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**Potential application of Shared Space principles in urban
road design: effects on safety and amenity**

Report to the NRMA-ACT Road Safety Trust

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March, 2012

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE REPORT DOCUMENTATION
PAGE

Report No.	Date	ISBN	ISSN	Pages
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Title and sub-title:

Potential application of Shared Space principles in road design: effects on safety and amenity

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Preparation of this report was supported by a grant from NRMA-ACT Road Safety Trust

Abstract:

‘Shared space’ is an approach to road design that is growing in popularity around the world. The idea is that instead of being segregated into their own sections of pavement, vehicles, pedestrians and cyclists are free to move through the space more or less at will, negotiating right of way with other road users via eye contact and social norms. In theory, the increased perceived risk of such a situation causes road users to slow down and be more aware and considerate of other road users. However, concerns have been raised that vulnerable pedestrians (particularly those with visual impairments) are not able to negotiate such spaces safely, and may be forced to avoid them, thus reducing their mobility. The limited data available so far on shared spaces that have been constructed in the Netherlands and UK suggest that crash rates are no higher than comparable traditional environments, and in some cases may be lower. However many crash evaluations suffer from problems such as limited data collection times and the lack of a comparison site, thus running the risk of biased data. There is also limited information on whether vulnerable pedestrians are able to use these areas safely. It is important to understand the usage of such shared spaces and the behaviour of road users in more detail before large amounts of public space are converted to this style of design.

Key Words:

Pedestrian safety; cyclist safety; accessibility; vulnerable road users

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Preface

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Contributorship Statement

JE researched and wrote the report.

BC provided expert commentary and reviewed the report.

Ethics Statement

Ethics approval was not required for this project.

EXECUTIVE SUMMARY

‘Shared Space’ refers to a road design involving desegregation of different road users, aiming to replace traffic controls with social protocols and negotiation. Instead of a clearly marked roadway that vehicle drivers feel they ‘own’, shared spaces use minimal signage, and are designed to encourage pedestrian use. In theory, the uncertainty of the environment influences drivers to slow down to walking pace as they travel through the area. Shared spaces, ideally, thus encourage both safer speeds and safer, more diligent behaviour.

However, concerns have been raised that not all drivers will be able or willing to adapt to the new protocols and give way to pedestrians and cyclists when appropriate. Because the approach is new, it is not yet known whether the effects on driver behaviour are permanent, or merely a response to a novel environment. Differences in road culture may make it difficult to transfer the concept outside of northern Europe. Importantly, vulnerable pedestrians such as elderly, child, vision- and mobility-impaired pedestrians may be at greater risk in such environments.

The present project aimed to review collision data from existing Shared Space implementations around the world. Where possible, information was also gathered on other important factors such as perceived safety, accessibility and amenity for pedestrians, cyclists and vehicles. The potential effects of road culture on the success of Shared Spaces are examined. Usability issues are explored, including consideration of how to make Shared Spaces more usable for vulnerable pedestrians. Alternatives to Shared Spaces are considered. Finally, recommendations are made for best practice implementations of Shared Space designs.

Collision data was available for eighteen road spaces using Shared Space principles to a greater or lesser extent (mostly in the Netherlands or Britain). The limited data available so far suggest that crash rates are not consistently either higher or lower than comparable traditional environments. There is wide variability between sites in both the extent of the application of Shared Space principles, and the effect of the reconstruction on crash rates. Many of the crash evaluations suffer from problems such as limited data collection times, the lack of a comparison site or control data to account for wider trends, failure to collect exposure data, and failure to collect injury data for collisions not involving vehicles (i.e. pedestrian-cyclist collisions, single-cyclist and pedestrian fall incidents). These limitations constrain the conclusions that can be drawn about the effects of Shared Spaces on safety.

There is even less information available on the effects of Shared Spaces on other measures. The evidence so far suggests that removal of traffic signals results in less delay and congestion for most users, but lower perceptions of safety. Limited data on perceptions of amenity and spatial quality suggest that these improve. Changes in site usage by different road user groups are difficult to measure and highly site-dependent. Interactions between different road users in Shared Spaces have been insufficiently studied, however data so far indicates that driver and pedestrian behaviour depends on relative vehicle/pedestrian flow and traffic speed.

This may reflect the importance of differences in the road culture of particular road environments. There are also differences in national road cultures that might be expected to affect the use of Shared Spaces. These include the mode mix (proportion of trips made by private vehicle, public transport, bicycle or on foot), legislation (e.g. who is considered to be at fault in a collision between a pedestrian and a vehicle), enforcement, education and other factors.

Many concerns have been raised about the safety of Shared Spaces for vulnerable pedestrians. In particular, blind and visually impaired pedestrians are not able to make eye contact with other road users, and if space negotiation in shared spaces is truly based on eye contact then these users are at an obvious disadvantage. Deaf and hearing-impaired pedestrians may also be disadvantaged by the inability to hear vehicles and bicycles approaching from behind. Mobility-impaired and elderly pedestrians may be less able to quickly adapt their course to get out of the way of faster vehicles. Older pedestrians, child pedestrians and cognitively-impaired pedestrians may find the lack of clear cues and rules about when to cross the space confusing and difficult to negotiate. These problems may lead to such potential users avoiding the space entirely, thus decreasing mobility for these users. With the exception of a series of studies by the Guide Dogs Association of the UK, these issues have been under-researched.

Shared space is just one of a variety of options for urban centres needing to better balance mobility, safety, community desires and the needs of different road users. Other options include reduced speed limits (on a permanent or timed basis); vehicle restrictions (permanent, timed, or partial such that only certain vehicle types may use the area); reallocation of road space to pedestrian and/or cycle facilities; traffic calming road engineering; perceptual countermeasures to reduce speeds; or the use of novel traffic controls such as alternating timed priority (in effect pedestrian crossing signals that stretch along the entire length of the road space rather than being restricted to a single crossing point).

Which of these options is best for a particular road space will depend on current and future user needs. It is therefore important to gather accurate data on the usage of the space (e.g. current and anticipated vehicle flow and speeds, mode mix, pedestrian and cyclist flow and desire lines, special needs for public transport such as safe waiting and alighting areas, attractors for 'sojourning' activities such as shops, cafes, parks and other destinations next to the space) as well as any currently unmet needs (e.g. accessibility for vision-, hearing- or mobility-impaired pedestrians).

Because Shared Space is such an innovative and different concept compared to traditional road designs, it is important that a high level of public consultation and education is undertaken at all stages of a project, from before the design stage to operating the new space. Special care should be taken to ensure that the space is usable for particularly vulnerable groups, such as vision-impaired pedestrians (e.g. if kerbs are removed, the use of tactile markers to differentiate the vehicle movement corridor); it is vital that these groups are consulted early in the design process. Safe edge space where vehicles cannot move or park should be reserved for pedestrians to walk and linger. Physical and visual aspects of the space should encourage low speeds. Education and enforcement campaigns may be necessary to ensure that all road users behave appropriately in the new space. More detailed recommendations for best practice implementations are given in the body of the report.

Higher use of active transport modes, and public spaces that serve multiple uses, are vital for sustainable, healthy and prosperous cities. It is our hope that the present report provides useful information to help policy-makers and practitioners create the best possible urban road spaces for all road users.

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Glossary

‘Casualty crash’: a collision in which one or more person(s) sustains an injury. Severity of injury included in this definition may vary by jurisdiction and is often not defined, however receipt of medical attention is a common criterion.

‘Level surface’: a space in which the vehicle and foot traffic areas are at the same level, rather than being separated by a vertical kerb.

‘Public space’: any space not owned by individuals or corporations where members of the public may travel or linger. For example, in a street lined by shops, the space between the shopfronts is public space, including the road.

‘Road culture’: the beliefs, attitudes, perceptions and values of the users of a particular road or road network; these both contribute to and are affected by road user behaviour.

‘Shared Space’: a public road space reconstructed so that the sole emphasis is not on vehicle movement (although this is permitted). May use a variety of design options to encourage slower vehicle speeds, individual negotiations of right-of-way between road users (rather than permanent or timed priority rules, as in sign and signal-controlled intersections), and ‘staying’ rather than ‘movement’ functions of the space.

‘Shared surface’: a space in which the road/place surface is completely undifferentiated by kerbs or guidance strips, such that there is no enforced or suggested segregation of different road users.

‘Sojourning’: Activities such as shopping, eating, playing, etc in public space rather than merely moving through it on the way to somewhere else.

1 INTRODUCTION: BACKGROUND TO THE 'SHARED SPACE' CONCEPT

'Shared space' is an innovative concept in pedestrian-friendly road design, originating in Northern Europe (Shared Space Institute, 2009). Instead of a clearly marked roadway that vehicle drivers feel they 'own', shared spaces use minimal signage, and are designed to encourage pedestrian use. Social protocols instead of traffic controls determine who has the current right of way. In theory, the uncertainty of the environment influences drivers to slow down to walking pace as they travel through the area. Shared spaces, ideally, thus encourage both safer speeds and safer, more diligent behaviour.

The term 'Shared Space' (SS) was popularised by the European Commission 'Shared Space' project, led by Dutch traffic engineer Hans Monderman and British urban designer Ben Hamilton-Baillie (www.shared-space.org). The basic idea is that streets that look like social spaces will promote slow, negotiated social behaviour, while streets that look like roads (segregated areas for different users, many signs and markings) will promote travel-focussed 'traffic behaviour' (Shared Space Project, 2005). Monderman redesigned several roads in the Netherlands province of Fryslân along Shared Space principles, and saw good outcomes; however he did not publish the results of any of these schemes.

Hamilton-Baillie (Hamilton-Baillie, 2008a, 2008b; Hamilton-Baillie & Jones, 2005) expands the theoretical underpinning of the idea: when a space looks unsafe and people/drivers are not sure how to behave, they will slow down and negotiate the space carefully, thus *increasing* safety. This concept is based on the risk perception work of John Adams, emeritus professor of geography at University College London (e.g. Adams, 2008; Adams, 1988).

Changed behaviour in response to perceived risk is a form of behavioural adaptation (BA) (OECD, 1990). Usually BA occurs in response to an intended road safety improvement (for example a widened road): drivers reduce their safety margins and this reduces the effect of the intervention (negative BA). It is also possible to have positive BA to a more dangerous road situation, however drivers are poor at estimating true risk, and may not compensate sufficiently (e.g. Edquist, Rudin-Brown, & Lenné, 2012).

