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We are grateful to Wendy Sarkissian for kind permission to reproduce the cover photo

Apology

In the last issue of the journal (22.3) we misspelt the names of the authors of the article "Density linked framework for planning mass transit in the context of Indian cities". We are very sorry indeed about this error and reproduce here the correct information exactly as supplied by the authors.

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First of all an apology for the late appearance of this issue. This was supposed to be the last issue of 2016 and it is appearing in February 2017. I will avoid the temptation to produce a list of excuses for the delay but one of the excuses is very relevant to the purpose of this journal so I will explain some of the context.

The Welsh Government has agreed to spend £1.1 billion on a 14 mile stretch of new road around Newport in South Wales. This is known as the M4 relief road. Our readers in Australia will be familiar with the deficient reasoning and poor quality understanding of transport that goes into such destructive, useless and very expensive new roads. You can explore some of the documentation here:

<http://www.gwentwildlife.org/how-you-can-help/m4-relief-road-help-us-protect-gwent-levels>

I have been asked to write evidence in support of the case against this new road and this will be considered at a Public Inquiry (PI) charged with interrogating the evidence for and against and making a recommendation to Government on whether or not it should go ahead. Writing evidence for a PI is hugely time consuming and is subject to a quasi-judicial style of interrogation in open "court". Evidence is presented, the witness is cross-examined by barristers for the "other side", then re-examined by barristers for "your side", then the witness is asked questions by the person running the PI, the Inspector. This is very demanding indeed and PIs are stressful.

The M4 relief road is relevant to the subjects covered in this journal. It is a road that cannot deliver its stated objectives. It will not relieve congestion. It will add to congestion. It is routed through an important nature reserve. It is a huge waste of public funds and £1.1 billion would make a substantial contribution to much needed rail and metro services on what is a heavily used commuter corridor. Demand management of the kind promoted in travel plans (PAS500) have the poten-

tial to shift commuters from car to public transport very effectively and have the advantage of avoiding this huge waste of public funds on 14 miles of road. A suite of sustainable transport interventions will be much cheaper, will reduce congestion, will reduce greenhouse gases, noise and air pollution, avoid severe damage to a nature reserve and will not be adopted. Road building is now a rampant ideology and destructive paradigm and is at work in most countries around the world.

This journal has always been very clear that transport policies are a key component of public health, quality of life and fiscal prudence and road building takes all these things in the wrong direction. It is the triumph of blind prejudice and anti-science ideology. We know that new roads "do not work". A recent article by three US colleagues, John Pucher, Ralph Buehler and Alan Altshuler, very accurately and employing robust science, shows that sustainable transport interventions work very well and deliver huge gains in quality of life. It is so sad that urban areas in South Wales need this approach and are going to get exactly the opposite and a very expensive destructive project that damages nature, climate change and public health.

It is even sadder that the Public Inquiry in spite of thousands of hours of detailed work by those arguing that it is the wrong approach to solving problems, will decide in favour of the new road. Transport policy in the UK in the late 20th and early 21st century is dominated by an anti-scientific approach that rejects evidence and embraces a futile belief that new roads bring jobs, investment and smooth flowing traffic. Every time we build a new road we re-state these reasons and every time the results do not deliver what is promised and then we make the same mistake again.

In this issue we return to some key themes in sustainable transport. The article by Wendy Sarkissian and Lori Mooren reflects on the death in a road crash of Wendy's husband and puts this dreadful experience in a wider context of how we should deal with eliminating death and injury on the roads and how we should im-

prove our ability to react to tragedies of this kind. At a time when 3 cyclists this year (January and February 2017) have been killed in London (see reference list) we are even more acutely aware than ever that these horrific tragedies are not interrogated systematically and thoroughly and not translated into immediate action to get the chances of death and serious injury as near to zero as we can. This is the point of Vision Zero, the Swedish road safety policy that says "a mistake in the road traffic environment must not attract the death penalty".

Colin Clarke returns to the controversial subject of cycle helmets. He is sceptical of the evidence that shows that helmet wearing produces clearly demonstrable public health benefits especially when set against the wider context of cycling rates and the possibility that helmet wearing deters cycling. It is also the case that if we return to Vision Zero as a concept then we have to avoid the temptation to focus on helmets and high visibility clothing as if this protects cyclists. The overriding need to protect cyclists requires a multi-pronged approach including 20mph speed limits, segregated bike paths, lorry bans, junction re-modelling and measures that deliver very cautious and modest bus driving. Helmet wearing does not deliver fundamental total safety gains nor does it deliver road traffic danger reduction.

Hazem El Jouzou presents a detailed analysis of aerial ropeway systems (ART/cable cars) as a valuable contribution to sustainable transport alternatives in cities. He makes a persuasive case and there are circumstances where the ART will add to the choices available to those making trips in cities but the overall context still matters. The key to the success of many sustainable transport interventions is space. How much space is allocated to roads and how much to car parking? The author makes a convincing case for ART as a sustainable mode but if this is pursued as a stand-alone policy it runs the risk of making more road space available for cars and triggering newly generated traffic. Central to any sustainable transport intervention must be the removal of road space for traffic and the reduction of car parking. We can build much needed new, afford-

able, energy efficient homes on car parks and we can remove road space and reallocate it to bikes, pedestrians and buses. In the case of Nottingham and Birmingham in the UK new tram systems have taken up road space and this needs a strong signal in favour of sustainable transport.

Jessica Lisle picks up on the urban space question very strongly and shows how a traditional car-oriented suburban shopping centre in Australia can be converted into a mixed use, walking, cycling and high quality, and people-friendly, public transport environment. Transport planning and spending still has a long way to go before it appreciates the significance of conversion. Streets can be converted so that they provide much more space than now to alternatives to the car or lorry. They can also become vibrant, attractive, social, child-friendly spaces. Car parks can be converted into housing and shopping centres can be converted into highly attractive people-friendly spaces along the lines described so eloquently by Jan Gehl.

We return to Jan Gel in the book review in this issue

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Cyclist deaths in London
<https://uk.news.yahoo.com/cyclist-helmet-hi-vis-jacket-065600334.html>

Weaknesses with a meta-analysis approach to assessing cycle helmets

Colin Clarke

Abstract:

Cycle helmets are a contentious issue which stems from evidence both for and against their use and the negative effects from when legislation is imposed, which has led to fines for non-wearers, some people cycling less or stopping and health implications. A meta-analysis by Olivier and Creighton includes reports that compare the proportion of head injuries or other injuries for wearer vs non-wearers. Weaknesses in this approach stem from the combined effect of issues which affect both the accident rate and head injury rate for helmeted vs non-helmeted or not fully being able to evaluate the differences that occur. The meta-analysis claims that helmet use is associated with odds reductions of 51% for head injury, 69% for serious head injury, 33% for face injury and 65% for fatal head injury. When examined in detail, all were found to be unreliable claims due to weaknesses of the supporting evidence and methodology.

Keywords: cyclists, helmets, meta-analysis, bicycle injuries

Rethinking the design of suburban shopping centres: A new blueprint for Westfield Chermside and other centres

Jessica Lisle

Abstract:

This journal article assesses the opportunities for the sustainable redevelopment of suburban shopping centres. It first examines the origin of suburban shopping centre design correlated to the changes in urban density and car dependence. This is followed by a review of the changes in cities including increase in walkability, public transport patronage, choice of higher density living and the associated economic benefits. By exploring how the suburban shopping mall Villa Italia in Lakewood, Colorado transformed into the mixed-use urban centre of Belmar,

this article presents an alternative redevelopment model for Westfield Chermside in Brisbane, Australia that can be applied to suburban shopping centres. The design supports the transition from a car dependent retail-only space to an integrated mixed-use town center precinct that provides residential, retail and commercial land uses.

Keywords: Green cities, sustainable cities, urban development, sustainable development, suburban shopping centres, mixed-use centre,

A Comparative Study of Aerial Rope-way Transit (ART) Systems

Hazem El Jouzou

Abstract:

Aiming to research alternative and green modes of transport, ones which have the potential to take a major role in future transportation systems, this article studies Aerial ropeway transit (AKA: cable cars, gondolas) systems and question their applicability as backbone transport systems in the future. It starts by explaining the challenges of transportation in contemporary cities, and propose ART (Aerial Rope-way Transit) systems as a transport mode which could be part of the wider solution to tackle automobile dependence. The article explains in detail what ART systems are, their specifications, their advantages and disadvantages, and why they should be regarded as an important asset in future urban transportation systems. Further to that, the research gives two examples of locations and systems where ART is implemented.

Finally, the research will demonstrate the applicability of ART systems as a full backbone Urban Public Transport (UPT) systems. For that purpose, the article proposes an ART transportation system in the cities of Wiesbaden, Germany and Beirut, Lebanon. Through demonstrating a realistic ART system, the article aims to assess and compare the applicability of ART systems to other transport modes with respect to costs, speed, and capacity. Upon that, and building on the information and data introduced, the article will lay down its conclusion regarding the topic.

We need a louder road safety voice

Lori Mooren PhD with Wendy Sarkissian PhD

Abstract:

The regularity of road tragedies in Australia and internationally prompted the authors to question the complacency that allows some 1.25 million people to die globally each year on our roads. We know much about road injury causation. We also know a great deal about exactly what to do to prevent these injuries and deaths. Nevertheless, as a global community, we choose to remain passive about this crisis. This paper uses an Australian case study to illustrate how an unsafe road system can kill someone, simply because he made a small mistake. It describes the characteristics of a *Safe System* approach to road planning and management, endorsed in Australia and internationally. It then suggests that a louder community voice is the key missing element in the struggle to eliminate road injuries and deaths.

Keywords: Road death and injury, complacency, Vision Zero, safe systems, Australia

Weaknesses with a meta-analysis approach to assessing cycle helmets

Colin Clarke

Introduction

Recently Olivier and Creighton provided a meta-analysis of bicycle injuries and helmet use claiming helmets provide a significant benefit¹. Other research has reported a negative safety² and negative societal health outcome when the effects of helmet legislation and reduced cycling levels are considered³. These issues are considered to see if the results from the meta-analysis by Olivier and Creighton are reliable or have overlooked essential considerations.

Method

Consideration is given to the detailed reports and approaches used to evaluating cycle helmet. Most of the reports included in a meta-analysis use similar methods that have weaknesses in not always fully detailing the differences in behaviour of wearers v non-wearers and accident situations. In all cases they also do not have any measure of the accident rate per km of travel. The basic approach of considering helmet use v injury outcome is basically considering two groups and may be insufficient to fully evaluate helmet effects. Attention is given to the fatality claims, serious head injury, head injury, face and neck claims and the merits of the supporting evidence. Additional consideration is given to other research giving an indication of safety and societal health outcome when the effects of helmet legislation and cycling levels are combined.

Meta-analysis claims

Olivier and Creighton based their overall claims on a reported 40 studies and data from 64708 injured cyclists, they state;

For cyclists involved in a crash or fall, helmet use was associated with odds reductions for head (OR=0.49, 95% confidence interval (CI): 0.42–0.57), serious head (OR=0.31, 95% CI: 0.25–0.37), face (OR=0.67, 95% CI: 0.56–0.81) and fatal head injury (OR=0.35, 95% CI: 0.14–0.88).

and

Helmet use is associated with odds reductions of 51% for head injury, 69% for serious head injury, 33% for face injury and 65% for fatal head injury.

and

Any comprehensive cycling safety strategy should consider the promotion or legislation of bicycle helmets only in concert with other injury prevention strategies.

Head injury considerations

The meta-analysis uses 38 reports to assess if helmet use lowers the proportion of head injuries (30 reports for serious head injury, 28 for head injury). The 38 reports compared 'cases' (with head injuries) to 'controls' (generally without head injuries). The ratio of the number of cases to controls varied in the reports from 1.1% to 190%, e.g. Olofsson et al for serious head injury details 24 cases vs 2123 controls, 1.1%, whereas Borglung et al for head injury, documented 80 cases vs 42 controls, 190%. The wide range implies that the criteria/selection or data source used may have varied substantially. The Olivier and Terlich study shows that approximately 93% of head injuries were considered minor, 5% moderate, 2% serious and 1% severe. One study, Wager et al reported an increased risk of severe head injury based on a small sample size. Three studies indicated an increased risk of 'head injury', Wager et al, Shafi et al, and Malczyk et al. The definition of head injury to include 'multiple injuries', may have an adverse effect on the soundness of the assessment, by children having a higher rate of multiple injuries⁴ and reportedly lower wearing rates. Bambach et al 2013 reported on NSW data 2001-2009 stating;

Notably, 47.2% of 0 to 12 year-olds and 50.3% of 13 to 19 year-olds were non-helmeted, compared with 14.6% of the 30 to 39 year-olds⁵.

Bambach et al reported some of the differences between helmet wearers and non-wearers for cycle accidents with motor ve-

hicles involved, as shown in Table 1. e.g. 55% of those not wearing a helmet were in the age 0-19 yrs.

Disobeying traffic control and having a

	No helmet	Helmet
Age 0-19	55%	18.5%
Disobeying traffic control	9.4%	3.3%
BAC over 0.5	7.2%	1.7%
Riding on footpath	34.4%	12.9%
Serious injury other than head	9.5%	7.3%
Not in day-time	27.9%	23.3%

Table 1

BAC over 0.5 comprised 16.6% for the no-helmet group compared with 5% for helmeted. Bambach et al did not provide details of wearing hi-visibility attire.

Clarke⁶ reported on TAC accident data 1987-89 from Victoria, showing the younger aged groups to have a higher proportion of head / concussion injuries, as shown in Table 2.

Table 2 shows that the 0-17 age group had

Age	Head	Concussion	Hd + Conc	Total claims	Percent Hd+Conc	Approximate exposure, billions of seconds per week
0-11	48	27	75	514	14.6	5-6
12-17	82	45	127	1162	10.9	9-11
18+	40	22	62	812	7.6	5-6
total	170	94	264	2488	10.6	20-24

Table 2: TAC head injury claimants 1987-89

130 'head' claimants (7.8%), whereas the 18+ age group had 40 claimants (4.9%). The younger age group had a 59% higher proportion of head injuries (7.8/4.9 = 1.59). The meta-analysis appears not to fully take account of the different types of accident and age grouping and the proportion of head injuries that occurs from different types of accidents.

Bambach et al 2013 reported;

Non-helmeted cyclists were more likely to display risky riding behaviour, however, were less likely to cycle in risky areas; the net result of which was that they were more likely to be involved in more severe crashes.

Bambach et al shows about 14% (Fig 1 part b) of hospitalised cyclists had serious head injuries (based on population and numbers reported this equates to approximately 1 in 60,000 people). They also reported non-wearers riding on the footpath in 34.4% of cases compared with 12.9% for wearers. Generally footpath cycling is considered to be safer but it was reported;

...cycling on arterial footpaths is a riskier activity than cycling on non-arterial roads (because of the enormous danger of transitional cycling, as Figure 17 demonstrates).

Data from 1988 reported on cyclist hospital admissions, the percentage of admissions for footpath vs non-footpath, was 42.8% v 33.2%. It was speculated that some footpath related accidents may be escaping both the Police and Hospital based reporting systems, resulting in increasing the proportions of the more severe injury levels⁷.

Serious head injuries

Details of serious head injury (SH) in the meta-analysis were based on 30 reports in total, 6 for 'Adults', 10 for 'Child' and 14 for 'All' ages.

Adults reports (6) serious head injury and OR values

Dinh 2010 et al - 0.23, Dinh 2013 et al - 0.17, Dinh et al 2015 - 0.16, Crocker et al 2012 - 0.52, Wagner et al 2012 - 1.17 and Zibung et al 2014 - 0.54. From the 6 report, 3 from Sydney Australia, 2 from USA and 1 from Sweden.

Dinh et al 2010⁸ Australia

Reported on cyclist injuries 2008 -2010 from Royal Prince Alfred Hospital (RPAH), Sydney, but failed to provide any details on intoxication. Details of 'Fall off bicycle' revealed 28% for no-helmet v 34% for helmeted. Information provided also shows trends in severe head injury 1991-2010 but without sufficient details on the age grouping changes over time.

Dinh et al 2013⁹ Australia

The information provided was from seven hospitals around Sydney and published in a letter to the MJA. It did not provide details on intoxication or other injuries to such as arms and legs. It details that the medium cost was lower for non-helmet v helmeted, \$5600 v \$6500. Insufficient details are provided to fully assess any confounding aspects. It states;

Limitations to our study include the small number of patients with severe head injury, and the inability to control for other incident factors such as speed, collision details and intoxication.

Dinh et al 2015¹⁰ Australia

Reported on injuries from inner city locations in Sydney NSW, 2012-14, showing 62% of helmeted having upper limb injuries v 41% for non-wearers¹¹. Similar data was reported from Queensland that Clarke 2015¹² refers to;

Monograph 5 Table 14 shows helmet wearers to have a 'Shoulder/Upper limb' rate of 28.3% and non-wearers a rate of 18.4%.

Bicycle alone accidents result in a higher proportion of arm fractures than bicycle/

motor vehicle accidents¹³, so it appears helmet wearers may have had a larger proportion of injuries due to bicycle alone type accidents or falls. Cyclist head injuries due to falls have been reported to have about half the average length of hospital stay compared with cyclists involved in collisions with motor vehicles. Dinh et al detailed for intoxication, 2% for helmeted v 20% for non-wearers, a major difference.

The three reports by Dinh indicate that wearers had a higher proportion of falls that generally result in a lower proportion of serious injuries compared with motor vehicles collisions. The meta-analysis does not adequately consider this aspect.

Crocker et al 2012¹⁴ USA

It reports;

For any head or brain injury, the odds ratios for helmet use and alcohol use were 0.5 (95% confidence interval [CI] 0.32-0.78) and 2.68 (95% CI 1.66-4.33). Of accidents presenting to the ED, helmeted riders were less likely to sustain a head or brain injury, and riders who reported alcohol use were more likely to sustain a head or brain injury.

Crocker states;

Alcohol use and head or brain injury continued to demonstrate positive correlation in both the helmet-wearing and non-helmet-wearing groups independently ($p < 0.05$ and $p < 0.005$, respectively), indicating that alcohol use is linked to increased likelihood of a head or brain injury whether or not the rider is wearing a helmet.

Alcohol or drug use was reported as 1.5% for helmeted vs 33.4% for non-helmeted.

Zibung et al 2014¹⁵ Sweden

A study of 186 patients treated for bicycle related injuries at a Level 1 Trauma Centre in Sweden during a 3-year period.

The conclusions from this report reads;

'Non-helmet use is associated with an increased risk of injury to head and face in collisions, whereas helmet use is associated with an increased risk of limb injuries in all types of crashes.'

It details that 7.9% of wearers vs 32% of non-helmeted had taken alcohol and that 61.9% of non-helmeted had single vehicle crashes (falls) compared with 40.7% for wearers. Accidents from single vehicle crashes did not show a reduced head injury risk to wearers.

From the six 'Adult' reports, Wagner found an increased risk of serious head injury with helmet use. Dinh et al reports tend to show a higher rate of falls for helmeted and for non-helmeted a higher proportion that had been drinking. The average OR value from the six reports is 0.46 but it may not be a reliable indicator of overall safety because it is a comparison of the proportion of serious head injury, that form approximately 2% of cyclist injuries and non-helmeted often had higher levels of alcohol use and other differences.

Child reports (10) serious head injury and OR values

Thomas et al. - 0.29, Li et al. - 0.44, Finvers et al. - 0.32, Linn et al. - 0.26, Shafi et al. - 0.37, Borglund et al. - 0.74, Lindsay & Brussoni - 0.12, Gulack et al. - 0.28, Kaushik et al. - 0.31, Olofsson et al. - 0.33.

From the 10 report, 1 from Australia, 1 from Sweden and 8 from either the USA or Canada.

Thomas et al 1994¹⁶ Australia

BHRF provides commentary on this report and includes;

Based on Towner et al, 2002:

- The circumstances of crashes were different between cases and controls. Head injured cyclists were more likely to have made contact with a motor vehicle, crashed on a hard surface and to have had a bicycle in need of subsequent repair. Thus the two groups are not adequate for meaningful comparison.
- It is not clear if unhelmeted children are over-represented in more severe crashes.
- The study did not examine injuries to other parts of the body so it is not clear if children with head injury were involved in different types of accident.
- Young children are over-represented amongst the controls.
- The questionnaire was self-administered and response rates are not given.
- Data collection time spans period when helmet legislation introduced. There is no differentiation between pre and post law.
- Missing data could potentially cause serious bias in reported results.
- Childhood accidents - losing control of bicycle - may be very different to protective effect provided to all age groups.
- The degree of damage to the bicycle was used as a proxy to assess the severity of impact.
- Question not answered by this study is whether influences leading to non-helmet wearing are associated with other risk taking behaviour.

Conclusion

The study has compared quite different groups of children, lacks important checks on its findings and is not robust. The authors' conclusion that this work justifies legislation to enforce helmet use among children is not valid

At the time of the study 1991/1992 the wearing rate for children varied by age

group and location¹⁷. Generally younger children had higher wearing rates. Younger children generally had shorter hospital stays and will on average fall from a lower height and may be cycling slower.

Li et al 1995¹⁸ USA/Canada

The abstract reads;

Using data from the National Pediatric Trauma Registry, this study examined the characteristics of bicycle-related head injury, factors related to the presence of head injury, and different outcomes of head injury up to the time of discharge. Of the 2,333 patients ages 0 to 14 years who were admitted to trauma centers because of bicycle-related injury during 1989 through 1992, more than one-half (54%) sustained head injury, predominantly concussions and skull fractures. With adjustment for age, sex, and motor vehicle involvement, children who had pre-existing mental disorders, who did not wear a helmet at the time of injury, or who were injured on roads had a significantly increased likelihood of sustaining head injuries. Patients with a head injury were four times as likely as patients with no head injury to be treated in intensive care units, and were almost twice as likely to develop complications. Head injury was associated with an increased risk of in-hospital fatality and high prevalence rates of communication and behavior impairments at discharge. Although it is urgent to increase helmet use substantially by child bicyclists, special attention should be paid to high-risk groups, such as children with mental disorders and children who are likely to ride in traffic.

The data suggests about 583 cases per year (2333/4=583) and 54% sustained head injuries, approximately 314 cases per year. The USA population for ages 0-14 years was about 21.7 million in 1990¹⁹ and 314 cases would equate to one in 69108 children. A proportion of cases would have been detained for overnight observation.

Finvers et al 1996²⁰ Canada – Alberta

BHRF²¹ provides commentary on this report and includes;

Based on Towner et al, 2002:

- No cycling exposure data presented and no clear information on population helmet wearing rates in this age group.
- The most seriously injured may be excluded as these are taken direct to the Intensive Care Unit.
- It is not clear if helmets protect against non-serious injuries.
- No numerical data presented on serious injuries to the rest of the body.
- No adjustment for possible confounding factors.
- Self-reporting of important information.
- Parents may false positive report helmet use in injured children.
- Average age (8 – 9 years) given by no standard deviation.
- Insufficient data to draw clear conclusions.

The report states,

'There is no significant difference in terms of serious injury overall comparing helmeted and nonhelmeted children ((odds ratio 1.11, 85% CI = 0.72-1.72).

Linn et al 1998²² Canada – British Columbia

BHRF provides commentary on this report and includes:

Based on Towner et al, 2002:

- It is not clear whether cases and controls were well matched, their characteristics were not clear. Similarly it is not clear whether there is inherent bias in the sample.
- No exposure data; only injured children were included.
- Not enough breakdown of figures.
- Difficult to know when unhelmeted children had more severe injuries to other body parts.

- Traffic accidents increased with age and more likely to lead to admission.
- Partly self-report.
- Both helmet use and dental injuries increased over the period

The report uses data from cycle accidents in British Columbia for ages 1-19 years over a 5 year period. In total it refers to 568 head and face injuries. Approximately 114 per year from a population size of approximately 800,000, approximately 1 in 7000. Data from Australia shows head injuries to be 10% and face 24%, of children's injuries²³.

Information from the USA has reported alcohol and other psychoactive drugs in trauma patients aged 10-14 years²⁴, so it seems likely that some of the older age groups, in the 10-19 years may have been subject to alcohol and other psychoactive drugs.

Shafi et al 1998²⁵ USA

BHRF provides commentary on this report and includes:

By Towner et al, 2002:

- Only included children who were admitted to hospital, who were much more likely to have head injury than others.
- No protective effect for overall head injury.
- Helmeted children showed greater incidence of concussion alone, but numbers very small.
- Numbers were very small for some calculations.
- This study was difficult to interpret as it suggests that helmets do not protect children from head injuries per se, but only from more severe injuries.
- The authors did not attempt to assess the effect of introducing legislation on the pattern of head injuries.

Conclusions

It seems improbable that helmets could protect from serious head injuries but not less serious ones; this also conflicts with research that suggests the opposite. The

sample size was too small for reliable comparisons.

The report was unable to show a significant difference between helmeted and nonhelmeted for length of hospital stay or charges for initial hospitalization.

Borglund et al 1999²⁶ USA

The report compares injuries from two groups of 72 children, one group before legislation was introduced and a second group after legislation. Helmet use rose from 4% to 20.8%. The first group had 6 months of daylight saving time in their study period compared with 10 months for the second group. The report details;

The after-law group (AL) consisted of children admitted immediately after the helmet law's effective date from January 1, 1997, to July 31, 1998. A 1-year gap in data collection was allowed because of the intense community-wide bicycle safety campaign waged during the year prior to the effective date of the mandatory helmet law.

The report provides one figure and no tables, so details of types of injuries are inadequate. Children in the second group had been subject to 'intense community-wide bicycle safety campaign' and this will have made them more safety conscious.

Lindsay & Brussoni 2014²⁷ Canada

The report relates to the 2004-09 period (6 years) for pediatric injuries for Canada, ages 1-16, for non-motorized wheeled activity bicycles, skateboards, scooters and inline skates. It details for 'bicycle' 26421 injuries (20838 patients), including head injury (minor) 2278 (8.6%) and head severe 166 (0.6%). The population for the 1-16 age group was approximately 6 million. The medium age for cyclists was 10.9 years. The number of cyclists presenting with injuries decreased on average about 5.1% per year. No information is provided on the decrease for provinces with helmet legislation vs others or the distribution of injuries and age/sex group per province. Details for Vancouver in 2011 revealed the age group 0-15 comprised 7% of bicycle trips and indicates a low level of cycling activity for children from a province with all age helmet legislation.

Gulack et al 2015²⁸ USA

It reported national trauma data (years 2007, 2010, and 2011) for children younger than the age of 16 years who were involved in a bicycle accident. They included 7678 children in their analysis, with 1695 helmeted and 5983 no-helmet. The average wearing rate for the 0-10 year group was approximately 24.2% v 20.3% for the 11 to 15 age group. Research by Whately²⁹ detailed the average length of hospital stay by age group for children from cycling accidents, 0-10 years 4.9 days 11-20 years 6 days. It appears likely that the younger cyclists had more falls, from a lower height, compared to older children/teenagers who may have cycled more in traffic and on road. Hillman refers to age group data, 0-10, 11-15 and 16+ year olds and the proportion of cycle accidents of all severity where motor vehicles were involved rose from 13 to 28 and 52 per cent³⁰. Table 2 in the report shows details for Abdomen/pelvis injuries, no-helmet 18.8% of injuries, helmeted 27.0% and tends to suggest that helmeted had a higher proportion of falls. It concludes with;

Children who are black or who are on Medicaid are less likely to be wearing a helmet when involved in a bicycle accident than white children or children with private insurance, respectively. Future efforts to promote helmet use should be directed towards these groups.

Kaushik et al 2015³¹ USA

It reported on Minnesota residents 5 to 18 years of age with a bicycle injury that occurred between 2002 and 2011. A total of 1189 bicycle injuries were identified and it details;

'The overall age-adjusted incidence rate of all injuries was 278 (95 % CI, 249 to 306) per 100,000 person-years for females and 589 (95 % CI, 549 to 629) for males. The corresponding rates for head injuries were 104 (95 % CI, 87 to 121) for females and 255 (95 % CI, 229 to 281) for males.'

The rates for 'Any injury' and 'Head injury' per 100,000 population were 438 and 182 per year respectively. For head this equates to one per 549 years cycled on average.

Head injuries reported were 500, 87 cyclists wearing helmets vs 224 not wearing and 189 unknown if wearing or not. They resulted in 27 hospital admissions, 3 helmeted, 19 no helmet and 5 'unknowns'. This averages about 2 to 3 admissions per year.

It states;

Children and adolescents presenting with head injuries were more likely to have documentation of helmet use/non-use in the medical record and were more likely to have not been wearing a helmet.

Fig 3 in the report shows the incidents of head injury for ages 12, 13 and 14 to be elevated and these children may have been cycling faster or been involved in a motor vehicle collision and consequently could be at a higher risk of head injury. The report fails to provide sufficient information to fully evaluate overall safety for wearers vs non-wearers. More details about other aspects could have been provided, e.g. average age of wearers vs non-wearers and number of motor vehicle collisions for wearers vs non-wearers.

Olofsson et al 2016³² Sweden

The stated aim was to;

To investigate the use and protective effect of helmets in children injured in bicycle crashes and changes in injury patterns during a period of increased helmet use.

