principle

over the decades—the most important of which (in the UK) is the *Design Manual for Roads and Bridges*.[5] Throughout this time, the separation between urban design and traffic engineering has remained a constant theme in technical guidance and standards.

Whereas it is rarely possible to achieve complete segregation, as in Radburn or Houten, conventional traffic engineering still seeks to minimise the potential 'conflict' between cars and people. Safety advertising campaigns have urged parents to discourage children from playing near roads. Pedestrian barriers, defined crossing points, underpasses and bridges have become the common vocabulary of the urban environment.

Segregation versus integration

Professor Jan Gehl of Denmark has identified four distinct models for defining the relationship between people and cars in urban areas (Fig. 5).[6] In the first, although cars share the environment with people, traffic has become dominant (e.g. Los Angeles). At the other end of the spectrum are places where traffic is entirely excluded, such as Venice. Between these two extremes lie two parallel, contrasting approaches to the relationship. In Radburn and Houten there is segregation between traffic and pedestrians, offering separate infrastructure to serve each mode. Traffic engineering and urban planning in the UK has generally adopted this model, although there has been a move away from its more extreme manifestations in recent years—the removal of many pedestrian underpasses is an example.

The third model, which we believe offers significant advantages, relies on the integration of cars and people. This approach grew from the *woonerf* principles developed in the Netherlands during the late 1960s and early 1970s. Here, pioneers such as Niek de Boer and Joost Vahl began to experiment with techniques to enable pedestrian movements, children's play and social activities to be combined with traffic movements, such that each influenced the other.[7] The idea was applied to quieter residential streets but used urban design and landscaping to break down the notional barrier between the carriageway and the 'public realm'. Hugely popular across the Netherlands, Joost Vahl's ideas spread to a number of other mainland European countries, particularly Denmark, Sweden and parts of Germany.

In 1999, the UK Government began to encourage experimentation with such ideas through a pilot 'Home Zones' programme and is now giving strong encouragement to the widespread adoption of these techniques in both existing and in new streets. Around 60 existing areas will have been converted to Home Zones by the end of 2005 and many developers are now incorporating Home Zones into new residential areas (Fig. 6).

Home Zones are important because they give official recognition in the UK to the principle that contextual design can be employed to influence traffic speeds and driver behaviour, a fact that has been confirmed through research. Work in Scotland on 'environmental' traffic calming showed that drivers respond to more complex environments by slowing down and that traffic calming devices that relate well to their surroundings are more effective.[8]

However, Home Zones are only part of a sea change away from the principle of traffic segregation towards integration. Pioneering safety specialists, traffic planners and urban designers in Denmark, Sweden and Holland have started to apply principles of behavioural psychology to street design and to use the principles of legibility and context with surprising and counter-intuitive results. One of the most respected practitioners in this movement is Hans Monderman, working in the province of Friesland in the north of the Netherlands. His work takes the principles of integration far beyond the confines of quiet residential streets, and demonstrates how urban design and traffic engineering can work together in a new paradigm.

Traffic zones and public realms

Conventional traffic engineering has defined a hierarchy of road types, suitable for various functions, speeds and traffic volumes, ranging from motorways and trunk roads, through to distributor roads, estate roads and so on. Hans Monderman

Fig. 7. There are striking differences between uniform and predictable highway environments and complex and unpredictable social zones or 'public realms'

premises his work on a much simpler definition. On the one hand, we need space given over solely for the purpose of the movement of traffic—the 'traffic zone'. Our urban settlements and economic patterns demand such infrastructure. But there are also significant elements of the road network where the movement of vehicles is only one of a range of activities—the 'social zone', which we can also call the 'public realm' (Fig. 7).

The contrasts between these two worlds are striking; the traffic zone (such as the motorway) serves a single purpose. It is highly regulated by the state through rules, regulations, examination and legal enforcement and is, in theory, predictable. It is impersonal and uniform. But the qualities that we most associate with a rich and varied public realm are exactly the opposite. Cities accommodate a multitude of simultaneous functions. They are highly diverse and are governed by a complex web of ever-evolving social and cultural conventions. Cities are unpredictable, and the best and richest urban environments offer surprise, serendipity and ambiguity.

Clarifying whether each part of the highway network lies in the traffic zone or the public realm underpins Hans Monderman's work. The traffic zone is not a place for anything but the movement of traffic, and segregation is usually appropriate. But traffic can also coexist with other social activities within the public realm, so long as the cultural messages that govern human behaviour are made explicit. The driver becomes a citizen. Eye contact and human interaction replaces signs and rules. But for this to work, the transition between the two worlds needs to be made clear.