There are many examples from the road safety literature that can inform us on the extent of drivers' slowing and/or more cautious behaviour in the presence of an apparently dangerous environment. A previous review of the effects of road environment on speed (Edquist, Rudin-Brown, & Lenné, 2009) found that drivers:

- Speed up when guidance (in the form of clear centrelines or edge-lines) improves (negative BA)
- Slow down when the road is narrow, or looks narrow (positive BA)
- Drive at whatever speed they are most comfortable with for that road, which may be higher or lower than the official speed limit, when under high mental workload (may be positive or negative)
- Slow down when sight distance is restricted, but not sufficiently to react in time to a hazard emerging from the unseen area (positive but limited BA).

In addition, it is known that people acclimatise to risk with familiarity. For example, at rail level crossings both drivers and pedestrians are less likely to look for trains and more likely to violate ‘train coming’ warnings when they are familiar with the crossing. (Davis Associates Limited, 2005; Pitsopoulos et al., 2007). It is possible that any effects of a perceived ‘more risky’ environment will be temporary, and wear out as users become accustomed to this level of risk and uncertainty in the space.

A further concern is whether all road users adapt positively to the new space, or whether some will continue to behave unsafely. Not all drivers follow existing road rules and social norms, as evidenced by continuing crashes caused by disqualified drivers, drink driving, and speeding. Hans Monderman himself acknowledged that road design would not change the behaviour of “the 15 percent of drivers who will behave badly no matter what the rules are” (Lyll, 2005). Young, inexperienced drivers may simply be incapable of adequately assessing the risk of a shared space environment and behaving appropriately; it is known that young drivers underestimate risks, overestimate their driving capability (Brown & Groeger, 1988), and fail to adapt their visual scanning and driving behaviour to more complex road environments (Underwood, 2007).

If some drivers fail to change their behaviour appropriately in shared spaces by slowing down and negotiating priority, they will directly affect the safety of other road users. In addition, it is possible that when a large minority of drivers on shared streets are driving at inappropriate speeds, they will alter the social norm such that driving faster than is safe becomes the most common behaviour. Recent research on the influence of surrounding vehicles on speeds found that many drivers across multiple driver groups felt pressure to speed up from other drivers (Fleiter, Lennon, & Watson, 2010). This has the potential to completely remove any positive effects of redesigning a street into a shared space; vehicular traffic at standard speeds would take over, and pedestrians and cyclists would be left without any of the usual crossing facilities provided in standard roads. How this influence could affect pedestrian safety is further discussed in chapters 3 and 4.

The present project aimed to examine the evidence for changed behaviour and improved safety in Shared Space environments, to explore the factors that affect the success or otherwise of Shared Space road designs, and to make recommendations for the potential application of Shared Space principles in the ACT and other jurisdictions.

2 SHARED SPACE IN PRACTICE

2.1 Previous implementations

Many of the implementations discussed below are covered in Google Maps/Street View, which provides a useful method of seeing the varieties of streetscape possible in Shared Spaces without a site visit. Unfortunately it is not possible to reproduce these images in print, however the application can be accessed at maps.google.com.

Several noted examples of shared space are in the Netherlands (NL), where Hans Monderman worked. Possibly the most famous of these is the Laweiplein 'squareabout' in Drachten, intended as a cross between a roundabout for vehicles and a public square. Here, a signal-controlled four-leg intersection was converted into a roundabout with fountains and courtesy crossings for pedestrians. Signage and road marking were minimised so that cyclists could choose to use the edge of the space and cross vehicle flows at the pedestrian crossings, or mix with motorised traffic. This intersection has a high and increasing traffic flow; peak hour volumes were 1407 vehicles/hour in 2000 (or approximately 18,000 vehicles per day according to Gerlach, Methorst and colleagues, 2008), increasing to 1854 vehicles/hour in 2005 (approximately 22,000 vehicles per day according to Hamilton-Baillie, 2008). However, delays at the intersection decreased from an average of 50 seconds with signals to between 15 and 30 seconds for the roundabout, depending on entry and exit roads (Noordelijke Hogeschool Leeuwarden, 2007). The number of crashes was not particularly high before reconstruction, and seems to have dropped afterwards; Table 1 gives crash data from the official evaluation (Noordelijke Hogeschool Leeuwarden, 2007) and updated numbers from Gerlach et al (2008). This is one of the few sites where crash data is available separated out by level of severity, and thus the data is reproduced in full.

Table 1. Crash figures for the Laweiplein 'squareabout'.

Time period	Fatal	Serious injury	Minor injury	Damage only	Total
1995-1997 (long before)	0	2	7	17	26
1998-2000 (just before)	0	1	3	27	31
2001-2003 (during reconstruction)	0	0	2	15	17
2004-2006 (after reconstruction)	0	0	0	4	4

Gerlach et al (2008) notes that this reduction in crashes is quite normal when a signal-controlled intersection is converted to a roundabout, so the contribution of 'shared space' design over and above this effect is unknown.

Nearby, another intersection in Drachten received a Shared Space redesign in 1998. The Drift/Torenstraat/Kaden four-leg intersection, previously signal-controlled, was converted to a level surface, unsigned intersection where road users are expected to yield to other users on the right. Pedestrian zones are separated from the motor vehicle area by bollards; crossings are also differentiated by changes in the paving and tactile guidance strips. One leg is a bicycle access way (no motor vehicles) used by ~7000 bicycles per day. Vehicle flow is ~ 15,000 vehicles per day (VPD) (Gerlach et al., 2008). In the four years before

conversion (1994-1997), this intersection recorded 1 minor injury and 19 damage only crashes. During 1998, 1 minor injury and 2 damage only crashes occurred. After conversion, in the period 1999-2002 there were 3 minor injuries and 13 damage only crashes; in the period 2003-2006 there were 6 minor injuries and 15 damage only crashes. The injury crashes tend to involve cyclists.

In the suburb of Haren (NL) the Rijksweg shopping street and two intersections were modified in 2003. The road and pedestrian zones are at the same level; along the street the road is asphalt, while paving extends across the entire intersections. Occasional fences, trees and lamp posts separate the pedestrian zone and prevent cars parking there. Traffic flow along the street is only 8000 vehicles per day (Gerlach et al, 2008), however one serious injury, 2 minor injuries and 32 damage only crashes occurred during the three years before conversion. During 2003, while the road was being reconstructed, there were 11 damage only crashes. In the three years afterwards, there were no injury crashes and 17 damage only crashes.

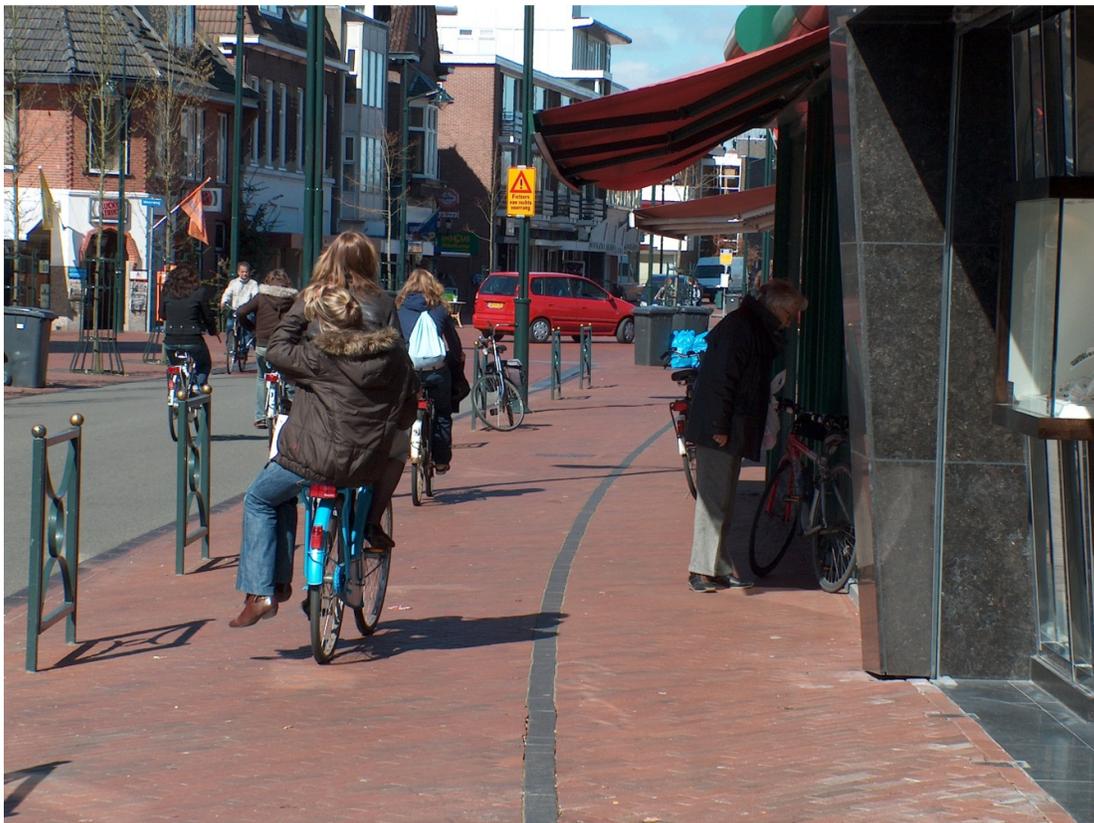


Figure 1. Rijksweg, Haren, NL shared space. Source: Methorst et al 2007 (reproduced with permission).

A report from TRL in the UK (Quimby & Castle, 2007) considered the success of several Netherlands schemes, and whether they could be applied in the UK. As well as a thorough literature review, they surveyed local authorities in areas where ‘simplified streetscapes’ had been introduced, and gathered data on collisions, injuries and any other results of the scheme such as speed reductions or changes in use by pedestrians or vehicles. The report includes the Drachten Torenstraat/Kaden intersection described above, as well as two nearby intersections given similar treatment. At the Kaden/Dwassva crossroads (which had similar traffic flows as Kaden/Torenstraat), traffic signals were removed, cycle lanes and

parking spaces indicated with different textures and colours, pedestrian crossings were painted on the busiest arms and trees were planted. During the six years before the change, there were 3 injury crashes and 17 damage only; during 2001, after conversion, there was 1 injury crash and 6 damage only crashes. This rate is higher than was expected, so the speed limit was reduced from 50 to 30 km/h. The Torenstraat/Vogelzang intersection is in a less trafficked residential area; signals were removed and coloured areas painted on the road to emphasise cycle lanes. Again, the rate of collisions increased somewhat.