Injuries to 4246 children below 16 years of age, who attended an A&E ward after a bicycle crash in the Gothenburg region during 1993–2006, were analyzed. They did not have data on the levels of cycling activity during the period. Road deaths in Sweden reduced from 591 in 2000, 480 in 2004 and 264 in 2013³³, so major improvements to road safety have occurred. They reported 4318 injured cyclists below

the age of 16 from the 14 year period, approximately 270 per year (2051 from 1993-1999 and 1660 from 2000-2006). A 9% reduction occurred between the two periods. Single crashes comprised 87.3%. Helmet use was highest for the 4-9 aged group (approximately 65% to 75%) with teenagers having the lowest levels (approximately 20% to 30%). It reports;

The proportion with skull/brain injuries of any severity (14–20%) did not change significantly during the period (Fig. 2, Table 4). The proportion with upper extremity injuries of any severity increased from 44% to 58% and the proportion with facial injuries of any severity decreased from 34% to 23%.

Children's upper extremity injuries are normally higher in proportion than face injuries, 35% v 24% according the VISS data³⁴ so that a 14% increase (44% to 58%) and an 11% decrease (34% to 23%) would equate to a net small percentage increase overall. Upper extremity injuries are associated with falling off and all other injuries could also tend to increase with extra falls. Table 3 in the report details a reduced risk of skull/brain injury with helmet use, OR 0.45 for AIS2+ but it appears that younger children with higher helmet usage and lower speed/lower fall heights may have contributed to the lower figure compared with teenagers cycling at higher speeds and probably more involved in traffic accidents. The OR 0.45 figure was derived from using extremity injuries as an indication of exposure, this is unsound practice for cycle helmets with evidence showing the accident rate can increase with helmet usage and evidence showing a higher proportion of falls. Fig 2 in the report shows a definite increase in upper extremity injuries over the period 1993 to 2006. Table 4 also details increases for neck, upper extremity, upper trunk, lower trunk for AIS of any grade and worrying for AIS 3 it shows 6 categories to increase with only face to decrease from 1993 to 2006. Face injuries are more common in young children and changes to population and cycling activity levels could have some effect.

All age reports (14) serious head injury and OR values

Thompson et al.- 0.13, Spaite et al. – 0.03, McDermott et al. – 0.48, Maimaris et al. – 0.28, Thompson et al. – 0.31, Heng et al. – 0.18, Amoros et al. – 0.41, Bambach et al. – 0.31, McIntosh et al. – 0.18, Webman et al. – 0.43, Malczyk et al. – 0.12, Otte & Wiese – 0.13, Harada et al. – 0.49, Sethi et al. – 0.49. From the 14 report, 6 from USA, 3 from Australia, 2 from Germany, 1 from UK, Singapore and France.

Thompson et al 1989³⁵ USA

BHRF commentary³⁶ on this paper includes;

'In this study, a comparison was made between 145 children treated in hospitals in Seattle for a head injury (the 'cases'), and a 'community control' group of 480 children who had, in one way or another, simply fallen from their bikes. A comparison of the two groups based mainly on helmet use of children under 15 years (21.1% of 'control' vs 2.1% of 'case' children) leads to the frequently quoted claim that the reduction in head injury due to helmets is 85%.

However, at the same time as this research was being carried out, there was a much more extensive survey of helmet use in the city of Seattle (DiGiuseppi, Rivara, Koepsell and Polissar, 1989). Of 4,501 child cyclists observed cycling around Seattle, just 3.2% wore helmets. This is not statistically different from the 2.1% of the hospital cases who were wearing helmets.

As well as having a helmet wearing rate 7 times that of the cyclists riding round Seattle, the 'community control' group came from higher income households and had parents with higher educational levels. The observational survey of child cyclists riding in Seattle found that helmet wearers were predominantly white, middle class, riding with their parents in parks, whereas the non-wearers were more often black or other races riding alone on busy city streets. The risk profile of these two groups would be quite different.'

Spaite et al 1991³⁷ USA

A report from Arizona with data from January 1986 to January 1989, shows 41% of accidents involved wearers when the wearing rate in the USA was reported lower, Wasserman 1988³⁸ provided details showing a 7.8% wearing rate for example. Commentary on Spaite et al by BHRF³⁹ includes;

'However, a striking finding was noted when the group of patients without major head injuries was analysed separately. Helmet users in this group had much less serious injuries than non-users. The researchers concluded that helmet non-use is strongly associated with serious injuries even if those without serious head injuries are excluded. This implies that non-users of helmets tend to be in higher impact crashes than helmet users, since the injuries suffered in body areas other than the head also tend to be much more severe. It is possible that at least some of the 'protection' afforded helmet wearers in previous studies may be explained by safer riding habits rather than solely a direct effect of the helmets themselves'

The exceptional low OR value from this report 0.03, is probably due to helmet users in this group having much less serious injuries in general than non-users.

McDermott et al 1993⁴⁰ Australia

BHRF provides commentary⁴¹ on this report and includes;

By Towner et al, 2002:

- Half of the sample had no impact.
- It is difficult to interpret some of the comparisons.
- Increased risk of neck injury among helmeted cyclists, though this may have been an artefact of the study design rather than a real effect.
- Inappropriate design does not necessarily under-estimate protective effect of helmets (as claimed by authors). Bias could go in either direction.
- Those wearing non-approved hel-

mets were older.

- Self-report crash circumstances and helmet use.

Additional information provided by Curnow includes;

Data of Tables 3 and 5, Figure 10 and the text show that most of the helmets of the more severely injured (AIS 3 and 4-6) were dislodged. Hence, the study's conclusions that there was a protective effect for head injury of severity AIS 4-6 and that its findings provide evidence of benefit from mandatory wearing are only assumptions.

Additional information provided by Keatinge and Perry includes;

The authors fail to mention the work of Spaite et al, 1991, who studied cyclists attending a university trauma centre after being hit by cars. Both head and non-head injuries of people who had voluntarily been wearing helmets were less severe than those of people who had not been wearing helmets. Presumably people who voluntarily wore helmets behaved more cautiously in general, perhaps riding more carefully or being more likely to attend hospital after an accident. This sort of confounding means that studies of voluntary helmet wearing cannot test the hypothesis of protection conferred by helmets

Maimaris et al 1994⁴² UK

The paper was based on 11% wearing helmets at the time of their accident in the Cambridge area in 1991. The community wearing rate was about 9%. Helmet wearers had a lower proportion of accidents involving motor vehicles (25% vs 28%) and a higher proportion of falls (70% vs 63%) both would contribute to a lower proportion of serious accidents. A higher proportion of children wore helmets than adults 16% vs 9%. It appears likely that the younger age groups had higher wearing rates than older children and would have incurred more falls with fewer serious head injuries. From the 50 children wearing helmets 9 had accidents involving motor vehicles and from 259 not wear-

ing, 44 had motor vehicles involved, similar proportions. There is little information about the severity of head or other injuries and divisions of data for ages less than 16 years old.

BHRF provides additional commentary on this paper⁴³.

Thompson et al 1996⁴⁴ USA

BHRF commentary⁴⁵ on this paper includes;

'Motor vehicle involvement increases the risk of head injury 3-5 times and the risk of head injury for children is something like double that of adults. Non wearers in this study were younger than wearers (so should have had a higher rate of head injury because of that) and also 41% more likely to have collided with a motor vehicle (18.0% of non wearers vs 12.7% of wearers), again increasing the rate of head injury for non-wearers relative to wearers.'

Heng et al. 2006⁴⁶ Singapore

This report included questionnaire data from an 8 month period. It had 160 bicyclists in total, 17 helmeted (14 recreational/sports cyclists – 83%) and 143 without helmets (56 recreational/sports cyclists – 36%). Alcohol involvement was zero for helmeted vs 18 cases for non-helmeted. Age range 17-49 for helmeted and 10-89 for non-helmeted. Helmeted sustained 4 limb fractures vs 40 for non-helmeted. The injury severity score was 4.0 for wearers vs 8.8 for non-wearers. The helmeted group had no children or old people (both higher risk groups) or any that had been drinking and they were nearly all recreational/sports cyclists (14 from 17). Three of the helmeted group were non-residents of Singapore vs 46 of the non-helmeted group, a possible factor leading to a higher accident rate.

Amoros et al. 2012 France

Over the 1998–2008 period, 13 797 cyclist casualties were identified in this French report. It states;

Results The fully adjusted ORs of helmeted versus unhelmeted cyclists are: for AIS1+ head injuries, 0.69 (95% CI 0.59 to 0.81); for AIS3+ head injuries sustained in urban areas, 0.34 (95% CI 0.15 to 0.65), those sustained in rural areas, 0.07 (95% CI 0.02 to 0.23); for AIS1+ facial injuries, 0.72 (95% CI 0.62 to 0.83); and for AIS1+ neck injuries, 1.18 (95% CI 0.94 to 1.47). Conclusion This study confirms the protective effect for head and facial injuries, even though soft-shell helmets have now become more common. The reduction of risk is greater for serious head injuries. The study is inconclusive about the risk for neck injuries.

Of the 8373 injured cyclists with known helmet status, 1720 (26%) were wearing a helmet at the time of the crash and 6653 (74%) were not. For children 0-14 age group, 365 (12%) wore helmets and 2625 (88%) did not. There was a difference in the age grouping of wearers to non-wearers, 63.1% of helmeted were in the 25+ age group vs 37.1% for non-helmeted. It reports for 'Off road' crashes, 20.7% helmeted vs 13.4% for non-helmeted, however details for crash opponent shows similar data for both groups. Roughly from the 11 years of data and population of 1.6 million in the Rhone County they had 144 serious head injuries recorded, on average 13.1 per year. No information on alcohol use was provided.

Bambach 2013 Australia

Refer details above in 'Head injury considerations'.

McIntosh et al. 2013⁴⁷

Data for pedal- and motor- cyclist injuries were extracted from the trauma registry of St. George Public Hospital (SGH) in Sydney, a level one trauma centre from an eighteen-month period between July 2008 and December 2009. A total of 137 pedal cyclists met the study's inclusion criteria. Reportedly 63.5% of cyclists wore a helmet

at the time of the crash with serious head injury to 4 non-wearers and 2 to wearers. The median ages for unhelmeted and helmeted pedal cyclists were 21.0 years and 36.0 years, respectively. Upper limb injuries reported 23 from 87 for helmeted and 8 from 50 for non-helmeted, i.e. 26.4% vs 16%, indicating that wearers had a higher proportion of falls. Accidents from falls result in a lower proportion of serious head injuries compared with motor vehicle accidents.

The report mentions;

Finally, the SGH registry only categorises helmet use as 'yes' or 'no'. If information on whether a helmet was worn were not available in the hospital or ambulance notes, it would most likely have been entered as 'no'. Data on whether a helmet came off during the impact, which is also critical in evaluating its effectiveness, were not available [41].

Information above from Dinh 2015 show similar patterns, indicating a higher rate of falling off for helmet wearers. McIntosh et al did not provide information on alcohol use.

Webman et al 2013⁴⁸ USA

This report details information from New York City;

Of 374 patients, 113 (30.2%) were wearing helmets. White bicyclists were more likely to wear helmets; black bicyclists were less likely ($p = 0.037$). Patients with private insurance were more likely to wear helmets, those with Medicaid or no insurance were less likely ($p = 0.027$). Helmeted bicyclists were more likely to ride with the flow of traffic (97.2%) and within bike lanes (83.7%) ($p < 0.001$ and $p = 0.013$, respectively). Nonhelmeted bicyclists were more likely to ride against traffic flow ($p = 0.003$). There were no statistically significant differences in mean GCS score, AIS score, and mean ISS for helmeted versus nonhelmeted bicyclists. Nonhelmeted patients were more likely to have head computed tomographic scans ($p = 0.049$) and to be admitted ($p = 0.030$).

Some aspects in the report can affect the overall accident rate. One estimate for the risk factor for riding against traffic was between 2.0 and 6.6⁴⁹. The report details 6.3% of helmeted had alcohol involvement vs 11.1% for non-wearers. There was distinct difference in behaviour and for non-wearers that may have resulting in more scalp damage than for wearers and hospital staff may have been more cautious and conducted CT scans.

Malczyk et al⁵⁰ 2014 Germany

They report;

Two hospitals in two major German cities documented 543 injured bicyclists arriving at the emergency departments. Injuries to the head and face were present in 239 bicyclists. 77 % received only AIS 1 injuries consisting of soft tissue injury, cerebral concussion and minor facial fractures. Nearly 10 % sustained AIS 3+ head injuries. Cyclists with head and face injuries tended to be older than the control group without head injuries, were involved more often in collisions with motor-vehicles and were cycling faster. Helmet rate was 17 % among cyclists without and 18 % among those with head injury. No AIS 3+ head injuries were seen in helmet-users.

For the purpose of this study, the head includes the face (and excludes the neck), unless otherwise noted. Helmet wearing includes also cases where the helmet came off the head in the course of the crash. The report finds head injuries to increase slightly with helmet use but serious head injuries to reduce appreciably.

Among unhelmeted cyclists, AIS 1 concussive injury accounted for 25.8 % and AIS 2 concussion for 9.0 %. Of the helmet-users, 35.3 % displayed AIS 1 concussion and 8.8 % sustained AIS 2 concussion.

They state;

Nevertheless, our study confirms that collisions with motor-vehicles play a crucial role when serious head injuries are concerned.

and

Therefore, the positive effect of a bicycle helmet may be outweighed by the effect of riskier cycling. Research and discussion about bicyclist head protection may provide wrong conclusions if analysis of real world data is based solely on the incidence of head injuries. Ideally, head injury severity, but also cycling behavior which largely determines exposition and crash risk, should be considered as well.

Of all 93 cyclists in the age categories up to 34 years, only one person, aged 15 and riding without a helmet, sustained AIS 3+ head injury. Most of the serious head injuries came from the older groups. The vast majority of head trauma in their material consisted of AIS 1 injuries to the face, the skull or concussions of minor severity. No details of alcohol use are provided. Harada et al. 2015 reports;

Orsi et al. describes Germany's experience with cycling collisions, observing that cyclists who did not wear a helmet were more than twice as likely to have consumed alcohol.

Waard et al⁵¹ report mentions,

A Finnish study also showed that the risk on being injured while cycling with a BAC of 1.0g/l is ten times as larger than the risk of injury for a sober bicyclist (Oikkonen and Honkanen, 1990).

Otte & Wiese 2014⁵² Germany

This study deals with the risk of injury to the bicyclist's head and the benefits of wearing a bicycle helmet in terms of reduction of injury severity or even injury avoidance. The accident data of 4,245 injured bicyclists as a randomized sample, collected by a scientific research team within the GIDAS project (German In-Depth Accident Study) were analyzed. Given that head injuries result in approximately 40% of bicycle-related crashes, helmet usage provides a sensible first-level approach for improving incidence and severity of head injuries. The effectiveness of the bicycle helmet was examined using descriptive and multivariate analysis for 433 bicyclists

with a helmet and 3,812 bicyclists without a helmet. Skull fractures, severe brain injuries and skull base fractures were up to 80% less frequent for bicyclists wearing a helmet. Among individuals 40 years of age and older, a significant increase of severe head injuries occurred if no helmet was used compared to younger persons with helmet.

Sethi et al.2015⁵³ USA- NYC

It reported on accidents from New York City (NYC) 2012 -2014. Some of the differences between wearers and non-wearers are shown in Table 3:

	No helmet	Helmet
Alcohol use	20.2%	6.2%
Electronic Device use, column	13.7%	7.9%
Cyclist crossed against signal	10.7%	5.8%
Time of day (9pm -5.59am)	26.6%	14.3%
Motor Vehicle collision	67.5%	59.8%
Ethnicity - White	42.9%	52.9%

Table 3

The data shows that non-wearers incurred a higher proportion of night time injuries, alcohol use and crossing against signals. Most of these increase the risk of accident and head injury.

The method and results state;

A retrospective review of trauma patients presenting to a Level I trauma center after bicycle-related crashes from January 2002 to December 2011 was conducted. Demographics, injury data, alcohol intoxication, helmet use, and clinical outcomes were reviewed. Blood alcohol level (BAL) was considered positive if >0.01 g/dL. Variables were compared between patients based on BAL: negative, 0.01-0.16 g/dL, and >0.16 g/dL.

Results:

During the 10 year study period, 563 patients met study criteria; mean age was 33.5 ± 16.5 years, 87% were male, and mortality was 1%. On average, bicycle crashes increased over the study period by 4.4 collisions per year. BAL was tested in 211 (38%) patients. Mean BAL was 0.24 g/dL, with 37% of these patients being intoxicated (BAL ≥ 0.010 g/dL). Intoxicated patients were significantly less likely to wear a helmet (4.7% vs. 22.2%, p = 0.002) and to be involved in motor vehicle crash (59.0% vs. 81.2%, p < 0.001). There was no difference noted in the injury burden including ISS ≥ 16 (14.3% vs. 19.5%, p = 0.335) and AIS Head ≥ 3 (17.9% vs. 21.8%, p = 0.502). When comparing patients according to their BAL, there was a decreasing risk of motor vehicle collision with increasing BAL (81.2% for undetected, 76.5% for BAL ≤ 0.16 g/dL and 54.1% for BAL >0.16 g/dL, p < 0.001). The risk for a severe head injury (AIS Head ≥ 3) was significantly lower in helmeted patients (8.4% vs. 15.8%, p = 0.035).

Conclusions:

The incidence of bicycle-related crashes is increasing and more than a third of patients tested for alcohol after bicycle-related crashes are found to be intoxicated. The injury burden in intoxicated patients, including head trauma, was not different compared to non-intoxicated patients. In addition, the

risk for a collision with a motor vehicle was significantly lower. Nonetheless, these patients rarely utilize a helmet. The findings from this study can be used for the development and implementation of preventive strategies to minimize the injury burden associated with bicycle crashes and intoxicated cyclists.

The report shows 8.3% of intoxicated had a GCS of less than 8 (severe head injury) compared with 3% for non-intoxicated. This means a higher proportion of intoxicated had severe head injuries and also had a low use of helmets (4.7%). The report could have provided more details for falls and accidents from motor vehicles for helmeted v non-helmeted and alcohol use.

Discussion on serious head injury reports

From the meta-analysis reports, some show that adult non-wearers have higher alcohol use and this affects both the risk of accident and head injury risk. The proportion of accidents and injuries for intoxicated riders may change by having more falls. It appears that alcohol use has an increased accident risk factor in the region of 3 to 1 or up to 20 to 1 in some cases⁵⁵.

BHRF reports⁵⁶;

However, as the research progressed, it became clear that the strongest link with head injury was not helmets but alcohol use by cyclists. Of 40 alcohol-affected cyclists, 57.5% had head injuries, compared to 29.5% of cyclists who had not used alcohol, a highly significant difference. In fact, the research found no significant relationship between helmet use and head injury for sober cyclists. It just so happened that all the intoxicated cyclists except one did not wear a helmet

BHRF also reports⁵⁷;

Results

Two hundred patients 18 years or older were enrolled from December 2006 through November 2007. Alcohol use showed a strong correlation with head injury (odds ratio, 3.23; 95% confi-

dence interval, 1.57-6.63; $P = .001$). Impaired riders were less experienced, less likely to have medical insurance, rarely wore helmets, were more likely to ride at night and in slower speed zones such as city streets, and their hospital charges were double (all P values $<.05$).

From the meta-analysis serious head injury results, Spaite et al 1991 provided the strongest OR value of 0.03 that was probably due to helmet users in this group having much less serious injuries in general than non-users. Three reports from Dinh et al also provided low OR values, 0.23, 0.17 and 0.16. In the third report it details 62% of helmeted having upper limb injuries v 41% for non-wearers, so it appears helmet wearers may have had a larger proportion of injuries due to falls. It also detailed for intoxication, 2% for helmeted v 20% for non-wearers, a major difference that was not fully considered. Sethi et al also provided a low OR value 0.20 and reported for alcohol use, 6.2% for helmeted v 20.2% for non-wearers. The shortcomings in the approach and Summary Odds Ratio value of 0.31 should be considered unreliable because it fails to take full account of the rate of falling, alcohol use and other aspects.

Head injuries

Details of head injury (HI) in the meta-analysis were based on 28 reports in total, 23 discussed above with extra ones by Thompson et al.1996, Jacobson et al., Hansen et al., Airaksinen et al. and Sze et al. The overall OR value for the 28 reports was 0.49 indicating less or a benefit compared to the 0.31 quoted for Serious Head Injury, refer Olivier and Creighton report for full details of OR values for 'Head Injury'. The 5 additional reports are listed below.

Five additional reports

Thompson et al.1996⁵⁸ USA – OR value 0.30

BHRF reports;

The same data set is used in these other papers by the same authors: Effectiveness of bicycle safety helmets in preventing serious facial injury. JAMA, 1996a;276(24):1974-1975.

Refer commentary above on Thompson et al.1996.

Jacobson et al.1998⁵⁹ Australia – OR value 0.37

BHRF provides commentary⁶⁰ on this paper;

*Peer criticism
By Towner et al, 2002:*

Little information is given about the cyclists.

Possible bias due to false self-reporting of helmet use (to avoid prosecution) and over-representation of helmet wearing.

The protective effect of helmets seems to decrease with age.

Small numbers of adults makes some comparisons difficult to interpret.

Only 2 years data on reported helmet use.

No breakdown by injury severity or sense of the severity of injuries.

It is not clear if 'head' injuries include the face etc, which are not likely to be protected by a helmet.

Some groups small.

The probability of cycling off-road depended on age. The probability of wearing a helmet depended on age and whether the cyclist was riding on or off-road. The probability of head injury among those who used helmets

depended on age.

Conclusion

In summary the paper proves little, except that cycling injuries are usually not serious, and helmets not obviously effective, even when slight injuries are captured as well as those more serious.

Hansen et al.⁶¹ 2003 Norway

The study involved 991 cyclists treated for accidents in an 18 month period and information from questionnaires answered. Head injuries were divided into head or face. One boy with severe head injuries (not wearing a helmet) died. It is not detailed if he would have been expected to live if helmeted. From the 991 cyclists, 705 were in the age group to 15 years old, 284 older than 15 years and in total 282 wore helmets (28.4%). They state;

Overall 182 patients (18.4%) used a hard shell helmet at the time of the accident, and 100 (10.4%) had been using a foam helmet.

The report details;

Helmet users were more often involved in accidents with a moving object than non-users (8.3% versus 4.6%).

From 282 who wore helmets this relates to 23 accidents and from 670 not wearing helmets 31 accidents (for 282 none wearers this would equate to 13 accidents). Even if the proportion of head injuries were lower by wearing helmets any increase in the risk of accident is very concerning. Table 2 shows the OR value to be 1.81 for the increased risk of collision with car from the effects of using a bicycle helmet.

No details of alcohol use are provided.

BHRF reports some concerns from Norway⁶² stating;

'In Norway there has been a shift towards more severe injuries among cyclists at the same time that cycle helmet use has increased.'

How reliable the findings are from the Hansen et al paper is difficult to assess.

Airaksinen et al. 2010⁶³ Finland

The report includes details of 216 cyclists who attended for acute care and 2 deaths in a 24 month period, June 2004 to May 2006. The crashes were mainly due to cyclists falling off, 31% of crashes were alcohol related. For helmeted cyclists 15% incurred a head injury vs 43% for non-wearers. The majority of injuries 91%, were minor to moderate with 16 cases (7.4%) leading to serious injury, 1 severe, 1 critical and 2 deaths. Reportedly none of the 29 helmet wearers was affected by alcohol.

Injuries to hand, wrist, arm and shoulder were 51% for helmet wearers and 25% for non-wearers, strongly suggesting helmet wearers had a higher proportion of simple falls. They report 67 cases (31%) of cyclists being under the influence of alcohol, with 87% of these having high readings. Alcohol related crashes led to 60% having head injuries vs 29% for sober cyclists. Most alcohol related crashes had minor to moderate injuries.

Sze et al. 2011⁶⁴ Hong Kong

The study included a total of 682 injured cyclists during the study period from 1 January 2004 to 31 December 2006. The Conclusions reads: Middle-aged casualties, the presence of head injuries, and the involvement of motor vehicles all increase the risk of more severe injury in bicycle-related crashes. Safety education and countermeasures should target at middle-aged and elderly cyclists and discourage cycling on the motorway.

From the 682 cyclists, 69 (10.1%) had a severe injury and 8 (1.2%) a life-threatening injury. The helmet use rate was very low (15, 2.2%). The OR value was 0.98 indicating a slight benefit from helmet use. They define 'head injury' to include head, face and neck. It explains;

In Hong Kong, owners of restaurants and food stalls usually employ cyclists to deliver food ordered by clients far away from the restaurants or food

stalls. Many of these "occupational cyclists" are middle-aged and even elderly cyclists who are usually not well educated. Many delivering destinations are in business areas or residential areas not accessible or connected by any bicycle lanes. These cyclists are forced to drive on major roads. In order to do more business and to shorten the turn-around time,

There has been an increase in the proportion of road crashes involving bicycles in Hong Kong in the past decade from 5.3% in 1997 to 10.5% in 2006. It appears that 15 helmet wearers from a 682 sample of cyclists may be too low a sample size to draw conclusions about helmet use in this case.

Discussion on 'head injury' reports

From the 28 reports an OR value of 0.49 was reported. Three reports found a negative result for helmets with OR values, 1.37, 1.82 and 1.10, namely Shafi et al, Wagner et al, and Malczyk. The strongest positive results for helmets came from Heng et al, Sethi et al and Dinh et al 2013 with OR values 0.09, 0.22 and 0.22 respectively. Two of these reports included alcohol details for wearers vs non-wearers, namely, Heng et al, 0% vs 12.5% and Sethi et al, 6.2% vs 20.2%. Dinh et al 2013 did not provide details of alcohol use but later in 2015 detailed 2% vs 20% for wearers vs non-wearers.

Two other reports with low OR values were Airaksinen et al 0.31 and McIntosh et al – 0.35. Airaksinen et al reported 31% of cyclists being under the influence of alcohol but none of the helmet wearers was affected by alcohol. McIntosh et al provided data from Sydney without details of alcohol use but Dinh et al 2015 disclosed alcohol use data showing 2% vs 20% had occurred.

With three reports finding a negative outcome from helmet use and other results having issues with alcohol it does not provide reliable evidence of a benefit in terms of overall safety.

Facial Injury

The meta-analysis used 17 reports with an overall OR result of 0.67. Two reports found an increased face injury risk, Thomas et al. - 1.15 and Hansen et al. - 1.15. Two other reports found near to zero effect, Olofsson et al. - 0.98 and Wagner et al.- 0.96. Some of the strongest results showing a helmet benefit came from Heng et al.- 0.11, Dinh et al. 2015 - 0.31, Dinh et al. 2013 - 0.39 and Webman et al 2013 - 0.47. Alcohol use for these reports detailed for wearers vs non-wearers, Heng et al, 0% vs 12.5%, Dinh et al 2015, 2% vs 20%, Webman et al 2013, 6.3% vs 11.1% and Dinh et al 2013 did not provide alcohol use details. Thomas et al and Olofsson et al both had children only in their reports, so alcohol would not be expected to be significant, Hanson et al had mainly children. There is reasonable doubt if the overall claim of a benefit from helmet use reducing face injury can be considered reliable. A recent report by Stire et al⁶⁵ reported an increased risk from helmet use of mandibular (jawbone) fractures and this could have implications for concussions or more serious brain injury; however more research appears to be needed in this area.

Neck Injury

The meta-analysis used 12 reports with an overall OR result of 0.98. Five reports found an increased risk, McDermott et al. – 1.80, Amoros et al. – 1.26, Webman et al – 1.08, Zibung et al. – 1.43 and Sethi et al. – 1.53. In Attewell et al⁶⁶ they included Wasserman & Buuccini 1990 report with an OR 1.87 but it was not included in this meta analysis. Some cyclists will have neck problems due to wear and tear. The long term use of helmets adds more stress and wear to the neck and some cyclists mention neck problems, probably more so in later life.

Fatality considerations

The fatality claim of 65% odds reduction is based on two reports^{67,68}, and 159 deaths, one report from Western Australia in 1993, Cooke et al, involving 64 fatalities (1984-1992 period) of which they included 30 fatalities in the meta-analysis, 24 cases and 6 controls. Most of the 64

fatalities (59%) involved children or young adults less than 20 years of age. A second report was based on data from Ontario, Canada in 2012, Persaud et al, involved 129 fatalities, where 30 had taken alcohol or drugs⁶⁹. The Persaud et al study does not mention the 30 that had taken alcohol or drugs. A question was reported;

What was the helmet wearing status of these individuals? Have the authors overestimated the value of helmets by not accounting for this factor?

Persaud et al failed to answer the question or provide the information requested⁷⁰.

Types of fatal accidents

Cyclist fatalities occur from a range of situations, for example motor vehicle hitting a cyclist from behind. In this situation the bicycle may be the first point of impact. One Australian report detailed;

*More than two-thirds of the deaths of cyclists aged 5–17 years were the result of the cyclist failing to give way to oncoming traffic and about half of these cases occurred at intersections. A typical behaviour for the younger (preteenage) cyclists was to enter the intersection from a footway without dismounting and without looking.*⁷¹

These types of situations may result in side impacts where the legs, body and head may all come into contact with a vehicle and be severe due to drivers often having little warning and time to slow down. Data from the Netherlands reported 50% to 65% of cyclists were hit from the side by the front of the vehicle⁷².

The definition used by Olivier and Creighton was;

Cycling fatalities with multiple injuries including the head were categorized as a head injury.

