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Shared Space: Measuring the Boundaries and Assessing the Efficiencies

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Shared Space: Measuring the Boundaries and Assessing the Efficiencies

Benjamin William Wargo

B.S., University of Connecticut, 2011

A Thesis

Submitted in Partial Fulfillment of the

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Shared Space: Measuring the Boundaries and Assessing the Efficiencies

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3.0 ABSTRACT

Shared space is a design concept becoming increasingly common in European countries. It intentionally blurs pedestrian-driver boundaries in order to reduce vehicle speeds, create more walkable areas, and improve aesthetics and sense of place. What constitutes a shared space is not clearly defined in the existing literature. Steps toward a systematic method for assessing a space's "level of sharedness" have been developed in this research to minimize the present ambiguity.

A paradox of shared space, suggested by numerous observers but little studied, is that while allowing freer pedestrian movement, shared space also appears to promote greater vehicle efficiency than conventional traffic control systems.

This study also investigates the shared space paradox. Pedestrian and vehicle characteristics and behaviors were measured for a range of shared spaces in five different countries, including the United States.

Traffic analysis software was then used to determine the expected vehicle delay at intersections with traditional control systems and the same number of pedestrians, vehicles, and lanes as the shared spaces. The measured vehicle delays at the shared spaces were found to be considerably lower than the expected vehicle delays at comparable intersections using traditional control systems. The low vehicle delays at the shared spaces are attributed to low vehicle speeds, which, in turn, lead to more seamless and efficient pedestrian-vehicle interactions, and considerably less stop-and-go vehicle behavior.

The study results suggest that shared space can provide much greater vehicle capacity than conventional intersections, while also better accommodating pedestrians. If intersections using traditional control systems were to offer the same vehicle capacities as shared spaces, more

vehicle lanes would likely be necessary. This would, in turn, result in places that are significantly less supportive of urban life and pedestrian activity.

4.0 INTRODUCTION

Shared space is an urban design concept which reduces the amount of segregation between pedestrians and vehicles in order to lower vehicle speeds, create more walkable areas, and improve aesthetics and sense of place.

All shared space, however, was not created equal. The UK Department for Transport's Shared Space Guidelines affirm this notion. The Guidelines note that a definitive shared space design does not exist (DfT, 2011). Shared space designs vary greatly, depending on the street configuration and the surrounding context of the built environment.

In order to overcome this ambiguity, the first report in this document offers an in-depth discussion of how one shared space can differ from another, and how to assess a shared space's "level of sharedness." The second report explores the pedestrian and vehicle characteristics and behaviors at six shared spaces with varying levels of sharedness.

Understanding and defining the variation in shared space design is of great importance for the continued implementation of shared space. Especially in the United States, legislators and policy makers tend to require planners and designers to refer to guidebooks and codes in order to show that a particular type of design is appropriate for the context. Current guides offer no solution for shared space proponents and planners to turn to.

Newer street design guides such as the ITE/CNU Design Guidelines (ITE/CNU, 2010) provide designers and engineers with contextual, behavioral, and physical differences among varying types of conventional roadways. To varying extents, the guides describe distinct types of thoroughfares with distinct characteristics and situations where the implementation of such a thoroughfare is appropriate. Planners are able to select the appropriate type of thoroughfare, and can then find various geometric features and design codes associated with the chosen

thoroughfare. Since no such guide has been developed specifically for shared space design, however, it is difficult for transportation engineers and urban planners to know when to apply one type of shared space design as opposed to another. Perhaps such a guide for shared space is neither possible to create nor desired, due to the complex nature of shared space design, and the inherent restrictions that guides imply. What is necessary, however, is the understanding that a range of shared space designs does indeed exist, and that the behavior of pedestrians and vehicles will depend greatly upon the particular design.

The first report seeks to provide a method for determining the range of shared space designs across our global infrastructure and to provide a foundation for the assessment of pedestrian and vehicle behaviors and characteristics present at the range of different shared spaces.

The basic premise of shared space is not new. Streets designed on this basis are meant to reduce the power differential between pedestrians and vehicles, and were, in fact, the norm in the early 1900s before traffic engineers began seeking ways to maximize vehicle traffic flow by strictly segregating vehicles from people (Norton, 2011). Some proponents of shared space suggest that perhaps traffic engineers should not have been so quick to move away from streets designed as shared spaces. Maybe the more complex environment where pedestrians are not restricted to using *only* the sidewalk, and crossing *only* at well-marked crosswalks, and vehicles are not completely controlled by stoplights and signs is actually more efficient for everyone, at least in some situations. The study in this thesis, highlighted in the second report, investigates this seeming paradox. Specifically, the second report seeks to determine whether shared spaces reduce the delays experienced by vehicles and by pedestrians when compared to conventional control systems like roundabout, all-way stop, and signalized intersections.

The modern concept of shared space originated in the Netherlands in the late 1960s when Joost Vahl experimented with intentionally integrating vehicle traffic back into social spaces in order to expand children's play areas (Hamilton-Baillie, 2008). In the early 1990s, Hans Monderman found that encouraging pedestrians and vehicles to share the same space by reducing the amount of segregation between vehicles and pedestrians (removing signs, road markings, and curbs) and by lowering vehicle speeds increased safety for all users and enabled pedestrians to cross streets wherever and whenever they wanted (Hamilton-Baillie, 2008; Karndacharuk, 2013). Over the last 20 years, shared space has become increasingly popular across the world, and has even begun to appear anew in some American cities. In addition to the advantages noted by Monderman, implementing shared space design in an area has been found to increase that area's sense of place and economic activity (Karndacharuk, 2013; Reid, 2009; Buchanan, 2007).

As mentioned above, however, what actually constitutes a "shared space," is not clearly delineated (DfT, 2011; Hammond and Musselwhite, 2012). According to the UK Department for Transport, the two major factors differentiating one shared space from another are the level of demarcation between pedestrians and vehicles, and the amount of interaction that occurs between users (Reid, 2009; DfT, 2011). These factors are illustrated in FIGURE 1:

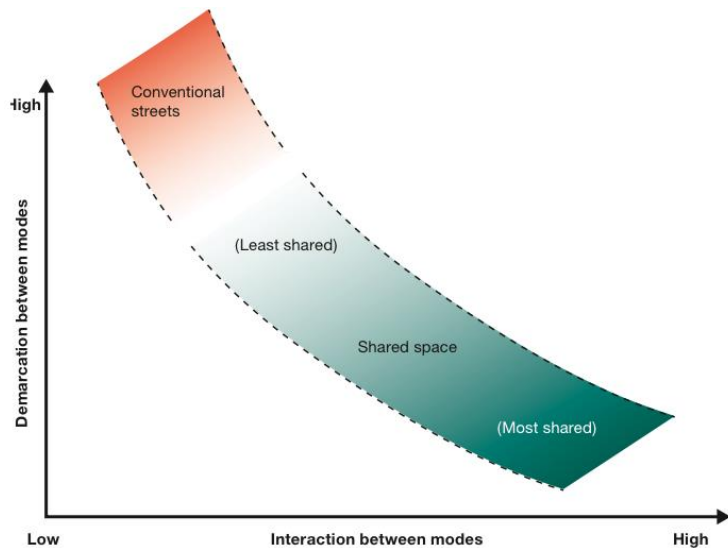


FIGURE 1: Interaction versus Demarcation Between Modes (DfT, 2011)

On the “least shared” end of the spectrum, pedestrians and vehicles are segregated by painted lines, high curbs, tall bollards, and/or drastically different material types. In these “least shared” environments, pedestrians and vehicles most commonly interact only at formal crosswalks (DfT, 2011). In the “most shared” places, there is much less distinction between the pedestrian and vehicle spaces.

To best explore pedestrian and vehicle behaviors, six shared spaces with varying types of demarcation and levels of interaction (falling at different locations on FIGURE 1), and varying pedestrian and vehicle volumes were observed in the second report. All sites were circular intersections with one entry and one exit vehicle lane per approach. As part of this second report, a variety of pedestrian and vehicle behaviors were measured, including the time that pedestrians waited to cross the vehicle space, vehicle speed, and pedestrian and vehicle delay.

The pedestrian and vehicle volumes and number of lanes at the shared spaces were inputted into three different modules of a traffic analysis software package (one used for predicting behavior at signalized intersections, one for all-way stop intersections, and one for roundabouts). The software generated reports showing the hypothetical expected vehicle delays

if the shared space intersections were converted into conventional intersections using a given type of formal control system, while still maintaining the same pedestrian and vehicle volumes and number of vehicle lanes.

The measured vehicle delays at the shared spaces were then compared to the predicted vehicle delays expected at the sites if the intersections were to operate under the conditions of the three familiar types of conventional controls.