Oosterwolde is a market town in the Netherlands. Formerly signal-controlled, the intersection of de Brink and Rode Plein was converted to shared space by removing signals, signs and lines, using a coloured surface and scattered bollards, tree planting and seating to imply the location of pedestrian zones. Vehicle flow data was not available. In the five years prior to conversion there were 8 damage only crashes and no injury crashes; in the three years afterwards there were 8 damage only crashes and a serious injury crash (Quimby & Castle, 2007). Quimby and Castle also note a spike in the rate of (damage only) crashes during conversion, with 6 recorded during the year of the change. In contrast to these figures, Hamilton-Baillie (2008a) states that ‘in its nine years of operation, speeds and serious accidents have reduced, traffic flows remain unaffected despite significant increases in numbers of vehicles’ however he does not provide a source for this information. While specific crash numbers are not reported, Quimby and Castle (2007) note that the scheme was extended along a shopping street, where casualties fell by 10% in the three years after the scheme was implemented.

In Donkerbroeke, different coloured and textured road surfaces were used to highlight a junction in 1998. Provisional data indicate a slight rise in damage-only crashes (Quimby & Castle, 2007). In 1997 in market town Wolvega, traffic signals were removed from the intersection between the main shopping street and a former national road; the road surface is coloured differently, but there are no kerbs to mark pedestrian zones. Provisional data here indicate a slight drop in damage only crashes, with 1 injury crash in both the four years before and the four years after conversion (Quimby & Castle, 2007).

Hamilton-Baillie (2008a) describes the village of Makkinga as having removed all standard road signs and signals in 1992, and states that ‘The lack of priority signs and markings at junctions seemed to make no difference to the safe movement of traffic, cyclists and pedestrians.’ No references are given. However, Quimby and Castle (2007) report crash data from two Makkinga intersections redesigned in 1997 (apparently as part of the ongoing project). These residential intersections have kerbs, with different coloured/textured surfaces suggesting cycle lanes and a ‘roundabout’ covering most of the intersection. Importantly, the redesign reduced the speed limit from 50 km/h to 30 km/h, as well as removing road signs (although other sources suggest that road signs were removed earlier). In the four years prior to the change there were no injury crashes and 2 damage only crashes, while there were 2 injury crashes and 3 damage only crashes in the four years afterwards. No data are reported for 1992 or earlier.

Several schemes that covered entire small villages were also described (Quimby & Castle, 2007). The entrance to Opeinde village is marked with a large steel arch over the road; within, road width is reduced from 9 to 6m, the road surface is paved with bricks rather than asphalt, kerbs and markings have been removed, and the footpath is differentiated only by a strip of differently coloured bricks. Vehicle flow data were not available, however in the five years before conversion there were 32 collisions including one fatality. In the three years after conversion, there were 6 damage-only collisions and no injury crashes. A similar treatment (no kerbs, paved coloured road surface) was applied to the

village of Olderberkoop. Collision rates there dropped slightly, and importantly there were no further injury crashes in the two years of after data (Quimby & Castle, 2007).

In Denmark, the town of Christianfeld introduced shared space in the central intersection. All conventional traffic engineering was removed, and surface treatments used instead; there is no official prioritisation of road users, requiring individuals to negotiate who will take right of way. Quimby and Castle (2007) state that before conversion this intersection experienced on average 3 crashes per year in which someone was killed or received a serious injury; no such collisions have been recorded in the three years since conversion (year of reconstruction is not reported). Traffic speeds, tailbacks and delays during peak periods at the intersection have also apparently reduced.

In Sweden, the town of Norrköping redesigned a central five-way intersection. Skvallertorget is a square with a university campus on one side, used by 13,500 vehicles, 'many cyclists' and up to 1700 pedestrians per day (Shared Space Project Management Team, 2007). In 2000, zebra crossings and some traffic signs were removed, the paving was changed from asphalt to pedestrian-area style coloured bricks, and benches and a fountain were added to encourage pedestrian usage of the square. Mean traffic speeds are now 16 to 21 km/hr, and 70% of pedestrians surveyed after the change said that they can now cross the square without stopping (Shared Space Project Management Team, 2007). The newsletter from the Shared Space Project (2007) also reported that since the redevelopment there have been no collisions in the square, although previous crash history was not reported.

In Germany, the town of Hennef redesigned the main street in 1989. Vehicle flow on this national road was approximately 12,000 VPD. The road was narrowed from four to two lanes, the footpath widened, and a granite strip with concrete posts for light poles laid down the centre of the road to provide a pedestrian refuge. According to Quimby and Castle (2007), traffic speeds reduced, however it was not possible to obtain collision figures.

Also in Germany, the town of Bohmte experienced 12,600 VPD travelling the main street Bremer Strasse, despite having a population of only 13,500 people. A highway bypass and the EU Shared Space project provided the opportunity to redesign the street: segregation between vehicle and pedestrian areas was removed, and a roundabout constructed at the main intersection. Unfortunately the EU Shared Space project final report does not provide concrete results in terms of speeds, traffic flow or crash statistics. Gillies (2009) cites a German evaluation report (Bode, Deutler, Wessling, Fennhoff, & Grottendieck, 2009) as stating that one year after completion (in 2008), traffic volume has fallen slightly to 700-800 vehicles per hour, with truck traffic decreasing significantly; damage only crashes have increased somewhat, while injury crashes have dropped compared to the district as a whole. There was a spike in collisions during the construction phase. The report also notes that while most users regarded the project a success, they felt less safe in the space. Both pedestrians and cyclists tended to stay behind the tactile guidance lines differentiating the footpath from the carriageway; this has safety implications for both cyclists (potential to slip on the tactile strips) and pedestrians (potential to be involved in collisions with faster cyclists).

The EU Shared Space programme included pilot projects in Friesland (Netherlands - a rural road), Emmen (Netherlands - a residential area), Haren (Netherlands - a road near a primary school and a village centre), Ejby (Denmark - a village centre and road/rail crossing), Bohmte (see above), Oostende (Belgium - a residential area) and Suffolk (UK -

a mixed use development). The final report (Shared Space Institute, 2009) does not provide any traffic safety comparisons, but instead describes the process used to design the new spaces as critical to their acceptance and success.

Ashford Ring Road in Kent County, UK, was redesigned as shared space in 2007-8. The project involved the break-up of the four-lane, one-way ring road into several two-way streets. Pedestrian guard railings, signs and traffic lights were removed, the carriageway narrowed and the speed limit dropped to 20 mph (32 km/h). Gillies (2009) observes that pedestrian crossings remain, and that average recorded speeds are about 25mph (40 km/h). He cites a 2009 report on the Kent County website as stating that the accident rate has dropped 44%; this report is no longer available. The website does quote a councillor as saying in 2010 that “Since its launch, the area has been accident-free’ (Kent County Council, 2010). However, this statement contradicts police crash statistics obtained by a local newspaper, stating that there were three crashes in 2009 and three in 2010 (Scott, 2011). Unfortunately there does not seem to have been any official evaluation of the effects on crashes or accessibility. Despite this lack, the scheme has won several planning awards. Examination of pictures in the official report on the project (Pillory Barn Creative for Kent City Council, 2009) and using Google Street View shows many areas have a large distinction between the road area and the surrounding land use, with a corresponding lack of pedestrian usage. This may be an example of the need for pedestrian attractors to ensure that a redesigned area is well-used and that the full speed-reducing benefits of high pedestrian presence are realised.

Also in the UK, Reid et al (2009) cite reports by Wheeler on traffic calming projects in Historic Core Zones of three villages. While not designed as Shared Spaces per se, the projects shared similar aims to reduce the dominance of vehicles and modern traffic engineering paraphernalia, and restore the sense of place; thus similar design criteria were used (such as removing traffic signs and replacing asphalt with old-style paving). Casualty data for five years before and after the projects were completed suggests little effect on crashes.

The above available crash data, sources and implementation type are summarised in Tables 2 and 3. As the most important information from a Safe System framework is not the number of crashes, but the number and severity of injuries, Figure 2 shows casualty crash data (where this is available). The before and after periods are not consistent across different sites, so Figure 2 should be read in conjunction with Table 3, noting that in some cases only one year of post-completion data are available and thus the results may not be reliable.

Table 2. Details of previous Shared Space implementations

Location	Type	Vehicle flow	Source
UK, Halifax Historic Core Zone	village centre	NA	Reid et al 09
UK, Bury St Edmunds HCZ Hatter st	village centre	NA	Reid et al 09
UK, Bury St Edmunds HCZ Crown st	village centre	NA	Reid et al 09
UK, Shrewsbury HCZ	village centre	NA	Reid et al 09
NL, Wolvega	intersection	"busy"	Quimby & Castle 07

NL, Makkinga	whole village/ residential intersections	NA	Quimby & Castle 07
NL, Oosterwolde: de Brink/Rode Plein	intersection	NA	Quimby & Castle 07
NL, Donkerbroek	intersection	NA	Quimby & Castle 07
NL, Opeinde	whole village	NA	Quimby & Castle 07
NL, Olderberkoop	whole village	NA	Quimby & Castle 07
NL, Drachten: Torenstraat/Kaden 1	intersection	17,000 vpd	Quimby & Castle 07
NL, Drachten: Drift/Torenstaat/Kaden 2	intersection	15,000 vpd	Gerlach et al 08
SE, Norrkoping: Svallertorget	intersection	13,500 vpd	Shared Space news 07
NL, Drachten: Kaden/Dwassva	intersection	17,000 vpd	Quimby & Castle 07
NL, Drachten: Torenstraat/Vogelzang	residential intersection	"lightly trafficked"	Quimby & Castle 07
NL, Drachten: Laweiplein	intersection	18,000 vpd	Gerlach et al 08
NL, Haren: Rijksweg	shopping st & intersection	8,000 vpd	Gerlach et al 08
DE, Bohmte	main street	12,600 vpd	Bode et al 09
DK, Christianfeld	intersection	NA	Hamilton-Baillie 05, Quimby & Castle 07

Table 3. Crash data from previous Shared Space implementations. * indicates year of conversion to shared space. M = minor injury, S = serious injury, F= fatality.

