The Feasibility of a New Shared Space in Canberra

Improving the Bunda Street Shareway Design and assessing the feasibility of converting Lonsdale Street into a shared space

u5589902

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Abstract

Shared spaces are a recent urban traffic engineering concept that aim to integrate road users through the removal of traditional traffic control devices. They reduce the dominance of cars in public spaces by allowing user behaviour to be determined by social protocols instead of traffic rules, with the ultimate aim of increasing accessibility and safety for pedestrians and cyclists. This report investigates the success of the Bunda Street Shareway design and how it could be improved, identifies safety issues through evaluating existing Shared Space implementations around the world and evaluates the feasibility of implementing a Shared Space on Lonsdale Street in Braddon. Various aspects of the Bunda Street Shareway design were examined, including the road changes, signage, advertisement, safety measures for vulnerable users, construction time and costs involved. Recommendations are made on how the design could be improved and how it would need to implemented if applied to Lonsdale Street.

Contents

Introduction to Shared Spaces

The ‘shared space’ concept is a novel approach to road design in Australia aimed at encouraging active transport and accessibility in public spaces. The design involves integration of different road users, where social protocols replace traffic controls to determine who has right of way. The shared space concept originated in Northern Europe (Shared Space Institute, 2009), and has recently been implemented in Bunda Street, Canberra.

The Woonerf principle was developed in the Netherlands in the late 1960’s and was used as the basis of the Bunda Street Shareway design. (B. Maynard et al. 2014) A ‘Woonerf’ is a residential street where cyclists and pedestrians have legal priority, and encourages slower speeds by adding traffic deflecting obstacles that vehicles need to navigate. (U.S. Department of Transportation, 2006) The Dutch traffic engineer Hans Monderman redesigned several roads in the Netherlands using the Woonerf principle in the nineties, and the concept was given the term ‘shared space’ in 2003 by British architect and urban designer Benjamin Hamilton-Baillie. (Edquist, J. Corben, B. 2012)

The theoretical idea underpinning the shared space concept is that introducing an element of risk changes user behaviour. (Hamilton-Baillie, 2008) When drivers are uncertain of how to behave and a space seems unsafe, they will slow down and negotiate movement through social means such as eye contact. Previous implementations of shared space schemes have demonstrated a reduction in vehicle speeds, reduced congestion, fewer collisions and more visually appealing streets.

This report will assess the suitability of a shared space to improve pedestrian accessibility on Lonsdale Street, evaluate the Bunda Street Shareway design and identify design improvements. Human, time, material and energy aspects of the design will be considered for improvement, as well as implementing a feedback system and considering overall costs and benefits.

Assessing the suitability of more shared spaces in Canberra

Lonsdale Street has one of the largest numbers of retail drink/food entrances within view of the street in Canberra Central. (ACT Government, 2012) It has high pedestrian density and currently does not have any crossings or traffic lights to facilitate safe pedestrian crossing. The general cross section layout of Lonsdale Street is shown in figure 1. The median strip allows for centre of the road parking, which combined with the trees obstructs drivers ability to see pedestrians crossing. The current speed limit is 50 km/hr, which is high considering the high pedestrian movement in the street. These current issues make it clear that Lonsdale Street requires development to increase pedestrian accessibility, therefore transforming the street into a shared space is a feasible option.

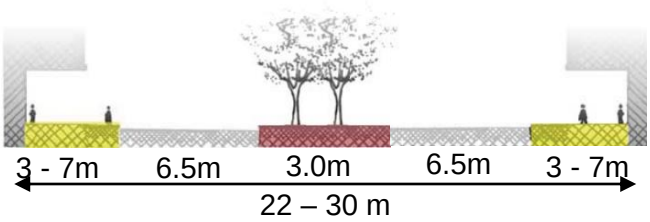

Figure 1: General cross sectional layout of Lonsdale Street

Assessing whether a road space is suitable for transformation into a shared space is a complex problem, as successful implementations around the world vary in both design and functionality. Therefore there is no standard criteria that can be used for evaluation, or a standard design that should be applied. The core principle of a shared space is achieving integration instead of segregation between road users, such that vehicles do not dominate the space. To determine whether integration is feasible, Monderman's classification of all roads as either 'traffic zones' or 'social zones' serves as a useful segregation of road types for suitability as shared spaces. The sole purpose of a traffic zone is the movement of traffic, and it is defined by strict regulations, uniform standards and predictable movement. 'Social zones' are multi-functional, they serve a diverse range of purposes and are more personal and unpredictable. Since many road spaces can fall into both categories, understanding current road purpose and ability to implement a clear transition between the zones is necessary. (Edquist, J. Corben, B. 2012)

Determining whether Lonsdale Street is classified as a 'traffic zone' or 'social zone' can be achieved by considering its current uses. Currently Lonsdale Street has one of the largest numbers of retail drink/food entrances within view of the street in Canberra Central, at more than 50. (ACT Government, 2012) It also has high pedestrian and cyclist density, and does not need to be used as a through route by cars since Mort Street and Torrens Street both provide alternatives. Considering its multi-functionality due to surrounding businesses and social spaces, Lonsdale Street can be considered a 'social zone'.

Feasibility and Design Survey

In order to assess the feasibility of another road space in Canberra implementing the shared space methodology, gauging the current opinion of the recent Bunda Street development can provide information on how a new shared space would be received. A survey was conducted to gain the perspectives of current stakeholders. Business owners along Bunda Street were surveyed individually to gain an understanding of how the Bunda Street Shareway has been received by businesses and highlight any problems with the current design. The surveys were conducted as in-person interviews with the respondents remaining anonymous. Steps were taken to reduce interviewer induced bias, through careful question phrasing and remaining neutral towards responses.