5.0 REPORT 1

MEASURING SPACE: FIRST STEPS TOWARD DEFINING THE RANGE OF SHARED SPACE

5.1 INTRODUCTION

All shared space was not created equal. The existing literature on shared space, however, makes little distinction between different types of shared spaces and the variations in vehicle and pedestrian behavior that occur within areas that are both contextually and physically different. Part of the problem is that the definition of “shared space” is somewhat ambiguous and seems to vary from one article to another. The Shared Space Guidelines, published by the Department for Transport in the UK, define shared space as “a street or place designed to improve pedestrian movement and comfort by reducing the dominance of motor vehicles and enabling all users to share the space rather than follow the clearly defined rules implied by conventional designs” (DfT, 2011). The guide goes on to note, however, that a definitive shared space design does not exist (DfT, 2011). So, how does one begin to examine and classify the different types of shared spaces?

Current guides offer no specific solutions. Recently developed guides such as the ITE/CNU Design Guidelines (ITE/CNU, 2010) provide designers and engineers with clear contextual, behavioral, and physical differences among varying types of conventional roadways. The ITE/CNU guide provides a classification system of different thoroughfare types in varying contexts (primarily urban and rural). The ITE/CNU guide provides parameters for eleven distinct types of thoroughfares (ranging from a freeway to a mew) in six different contexts (varying from a rural preserve to an urban core) (ITE/CNU, 2010). Each thoroughfare type described by various guides has distinct characteristics and is appropriate for different situations. A planner can select the thoroughfare type appropriate for the context, and then find various geometric features and design codes associated with the chosen thoroughfare.

Since no such guide has been developed specifically for shared space design, however, it is difficult for transportation engineers and urban planners to know when to apply one type of shared space design as opposed to another. Perhaps such a guide for shared space is neither possible to create nor desired, due to the complex nature of shared space design, and the inherent restrictions that guides imply. What is necessary, however, is the understanding that a range of shared space designs does indeed exist, and that the behavior of pedestrians and vehicles will depend greatly upon the particular design.

This paper seeks to provide a method for determining the range of shared space designs across our global infrastructure and to provide a foundation for the assessment of the different pedestrian and vehicle behaviors and characteristics present at the range of different shared spaces.

5.2 PREVIOUS WORK TOWARD DEFINING THE RANGE

Quimby and Castle were pioneers in their attempt to classify shared space schemes, which can also be referred to as simplified street schemes, naked streets, living streets, home zones, 20 mph zones, or woonerven (Quimby, 2006; Hamilton-Baillie, 2008; Anvari, 2015). The two researchers found their task difficult because the variation in schemes depends so greatly on the local culture and the context in which the scheme is implemented (Quimby, 2006). Hammond came to a similar conclusion when conducting research on Widemarsh Street in the UK, and suggested that shared space cannot be grouped into one particular concept, but must be thought of as a range, with priority assigned to different groups according to the context (Hammond, 2013).

Quimby and Castle also note that some schemes have been developed for centers of

cities, others for a lengthy stretch, and still others for only a single junction (Quimby, 2006). The reconstruction of areas into shared space schemes can involve both the elimination of old features (centerlines, signage, traffic signals, curbs) and the addition of new ones (pavers, bollards, etc.). Thus it is not possible to define the range of shared space solely on how “simple” the space is (Quimby, 2006).

Quimby and Castle propose grouping simplified street schemes into three main categories: 1. Schemes that reduce signs/markings, but maintain conventional priorities; 2. Schemes that maintain conventional physical features such as curbs, but remove many conventional priorities between road users; and 3. Schemes that are the idealized shared space schemes with neither signs nor priorities (Quimby, 2006). Quimby and Castle admit, however, that this classification system is not perfect, and that a more detailed structure is desired.

Shortly after Quimby and Castle’s publication, the Department for Transport released a “Manual for Streets” which provides an extensive context-sensitive design approach to local streets in the UK (DfT, 2007). The only specific mention of “shared space” in this guide highlights the fact that pedestrians will only share space with motorists when volumes are below 100 vehicles per hour. Above this threshold, pedestrians will treat the central carriageway as only a space to be crossed, rather than occupied (DfT, 2007). Based on the Manual’s approach, one question is whether or not spaces where pedestrians are only crossing the carriageway, and not occupying the space, should be excluded from the definition of shared space.

Reid’s “Shared Space Project-Stage 1” provides a method to answer this question by describing a complete list of the “objectives” of shared space design (Reid, 2009). These “objectives” can be used as a foundation to assess the level of sharedness of any particular design. As one might assume, this level of sharedness will vary across different contexts and

physical environments.

Reid's seven objectives are: increase sense of place; increase pedestrian ease of movement; change pedestrian activity; reduce vehicle traffic dominance; inspire economic regeneration; increase safety; and promote an inclusive design (Reid, 2009).

Varying contexts across different parts of the world, and even different parts of the same town, will require a different level of attention to each of Reid's seven objectives. It is important to understand that not *all* spaces that function as shared space will necessarily have sought to attain *maximum* fulfillment of, or even to address, all seven objectives. Most spaces that function as shared space will instead have obtained a context-specific balance across the spectrum within each of the seven objectives, resulting in varying amounts of sharing.

The techniques and measurement practices used in the remaining research literature on shared space design can be used to quantify a design's level of fulfillment of each of the seven objectives, and, ultimately, to gauge the level of sharedness of any particular design.

5.3 MEASURING THE SEVEN OBJECTIVES

5.3.1 Increase Sense of Place

Sense of place can be measured by obtaining the opinions of users, assessing the aesthetics and visual character of an area, and observing how various groups of people use the space and facilities provided.

The Shared Space Guidelines, published by the Department for Transport, and Karndacharuk, emphasize that one of the principal goals of shared space is to increase the sense of place in an area, while maintaining an acceptable amount of mobility for car and pedestrian movement (DfT, 2011; Karndacharuk, 2011). Figure 1, a figure from the Guidelines (DfT,

2011), illustrates the place/movement matrix.



Figure 1: Place/ Movement Matrix

The matrix shows that the most quintessential shared spaces will fall high on the x-axis or “place” scale as well as the y-axis or “movement” scale. Confusedly, the same diagram is used to illustrate how *all* UK local streets should be designed in the Manual for Streets published by the DfT as well (DfT, 2007). From this, we can conclude that all newly designed local streets in the UK will be a shared space to some degree, and that the level of sharedness can be partially determined by exactly where the area lies on the place/movement matrix.

Buchanan and Whyte have identified key indicators of a good, inclusive, and popular place to be: the amount of women in the area, the range of ages of the people in the area, and whether or not there are assemblies of people in the area (Buchanan, 2007; Whyte, 1980).

Numerous studies have included the responses of users who were surveyed. Nearly all of these studies report that respondents taking part in the surveys said that there had been an increase in visual amenity after the area was reconstructed to function as a shared space (Noordelijke, 2007; Palmblad, 2009; Webster, 2005).

5.3.2 Change Pedestrian Activity

Changing pedestrian activity refers to changing who uses a particular space and how they use it. This is highly related to increasing an area's sense of place. The changes can be tracked by measuring the total number of pedestrians, the type of pedestrian activity, and the overall comfort of the users. In general, the more "shared" an area is, the less pedestrians will treat the space as only a passageway for movement, and more as a destination. Areas with the highest levels of sharedness will encourage pedestrians to spend more time in the space.

"Measuring Pedestrian Activity," an article published by the Transport for London, recommends that, in order to accurately record pedestrian activity, a standard activity classification as well as a place-specific classification system should be established. Examples of standard activities include standing, café-sitting, formal-sitting (benches), and informal-sitting (ledges) (Buchanan, 2007).

5.3.3 Increase Ease of Pedestrian Movement

Ease of pedestrian movement can be measured by the ability/comfort for pedestrians to cross at any location, the number of people using the dedicated pedestrian links in comparison to those crossing at random locations, and the delay that pedestrians experience in traversing the space.

Will conversions to shared space result in definitively "freer" pedestrian movements? The jury is still out, but some studies note that a reduction in physical (and therefore, psychological) barriers and curbs will result in pedestrians crossing per their desire lines, instead of using dedicated pedestrian areas such as crosswalks (Reid, 2009).

The DfT Shared Space Guidelines note that the level of sharedness depends upon the amount of interaction between pedestrians and vehicles, and on the amount of demarcation

between modes. Figure 2 shows that areas with the highest levels of sharedness result when there is little demarcation between the “comfort space” used only by pedestrians and bicycles and the carriageway (DfT, 2011).