Location	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Halifax HCZ	5 yrs prior: 7M, 1 ped			*	8M (5 ped incl 1F, 1S)					?	?	?	?	?
B St E HCZ Hatter st	5 yrs prior: 4M			*	3M (1 ped)						?	?	?	?
B St E HCZ Crown st	5 yrs prior: 4M				*	2M (1 ped, 1 cyclist S)						?	?	?
Shrewsbury HCZ	5 yrs prior: 13M, 9 pedestrian				*	14M (9 pedestrian)						?	?	?
Wolvega	5 (1M) =1.2/yr				0*	0	3 (1M) =1/yr			?	?	?	?	?
Makkinga	2 =0.5/yr				3*	5(2M) =1.2/yr					?	?	?	?
de Brink/ Rode Plein	8 =1.6/yr					6*	9 (1S) =3/yr			?	?	?	?	?
Donkerbroek	12(1M) =2.4/yr					6*	9 =3/yr			?	?	?	?	?
Opeinde	24 (1F,7M) =6/yr				8	?	2	?	?	?	?	?	?	?
Olderberkoop	17 (3M) =2.8/yr					?	?	5 =2.5/yr		?	?	?	?	?
Torenstraat/ Kaden 1	30 (4M) =5/yr					?	?	4 =2/yr		?	?	?	?	?
Drift/Torenstaat/ Kaden 2	?	1	8	2	9(1M)	3*(1M)	4*	0	4	8(2M)	4(1M)	8(2M)	5(1M)	4(2M)
Svallertorget	?	?	?	?	?	?	0	0	0	0	0	?	?	?
Kaden/Dwassva	20 (3M) =2.9/yr							?	7(1M)					
Torenstraat/ Vogelzang	10 (3M) =1.4/yr							?	3					
Laweiplein	?	?	10(1S,3M)	9	13(1S,3M)	9	4*	10*(2M)	3*	1	1	2	?	?
Rikjksstraatweg	?	?	13(1S,2M)	16(4M)	16	9(1M)	19(1S,1M)	7	11*	4	6	7	?	?
Location	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bohmte	?	?	?	?	?	?	?	?	5(2M)	7(1M)	11(2M)	8(1M)	13*(2M)	12 (to end Aug)
Christianfeld	Year of conversion not reported. Average of 3 fatalities/serious injuries per year before conversion; 0 after.													

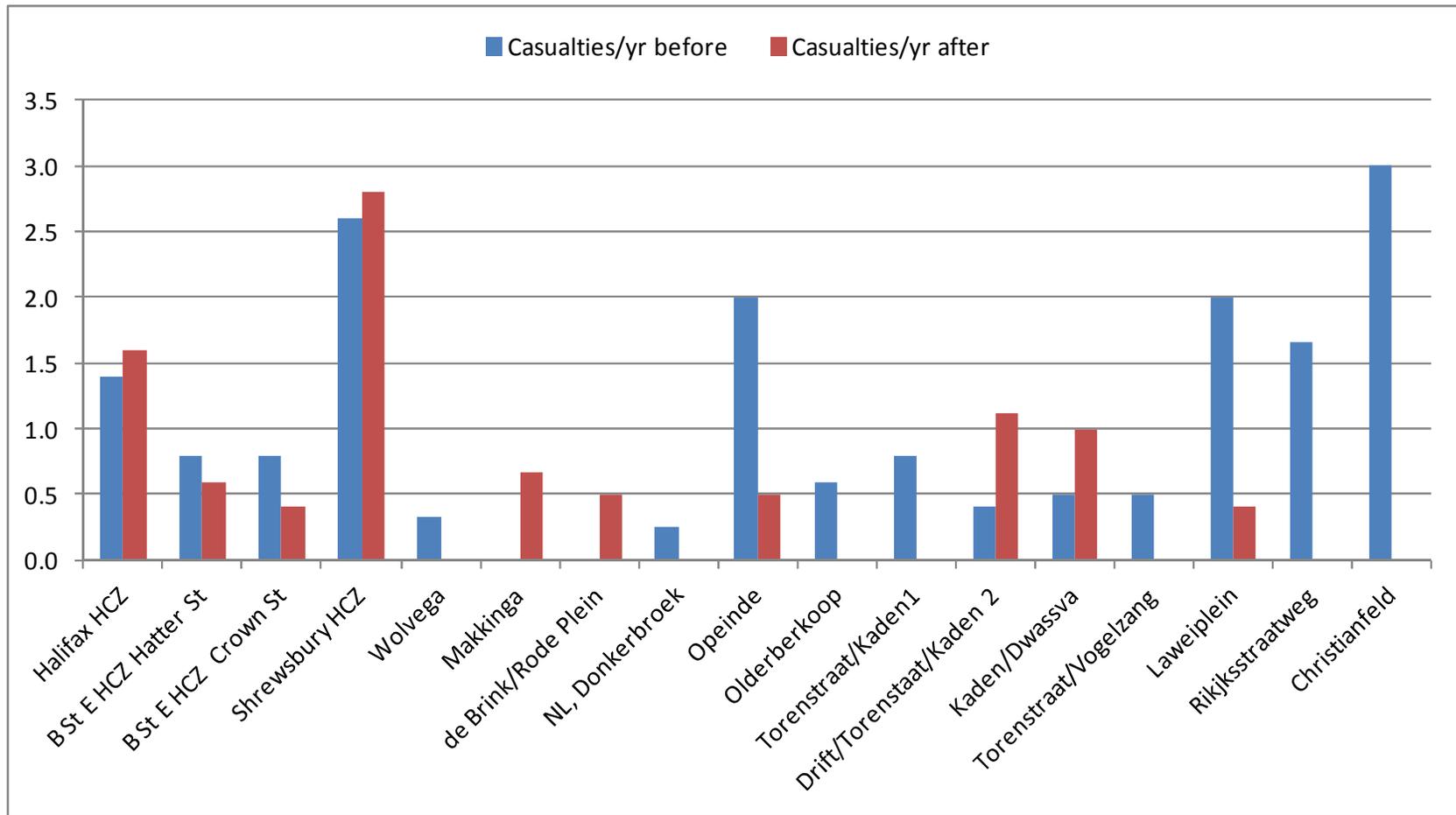


Figure 2. Casualties per year for all Shared Spaces with at least 1 year of data available before and after reconstruction. Includes minor and serious injuries plus fatalities, but not property damage only crashes. Note before-after periods vary; for dates see table 3. Note Wolvega, Olderkoop, Torenstraat/Vogelzang, Rijkstraatweg and Christianfeld have no reported casualties after reconstruction (using currently available data), while Makkinga and de Brink/Rode Plein had no reported casualties before.

2.2 Schemes similar to Shared Space

There are also roads that, while not true ‘shared space’, apply many of the same principles. Kensington High St, London underwent a simplification scheme in 2000. Pedestrian guard railings and many signs were removed, extra pedestrian crossings were provided and existing staggered crossings were straightened, traffic signal timings were changed, road markings were simplified, the footpath was widened and carriageway narrowed, and trees and cycle parking were introduced. Quimby and Castle (2007) report that over the length of the scheme, pedestrian flows increased by 7%, although this varied at different locations. Cycle flows also increased, with the morning peak flow eastbound rising 30%. Traffic flows decreased (however this may be related to the concurrent introduction of the London Congestion Charge). Provisional crash statistics for three years before and two years after were compared with the borough average for the same time periods to provide a control of other influences (such as the congestion charge). Average annual overall crashes fell 48.6% (borough average 37.2%), while average annual pedestrian crashes fell 68.4% (borough average 45.2%). Unfortunately the same success was not realised in average annual bicycle crashes, which fell only 29.1% (borough average 35.2%); this may be related to increased cycle flows. A later source including the full three years of after data states the fall in pedestrian crashes was 43%, compared to an average fall across London of 17% (Shared Space Project Management Team, 2007). It should be noted that this scheme cannot really be described as ‘shared space’ as the space is still segregated into areas for different road users and movement is still controlled by signs and signals; however with a traffic flow of over 40,000 vehicles per day (Hamilton-Baillie, 2008) it is difficult to imagine how this space could ever be totally uncontrolled and shared.

Similarly, the UK Mixed Priority Routes scheme aimed to reallocate road space and improve the streetscape quality while reducing casualties; these streets are not true ‘Shared Spaces’, but share similar ideals. While vehicle flow data were not available, each of the pilot sites had high levels of traffic, a mix of road users, a mix of residential and commercial frontages, and requirements for parking and deliveries; thus pedestrianisation was not considered desirable. The design of each of the ten pilot schemes was responsive to the local environment, rather than a standardised design. Key approaches across projects including provision of informal pedestrian crossings on desire lines; reduction of vehicle speeds via narrowed roads, vertical and horizontal deflection; and improving parking and loading arrangements (Department for Transport (UK), 2008). Construction periods varied, however all implementations were completed during the period 2002-2007 and most took around three years. When casualty crash data were compared for the three years before and after implementation of each scheme, reductions ranged from zero to 63%, compared to an expected reduction of around 17% based on the trend for all urban UK roads (Department for Transport (UK), 2011). None of the sites showed an increase in crashes after the redesign. Casualty crash data for these projects are given in Figure 3. The final report noted that similar reductions were achieved at lower cost in other schemes, however these did not have the additional aim of improving streetscape quality (which proved difficult to evaluate).

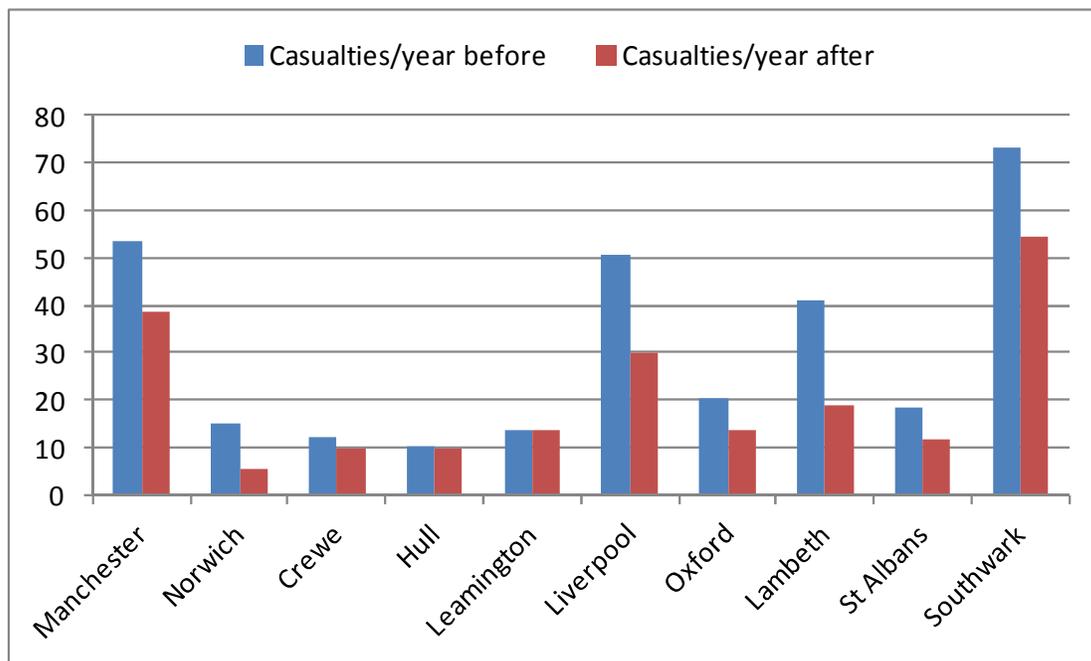


Figure 3. Casualty crash data for UK Mixed Priority Routes pilot project (Department for Transport (UK), 2011). All were main streets with road user segregation and control via signs and signals maintained, but other aspects of the Shared Space design concept implemented.