The surveys aimed to address the following research question, 'How has the Bunda Street Shareway been received by stakeholders, and what is the current opinion towards implementing the design in Lonsdale Street?' Two of the questions addressed how the Shareway has been received and how it has affected

businesses in the area. The results to these questions are shown below in figure 2, and indicate there is currently a mixed opinion towards the design but there has been little effect on business patronage.

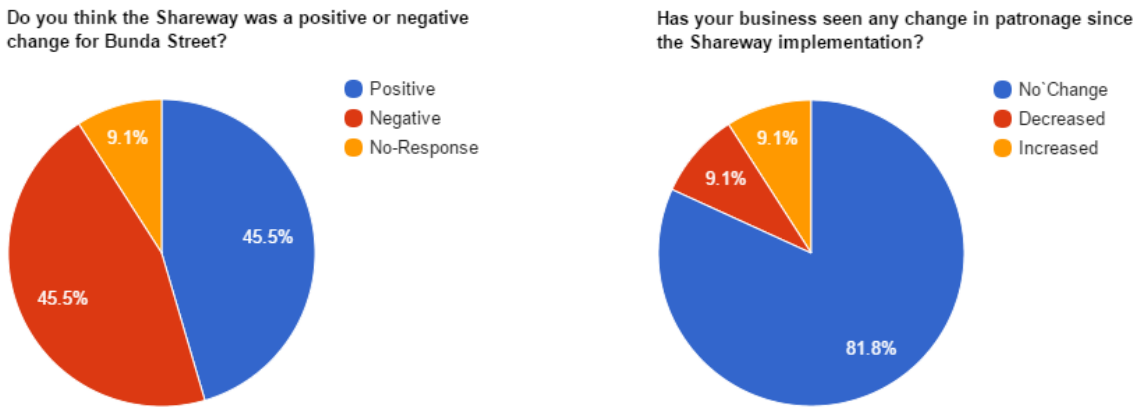

Figure 2: Pie charts representing results for first two survey questions

The third question aimed to determine what aspects of the design require improvement. As can be seen in the bar graph in figure 3, parking and user understanding were of particular concern to respondents. It is likely parking was identified as an issue because the primary concern of businesses is not losing customers due to inconvenience, however it will be later discussed how integral reduced parking is to pedestrian safety. User understanding is an important concern, as it is fundamental to the successful implementation of the shared space concept. This result indicates that there has not been adequate education on how the space works since the Shareway has been implemented.

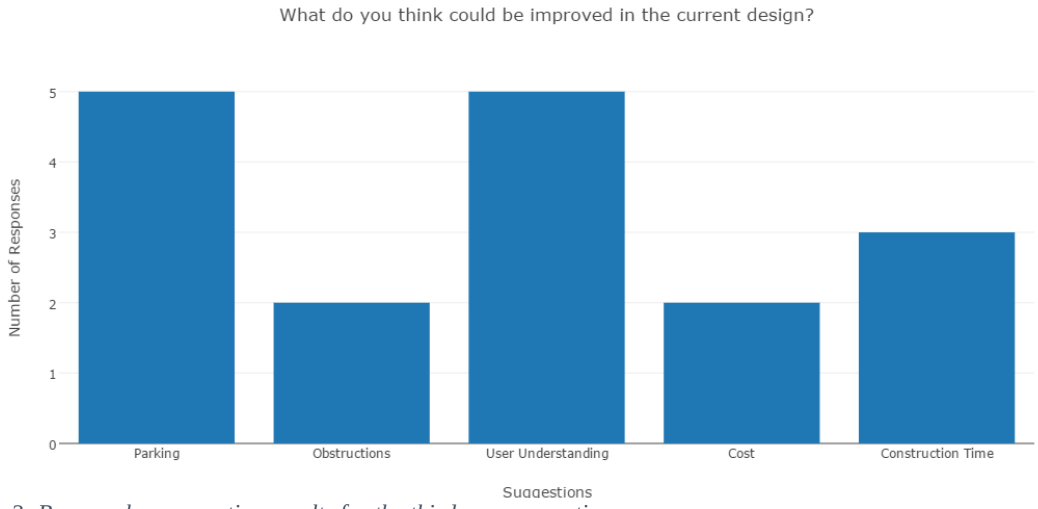

Figure 3: Bar graph representing results for the third survey question

The final question was simply to gauge the current public's response to the idea of transforming Lonsdale Street into a shared space, which as shown below had a mixed response. It should be considered that the respondents may have limited knowledge of Lonsdale Street, however this response indicates that the majority of respondents think the shared space concept has potential in other parts of Canberra.

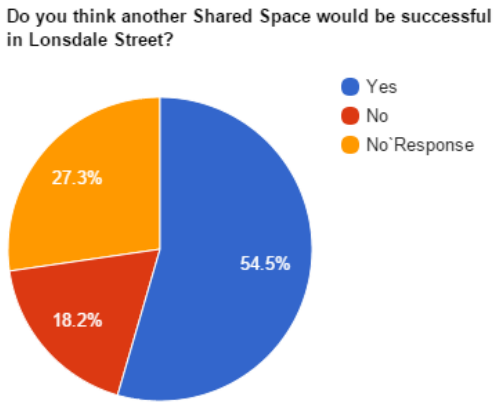

Figure 4: Pie chart representing survey results for the fourth question

The survey results provide an insight into how the Bunda Street design would need to be improved if implemented in Lonsdale Street, and indicates that the public is open to the idea of a Lonsdale Street as a shared space.