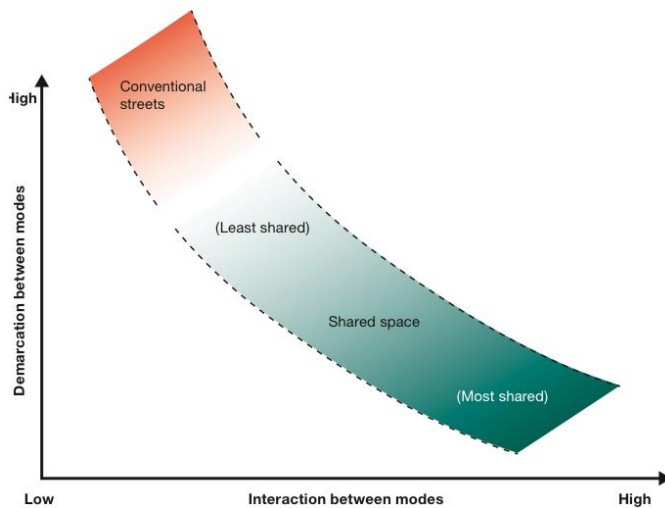


Figure 2: Interaction versus Demarcation Between Modes

Types of demarcation include curbs/sidewalk, separation through bollards and/or planters along with material variation, separation through material variation alone, and separation by a subtle line running alongside the carriageway. Reid also notes that the types of pedestrians present (e.g., shoppers, tourists, or residents) and how they are using the space (to sit and chat, to eat at cafes, etc.) greatly affects the level of sharing and the ease of pedestrian movement (Reid, 2009).

York concluded that pedestrian movements and patterns were perhaps most notably influenced by the location of trip attractors (York, 2003). Pedestrians will typically cross the carriageway when there is reason to do so. Thus, spaces will likely have pedestrians crossing, at informal locations and random angles, when there are attractions such as shops, schools, or offices on either side of the carriageway (York, 2003). Both Anvari and Schönauer measured

pedestrian trajectories, and pedestrian mean speeds in shared spaces located in Brighton, UK and Graz, Austria respectively (Anvari, 2015; Schönauer, 2012). While developing a shared space simulation model, Anvari concluded that shared space users will follow the shortest path to their destinations, as permitted by static objects and the built environment (Anvari, 2015). Schönauer found that pedestrians chose shorter paths when a roundabout was converted to a shared space. He also observed that the distribution of pedestrian speeds became narrower, since fewer pedestrians were seen hurrying across the road (Schönauer, 2012).

Despite the fact that well designed shared space areas have the potential to significantly reduce pedestrian crossing delay, no specific research has been found addressing the fact that the dwell-time or delay for pedestrians seeking to cross the carriageway might be reduced in shared space locations.

5.3.4 Reduce Vehicle Traffic Dominance

Reid suggests that the level of reduction in traffic dominance can be measured through traffic speed and flow, the amount of space available to pedestrians, the willingness of vehicles to yield to pedestrians, and the inclination of pedestrians to use any part of the street cross section (Reid, 2009).

As numerous researchers have emphasized, the level of traffic flow and speed of vehicles is critical to how safe and comfortable pedestrians feel sharing the space (Quimby, 2006; Reid, 2009; DfT, 2011; Bliet, 2010). While a shared space is still possible with high traffic volumes, the Department for Transport UK states that when traffic volumes exceed 100 vehicles/hour, pedestrians will only occupy the carriageway in order to cross to the opposite pedestrian zone at some lateral angle. According to the UK Department for Transport, only with traffic volumes

below 100 vehicles/hour will pedestrians be willing to occupy the central carriageway and move in longitudinal directions, parallel to the vehicles in the carriageway (DfT, 2011). The Department for Transport also states that ideal shared spaces will have target speeds below 20 mph.

York offers a variation to this argument. He discusses the following values or thresholds present when pedestrians are observed moving freely about the central carriageway, using the central carriageway area as though it were an extension of the sidewalk (in other words, a comfort space): Traffic volumes under 50 vehicles/hour, with speeds under 30 mph; Traffic volumes under 100 vehicles/hour, with speeds under 25 mph; and traffic volumes under 200 vehicles/hour, with speeds under 20 mph (York, 2003). Other research suggests that the traffic volume limits proposed by the Department for Transport and York may not be accurate, and that sharing can also take place at much higher vehicle volumes.

Through the investigation of a shared space in Norrköping, Sweden, Palmblad found that in the overwhelming majority of pedestrian-vehicle interactions and bicycle-vehicle interactions, it was the *vehicles* that either stopped or adjusted their behavior—not the pedestrians and cyclists (Palmblad, 2009). This reinforces the notion that vehicle speeds and behaviors will likely determine the potential for sharing in any environment.

Kennedy and fellow researchers concluded that environments with three-dimensional vertical objects such as buildings or trees in the peripheral vision of drivers reduced vehicle speeds. In addition, they found that indications of human activity such as the presence of pedestrians, vehicle parking, or bicycle parking were shown to reduce speeds (Kennedy, 2005).

A key indicator of shared space design is that social interactions determine the priority between users instead of conventional traffic devices such as crosswalks and traffic signals.

(Hamilton-Bailie, 2008; Anvari, 2015; Schönauer, 2012; DfT, 2011). This phenomenon can be measured by observing how often vehicles yield to pedestrians in unsignalized areas, or the willingness of drivers to share the road. Bliet conducted a study in Montreal comparing several shared space areas to similarly-dimensioned conventional intersections and found that vehicles were significantly more likely to yield to pedestrians in shared space areas (Bliet, 2010).

Kaparias conducted a study on Exhibition Road and determined that factors such as pedestrian density, vehicle density, and the speed of vehicles all affected drivers' willingness to share the space with pedestrians (Kaparias, 2011).

While it seems logical that level surfaces and the elimination of road markings will produce vehicle speed reductions, this notion has apparently not been studied specifically by anyone.

5.3.5 Inspire Economic Regeneration

The level of economic regeneration can be measured through economic activity, property values, and the shop occupancy rate within a particular area.

There is little evidence to suggest that shared space improves economic activity. Research does reveal, however, that walkable places, with reduced vehicle traffic, will indeed have a significant impact on the economic regeneration in an area (Speck, 2012). That being said, although economic regeneration of a space is not necessarily a requirement for shared space, it is certainly an accurate indicator of an area where high levels of sharing can potentially occur.

A study done by CAFE Space, led by Colin Buchanan, concluded that pedestrian-friendly areas with characteristics common to shared spaces, such as dropped curbs, non-

excessive traffic levels, high-quality materials, and public space along the street are correlated with increased rental values for surrounding retail locations (Space, 2007).

5.3.6 Improve Safety

The level of safety can most readily be measured through the rate of accidents and injury incidents. While all areas obviously *aim* to provide a safe environment, varying designs in varying contexts will likely see significantly different accident and injury reports.

Data suggesting significant increases in safety after reconstructing an area to a more shared space-like place is somewhat inconclusive. Dong found a slight decrease (approximately 20%) in the frequency of traffic conflicts, studying traffic risk on Exhibition Road after its reconstruction into a shared space type area (Dong, 2012). Swinburne found that the elimination of guardrails, and the installation of bicycle parking, on Kensington High Street had neither a positive nor a negative impact on total casualties and safety (Swinburne, 2010). The Laweiplein report found a dramatic reduction in traffic accidents after the redesign of a roundabout in Drachten, Netherlands, but the study focused only on the two years following the redesign and thus cannot be deemed conclusive (Noordelijke, 2007).

Quimby and Castle found casualty data for nine different Dutch shared space areas which suggest that, while casualty rates in shared space areas do not consistently decrease, there is no sign of *increased* casualties (Quimby, 2006). No distinction was made, however, as to how the nine areas varied in design and context.

5.3.7 Promote an Inclusive Design

Inclusive design refers to design which not only caters to the needs of pedestrians, bicyclists, and

vehicles, but also to disabled people and the elderly. This factor can most readily be measured by gathering the opinions of users and representative groups, and observing whether or not disabled people and the elderly are present in a particular space.

The Department for Transport UK strongly emphasizes that considering the needs of persons with reduced hearing or eyesight in the design of shared space is essential. The Department's guide underscores that this is particularly important in places where a level surface exists, since the typical curb separator between the carriageway and pedestrian comfort space has been removed (DfT, 2011).

A study by the Guide Dogs for the Blind Association found that the main concern of visually impaired persons regarding shared space was the difficulty to discern different parts of the street cross section, and the consequent risk associated with vehicles using the street (Guide, 2006). This is primarily an issue on level surface streets. In contrast, the same article notes that level surfaces also enable persons with less mobility to move about the area much easier, thus complicating the issue.