There are also intersections where signal control has been removed without any redesign of the space. Firth (2011) provides details of three short trials in the UK where signals were switched off at intersections with demand ranging from 2000 vehicles and 200 pedestrians per hour, to 600 vehicles and 3000 pedestrians per hour. Vehicle delays and queues reduced markedly at all three sites. Pedestrian crossing times also shortened somewhat, however user surveys at two of the sites showed that many pedestrians felt unsafe without signal control and would prefer the signals switched back on (45% at the site with fewer pedestrians, 75% at the site with more pedestrians).

2.3 The effect of Shared Spaces on crashes

The available crash data is summarised in Table 3 and Figures 2 and 3. It can be seen that while some Shared Spaces appear to have lower crash rates per year than prior to the redesign, others appear to have higher rates. Particularly concerning is the appearance of serious injury crashes where none were previously recorded, e.g. in the Halifax Historic Core Zone (UK) and the de Brink/Rode Plein intersection in Oosterwolde (NL). It is also notable that the crash rates per year (and particularly casualty crash rates) for many locations were already low before being turned into Shared Spaces, which makes it difficult to assess the significance of any changes and extrapolate to locations with higher existing crash rates.

Shared Space as a road safety intervention was included in the 2010 Norwegian edition of the Handbook of Road Safety measures. A meta-analysis of the effect of Shared Space redesigns on accidents for 24 sites from 10 studies (some of which are included above) found an overall effect of a 17% reduction in crashes (Sørensen, 2010, 2011). However this effect was not statistically reliable, with uncertainty ranging from a 40% reduction to a 14% increase. Sørensen notes several problems with the available data: the use of simple before-after studies without control sites, short data collection periods (particularly for after data), and the inclusion of sites (such as Kensington High Street) that are not 'true'

shared spaces. According to Sørensen's review, only six of the 24 sites included in the analysis can be characterised as 'real' shared spaces, and there were such large differences in the results for these six sites that it was not possible to calculate a combined crash effect for them.

Unfortunately, the crash evaluations available (apart from Kensington High St and the Mixed Priority Route pilots, which are not true shared space) do not include control sites to assess the contribution of wider trends (including overall crash rates in the region, trends in traffic volume, accident migration, regression to the mean, etc). There is also little data on the number of pedestrians and cyclists (and in some cases, vehicles) using the sites before and after redesign; changes in exposure of these road users could account for changes in crash rates per year. It should also be noted that collision numbers for road locations typically only include crashes involving a motor vehicle. Thus if shared spaces resulted in an increase in collisions between pedestrians and cyclists, the above collision records would not necessarily note this. Likewise, injury data is not available for injuries from non-vehicle incidents such as pedestrians and cyclists slipping on tactile guidance strips (which replace kerbs in many Shared Space implementations), falling after stopping suddenly to avoid another road user, or colliding with unexpectedly placed street furniture. Hospital admissions data are more likely to give a true picture of safety for pedestrians and cyclists, however this information may not be available in all jurisdictions, and was not included in any of the evaluations obtained for the present report.

2.4 The effect of Shared Spaces on other measures

Although there is less information available on other measures such as changes in vehicle and pedestrian flow, vehicle speeds, and delays to all road user types, the evaluations above tend to show that removal of signals in particular leads to reduced vehicle speeds as well as reduced delays to most users (as the stop-start pattern induced by signals is changed to a pattern of consistent slow movement). However, these objective benefits are not always apparent in subjective opinions of safety.

The Laweiplein evaluation (Noordelijke Hogeschool Leeuwarden, 2007) included surveys of public opinion via a local newspaper; 135 people responded in 2000 (before the redesign) and 186 responded in 2005 (afterwards). While ratings of traffic congestion improved markedly, ratings of traffic safety decreased, particularly among respondents aged over 60 years (26% of respondents in 2000, 38% in 2005), cyclists (50% of respondents in 2000, 56% in 2005) and drivers (34% of respondents in 2000, 31% in 2005). Pedestrians made up only 13% of respondents in 2000, 10% in 2005, and their ratings of traffic safety were not markedly different. A similar pattern of cyclists feeling particularly unsafe in shared space was evident in the Bohmte evaluation (according to translation by Gillies, 2009). Interestingly, perceptions of 'social safety'/personal security while using the area were higher in 2005, indicating improved spatial quality.

Reid and colleagues (2009) examined a number of measures in their appraisal of Shared Spaces across the Netherlands and UK. In summary, users of Shared Spaces feel that the amenity and spatial quality of the spaces is improved. This seems to be reflected in increasing economic activity (reflected by reduced shop vacancy rates) and property values. However, feelings of safety and ease of use vary widely, even within groups where it might be expected that most members would share similar opinions; for example, one study of visually impaired pedestrians using Home Zones (residential shared spaces that often include features such as level surfaces) found that responses were polarised between

those who found the spaces very easy to navigate safely with their guide dogs, and those who found the spaces very difficult to navigate due to the lack of cues to orient the dogs.

The effect of Shared Spaces on usage by different road user groups is difficult to quantify, as there are many other factors that can influence these variables. Changes in usage seem to be highly site-dependent. Vehicle flows may either decrease (possibly due to the requirement to move slowly and carefully through Shared Space) or increase (possibly due to reduced delays, or wider trends). It is encouraging that reductions in injury crashes have been achieved despite increased vehicle flows at some sites.

Pedestrian and cyclist flows are more difficult to measure as these road users are not restricted to a single path past a counter. Reid et al. (2009) note that pedestrian flows measured at fixed count points before and after the implementation of Mixed Priority Route and Historic Core Zone projects did not show a consistent pattern; at some sites, pedestrian counts at formal crossings increased, while at some sites they decreased. This may reflect either changes in the pedestrian usage of the whole area, or changes in where pedestrians choose to cross (at more formal crossing points, or distributed along the road length). Where evaluations of pedestrian footfall along the street (rather than across it) had been conducted, these generally showed increases, although changes in land use may account for some of this effect. Qualitative changes in pedestrian activity also appear, with Shared Spaces seeming to encourage more 'sojourning' (staying and using the space) rather than movement functions.

Interactions between different road users in shared spaces have been insufficiently studied. Reid and colleagues (2009) cite two studies, one in Sweden and one in the UK, showing that drivers' propensity to give way to pedestrians and cyclists (and vice versa) depends on the vehicle flow and speed. While interactions between different road user groups are likely to depend on the existing road culture to a large extent, this demonstrates the importance of ensuring low vehicle speeds for successful realisation of a Shared Space design.

3 EFFECT OF ROAD CULTURE ON SHARED SPACE SAFETY

Quimby and Castle (2007) summarise an unpublished TRL report on road sharing in and around pedestrianised areas with buses in the UK. The more vehicles using the road space, the fewer pedestrians walked in the centre of the space. When vehicle flows exceeded a certain level, pedestrians only used the edges of the space. This level was dependent on speed; when the 85th percentile speed was 30 mph (48 km/h), 50 vehicles per hour was enough to discourage pedestrians. When the 85th percentile speed was 20 mph (32 km/h), pedestrians ceased using the centre if there were more than 200 vehicles per hour. When pedestrians only used the edges of the space, there were fewer potential conflicts between vehicles and pedestrians. However, collision numbers were higher, indicating that conflicts were more likely to result in actual danger for pedestrians.

Similarly, Methorst and colleagues (2007) note that shared spaces may be less effective when there are large amounts of through traffic compared to local traffic; drivers must feel some tie to the area. Drivers who work, shop or reside in a particular street are more likely to feel part of a community with reciprocal ties to others, and thus more likely to interact respectfully with other road users. Drivers who are merely trying to negotiate their way through a street on their way to somewhere else are more likely to see other road users as obstacles, and to force their own right-of-way rather than giving way to crossing pedestrians.

In Australia, the only places on the road network where vehicles do not have legal priority over pedestrians is in signposted 'shared zones' (Standards Australia, 2008). These must be marked with a speed limit of 10 km/h and have design criteria (width, vertical and/or horizontal deflections in the vehicle path) that reinforce this speed limit, as well as high pedestrian usage. Gillies (2009) visited several of these sites around two major cities and found that the appearance of the sites had a large effect on their usage: shared zones that looked like typical streets (long, bitumen surface etc) were treated by both drivers and pedestrians as streets, with pedestrians giving way to vehicles despite the signage.

However in shared zones that looked like pedestrian areas (narrow lanes or wide squares, paving or stone surface, level kerbs, café seating or street furniture very close to or in middle of vehicle area) Gillies (2009) observed most vehicle drivers gave way to pedestrians, although there were exceptions. This suggests that the Shared Space design concept does change behaviour in the Australian context, however more work would be required to ensure that all drivers drive carefully in such spaces rather than aggressively seizing priority from other road users.

Lamíquiz Daudén and colleagues (2008) examined six Shared Space schemes in the Netherlands, and concluded that the presence of cyclists was an important mediator between vehicles and pedestrians. They suggested that successful implementation of Shared Space in Spain would require either a culture of respect between drivers and pedestrians, or an official priority rule.