Australian Legislation

These survey results provide a useful insight into the suitability of Lonsdale Street as a shared space, however it should also be considered how the space would align with current Australian legislation and guidelines. Shared spaces do not form a part of Australian Legislation, and since the ACT does not provide their own shared zone guidelines, the suitability of Bunda Street to be turned into a Shareway was assessed primarily against the Austroads *Guides to Traffic Management* shared zone guidance. (B. Maynard et al. 2014) The road characteristics that were assessed for Bunda Street prior to development are compared to the road characteristics of Lonsdale Street in table 1.

Table 1: Road characteristics comparison (ACT Government, 2012, B. Maynard et al.)

Road Characteristic	Recommended	Bunda Street Context	Lonsdale Street Context
Speed limit	10 km/hr	30-40 km/hr	50 km/hr
Vehicle volume/hour	100-200	500	~500
Vehicle volume/day	1000	4000-5000	-
Lane width	2.5m – 2.8m	3.5m – 4.0m	6.5m (approx.)
Road length	≤ 400m	> 600m	> 600m
Alternative through routes?	Yes	Yes	Yes
Pedestrian volume	High	825 / hour (approx.)	130 - 340 / hour (approx.)
Foot path space	Sufficient	6m – 8m	3-7m

Various values for Lonsdale Street were not able to be sourced, therefore the lane width, vehicle volume/hour and foot path space were independently measured and are only estimations. The main outcome of this comparison is that Lonsdale Street does not need to be used as a through route, has a sufficient pedestrian volume and adequate foot path space. This analysis highlights changes the shared space development will need to make, such as lane width, speed limit and vehicle volume, to make Lonsdale Street suitable as a shared space.

Since shared spaces are still a novel concept in Australia, previous shared space implementations around Europe can be looked to for comparison. Each of the road spaces which use shared space principles vary in design and purpose, highlighting the individuality of each implementation. Shared Spaces have been used to reduce traffic in busy CBD's, reduce waiting times at intersections, provide better pedestrian accessibility and safety in pedestrian dense areas, and even encourage more active travel in villages where a whole area have been converted to shared spaces. The common characteristics of these places are high pedestrian density, a need for reduction in traffic density or speed, surrounding social attractions and a desire to encourage active transport in the area. (Allan Quimbly and James Castle, 2006)

The qualitative and quantitative factors considered in this section suggest that Lonsdale Street is suitable for transformation into a shared space if the design is well thought-out and developed to cater for the individuality of the road space. The Bunda Street Shareway provides an effective model, however certain aspects of the design will need to be changed to suit the needs of Lonsdale Street.

Design Considerations

The design of a shared space is integral to it being successfully and safely utilised. They require a basic level of user understanding and accessibility to ensure safety, as well as a design that allows for sufficient traffic movement in order to make the space efficient. Construction time, materials and energy in the system need to be considered to reduce the environmental impact as well as the cost of development. Implementing a traffic feedback system can also increase the efficiency of traffic movement and maximise user safety.

The Bunda Street Shareway design provides a useful starting point for improvement, however overseas implementations also provide design insights. Since the fundamental purpose of a shared space is to improve the accessibility and safety of a road space for all road users, human factors are the most important design consideration.

Human Factors

The predominant human factor of concern in the design is safety. The most important safety considerations for design can be determined by reviewing the fundamental risk perception concepts that

define how shared spaces function, evaluating collision data from European implementations and considering user ergonomics to ensure 'vulnerable users' are not at risk.

Risk Perception

Shared spaces are still a novel traffic concept in modern society, and ultimately rely on underlying social protocols and user understanding to function effectively. It is difficult to discern the long term response to such a development, as any effects on drivers could be in response to a novel environment. The success of the design is highly dependent on how the behaviour of users changes with time. The underpinning theory behind the shared space concept is reported by Hamilton Baillie (2008), who states that removing defined traffic controls increases the perceived risk by the driver and allows more powerful social behavioural constraints to dictate movement. This idea is based on John Adams' work on risk perception, and suggests that risk removal encourages more engagement with surroundings by both pedestrians and drivers. (Adams, J. 2008; 1988) However, since this response relies partially on perceived risk and people acclimatise to risk with familiarity, the effects of this risk on behavioural adaption could reduce over time. (Maynard, B. et al. 2014)

By considering altering how much traffic control is removed we can increase or decrease perceived risk, and affect how cautious users are in the environment. Removing the defined lanes and road lines, and raising the pavement to footpath level is the first step in changing the road environment. It creates ambiguity, which increases risk for drivers and causes them to slow down. Minimalizing signage is also important to make the rules of the space simple, and reducing speeds makes the additional risks significantly safer. However, although increasing perceived risk will change the behaviour of the majority of drivers, as stated by Hans Monderman you cannot alter the behaviour of "the 15 percent of drivers who will behave badly no matter what the rules are" (Maynard, B. 2014). The important thing is that the actions of this minority do not alter the social norm and cause higher speeds to become common behaviour.

It is necessary for the design to make it clear to users that there has been a change from a normal road space to a shared road space. This involves changing the road surface to a material other than bitumen, such as stone pavement, and effective use of street furniture, so that clutter is reduced but the space still has a social atmosphere. One of the most important aspects of altering how a driver perceives risk is the number of pedestrians/cyclists using the space. The higher the number of pedestrians, the more clear it is to drivers that the space is shared.