5.4 CONCLUSION

After a thorough evaluation of the existing research literature on shared space designs, it is strikingly evident that a reliable universal method to differentiate one shared space from another does not exist. Often, the author will simply state the road name, the town, and whether the area is or is *not* a shared space. On rare occasions, information might be given to the reader about the surrounding context/buildings and/or some of the specifics of the street cross section. There is no way, however, for authors to explicitly describe how the level of sharedness differs from one place to another. To illustrate this point, one can think of Kensington High Street in London, UK

compared to Exhibition Road in London, UK. Both areas are referred to as streets that have been converted to shared spaces, yet the types of interactions, and the behaviors of various users that occur in each place, are extremely different. Measuring how each street meets Reid's seven objectives would allow us to more precisely describe Kensington High Street and Exhibition Road and to assign each place a certain level of sharedness.

Reid's seven objectives can be transformed, and viewed on sliding scales, for the following factors: 1. Sense of place; 2. Pedestrian comfort; 3. Ease in pedestrian movement; 4. Vehicle traffic dominance; 5. Economic regeneration; 6. Safety; and 7. Inclusive design.

Depending on the context and the design, shared spaces will fall in different places on the scale for each of these seven factors. The reach of the seven objectives can be measured through the methods and techniques applied in the existing literature discussed above.

In conjunction with this assessment, a clear physical description or rendering, along with the specifics of the context in which each space lies, should be provided in order for readers to fully understand the differences among varying shared spaces. The contexts described by Quimby and Castle (city center, long stretch of road, or single junction) in combination with the junction layouts, displayed in Figure 3, from the DfT Manual for Streets will allow authors to describe the context in detail. It is expected that areas with varying contexts will meet Reid's seven objectives to varying degrees and thus will have very different levels of sharedness.

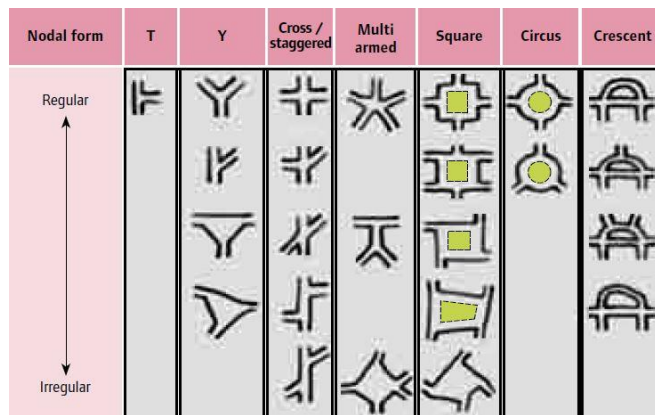


Figure 3: Junction Layouts

Assessing the level of sharedness of different spaces on a context-specific basis will allow deeper comprehension of what shared space really is. Such an assessment could potentially also be utilized in the future development of a detailed shared space design guide which would allow engineers and planners to be more confident when implementing variations of shared space design. Even though all shared spaces are not created equal, the range can be systematically classified, and the resulting classifications can be effectively utilized by transportation engineers and urban planners.

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6.0 REPORT 2

**SHARED SPACE: COULD LESS FORMAL STREETS BE BETTER FOR BOTH
PEDESTRIANS AND VEHICLES?**

6.1 INTRODUCTION

The basic premise of shared space is not new. Streets designed on this basis are meant to reduce the power differential between pedestrians and vehicles, and were, in fact, the norm in the early 1900s before traffic engineers began seeking ways to maximize vehicle traffic flow by strictly segregating vehicles from people (1). Some proponents of shared space suggest that perhaps traffic engineers should not have been so quick to move away from streets designed as shared spaces. Maybe the more complex environment where pedestrians are not restricted to using *only* the sidewalk, and crossing *only* at well-marked crosswalks, and vehicles are not completely controlled by stoplights and signs is actually more efficient for everyone, at least in some situations. This research was intended to investigate this seeming paradox. Specifically, this paper seeks to determine whether shared spaces reduce the delays experienced by vehicles and by pedestrians when compared to conventional control systems like roundabout, all-way stop, and signalized intersections.

The modern concept of shared space originated in the Netherlands in the late 1960s when Joost Vahl experimented with intentionally integrating vehicle traffic back into social spaces in order to expand children's play areas (2). In the early 1990s, Hans Monderman found that encouraging pedestrians and vehicles to share the same space by reducing the amount of segregation between vehicles and pedestrians (removing signs, road markings, and curbs) and by lowering vehicle speeds increased safety for all users and enabled pedestrians to cross streets wherever and whenever they wanted (2-3). Over the last 20 years, shared space has become increasingly popular across the world, and has even begun to appear anew in some United States cities. In addition to the advantages noted by Monderman, implementing shared space design in an area has been found to increase that area's sense of place and economic activity (3-5).

What actually constitutes a “shared space,” however, is not clearly delineated (6-7). Shared space designs vary greatly, depending on the street configuration and the surrounding context of the built environment. According to the UK Department for Transport, the two major factors differentiating one shared space from another are the level of demarcation between pedestrians and vehicles, and the amount of interaction that occurs between users (4,6). These factors are illustrated in FIGURE 1:

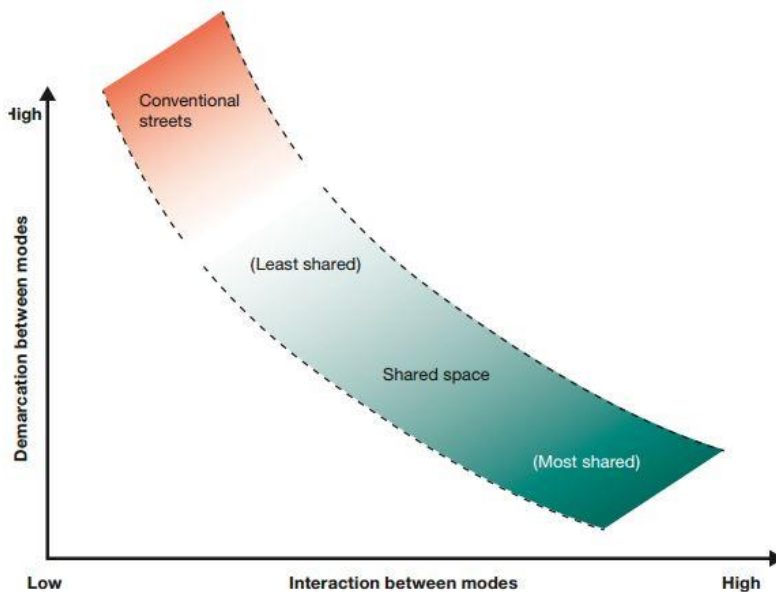


FIGURE 1: Interaction versus demarcation between modes (6).

On the “least shared” end of the spectrum, pedestrians and vehicles are segregated by painted lines, high curbs, tall bollards, and/or drastically different material types. In these “least shared” environments, pedestrians and vehicles most commonly interact only at formal crosswalks (6). In the “most shared” places, there is much less distinction between the pedestrian and vehicle spaces. The segregation is often made with slight variations in material color, objects like benches or rocks, and/or a tactile strip or drain. The lack of strict segregating features encourages pedestrians to cross the vehicle space wherever they desire, not just at formal crosswalks (6). In the “most shared” environments, pedestrians will often travel in the vehicle

space as though it were an extension of the sidewalk, and not just view the vehicle space as an area to cross (6).

The UK Department for Transport reports that a requirement for all types of shared spaces, from the “least shared” to the “most shared,” is that vehicle speeds must be low (6).

To best explore pedestrian and vehicle behaviors, six shared spaces were observed, each with varying types of demarcation and levels of interaction (falling at different locations on FIGURE 1), and varying pedestrian and vehicle volumes. All sites were circular intersections with one entry and one exit vehicle lane per approach. As part of the present research, a variety of pedestrian and vehicle behaviors were measured, including the time that pedestrians waited to cross the vehicle space, vehicle speed, and pedestrian and vehicle delay.

The pedestrian and vehicle volumes and number of lanes at the shared spaces were inputted into three different modules of a traffic analysis software package (one used for predicting behavior at signalized intersections, one for all-way stop intersections, and one for roundabouts). The software generated reports showing the hypothetical expected vehicle delays if the shared space intersections were converted into conventional intersections using a given type of formal control system, while still maintaining the same pedestrian and vehicle volumes and number of vehicle lanes.

The vehicle delays measured at the shared spaces were then compared to the vehicle delays predicted at the sites if the intersections were to operate under the conditions of the three familiar types of conventional controls.