The Netherlands has several important details of the sociocultural environment surrounding road use that would be expected to influence behaviour in shared spaces. Firstly, drivers are assumed to be at least partially liable in any collision with pedestrians or cyclists (Gillies, 2009). Secondly, active transport modes (walking and cycling) make up approximately half of all trips, compared to only one third of trips in the UK (Hamilton-Baillie, 2008a). This latter fact is important not only in that vehicle drivers are more used

to seeing and interacting with pedestrians and cyclists on roads, but also in that drivers are more likely to themselves spend time as a pedestrian or cyclist.

Drivers who expect all road users to behave like vehicles may be surprised when other road users perform unexpected (yet legal) manoeuvres (e.g. a motorcycle ‘filtering’ between two lanes of stationary traffic at lights; a bicyclist emerging from a cycle path onto a road; a pedestrian crossing at an intersection at the same time as vehicles are turning). This can lead to delayed responses or even a failure to notice the other road user at all, commonly referred to as a ‘looked but failed to see’ crash. It has been found that drivers who have large amounts of experience in motorcycle riding are more likely to understand the likely behaviour of motorcyclists, and therefore more able to perceive motorcyclists and anticipate potential conflicts (Crundall, Bibby, Clarke, Ward, & Bartle, 2007). It would be expected that this also holds for bicycles and pedestrians.

Drivers will also be better able to anticipate other road users’ behaviour when they have more regular experience of interacting with either road users, i.e. when the mode mix is not dominated entirely by standard passenger vehicles. This has been assumed to be the basis of the ‘Safety in Numbers’ effect, in which a higher numbers of pedestrians or cyclists is correlated with a lower risk of crashes for each pedestrian or cyclist (Jacobsen, 2003). The original paper on this effect concluded that simply encouraging more walking and cycling will thus lower crash risk, without other changes having to be made. However, it should be noted that there are alternative explanations for the correlation – for example, it is possible that more people walk and cycle in areas where there are safe walking and cycling facilities. It has also been noted that it is not just to place the entire burden of the safety of vulnerable road users on those same vulnerable road users, by asking them to expose themselves to the dangers of unmodified traffic flows in order to modify the traffic (Bhatia & Wier, 2011). Even the original proponent of the Safety in Numbers concept, Jacobsen, has recently argued that (potential) pedestrians and cyclists respond to the perceived risk of traffic by reducing levels of walking and cycling, and thus physical interventions should be used to reduce traffic speed and volume (Jacobsen, Racioppi, & Rutter, 2009).

This argument is crucial to the design of Shared Spaces. If all road users are thrown together in a space with an existing culture of vehicle dominance, high traffic speeds and volumes, and low levels of walking and cycling, it is likely that vehicle speeds and volumes will remain high and walking and cycling will remain low. In other words, the space will not truly be shared. It is therefore critical that engineering, education and enforcement are used together to encourage low vehicle speeds, transfer of trips to non-vehicle modes where possible, and respectful interactions between vehicles and vulnerable road users. Examples of such design features include horizontal and vertical deflections to the vehicle path at the start of a shared space, high-visibility ‘gateway’ features to suggest entry into a non-standard road space, strict enforcement of no-parking rules (particularly when the space is newly redesigned), and public consultation and education campaigns to educate all users of a space about how Shared Space should work and the new norms of behaviour required.

4 USABILITY OF SHARED SPACES

4.1 Concerns for vulnerable road users

Many concerns have been raised about the safety of shared spaces for vulnerable pedestrians. In particular, blind and visually impaired pedestrians are not able to make eye contact with other road users, and if space negotiation in shared spaces is truly on this basis then these users are at an obvious disadvantage. Blind and visually impaired pedestrians use the kerb to navigate and determine where the 'safe' footpath is and where they are stepping into the space where vehicles may be present. Removal of kerbs (in level surface or 'shared surface' implementations of shared space) removes an important guidance tool and leaves these pedestrians unable to determine when they are in potential danger (Childs, Thomas, Sharp, & Tyler, 2010), as well as unable to respond to visual signals from other road users who may not realise they cannot be seen.

Deaf and hearing impaired pedestrians may be similarly disadvantaged in shared spaces as they are not able to hear cars coming up behind or beside them (B. Lamb of the Royal National Institute for Deaf People, quoted in Thomas et al., 2006). Hearing impairments may be less visible than vision impairments, as hearing impaired pedestrians do not have obvious aids such as canes or guide dogs, so other road users are less likely to be aware of and compensate for these pedestrians' inability to hear.

In addition, concerns have been raised about the impact of undifferentiated level surfaces on young children's crossing behaviour. This relies on rules up until the age of around ten years (Lupton & Bayley, 2006). Young children do not have the experience to accurately interpret the actions and intentions of other road users, and their ability to judge speed and distance is low. Research asking young children about road crossing facilities reveals that they feel more comfortable crossing at signals (where drivers must give way) than in situations where it is ambiguous as to when they can cross (Lupton & Bayley, 2006).

The safety of child pedestrians is a major issue not only in terms of society's moral responsibility to protect the young, but simply in numerical terms. An in-depth study of crashes involving pedestrians in two areas of the UK (Cuerden & Richards, 2007) found that by far the highest percentage of crashes involved children (~24% were teens and ~22% were under 12, compared to about ~10% or fewer in each 10-year age cohort older than 19). Pedestrians aged under 16 were overrepresented in crashes involving a pedestrian running out onto a road without looking for vehicles, and crashes in which either the pedestrian or driver's vision was obstructed (e.g. by a bus, parked cars, or other traffic). This suggests that children are more likely to be injured in spaces without a clear signal for them to stop and look for vehicles, and/or in spaces where there is not a safe place from which they have a clear view of other road users and other road users have a clear view of them.

Shared spaces may also be especially difficult to navigate for elderly pedestrians and drivers. Older road users have slower reaction times, and find it harder to process cognitively complex situations; for older drivers, this leads to particular difficulties at intersections and when judging who has right of way (Simoes, 2002). Older road users also have difficulty incorporating the speed of oncoming traffic into gap acceptance judgements, which can lead to older pedestrians trying to cross roads when they do not have sufficient time (Dommes, Langevin, Cavallo, Oxley, & Vienne, 2011). Ageing also increases physical frailty, so that elderly people are more likely to be injured by a fall or minor collision.

Parked cars are typically banned in shared spaces, as they reduce visibility and may obstruct pedestrian desire lines. This introduces a problem for those with limited mobility. For people who do not use a wheelchair or mobility scooter but can only walk for short distances, removing parking spaces from a large section of road may make it simply impossible to reach shops and other locations within the no-parking zone. However shared spaces offer a benefit over full pedestrianisation, in that cars may pass through the space on route to off-street parking located near the middle of the shared space. The introduction of level surfaces (without kerbs) in Shared Space schemes has been assumed to be of benefit to mobility-impaired pedestrians and wheelchair/motorised scooter users. However, whether on wheels or on foot, the reduced agility of these pedestrians may make them feel unsafe sharing a space with vehicles. Additionally, the removal of kerbs in level surface implementations poses a problem in terms of access to buses, trams/streetcars and taxis for mobility-impaired pedestrians. Without a higher surface to enter from, access to these transport options requires modified vehicles.

The removal of a clear ‘movement corridor’ through a shared space may make cyclists more likely to ride on the edge of the space, near pedestrians (see Figure 1), as they do not feel safe sharing the centre of the space with vehicles (as found by the evaluation study for the Bohmte redesign; Gillies, 2009). This decreases safety for pedestrians, as there may be up to an order of magnitude difference in speeds between cyclists and pedestrians (Vandebona & Kiyota, 2001). CTC (the UK cyclist organisation) has conducted research showing that while shared use paths are considered better than no facilities, both cyclists and pedestrians feel unsafe in such areas and would like to see more guidance and demarcation (CTC (UK), undated). Haworth and Schramm (2011) surveyed 2532 cyclists and found that collisions with vehicles on roads were a much larger problem for cyclists than collisions with pedestrians on footpaths and shared paths, so cyclists who choose to share space with pedestrians rather than vehicles are behaving quite rationally. They note that collisions with pedestrians were twice as common on shared paths as on footpaths, and suggest that when cyclists are riding on paths that are clearly for pedestrians (although cyclists are legally allowed to ride on footpaths in the jurisdiction where the study was conducted) they may be more careful. It is unclear how cyclists would behave in a shared space where the ‘ownership’ of edge areas free of cars is not clear. Haworth and Schramm (2011) also noted the scarcity of research on pedestrian injuries due to crashes with cyclists; as the lower speed road user, the pedestrian is likely to have worse injuries than the cyclist in such a collision.

4.2 Making Shared Spaces more useable

A German town planner with experience in shared space designs suggests that it is not necessary, or indeed desirable, for the entire space between frontages to be shared (Heinz, 2010). He suggests instead that ‘Safe space’ for pedestrians should be reserved along the sides of the space, in the ratio 30:40:30. This can be achieved with the use of trees and street furniture to prevent vehicles from entering the side areas, while maintaining freedom of movement for pedestrians. Many shared spaces already incorporate this design aspect (and some additionally include a separate area between the safe pedestrian area and the central vehicle area for cyclists; this avoids the problems described above with pedestrian-cyclist crashes, but removes some of the desegregated philosophy of the original Shared Space concept).

Heinz (2010) notes that for it to be clear to all that the area has a social, ‘staying’ function rather than a movement corridor function, the edges of the space and patterns on the paving surface should not be in the direction of vehicle travel. Parked cars should be excluded as

they block visibility and make the space look like a standard street. Lighting design is also important to reinforce the ‘social not movement’ feel. These elements are particularly important at times of low pedestrian usage (e.g. at night) when otherwise vehicles would be the predominant road user and would ‘take over’ the space.

It is vitally important that these ‘safe spaces’ are marked with delineators detectable by blind and vision impaired pedestrians. Childs et al. (2010) conducted tests of several potential delineators with 106 vision impaired participants (including those using canes, dogs, or neither) and 77 mobility impaired participants (including those using wheelchairs, one or two crutches, walkers, pulling or pushing 10 kg on wheels, or wearing high heels). While they found no surfaces which all the vision impaired participants found easy to detect and all the mobility impaired participants found easy to cross, the most promising candidate was an 80cm wide strip of blister paving.