Evaluation of European Implementations

Evaluating collision data from European implementations is useful to gain an insight into how to increase the safety of shared spaces and what level of risk is necessary. In the Netherlands, the conversion of a four-leg intersection into a roundabout with fountains and courtesy crossings for pedestrians, known as the Laweiplein 'squareabout', had nearly a 90% decrease in crashes in the two years following

redevelopment. (Hamilton-Baillie, 2008) The design involved minimised signage and road markings, and was designed to have an unclear distinction between where the car zone finishes and the pedestrian zone starts. The majority of users polled after implementation felt the system was more dangerous, but it actually proved to be safer. (NHL, 2007)

In Freisland (also in the Netherlands), the town of Oosterwolde had a road junction and shopping street converted into a shared space with the removal of signs and lines and coloured surface treatment. The shopping street saw a 10% reduction in collisions in the 3 years following development. (Quimbly, A., Castle, J. 2006) A crossroads in Drachten had traffic signals removed and the road redesigned, however the speed limit was kept at 50 km/hr and there was a significant increase in collisions in the year following implementation. (Quimbly, A., Castle, J. 2006) At a different central crossroad junction in Drachten was converted to an open square with a textured surface, and traffic signals were removed. This change has currently seen a slight reduction in collisions. (Quimbly, A., Castle, J. 2006) Although this is only a small sample of shared space implementations, it is evident that the amount of risk integrated into the design significantly effects the safety of a shared space. If traffic signals are removed without a reduction in speed then the risk is too high, and can be dangerous for users. If users do not perceive there to be any risk they will not change their behaviour.

Evaluation of the Bunda Street Shareway

The Bunda Street Shareway design incorporated raised pavements, removed defined lanes and road lines and reduced signage (B. Maynard, et al. 2014). From the businesses surveyed, a common response when asked about the impact of the Shareway was that there was ‘confusion’ from all user types and the design ‘seemed dangerous’. This shows that there has been a noticeable level of risk implemented into the design, but whether it has had the desired effects on user behaviour is yet to be determined. As seen in the public’s response to the Laweiplein ‘squareabout’, user opinion of safety does not necessarily reflect how safety has been affected. In saying this, shared spaces are meant to be positive public spaces, and pedestrians should feel safe in the environment to ensure continued high pedestrian usage. This highlights that inadequate public communication of how the space functions was a flaw in the Bunda Street Shareway implementation, as the users do not yet understand that caution is a necessary part of the design.

Vulnerable Users

The final, and arguably most important, safety consideration is how shared spaces facilitate for ‘vulnerable users’. User ergonomics need to be considered when evaluating safety, as the size and physical ability of users may make them more at risk in a shared space environment. (Edquist, J. Corben, B. 2012) Blind and visually impaired users are not able to negotiate the space based on visual cues such as eye contact. Deaf and hearing-impaired users are unable to hear vehicles and pedestrians approaching from behind. Mobility impairment may make some users unable to avoid faster moving vehicles if necessary, and elderly, young or cognitively impaired pedestrians may lack a sufficient understanding of how the space works.

It is suggested by Heinz, a German town planner experienced in shared space design, that to make shared spaces more usable it is not necessary for the entire road space to be shared. Instead, there can be designated 'safe spaces' for pedestrians where vehicles do not enter side areas, typically in a 30:40:30 ratio. (Heinz, 2010) This segregation can be achieved through the addition of trees and furniture, and should marked with delineators for visually impaired pedestrians. Childs et al. (2010) found that the most effective method of delineation is the use of blister paving (in 80cm strips), which is the method used in the Bunda Street design.

It should also be considered that if safe spaces are marked with street furniture or trees they may act as obstructions for mobility impaired users. Therefore adequate space must be provided for user mobility. If parking is reduced or removed in the space than adequate nearby parking should be provided to ensure disabled and elderly users are still able to utilise the space. Finally, the most important point is to make sure there is significant consultation with the various vulnerable users groups throughout the whole detailed design process to ensure they are adequately catered for in the final design.

Through considering how human factors interact with the design, the following design recommendations can be made:

- Traffic control devices must be reduced to provide an adequate perception of risk and encourage users to act with caution
- Speeds need to be reduced so that the risk is controlled
- Public communication is of significant importance so that users are aware of the changed environment and pedestrians feel safe in using the space
- Safe spaces for pedestrians should be integrated into the design, possibly in a 30:40:30 ratio, and marked with delineators for visually impaired users
- There should be adequate space provided for user mobility in safe spaces, with nearby parking for accessibility

Time Factors

The shared space concept has various temporal aspects that require a fine balance to ensure optimal implementation of the design. The two temporal aspects that will be analysed are wait time, to ensure user satisfaction and increased safety, and construction time, to reduce the negative effects of implementation on businesses.

Wait times

Waiting times usually have negative effects on a system, causing additional costs and user dissatisfaction. However in shared spaces waiting times can play a significant role in the success of the design. After initial implementation, lowered speed limits and being required to stop for pedestrians/cyclists may

increase wait times for drivers who use the space as a through route, and may therefore encourage them to seek alternative routes. This in turn reduces traffic volume, which in turn can make the space more pedestrian focussed and increase safety. The changes in traffic density as waiting time increases over time is shown in figure 5, and from this graph it is evident that there is an optimal point where waiting time and traffic density cross. The effect occurs early in the development, as the change in street design rapidly increases waiting time which will in turn rapidly decrease the traffic volume. Once waiting time has been realised by users, both aspects will plateau.

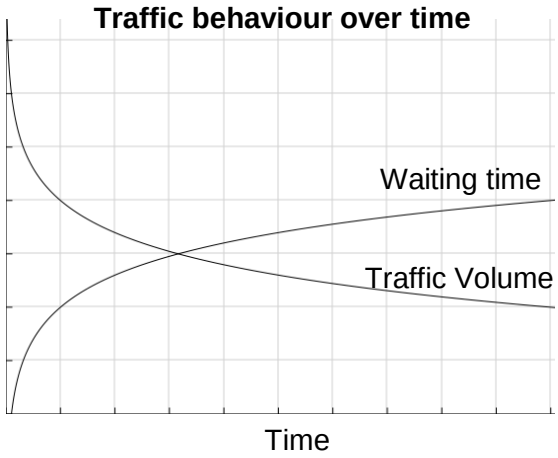

Figure 5: Traffic behaviour over time graph

In some situations, shared space design can eventually decrease overall waiting times for drivers. The previously mentioned Laweiplein 'squareabout' in the Netherlands saw a 20 second decrease in waiting time after implementation, despite an increase in vehicle volume. (Quimbly A. & Castle, J. 2006) In the case of Lonsdale Street, through qualitative observation of road users it was noted that main cause of vehicles needing to wait is because of other vehicles slowing down to park. Therefore if the design was implemented with reduced parking in order to encourage a more pedestrian focus, it is plausible that vehicles may travel with less interruption through the street, despite the slower speed.