6.2 BACKGROUND/LITERATURE REVIEW

Little research has been conducted into the actual effects of shared space design on vehicular and pedestrian traffic (4). Despite this fact, countries like Sweden, the Netherlands, the UK, France, Spain, and Germany have implemented shared space designs to revitalize public spaces in cities, towns, and villages (2). Having fewer signs, stoplights, high curbs, painted lines, and fences has been found by some to be potentially beneficial for pedestrians, vehicles, the disabled, and for the safety of all road users (3-4). The following sections review research relating to the benefits and potential pitfalls of shared space for different types of road users.

6.2.1 Pedestrian Use of Shared Space

While shared space has been suggested by many to be more advantageous for pedestrians than conventional intersections (2,8), that contention has been formally studied by only a few (3, 9, 10, 11). Schönauer et al. studied pedestrian traffic at an intersection converted into a shared space in Graz, Austria and found pedestrians using shorter crossing paths with briefer travel times even though their average walking speeds had decreased (9). Anvari et al. similarly observed pedestrians in a shared space in Brighton, UK following the shortest path to their destinations (10). Bliek noticed cars were more likely to yield to pedestrians after intersections in Montreal, Canada had been converted into shared spaces (11). Kaparias et al. concluded that shared space design on Exhibition Road in London resulted in reduced rates of pedestrian-vehicle conflicts (12). Karndacharuk et al. saw significant increases in the amount of pedestrian leisure activity and reduced vehicle speeds at three streets in New Zealand that had been converted into shared spaces, which resulted in a great increase in a sense of place (3).

6.2.2 Vehicle Travel in Shared Space

Several observers have noted that shared spaces appear to provide more capacity and less delay for vehicles than conventionally designed places (2,8,13). The Laweiplein Report, however, is the only publication known to this paper's author that studied this specific notion (13). The Laweiplein Report researchers observed vehicle delay at a shared space roundabout located in Drachten, the Netherlands. They used traffic analysis software to find predicted vehicle delays at a conventional roundabout with the same pedestrian and vehicle characteristics (13). When they compared their vehicle observations with the software predictions, they found that vehicle delay times at a conventional roundabout would be higher than those observed at the shared space (13). They also found that most drivers moved continuously, without stopping upon approach to the roundabout, and this was thought to be a major contributor to the observed low vehicle delay times (13).

6.2.3 Shared Space for The Disabled

Some researchers have criticized shared space's suitability to accommodate the disabled (14), but others have concluded that the problems presented are not the fault of shared space in general, but of avoidable design flaws such as poor contrast in material colors and/or unanticipated curb edges which could cause pedestrians to trip (7).

Research suggests that with careful consideration of the elderly and visually impaired population during the pre-implementation stage, shared space has the potential to be more easily navigable by the disabled than conventional intersections (6,7). For example, shared spaces without a curb edge segregating the vehicle and pedestrian spaces are a potential concern for the visually impaired and/or the disabled (4,7). However, some believe that this issue can be dealt with by providing a tactile strip indicating the separation (7). Areas without clearly delineated

and signed crosswalks are another noted concern for the disabled (14). Without such crosswalks, higher speed vehicles yielding to pedestrians are more concerning (14). For this reason, the UK Department for Transport emphasizes the importance of designing shared spaces that impede high vehicle speeds and force drivers to be aware of pedestrians (6).

6.2.4 User Safety and Shared Space

Many have found either a slight reduction or no change at all in accident rates once places have been converted into shared spaces (13,15-17). Dong found a slight decrease in the frequency of traffic conflicts on Exhibition Road after it was converted into a shared space (15). Swinburne found that eliminating guardrails, and installing bicycle parking, on Kensington High Street, had neither a positive nor a negative impact on total casualties and safety (16). The Laweiplein Report researchers found dramatic reductions in traffic accidents after an intersection was converted to a shared space in the Netherlands, but their study focused only on the two years following the redesign, and thus cannot be deemed conclusive (13). Quimby and Castle found casualty data for nine different Dutch shared spaces which suggest that, while casualty rates in shared space do not consistently decrease, there is no sign of any increase (17).

While the evidence to suggest that shared spaces are substantially safer than conventional intersections is limited, to the knowledge of this paper's author, no research has shown that shared space is more dangerous than conventionally designed intersections.

6.3 STUDY METHODOLOGY

In this study, videos of pedestrian and vehicle travel at six different shared space sites were obtained. Then various pedestrian and vehicle characteristics and behaviors were measured

using the videos. Traffic analysis software was utilized to find the hypothetical vehicle capacity and delay at conventional intersections controlled by roundabouts, stop signs, and stoplights. The conventional intersections were assumed to have equal numbers of pedestrians and vehicles, and the same number of lanes as the shared spaces. The software outputs, namely the predicted vehicle delays, were compared with the behaviors measured at the shared spaces.

6.3.1 Site Selection and Design Features

Since most shared spaces exist outside the US, this study examined video recordings obtained from a number of observers around the globe. Video footage from a range of different shared spaces possessing similar geometry was sought. Sites were selected where all approaches to the intersection had a single vehicle lane in each direction. Each site had varying types of segregation/demarcation between modes, and thus had varying levels of interaction between users. Photographs of the sites are provided in FIGURE 2.



(a) Uptown Circle, Normal, IL (18)



(b) Fountain Place, Poynton (19)



(c) Koenitz Strasse, Bern (20)



(d) Laweiplein, Drachten (21)



(e) Seven Dials, London (22)



(f) Sonnenfelsplatz, Graz (23)

FIGURE 2(a-f) Images of site locations (18-23).

6.3.1.1 *Site Location Design Features*

TABLE 1 lists the sites in order from the “least shared” places to the “most shared” places based on ratings of the sites. In this rating, the types of demarcation and observed interactions between modes at the given site were considered. The ratings are based on a 0-10 scale, with 10 being the

most shared. On this scale, signalized intersections would be given a rating of 0. The column titled “Pedestrians Occupying Vehicle Space” refers to whether or not pedestrians occupied the vehicle space as they would a sidewalk.

TABLE 1 Site Location Design Features

| Location | Intersection Control | Demarcation Type | Materials Used | Crosswalk Type | Pedestrians Occupying Vehicle Space | Level of Interaction Between Modes | Level of “Sharedness” |
|--|----------------------|---|--------------------------------------|---|-------------------------------------|------------------------------------|-----------------------|
| Uptown Circle, Normal, Illinois, United States | Yield Control Circle | Curbs, formal crosswalks (at all legs), some signage | Asphalt and concrete | Formal, painted, striped | No | Low | 4 |
| Fountain Place, Poynton, United Kingdom | Uncontrolled Circle | No curbs, no bollards, informal crosswalks, contrasting material color | Pavers of varying colors | Informal, different colored pavers | No | Moderate | 6 |
| Koenitz Strasse, Bern, Switzerland | Uncontrolled Circle | No curbs, Low bollards, contrasting material types, less signage | Asphalt and concrete | Two legs have formal, painted, one leg has none | No | Moderate-High | 7 |
| Lawei-plein, Drachten, the Netherlands | Uncontrolled Circle | Low curbs, contrasting material types, formal crosswalk (for one of four legs) | Asphalt and pavers | Three legs have none, one leg has formal, painted | No | High | 8 |
| Seven Dials, London, United Kingdom | Uncontrolled Circle | Some bollards, low curbs, contrasting material types, minimal signage | Pavers with varying colors and sizes | Informal, different colored pavers | No | High | 9 |
| Sonnen-felsplatz, Graz, Austria | Uncontrolled Circle | No curbs, some bollards and large stones, pedestrian-vehicle space not segregated | Concrete with varying colors | No crosswalks | Yes | Very High | 10 |

6.3.2 Measurements from the Videos

Numerous pedestrian and vehicle characteristics and behaviors including pedestrian and vehicle volumes, vehicle speeds, pedestrian wait times, vehicle behavior upon approach of the intersection, and vehicle delay were examined in this study.

6.3.2.1 Pedestrian and Vehicle Volumes

The number of pedestrians crossing each entry approach at each site was tallied, as was the number of vehicles for each turning movement (left, through, and right) at each entry approach. In the interest of space, only the data from the approach with the highest pedestrian crossing volume is reported. The total vehicle volume at that approach is also shown.

6.3.2.2 Vehicle Speeds

Vehicle speeds were measured by first finding the time that each vehicle took to travel through the shared spaces. This time was then divided into the distance that each vehicle travelled while traversing the intersection. With this information, the minimum, maximum, and average vehicle speeds at the shared space intersection were determined.

6.3.2.3 Pedestrian Wait Times

The amount of time that each pedestrian waited before attempting to cross the vehicle space at the shared space locations was recorded. All recorded pedestrian wait times that were fractions were rounded up to the nearest whole number. Pedestrians showing any sign of hesitation before crossing were recorded as waiting at least one full second.