Blister paving in an 80cm strip was detected by 99% of vision impaired participants, and 96% were fairly sure that this was a deliberate surface change (not just an irregular surface) and would stop if they encountered it in the street. All of the mobility impaired participants successfully crossed the strip, and 96% rated it as fairly easy to cross. It is important to note that a 40cm wide strip of blister paving was not detected by 19% of the vision impaired participants, so the full width is critical. Corduroy warning paving with ridges aligned parallel to the ‘kerb’ also performed well when approached at a 90 degree angle, however vision impaired pedestrians had trouble detecting this paving when they approached at an angle or when it was laid perpendicular to the ‘kerb’. Childs et al. (2010) suggest that this paving would not be suitable for streets with curved edges, or where pedestrians might step sideways on to the delineator (which might happen more often in a Shared Space environment when pedestrians must move around street furniture and other road users).

Disabled Motoring UK (2011) notes that the replacement of dropped kerbs with street furniture may actually cause obstructions for mobility-impaired pedestrians using wheelchairs and scooters. Additionally, the lack of a raised kerb makes getting in and out of vehicles such as buses more difficult for these users. If level surfaces are used, it is essential that there is a sufficient width of unobstructed safe edge space for pedestrians in mobility scooters and wheelchairs to move along the street, and provision must be made for access to transport. Their preferred option is for safe space to be reserved with a standard height kerb and dropped kerbs at regular intervals to assist in road crossing.

These safe spaces reserve areas free of vehicular traffic for non motorised users who do not need to use the centre of the space, but crossing the area where vehicles are moving may remain a problem for users who have difficulty in negotiating priority. In response to community demand, many ‘Shared’ spaces have incorporated or later added ‘courtesy crossings’ at points where pedestrians are most likely to cross. These usually consist of changes in the surface colour, possibly texture, and possibly height. The present review revealed no studies on whether such courtesy crossings have any effect on the safety of crossing pedestrians and cyclists. If drivers take extra care at these locations and yield more often to those crossing, this implies that they are taking less care and yielding less often in the rest of the space. The overall effect may therefore depend on the length of the Shared Space, as well as other variables.

Finally, if parked vehicles are to be banned from the Shared Space, it is important that there is nearby parking accessible from destinations in the Shared Space. This should include disabled spaces, and ideally loading spaces for local businesses that require goods

transport. Parking prohibitions and alternative parking locations should be widely publicised and well enforced, especially during the initial period, otherwise drivers may (unintentionally, or otherwise) park their cars in the edge space required for safe pedestrian movement.

As it is easy to overlook the requirements of small road user groups such as partially sighted people, it is essential that these groups be explicitly involved in the consultation and design phase. This may require more than the usual forms of public outreach; notices on-site or in local newspapers are not accessible to blind site users. When these users have been successfully contacted, it is important to listen to and address their concerns. Partially-sighted road users in the UK have reported that authorities involved in the redesign of one project were unwilling to add safety features requested by the users, which made them feel detached from the redesign process and unable to use the resulting space (Thomas et al., 2006).

Shared Space thus requires an entirely different approach from other road safety countermeasures, in which the road authority decides the appropriate countermeasure, or even other public architecture projects, in which there is little public consultation on the design of the new space. Reports from many different perspectives reinforce the necessity of extensive community involvement by all current and potential site users at each stage of the process.

5 ALTERNATIVES TO SHARED SPACES

Shared space is just one of a variety of options for urban centres needing to better balance mobility, safety, community desires and the needs of different road users. Starting from a traditional street with vehicle lanes in both directions, narrow footpaths between the road and commercial frontages or multiple demands on footpath space such as shop displays or café seating, the options below vary in terms of the weight they give to different uses of the space and the amount of engineering/redesign required.

One alternative to improve pedestrian safety without reallocating space is to reduce speed limits. This can be on a permanent basis, or timed (as with school zones). Victoria instituted a trial of 40 km/h speed limits during peak shopping hours on major shopping roads, using variable message signs to ensure drivers were aware of the applicable speed limit. An evaluation of the 18 pilot sites found a reduction in crashes of 8%, with a 17% reduction in pedestrian crashes (Scully, Newstead, & Corben, 2008). However there was a large amount of variability across sites, with some sites showing increased crash rates after the change; further research is required to examine why this occurred and what alternative countermeasures would better suit these sites. The Australian Capital Territory is currently conducting a similar trial across two centres of commercial activity, however no results were available at the time of writing.

It should be noted that reducing speed limits alone may not be sufficient to ensure either safety or perceptions of safety (and thus high pedestrian/cyclist usage). A study performed in Belgium, which has a high rate of cycling, found that parents were less likely to allow children under 12 to cycle on roads with a 30 km/h speed limit and no separate cycle lane than on roads with a 50 km/h speed limit and a separate cycle lane (Nevelsteen, Steenberghen, Van Rompaey, & Uyttersprot, 2012). Fewer crashes occurred on the roads with separate cycle lanes, suggesting that in this case the parents were accurately assessing the safety of the road environment. The safest road type, and the type where children were most often permitted to ride and walk, was where vehicle access was restricted. The authors concluded that infrastructure measures have a large effect on both child safety and the encouragement of walking and cycling.

If it is desirable to reallocate space away from vehicles and towards non-motorised transport, the cheapest option is simply to ban vehicles with signage. Vehicle bans may apply at all times (full pedestrianisation), at some times of day only (e.g. during shopping hours), or only certain types of vehicle may be banned (e.g. closing the street to private vehicles but allowing public transport, taxis, and loading vehicles with permits to use the street). Signage needs to be supported with large amounts of publicity to ensure that drivers are aware of the changed conditions, followed by enforcement to ensure that the new regulations are followed. Permanent full pedestrianisation may be better served by repaving the street to ensure a level surface for pedestrians that does not look like a vehicle thoroughfare. Pedestrianisation may improve shop patronage and property values. However, if the space is not well used at night there may be concerns about reduced security due to the lack of surveillance from passing motorists (Besley, 2010). As with shared spaces, it is possible that the traffic removed from the pedestrianised area may move into surrounding streets that may not be designed to cope with the increased traffic. It is therefore important that traffic modelling is undertaken to examine potential impacts on surrounding areas prior to pedestrianising a street.

An alternative that maintains the ability of vehicles to use the street at all times of day, while still allowing more freedom for pedestrians, is the use of alternating timed priorities,

suggested by Lamíquiz Daudén and colleagues as a solution for Madrid (2008). This would be similar to the operation of standard signalised pedestrian crossings, where pedestrians and vehicles alternate periods of moving and waiting, but would apply to a whole section of the street. Signals could be placed on bollards along a stretch of road; when these signals are activated (green), vehicles would stop and pedestrians would be able to cross the road at any point (see Figure 4). The concept is based on system currently in place at very wide pedestrian crossings in Bilbao. The authors suggest this alternative would be particularly useful in shopping streets with high pedestrian traffic (up to 2000 pedestrians per hour) and moderate vehicle traffic (up to 1000 vehicles per hour), where there are no more than two lanes of traffic (to ensure visibility of the signals) and where the pavement is wide enough (at least 1.5m) for pedestrians to wait for their turn.



Figure 4. Proposed pedestrian priority signals along a length of street. (Source: Lamíquiz Daudén et al., 2008; reproduced with permission)

More engineering-heavy options that maintain vehicle access (but do lower vehicle mobility) include reallocation of road space with segregation maintained (e.g. removing one lane of traffic to provide a wider footpath and/or a cycle path); and using traffic calming and/or perceptual countermeasures (e.g. gateways) to mark areas of a road where there are higher levels of pedestrian usage and slower speeds are appropriate. These may be more appropriate options in situations where the usage of the street and/or the prevailing road culture suggests that ‘true’ shared space would not be successful.

This was the alternative used in the UK’s Mixed Priority Routes project, discussed above in the section on schemes similar to Shared Space. These routes were ‘high streets’ outside CBD areas, which needed to serve the dual purpose of carrying large amounts of private traffic and public transport and allowing pedestrian access to shops. Across the various pilot projects, initiatives used included reducing carriageway width to reduced crossing lengths and/or widen footpaths, increasing the number of crossing points (not necessarily using formal, signalised pedestrian crossings), improved public transport infrastructure such as larger waiting areas, easy access kerbs and bus priority, adding cycle lanes,

improving parking and loading arrangements, and reducing vehicle speeds by narrowed carriageways, reduced visibility, vertical and horizontal deflection. In addition to the casualty crash reductions noted above, the pilot schemes were successful in improving accessibility for pedestrians, cyclists and vulnerable groups such as children and mobility impaired users; improved air quality and reduced noise pollution; reduced commercial vacancies and increased visitor numbers leading to improvements in the local economy (Department for Transport (UK), 2008).

Finally, the Australian Manual of uniform traffic control devices currently provides for one type of speed zone where pedestrians and cyclists have priority over motorised traffic: the 10 km/h shared zone. These are for use in 'confined areas where movement of pedestrians and cyclists has priority over motor vehicles' and must be signposted at the start and end (Standards Australia, 2008). In these zones, drivers must give way to pedestrians and cyclists (some states require a 'Give way to pedestrians' sign be installed as well as the '10[km/h] Shared Zone' sign). As shared zones are considered a speed zone rather than an engineering countermeasure, approval must be sought from the state road authority prior to use; speed limits higher than 10 km/h are not permitted to use the shared zone signage and pedestrian priority rules. State road authorities may specify design criteria that must be followed for a shared zone to be implemented. For example, the NSW RTA guidelines state that shared zones must be self-enforcing speed zones, while the VicRoads guidelines specify particular characteristics in terms of horizontal deflection, road width and kerb removal (Gillies, 2009).

It is interesting to note that there is no provision for pedestrian priority in speed zones higher than 10 km/hr. Car parks, recreational areas, local residential streets and commercial streets with high pedestrian activity and frequent road crossing, where pedestrians intermingle with motor vehicles are all subject to vehicle priority (Standards Australia, 2008), regardless of the level of vehicular traffic and the amount to which vehicular mobility would be impaired (or not) by providing pedestrian priority or equal priority.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of evidence regarding safety in Shared Spaces

The argument for Shared Spaces is that the obviously hazardous nature of the road environment should encourage drivers to slow down, thus both avoiding crashes and making them less severe. However there is not sufficient evidence that drivers adapt appropriately to the level of danger by slowing down and negotiating priority with other road users. Crash evaluations have shown mixed results, with some projects seeming to improve safety, some seeming to worsen safety, and most showing no difference due to low numbers of (casualty) crashes both before and after redesign. Most of the crash evaluations that have been done were not well controlled, and suffer from problems such as insufficient time periods, lack of comparison sites and lack of exposure data leading to unreliable results. The evidence currently available, in terms of both crashes and road user behaviour, is not adequate to determine whether Shared Spaces are truly a safety improvement, a safety risk, or have little effect on safety.