Construction Time

Another important time consideration is the stages in which the design is implemented. Timing the development steps can have significant impact on how construction affects businesses in the area and how the space is received by the public. The Bunda Street Shareway design was implemented in two stages. The first involved introducing the new speed limit, raised entry thresholds and raising of road surface at intersections, removal of formal crossings, semi-permanent stencils on the road surface and additional street furniture. The second stage involved complete raising of the road surface, stone paving on the raised surface and additional street trees. (Maynard, B. et al. 2014) The first stage was implemented between September and December of 2014, before the Christmas shopping period, and the second between January and April 2015. (Maynard, B. et al. 2014) As realised through the survey, the two stages meant two disruption periods for businesses.

The implementation process can be broken down in a PERT chart as shown in figure 6. The PERT chart shows that the two most time consuming stages of the critical path, shown in yellow, are project planning and construction. Reducing the amount of time dedicated to project planning is likely to increase the time taken to complete later stages, and is therefore not an effective method of decreasing the overall time of implementation. However, as shown with the Bunda Street design, construction time is critical to the success of how the space is received and the size of associated costs to stakeholders. The construction time of the Bunda Street Shareway was drawn out due to the repetition of steps, i.e. applying semi-permanent stencils and then later changing to stone paving. Therefore if the construction process was completed without interruption it would reduce the overall implementation time and have less of an impact on Lonsdale Street businesses.

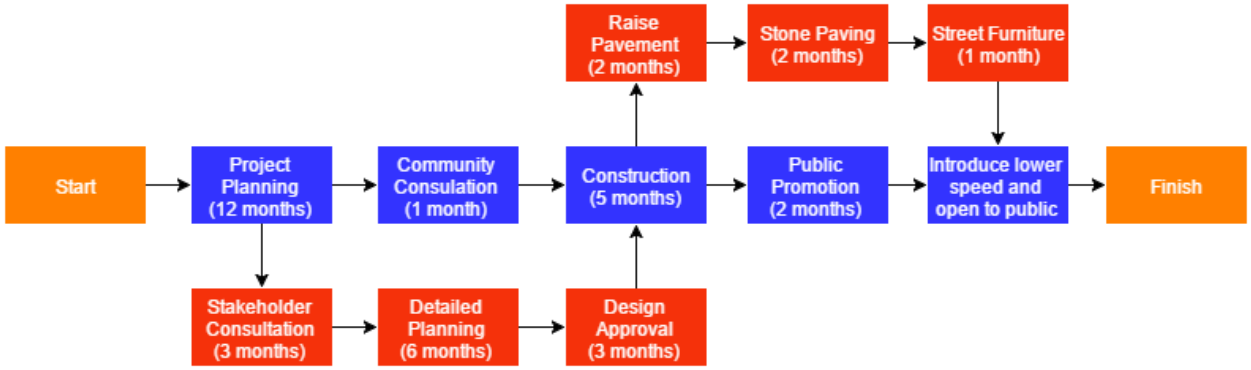

Figure 6: PERT chart for Lonsdale Street shared space implementation based on estimated times

Considering the impact of time factors leads to the following design recommendations:

- Reduce the number of parking spaces to encourage smooth traffic flow and reduce obstructions
- Complete construction in one stage to reduce overall implementation time

Material Factors

There a two major material aspects in this design; the removal of current road infrastructure, such as bitumen, and the addition of paving and more street furniture on the new raised road. Changing the road material is important for road aesthetics in order to make users more aware of the change in road space. Therefore considering the end of life of the current road space and the materials used in the new road space will enable the necessary design changes to occur whilst minimising material impact.

The bitumen in the road will need to be removed in order for it to be raised and paved. Bitumen can be recycled, and there is a recycling facility within 6 km of Braddon, REMONDIS Australia Pty Ltd. (Business Recycling, 2015) In order to decrease material removal, the plane tree lined nature strip through the middle of Lonsdale Street would be not need to be removed. It is already at the raised road level height, and the addition of trees assists in making the space seem smaller, segregates traffic moving in different directions and creates a further ‘hazard’ in the space to calm traffic speeds. The Braddon

Planning Study also make the point that the trees 'emphasise the link between Haig Park and the city' and provide 'significant amenity'. (ACT Planning and Land Authority, 2008)

The materials used in the implementation are predominately the paving material to raise the road level and the material of the street furniture such as bench seats and bike rails. The Bunda Street Shareway design used a stone sett material for paving, although it has been unspecified as to exactly what material was used. (Maynard, B. et al. 2014) It can be assumed granite was used as this aligns with the paving specifications listed in the Canberra Central Design Manual provided by the ACT Government Territory and Municipal Services. (Territory and Municipal Services, 2007)

Negligible process energy is involved with stone processing, as it is quarried and then cut at a factory. However, as it is a heavy material there is a lot of energy associated with transportation, therefore selecting a regional quarry could reduce the carbon emissions involved with transport. (Material Life, 2013) The Canberra Central Design manual also provides the technical details on the size and materials that should be used for street furniture. (Territory and Municipal Services, 2011) Assuming new seating would follow the seating with the half arms design, high strength, durable 306-stainless steel frame should be used with planking slats made from aggregate and polyester resin. Bike rails should be made out of 304-stainless steel. Determining exactly how many seats and bike rails are required would be a component of the more detailed design process, however an estimation can be made based on the shared space design proposal by TRACT, which suggested an extra 25 seats and 32 bike rails (TRACT, 2014). These figures seem reasonable as they are slightly higher than the Design Standards for Urban Infrastructure's guide to street furniture numbers, using the classification of Lonsdale as a suburban centre. (Urban Services, 2003) This is to be expected because the area can be approximated as a suburban centre but it also an urban space within the city, and therefore should be also evaluated on a specific needs basis.