It appears that young cyclists may have a higher proportion of side impacts due to riding into the road or at junctions and could be more likely to suffer multiple injuries including the head. The wearing rates for the younger cyclists could on average have been lower than adults⁷³. These aspects would probably affect the overall fatality risk and proportion of injuries apart from helmet use. In collisions with motor vehicles Spaite’s report 1991 found that helmet users without head injuries were also less severely injured than non-users without head injuries (4% v 32% and mean ISS 4 v 13 (injury severity score)⁷⁴.

If the 65% odds reduction calculation for fatal head injury had been a true reflection on helmets saving lives, a substantial drop in cycling fatalities relative to cycling levels and road safety trends would have been expected in Australia, New Zealand and Canada where the proportion wearing helmet has increased appreciably. Fatality data below is for cyclists from the three countries and to reflect general improvements trends in road safety pedestrian data is also shown, with the percentage of cyclist to pedestrian deaths (C/P%) provided.

For Australia there was strong evidence of cycling reducing in parts of the country following legislation, e.g. In Melbourne, road surveys revealed 30 more teenagers wearing helmets compared with 623 fewer cycling. In NSW, surveys showed 569 more children were wearing helmets compared

Years	86-89	90-93	94-97	98-01	02-05	06-09	10-13
Cyclists – C	342	224	216	161	144	139	155
Pedestrians – P	2079	1444	1444	1194	927	815	682
C/P%	16.45	15.51	14.96	13.48	15.53	17.05	22.7

Table 4: Fatality data for Australia, (helmet laws introduced between July 1990 and July 1992);

with 2658 fewer cycling. For adults counted at road sites in NSW a 26% reduction occurred from 1991 to 1993, from 7534 down to 4251. For Brisbane, Perth and Adelaide the census count for cycling to work in 1991 and 1996 shows a drop from 20054 to 14903, representing an approximate 30% drop when population growth is included. The reduction in cycling was disputed by Jake Olivier and others who presented evidence to the Australian Senate, however it was reported;

1.2 During the course of the hearing, and based on available data, it became clear MHL have undermined cycling participation rates. Attempts to argue to the contrary, especially given evidence from around the world, were not at all persuasive.⁷⁵

Olivier et al made further misleading claims of 'No strong evidence bicycle helmet legislation deters cycling'⁷⁶. The article selected evidence from telephone surveys in South Australia and Western Australia and did not relate to the levels of enforcement and overlooks the wider evidence available. Jake Olivier and Raphael Grzebleta, two of the authors of the MJA article gave evidence to the Senate hearing in Melbourne⁷⁷.

Note, in the 1991 census South Australia was subject to legislation and had a reduc-

tion in the proportion cycling to work and Western Australia was not subject to legislation and had an increase.

It was reported for Australia between 1991 and 2013 that 'cycling deaths following multivehicle crashes decreased at a rate of 2.9% per annum (95% CI: -4.0, -1.8), while deaths from single vehicle crashes increased by 5.8% per annum (95% CI: 4.1, 7.5). The difference between the two trends was statistically significant ($p < 0.001$)⁷⁸. Out of the 5.8% increase the proportion wearing helmets was not provided.

One estimate using census data for adults and accident data for the 0-16 age group indicated that cycling levels increased from 1986 to 1990 by 19%, reducing by 21% from 1990 to 1991 and reducing from 1991 to 2011 by 28%. For adults, from 1991 to 2011 census data indicated an increase of about 26.8% but accident data and other information for the 0-16 age group indicated a reduction of about 65% in cycling levels⁷⁹. From 2011 to 2015 details reported indicated a reduction in the proportion cycling. Reportedly, cycling participation rates across Australia are measured over the previous week, month and year. Measured over the previous week the cycling participation rate changed from 18.2% in 2011, to 16.5% in 2013 and 17.4% in 2015.

	1976	1981	1986	1991	1996	2001	2006	2011
SA (1.7.1991)	2.04	2.45	2.27	1.95	1.27	1.17	1.43	1.25
WA (1.1.1992)	0.98	1.48	1.72	1.85	1.20	1.28	1.25	1.34
Average	1.51	1.96	1.99	1.90	1.23	1.22	1.34	1.29
% drop from 1986				5%	38%	39%	33%	35%

Table 5: Census data, % cycling to work, for SA and WA (law introduced date)

Years	90-93	94-97	98-01	02-05	06-09	10-13
Cyclists - C	83	55	53	39	39	35
Pedestrians - P	342	242	221	172	161	130
C/P%	24.27	22.73	23.98	22.67	24.24	26.92

Table 6: Fatality data from New Zealand, (helmet law introduced 1st January 1994)

Only New Zealand from the three countries has published data on estimated hours walked and cycled on a regular basis⁸⁰, meaning their results may be a more reliable indicator of effects from helmet legislation. For New Zealand Clarke reported; 'From 1988–91 to 2003–07, cyclists' overall injury rate per hour increased by 20%' and 'Cycling usage reduced by 51%'. Wang et al criticised the findings and Clarke replied detailing that they had used the wrong data in their article⁸¹. Refer 'Additional information' and 'Additional concerns' for extra details on New Zealand.

tion to⁸⁶.

Clarke also reported on Canada with data indicated that cycling had been reduced by helmet legislation requirements⁸⁷.

Years	90-93	94-97	98-01	02-05	06-09	10-13
Cyclists - C	364	281	244	218	230	249
Pedestrians - P	2036	1727	1527	1456	1376	1261
C/P%	17.88	16.27	15.98	14.97	16.71	19.75

Table 7: Fatality data for Canada⁸², Four provinces introduced helmet legislation for either all-age or under-18 year olds in the period 1995 to 1997 and some others followed⁸³. (based on Road Traffic Collisions Statistics)

Cyclist's deaths reported for Canada show distinct differences, e.g. In 2011 the national road accident report details 52 deaths⁸⁴, whereas Statistics Canada details there were 90 deaths in 2011⁸⁵. It appears that Road Traffic Collision Statistics do not include cyclist deaths due to falls, i.e. 'Pedal cyclist injured in noncollision transport accident [V18]' group. From 2000 to 2004 there were 45 deaths from noncollision transport accident in the 5 year period from 2008 to 2012, there were 87 deaths.

Fatality discussion

Overall the fatality data from the three countries does not indicate a strong or any effect in helmets saving lives. It appears that cyclist deaths due to falls have increased and are not always included in road accident statistics. It was reported;

In over 60 per cent of crashes, the cyclist was deemed to be 'responsible' for the action that precipitated the fatal crash⁸⁸.

For Edmonton, Canada it was reported;

Surveys in Edmonton in 2000 (pre-law) and 2004 (post-law) suggest that cycling by children and teenagers has been significantly reduced compared with adults (59% children, 41% teenagers) (Hagel et al, 2006).

Close attention to details of why the accident occurred and behaviour is needed to assess what measures are desirable to improve safety.

A UK study reported;

A specialist biomechanical assessment of over 100 police forensic cyclist fatality reports predicted that between 10 and 16% could have been prevented if they had worn an appropriate cycle helmet⁸⁹.

and

There are in fact sharp falls in cycling after legislation evident in the data, which the authors do not draw atten-

In 1985 a New Zealand report based on 20 fatalities gave the coroner's opinion;

"This study indicates that compulsory wearing of suitable safety helmets by cyclists is unlikely to lead to a great reduction in fatal injuries, despite their enthusiastic advocacy".⁹⁰

Both the UK and NZ reports above did not relate to the accident rate per km for helmeted v non-wearers.

Additional Australian information has also been reported⁹¹;

e.g. For NSW in the period 1992-2011 there were 231 cyclist deaths, 154 helmeted, 66 not wearing and 11 unknowns. Of known cases, 70% were helmeted. The 1993 Smith survey reported wearing rates of 68% for children under 16 at road sites (56% for Sydney) and 83% for adults (77% for Sydney). The wearing rate for cyclists varied and the lowest use appears to be associated with nighttime cyclists and teenagers. The use of hi-vis vests is typically associated with adult cyclists and they reportedly result in a lower accident rate. Some non-wearers may typically be at higher risk due to other factors. Between 1996 and 2011, of known cases who had been drinking alcohol, 10 were helmeted and 12 were without helmet. Nine of the 12 non-helmeted cyclists had a Blood Alcohol Content (BAC) of 0.150 or above and only one of the 10 helmeted had this level. Six of the 10 helmeted had low levels of between 0.001-0.019. Of known cases, 10% of helmeted and 29% of non-helmeted had been drinking.

and

For Queensland in the period 1993-2008 there were 146 cyclist deaths, 82 helmeted, 44 not wearing and 20 unknowns. Of known cases, 65% were wearing helmets. In critical accidents helmets can dislodge and on inspection it may not be known if the rider was wearing or carrying a helmet. Of the 44 not wearing, 13 (29.5%) had been drinking alcohol and from the 82 helm-

eted, five (6.1%) had been drinking. In comparison, for pedestrians fatalities about 25% had been drinking alcohol. Queensland data (1999 to 2004) shows 51 deaths in the six years, 35 wearing, 10 not wearing and 6 unknown. Of known cases, 77.7% were wearing helmets which was similar to the reported wearing rate of 77%. From the 10 not wearing, three had been drinking alcohol and none of the 35 wearing helmets.

A number of reports mention alcohol⁹² but the Olivier / Creighton report fails to mention it has a possible contributory factor in fatality cases. One report from Canada mentions alcohol use was detected in 25 (25 %) of cases⁹³ and it reported;

'Fatally-injured cyclists who had evidence of alcohol consumption were less frequently reported to be wearing a helmet than deceased cyclists without documented alcohol use (4 % vs. 33 %; p=0.003).' Another report details; 'Alcohol use showed a strong correlation with head injury (odds ratio, 3.23; 95% confidence interval, 1.57-6.63; P = .001)⁹⁴.' Another report details; 'Main Outcome Measure Odds ratio of bicycling injury according to estimated BAC. Results An estimated positive BAC (≥ 0.02 g/dL) was detected in 12.9 of the case bicyclists (23.5% of the 34 fatally injured and 8.9% of the 90 seriously injured) compared with 2.9% of the control bicyclists (P<.001). Relative to an estimated BAC of less than 0.02 g/dL, the adjusted odds ratio of bicycling injury was 5.6 (95% confidence interval [CI], 2.2-14.0) for a BAC of 0.02 g/dL or higher and was 20.2 (95% CI, 4.2-96.3) for a BAC of 0.08 g/dL or higher. Rates of helmet use at the time of injury or interview were 5% and 35%, respectively, for those with and without a positive BAC (P = .007). Conclusion Alcohol use while bicycle riding is associated with a substantially increased risk of fatal or serious injury,⁹⁵

Australian national fatality data from 1988 reported the proportion of road accident deaths due to head injuries – see Table 8 for deaths and Table 9 for the coroner's as-

assessment of final cause of death. Cyclists are not at a particularly higher risk of fatal head injury than pedestrians.

Totals	Cyclist – 86	Peds. – 541	MVO – 1910
0-12 yrs	84% (19)	96% (72)	87% (79)
13+	79% (67)	76% (469)	67% (1831)

Table 8 (Note; MVO – Motor vehicle occupants)

Totals	Cyclist – 40	Peds. – 233	MVO – 688
0-12 yrs	58% (11)	54% (39)	53% (42)
13+	43% (29)	41% (194)	35% (646)

Table 9 (Note; MVO – Motor vehicle occupants)

For cyclists, approximately 86% had at least one other serious injury other than the head. Most had chest injuries, so even when helmeted, many may die due to other injuries.

The Cooke et al report mentions 'Most of the 64 fatalities (59%) occurred in children or young adults less than 20 years of age'. Fatality data and road accident data relating to children shows they have a higher proportion of head injuries compared with adults. Cooke et al paper mainly refers to the pre law period, 1984 to 1992, and mainly people wearing helmets would have done so by their own choice. Essentially these would be people trying to be safer and may differ in where they ride and behaviour compared to the average person.

The meta-analysis with two reports on fatalities and one not providing details regarding alcohol and drug use and the overall approach not taking full account of the differences in behaviour and type of accidents means it lacks important information. It is not sufficiently detailed to support reliable conclusions.

Olivier and Terlich reported on trying to take account of the many confounding elements that are sometimes involved in

cycle accidents⁹⁶. They used data related to Bambach 2013 report⁹⁷ as the basis of their assessments, this had 1.7% for wearers and 7.2% of non-helmeted with a BAC over 0.5 (ratio 1 to 4.2). Data from another NSW report, Dinh et al⁹⁸ 2015, reported on injuries from inner city locations in Sydney and detailed for intoxication, 2% for helmeted v 20% for non-wearers (ratio 1 to 10). As mentioned above for fatality cases in NSW; 'Nine of the 12 non-helmeted cyclists had a Blood Alcohol Content (BAC) of 0.150 or above and only one of the 10 helmeted had this level' The ratio of high BAC was 1 to 7.5, wearers v non-wearers. The ratio factors used could influence the calculation and their significance. As noted above 'adjusted odds ratio of bicycling injury was 20.2 (95% CI, 4.2 - 96.3) for a BAC of 0.08 g/dL or higher. Bambach et al was reporting on collisions with motor vehicles that would not include the most common type of cycle accident, 'fall off bicycle'. It appears that the meta-analysis has not accurately accounted for confounding factors and their combined effects.

Additional information

New Zealand data

New Zealand has national data on injuries and hours cycled, so provides a better basis for considering the overall effects from helmet legislation.

It was reported for New Zealand;

H) Increased risk of injury per cyclist since helmet laws were introduced

Several analyses have compared numbers of injuries with the numbers of cyclists. They all suggest that injuries per cyclist have increased from what would have been expected without helmet laws.

In New Zealand, from 1989 to 2011, average time spent cycling (on roads and footpaths) fell by 79% for children aged 5-12 (from 28 to 6 minutes per person per week) and 81% for 13-17 year olds (52 to 10 mins/person/week).

Adult cycling declined from 8 to 5 minutes/person/week then trended back up to 8 minutes. Graphs of cycle use over time provide strong evidence that the requirement to wear a helmet discouraged cycling. The reductions in cycling were accompanied by increased injury rates. Between 1989 and 2012, fatal or serious injuries per million hours of cycling increased by 86% for children (from 49 to 91), 181% for teenagers (from 18 to 51) and 64% for adults (from 23 to 38)⁹⁹.

Additional concerns

Robinson's 1996 report¹⁰⁰ provided injury data for children. In Victoria, the equivalent number of injuries for pre law levels of number of cyclists increased by 15% from 1990 to 1992. Robinson provides data in Table 2 for children in NSW. The equivalent number of injuries increased from 1310 (384 head + 926 other injuries) pre law in 1991 to 2083 (488 head + 1595 other injuries) in 1993. The relative injury rate increased by 59%, from 1310 to 2083. The relative increase in 'other' injuries of 72% and 27% for 'head' raises serious concerns. The proportion of head injuries decreased from 29.3% to 23.4% and would give the impression of a benefit if viewed in isolation.

Robinson 1996 also refers to the incidence of hitting their head/helmet in a cycling accident was "*significantly higher for helmet wearers (8/40 vs 13/476, i.e. 20% vs 2.7%, p 0.00001)*". A bare head width of approximately 150mm may avoid contact compared to a helmeted head at approximately 200mm width. Helmet wearers often report hitting their helmets and the 7 fold increase may have long term effects that may not show up in a meta-analysis.

Erke and Elvik 2007¹⁰¹ examined research from Australia and New Zealand and stated: "There is evidence of increased accident risk per cycling-km for cyclists wearing a helmet. In Australia and New Zealand, the increase is estimated to be around 14 per cent." The findings were based on six reports, four from when legislation was in place.

Clarke provided evaluations of both the New Zealand¹⁰² and Australia¹⁰³ bicycle helmet laws and reported;

This evaluation of NZ's bicycle helmet law finds it has failed in aspects of promoting cycling, safety, health, accident compensation, environmental issues and civil liberties. It is estimated to cost about 53 lives per year in premature deaths and result in thousands of fines plus legal aspects of discrimination in accident compensation cases.

and

Australia's bicycle helmet laws were introduced in 1990-1992. Surveys and census information show the laws discouraged cycling, by more than 40% in some cases. Per million population, approximately two cyclist deaths occur annually compared to 2000 from cardiovascular disease. Dr Mayer Hillman from the UK's Policy Studies Institute calculated that life years gained by cycling outweighed life years lost in accidents by 20 times. The helmet laws have not delivered a net societal health benefit, with a calculated cost benefit ratio of 109 to 1 against.

A recent report detailed that cyclists wearing helmets had more than twice the odds of suffering an injury than cyclists not wearing helmets,¹⁰⁴ with an OR value 2.81, 95% CL = 1.14, 6.94.

Conclusions

It appears that several contributing factors can lead to non-wearers having a higher proportion of head injuries compared to wearers because of differences in behaviour. The meta-analysis includes some reports indicating that wearers have a higher rate of falling off compared with the general community. It also includes reports indicating that wearers behave in some respect with more care. It does not adequately cover issues of alcohol/drug use and accident effects for injury severity from falls and motor vehicle accidents. It does not relate to risk per km of cycling and to the implications of helmet legislation, reducing cycling activity, health effects, reduced appeal for bike share

programmes, issues of accident compensation and civil liberties consideration for the individual to decide if wearing a helmet suits them. Some of the reports quote misleading information suggesting helmet legislation has not discouraged cycling. The fatality data from Australia, New Zealand and Canada indicates that cyclist fatalities have not reduced at a rate greater than that for pedestrians when considered against for changes in cycling levels.

The meta analysis concludes with;

'These results suggest that strategies to increase the uptake of bicycle helmets should be considered along with other injury prevention strategies as part of a comprehensive cycling safety plan.'

The conclusion here is that helmet legislation should not be supported or imposed and the focus on improving safety should be by other means, e.g. a minimum passing clearance law for vehicles overtaking cycling. A range of measures to improve safety, educate and encourage cycling without a focus on helmets. How best to educate cyclists to ride safely and avoid undue risks is also a key task to improving cyclist safety, a code of conduct to learn and follow.

The claim that helmet use is associated with odds reductions of 65% for fatal head injury looks to be unreliable because it fails to take account of a range of information on fatality circumstances and trends in deaths. It gives the impression of a major benefit that is not sufficiently supported by the data from countries where helmet use is now widespread. The meta-analysis does not provide a reliable guide to overall safety for cycle helmet use or to the major disadvantages to helmet legislation. Due to the weaknesses in its approach, it over estimates potential benefits, if any, from helmet usage. The results claimed for fatal head injury, serious head injury, head injury, face injury can all be considered unreliable.

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Rethinking the design of suburban shopping centres: A new blueprint for Westfield Chermside and other centres

Jessica Lisle

The suburban shopping centre concept evolved in a period in which car dependence was increasing, supporting the increase in low-density housing options and reduced walkability. This article explores how the shift in behaviours around mobility, housing choice and retail are influencing some changes to cities such as revitalisation of inner city areas, increase in urban density and uptake of more sustainable transport. By exploring examples such as New York City's pedestrianisation strategy and the transition of the Villa Italia Mall to the mixed-use town centre of Belmar in Lakewood, Colorado, this article determines that suburban shopping centres require a new design strategy that provides greater accessibility and diversity. Using Westfield's Chermside in Brisbane, Australia as an example, this article presents a new blueprint for suburban shopping centres that provides a walkable mixed-use precinct that is integrated into the surrounding community.

Car dependence, urban density and the link to suburban shopping centres

The future of cities will inevitably see a decline in car use and an increase in urban density. These two characteristics of cities are linked, with cities that have higher urban density reporting low car use and, conversely, low-density cities with high car dependence (Newman and Kenworthy 2015). In the Global Cities Database prepared by Newman and Kenworthy (2015) there is evidence that the urban density of most cities experienced a decline from the 1960's. In Australian and American cities experienced a decline in the average urban density from 17.7 to 14.4 persons per hectare from 1960 to 1980 (Figure 1) (Newman and Kenworthy, 2015). At the same time overall car use increased with some cities seeing vehicle kilometres travelled per capita (VKT/capita) more than double in the same period (Newman and Kenworthy, 2015). It was in this period that suburban shopping centres flourished.

Suburban shopping centres emerged in places like the United States and Australia in the 1950's, maximising on the increase in private car ownership and providing a central place for retail shopping. In this

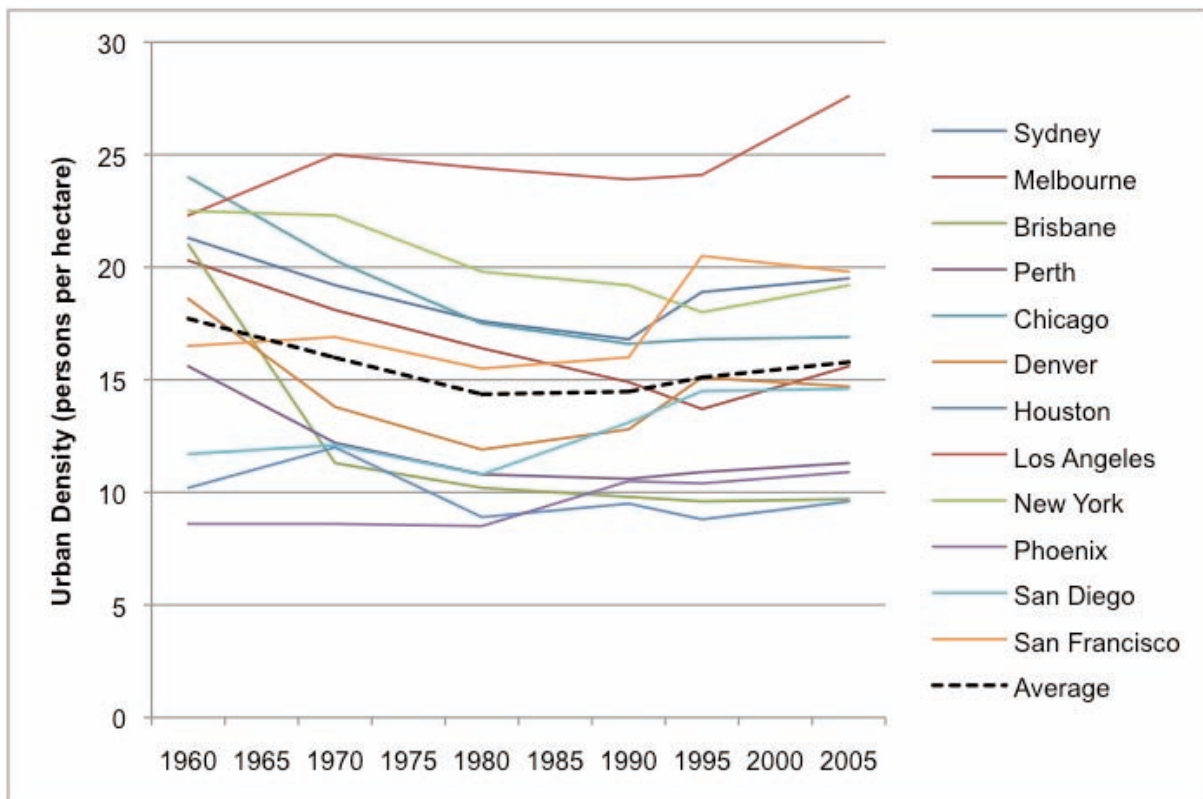


Figure 1: Urban density (persons per hectare) for Australian and American cities (Newman and Kenworthy 2015).

period urban density had begun to decline as the increase in car ownership allowed for lower density housing (Newman and Kenworthy 2015). Suburban shopping centres were located on what was the periphery of cities and usually contained a large expanse of car parking with limited pedestrian access (refer to Figure 2). The lower density of housing and push towards shopping that was reliant on car use influenced how cities evolved.



Figure 2: Early images of suburban shopping centres including Villa Italia Mall in Lakewood, Colorado (Myers 2013) and a Westfield Centre in Australia (Westfield Corp 2016).

However following the 1980's American and Australian cities have, on average, seen a gradual increase in urban density (Figure 1) (Newman and Kenworthy, 2015). Between 1995 and 2005 some cities, including Houston and San Francisco, saw a decline in VKT/capita and, while car use in other cities is still gradually increasing, the trend is stabilising (Newman and Kenworthy, 2015). This gradual increase in urban density and associated stabilisation and predicted decline in car use is and will continue to create a ripple event in other elements of urban planning and design.

How the shift in mobility, housing choice and retail is affecting city design
The shift in urban density and car use behaviour is linked to other changes in behaviour around mobility and housing choice. The stabilisation in car use correlates to an increase in public transport patronage and non-motorised means of transport (walking and cycling) (Newman and Kenworthy, 2015). Generationally Millennials and the retiring Baby Boomer generation are choosing denser, more diverse, connected and walkable communities and shying away from their suburban

roots (Moos 2015; Newman and Kenworthy 2015; Leinberger 2011). This has created unprecedented demand for medium- to high-density living options (Udell et al. 2014). As the residentialisation of inner city areas occur, commuters are switching to more sustainable means of transport (Newman and Kenworthy 2015; Montgomery 2013).

Retail behaviour is also shifting with the rise of online shopping and demand for flexibility from consumers (Experian Marketing Services 2012). As people adjust to their more urban lifestyle, there is also a shift in the dining and entertainment scenes with growing popularity of boutique cafes, bars and restaurants and decline in popularity of large food chains and fast food (Olinga 2014; Passikoff 2014). This change in transport behaviour as well as lifestyle and shopping habits is gradually redesigning cities.

Urban design and planning is responding to this shift by creating more walkable centres that promote public transport and cycling (Newman and Kenworthy 2015; Leinberger and Lynch 2014; Gehl 2010). To address the demand for more urban lifestyles there is an increase in medium- to high-density living options, revitalisation of accessible inner city burrows, provision of urban green space and residentialisation of central business districts (Newman and Kenworthy 2015; Leinberger and Lynch 2014). Gehl (2010) celebrates this transition, arguing that sustainable cities need to be varied and complex, putting people at the centre of design.

This transition to more walkable cities is beneficial to not only the wellbeing of urban dwellers but also the economy. The Heart Foundation of Australia has earmarked density, when delivered in an effective manner, as one of the most important aspects in promoting physical activity (Udell et al. 2014). Smart Growth America (2015) points out that the more diverse an urban centre is, the safer, more accessible and economically resilient it will become. From an economic perspective, a study completed by Leinberger and Lynch (2014) demonstrated that the walkability of an urban centre could be correlated to better economic performance. This has been demonstrated in New York City where several redevelopment projects have repurposed over 10.5ha of car lanes into pedestrian space, which has led to higher foot traffic, an increase in retail sales, decline commercial vacancies and doubling of rent of retail stores, when compared to neighbouring areas (Sadik-Khan, 2013). While the creation of walkable urban centres has numerous environmental benefits, developers and government agencies alike are recognising the economic and social value as being the key drivers to make it happen.

Impacts of changing urban environments on suburban shopping centres

This transformational change in the way that cities operate will inevitably have consequences on suburban shopping centres. The current design of prioritising access by car will become redundant and should prompt centres to completely rethink their design. There are a number of examples where suburban centres have experienced economic decline as a result of reduced retail sales and foot traffic. This results in less secure retail tenancies, and in some cases the complete closure of the centre. Shopping centre owners and governments are looking at innovative ways to adapt.

The prominent owner of shopping centres in Australia and America, Westfield, is responding to this shift in city design and shopping behaviour by increasing the number of inner urban centres, such as the Westfield Stratford City Centre completed in the same area as London Olympic Park and the redeveloped Westfield's

Sydney Centre located in a high-density precinct within Sydney CBD. When compared to a suburban centre, such as Westfield's Chermside in Brisbane, the Sydney Centre has 200% more annual customer visits yet provides less than 3% of the parking (Scentre Group 2016 a, b). The residential and commercial office space surrounding the centre and the accessible nature of Sydney CBD by public transport supports the high annual customer visits without Westfield having to provide that diversification of land use within the design. However for suburban centres, the walkability and public transport access to and from the centre is more dependent on the centre design than the location. In addition, the large outward (rather than upward) footprint of the centre disconnects suburban centres from surrounding residential or commercial land uses thereby limiting their customer catchment.

Many of Westfield's older suburban shopping centres are in precincts of cities that are becoming gradually denser and better serviced by public transport, a big shift from their original low-density urban-periphery identity. The Chermside centre, located about 10km north of Brisbane's CBD, is one of Westfield's oldest centres, originally built in the late 1950's. The centre has undergone various redevelopments, the most recent of which does try and emulate the feeling of a traditional main street (refer to Figure 3, left). Yet the centre itself is still largely disconnected from the surrounding community and only provides retail and dining options as the sole land use on the site (refer to Figure 3, right). This disconnected design of the centre encourages access by car and limits foot traffic. The enclosed nature of the design means that stores are restricted to the opening hours of the centre, preventing that flexibility that consumers want in retail and in dining and entertainment. The design of suburban centres not only encourages car dependence, it limits the economic and social potential that mixed-use urban centres could provide.



Figure 3: Proposed redevelopment of Chermiside Shopping Centre emulates the main street feel (left) but is still disconnected from the surrounding community (right) (Scen-tre Group 2016c).