Historically, city walls marked the transition between the highway and the city (Fig. 8) and passage through a gateway took the traveller between the two environments. Modern settlements have

The driver becomes a citizen. Eye contact and human interaction replaces signs and rules. But for this to work, the transition between the two worlds needs to be made clear

Fig. 8. City gates traditionally marked the transition between highways and cities

Fig. 9. New urban gateway at Opeinde, Netherlands—once inside the arch, the road surface changes and road markings and kerbs disappear

We are designed to withstand impact at our maximum theoretical running speed, that of a fit young adult running downhill

spread beyond such clear edges and the transition has become blurred or invisible. The work of Hans Monderman and other proponents, such as Bjarne Winterburg from Denmark, places great emphasis on the reintroduction of very definite entry gateways. Public art plays an important role in this new approach to traffic engineering.

The entry point into the town of Opeinde in Friesland (Fig. 9) is celebrated by a large tubular steel arch. Once inside the arch, everything changes. The road surface is different. Road markings and kerbs disappear. Lighting lowers to an intimate pedestrian level. Alignments, surface patterns and drainage details reflect and underscore the principal buildings. Driver behaviour responds to the change from the traffic world to the public realm; signs and speed limits seem redundant.

Central to this approach is the understanding that environmental context strongly determines behaviour, and more powerfully than legislation and formal rules. Our behaviour in a theatre or a council chamber differs from a pub or in a football stadium. We understand the signs and signals through years of cultural immersion. And we know from campaigns to change codes of behaviour, such as those for smoking or drink-driving, that such cultural mores are much more effective than legal strictures. Thus a rural road covered in cowpats, winding past a smelly farmyard, does not need a sign warning you of cattle in the road. Equally signs in city centres reading 'Caution: beware of pedestrians' are not only redundant but are also demeaning to the intelligence. Hans Monderman's work suggests they also increase the risk of accidents by absolving drivers from having to use their intelligence and engage with their surroundings.

Speed and eye contact

The use of social and physical context as a means to adapt traffic behaviour is critically dependent on speed. Thus European countries adopting the principles of integration of traffic in towns are also placing great emphasis on the introduction of 30 km/h (19 mph) as the maximum design speed for all built-up areas. Given the importance of speed to the idea of legible traffic design, it is worth a brief detour to explore why it appears to be so critical to the approach.

Researchers[9] have long noted a 'kink' in the graph relating the impact speed of vehicles with the severity of pedestrian injury. One would expect the likelihood of death or serious injury to increase with speed, but the statistics suggest a very sharp upward movement in the graph at around 32 km/h (20 mph). From 5% fatalities at 32 km/h, fatalities increase to 45% at 48 km/h (30 mph), and 85% at 64 km/h (40 mph). A similar kink in the graph at around 32 km/h occurs when comfort levels of pedestrians and cyclists are plotted against speed.

Evolutionary biology may help to explain this. Our human physiology, the strength of our skulls and physical frames, are designed to withstand impact at our maximum theoretical running speed, that of a fit young adult running downhill. Fall and hit a rock at this speed and you will have a headache, but you will probably survive. Protection from impact above such speeds was evolutionary unnecessary.

Moreover, our ability to retain eye contact with our fellow humans appears to diminish rapidly when we move faster than our maximum running speed. Research into driver behaviour suggests that eye contact between drivers, and between drivers and pedestrians, decreases rapidly beyond the 32 km/h threshold.

Fig. 10. Fatalities and serious accidents ceased and traffic tailbacks reduced when all traffic signals, signs and road markings were removed from the central junction in Christiansfeld, Denmark

Fig. 11. The complex de Brink road junction in Oosterwolde, Netherlands has been converted to a shared public square without road markings or signs

The effective communication through eye contact of social rules and subtle messages about status, hierarchy and priorities are essential to the functioning of public space. Thus it appears that speed may be a factor in urban quality in a wider context than simple safety and accident reduction.

Safety through ambiguity

Joost Vahl, pioneer of *woonerf* ideas, highlights the counter-intuitive nature of the new approach to traffic engineering with his conclusion that 'the only way to make a traffic junction safe, is to make it dangerous!'

But such contradictions appear to be borne out by the reductions in injuries resulting from some remarkable changes to busy traffic intersections in both Denmark and Holland, where ambiguity has replaced conventional traffic controls.