Table 2: Material Audit (YourHome.gov, 2013, Hiroyuki Fujii, et al. 2005)

Part	Material	Mass required	Embodied energy/kg	Total embodied energy
Pavement	Granite	3148470 kg	5.9 MJ/kg	18575.97 GJ
Seating	306-stainless steel	101.8kg/bench	54 MJ/kg	137 440 MJ
	Polyester resin	15.8kg/bench	90 MJ/kg	35 551 MJ
Bike Rails	304-stainless steel	48.8kg/bike rail	54 MJ/kg	84 354 MJ

Back of the envelope estimations can be used to provide an estimate of the embodied energy of the required materials, through estimating the mass of materials needed for each component and multiplying it by embodied energy/kg of the material. The details of the mass fermi estimates can be found in Appendix A and the material audit can be seen in table 2.

The materials analysis indicates that to reduce the material impact of this design, a balance needs to be found in the detailed design stages between aesthetics and material reduction to determine the minimum amount of street furniture needed. From this analysis the following recommendations can be made:

- Bitumen should be recycled after removal and the nature strip should remain as a feature of the shared space
- The minimal amount of seating and bike rails should be determined to reduce the material impact

Energy Factors

Shared spaces aim to reduce energy consumption by encouraging active or public transport over private vehicle use. Therefore the reduction in energy consumption of the system will be dependent on how effectively the shared space alters the transport mode of road users. The energy flow in the system is represented by the vehicles making use of the space, as all vehicles using the space instead of public transport can signify an energy loss. In order to analyse the current energy flows in the system, a traffic flow Sankey diagram, figure 7, was created to visualise the primary movement of vehicles. The data for the Sankey diagram was independently gathered at the roundabout at the junction between Elouera Street and Lonsdale Street, and represents traffic movement within one hour.

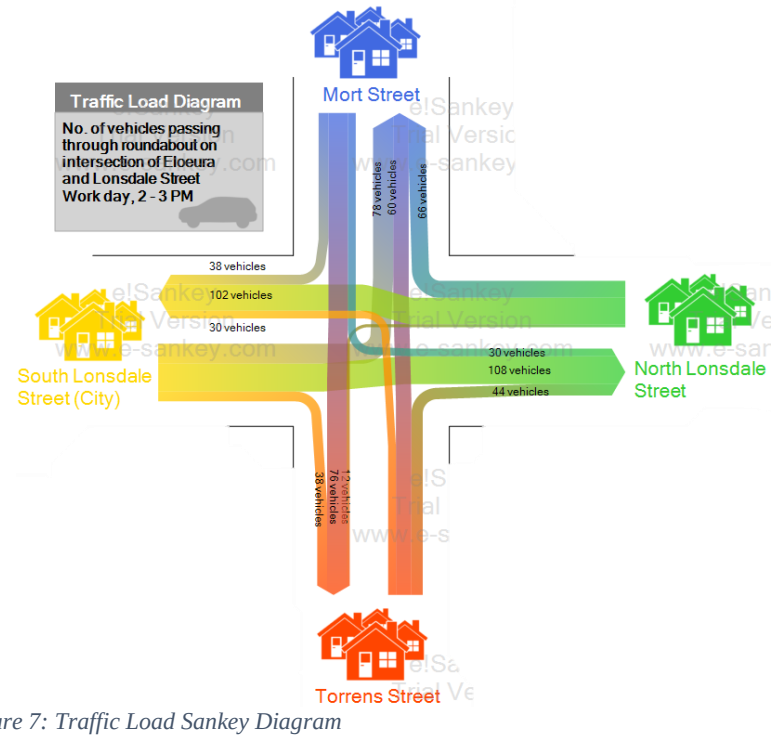

Figure 7: Traffic Load Sankey Diagram

Using the Pareto principle to analyse this Sankey diagram, it can be seen that the heaviest traffic flow is along Lonsdale Street. This presents the best opportunity for reducing energy losses, since users travelling by vehicle along Lonsdale Street can be encouraged to use public or active transport to access the street instead. It also indicates that cars are currently using Lonsdale Street as a through route, however since

there are two alternative options (Mort Street and Torrens Street) a shared space would likely encourage these users to use an alternative through route if Lonsdale Street is not their destination point.