In Lakewood, Colorado¹ the Villa Italia Mall, originally built in the 1960's (shown in Figure 2 and 4), was recently redeveloped into a mixed-use town centre. The Mall experienced heavy economic decline in the 1990's, which prompted the City Council to purchase and redevelop the 40.4ha site to a mixed used town centre (Myers 2013). The new town centre, Belmar, includes a mixture of residential living options, commercial office space, retail and department stores, and entertainment options (Arcadis 2016). By shifting the design to an urban village, the shopping 'centre' is also thereby includes access to 3.6ha of green space and provides flexible opening hours to dining and entertainment leases (CNU 2015). Like many suburban areas in America, the shopping centre had previously robbed the community of a traditional centre or meeting place, whereas

following the redevelopment Lakewood has re-established the traditional town centre and created a walkable community (CNU 2015).

While the transformation of the Lakewood centre has been successful, one could argue that it hasn't gone far enough by still incorporating a large provision of parking and a fairly coarsely grained street network (refer to Figure 5). The neighbouring residential areas have remained at the same density, without maximising on the opportunity for those areas to be redeveloped and support medium density living. The centre provides a shuttle service to the nearest light rail hub (1.6km away) (Myers 2013) but ideally should support the extension of light rail to further reduce car dependence. One could argue that these shortfalls in the design limit the potential



Figure 4: The transition of the Villa Italia Mall from a suburban shopping centre to Belmar, a mixed-use town centre (Van Meter Williams Pollack 2015).

¹ Lakewood is located in the municipality of Denver. In the Global Cities Database (Newman and Kenworthy 2015) Denver did experience a decline in urban density from 1960 however since 1980 urban density has increased from 11.9 in 1980 to 14.9 in 2000. Car use is showing signs of stabilising with a decline in car ownership and parking availability in the CBD. There is also an increase in public transport patronage.

of Belmar to become a successful walkable urban centre. The new urban village at Lakewood demonstrates that the transition from the traditional suburban shopping centre is feasible, but the design does need to embrace the concept of a walkable



Figure 5: Recent aerial image of Belmar, Lakewood, Colorado indicating the high availability of car parking and proximity of low-density housing (Google Earth 2016).

urban centre in order for retail and other commercial uses to secure the benefits of a walkable community.

A proposed new blueprint for suburban shopping centres

Based on this analysis, a new blueprint for re-designing suburban shopping centres is needed. This proposed blueprint for suburban shopping centres will allow our car dominated and disconnected centres to transition to an integrated mixed-use town center precinct that provides both residential and commercial land uses. The design will be symbolic of a traditional town center and, while maintaining the existing retail floor space, will also provide a diverse array of residential housing options and commercial office space. This design will support flexible opening hours for retail stores and dining and entertainment options, which in turn will create increased foot traffic and a knock on benefit to retailers. The presence of more than just retail land use will create multiple revenue streams for the developer plus provide more people to be engaged with retail and other commercial uses.

The redesign of suburban shopping centres to a mixed-use town center layout will provide more than just economic opportunity for the center management and retailers. By creating a walkable urban center, use of more sustainable means of transport (walking, cycling and public transport) will increase within the new center and the surrounding community. This will reduce traffic, reduce emissions and foster more active lifestyles. By segregating retail stores into a street network the resource and environmental cost of energy and water to retailers will be reduced, with new sustainable built form enabling energy and water efficiency and providing opportunity for renewable energy and rainwater capture. The mixed-use urban center will help build a sense of place for the community, establishing a town square, park network and spaces that encourage community interaction.

Using Chermside as an example, Figure 6 proposes how suburban shopping centers can be redeveloped into a mixed-use town center. By designing shopping centers as town center precincts, retail land uses will operate in unison with commercial office space and residential living options. The center will become a walkable street net-

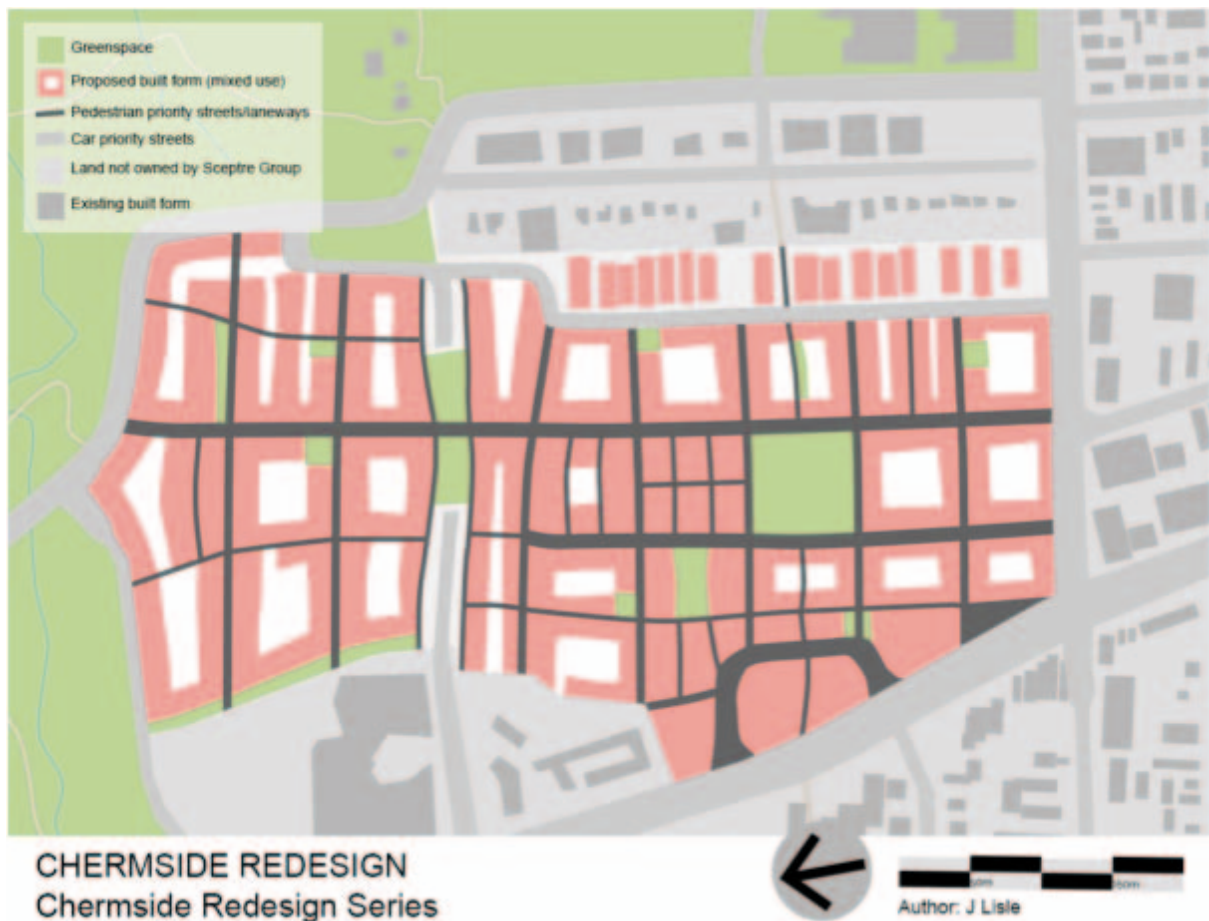


Figure 6: Proposed redesign of Chermeside Shopping Centre to a mixed-use urban community. (Jess Lisle 2016)

work that varies from three to six stories high. The street level will provide retail land use with short yet more active frontages and the ability to expand upward rather than outward. In the floors above, the commercial office space and residential living options will be well connected to retail and dining options and have good visibility onto the street. The mixed-use nature of the design will allow for a diversity of office and apartment sizes from a small studio to a large two-story townhouse style apartment.

Drawing on the design principles put forward by Gehl (2010), the design will include a walkable street network that is narrow and permeable and have the ability to be designed for solar access. The streets will have places to sit and pause and be well connected to green space. Further, streets will be predominately used by pedestrians and cyclists with public transport restricted to designated routes. Car access will be limited to the underground car park with on street parking only permitted

for service, delivery and emergency vehicles. The precinct will be integrated with public transport and give priority to light rail infrastructure.

The redevelopment of suburban shopping centers shouldn't create an imposition to existing retail stores, but rather work with the site to stage the development so that minimal disruption is caused to center. Staging will also provide a revenue stream to fund the redevelopment with sales of initial stages used to fund the remaining build out. A proposed staging plan is included in Figure 7 where the older part of the Chermeside center is redeveloped first to create the Town Centre and Entry Precinct. It is envisaged that by the stage of full completion surrounding landowners will embrace the concept and switch to a street based network of retail, commercial and residential.

In essence, suburban shopping centers need a radical rethink in the way they are designed. The increase in urban density



Figure 7: Staging of the redevelopment to allow continuation of most of the retailers during redevelopment from current form (top left) to Stage 1: Town Square and Entry Precinct (top right), Stage 2: Completion of Town Square and Main Streets (bottom left), Stage 3: Full completion (Figure 5) and Stage 4: Surrounding landowners embrace the concept (bottom right). (Jess Lisle 2016)

and decline in car dependence will inevitably require shopping centers to be more integrated into the surrounding community, supporting a diverse range of customers, access by public transport and easy walking and cycling access. Cities are experiencing a shift in mobility, housing choice and retail behavior and as a result are becoming more walkable, dense and diverse with studies showing that walkable centers are more economical and better for health and wellbeing. In response, suburban shopping centers are adapting with the newly created Belmar on Lakewood demonstrating how a center can transition to a walkable mixed-use center. A new blueprint for the redesign of suburban shopping centers requires an integrated mixed-use center that supports residential living, commercial office space, retail and dining and entertainment. By applying a walkable and fine-grained street network at Westfield's ChermSIDE, this new blueprint demonstrates that this approach to sub-

urban shopping centers not only responds to the challenges of creating viable retail, but also creates a diverse, inclusive and sustainable new community for the future.

Originality

This concept was originally submitted in a presentation for a Unit in the Curtin University Masters of Sustainability and Climate Policy program.

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A Comparative Study of Aerial Rope-way Transit (ART) Systems

Hazem El Jouzou

Agglomerations, Urbanization and Mobility

Today's urban agglomerations and their infrastructures are under continuously increasing pressures. While the human population is in steady increase, humanity is moving more and more towards urbanization. Beside urbanization, climate challenge became a demanding and urgent topic to comprehend. Earth's temperatures are rising to a record high, and many of the transportation modes used today are contributing to that increase. In addition to the bad effect they have on climate, those selective modes are proving to be inefficient, and therefore are making mobility and transportation in cities problematic and less productive. (United Nations, 2015, p. 2) (United Nations, 2014, p. 1) (Carrington, Damian; Slezak, Michael; The Guardian, 2016) (Cox, 2009).

Being a transport mode with the highest greenhouse emissions production (C2ES, 2013), the highest road congestions production, and in return the worst contribution to human health (Douglas, et al., 2011), automobile in its conventional form has become a major part of the transport problem. It is for that reason, that major automobile industries are promoting

smaller, electric, and self-driven vehicles as a solution for the car problem. Yet, although these trends appear to many as the transport mode of the future (LeBeau, 2014), and even though the new car trends are a good solution to reduce carbon emissions, the size of the vehicle will still be disproportionate to the number of passengers (in comparison to other modes), and therefore such solutions alone will not be enough to stop traffic congestion (Henderson, 2016)(Plate 1). These congestions might therefore continue to increase in size if TODs and other forms of green transportation did not take a credible part of the load of which the automotive mode occupies.

Beside orienting towards TOD, revitalizing traditional transport trends like walking and cycling through adequate urban planning and streets designs which realize their importance and simplifies and encourages their use can have a big positive effect on cities and communities in terms of transportation, congestion, carbon emission and health (GURGAON, 2015) (Kleinert, 2016). In this sense, promoting viable and compact cities design (cities that provide their inhabitants jobs, retail, recreation, and residency within short distances) becomes a necessity by itself to reduce automobile dependence (Newman & Kenworthy, 2006).



Plate 1: Space consumption to number of users in bicycles, car and buses

Source: Cycling Promotion Fund®, 2012

In contemporary cities mobility is no more a commodity. Mobility is a direct derivative to jobs access, services access, and in the bigger picture, to social mixture and social equality (Dávila, 2013, p. 17). It is due to this fact and the challenges above, that it becomes vital to cities and urban planners to think outside the box, evolve, and find solutions that are innovative, green, quick, affordable, and practical. In this direction, this research is aiming to introduce ART (Aerial Ropeway Transit) systems as a possible transport solution which, in cooperation with other transport innovations and solutions, could create a brighter outcome for cities and transportation systems around the world.

ART Systems: Potentials and Characteristics

While new trends are shifting towards self-driven cars, and e-mobility, and while these trends are presented as revolutionary, the real transportation revolution is in reality already happening. This revolution is happening in the simplest and cheapest forms a few meters above our eyes. Gondolas and aerial ropeways systems (ART) are taking part in changing our perception of transportation in our cities (Herwig, 2013, p. 49). This relatively slow but steady form of green transportation is spreading and conquering many cities in the developing world and have the potential to change the image of our cities in the near future. Functioning like a flying conveyer belt, ART systems know no traffic jams, and no schedule delays. While passengers using cars, busses, and street trams lose time in traffic congestion and schedule delays, passengers on gondolas moving above are enjoy a Birdseye view of the city while they move continuously and nonstop to their destination.

Although the traditional image of cable cars as alpine and ski transport tool still appears in our minds, the role of these systems has in reality changed. Cities like Medellin, Caracas, Vancouver, Portland, London, and Koblenz beside others have demonstrated to us how cities can overcome topographic obstacles and challenging urban agglomerations in an elegant, green, and cheap form, overcoming the problems of the conventional transport

networks and overcoming any need to drastically change the urban form. ART systems are changing rapidly from and isolated niche solution to a transportation mode integrated in to the infrastructure of our cities (Herwig, 2013, p. 49).

In the rapidly growing agglomerations of contemporary cities, ART systems have become a rapid, cheap, and green form of urban transport solution. These systems have helped improve these neighborhoods value in the eyes of locals and visitors alike (Dávila, 2013, p. 12). The speed in which they can be erected is incomparable to any other transport system. While cities wait 10 to 15 years to construct a Tram line or an inter urban railway track, gondolas can be built and can start operating in a short period of 14 months (Herwig, 2013, p. 39) (Seilbahn Koblenz, 2011). Furthermore, while these lines and railways can cost up to 30M € to cover a distance of 850m, ART systems achieve that in 13 M € only (Koblenz Seilbahn or cable cars an example). Beside the fact that ART systems are completely electrical and are by some measures the greenest urban transport systems is the world (Herwig, 2013, p. 39) , these Advantages give ART the potential of being a major transport system in urban environments in contemporary and future cities.

ART System Overview

ART Definition

Aerial ropeway transport system (ART, AKA cable cars, and Gondolas) is a public transport technology that transfers people in motor-less, engineless cabins which are suspended and propelled by a cable above. Through a single motor located in one of the two main stations, cabins are propelled in the air from one station to another. Although this system has been mainly and historically used in sky resorts to transfer skiers and tourists over difficult terrains and challenging surfaces, in recent years it has been used in urban location especially ones with difficult geographical characteristics. (Alshalalfah, et al., 2012, p. 1) (CUP, 2016)

The ART system components are divided in to five parts. The Terminals (stations),

the towers, the cables, the evacuation and rescue systems, and the cabins.

The Terminals: (main stations) They are the main elements (and in size the largest) in this system. They are located on the beginning and end of the transit line (drive

and return terminals or lower and upper terminals) and contain at one side the motor and bull wheel that rotates the cable and moves the cabins and on the other a support or haul wheel that helps the cable run in a continuous loop (Alshalalfah, et al., 2012, p. 2). They also contain the de-



Plate 2: ART Terminals - Koblenz
Source: Schulze, 2011



Plate 3: ART Terminal - Caracas
Source: Láscar, 2016

taching and slowing down area where embarking and disembarking from and to the cabins takes place, and the maintenance areas for these cabins. Further to that, some systems have intermediate smaller stations between the two main ones (Alshalalfah, et al., 2012, p. 2). The size of the main stations and their footprint area seems to be a challenge for designer's and planners when applying ART in areas with small building blocks (ex. informal settlements) (STRMTG & CEREMA, 2011, pp. 8,12). Plate 2 and Plate 3 show examples of main stations in Koblenz-Germany and Caracas-Venezuela.

The Towers: They are intermediate structures that support the cables between the stations. They are usually Truss-shape towers (lattice form or poly-shape) and they only serve as pivot point to raise or rotate the ropeway line and thus keep the cable moving between the bull wheels. (Alshalalfah, et al., 2012, p. 2) (CUP, 2016). When ART systems began to be used in urban environments, many urbanists and communities argued about the visual pollution such structures and towers produce in the urban environment. Thus a newer version of towers the so called "Sculpture towers" appeared in ART systems like the Portland Aerial Tram and the London Air-line (Dale,

2010). Plate 4 shows the two types of towers used in cable cars around the world.

The Cables: The cables are the core element in this system. These steel cables rotate around the bull-wheels in the main stations and move between them dragging the attached cabins with them from one station to another (Alshalalfah, et al., 2012, p. 2). The number of cables vary between the systems from one to three cables. These cables are used to propel the cabins and stabilize their movement and help the cabins resist wind pressure. They also help increase the capacity of the cabins. The technologies, and the amount of cables each system requires will be discussed further in the ART Technologies: section yet in short, the MDG gondolas use one cable, BDGs use two, and TDGs use three. In both the MDG and the TDG systems one cable works to stabilize, propel and move the cabin, in the TDGs the other two cables function also as means of stability. On the other hand, the BDGs the two cables move inversely, stabilize, and propel the cabin. (Alshalalfah, et al., 2012, pp. 2-3) (CUP, 2016)

The Evacuation and Rescue system: In multi-cable systems (Aerial Tram, Dual Haul, BDGs and TDGs), ART systems have



Plate 0: Towers of ART system comparison.

To the left: Koblenz towers (Trusses). Source: (Gruber, 2016) -Edited,

To the right: Portland Towers (Sculpture). Source: (Morgan, 2016) -Edited

Plate 4: Comparison of ART system towers

Left: Koblenz (trusses). Source: Gruber, 2016 - edited

Right: Portland (sculpture). Source: Morgan, 2016 - edited

"Cabin recovery technique" which allows the recovery of all the cabins to the main station during a system breakdown (CUP, 2016). When other failures occur, the most basic form of evacuation is the abseil technique by ropes which is only applicable with low ground clearances. (Alshalalfah, et al., 2012, p. 254) In monocable gondolas and when the failure is not power outages related, abseil technique is a seldom rescue method. It should be noted gondolas have an astonishingly high reliability factor which reduces the fear of such occurrences.

The Cabins: The cabins are the units that transport the passengers from one station to another. They are divided in size in to small, medium, and large where small carry up to 15 users, and large can carry up to 200. These cabins are totally enclosed, and receive normal ventilation or air conditioning depending on the system characteristic and/or the weather. The size of the cabin and its capacity depend on the amount of cables the system uses and the technology used (Alshalalfah, et al., 2012, p. 254).

ART: Historical Overview

The ART system or in its simple form the "ropeway" is one of the oldest mode of transport used by humanity to overcome obstacles. Some drawings of this transport mode date back to the year 250 BC in the south China area (Hoffmann, 2006, p. 1). Because it is a transport mode with a long history, this old mode of transport is simple, cheap, and tested through centuries of human use.

In the modern era, there were only seldom examples of ART used in urban environment. One of the few countries who utilized this technology for public transport in that era was the city of Alger in Algeria. In 1956 it constructed the first aerial tramway line "El Madania" to link two neighborhoods that were 83m above one another, the system had a distance of 215m. (Bergerhoff & Perschon, 2012, p. 4) (Alshalalfah, et al., 2012, p. 260)

The second attempt was the Cologne Rhine cableway. Constructed in 1957, with a cost of 1.5 million Deutschmark, the cableway was initially an attraction to the Federal

Garden Show help on the right side of the Rhine (where the park now lays). The service was so popular that the people of Cologne did not want it to be removed afterwards. It was temporary dismantled in 1963 because its supports overlapped with the construction plans of the zoo on the right side of the Rhine (Herwig, 2013, p. 49). Further to that period, the cableway was reopened in 1966 after changing its path and moving it southward. The system has 41 four-seat small cabins which result in a 1,600PPHPD on a total distance of 935 m. (Herwig, 2013, p. 49)

The third attempt was the Roosevelt Island Tramway. This system was built in the USA linking the Roosevelt Island to Manhattan. In 1976, and in the efforts to accommodate and to link the new middle- and low-income housing units being built in the island, an aerial tramway system was commissioned. This aerial tramway was intended to replace the old and deteriorated trolley system that was there since 1909. (Alshalalfah, et al., 2012, p. 259) (CUP, 2016).

Yet in reality, ART began first to catch steam in 2004, when the city of Medellin in Colombia opened its first MDG system (Line K) to connect the informal settlements (the Communes) in the hilly area of Santo Domingo to the metro transport system in Medellin city. After the installation of this systems, the residents of Santo Domingo could in less than 30 minutes cover the distance that required two to two and a half-hour before the cable, using small private busses. (Bergerhoff & Perschon, 2012, p. 4) (Herwig, 2013, p. 52) (Alshalalfah, et al., 2012, p. 259). After the success of the Medellin ART system, many countries especially in south America adopted the ART system and integrated it to their public transport systems. The most interesting one of these systems were, Caracas(Venezuela), and Koblenz(Germany), La Paz (Bolivia). The time line of these systems also demonstrates the evolution of the ART systems and technologies.

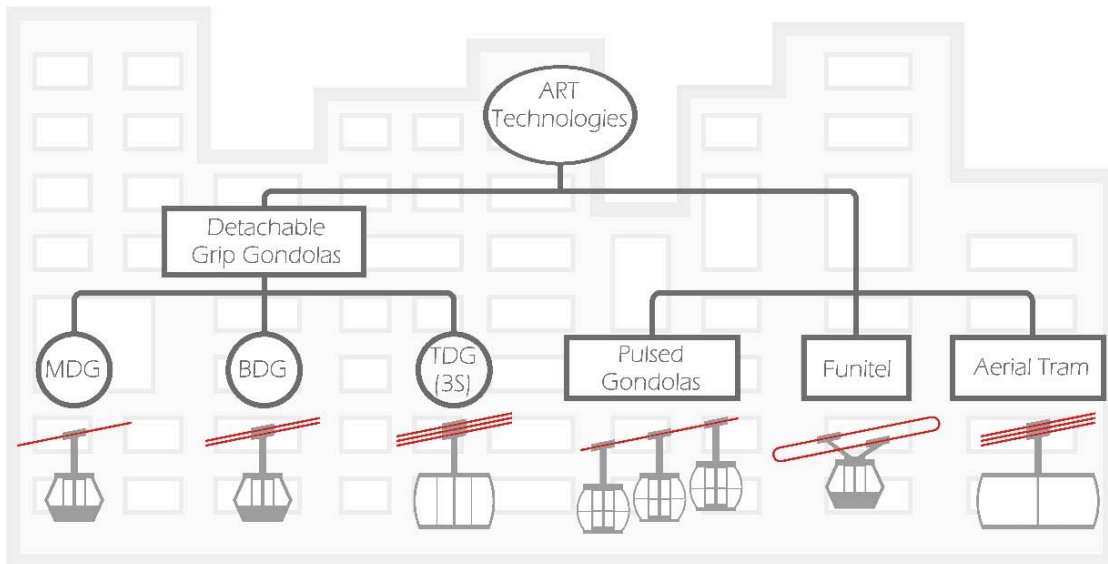


Plate 5: ART Technologies

Source: Author.

Data Source: CUP, 2013

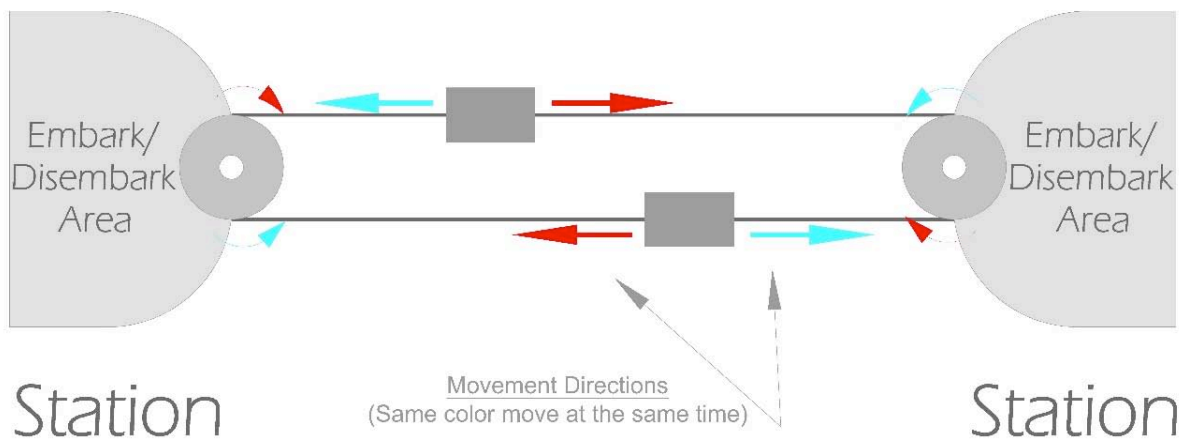


Plate 0: Aerial tramways & dual-haul ART systems operations.

Source: Own Illustration. Data source: (Alshalalfah, et al., 2012) (CUP , 2013)

Plate 6: Aerial tramways and dual-haul ART systems operations

Source: Author.

Data Source: Alshalalfah, et al. 2012; CUP 2013

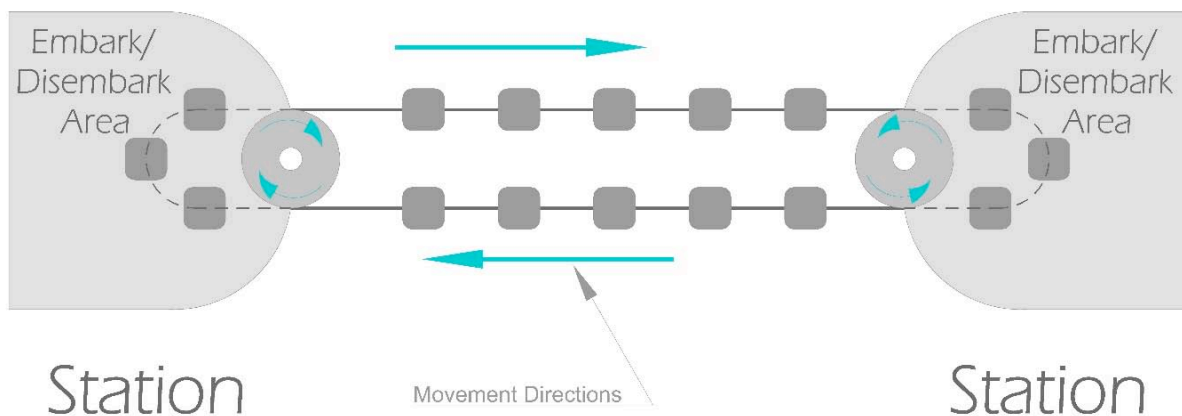


Plate 7: Illustration of gondolas system operation

Source: Alshalalfah, et al. 2012; CUP 2013



Dual-haul tramway, New York
Source: Autopilot, 2010 - edited



Aerial Tramway, Portland
Source: Adams, 2013 -edited



Pulse system, Grenoble, France
Source: Riegler, 2009 - edited



MDG ART system
Source: eltpics, 2012 -edited



BDG ART system. Ngong Ping
Cable Cabin
Source: Tkstevan, 2008 - edited



TDG -3S ART system, Koblenz.
Source: Schulze, 2011 - edited

Plate 8: Various types of ART systems

ART Technologies:

There are many technologies used in aerial transportation. These technologies have the characteristic of: using green energy (all ART systems are electric), not overlapping with other transport systems, and overcoming demanding terrains. They are mainly divided into three branches: the

detachable gondolas technologies, the reverse ropeway technologies, and the pulsed gondolas. (Alshalalfah, et al., 2012, p. 255) (Hoffmann & Liehl, 2005, pp. 26-32) (CUP, 2016)

The reverse ropeway technology uses only two non-detachable cabins. These cabins

carry a large number of passengers (up to 200 passengers), they move inversely or in opposite directions to each other in a back and forth movement. The cabins remain on their side of the cable and only meet each other in the rope's midpoint. Examples of these systems are Aerial tramways and Dual-Haul Aerial Tramways. Although the systems large cabins might give the impression of high capacity, these systems do not reach a line capacity higher than 2000PPHPD. (Alshalalfah, et al., 2012, p. 255) (CUP, 2016) (STRMTG & CEREMA, 2011, p. 7)

Detachable Gondolas are driverless, automated, continuously moving ART systems, where the cabin, which carries from 4 up to 35 passengers, is attached to the cables that propel it from and to the stations. These cabins use clutching and declutching mechanism to be detached from the cable and stopped for users to embark/disembark. It then gets pushed back with high speed to the cable line to continue its journey in the opposite direction. Detachable gondolas have a unique embark/disembark mechanism that allows entry and exit arrangements which optimizes the capacity of their systems. (Alshalalfah, et al., 2012, p. 256) (STRMTG & CEREMA, 2011, p. 7) (CUP, 2016)

Pulsed Gondolas are a mixture between aerial tramways and mono detachable gondolas. While it utilizes one cable and

carries several small cabins like the mono detachable gondolas, these cabins are not detachable. They are aligned together in "Pulses", they move together, slowdown together, and stop together at stations to embark or disembark. (CUP, 2016).