In the town of Christiansfeld in Denmark, Bjarne Winterberg and the engineering firm Rambøll tackled the high casualty rate on the town's central traffic intersection through the introduction of ambiguity and urban legibility (Fig. 10). Rather than adding additional warning signs, road markings or traffic signals to a junction that was seeing an average of three killed or serious injuries (KSI) a year, the scheme removed every trace of conventional traffic engineering. Traffic signals were removed, along with all road markings. Instead, the notion of a 'place' at the intersection has been emphasised through the surface treatment, the lighting columns and the squared-up corners of the junction. It feels like the centre of the town again. No special priority is afforded to direction of travel, and pedestrians, cars, buses, bikes and trucks are thrown back on negotiating movement through eye contact. To many people's surprise, not only has the KSI rate fallen to zero for three years, but tailbacks of traffic during peak periods have also reduced. It seems that the ambiguous junction provides improved capacity for traffic and fewer delays than traffic signal control systems. Similar junction treatments can be found across Denmark.

In Holland, Hans Monderman has taken the principle further, redesigning many busy traffic intersections into public squares. Changes in level, shifts in the road alignment, and architectural elements are inserted not for conventional traffic-calming purposes but merely to emphasise the peculiarities of 'place'.

At the de Brink junction in the centre of the Friesland market town of Oosterwolde (Fig. 11), trucks, bikes, cars and pedestrians intermingle with apparent chaos and disorder, using eye contact and careful observation to negotiate the space. The guiding control of the state is absent; it relies entirely on informal convention and legibility.[7]

A less complex, but busier, crossroads junction is found in the centre of the nearby town of Drachten. As in Christianfeld, a set of traffic signals was removed and none of the approach roads are now given right of way. Vehicle, cycle and pedestrian flows are high at around 20 000 per day and yet there have been only four accidents (all of which were damage-only) in the two years since the junction was remodelled. This compares to 30 accidents (including four injury accidents) in the previous seven years when the junction was under signal control.

In Makkinga, a village close to Oosterwolde, the complete absence of signs and markings gives the driver an awareness of the desire lines between the church, the pub and the village green. You know where to expect children to run out of the playground, or drunks to stagger out of the bar, and you change

Fig. 12. Open footpath–road junction at Makkinga, Netherlands—motorists have their attention drawn to it by a change in surface treatment and a slight rise in road level

Fig. 13. A barriered footpath–road junction in Holsworthy, Devon does little to encourage motorists to slow down

your driving habits accordingly. In a suburban street, a footpath meets a main estate road at right angles (Fig. 12). In the UK, this insignificant intersection would probably be marked by a 'safety barrier' to cut the footpath from the road (e.g. Fig. 13). By contrast, Monderman expresses the presence of the footpath into the road through special surface treatment and a slight rise in level; not enough to constitute a speed hump, but enough to draw subtle attention to the driver of the status and significance of the footpath, and the possible arrival of teenage skateboarders. It contributes to a rich, legible and humane urban language.

Developments in the UK

It would be easy to show examples of poor integration of urban design and traffic engineering taken from any town or city in the UK that would present a contrast with the pioneering examples from mainland Europe. We prefer to comment on the increasing signs that this integrated approach is now beginning to take root in the UK. We have earlier referred to the Home Zone movement, which is already bearing fruit, but some authorities are being more ambitious.

Wiltshire County Council has been experimenting with the omission of centre-line markings in 48 km/h (30 mph) areas through villages since March 2003.[10] The authority found that across 12 sites, speeds were reduced for the most part and the total number of collisions went down from 17 to 11 per year.

Suffolk County Council is taking part in the EU-sponsored research project 'Shared Space' (www.shared-space.org) whereby context-sensitive road designs are being developed in several urban areas across northern Europe. The project, which will run until 2006, involves the sharing of experiences between participating authorities. The Suffolk project consists of the redesign of several streets near the centre of Ipswich to improve conditions for local residents.

The London Borough of Kensington and Chelsea has embarked on a programme of streetscene improvements to Kensington High Street, a busy route through one of London's main retail centres. Much has already been achieved,

including the removal of large amounts of pedestrian guard-railing and the rationalisation and reduction of signage and other street furniture. Conventional priorities remain in force, but it will be interesting to see whether the removal of so much safety-led infrastructure has any effect on casualties. Certainly the street looks substantially better for it. The borough is now considering more radical interventions in other locations, including Exhibition Road, which has received considerable press coverage.

Value for money

The most successful shared space schemes rely on simplicity. The removal of the conventional highway components of signals, barriers, bollards, bumps and signs does not merely achieve advantages for traffic movement, safety, accessibility and environmental quality. It also allows resources to be diverted from high maintenance equipment towards simple, durable materials (Fig. 14). Developers of new streets and public spaces are showing interest because of the simple economic wisdom of avoiding unnecessary expenditure on expensive traffic engineering.