This analysis highlights the importance of integrating public and active transport facilities into the design. If users are provided with a more appealing and convenient option, the system will become more energy effective. This can be achieved through more bus stops near entrances to the street, increased bike storage, accessible cycling lanes and footpaths in surrounding streets and alternative parking options close by to allow users to walk the rest of the distance to their destination. Therefore the recommendations from this analysis are:

- Increase accessibility to public and active transport in the area through improvement of bus services and pedestrian/cyclist accessibility
- Assess the feasibility of adding alternative parking options in the surrounding area

Dynamics and Control

Shared spaces are dynamic systems that rely on steady traffic flow (of both pedestrians and vehicles) to minimise delays. As aforementioned, waiting times are important in controlling traffic density and subsequently increasing user safety. Applying a method of feedback within the shared space design could assist the system in finding the optimal waiting time and traffic density while reducing user dissatisfaction caused by vehicle congestion. The aim of the feedback system is to notify users of the current traffic volume before entering the space, so that they can make a more informed decision on whether it is beneficial to enter. Feedback systems have been used in other shared space implementations, most notably at the Laweiplein 'squareabout'. (Quimbly A. & Castle, J. 2006) Water jets by the side of the road are connected to traffic sensors and respond to traffic volume by changing the water jet height, and have proven effective in controlling traffic activity. The water jets also have the duel benefit of attracting human activity and changing the feel of the space, which helps to further slow traffic. In this feedback system the traffic sensors are the sensing mechanism, the water jets are the actuation mechanism and the computation is the user determining whether or not to enter the space. The feedback loop of this situation can be visualized as follows:

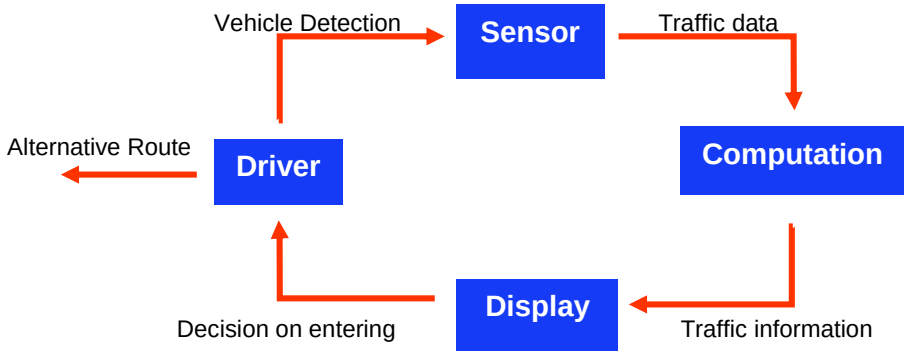

Figure 8: Feedback system to alert road users of traffic density

The Bunda Street Shareway design does not incorporate a feedback system, however it has five entry and exit points at different locations that may have made this addition more difficult. (TRACT, 2014) Lonsdale Street on the other hand has only three entry and exit points for vehicles, therefore setting up a traffic feedback system is feasible. This could be in the form of water jets, or simply a number display, at the entrances/exits. The feedback response of drivers would reduce congestion, which in turn makes the shared space more accessible for pedestrians and encourages other methods of transport into the area. The primary recommendation of this analysis is to implement a feedback system into the final design.

Cost factors

Cost will be influential in several of the design choices, but it should be a secondary consideration to safety and aspects involving efficient traffic flow. A shared space is public infrastructure that would be of benefit to the community in more ways than monetary profit, therefore the community benefits of the design need to be considered in conjunction with the cost.

Currently business owners in Braddon pay a business levy, along with all other commercial properties in the CBD, to the ACT treasury which is distributed as a grant by the Economic Development Directorate. (Canberra CBD Ltd., 2015) The first levy was granted to the non-for-profit business Canberra CBD Limited in 2007 to fund their goal of improving Canberra's business district. Braddon property owners have recently spoken out about the business levy not being put to use in the district, and are calling for the Government to designate more of the funds on improving the area. (ABC, 2015) Therefore it is likely with enough public pressure and evident need that the Government will include Braddon as a focus of further city improvements.

The Bunda Street Shareway was funded as a part of the ACT Government's $6 million Civic Cycle Loop project (ACT Government, 2015), with the probable construction costs for the Bunda Street section of the development projected to be $0.55 million. (ACT Government, 2011) There is no public confirmation on the final cost of the development and no publicly available cost evaluation. Assuming the projected cost to be accurate, it is reasonable to expect a shared space on Lonsdale Street to have similar costing based on it being a similar length and being modelled off the same design.

The most beneficial way to evaluate whether the development is economically feasible is to conduct a cost-benefit analysis. This should be a major component of the design process. A good cost benefit analysis factors in economic and population growth over time and considers future benefits and risks that are unknown or difficult to quantify (Business Council of Australia, 2012). The base case would need to include an assessment of the costs of the Bunda Street development, the current and projected ongoing costs of its maintenance, how the development has been received by the general public and the benefits of the current design. A policy option that can be compared to the base case is implementing a new shared space in Lonsdale Street. The costs associated with this policy will be the cost of infrastructure, such as

raising the road level, increasing seating and bike rails, the cost to businesses in the area during construction, cost of advertisement, cost of noise pollution to community, cost of traffic disruption to community and ongoing maintenance costs. The benefits associated with this policy are increased pedestrian traffic to businesses, increased pedestrian safety and accessibility, community connectivity (due to use for social events), increase in active and public transport use and decreased vehicle congestion in the city.

To assign values to these costs and benefits, we determine what can and cannot be quantitatively valued. For instance, infrastructure has aspects with a market price such as materials, construction labour and maintenance which can be quantitatively valued. However some aspects can only be qualitatively valued, such as pedestrian confidence in safety and user cost of traffic disruption. It should be noted that some assumptions may have to be stated in order to determine values, and the values determined will likely be based of today's values. To avoid discounting the value, the impact of the discount rate would need to be evaluated.

To calculate the overall value, the net present value is the most straight forward method for this project. This involves comparing all future discounted benefits with future discounted costs to arrive at a single value. Obtaining this result from conducting a cost benefit analysis will be a useful tool in determining the feasibility of this implementation, and it is recommended that it forms a major part of the detailed design process.