Plate 8 show examples of each one of the systems mentioned above.

Since the main factors in the success of these systems are the capacity in terms of PPHPD, and cost, many of the ART technologies lost their feasibility relatively quickly, some are even becoming obsolete (CUP, 2016). The author thus will focus on the systems which seem to be mostly feasible, and which are most applied in the world, these systems are the detachable gondola system. Below is the definition and criteria of the detachable gondola branches:

Monocable Detachable Gondolas (MDG):

Monocable detachable gondolas are the most basic, the most used, and the cheapest of the ART systems used in urban transit. As the name says, the cabin of the MDG which allows between four to fifteen passengers (4-15riders) has a detachable grip which detaches it from the continuously circulating propulsion cable and reattaches it to that cable upon exit. MDG systems have a limited pylon span

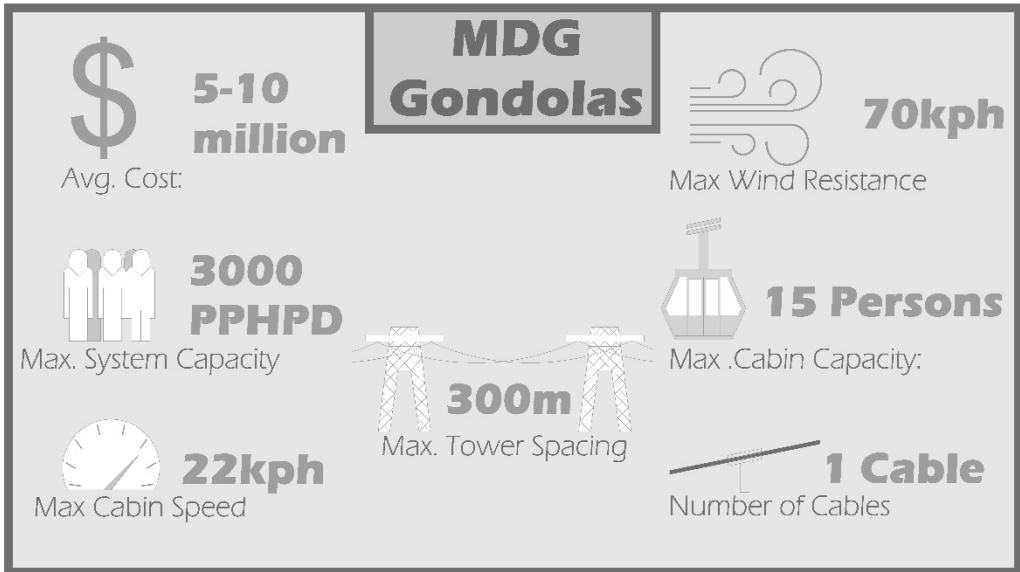


Figure 1: MDG Technical Stats.

Source: Author.

Data Source: Alshalalfah, et al. 2012; CUP, 2016; Winter, 2016; Dopplemayr, 2016

of 300m (CUP, 2016). Mainly, and commonly, MDGs are used for tourist-oriented projects. Nevertheless, because MDGs are easily adaptable and well suitable to urban environment, they eventually got used in cities like Medellin as transportation feeders similar to busses (BRT). This system further operates as a branch for the primary transportation lines in bigger cities like Caracas. (CUP, 2016) (STRMTG & CEREMA, 2011, p. 3) (Iván Sarmiento, et al., 2013, pp. 82-83)

Examples: Medellin Metrocable, Metrocable de Caracas.

Bicable Detachable Gondola (BDG):

Bicable detachable Gondolas are an example of technologies that are becoming obsolete. The technology was developed to achieve higher capacity, higher speeds, and more stability than MDGs and without the cost and complexity of TDGs. Yet, with the advancement in MDG and 3S or TDG technologies, BDG systems lost their feasibility, that is because they have capabilities a bit higher than that of the MDG systems yet with the extra price of a second cable. (CUP, 2016).

BDG systems are a mixture from both gondolas and reversible ropeway systems. The two cables that carry the cable have different rolls, where the first statically supports the cabin and the other drags

the cabin. This allows for bigger spans between towers and stations and thus allows to overcome difficult terrains. The BDG system operates similarly to MDG system when the cabin arrives to the terminal, where it gets detached from the rope, slowed down, and halted in the embark/disembark area, then speeded back again to the cables after embarking is complete. Examples: Ngong Ping Cable Car, Singapore Cable Car. (Alshalalfah, et al., 2012, p. 257) (STRMTG & CEREMA, 2011, pp. 3-7)

Tricable Detachable Gondola (TDG) (3S):

Tricable Detachable Gondolas are ones that use three cables to drive and handle the cabins. Similar to the BDG system, the TDG systems which are also called 3S technology have a cable that propels the cabins while the other two cables function as stability components. The cars function similarly at the station where they detach similar to the MDG and BDG systems.

What makes this system one with large potentials is the high statistical values it achieves. TDG systems have a capacity of 3,800PPHPD (Seilbahn Koblenz, 2011) and have the ability to achieve 7,000PPHPD (Winter, 2016). Its cabins are large enough to carry 35passengers (38 in some statistics), and it can cover a very long pylon span of 3km. Besides

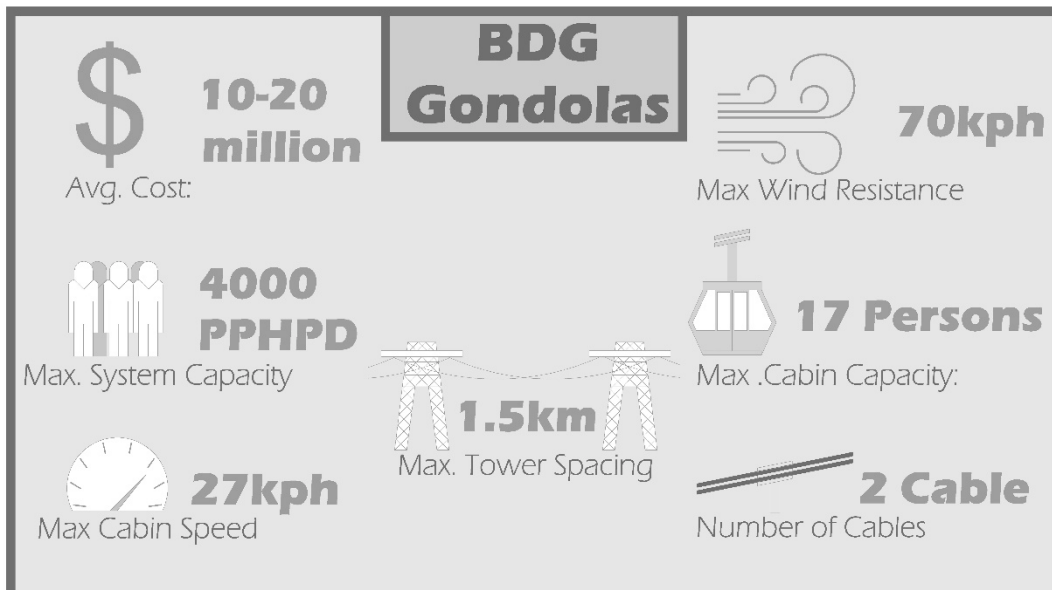


Figure 2: BDG Technical Stats.

Source: Author.

Data Source: CUP, 2016; Alshalalfah, et al. 2012; Winter, 2016; Dopplemayr, 2016

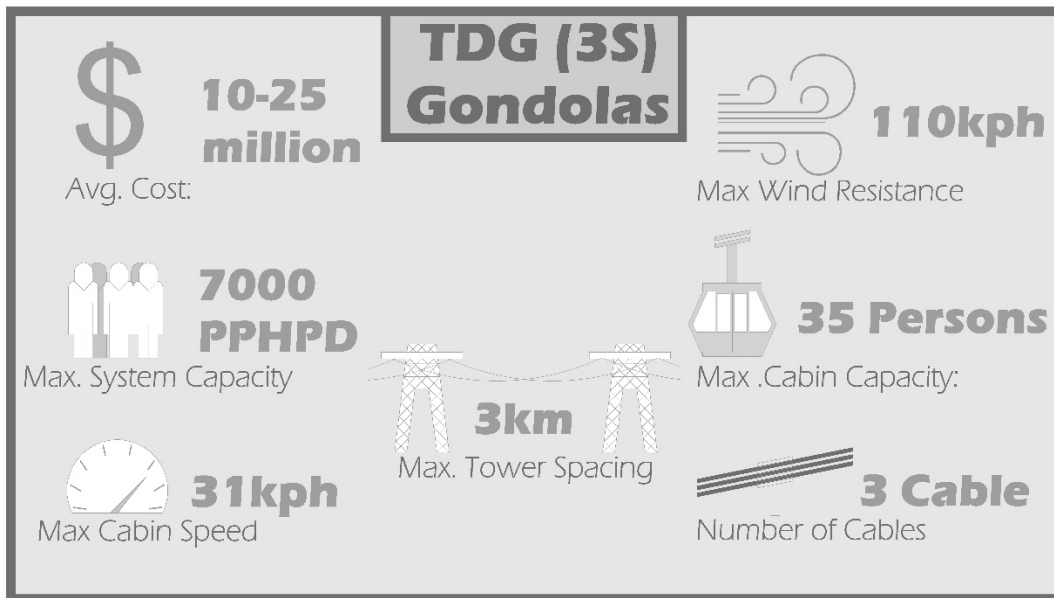


Figure 3: TDG Technical Stats.

Source: Author.

Data Source: Alshalalfah, et al. 2012; CUP, 2016; Winter, 2016; Dopplemayr, 2016

that, 3S systems are known for their high wind stability where they resist up to 110km/h winds and have relatively a low power consumption. they also can reach speeds up to 31km/h in non-urban areas. The system is used only once in urban environment for touristic reasons in Koblenz, yet the successful implementation of this system in urban environments opens the door for more application in that direction. Examples: Seilbahn Koblenz. (Alshalalfah, et al., 2012, p. 257) (CUP, 2016) (STRMTG & CEREMA, 2011, pp. 3-7) (Alshalalfah, et al., 2015, p. 394)

ART Systems and Conventional Transit Systems:

Table 1 shows a comparison between ART transit modes and conventional transit modes. These comparisons are made mainly in terms of system capacity (PPHPD), speed, and construction cost per km length, it also contains many other relevant comparisons. This table shows that ART (3S) systems lay in the same band of BRT semi rapid transit systems in terms of speed, capacity in PPHPD, and cost.

What this table also shows is how miss leading some numbers might be. For example, although aerial trams have cabins that carry up to 200 passengers, and have a speed up to 43km/h, they actually have a less line capacity than the MDG and BDG systems with small cabins (up to 15 pas-

sengers) and speed only up to 21.6km/h. That is because aerial trams only have 2 cabins while the others have many. Also, and most importantly that is because MDGs and BDGs have a very high frequency and a short headway of 12 seconds. It has to be mentioned also that the costs of the detached gondolas, which are relatively low, are mainly to the costs of the two station, since the remaining costs for the towers or cable systems are relatively very low. Yet these stations remove the need to build maintenance hangars since they contain the areas for repair and maintenance. (STRMTG & CEREMA, 2011, p. 5) (Alshalalfah, et al., 2012, p. 254)

Examples of ART Systems

There are many examples of ART systems in urban environment around the world. In many cases, the catalyst for their construction was mainly the need for a functional and quick built system for a certain sports event or festival (at least in Europe). Yet these systems in all the examples received a large interest from the public and remained operational even after the events were finished (Herwig, 2013, p. 49).

Beside ones built purely for urban transport (like Metrocable Medellin, Metrocable Caracas in Venezuela, Constantine Telerpherique in Algeria, Mi Teleferico La Paz in Bolivia, Teleférico do Complexo do Alemão in Rio De Janeiro in Brazil, Roosevelt

Transport Mode	Investment Cost (\$Million/km)		Line Capacity (PPHPD)	Vehicle Capacity (Passenger)	Operational Speed (km/h)	Cars/TU
	Street Transit	Bus				
Street Transit	0.5-0.6	3,000-6,000	80-125	15-25	1	
Semirapid Transit	Tram	5-10	10,000-20,000	100-300	12-20	1-3
	BRT	5-40	6,000-24,000	80-180	20-40	1
Rapid Transit	LRT	10-50	10,000-24,000	100-720	20-45	1-4
	Metro	40-100	40,000-70,000	720-2,500	25-80	4-10
ART Transit Systems	Regional	50-120	25,000-40,000	150-1,800	40-80	1-10
	Aerial Tram	15-25	500-2,800	20-200	43.2 Max.	1
Conventional Transit Systems	Dual-haul	20-25	2,000 Max.	100 Max.	27 Max.	1
	MDG	5-10	3,600 Max.	4-15	21.6 Max.	1
	BDG	10-20	4,000 Max.	4-17	25.2 Max.	1
	TDG	15-25	7,000 Max.	35 Max.	30.6 Max	1

Table 1: Service Characteristics of ART and Conventional Public Transit Systems

Source: Author

Data source: Alshalalfah, et al. 2012; Winter, 2016; CUP, 2016

ART System	Country	Opening year	ART Type	Line Length (km)	Line Speed (km/h)	Peak Headways (sec)	Number of Canins	Cabin Capacity	Line Capacity (PPHPD)
Cable Constantine	Algeria	1956	MDG	1.516	21.6	22.5	35	15	2,400
Singapore Cable Car	Singapore	1974	BDG	1.65	14.4	15	81	6	1,400
Rosevelt Island Tramway	USA	1976	Aerial Tram	0.96	30	450	2	110	1,500
Telluride Gondola	USA	1996	MDG	0.96	17.7	30	32	4	480
Medellin Metrocable Line K	Colombia	2006	MDG	4.0	18	12	93	10	3,000
Ngnong Ping Cable Cars	Hongkong	2006	BDG	5.7	27	18	112	17	3,500
Portland Aerial Tram	USA	2007	Aerial Tram	1.005	35.4	300	2	78	936
Medellin Metrocable	Line J Colombia	2008	MDG	2.789	18	12	119	10	3,000
	Line L Colombia	2010	MDG	2.072	22	65	27	10	550
Caracas MetroCale	Venezuela	2010	MDG	4.595	18	12	70	10	3,000
Seilbahn Koblenz	Germany	2010	3S	0.89	19.8	34	18	35	3,800
Complexo Do Alemao	Brazil	2011	MDG	4.2583	21.6	12	152	10	3,000
London Emirates Line	UK	2012	MDG	1.1	21.6	30	34	10	2,500

MDG
 BDG
 3S (TDG)

Table 2: Operational ART Systems Worldwide

Source: Author

Datsa source: Alshalalfah, et al. 2014; Winter, 2016; Bergerhoff & Perschon, 2012; Seilbahn Koblenz, 2011

Island Aerial Tramway in New York USA, and Portland Aerial Tramway in Oregon USA), many examples from Europe were event- and tourist- oriented. This list includes the Seilbahn Koblenz in Germany, the London Emirates Air-Line in the UK, and the Sochi line in the Russian federation. This was also the case for the Ngong Ping Cable Car 360 in Hong Kong. Table 2 shows a list of some of the operational ART systems in the world.

The article will focus in this regards on two main examples. Metrocables Medellin in Medellin, Colombia which represents the first major detachable gondola ART system in urban context, and Seilbahn Koblenz in Koblenz Germany which represents the most advanced ART system used in urban context.

Metrocables Medellin

The ART system in Medellin consists of three lines. The first one is Line K which is the first to become operational in 2004, this line consists of three stations, and has a line length of 2km. It connects Communes (Districts) 1 and 2 on the north east of the city to the Metro system at Acevedo station. The second is Line J which started operation in 2008, and also consists of three stations, and has a line length of 2.9km on the west of the city through

Communes 7 and 13. It connect to the Metro system at San Javier station.

The third line is Line L which is a touristic line not integrated in the public transport system, and that started functioning in 2014 and connects the station at Like K (Santo Domingo terminal station) to the touristic ecotourism Arví Park. This line has a length of 4.6km and has a separate ticket not integrated with the Metro system (Heinrichsa & Bernet, 2014) (Brand & Dávila, 2013) (Iván Sarmiento, et al., 2013).

Plate 9 shows the city districts to the right and the Metro line including the Metrocables (ART) to the right. Plate 10 shows these lines on the satellite image of the city.

In terms of cost, K-line has cost US \$24 million, and has a capacity of 3000 PPHPD. Bu 2012, it had reach a capacity 30,000 journeys per day. J-Line on the other hand had a cost of construction of US \$47 million. It has a similar capacity and characteristic as K-line, yet did not reach the capacity levels of K-line. By 2013, Lines K and J together transferred 67,000 people on daily bases (BLANCO & KOBAYASHI, 2009). Lines K and J both use a monocable Gondola with a capacity 10 people per Gondola. They are connected to the

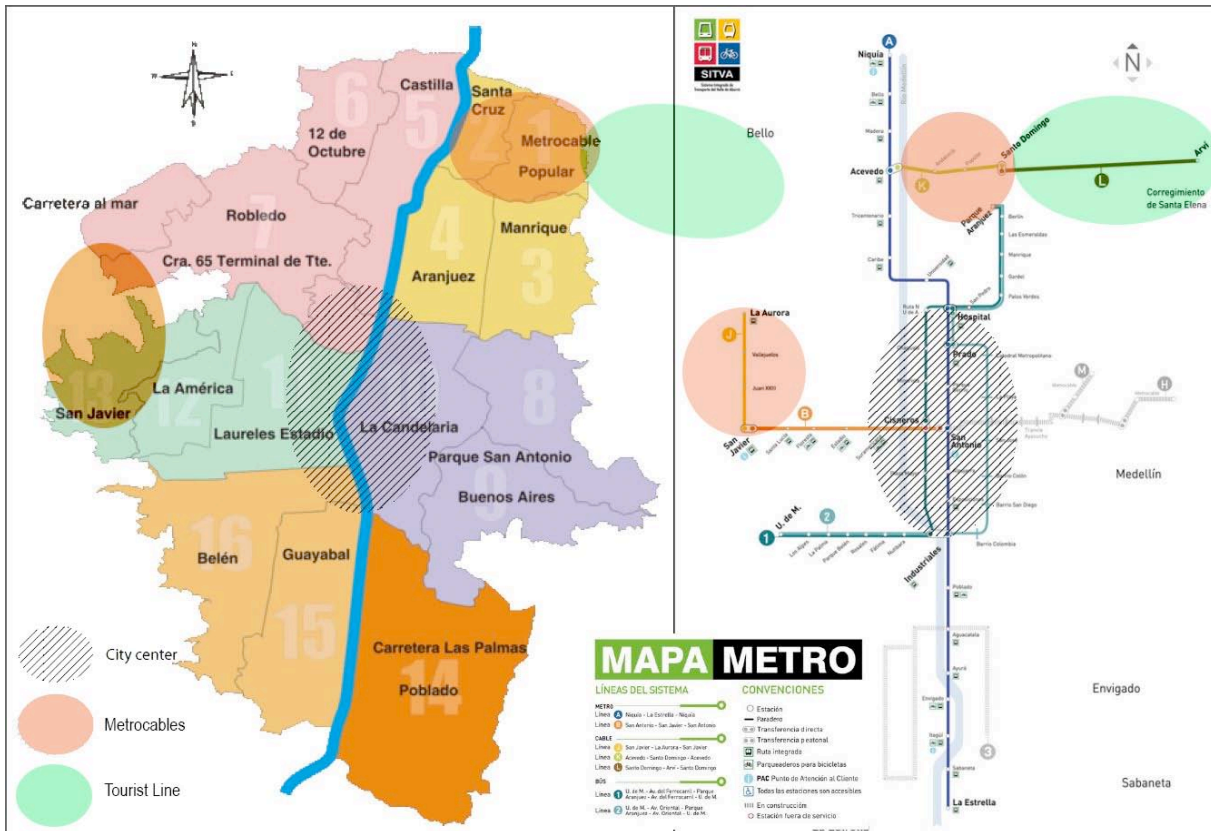


Plate 9: Medellin Metrocable - Showing to the left the city districts and the Metro line in general; to the right the specific Metrocables.
 Source: Heinrichsa & Bernet, 2014 - edited

metro system and have a flat rate ticket of COL \$1,750 (US \$0.97) that allows travelers to use the metro system in the city without further charges (Davila & Brand, 2011) (Brand & Dávila, 2013) (Dávila & Daste, 2011) (Coupé, et al., 2013). In terms of catchments, K-line has a catchment area consisting of 23 neighborhoods with approx. 230,000 inhabitants

(12 neighborhoods in Commune 1 with 129,806 inhabitants and 11 in Commune 2 with 99,381 inhabitants) (Iván Sarmiento, et al., 2013). J-line on the other hand has a catchment area of a total of 37 neighborhoods, with approximately 315,000 inhabitants divided to 24 neighborhoods and 181,970 inhabitants in Commune 7 and 20 neighborhoods and 134,365 in commune



Plate 10: Metro lines over the satellite map of Medellin.
 Source: Iván Sarmiento, et al., 2013

	K Line	J Line	L Line
Launch date	August 2004	March 2008	February 2010
Construction time	14 months	15 months	10 months
Length	2,072 m	2,782 m	4,469 m
Commercial speed	5 m/s	5 m/s	6 m/s
Number of pylons	20	31	25
Number of stations	4 (including Metro station)	4 (including Metro station)	2
Number of cabins (capacity 10)	93	119	27
Distance between cabins	60 m	60 m	340 m
Operational capacity	3,000 passengers/hour	3,000 passengers/hour	1,200 passengers/hour
Estimated total cost	US\$24 million (at average 2003 exchange rate)	US\$47 million (at average 2007 exchange rate)	US\$21 million (at average 2009 exchange rate)
Cost per kilometre	US\$11.6 million	US\$16.9 million	US\$4.7 million
Funding sources	Municipality: 55% Metro: 45%	Municipality: 73% Metro: 27%	Municipality: 38% Metro: 34% Provincial government: 17% Transport Ministry: 9% Other: 2%

Table 3: Medellín Metrocables line characteristics.
Source: Brand & Dávila, 2013

13 (Iván Sarmiento, et al., 2013). Table 3 shows the characteristics of the ART lines in Medellín in terms of date of completion, construction time, system capacity, system speed, cost of the project and other important information.

In terms of the land characteristic in the project areas of the “Metrocables”, K-Line covers and connects commune 1 and 2 to the metro system, these two communes have many similarities, yet they differ in aspects related to the circumstance in which they were built. In this regard, Commune 2 has smoothly graded slope with informal housing properties. The first part of this commune was made of grid formed plots without planning permissions more than 50 years ago, this grid pattern helped in creating better roads and connections afterward. Commune 1 on the other hand has steeply-sloped nature, and was built without land plots through land invasions of people who could not afford to buy a legal plot in the 70s. Dwellers in this commune are usually smaller houses that started as shacks. While the ART system mainly passes over roads in commune 2, it hovers over the dwellings in Commune 1. This also meant that to construct the ART system, a large number of expropriations and changes in right of way were needed (Coupé, et al., 2013).

With respect to J-line, it is seen as a link that connects the Metro system with the cities new suburban expansion in the sub-center area of San Javier. Instead of passing over Communes 7 and 13, it actually passes at their edge, this in addition to the scattered urban innervations in the commune resulted in lesser success and appreciation for this line in comparison to like K (Brand & Dávila, 2013). These down-sides sides will be discussed later in the impact and achievements chapter.

In terms of public transportation, the communes where the ART systems were applied are places relatively well served with conventional busses and small number of taxis. These busses do not follow time tables and their availability depends on traffic situation on the streets. In this regard, people wait relatively long for unannounced arrival of busses, and then loose “One and a half hours” to “two hours” (Heinrichsa & Bernet, 2014) on the way depending on the traffic situation as some of the Barrios residents explained in interviews in those areas. Some residents also pointed to the dangers of those busses because their drivers are related to the gangs in the neighborhoods. In these communes, statistics show a 7vehicles/1000inhabitants ration in 2005, compared to an average of 54 vehicles/1000inhabitants in the city. This transformed into a mobility ration of 1.2 trips/Person/Day in those communes in 2005 (Heinrichsa & Bernet, 2014).

In contrary with the previous system of transportation, the ART systems are a form of a continuous conveyor belt with cabins arriving continuously, which eliminated the need for waiting time or for timelines. In terms of personal and system safety, ART systems have an astonishingly low accident ratio because its dedicated line does not coincide with pedestrians or traffic on one hand and because the conveyor belt system eliminates any chance for cabin to cabin accidents. With respect to personal safety, the size of the cabin which allows 10 passengers (8 sitting and two standing), is on one hand spacious enough even when full, and since passengers sit facing each other, this makes it nearly impossible for misconduct within the cabin (female grouping in public transport is a common problem in Latin America). Furthermore, users of the cabins can easily jump of a cabin and into the other without waiting time in any station if they feel uncomfortable in the cabin the first used (Heinrichsa & Bernet, 2014). ART systems came also as a solution for a population of 50,000 inhabitants who have disabilities and are unable to use the old or unequipped or small busses. The stations that are all barrier free designed give a chance for those people to peruse a normal life and travel to the city center. It should be noted also that in terms of power, Medellin has a special characteristic, where the ART systems operate on electricity received from hydroelectric-source, which eliminated any source of greenhouse emissions.

These above characteristics give the ART systems the upper hand in those communes, and gave a transport solution to residents in areas where previously, difficult and no alternative transportation mode were available (BLANCO & KOBAYASHI, 2009). This can be interpreted through the increase in the travel rate in those communes, where the ART system through its long daily operating hours from 4:30am to 11:0pm, were able in 2013 to transport a total of 43,000passenger/day and thus increasing the trip/person/day ration in those communes from 1.2 to 1.7 (Heinrichsa &

Seilbahn Koblenz

The ART system in Koblenz was erected through private investment in 2010 without any dependence on Tax money. The aim was to transfer two million visitors from and to the show in the "difficult to reach" Ehrenbreitstein Fortress (Dale, 2010). Its stations are located in the open on the river side near the "German Corner" (Lower station at Konrad-Adenauer-Ufer) and in the green field leading to the Ehrenbreitstein Fortress on the other side (Seilbahn Koblenz, 2011). Seilbahn Koblenz demonstrate the power of ART systems in overcoming difficult terrains in relatively very short period of time. Instead of the 25 minutes that the bus would take to transfer the visitors to the fortress, Seilbahn Koblenz does that in only 5 minutes (one fifth of the time) (Doppelmayr Urban Solutions, 2015). Plate 11 shows a comparison in route and time between using the bus system and the ART system. It displays the time advantage Seilbahn Koblenz has on the bus in that regard.

Being not surrounding by any form of urban fabric on both sides of the cable, the stations were designed in a slender, ambient, and light shell form which integrates and blends fully with the surrounding green area (CUP, 2016). These stations allow the embark/disembark of two

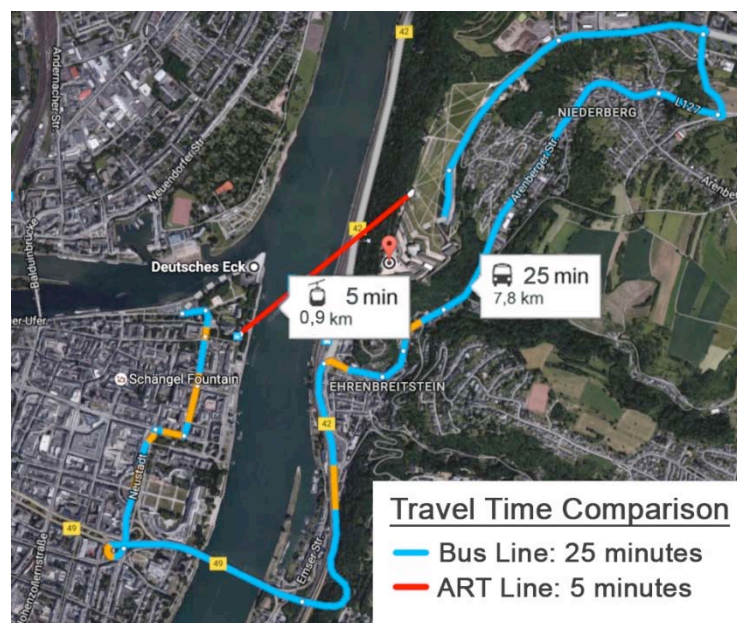


Plate 11: Comparison between ART and bus transport time, Koblenz

Source: Google Maps - edited

Data source: Doppelmayr Urban Solutions, 2015



Plate 12: Embark area in Koblenz ART system
Source: Author

35-passenger cabins at a time (2 cabins disembarking, while 2 cabins embarking) as seen in Plate 12.

Yet and although they are not located in a populated urban fabric, the footprint of those stations is impressively small in comparison to ones in other ART systems, these small stations are able also to store and maintain the vehicles without the need of extra maintenance and storage areas. (Dale, 2010). Plate 13 shows an image of the ambient, shell-form, small sized stations of the ART system in Koblenz.

In terms of capability and specification, Seilbahn Koblenz uses the newest in ART technologies. The 3S or TDG technology applied in that system allows for the highest capability in terms of capacity, speed, and span length of any ART systems around the world (Seilbahn Koblenz, 2011). Besides that, the station and cabin design allows the system to be a barrier-free, which allows transport for people with disabilities and even bicycles. In terms of performance, and because the system has a more touristic aim, the performance of

this system is reduced in terms of speed and capacity and thus allowing also longer headways periods.