Whereas Home Zones have been considered as expensive because of the focusing of improvements on specific streets, there is no reason why shared space should not offer opportunities for savings for highway authorities. Traffic signals, guardrails and illuminated bollards are not cheap to install or maintain. By contrast, there are plenty of established examples across Europe where simple design and dimensions have achieved a satisfactory balance between people, places and traffic with low-cost solutions. Shared space design need not be expensive.

Conclusion

The emerging techniques that aim to integrate vehicles into the public realm present a vastly expanded palette of design solutions to engineers and designers. Surface materials, lighting, kerb lines, street furniture and gateways can be deployed in ways never detailed in standard engineering guidelines. Indeed, most of the techniques would be proscribed by conventional guidelines, and rejected by a 'safety audit'.

However, the data emerging from some of the schemes referred to in this paper suggest that safety might be significantly improved by counter-intuitively removing many of the measures employed with this aim in mind since the middle of the last century.

A new paradigm for traffic in towns suggests a way to move towards a continuous, coherent, unsegregated public realm, where cars no longer divide neighbourhood from neighbourhood (Fig. 14). Accentuating a sense of place appears to offer the prospect of modifying speeds and driver behaviour in ways never imagined by Henard or Buchanan.

The European mainland has shown it is possible to combine movement and places without the need for road markings, signs and barriers. It seems to be a good moment for the UK to bring traffic engineering and urban design together to accentuate the particular qualities of place, and thereby create safe, legible cities.

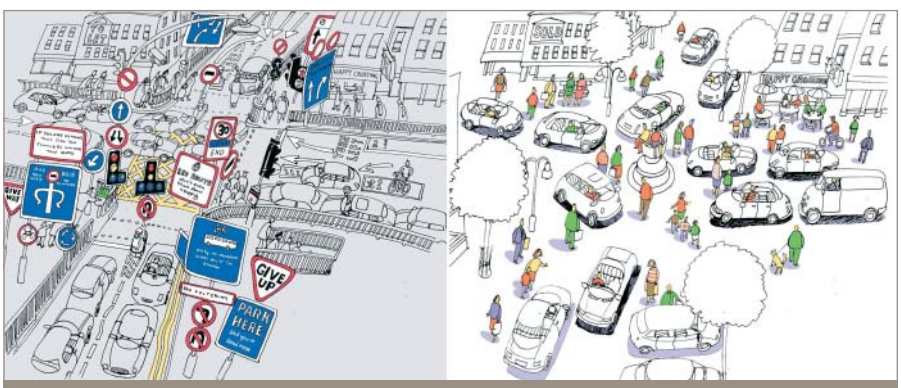

Fig. 14. Shared space design also avoids the cost of installing and maintaining a wide range of expensive highway components

Acknowledgements

An earlier version of this paper, by the lead author, was published in *Journal of Urban Technology,* 2004, **11**, No. 1, entitled 'Urban design: Why don't we do it in the road? Modifying traffic behavior through legible urban design'. Crown copyright material is reproduced with permission of the Controller of HMSO and the Queen's Printer for Scotland.

References

1. Department for Transport. *Full Guidance on Local Transport Plans*, 2nd edn. DfT, London, 2004.
2. Wolf P. M. *Eugene Henard and the Beginning of Urbanism in Paris, 1900–1914*. International Federation for Housing and Planning, The Hague, 1969.
3. Lay M. G. *Ways of the World*. Rutgers University, New Jersey, 1992.
4. Buchanan C. *Traffic in Towns*. The Stationary Office, London, 1963.
5. Available at: http://www.official-documents.co.uk/document/deps/ha/dmrb/index.html
6. Gehl J. *Life Between Buildings*. Van Nostrand, New York, 1987.
7. van den Boomen T. Het Nieuwe Woonerf–weg met de regels! *NCR Handelsblad*, 7–8, 2001.
8. Land Use Consultants and JMP Consultants. *Natural Traffic Calming—Guidance and Research Report*. Scottish Executive, Glasgow, 1999.
9. Ashton S. and Mackay G. Some characteristics of the population who suffer trauma as pedestrians when hit by cars and some resulting implications. *Proceedings of the 4th International Research Council on the Biomechanics of Impact International Conference,* Gothenburg, Sweden, 39–48, 1979.
10. Wiltshire County Council. *Report to Overview And Scrutiny Management Committee*, Wilture County Council, Trowbridge, 2004.

What do you think?

If you would like to comment on this paper, please email up to 200 words to the editor at editor@ice.org.uk.

If you would like to write a paper of 2000 to 3500 words about your own experience in this or any related area of civil engineering, the editor will be happy to provide any help or advice you need.