6.3.2.4 *Vehicles' Behavior Upon Approach*

The number of vehicles that stopped at least once, versus those that moved continuously before entering the roundabout portion of the intersection, was counted. Vehicles were recorded as having stopped regardless of the reason for the stop. Common reasons for stopping included pedestrian crossings, queued vehicles ahead, and conflicting vehicle flows.

6.3.2.5 *Vehicle Delay*

The delay of each vehicle at the shared spaces was measured according to standard procedures outlined in an NCHRP report on roundabouts (24), the primary document used to formulate the equations in the roundabout section of the 2010 Highway Capacity Manual (HCM 2010) (25). This particular procedure was used since driver behavior at the selected sites most closely represented driver behavior at conventional roundabouts. Vehicle delay was found by first measuring the travel time of each vehicle from an arbitrary point, upstream of the maximum vehicle queue, to a point just after the vehicles entered the roundabout portion of the intersections. Then the travel time of a vehicle travelling between the same two points, but unconstrained by any stopped vehicles or pedestrian crossings, was measured. The difference between the travel time of each vehicle and the travel time of an unconstrained vehicle is the calculated vehicle delay (24).

This type of delay is officially called “control delay,” but, in this paper, it is referred to simply as “delay.” The “geometric delay,” or the extra time vehicles spend travelling through the actual intersection, is assumed to be negligible by the NCHRP report (24), and thus was not measured in this research.

6.3.3 Use of Software

The software used in this research was the 2010 Highway Capacity Software (HCS 2010). This software was used to determine the expected capacity and the resulting vehicle delay of hypothetical conventional intersections were they to have the same pedestrian, vehicle, and number of lanes as the shared spaces. This predicted vehicle delay at the conventional intersections was compared with the measured vehicle delay at the shared spaces in order to judge whether the shared spaces provide more vehicle efficiency than conventional intersections. In order for the reader to better understand the use of the software in this research, pertinent background information regarding the software is given below.

6.3.3.1 Software Background

Within HCS 2010, there are three separate modules for three different types of conventional controls: signalized intersections, all-way stop intersections, and roundabouts. Each module allows a user to input characteristics (pedestrian and vehicle volumes, number and orientation of lanes, etc.), and the software then generates a report showing how the intersection is expected to perform given the inputted characteristics and control type (26). The intersection's performance within each module is measured by the expected vehicle capacity of the intersection and, ultimately, the amount of delay that each vehicle is expected to experience.

Since driver behavior and the operation of each type of conventional intersection varies, each module within the software relies on a different set of equations and assumptions to predict the capacity and vehicle delay. These equations and assumptions are taken from the HCM 2010 (25-26). One important issue for this study is the extent to which the HCM 2010 accurately

simulates performance in the field. A discussion of the accuracy of the equations and assumptions within each module is provided below.

6.3.3.1.1 Signalized Intersection Module Driver behavior and the operation of signalized intersections is ultimately controlled by the computer that operates the signal. Thus, it is logical that the simulated operation and predicted performance of a signalized intersection within the software would have a high degree of accuracy. A recent publication claims to improve the accuracy of predicted vehicle delay within the signalized intersection module by adding a component to the delay equation which more realistically simulates the discharge of vehicles queued at a stoplight (27). The suggestion, however, only claims to improve the accuracy of predicted delay by a small percentage (27). This confirms the notion that the predictions of vehicle delay at signalized intersections are likely to be good estimations of vehicle delays at actual intersections.

6.3.3.1.2 All-Way Stop Intersection Module Driver behavior and the operation of all-way stop intersections is slightly less mechanical, so individual drivers can potentially have more influence on the overall operation of these intersections. Some have commented that the default values within the software associated with the time between vehicles traversing an all-way stop intersection are larger than real driver responses in countries outside the US (28). They note that using the same values in countries outside the US could lead to slight overestimations of vehicle delay (28). The HCM 2010 notes, however, that these default values associated with driver behavior at all-way stop intersections represent the average US driver (25). More significantly, due to a lack of data, the all-way stop module in the software does not consider pedestrian

volumes. Thus, the predicted vehicle delays at all-way stop intersections are likely to be underestimations of the vehicle delay at an actual stop-controlled intersection in the US where any level of pedestrian activity is present.

6.3.3.1.3 Roundabout Module Driver behavior has even more influence on the operation and performance of conventional roundabouts. Some note that using the default constants within the software associated with driver behavior could lead to overestimations of vehicle delay at conventional roundabouts (29-31). The HCM 2010 argues, however, that the default values associated with driver behavior within the roundabout module of the software also represent the average US driver (25). The HCM 2010 cautions against using the software in situations where “high” volumes of pedestrians are present, noting that it might not provide accurate predictions of performance at conventional roundabouts in these situations (25). The manual does not define what constitutes a “high” pedestrian volume, but the maximum number of pedestrians that the roundabout module of the software allows a user to input is 1200 pedestrians per hour. It would appear that 1200 pedestrians per hour is the limit for accurate predictions. Thus, the predicted vehicle delays at conventional roundabouts are likely to be good estimations of the vehicle delay at actual conventional roundabouts in the US, but the degree of accuracy under “high” pedestrian volumes is unknown.

6.3.3.2 Software Inputs

As indicated, numerous variables can influence the preciseness of the predicted vehicle capacities and vehicle delays within the software modules. In this research, variables were either set to their most conservative setting, or to their default values.

Examples of conservative settings include bus, truck, and bicycle crossing volumes set to zero, despite such transportation modes having been observed at some sites. In addition, a peak-hour factor of “one” was used. These conservative settings led to slight overestimations of vehicle capacity and slight underestimations of vehicle delay at the conventional intersections.

Also considered conservative is the way that pedestrians were regarded in each module. In the signalized intersection module, pedestrians were neither assumed to have their own pedestrian signal nor an exclusive pedestrian phase in the signal timing. In the all-way stop intersection module, pedestrians were not considered at all. In the roundabout module, pedestrian volumes were limited to 1200 pedestrians per hour. All of these settings are presumed to lead to underestimations of vehicle delay at the conventional intersections.

Signal timing at the signalized intersections was automatically generated by the software, and was optimized to achieve minimum average vehicle delay at the intersection. It is considered to be the best possible timing scheme, leading to the least amount of vehicle delay at the intersections.

Default values associated with driver behavior under the conditions of different control systems were used in all cases. These default values, as mentioned, are assumed to represent the behavior of the average US driver (25).

6.4 RESULTS AND DISCUSSION

6.4.1 Assessment of Volumes, Speeds, and Other Behaviors at Shared Spaces

TABLE 2 shows the measured pedestrian and vehicle volumes from the approach at each site with the highest observed pedestrian volume. Also shown are average vehicle speeds, range of vehicle speeds, average pedestrian wait times, and the percent of vehicles that came to at least

one stop before entering the intersection at each given site. The number of vehicles and pedestrians used to calculate the vehicle speeds and pedestrian wait times are shown below as well.

TABLE 2 Volumes, Vehicle Speeds, Pedestrian Wait Times, and Vehicle Behavior

| Location | Highest Pedestrian Volume (ped/hr) | Vehicle Volume (veh/hr) | Average Vehicle Speeds (mph) | Range of Vehicle Speeds (mph) | Number of Vehicles Observed | Average Pedestrian Wait Time (seconds) | Number of Pedestrians Observed | Vehicles Coming To A Stop (% Vehicles) |
|---------------------------|------------------------------------|-------------------------|------------------------------|-------------------------------|-----------------------------|--|--------------------------------|--|
| Uptown Circle, Normal, IL | 270 | 81 | 10 | 4-23 | 64 | 0.4 | 101 | 13 |
| Fountain Place, Poynton | 137 | 600 | 6 | 3-17 | 53 | 0.7 | 11 | 48 |
| Koenitz Strasse, Bern | 1536* | 624 | 9 | 4-17 | 46 | 0.2 | 82 | 34 |
| Laweiplein, Drachten | 150 | 680 | 5 | 3-11 | 27 | 0.2 | 10 | 37 |
| Seven Dials, London | 514 | 153 | 6 | 3-12 | 20 | 0.1 | 132 | 11 |
| Sonnenfelsplatz, Graz | 1125 | 383 | 5 | 2-13 | 47 | 0.2 | 80 | 15 |

NOTE: ped/hr = pedestrians per hour , veh/hr = vehicles per hour, mph = miles per hour, % = percentage, * = only 1200 ped/hr was inputted into software.