The system has a length of 890m consisting of an 850m free span over the Rhine river and a height difference of 112m between the German Corner on the lower side and the Ehrenbreitstein Fortress on the upper side. These spans are only supported by two towers located near the stations at the beginning and the end of the span (Seilbahn Koblenz, 2011).

As previously explained, Seilbahn Koblenz has an intentional capability reduction. This results in a transport speed of 16km/h (4.5m/s) (Seilbahn Koblenz, 2011) which in return allows tourists a longer view of the river and the scenery on their way to the fortress. In terms of capacity, the system allows for a 3,800 PPHPD (Seilbahn Koblenz, 2011). In terms of headways, Koblenz stations allow a long, and comfortable 34 second period and the embark/disembark of two 35-passenger cabins at a time (2 cabins disembarking, while 2 cabins embarking) (Dale, 2010). This 34



Plate 13: Koblenz ART stations blended with the surroundings
Source: Author

second is a long headway period intended to give bigger comfort for the touristic means of the system.

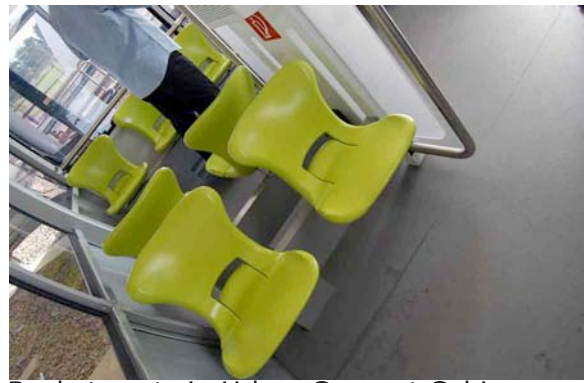
With reference to the Cabins (Gondolas), Seilbahn Koblenz ART system consists of 18 cabins divided into three types. These types are divided into 16 regular touristic cabins with wooden elegant seats which allows the option for bicycles and mobility impaired people travel, a further touristic cabin with a glass floor and lesser seats which allow no bicycle or mobility impaired people travel option (Gondola 17), and a cabin with green bucket seats which showcases the "Urban Concept" de-

sign. This cabin is optimized for maximum capacity as an example of a "Local public transport" cabin (Gondola 18) (Seilbahn Koblenz, 2011). These cabins are all designed with glass outer surfaces from all four sides to allow a panoramic view, the seating in those cabins are also situated in a way to allow maximum view during the travel. They also have small ventilation windows on the upper sides of the glass. Plate 14 shows various characteristics of those cabins.

In terms of cost and construction time, Seilbahn Koblenz was constructed in a period of 14 months and required an in-



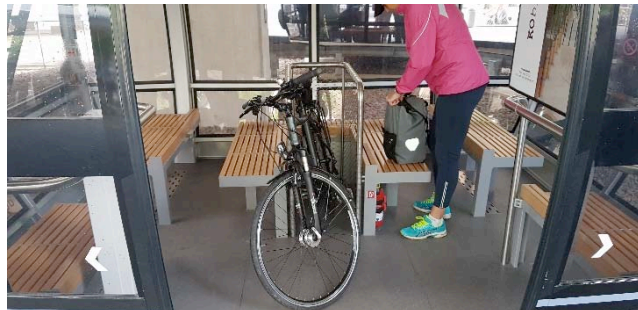
Fully glassed cabins allowing panoramic views. Source: Author



Bucket seats in Urban Concept Cabin Source: Dale, 2010



Cabins providing barrier free access. Source: Dale, 2010



Bicycle transport in Koblenz cabins Source: Author



Glass floor window, Koblenz ART cabin 17. Source: Author



Koblenz ART cabins - ventilation windows Source: Author

Plate 14: Various images of Koblenz ART cabins



Plate 15: Automated entrances at Koblenz ART station.

Source: Author

vestment cost of 13€ million (Seilbahn Koblenz, 2011). It could be assumed that the operation costs are relatively low, since only two personnel operate each station, and the process is fully automated. Plate 15 shows this automated process at the stations.

ART Systems - Advantages and Disadvantages

To be able to understand the main advantages and disadvantages of ART systems, the study created a list of factors that seem important to identify those weaknesses and strengths. These SWOT factors can be summed in the following buzzword: Investment and operational Cost, Capacity, Construction Time, Transport Speed, Wind Resistance, Safety, Reliability, Noise Pollution, Visual Pollution, Comfort, Availability (Wait times), Accessibility, Barrier free & Bicycles, Carbon foot print (Environment), Privacy, Land take, Branching, Applicability, Success rates.

Comfort

Gondolas offer sitting and standing areas in their cabins. These cabins beside the stations are provided with air conditioning systems which cool or heat their atmosphere depending on the weather necessities (Winter, 2016) (O'Connor & Dale, 2011, p. 18) (CUP, 2016) (Alshalalfah, et al., 2015). In addition, and since those cabins pass relatively higher than the urban topography, weather conditions in these

heights tend to be less humid and less hot than the one on the urban surface. This in return reduces the need for air conditioning in summer where the cabins in this case can rely on natural ventilation (The Don Valley Cable Car Community, 2016). Furthermore, newer ART systems (ex: La Paz, Bolivia) have even introduced WIFI powered by solar panels on the roofs of the cabins to give even more comfort and connectivity (AJ+, 2016, p. Sec:42)

Availability and Headway

The factor of availability is dependent on many other factors like the cabin size, number of cabins in the system, size of embark/disembark area, and speed of the system. Yet since the cabins in ART systems are in continuous loop movement between two stations, waiting time to board these system does not exceed one minute. This in return removes the need for schedules (CUP, 2016) and thus gives ART system a large advantage over busses and trains and challenges the supremacy of private transport automobiles in terms of freedom and independence from fixed and sometimes unsuitable schedules (of public transport systems). While some ART systems have a very short headway of 12 seconds (Medellin) (STRMTG & CEREMA, 2011, p. 5), other systems have a longer waiting time of 34 seconds (Koblenz) (Dale, 2010), this number is not due to the number of cabins but to operational arrangements such as improving accessibility for mobility impaired people, or for



Plate 16: Smart Glass in Bukit Panjang LRT line in Singapore
Source: Chong, 2009

managerial measures to give enough time gap to separate passenger getting in and ones getting out of the cabins (STRMTG & CEREMA, 2011, p. 5).

Reliability

Usually reliability factors in transport systems are deduced from measuring the rates of on-time performance, vehicle failures, maintenance procedures, and other factors like number of stops and distances the vehicles run, (American Public Transportation Association, 2012, p. 5) yet those other factors do not effect ART systems which are on continuous rotation. On the other hand, wind speed is an additional factor to be taken into consideration when measuring ART systems reliability. That is since the cabins of this system are hung in the air and are subjected to tilting due to wind pressure.

In terms of reliability, ART systems have a big advantage over other transport systems with a remarkably high reliability rate of 99.3% to 99.9%. This high rate is maintained though strict preventive maintenance guidelines, and through innovative technologies that allow the cabins to resist winds up to 110kmh (ex. TDG/3S) (CUP, 2016)

Environment

Visual Pollution: visual impact and visual intrusion remains a major challenge for ART. As for the visual impact, and since ART system was rarely used historically as a transport system in urban environment, it remains to be seen unfamiliar to the urban environment, and thus receives sometimes opposition from residents (STRMTG & CEREMA, 2011, p. 10). This opposition

could largely increase when ART systems pass over the skyline of historic cities. The other factor is visual intrusion, residents and land owners around the area where the ART lines will be installed have usually worries of what the cabin passengers can see, and if that is an intrusion to their privacy, they also worry on the value of their property due to that (STRMTG & CEREMA, 2011, p. 10).

In that regards, new technologies have widely reduced the possible negative effects that might appear with regards to urban environment or visual intrusion. In terms of being unfamiliar or unsuitable for instance in historic cities, the good design of the 3S ART system in Koblenz made UNESCO approve its existence although Koblenz is a world heritage city (Georgi, 2013). In terms of visual intrusion, new glass technologies (Smart Glass) which are already used in public transport systems (Singapore) allow the glass panels of the cabins to become opaque when passing near from houses, blocking any form of intrusion (Dale, 2011).

Noise Pollution: Since the cabins in ART systems do not contain any motor, the system is considered a very low noise producer. Gondolas therefore, are a very quiet transport unit in comparison to other transport system (Winter, 2016). The noise they generate will be in most cases indistinguishable from ambient noises produced by other transport systems (traffic for instance) (The Don Valley Cable Car Community, 2016) . The minimal noises that come out of this system is in the station where the large motor is available and in the intermediate tower while the cabins overpass them. Yet even those are barely heard (CUP, 2016).

Transport mode	CO2 Emissions in g/pkm
Petrol-Powered motor vehicles	248
Diesel-Powered Busses	38.5
Electric Locomotive Trains	30
Cable Cars	27

Table 4: Carbon Emissions.

Data source: Herwig, 2013

Carbon Footprint: the carbon footprint is a measurement which shows how much carbon will a certain system produce directly or indirectly. The results of such tests deduce how green is the subject system in terms of energy. The calculation is either done directly when the system produces greenhouse gases, or indirectly by calculating for example how much carbon emissions would be produced to supply a certain system with electricity.

In terms of carbon footprint, many countries like France, consider ART systems by the law as an alternative system that could (when used in a general policy) reduce pollution and greenhouse emissions. Many projects are under research in French local authorities under that topic. (STRMTG & CEREMA, 2011, p. 1)

Yet to explain in numbers the small footprint ART systems produce, the strategy consulting firm ClimatePartner Austria conducted a study in 2009 regarding the carbon footprint of Art systems in comparison to cars, busses, and trains. This study showed that when cable cars utilizing 50% capacity and above have the lowest greenhouse emissions of all these systems. This makes ART systems the world greenest transport system. Table 4 shows the finding of this study.

To put this advantage into physical benefit, the city of Medellin used the UN concept of climate protection by “Carbon trading” to sell its share of carbon to other cities and use the money to further develop its transportation systems (Herwig, 2013, p. 52). In numbers, the city of Medellin, like other cities that used the ART systems saw

	2009	2010	2011	2012	2013	2014	2015	2016	Total
Baseline emissions in tCO ₂ eq	-	14,005	24,434	30,103	30,382	31,189	31,458	32,311	193,881
Project emissions in tCO ₂ eq	-	5,135	9,083	11,208	11,450	11,724	11,980	12,274	72,853
Emissions reduction in tCO ₂ eq	-	8,870	15,350	18,895	18,932	19,465	19,478	20,038	121,029

Table 5: Medellin projected emission reduction from six aerial cable cars

Source: UN - HABITAT, 2012

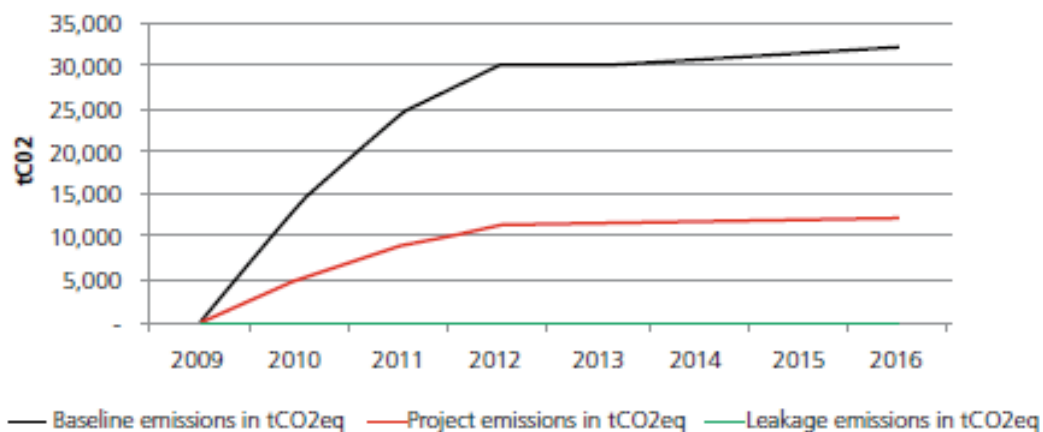


Figure 4: Medellin projected emission reduction from six aerial cable cars

Source: UN - HABITAT, 2012

a drop in its greenhouse emissions, and so did their carbon foot print. Table 5 and Figure 4 show this drop in emissions in the city of Medellin, from 30+ tCO2 to 10+ tCO2 per year (Bergerhoff & Perschon, 2012).

On average, Medellin saves around 20,000 Tons CO2 each year and sells the corresponding emission certificates. This is in the minds of many an environmental benefit for all (Herwig, 2013, p. 52).

Capacity

The capacity of ART systems depends among others on the capacity of the cabins, the spacing between the cabins, the speed of the traction cable, and thus the number of cables used. Because ART systems operate on their own dedicated space, and do not mix with other transport modes, and because they are in continuous automated move, this allows for a consistent journey time, and a thus a consistent capacity with a consistent passenger throughput (STRMTG & CEREMA, 2011, p. 7).

The capacity of ART systems is in continuous increase. In comparison to other transport modes, the MDGs and BDGs have a capacity nearly equivalent to a small rail-based tram, whereas the TDGs and with newer figures and with a capacity of 7,000PPHPD (Winter, 2016) show the

potential of overcoming rail-based tramways as large as 43mx2.65m. Figure 5 shows an relatively new yet outdated table from 2011 showing a comparison between the capacities of several transport systems including ART. The table was edited to include the capacities of ART systems described by newer sources like Seilbahn Koblenz. As a result, one can see that 3S systems reach a higher capacity than rail based tramways as large as 43mx2.65m.

Safety

ART systems are systems that operate continuously in loops, without a motor on board and without a driver. This makes the possibility of accidents incredibly low. Therefore, many urban planners and transport engineers call ART systems the safest means of transport in the world. This is based on the ratio of the number of accidents to the number of people transported per kilometer. (STRMTG & CEREMA, 2011, p. 6) (Herwig, 2013, p. 51)

Construction Time

ART systems require a relatively short building time. While other modes of transport require 10 to 15 years to build their lines (metros for example) (Herwig, 2013, p. 49)the total building time for these systems has been 13 months in Koblenz (Alshalalfah, et al., 2014, p. 260) (Seil-

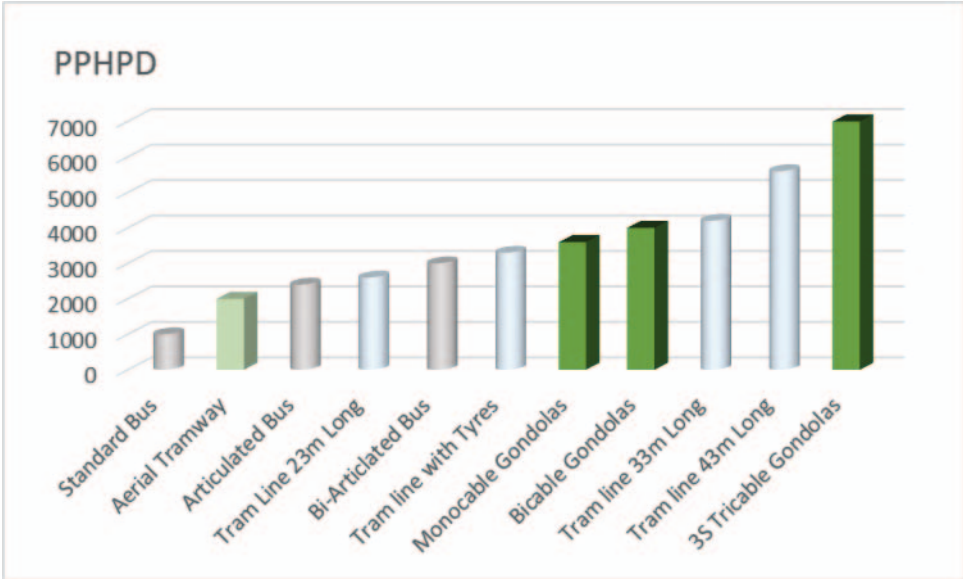


Figure 5: Capacity in PPHPD of urban transport systems
 Source: Author
 Data source: STRMTG & CEREMA; Winter, 2016

bahn Koblenz, 2011) and two years in La Paz (LAPAZLIFE, 2014). This huge reduction in construction time proves essential to cope with the rapid expansions of some metropolises and the rapid pressure increase on available infrastructures.

Land Take (Footprint)

ART systems can overcome obstacles and topography levels. Their land take on ground level therefore is very limited, and is only confined to that of the station and pylons. The land under the cables can be utilized of other purposes, and thus not considered as land take. (STRMTG & CEREMA, 2011, p. 8)

The standard area of the main stations is usually 250 SQM (25mx10m) and 50 SQM for intermediate stations. These areas are also subjective to the architectural design on the station. Stations that have the embark/disembark area on the ground floor need to have a sufficient clearance area for the cabins that are in this case lowered to the station. Thus, stations which allow embark/disembark on upper floors require less land, and can utilize the extra floors in creating shops or storage areas for the system (STRMTG & CEREMA, 2011, p. 8).

However, Art systems always move in a straight line between stations or at least between pylons. This in addition the cable length having a preferable limit of 6kms (Winter, 2016), can be a negative aspect in connecting urban environments. Hence, and even though ART systems require small land take, integrating stations in urban environments can be problematic. In addition, regulation in countries require safety margins along the path of the gondolas not to be effected in case of fire in a building that the cabins overpass. Furthermore, any passage of a cable line over private ownerships requires compulsory purchase, or negotiation with the owners regarding those lands. (STRMTG & CEREMA, 2011, p. 9)

Investment Cost

It is a difficult matter to acquire investment costs data regarding ART systems in urban environments. That is because that data is considered commercial data for manufacturers and prime contractors. Yet to have a general figure CETE Lyon came up with figures of those systems in mountainous environments. Table 6 shows figures and

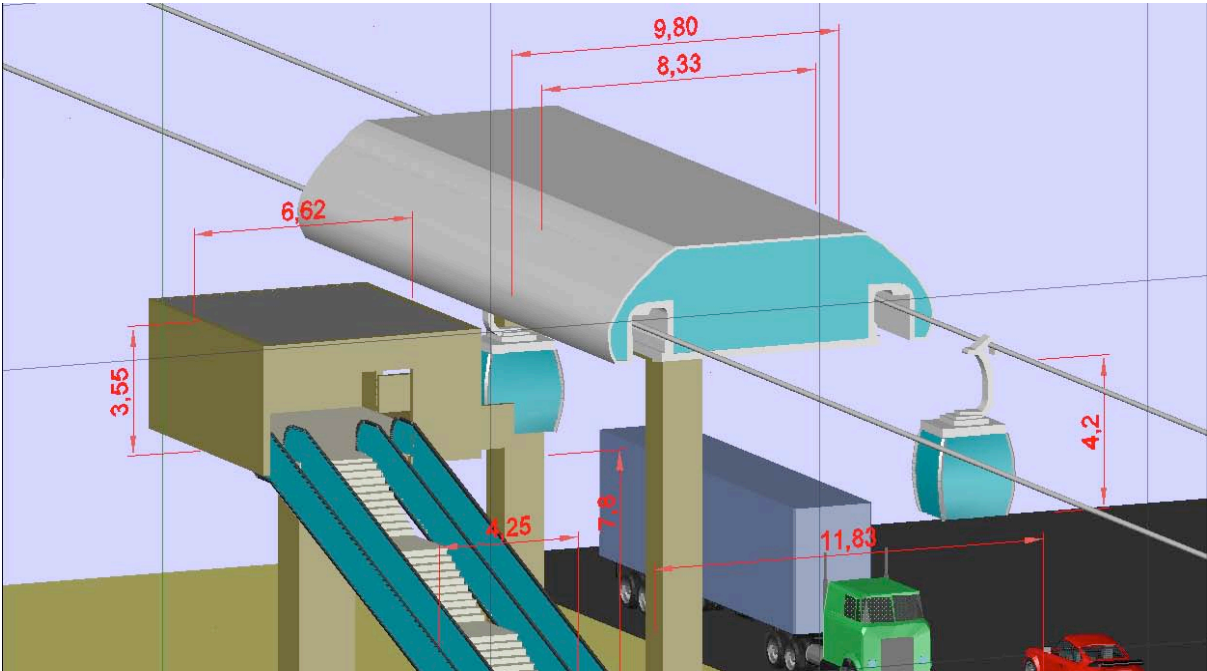


Plate 17: Example of station design with minimum footprint
 Source: Author
 Data source: Dopplemayr Urban Solutions, 2015

System Part	Cost	
	Monocable Gondola	3S Tricable Gondola
Start/End Station	M€2.5 to 3	M€4 to 5
Intermediate Station	M€1.2 to 1.5	
Pylon	M€0.1	M€0.5
Cabins	4 to 15 Seats	35 Seats
	30,000€	300,000€

Table 6: Breakdown of investemtn costs in mountain area

Source: Author

Data source: STRMTG & CEREMA, 2011

costs of ART system in mountainous environments. Comparing those numbers to known cots of ART systems built in urban environments (like Koblenz) prove those numbers could be even smaller in urban context.

Maintenance and Operational Cost

In ART systems, operating the system require only a number of four personnel. These four personnel provide assistance in boarding and un-boarding the cabins, overlook the system, and do the necessary maintenances. The operational cost is thus related to the overhead cost of those employees and that of the spare parts for the system. As an example, a simple MDG system requires an annual operational cost of 1.5 M€ on a 7000-operating hour basis (STRMTG & CEREMA, 2011, p. 9). These running costs and life cycle costs are dras-

tically smaller than those of individually motorized vehicles. This is because the whole system has a single stationary motor that runs the whole system. This criterion therefore, give advantage for ART systems over other motorized modes of transport (STRMTG & CEREMA, 2011, p. 9).

What makes ART systems even more feasible and give them the upper hand over conventional UPT (urban public transport) is that unlike trams and busses, the increase in capacity in ART systems has a minimal effect on the operational cost of the system. Figure 6 shows the increase of running cost of buses, trams and ART systems with respect to the increase in capacity. The cost increase is rather very small during the expansion of the ART systems and the increase of passengers per hour rate. This is contrary to bus or rail systems

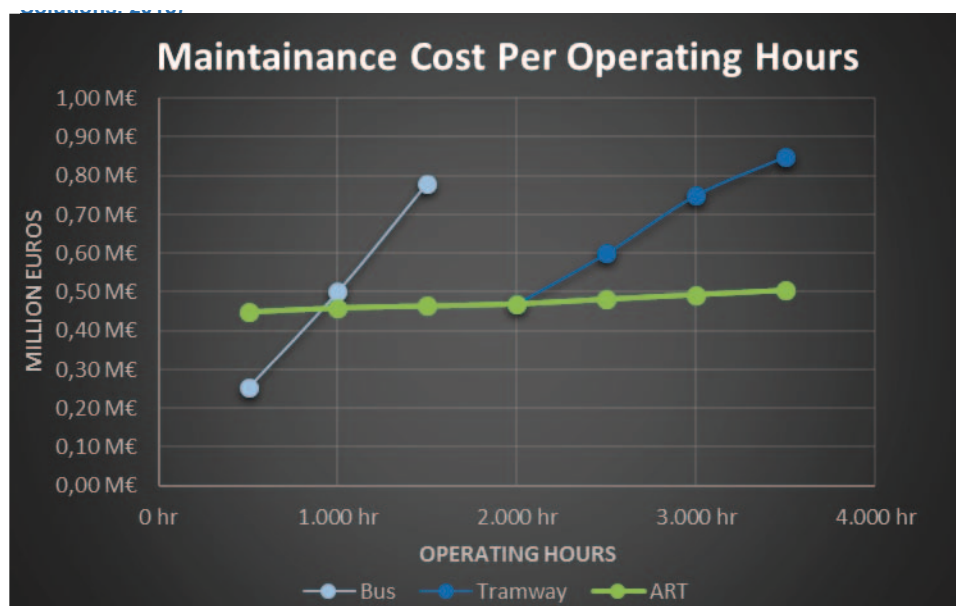


Figure 6: Comparison between operational costs of Buses, Trams and ART systems

Source: Author

Data source: Bergerhoff & Perschon, 2012; Dopplemayr Urban Solutions, 2015

which push the costs dramatically with the increase of capacity. The relatively low operational cost and low building cost show great potential for a wider implementation of ART systems in urban context, and so does the evolution is ART specification and design. Figure 6 shows a comparison of operational cost with respect to capacity increase, over the same route between road based modes of transport and ART systems taken from the city of Grenoble, France.

Energy Efficiency

Cable cars are considered highly efficient in terms of energy consumption. Although the whole system has to be activated even if one passenger is riding it, at a 50% load it is considered a very energy efficient transport system that produces the least carbon footprint in the world (Herwig, 2013, p. 49). That is due to the following criteria as explained by Joachim Bergerhoff & Jurgen Perschon (Bergerhoff & Perschon, 2012) and also by CERTU (STRMTG & CEREMA, 2011, p. 11) :

- A single stationary electric engine moves the entire system at a steady, efficient pace.
- The gondolas do not have to carry engines, fuel, wheels, suspensions, reinforced chassis and thus are of relatively low weight and drag.
- Descending gondolas help pulling up ascending gondolas; hardly any additional energy is required for acceleration of individual cabins or is lost when slowing down cabins in (rare) stations.
- And, apparently, the aerial ropeway does not suffer rolling resistance.
- Load and changes in level have a limited impact overall.

ART: Technical Potentials and Developments

To understand the direction and the future of the ART systems, the author contacted Doppelmayr officials to receive more accurate figures and information. During the conversation with Mr. Winter the head of operations services in Doppelmayr, the background theme of the discussion was 'there is not limit, everything is possible'. And these possibilities and achievements are as follows:

- Current ART systems have ACs (Air conditions), the cabins use batteries that quick-charge when the cabins enter the station and give AC during the way.
- There is no limit to the capacity of ART, the way to increase the capacity is building two overlapping or adjacent lines attached to the same station since the main price tag is the stations. The capacity can also be increased by allowing embark and disembark to happen on two or more floors. Plate 18 shows an example of adjacent lines attached to the same station.



Plate 18: Hong Kong Ocean Park Gondolas - showing two adjacent lines attached to the same station

Source: Lau, 2016

- There is no limit to the length of the ART systems. The limit is the cost. The only physical limit is that of the steel cable, or in other words, the distance from station to station. In this regard, even if the line length is a 100km long, it's stations have to be preferably not more than 6km away from each other. Yet the Author found that 6km is not a technological barrier, since in some cases the rope went up to 11.84 km long like the ART system in Ba Na Big resort in Vietnam for example (Fatzer AG, 2016).
- ART systems can branch, and merge without any problems, they can even do that automatically without the need for the user to change cabins. Further to that they can deflect and deviate on angles up to 90 degrees in stations. Plate 19 shows the stations in Caracas performing a passive deflection on a right angle.
- Designs like full-stop cabins, cabin doors, and other improvements are already done and will be applied in the close future. This helps reduce the dependency on operators to run the systems.



Plate 19: Passive deflection wheel at angle stations
Source: CUP, 2016

Finally, it is important to mention that while speed could be a demotivating element for ART systems (where 3S which are the fastest detachable gondolas have a max speed of 8.5 m/s or 30.6 km/h only) new advances in terms of cable technology and in terms of its ability to handle bigger speeds are emerging. Companies like Fater AG are producing cables tested for speeds up to 64 km/h (CUP, 2016). This opens the door for faster ART systems in the near future.

Proposals for Future ART Systems

In the previous examples, Metrocables Medellin function mainly as feeders that supply a bigger metro and public transport system in the city center. They transit residents from remote and difficult topographic informal districts at the edge of the city to the main metro line and the city

center. Hence the system, and although fully integrated with the public transport system, does not rise to the level of a transport system. On the other hand, Seilbahn Koblenz functions as a link over the Rhine River between the city center and the festival area near the Ehrenbreitstein Fortress. The system is neither connected to the public transport system nor is it intended to function as a public or urban transport system. In Koblenz, the ART system functions as a touristic attraction or a limited transport mode with touristic features.