Conclusion

This report has found that the conversion of Lonsdale Street into a shared space is a feasible option for increasing pedestrian accessibility and road safety in Canberra's CBD. The qualitative and quantitative analyses confirm that Lonsdale Street is a suitable road space for the implementation of the shared space concept if the Bunda Street Shareway design is improved. The design considerations are evaluated using various analysis techniques and recommendations are made for the design as a result of these analyses. A summary of the primary recommendations for the shared space design can be found in appendix B. These recommendations can be used as a guide to highlight the primary considerations of a new shared space development, and provide the foundations for a more detailed design to take place.

If this concept is to move forward, the final recommendation of this document is to not underestimate the importance of community consultation. Shared spaces are meant to benefit users and enhance road spaces, therefore the needs of the users and the individuality of the road space need to be the primary consideration of any shared space design.

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APPENDIX A – Mass Estimations for Material Audit

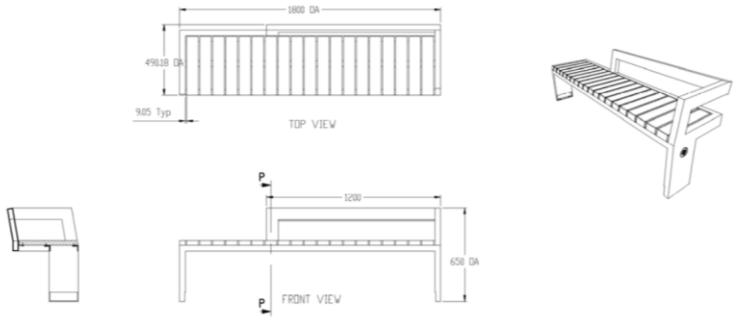
The fermi estimates for mass for the materials analysis are explained below. Available data was used where possible to assist with accurate assumptions however, as is the nature of fermi estimations, the accuracy of the resulting numbers cannot be confirmed.

Granite paving

If granite paving was used for Lonsdale Street, the area that would need to be covered is approximately 15,600 m^2 (based on independent approximate measurements). Assuming 60 mm thick slabs, 1170 m^3 of granite would be needed. The density of granite is 2691 kg/m^3 therefore the overall mass of the granite needed is 3148.47 tonne. (SI Metric, 2011)

Seating

Assuming the seating with the half arms design, using 306 stainless steel and the dimensions specified in the Canberra Central Design manual, the amount of steel in a single chair was estimated.



Cross section of hollow steel rectangular tube: $(10 \times 20 \times 2) + (10 \times 70 \times 2) = 1800mm^2$

Total volume needed: $1800[(4 \times 200) + 1200 + (3 \times 490) + (2 \times 1800)] = 0.012726m^3$

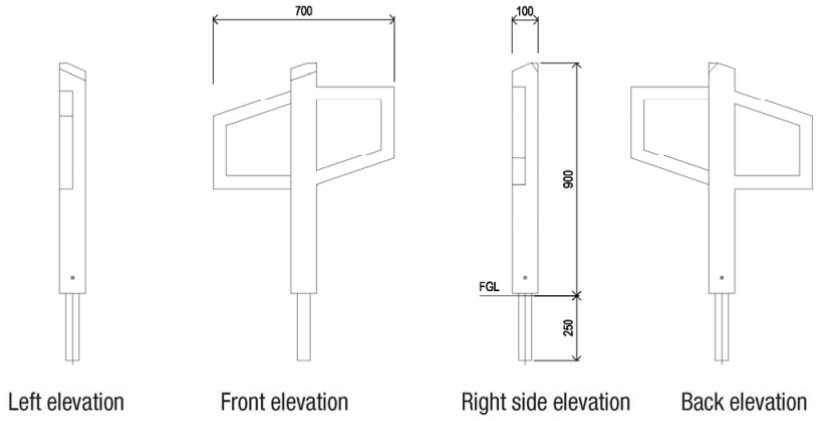
Total mass (using density of steel as 8000kg/m^3): 101.8 kg

For the planking: volume of planks = $(450 \times 77 \times 20) = 693000\ mm^3 \times 19\ planks = 0.013167m^3$

Plank mass (assuming epoxy resin aggregate density is 1200kg/m^3) = 15.8 kg

Bike rails

Assuming the design specified in the Canberra Central design manual, the amount of steel in the bike rails was estimated (approximating all parts of the bike rail to be straight)



Cross section of hollow steel rectangular tube: $(10 \times 20 \times 2) + (10 \times 70 \times 2) = 1800mm^2$

Volume required: $(1800 \times 700 \times 3) + (1800 \times 430 \times 3) = 0.006102\ m^3$

Therefore mass required (using the density of 304-steel): 48.82 kg

All density values were sourced from Engineering ToolBox, (2015)

APPENDIX B - Summary of recommendations

- Traffic control devices must be reduced to provide an adequate perception of risk and encourage users to act with caution
- Speeds need to be reduced so that the risk is controlled
- Public communication is of significant importance so that users are aware of the changed environment and pedestrians feel safe in using the space
- Safe spaces for pedestrians should be integrated into the design, possibly in a 30:40:30 ratio, and marked with delineators for visually impaired users
- There should be adequate space provided for user mobility in safe spaces, with nearby parking for accessibility
- Reduce the number of parking spaces to encourage smooth traffic flow and reduce obstructions
- Complete construction in one stage to reduce overall implementation time
- Bitumen should be recycled after removal and the nature strip should remain as a feature of the shared space
- The minimal amount of seating and bike rails should be determined to reduce the material impact
- Increase accessibility to public and active transport in the area through improvement of bus services and pedestrian/cyclist accessibility
- Assess the feasibility of adding alternative parking options in the surrounding area
- Implement an appropriate feedback system into the final design, such as those discussed in the dynamics and control analysis
- Conduct a cost-benefit analysis during the detailed design process