6.4.1.1 *Assessment of Volume*

Pedestrian and vehicle volumes varied widely at the observed sites. The pedestrian volumes ranged from just 137 pedestrians per hour at Fountain Place to 1536 pedestrians per hour at Koenitz Strasse. This latter value exceeded the value of 1200 pedestrians per hour that is the maximum number considered in the HCS 2010 software for assessing conventional intersections. The range in vehicle volumes was from 81 vehicles per hour at Uptown Circle to 680 vehicles per hour at Laweiplein. The volumes on these six intersections encompass the full range of traffic conditions that could be expected at intersections fed by two-lane streets. In fact, the traffic volumes at three of the six intersections exceed the expected capacity for intersections with one entering lane in each direction of travel. As indicated before, in addition to carrying such high volumes of vehicular traffic, some of these intersections were also carrying equally

large volumes of pedestrian traffic. The six intersections thus represent shared spaces under different conditions ranging from low to very congested travel.

6.4.1.2 *Assessment of Vehicle Speed*

The average measured vehicle speeds at all sites were low, ranging from an average of about 5 to 10 miles per hour. Low vehicle speeds are considered to be essential for the successful operation of any shared space (6), and are most likely a desired outcome of the design at these sites. A clear pattern can be seen in the variation in speed. As the type of shared space becomes “more shared,” the average vehicle speeds get lower—a pattern expected from the theory. This pattern is illustrated in FIGURE 3.

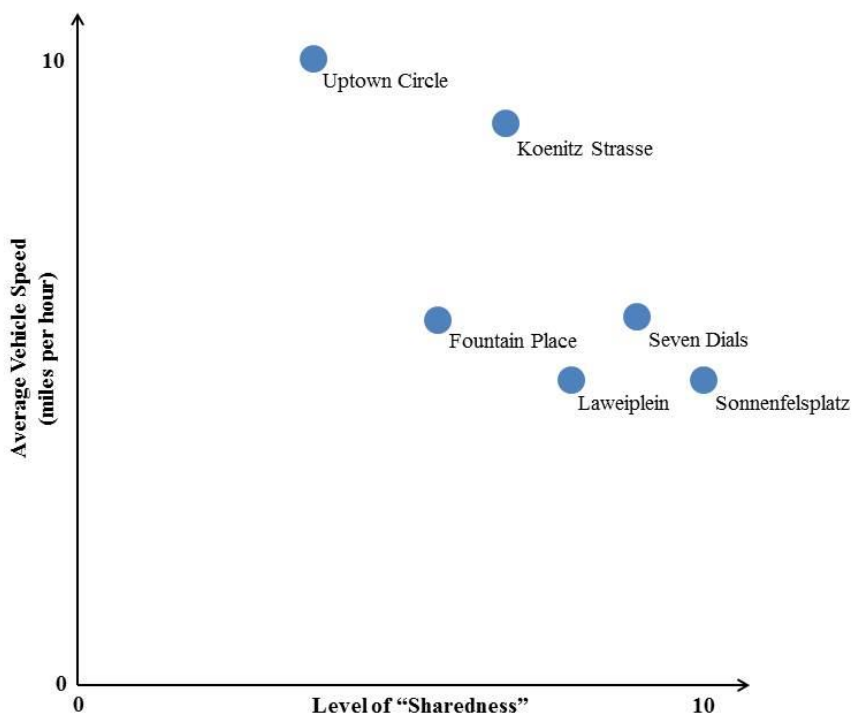


FIGURE 3 Level of “sharedness” versus average vehicle speed.

6.4.1.3 Assessment of Pedestrian Wait Times

Pedestrian wait times measured at all six locations were all less than one second. The pedestrians at the shared spaces showed little or no hesitation before crossing. The low average pedestrian wait times are likely a function of the vehicle speeds, but they also depend on vehicle volumes at the sites.

6.4.1.4 Vehicle Behavior Upon Approach Assessment

Small percentages of vehicles at all of the shared spaces came to complete stops before entering the intersections. It appears that smaller percentages of vehicles came to complete stops in the “more shared” environments. This is likely related to the lower vehicle speeds, but vehicle and pedestrian volumes also play a role.

6.4.2 Comparing Shared Space to Conventional Design

As mentioned earlier, HCS 2010 was utilized to compare the pedestrian and vehicle efficiency of the existing shared spaces to the pedestrian and vehicle efficiency of the sites if they were converted into conventional intersections.

The software did not provide any analysis regarding the efficiency of conventional control systems for pedestrians. For this reason, the measured pedestrian wait times at the shared spaces were compared to data in a national report.

As noted, however, the software *did* provide an analysis regarding the efficiency of conventional control systems for vehicles. The expected efficiency for vehicles is measured in terms of predicted vehicle capacity, and predicted vehicle delay. These predictions were compared to the vehicle delay measured at the shared spaces. The vehicle volumes, predicted

capacity, predicted volume-to-capacity ratio, measured delay, and predicted delay are shown below in TABLE 3.

The predictions are presented from the most to least segregated conventional intersection types: signalized intersections first, all-way stop intersections second, and conventional roundabouts last.

TABLE 3(a-c) Comparing Shared Space to Conventional Design

TABLE 3(a) Shared Space Measurements vs. Signalized Intersection

| Location | Measured Vehicle Volume (veh/hr) | Predicted Capacity (veh/hr) | Predicted Volume-to-Capacity Ratio | Measured Delay (sec/veh) | Predicted Delay (sec/veh) |
|---------------------------|----------------------------------|-----------------------------|------------------------------------|--------------------------|---------------------------|
| Uptown Circle, Normal, IL | 81 | 115 | 0.70 | 4 | 15 |
| Fountain Place, Poynton | 600 | 536 | 1.12 | 6 | 140 |
| Koenitz Strasse, Bern | 624 | 729 | 0.86 | 16 | 15 |
| Laweiplein, Drachten | 680 | 709 | 0.96 | 10 | 49 |
| Seven Dials, London | 153 | 577 | 0.27 | 1 | 6 |
| Sonnenfelsplatz, Graz | 383 | 305 | 1.26 | 8 | 171 |

NOTE: vs. = versus , veh/hr = vehicles per hour, sec/veh = seconds per vehicle.

TABLE 3(b) Shared Space Measurements vs. All-Way Stop Intersection

| Location | Measured Vehicle Volume (veh/hr) | Predicted Capacity (veh/hr) | Predicted Volume-to-Capacity Ratio | Measured Delay (sec/veh) | Predicted Delay (sec/veh) |
|---------------------------|----------------------------------|-----------------------------|------------------------------------|--------------------------|---------------------------|
| Uptown Circle, Normal, IL | 81 | 331 | 0.24 | 4 | 8 |
| Fountain Place, Poynton | 600 | 600 | 1.00 | 6 | 213 |
| Koenitz Strasse, Bern | 624 | 624 | 1.00 | 16 | 72 |
| Laweiplein, Drachten | 680 | 680 | 1.00 | 10 | 346 |
| Seven Dials, London | 153 | 403 | 0.38 | 1 | 8 |
| Sonnenfelsplatz, Graz | 383 | 506 | 0.76 | 8 | 24 |

NOTE: vs. = versus , veh/hr = vehicles per hour, sec/veh = seconds per vehicle.

TABLE 3(c) Shared Space Measurements vs. Conventional Roundabout

| Location | Measured Vehicle Volume (veh/hr) | Predicted Capacity (veh/hr) | Predicted Volume-to-Capacity Ratio | Measured Delay (sec/veh) | Predicted Delay (sec/veh) |
|---------------------------|----------------------------------|-----------------------------|------------------------------------|--------------------------|---------------------------|
| Uptown Circle, Normal, IL | 81 | 927 | 0.09 | 4 | 5 |
| Fountain Place, Poynton | 600 | 737 | 0.81 | 6 | 27 |
| Koenitz Strasse, Bern | 624 | 370 | 1.69 | 16 | 346 |
| Laweiplein, Drachten | 680 | 807 | 0.84 | 10 | 28 |
| Seven Dials, London | 153 | 757 | 0.20 | 1 | 7 |
| Sonnenfelsplatz, Graz | 383 | 410 | 0.93 | 8 | 61 |

NOTE: vs. = versus , veh/hr = vehicles per hour, sec/veh = seconds per vehicle.

6.4.2.1 Shared Space versus Signalized Intersections

According to a national report, pedestrians at signalized intersections have been found to wait an average of 10.7 seconds before being able to cross (32). This is considerably higher than the

pedestrian wait times observed at the shared spaces, which were all less than 1 second. The shared spaces are undoubtedly more efficient for pedestrians than signalized intersections.

TABLE 3(a) shows the predicted capacities and delays if the shared spaces were to operate using a signalized intersection. The predictions suggest that signalized intersections will not offer a vehicle capacity as great as the shared spaces and will produce much more vehicle delay in most cases.