These two example cities, although capable of showing the potentials and revealing the strong features of ART systems, do not give a conclusive insight into the full capability, the limits and the applicability of ART systems. To be able to better assess the applicability of ART systems in various

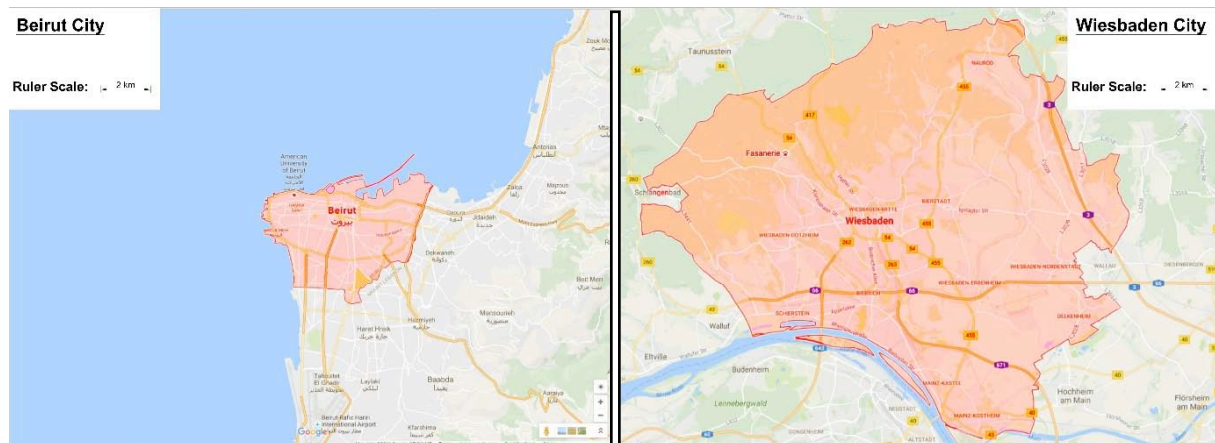


Plate 20: Beirut City and Wiesbaden - size comparison
Source: Google Maps

urban forms, and to be able to measure the sheer capability of the ART system, the research will study the applicability of ART systems in two different case study cities. These cities have two different sets of urban forms, characteristics, and demographics. Through studying these two case studies and through proposing an ART system in those cities, the research will be able to better assess the challenges and the opportunities the ART systems could produce. Through the two proposed ART systems the research will deliver a better understanding regarding the applicability, capability, potentials and limit of the ART system. It will further assess the potential for ART systems to become a major player in inner-city and inter-city transport in urban agglomerations in the near future around the world.

The two case study cities proposed are the city of Wiesbaden, the capital of Hesse in Germany, and Beirut the capital of Lebanon. While the first represents an influential and historic city in a developed world, the other is an example of a capital city in a developing and troubled country. These two cities that are nearly at odds in most of the urban characteristics will help better understand if the ART system is one

that is suitable for all city types and urban forms or not.

Beirut

Being the capital of a strongly centralized political and financial system, made Beirut the booming hub for sectors like commerce, services, education, tourism, gastronomy, art, and culture in the country. This in return made Beirut by far the main jobs creator and contributor in comparison to other cities in the country. As a result, and mainly after the civil war was over, the city witnessed an intense amount of urbanization that converted the city to a “concrete jungle” (Galey, 2010) , and resulted in urban sprawl patterns that that spread sometimes far from the Beirut GBA area and reached in some cases cities that are 40km away.

On the other hand, being located in the narrow land strip between the Lebanese west mountain ridge and the Mediterranean sea, the city does not have a large number of entrances. Furthermore, the presence of a limited number of entrances to the city, and the presence of bottlenecks along those entrances made traffic congestion extremely high during peak hours

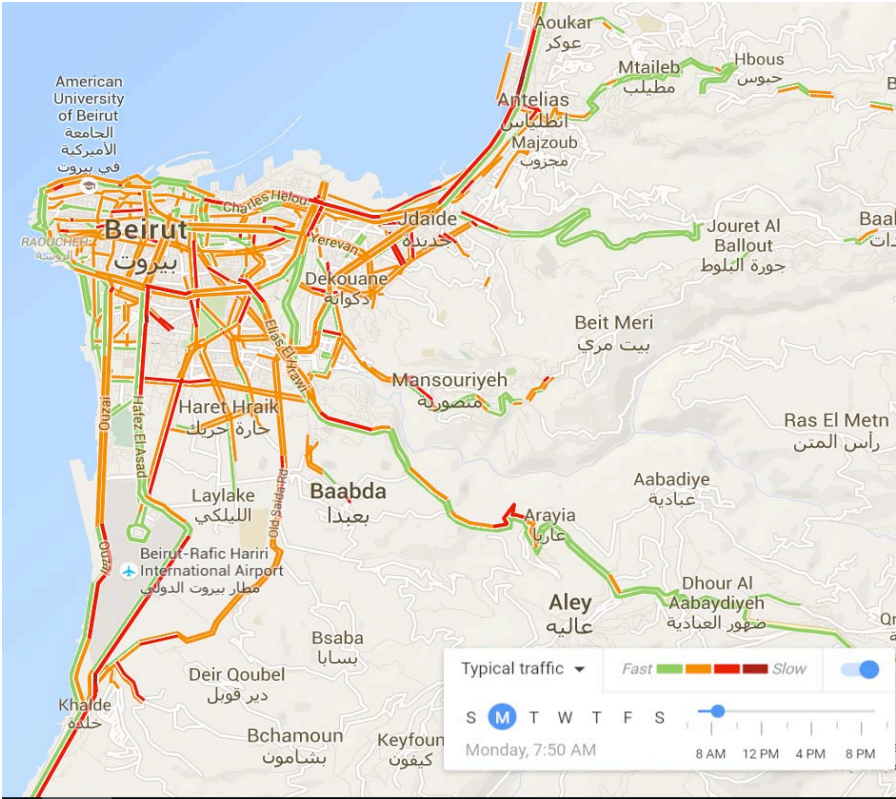


Plate 21: Traffic flow in and to Beirut during peak time
Source: Goolge Maps

(YASA WEB , YASA, 2009) (MoE Lebanon, 2000, p. Appendix A). Yet this is only a part of the traffic problem in Lebanon, the bigger part is the absence of a functioning public transport system. This in return makes the Automotive transport mode the

main and predominant mode of transport in and to the city. This fact intensified the problem of traffic congestion exponentially. Plate 21 shows the traffic congestion in and to Beirut city during morning peak hours. The image shows a high amount of



Plate 22: Beirut ART lines and their stations
Source: Google Earth - edited

congestion to the north entrance at Antelias, and the south entrance at Khaldeh, it also shows a rather high amount of traffic flow in the whole city.

Further to this, by analyzing the increase of the annual growth rates of traffic in Beirut from the "Urban Transport Development Project -Report" (CDR, 2013) one can calculate that Beirut city will have an approximation of 1.9 million cars in 2025. While the city morphology is not changing, and while the city borders and subcenters are not increasing, such an increase in automobile use could have a tragic outcome on the city's future, one which no small fixes can address. It is therefore vitally important for Beirut to introduce a system that break the vicious circle and change the tragic path the city is heading towards.

ART System Proposal

Building on the challenges above, the proposed system consists of five lines and 29 stations. Four of those five lines start from areas of high density, or bottlenecks, while the fifth moves over the boundary areas of the city. After collecting the large number of incomer before the entrances of Beirut, the lines move towards the "no go" areas the, slums and informal settlements around and in Beirut city. Afterwards the lines continue to end up in locations with economic or touristic importance in the city of Beirut. The 29 stations therefore can be categorized and divided into: six stations for daily incomers, many of these are equipped with P+R (Park and Ride) stations; four stations with touristic purpose; fifteen stations are located in areas with heavy density (dense urban fabric, schools, shopping malls, libraries); and four for governmental and multipurpose locations (City center, ministries, schools, universities).

Example line: Line 1

After designating the stations and the lines of the proposed system in Beirut, the research focuses on one line (Line 1) to compare it with the travel time of the automobile and compare its cost to that of other modes. Upon doing so, the following data was deduced:

- The capacity of the system in Beirut is (5Lines X 7000 PPHPD) which results in a total capacity of 35,000 PPHPD. Considering that the system would be operational for 21 hours like the public transport in Germany, this leads to a total of 735,000 persons/day/direction and a total of 1,470,000 journeys/day. This number is nearly equal to the total travel journeys in Beirut per day presented which is 1.5 Million (CDR, 2013).

- In terms of costs, using the ART systems costs data from Table 1, and assuming the line of 31.4km uses 1500 3S-35 passenger cabins, two main stations, six intermediate stations, and ten pylons the price of the line was 471 € Million. In comparison, and using data from transportation systems costs in article 1, on average a BRT or LRT with the same distance would cost respectively 706.5\$ Million for BRT and 942\$ Million for LRT. The price of the ART proves to be nearly half of its competitors. It also shows that the biggest cost in the ART system was for the 1500 cabin, these cabins can be increased or reduced upon line demand, or the financial capacity of the city.

- In terms of travel times, the research conducted duration comparison on Line 1 between the automotive and the ART system. The comparisons were done on two stages:

- o A total journey duration: the travel duration was conducted from the far utmost stations to the Beirut city center station in Peak hours. The aim is to see the effect that an ART system could have on long distance commuters who conduct job related daily journeys to the city, and thus to see if an ART system is feasible for serving this group of commuters and if ART is feasible for inter-city transport.

- o A station to station duration: The comparison was conducted between the stations of Line 1 to see if the ART system is effective as an inner-city transport means. The comparison shows the travel durations by the automotive transport and the ART, between important locations in Beirut city.

For these comparisons, the ART system was considered to be using the top speed of 31Km/h. Further to that, for total journey comparison, the ART system was con-



Plate 0: Beirut ART Line 1
Plate 23: Beirut ART Line 1
 Source: Google Earth

sidered to have every intermediate station capable of allowing cabins to go back or to continue without the need to disassemble/ assemble. In other words, the passengers ride their cabin from the furthest station and do not disassemble until they reach their destination. On the other hand, Google maps was used to measure the time required to achieve the journeys by the automotive transport in peak times on regular working days.

In this comparison, the ART system overtook the automotive in all segments and in the overall journeys. In some cases, the ART system achieved its journey in less than half the time of the automotive. Table 7 shows the comparisons between

those durations and those of ART system to achieve the same journeys.

ART systems shows a measurable advantage over the automotive transport in almost all the lines and line segments measured in Beirut. Yet what seems also important is that in the inner city, and on lines that cross over obstacles like water boundaries, ART systems achieved those journeys in half the time. Indeed, and because the speed limit in inner cities areas is regulated between 30 and 40 km/h, ART systems can even overcome the automotive transport in non-congested streets and in any time of the day. This advantage though becomes less significant when the ART line passed parallel the highway lines

		Line 1			
		System	Journey (From-To)	Distance	Duration
Total Journey	Automobile		Kasslik-Beirut City	16.7Km	42 Min 30 sec.(avrg.)
	ART		Center	14.7Km	28 Min 27 sec.
	Automobile		Khaldeh- Beirut City	13.8Km	28 Min 30 sec.(avrg.)
	ART		Center	13.1Km	25 Min 21 sec.
Station to Station Journey	Automobile		Kallik-Dbayeh	6.7Km	14 Min 0 sec.(avrg.)
	ART			3.17Km	6 Min 8 sec.
	Automobile		Dbayeh-Forum	7.5Km	26 Min 30 sec.(avrg.)
	ART			5.73Km	11 Min 5 sec.
	Automobile		Forum-Beirut City	3.4Km	8 Min 30 sec.(avrg.)
	ART		Center	2.98Km	5 Min 46 sec.
	Automobile		Bchara Khoury- Beirut City Center	1.3Km	5 Min 0 sec.(avrg.)
	ART			1.2Km	2 Min 19 sec.
	Automobile		Barbir- Bchara Khoury	1.1Km	3 Min 0 sec.(avrg.)
	ART			1.03Km	1 Min 59 sec.
	Automobile		Shohada- Barbir	1.2Km	5 Min 0 sec.(avrg.)
	ART			1.2Km	2 Min 19 sec.
	Automobile		Hay Esselom- Shohada	5.7Km	16 Min 0 sec. (avrg.)
	ART			4.82Km	9 Min 19 sec.
	Automobile		Khaldeh- Hay Esselom	6.2Km	14 Min 0 sec. (avrg.)
	ART			4.92Km	9 Min 31 sec.

Table 7: Journey time and distance comparison between automotive and ART at peak times - Beirut
Source: Author

for example due to the existence of an airport, which both the automotive and the ART cannot over cross (case of the second journey in Table 7).

Another well-known piece of information regarding Lebanon, is that accidents on highways are a regular occurrence due to the lack of safety measures, reckless driving, and bad roads (Misbah, 2010). When these accidents occur, journey durations increase exponentially. That is in part because commuters coming to Beirut do not have various highways to choose from. From each side (north, south, east) there is only one highway. Thus, commuters in many cases have to still use the highway that they know is blocked due to an accident.

Having a transport mode that does not use the road network of the automobile and does not suffer accidents like the ART is a luxury which commuters would not want to miss even if the journey times did not show significant differences. Yet there is one extra data to be added to the figure

regarding Beirut. Many of the people living in poor areas in and around Beirut (especially in refugee camps and slums) are heavily armed. Bearing in mind the example of Line-J in Medellin, such downside might discourage users to use lines that pass over these areas. Like in Medellin, before applying ART lines in such areas, a whole bundle of reform has to be initialized. One that will ensure the safety of the system and its users.

Table 8 shows a comparison between the current conventional transport system in Beirut and that of the ART system proposed. It shows advantages for the ART system in journey time, safety, reliability, comfort, and pollution. Beside the fact that the cost of the system is affordable, and the construction time is relatively short, these statistics make the ART an attractive system for both inner and inter-city transport in Beirut.

	Journey Time	Pollution	Comfort	Reliability	Safety
ART system	Short	No Pollution	Comfortable, with beautiful scenery	Reliable	No accidents
Automotive	Indefinite	High Pollution	Confined in traffic	Possibility for long latency	Potential for accident
Bus system	Indefinite	Low Pollution	Confined in traffic/ congested cabins	Possibility for long latency	Potential for accident

Table 8: Comparison between ART and conventional transport in Beirut
Source: Author

Wiesbaden

Being a capital city, and an important city with various industries and jobs, the city of Wiesbaden attracts a formidable amount of working force, and in return job related daily transport (Baier, et al., 2012). As Figure 7 shows, in the year 2000 those daily travel journeys were an approximation of 1.2 million. Those patterns show a high dependency on motorized private transport (Automotive) with a percentage of 52.8%. Numbers show further that this mode is even more favorable by job trips coming in to Wiesbaden from residents of surrounding areas. In this case, the ratio goes higher to a 72.4%.

The second mode of transport in Wiesbaden is surprisingly not the UPT but the foot mode, where 20.2% of the job journeys happen by foot. Public transport comes third in Wiesbaden with a ratio of

18% only. This mode of transport is served locally by a bus system that covers the total area of Wiesbaden city center and the surrounding. Wiesbaden is connected to other cities in Germany by a main train station (Wiesbaden HBF).

Having a high ratio of walking journeys is not a negative sign. Indeed, it could be seen as a positive sign for good urban planning in terms of accessibility and permeability, and a good application of concepts like "Compact city" and "City of short distances". Yet the difference in ratio between the use of UPT and the Automotive which reaches in some cases a four to one advantage for the Automotive demonstrates a challenge to the city of Wiesbaden.

The UPT system in Wiesbaden consists of 32 bus lines, 18 of which reach an availability period of 10 minutes or less in peak times and school periods (RMV, 2016).

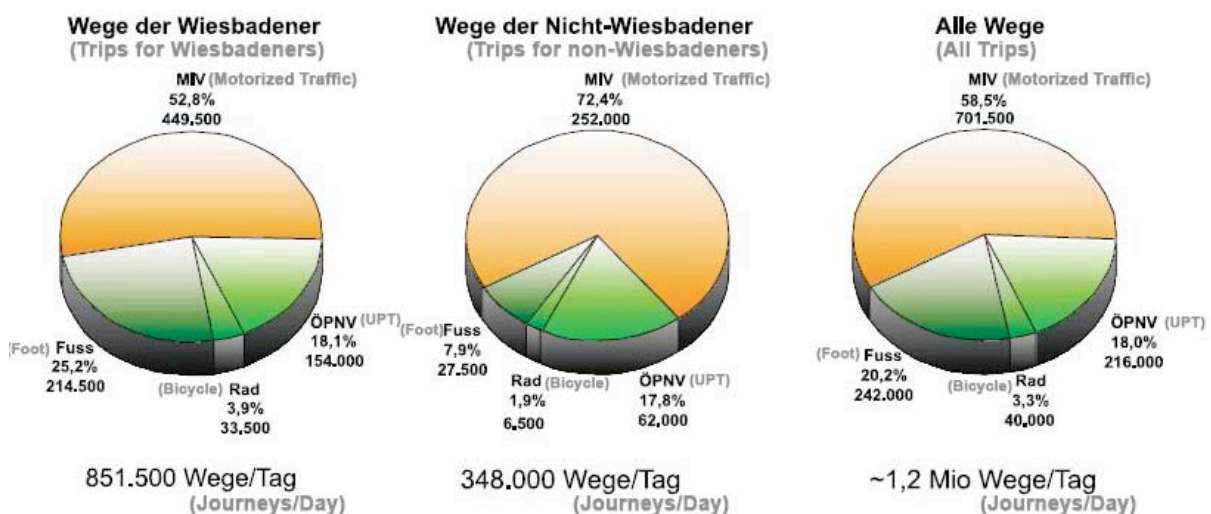


Figure 7: Daily travel modes in the city of Wiesbaden, 2000
Source: Baier, et al., 2012

In terms of coverage, and using the radii analyses of the catchment areas, it was found that those lines have a sufficient and impressive degree of overlap and coverage.

On the other hand, based on the field observation and meetings with transport officials (Murtezi & Kurz, 2016), it could be concluded that Wiesbaden's bus system has insufficient ticketing machines on the bus station/stops and uses the traditional method of paying to the driver. Adding that to the fact that Wiesbaden's bus system uses the congested road network, it could be concluded that this bus system suffers from constant short period latencies. In addition, and due to the short distances between bus stations (Which reflects good coverage), busses need in many cases stop every 300 m or every few minutes (and opening their door). In return, they lose the ability to cool or heat the inner of the busses sufficiently. This makes the system further unattractive in cold or hot weather (Murtezi & Kurz, 2016).

Hence, and although many of the lines have high availability and although the system covers the city urban fabric to a very sufficient level, the system could lose attraction due to the latency resultant from being stuck in traffic congestion or from latencies related to payments to the driver on every stop. Beside these factors, the fact that these systems can be not comfortable due to weather or due to being over congested makes this system less and less attractive.

Knowing that the city does not have in mind building any new conventional UPT systems (Murtezi & Kurz, 2016), one can imagine that the transportation trajectory the city is heading in until 2025 is a stagnated one, which will work on improving what is already there. That is through making cycling and walking even more attractive, and through finetuning the current bus system and increasing its capacity. Such approaches will definitely promote sustainable transport modes and reduce automobile dependence, yet the extent of the change is not presumed to be large. That is because the bus system is already carefully planned and finetuned, and because approximately 350 thousand

journeys to Wiesbaden happen daily from surrounding regions and towns (Figure7). For such travelers, walking and cycling is inapplicable, and the bus systems does not seem to be satisfactory.

ART System Proposal:

The proposed system consists of four lines and 25 stations. The lines start at the outskirts of Wiesbaden and pass the inner city to end up at the outskirts from another side. The aim is to collect a credible amount of the 348,000 daily commuters from outside the city which in return would reduce traffic jam on the highways used as entrances to Wiesbaden city, and in the inner city. The lines that start mostly outside Wiesbaden move towards the city center creating a ring around the city center. These lines consist of 24 stations which can be categorized and divided into: seven stations for daily incomers, many of these are equipped with P+R stations; eight stations with touristic purpose; eight for locations with heavy density (dense urban fabric, schools, shopping malls, libraries); and two for governmental and multipurpose locations (City center, city hall, main station).

Plate 24 shows the proposed ART lines in Wiesbaden, and their stations.

Example Line: Line 1

Similar to the Beirut example, the research focuses on one line (Line 1) to compare it with the travel time of the automobile and compare its cost to that of other modes. Upon doing so, the following data was deduced:

- The system in Wiesbaden can carry up to (4Lines X 7000 PPHPD) which results in a total capacity of 28,000 PPHPD. Considering that the system, would like any other public transport in Germany, run from 4am to 1am daily leads to a total of 21 hours of operations and thus a total of 588,000 persons/day/direction and a total of 1,176,000 travelers/day. This number is nearly equal to the total travel journeys in Wiesbaden per day presented in Figure 7.
- In terms of cost, using the data from the ART cost table in article 1 and

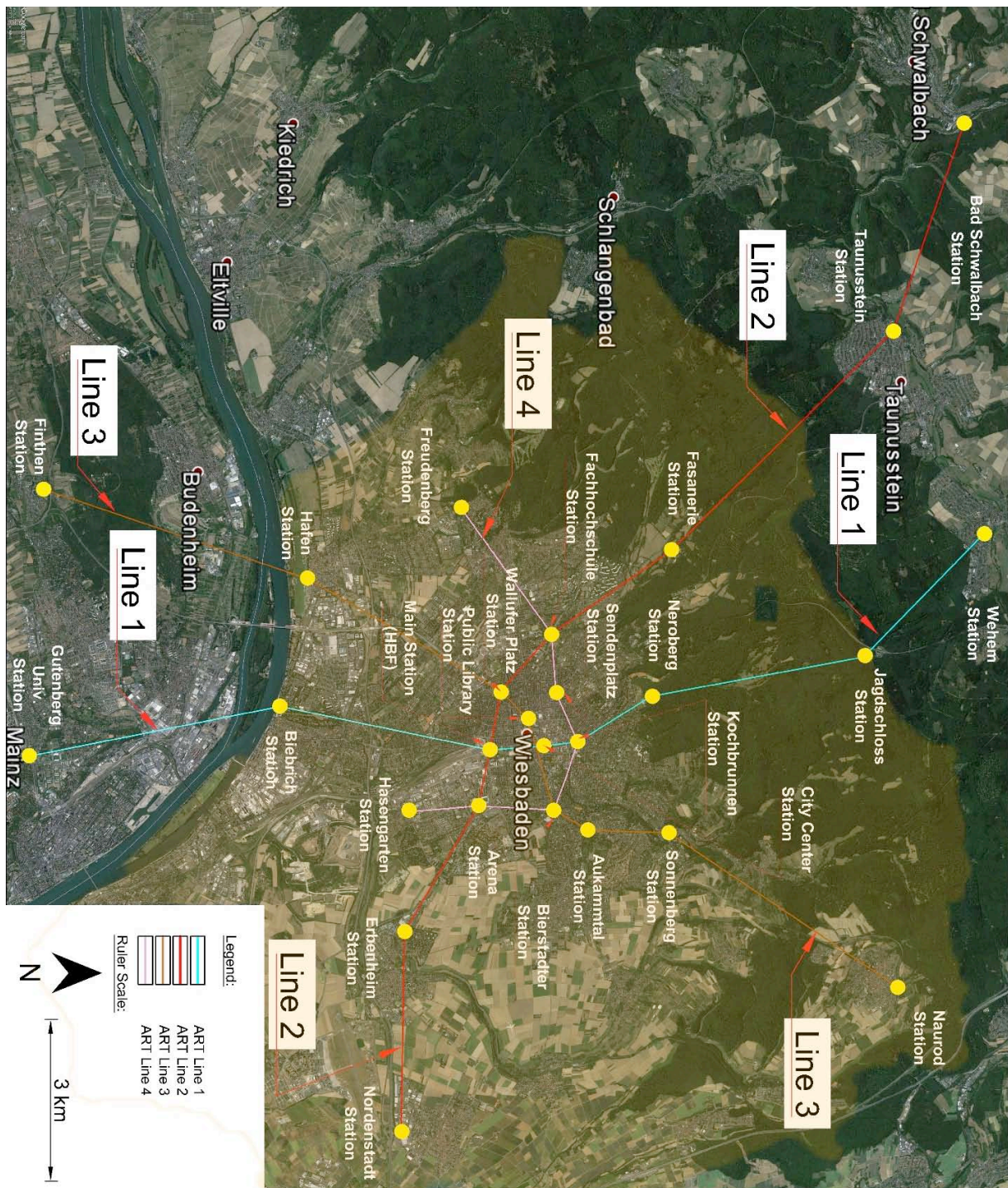


Plate 24: The proposed lines and their designated stations - Wiesbaden
 Source: Google Earth - edited

the transport systems cost also in that article, the cost of the ART line 1 with a length of 19 km and assuming the line will have 1000 3S-35 passenger cabins, two main stations, six intermediate stations, and ten pylons, will cost 321€ Million. In comparison, the cost for similar length for BRT is on average 481\$ Million, and LRT 570\$ Million. Again, ART systems seem to be the cheapest in comparison to its competitors.

- In terms of travel times, the re-

search conducted duration comparison on Line 1 between the automotive and the ART system. Similar to Beirut, these were divided into two types, total journey and station to station.

the top speed of 31Km/h was used here also. In this comparison, and like in in the Beirut comparison, the ART system overtook the automotive in all segments and in the overall journeys. In some cases, here also, the ART system achieved its journey

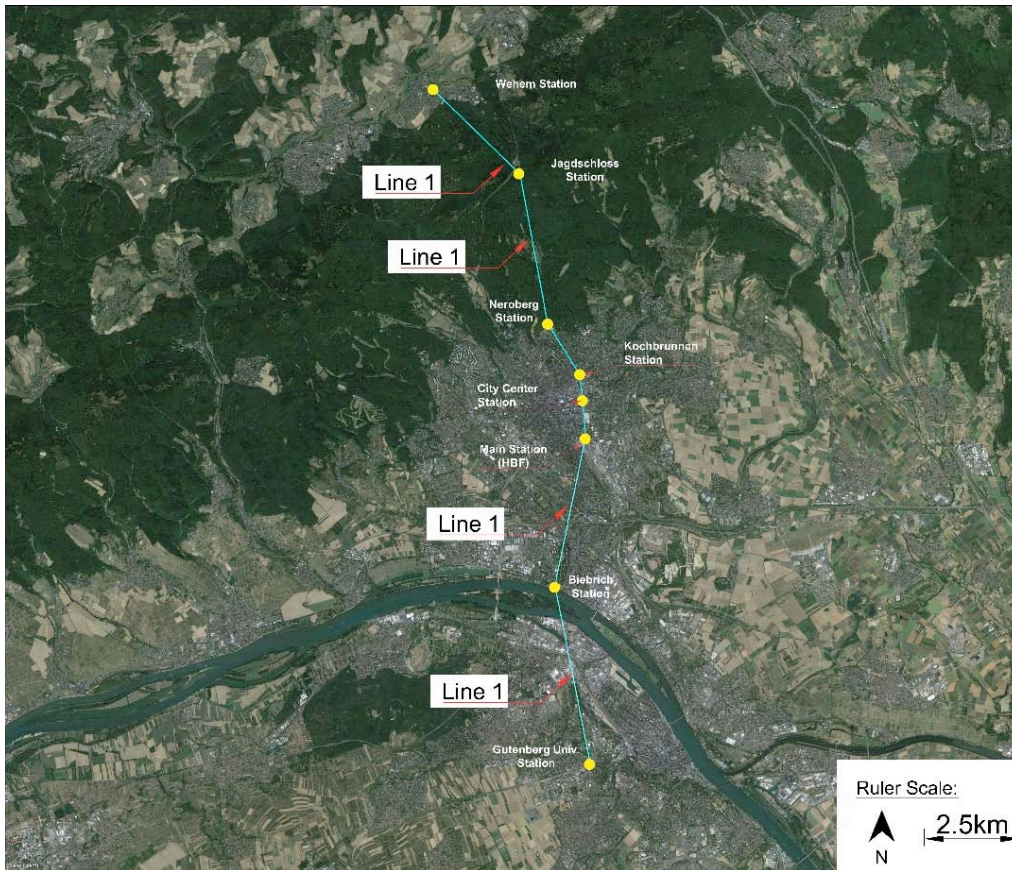


Plate 25: Wiesbaden ART Line 1
Source: Goolge Earth, Author

in less than half the time of the automotive. Table 9 shows the comparisons be-

tween those durations and those of ART system to achieve the same journeys.

Line 1				
	System	Journey (From-To)	Distance	Duration
Total Journey	Automobile	Wehem- Wiesbaden	12.4Km	23 Min 0 sec.(avg.)
	ART	HBF	10.3Km	20 Min 31 sec.
	Automobile	Gutenberg Univ- Wiesbaden	16.8Km	38 Min 0 sec.(avg.)
	ART	HBF	8.64Km	17 Min 13 sec.
Wiesbaden Station to Station Journey	Automobile	Wehem-Jagdschloss	4.1Km	8 Min 0 sec.(avg.)
	ART		3.17Km	6 Min 19 sec.
	Automobile	Jagdschloss- Neroberg	9.3Km	16 Min 0 sec.(avg.)
	ART		3.95Km	7 Min 52 sec.
	Automobile	Neroberg- Kochbrunnen	2.3Km	7 Min 0 sec.(avg.)
	ART		1.58Km	3 Min 8 sec.
	Automobile	Kochbrunnen- Dernsches Gelände	1.61Km	6 Min 0 sec.(avg.)
	ART		0.6Km	1 Min 11 sec.
	Automobile	Dernsches Gelände- Wiesbaden HBF	1.Km	5 Min 0 sec.(avg.)
	ART		1.Km	1 Min 59 sec.
	Automobile	Biebrich Palace - Wiesbaden HBF	5.1Km	13 Min 0 sec.(avg.)
	ART		3.91Km	7 Min 47 sec.
Automobile	Gutenberg Univ. - Biebrich Palace	13.7Km	17 Min 0 sec. (avg.)	
ART		4.73Km	9 Min 25 sec.	

Table 9: Journey time and distance comparison between automotive and ART at peak time - Wiesbaden
Source: Author

Conclusion

ART proves to be an old yet innovative transport method which, in light of its latest innovations, can be proposed not just as a feeder or a touristic element in a ski resort, but as a transport mode that holds very significant potentials. This relatively new urban transport mode shows a rapid pace in innovation and upgrades in the last decade. These innovations and this rate of upgrade prove the mode to have a promising future and bigger role in future city transportation systems. In comparison to traditional transport modes the advantages of the ART systems can be seen in various aspects. Those aspects are ones of comfort, availability, reliability, safety, construction time, land take, cost, environment, and energy efficiency. In all of those aspects, ART systems have the upper hand on conventional transport modes. It is in light of those advantages, that the research finds potential in implementing ART systems as full urban public transport systems. Ones that can function as a backbone, yet also compliment with other existing systems.