It is hoped that this situation will improve as the results of more Shared Space evaluations become available. However the early publicity surrounding Shared Spaces may lead to an assumption that Shared Spaces are safe, without the appropriate evaluations being performed. It is vital that further research continues to be conducted into the implementation of Shared Space in practice to enable the spread of best practice solutions. This is particularly important due to the wide variety of locations in which Shared Spaces have been proposed, and the wide variety of factors that can affect the success of Shared Spaces.

Road culture and usage affect road user behaviour, and thus would be expected to affect safety in Shared Spaces. Vehicle speeds higher than 30 km/h, and/or high levels of traffic, discourage pedestrians from using the centre of the road and prevent Shared Spaces from being utilised as intended. Road design also has a clear effect, in that the more a space looks like a typical road, the more it will be treated as a typical road by all potential users of the space. Existing levels of walking and cycling may affect motorist responses to pedestrians and cyclists. Legal frameworks and social norms are also likely to affect interactions between different road users. All of these factors will have individual and combined effects on the number and seriousness of crashes within a Shared Space road environment.

Jurisdictions wishing to improve the balance between the needs of different road user groups must therefore make their decisions on other grounds than known safety records. However, it should be noted that many current traffic management decisions have also not been made on the basis of safety. Mobility for motorised traffic has been the over-riding consideration for traffic engineers, and it is reasonable to suggest that this should not be the sole concern when planning the layout of multi-functional public spaces such as urban main roads. Shared spaces aim to meet multiple needs along with safety; as indeed do all road design decisions. While it is not yet established that Shared Spaces are safer than traditional road environments, it is also not established that they are any less safe. Thus Shared Spaces and similar models may well fill an important gap in the available palette of road designs. It is, however, important that new implementations continue to be evaluated (particularly in terms of outcomes for highly vulnerable user groups) and the results made available to other jurisdictions, so that all can benefit from new approaches to better balancing the many uses of public roads.

6.2 Application to the ACT

It was hoped that the current project would be able to provide specific recommendations based on the crash evidence as to the situations in which Shared Space is likely to improve or diminish safety and accessibility for non-motorised road users. Unfortunately the current evidence base is insufficient to provide this information. However it is clear that extensive public consultation and education must be undertaken before the introduction of such a novel traffic management scheme. In particular, the opinions of vulnerable road users such as visually-impaired pedestrians and pedestrians with limited mobility should be sought out, and their needs taken into account.

Shared spaces were proposed as a potential improvement to pedestrian and cyclist accessibility for two ACT locations in a recent review of cycling and pedestrian facilities (Cardno Eppell Olsen, 2011). The report notes that Bunda St between Mort St and Akuna St in the CBD, and Hibberson St in Gungahlin, had potential to be improved by redesign into Shared Spaces. However no details were given as to why this suggestion was chosen over other alternatives to improve accessibility in these spaces. Shared Spaces were rated at the highest level of safety, however no references were given to justify this assumption. The report does note that further investigation would be required, including ‘a detailed feasibility study, impacts on other modes and operation in these locations, cost effectiveness, detailed costing, further consultation with adjacent stakeholders’ before a plan for implementation could be developed.

One alternative to entirely redesigning the street that is currently being trialled in the ACT is the use of 40 km/h zones in high pedestrian activity areas. Lowering vehicle speeds using signage and enforcement may be a cheaper method than lowering vehicle speeds using road design and engineering features. The evaluation of the trial will include determining:

- whether speeds are reduced in the trial area
- whether the trial results in increased pedestrian and/or cyclist numbers
- whether a reduced speed limit is supported by residents, businesses and employees
- the acceptance of details of the 40 km/h areas, including the boundaries, hours of operation, traffic calming treatments and signage
- any undesirable impacts of the trial.

The trial will finish in January 2012, with evaluation to follow (Territory and Municipal Services, 2011). No results were available at the time of writing. If the evaluation of the trial is positive, this may be considered a more effective method to improve safety and encourage walking and cycling in town centres.

6.3 Summary of best practice

Many cities, including Canberra, are looking at ways to encourage active transport modes and discourage travel by private vehicle. These strategies have multiple aims, only one of which is improving road safety. Shared Spaces may thus be considered an appropriate design choice regardless of the unknown likely effects on safety. Several alternatives to Shared Spaces have been considered above; however all have different benefits and drawbacks. If Shared Spaces are to be implemented in the ACT, the following recommendations are made:

- Shared spaces are only appropriate in areas with high usage by pedestrians and cyclists. If there are few non-motorised road users present, vehicles are unlikely to give way to those non-motorised users who do try to cross the central road space. Surrounding commercial development and/or other attractions are important to ensure the required level of usage by foot traffic.
- Shared spaces seem to be more effective when most of those travelling through the space have origins or destinations in the local area, rather than far away. For this reason, shared space designs may be more suited to local shopping centres than to major town centres with large amounts of through traffic.
- Shared spaces are more effective when vehicle traffic is below 50 vehicles per hour (when traffic speeds are moderate, i.e. 50 km/h) or 200 vehicles per hour when traffic speeds are low (30 km/h). When traffic flow is higher, motorists tend to follow each other in platoons rather than watching for other road users; similarly when vehicle speeds are higher drivers do not have time to analyse the intentions of slower-moving road users and adapt accordingly. Steps should be taken to ensure that vehicle speeds and densities are no higher than these levels. It cannot be assumed that the presence of pedestrians and cyclists will reduce vehicle speeds without any other changes to the road environment.
- High levels of consultation with local stakeholders are vital, particularly with vulnerable groups. It is important that this consultation is an ongoing process throughout the design, construction and early operation phases of any implementation, not just a token community meeting once the design has already been created. Shared Spaces are not just another traffic countermeasure; they are a new way of thinking about streets. The consultation process is actually part of the process of educating people how to behave in this novel context. It is also essential to ensure the needs of all user groups are satisfied, and expensive redesigns are not required post-implementation.
- Publicity campaigns should accompany the redesign so that all road users know how to behave in the new space.
- Parking within a Shared Space area obstructs pedestrian visibility. It is therefore desirable that parking for goods transport and visitors to shops is provided off-street or outside the Shared Space.
- Disabled parking should be available close enough to allow access to destinations within the Shared Space area for pedestrians with limited mobility.
- Removal of kerbs and use of paving rather than bitumen improves the recognition of the Shared Space as an area where pedestrians may cross at any point and vehicles should not take their right-of-way for granted. However, it is important that all surfaces used are suitable for mobility-impaired pedestrians, and that safe edge space and the vehicle carriageway are delineated by tactile surfaces easily perceived by the visually impaired.

- If kerbs are removed, provision should be made for access to transport by mobility-impaired pedestrians (e.g. buses with the capability to lower floor levels and/or extend ramps towards waiting passengers). Waiting areas for public transport should be sufficiently wide to serve demand, and should be in an area protected from traffic and where waiting passengers will not impede access to shops.
- Safe edge space should be reserved for pedestrian usage by the use of kerbs with regular dropped crossing points or raised tables, or by the placement of street furniture, lighting, bollards, drainage channels, tactile delineators, trees and other vegetation. If the latter option is chosen, care must be taken that street furniture and other objects do not create an obstacle for pedestrians in wheelchairs and mobility scooters, and visually impaired pedestrians must be satisfied that they are able to detect the tactile delineators and safely navigate through the space.
- Edge space should be wide enough to accommodate uninterrupted pedestrian movement along the road corridor for the number of pedestrians expected, as well as outdoor café seating and shop displays. This may require not only measurement of current pedestrian flows, but surveys of intended pedestrian usage of a redesigned space.
- It may also be necessary to provide a separate space for cyclist movement along the corridor, as not all cyclists feel safe sharing the centre of the space with motorised traffic, and mixing pedestrians and cyclists in the edge zone may lead to negative safety outcomes.
- It is important that the space does not look like a typical street and invite rapid vehicular movement. Design options to avoid this include limiting the area of straight road and/or visibility ahead for vehicles, pavement designs that suggest movement along pedestrian desire lines rather than vehicle desire lines, and the use of surfaces that are uncomfortable for vehicle occupants when driven over at high speeds (although these surfaces must be acceptable to mobility- and vision-impaired pedestrians).
- Lighting designs should also reinforce the social rather than movement functions of the space (for example, lights in the ground, as part of street furniture, or at pedestrian level, rather than typical overhead street lighting). Lighting should be sufficient that the space feels safe and encourages continued pedestrian usage at night.
- It may be necessary to introduce changes to the Road Rules prior to the introduction of a Shared Space, as currently in all road environments outside signed Shared Zone 10km/h areas it is the responsibility of pedestrians not to impede vehicle traffic, rather than the responsibility of vehicle traffic to allow pedestrians free movement.
- The current legal framework in Australia also specifies that road authorities have the responsibility to warn drivers of hazards. Road authorities in jurisdictions

wishing to introduce Shared Space may therefore need to seek legal advice on how this responsibility would be fulfilled within the low signage framework of a Shared Space (for example, would signage at the entry and exit of the space be sufficient).

- Where it is decided that Shared Space is not suitable for a particular area with high levels of non-motorised transport, consideration should be given to other design alternatives that prioritise the needs of non-motorised road users.

The recent OECD report ‘Pedestrian Safety, Urban Space and Health’ (OECD International Transport Forum, 2011) notes that while walking and sojourning in public spaces is an essential part of liveable, prosperous, healthy and sustainable urban areas, and while all journeys begin and end on foot, the needs of pedestrians have typically been overlooked. The report recommends the collection of better data on travel patterns of non-motorised transport users and the integration of their needs into urban design. In particular, the report notes the need for more space to be accessible to pedestrians in city centres; traffic calming and 30km/h zones should also be implemented in city centres and other high-pedestrian use areas.

Shared Space, when implemented according to best-practice principles outlined above, has the potential to fulfil these goals of vital and sustainable urban areas. Street design can have large effects on the behaviour of road users, and traditional road designs do not guarantee safety for vulnerable road users. It is thus worthwhile examining other alternatives. While the Shared Space concept is relatively novel and untested, and may not be suitable for all areas, the fundamental principle that people outside vehicles deserve to be able to use public road spaces too is vital to the future liveability and sustainability of our cities. It is our hope that the present report provides useful information to help policy-makers and practitioners create the best possible urban road spaces for all road users.

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