Fountain Place and Sonnenfelsplatz both have expected volume-to-capacity ratios greater than 1 (1.12 and 1.26, respectively), which led to extremely high predicted vehicle delays that are 134 and 163 seconds higher, respectively, than the measured delay times. In situations where a signalized intersection is expected to offer a capacity just above the vehicle volume, as is the case in Laweiplein, with a volume-to-capacity ratio of 0.96, the vehicle delay is still expected to be considerably higher (by 39 seconds) than the measured delay at the shared space.

The variation in the capacity and delay at signalized intersections is dependent on the vehicle volumes at the intersection, and on the respective signal timing.

As mentioned, the estimates of vehicle capacity and vehicle delay at signalized intersections are likely to be conservative in that they do not consider trucks, busses, bicycles, or a peak-hour factor. The literature review suggests that the predictions within the signalized intersection module of the software are reliable (27).

Thus, the results indicate that the shared space intersections operate much more efficiently and produce less delay for pedestrians and vehicles than signalized controls would at the intersections.

6.4.2.2 *Shared Space versus All-Way Stop Intersections*

No existing data regarding pedestrian wait times at all-way stop intersections could be found. As mentioned, however, average pedestrian wait times at all of the shared spaces were under 1 second. In addition, the majority of pedestrians were observed crossing per their desire lines, not at well-defined crosswalks. Thus, even if it is assumed pedestrians wait zero seconds to cross at all-way stop intersections, one must also consider the fact that they are likely not using the shortest path to their destinations as they do at the shared spaces. Considering this, the total travel time for pedestrians at an all-way stop intersection will undoubtedly be longer.

TABLE 3(b) shows the predicted capacities and vehicle delays if the shared spaces are to operate as all-way stop intersections. As was the case with signalized intersections, the predictions suggest that all-way stop intersections will not provide as great a vehicle capacity as the shared spaces, and will produce much more delay.

In situations where the all-way stop intersection offered a capacity equal to the vehicle volume, as is the case at Fountain Place, Koenitz Strasse, and Laweiplein, vehicle delays are expected to be 207, 56, and 336 seconds higher, respectively, than the vehicle delays measured at the shared spaces. These high vehicle delay times are a direct result of high vehicle volumes. But, even in cases where the all-way stop intersection offered a capacity greater than the vehicle volume, the predicted delays at all-way stop intersections were still higher than those observed at the shared spaces.

As indicated, the estimates of capacity and vehicle delay at an all-way stop intersection are also likely to be conservative, since pedestrian volumes, trucks, busses, bicycles, and a peak-hour factor are not considered. The literature suggests that the predictions within the all-way stop module of the software provide good estimations of the operation of actual stop-controlled intersections in the US (25,28).

Thus, the results indicate that the shared space intersections operate much more efficiently and produce less delay for pedestrians and vehicles than all-way stop controls would at these intersections.

6.4.2.3 *Shared Space versus Conventional Roundabouts*

According to a national report, average pedestrian wait times at conventional roundabouts are expected to be 2.1 seconds (32). As mentioned before, the average pedestrian wait times at the shared spaces were all less than 1 second, which suggests that pedestrians hesitate considerably less at the shared spaces than they do at conventional roundabouts.

TABLE 3(c) shows the predicted capacities and vehicle delays if the shared spaces were to operate like conventional roundabouts. The predictions suggest that conventional roundabouts can sometimes provide similar capacities, and produce similar vehicle delays as the shared spaces. The software predicted that a conventional roundabout at Uptown Circle and Seven Dials would produce vehicle delays just 1 and 6 seconds higher (respectively) than the measured vehicle delay at the shared spaces. At other times, however, the capacities of conventional roundabouts appear to be far less than the capacities of the shared spaces, as is the case at Koenitz Strasse and Sonnenfelsplatz, which had volume-to-capacity ratios of 1.69 and 0.93, respectively. These high volume-to-capacity ratios are expected to produce vehicle delays that are 330 and 53 seconds higher than the measured delay times at the shared spaces.

The high vehicle delays expected at a conventional roundabout for Koenitz Strasse and Sonnenfelsplatz appear to be a result of high pedestrian volumes coupled with moderate-to-high vehicle volumes at these sites. The predicted delay at a conventional roundabout for Uptown Circle is very similar to the delay time measured at the shared space. Since the design of

Uptown Circle is very similar to the design of a conventional roundabout, the similarity in vehicle delay time is expected.

As previously mentioned, and as with the signalized intersection and all-way stop intersection modules, the estimates of vehicle capacities and delays are likely to be conservative since trucks, busses, bicycle crossings, and a peak-hour factor were not considered. The literature suggests, however, that the predictions of vehicle delay within the roundabout module of the software might not be reliable (29-31).

In situations with lower pedestrian and/or vehicle volumes, it cannot be stated with certainty whether conventional roundabouts are more efficient for both pedestrians and vehicles than shared space. The results definitively indicate, however, that the shared spaces *are* more efficient and produce less delay for pedestrians and vehicles than conventional roundabouts when vehicle volumes are moderate-to-high and pedestrian volumes are high.

6.5 CONCLUSION

In this study, the characteristics and behaviors of pedestrians and vehicles at six shared spaces in five different countries were observed. The shared spaces carried up to 680 vehicles per hour and up to 1536 pedestrians per hour, exceeding volumes typical of conventional intersections with one approaching vehicle lane in each direction. Average vehicle speeds at the sites ranged from 5 to 10 miles per hour and appeared to be a function of the level of “sharedness” of a given site.

Traffic analysis software was used to determine the expected vehicle delay at intersections using traditional control systems with the same number of pedestrians, vehicles, and vehicle lanes as the shared spaces. The measured vehicle delays at the shared spaces were much

lower than the vehicle delays expected at intersections using traditional control systems.

Pedestrian wait times were also measured, and were found to be less than one second at all shared spaces studied.

This research suggests that the observed paradox of shared space—that while allowing freer pedestrian movement, shared space also promotes greater vehicle efficiency than conventional control systems—is indeed true. Both pedestrians and vehicles experience less delay at shared space intersections than they do at intersections using conventional controls. In addition to providing greater efficiency for pedestrians and vehicles, shared spaces' levels of safety are comparable to those of conventionally designed places (13,15-17), and shared spaces also deliver a much greater sense of place (3).

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7.0 CONCLUSION

From the literature review in the first report, it is strikingly evident that a reliable universal method to differentiate one shared space from another does not exist. Using Reid's seven objectives, however, allows one to assess how the level of sharedness varies from one street to another.

Reid's seven objectives can be transformed, and viewed on sliding scales for the following factors: 1. Sense of place; 2. Pedestrian comfort; 3. Ease in pedestrian movement; 4. Vehicle traffic dominance; 5. Economic regeneration; 6. Safety; and 7. Inclusive design.

Depending on the context and the design, shared spaces will fall in different places on the scale for each of these seven factors. The reach of the seven objectives can be measured through the methods and techniques applied in the existing literature discussed in the first report.

In conjunction with this assessment, a clear physical description or rendering, along with the specifics of the context in which each space lies, should be provided in order for readers to fully understand the differences among varying shared spaces. This is why the second report provides readers with photographs and clear descriptions of each study location.

In the second report, the characteristics and behaviors of pedestrians and vehicles at six shared spaces in five different countries were observed. The shared spaces carried up to 680 vehicles per hour and up to 1536 pedestrians per hour, exceeding volumes typical for conventional intersections with one approaching vehicle lane in each direction. Average vehicle speeds at the sites ranged from 5 to 10 miles per hour and appeared to be a function of the level of "sharedness" of a given site.

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vehicle lanes as the shared spaces. The measured vehicle delays at the shared spaces were much lower than the vehicle delays expected at intersections using traditional control systems.

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This research suggests that the observed paradox of shared space—that while allowing freer pedestrian movement, shared space also promotes greater vehicle efficiency than conventional control systems—is indeed true. Both pedestrians and vehicles experience less delay at shared space intersections than they do at intersections using conventional controls. In addition to providing greater efficiency for pedestrians and vehicles, shared spaces' levels of safety are comparable to those of conventionally designed places (Euser, 2007; Dong, 2012; Swinburne, 2006; Quimby and Castle, 2006), and shared spaces also deliver a much greater sense of place (Karndacharuk, 2013).

The two reports included are not exhaustive of the matters discussed. They are meant to provide motivation for future work and future study. Even though all shared space has not been created equal, its range can be systematically classified, and the resulting classifications could be effectively utilized by transportation engineers and urban planners. The methodology applied in the second report could be extended by observing the shared spaces under varying conditions, and utilizing other traffic analysis or traffic simulation software packages, such as Vissim or Synchro, that potentially provide a more sophisticated analysis of pedestrian-vehicle interactions and behavior.

8.0 APPENDIX A

LIST OF REFERENCES FOR [4.0 INTRODUCTION] AND [7.0 CONCLUSION]

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