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We need a louder road safety voice

Lori Mooren PhD with Wendy Sarkissian PhD

Introduction

This paper examines current leading-practice approaches to road safety through the lens of a recent tragic fatal crash that occurred on a rural road in New South Wales, Australia. Dr Wendy Sarkissian, a community planner and ethicist, describes the crash she witnessed and survived – a crash that killed her husband. Dr Lori Mooren, a road safety specialist and research consultant at the University of New South Wales in Sydney, examines how Australian road authorities fail to provide survivable road systems.

The first recorded automobile fatality occurred in Ireland in 1869 (Fallon and O'Neill, 2005). The event was described as a "public scourge and a private tragedy". The coroner was moved to say, "This must never happen again." Nearly a century later, in post-war 1947, J S Dean, in *Murder Most Foul: A Study of the Road Deaths Problem*, concluded that "The 'reconstruction of Britain' will indeed be a dismal failure if it includes as a permanent feature of the national life the killing and maiming of a quarter of a million, or more, of persons every year on the roads...there is no reason for failure... All that is needed is the will to act" (Dean, 1947, reprinted 2007 p. 114).

Several decades later, Whitelegg (1983) highlighted the futility of the prevailing approach to road safety, insofar that the research questions begin by assuming that motor vehicle travel is the inevitable norm in human transport. He concluded that we have created a dependency on a mode of transport, "which is structurally determined to eradicate choice in our environment and to perpetuate a system which in spite of significant gains will continue to be destructive of human life and talent" (Whitelegg, 1983, p. 159). May et al. (2008) echoed this sentiment, calling for a more holistic approach to meeting the mobility needs of people in ways that are far less damaging to life and the environment. They suggested that we need a fundamental change in the culture of means of travel.

In its global status report on road safety 2015, the World Health Organisation (WHO) reported that the worldwide number of traffic deaths has plateaued, with 1.25 million people dying each year on the world's roads (World Health Organisation, 2015). In 2004, leading road safety researchers (Peden et al., 2004) estimated that road fatalities and serious injuries will rise by 65% by the year 2020. Deaths resulting from road crashes will exceed deaths from HIV, malaria and tuberculosis and road deaths are predicted to become the third leading contributor to the global burden of disease and injury.

Road safety is a political and community issue – and it has been for a long time (Mooren, 2000; Mooren and Grzebieta, 2009). Decisions by government leaders are shaped by the perceived demands of their constituencies (Mooren, 2000). Further, demands for safe road systems have been too weak by comparison to other perceived community demands.

An examination of the magnitude of this problem and the threat to our communities reveals the total number of deaths that occur in any country resulting from traffic crashes. When we compare that figure with the number of deaths resulting from all the wars and disasters, some startling results emerge. For example, the total number of fatalities Australia has suffered in all wars to date is around 103,000, of which only 36,000 occurred since 1925 (Australian War Memorial, 2013). If we add the number of Australians who have died as a result of natural and human-created disasters (fires, bridge collapses, bombings, etc.) – only around 1000 – we can then compare this total to around 171,000 fatalities resulting from all road crashes since record-keeping began in 1925. Since 1925, 82% of all Australian fatalities, not from natural causes, were due to road crashes.

The figures compare to those for the USA. Around 1.8 million road fatalities to date have been recorded since only 1966 ([US] National Center for Statistics and Analysis, 2004), compared to around 1.4 million fatalities from all wars, including the US Civil War and disasters that include heat waves, hurricanes, floods, bombings, etc (White,

2010). In 2000, fewer than 4,000 people were killed in the Twin Towers terrorist attacks in New York, but more than 40,000 Americans are killed in road crashes every year. Nevertheless, the US Government's attention to anti-terrorist initiatives far outweighs that given to road safety in that country. Indeed, a comparison between casualties from wars and disasters and casualties from traffic crashes for just about any developed nation reveals that traffic crashes are a much greater risk to a community's health and well-being. Moreover, the incidence and severity of road crashes are somewhat more predictable and preventable than are other forms of injury causation. In the case of natural disasters, for example, magnitude and location are difficult to predict. In the case of wars, where injury is intentional, incidence and severity are also difficult to predict. On the other hand, we know that road trauma is caused by certain characteristics of roads, vehicles and behaviours – all of which can be ameliorated.

Since the early 1990s, researchers and practitioners in the Netherlands sought to find ways dramatically to reduce road deaths. Recognising that human error plays a large part in road injury risk, Dutch government stakeholders, at national, provincial and local levels, committed to take a planning and design approach to developing a sustainable safe road traffic system. Their strategy emphasises the application of three safety principles in a functional hierarchy within the road network: functionality, homogeneity and predictability (Wegman, 2005). The challenge is to reorganise the road network into roads with flow functions, distribution functions and local access functions and to manage speeds, types of vehicles and road users' behaviours in accordance with the safety parameters that would enable people in the road environment to remain unharmed. The objective is to provide a road traffic system adapted to the capabilities and limitations of human road users. The design reference is the human being, considering human error and human physical tolerance to mechanical forces.

A strong ethical basis for road safety underpinned the passage of the Vision Zero legislation by the Swedish Parliament in

1997 (Johansson, 2009). The Swedes took the bold position that it is unacceptable to trade safety for mobility in the road environment. One key premise of this new approach was that, "...the speed limits within the road transport system should be determined by the technical standard of vehicles and roads so as not to exceed the level of violence that the human body can tolerate" (Tingvall and Haworth, 1999 p. 2). The strategy underpinning the Vision is a quality-management approach to managing safety in the road transport system. Road system designers, vehicle manufacturers and those who employ professional drivers have roles to play in developing and managing an inherently safe road transport system. We must design road infrastructure and vehicles to protect human bodies from the risk of injury. And we must encourage – or force – road users themselves to use vehicles and roads safely. Moreover, if the system is found not to meet these standards in any way, designers must correct the defects. The principles of Vision Zero are the following:

1. The designers of the system are ultimately responsible for the design, operation and use of the road transport system and thereby responsible for the level of safety within the entire system;
2. Road users are responsible for following the rules for using the road transport system set by the designers; and
3. If road users fail to obey these rules due to lack of knowledge, acceptance or ability, or if injuries occur, the system designers are required to take necessary steps to counteract people being killed or seriously injured (Tingvall and Haworth, 1999 p.2).

Throughout the 1990s, Australian States were actively pursuing road safety based on analysis of crash injury data and cost-beneficial selection and implementation of countermeasures to address road, vehicle and human factors attributable to road injury and death (Torpey, 1991). While this approach was achieving reductions in road fatalities, the reduction line on the graph was flattening in raw numbers. By the late 1990s, Australian researchers began to highlight systemic risks in the road traffic

system and in vehicles, calling for more attention to address these systemic problems (Grzebieta, 2001, 2002; Rechnitzer and Grzebieta, 1999). And in 2004, the Australian Transport Council (of Ministers) adopted the *Safe System* principle as the basis of Australian road safety strategies, announcing in a joint communiqué (Australian Transport Council, 2004) that all Ministers agreed on a plan that “lays out a clear set of priorities for national road safety and highlights the *Safe System* concept as an overarching framework.”

Then, in 2010, the United Nations General Assembly unanimously resolved to declare 2011-2020 a Decade of Action for Road Safety (United Nations 64th Plenary Meeting, 2010). The *Safe System* principle underpinned an agreed Global Plan for the Decade. But again May et al. (2011) warned that unless we have strong transformational leadership integrating energy, transportation, health, environmental and educational goals, we are unlikely to achieve our ambitious road safety targets that require a deep level of changed thinking. Even in 2016 – more than halfway through the Decade that sought to reduce by half the world’s road fatalities – they are not declining at all. There is a growing concern that the *Safe System* principles meant to underpin the Global Plan are not being applied in countries that are UN signatories to this global commitment.

In essence, applying *Safe System* principles means that we design and managed the road traffic system so that crashes are survivable. This approach assumes that people will make mistakes in the road environment. We make every effort to correct for, or ameliorate, the harmful effects of any impacts on the human body that may result from a crash event. The approach involves applying resources to prevent the risks of serious injury crashes, based on an understanding of the possible crash types and likely harm to human road users that could result from these crashes. The approach also addresses road, vehicle and human behaviours, as well as emergency response services, to prevent this harm from occurring. While the ideal is to prevent crashes from occurring, the focus of the *Safe System* approach is to eliminate the possibility of kinetic energy forces in a crash, resulting in an impact on the

human body causing serious harm. This approach acknowledges that human beings are fallible. They make mistakes; thus, we need systemic safeguards to “forgive” these mistakes. To the extent that humans control motor vehicles, lapses and errors are likely to result in crashes in the near future. A safe road system would prevent those mistakes becoming fatal or seriously harmful. This is a systemic approach, grounded in evidence-based research. A system-focussed analysis of how serious injury crashes occur can demonstrate how system failures contribute to human tragedies. Just as we conduct root cause analyses in workplace health and safety, we can apply a similar process to the analyses of road trauma events.

Let’s apply a system-focussed analysis to one example of a fatal crash that occurred in February, 2016 on a rural road in Australia. This is a true story. Wendy Sarkisian lost her husband in a car crash that should not have happened. It is a story of what happened to an elderly couple returning from a lunch outing for Wendy’s birthday. It is a classic illustration of a tragic system failure.

Wendy’s Story

After the last two fatalities on the road we travelled to return home, had the local road authority built a guardrail and improved the safety of the stretch of road where my husband died, I would be a happily married woman with a beautiful, creative husband six years my junior. I would be working as a planning consultant and author and living in the house we designed, and built, on a rural block in a tropical region of Australia.

I believe that Karl’s death resulted directly from the road authority’s decision (following the last crash in 2015 that resulted in two fatalities) not to erect a guardrail on the stretch of road that is winding and dangerous, with inappropriate and dangerous road camber, a deteriorated, rutted road edge, frequent pooling of water and steep embankments. The memorial cross for that 2015 crash (that killed mother Cecilia and fifteen-year-old daughter Matilda) stands only eight metres from where our car mounted the kerb and tumbled 30 me-



Plate 1: The crash site

tres over the cliff into a shallow tidal creek. The autopsy report showed that drowning was the sole cause of Karl's death. He had not a scratch on him.

We'd been out celebrating my birthday and we'd had a stellar day. We had had such a brilliant lunch that we reckoned there was no need for dinner. We were in no hurry. We had travelled that stretch of road hundreds of times since we bought our rural block in 2001. We knew the road very well. On the wet road, the car aquaplaned on a bend, crossed the double line, hit the kerb, rolled down a steep bank for thirty metres, and landed on its roof in a shallow creek, facing in the opposite direction. I briefly blacked out and regained consciousness in the water.

I find myself upside down. After seconds or minutes that seemed like hours, I locate and unfasten my seat belt, as I watch water rising and coming through one open front window. Then it stops rising, leaving me a small air pocket.

I'm sitting upright in the upside-down car in the creek, on the roof, with water to my chin, air above, and the floor above that. It is quite dark in the car because of the muddy water, even though it is light outside. Karl seems some distance from me. I've been pushed (probably by the airbag) into the back of the car, facing Karl's back. He's tangled in his seat belt.

I have air on my side (the back) and he has none because the car landed on an angle. He's sitting up, silhouetted in water as dark as chocolate milk. I can barely see his head and cannot reach forward far enough to untangle him. His swimming hands describe small circles around his body. He

appears to be unconscious. I reach forward and grasp one circling hand with my left hand. He has had no option but to surrender to the water that fills his space and then his lungs. He does not struggle. I hold his hand as he drowns, hearing a shocking gurgle of water, like a large sink emptying, as the water fills his lungs. His head flops to one side.

I'm desperate now. The water is still rising. The doors I can reach are stuck in mud. I scream: "Karl! Hold your head up!" Screaming at a dead man.

I take a last look at Karl, now slumped forward, and dive down to reach the passenger side open window. I force my shoulders through it, imagining I will need powerful strokes to reach the surface light. I forget to take a breath, swallow, splutter muddy water and cough. Then I find myself standing in a metre of water outside the car. Already people are crowding the narrow roadside above. "My husband's drowning!" I scream to those above. "Help us! Help us!"

Barefoot, trembling, stones cutting my feet, I observe a surreal tableau of airbags, shopping bags and roadmaps floating slowly through the hatch door, heading downstream. I reach for a shopping bag and stop. How ridiculous!

Then I turn to see two men – later known as Rob and Bill – scrambling down the slippery, reedy bank. They wrench a huge stone from the creek side and smash the driver's side window. Rob dives in three times before he untangles Karl and hauls his lifeless body from the wreck.

When attempts at CPR fail, a police officer announces, first to others ("There's no

pulse”), and then to me (“Madam, I regret to inform you that your husband is deceased”).

A Safe System?

Australia first developed the *Safe System* approach based on the principles underlying Sweden’s Vision Zero (Johansson, 2009) and the Netherlands’ Sustainable Safety strategy (Wegman, 2005). In 2004, all Australian Transport Ministers adopted *Safe System* principles to underpin their road safety strategies (Australian Transport Council, 2004). This commitment promised to ensure that systemic safeguards would prevent inherently fallible human road users dying as a result of a mistake they make on Australian roads. In Wendy’s story, Karl might have made a mistake. Although he was not exceeding the speed limit, he might have misjudged the condition of the road and driven too fast for that bend. It was not raining at the time of the crash and Karl thought he knew the road well. The speed limit was 80kmh, but the advisory speed on the bend in the road was 45kmh. Police esti-

mated that he was travelling between 50 and 60kmh. The local road authority had made no physical improvements to the road environment since the last fatality.

“Speed was the root cause of the crash,” the road authority officially claimed, despite one staff member vehemently disagreeing in a meeting with us, arguing that the tight curve was the root cause of the crash. Moreover, despite the police report of the crash that claimed that the car had aquaplaned, authority members officially argued that, “the car could not have aquaplaned.” Their reason for this contention is that a drain culvert is located near the crash site. However, when we inspected the site – three days after and even months later – the drain was covered in fallen leaves. The Police also observed that fruit and leaves that drop on the road from a dense canopy of overhanging trees in that sub-tropical area contribute to the road’s slipperiness. The local Police advised Wendy that, had the authority installed a guardrail in that section of road, Karl might well have survived. The report on this crash included statements by Police that mentioned a his-



Plate 2: The point at which the car left the road



Plate 3: Deteriorated pavement

tory of serious crashes on this stretch of road – including ones where vehicles had landed in the creek. Police also explained that to Wendy following her crash.

However, despite this advice from the attending Police, the solution adopted by the local authority in 2015 was to advise mo-

torists of the danger of that section of road and install new interactive speed signs, telling drivers how fast they are traveling. By September, 2016 (seven months after Wendy and Karl's crash) the authority's only road-amelioration action was to prepare applications for Federal Black Spot

funding.¹ The authority management has advised us that they intend to make safety improvements to this rural road – if the Federal or State Governments allocate funds for this purpose. They have made no firm undertaking that they will fund the guardrail from their own funds if their bid is unsuccessful, despite our repeated requests. The authority expects notification of their applications' outcome in February, 2017 (one year after Karl's death and more than two years after the double fatality that claimed the lives of Cecilia Bevelander and her daughter, Matilda Bevelander).

Would the 2016 crash have been avoided or its severity lessened if Karl had been driving more slowly? If Karl had seen the pooling of water as he navigated the tight curve, would he have slowed down, thus reducing the likelihood of the crash? Would Karl have survived if he had not been knocked unconscious by his airbag and subsequently trapped by his seatbelt? Wendy and Karl were travelling in a 2005,

5-star ANCAP-rated² Volkswagen Golf. The airbags were deployed in the crash. If Karl had been superhuman, anticipated all possible hazards on that road, and adjusted his driving accordingly, perhaps he could have avoided this fatal event. Clearly, he did not. By their own accounts, the road system managers did not take this possibility – this likelihood – into account. Systemic safeguards were woefully deficient.

Systemic anatomy of Karl's fatal crash

As early as 1931, those researching injury causation in the workplace applied systems thinking principles. Heinrich introduced his Domino Theory that year (Heinrich, 1931). This model explains accidents as a chain of causes and effects, suggesting that a weakness in safety defences in the system of work can undermine the more proximal defences. James Reason extended this thinking, pointing out that pre-existing injury causation factors may lie dormant or latent for a long time – even years (Rea-

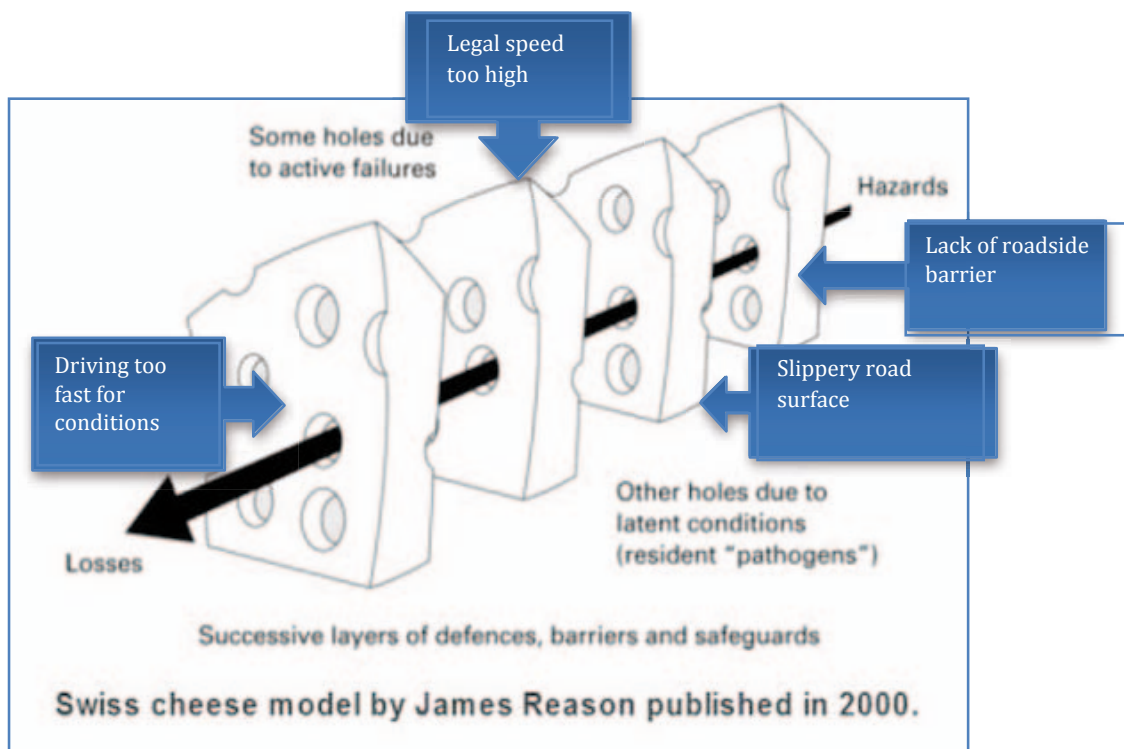


Figure 1: Labelled Swiss Cheese model of system accidents (based on Reason, 2000)

1 Black Spot funding is available from a Federally-funded scheme for road authorities. In 2016, the State of New South Wales alone had 500 active applications. Because the road authority waited until three fatalities occurred on the same site, they might have an increased chance of gaining funding than they would have if they had acted promptly after the January 2015 crash. Funding results will be released in February 2017.

2 See Australasian New Car Assessment Program information at <https://www.ancap.com.au>

son, 1997). His important contribution was to explore the role of error in accidents to encompass the possibility that errors can occur because of the system itself and that holes in injury defence barriers – like holes in Swiss cheese – enable an accident trajectory to continue until harm occurs. Using Reason’s model of system accidents, we can see that “the holes lined up” to enable a tragedy to unfold for Wendy and Karl. Figure 1 below depicts the gaps in the systemic safety barriers, using Reason’s model.

These holes in safety defences can be further defined in terms of factors relating to the road, the vehicle and human behaviour. Specifically, Figure 2 below illustrates the factors involved in Karl’s death.

While the factors and failures identified here do not represent a comprehensive root cause analysis, they do reveal some of the systemic inadequacies that contributed to Karl’s death.

The road was inherently unsafe for human motor vehicle operations. There were no safety barriers on a sharp bend with no shoulder and a steep embankment down to a tidal creek (part of a river) (at least 30 metres below). The road surface was slippery from rutted and worn pavement, pooling water, and leaves and fruit droppings. Perhaps a heavier car would have held the road better. The car, with a 5-star safety rating, had recently undergone a

registration check and had new tyres. It was structurally sound and there was little or no intrusion into the cabin. It is likely that the force of vehicle against the left, then right kerbing spun the car backwards, causing it to tumble down the steep embankment, which overturned the car (so that it landed upside down).

The airbags deployed with a force that prevented the driver sustaining impact injuries, but probably caused him to be unconscious and therefore unable to undo his seat belt. (A lean man of slight stature, Karl did not regain consciousness following the impact of the airbag. Larger in size, Wendy did regain consciousness in the water after the car landed.) The driver was travelling well under the speed limit, suggesting that the legal speed was set too high. Misjudgements about speed and road conditions could have contributed to the crash, perhaps because of Karl’s familiarity of the road, possibly resulting in overconfidence.

This brief systemic analysis illustrates how human errors, combined with a lack of safety management, particularly of the road conditions, could result in a fatality. In this case, part of the systemic problem is a lack of proactive safety management on the part of the road authority. Wendy also argues that “nobody was minding the shop” and that poor coordination among responsible agencies (the coroner, the Police and the local road authority) after

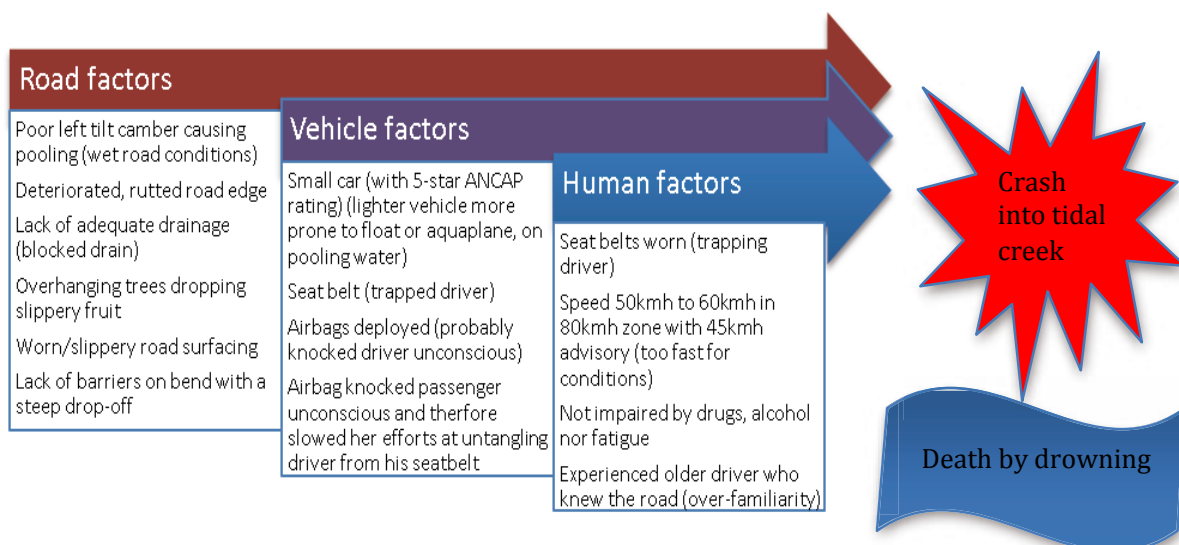


Figure 2: System failures in Karl’s fatal injury

the 2015 crash also contributed to Karl's death. The fact that there had been a number of crashes at this site suggests some negligence on the part of the road managers. If the authority had treated the road in the same way as they treat their workplace, it would probably be deemed culpable for the injuries that resulted from these crashes. Instead, the apparent attitude of those staff and managers was that the driver was responsible for safely operating the motor vehicle, regardless of the unsafe road conditions. The authority managers even prevented the widow (Wendy) from explaining to them how this tragedy has affected her – citing concerns about the occupational health and safety of their staff (who might be upset by her story). Muzzled, she was limited to describing the "circumstances of the crash".

Unprotected roadsides on slippery roads with tight curves are antithetical to the *Safe System* approach adopted as police by all Australian Transport Ministers in 2004. Roadside and median barriers were tested in 2013 at the Crashlab (Transport for New South Wales) and wire rope barriers in particular were found to be very effective in preventing serious injury crashes.³ Nevertheless, the local road authority ignored Police advice to install guardrails. When we met with this authority on 12 September 2016, they advised that speed was the root cause of the crash, not aquaplaning as advised by Police attending the crash site. They further argued, "[We] have not pursued guardrail at this location in isolation as it does not address these root causes of the crashes at this location. If [we] do not address the factors leading to loss of control on the corner, which we consider to be mainly speed related, [we] will potentially be faced with a maintenance issue from vehicles impacting with the guardrail, and new hazards the guardrail may create."

The road authority management decided that speed and driver error were the core causal factors, despite the strong views of local Police (expressed to Wendy on 19 February 2016) that, "Police are of the opinion that the roadway was a factor." **Astonishingly, not one responsible road**

³ These tests may be viewed at <http://road-safety.transport.nsw.gov.au/research/safer-roads/road-safety-barriers.html>

authority officer visited the site immediately after the Saturday afternoon crash (although their office is located only 12 kilometres from the site). Therefore, the authority missed valuable data, such as skid marks and debris on the roadway. They did not assess the condition of the culvert and the drain. By their own admission to us, they collected no site-specific accurate weather and/or rainfall data for the exact site. They took no photographs of the site near the time of the crash.

More than six months after Wendy and Karl's crash (and 18 months after the previous double fatality at the same site), the local authority finally reduced the speed limit from 80kmh to 60kmh. Police estimated that Karl was driving no faster than 60kmh. The advisory speed sign suggests 45kmh around the curve. And while Karl, being familiar with the road, may have been driving faster than was safe for the prevailing conditions, a 60kmh crash into a guardrail would have caused the authority some "maintenance" issues. Nevertheless, the Police advised Wendy immediately after the crash, had there been a guardrail, Karl probably would not have died. The authority expressed concern about the costs of erecting guardrails when we met with them. However, an examination of their recent budget papers indicates that they spent \$13 million last year on recreational facilities. Erecting a guardrail would have cost around \$100,000.

The theme for the 2016 World Day of Remembrance for Road Traffic victims (see <http://worlddayofremembrance.org>) is "Vital post-crash actions: Medical Care, Investigation, Justice". In Karl's crash case, investigation and justice were all but absent.⁴

As noted above, the Police attending the crash expressed the view that a guardrail would have saved Karl's life. In their view,

⁴ For details of our response to the World Day of Remembrance for Road Traffic Victims (<http://worlddayofremembrance.org/>), honouring Karl and raising local awareness of the dangers of the road, see our November 2016 video: <https://youtu.be/FyI5jNqqYdE>

The road authority promptly removed our memorial sign, as it is not consistent with their policy (which does not permit memorial signs).

the authority should install a kilometre of guardrail. However, Police views did not influence the report of the road authority's Traffic Committee. This road authority instead blamed the driver for his death. Where is the justice in that approach? As long as this complacency and displaced sense of responsibility persist in Australian road-managing agencies, realising the dream of *Safe System* is a long way off.

Scientific evidence alone appears to be insufficient to influence policy makers, despite a wealth of research findings that can guide road designers and managers. We have abundant knowledge of the factors involved in injury crashes, as well as knowledge of the solutions and technologies we can use to ameliorate these factors. Clearly, there are limitations on resources available to create a truly safe



Plate 4: Wendy with the poster of Karl at the crash site

road and traffic system. However, the Safe System principle demands that crashes should not result in injuries – certainly not in multiple fatalities at the same spot in a road network within a one-year period.

Increasingly, we hear voices supporting a greater advocacy role for road safety researchers. While some barriers might prevent researchers assuming a policy advocacy role, by and large, Australian road safety stakeholders want to see road safety researchers become more pro-active in this space (Hinchcliff et al., 2008). The barriers identified include the following:

- Reluctance to upset or offend research funders;
- Lack of media advocacy skills;
- Lack of time to do unpaid work;
- Reluctance to appear biased; and
- Policy-makers' opposition to researcher media advocacy.

Nonetheless, the majority of stakeholders participating in the consultations undertaken by Hinchcliff et al. reported that they believed that researcher media advocacy is a significant force within the road safety policy process.

The community voice for road safety in Australia has generally been quiet, relative to the voices in other countries. One notable voice has been Safer Australian Roads and Highways (SARAH), a not-for-profit association established by Sarah Fraser's family and friends, following the crash that killed her. Their mission is to advocate for road safety and to support those affected by road tragedies. In Sarah's case, a truck crashed into her vehicle (parked in a breakdown lane too narrow for her to move her car completely off the motorway). That crash killed her and the person who came to try to fix her car. The principles underpinning the work of SARAH are as follows:

1. *Each person's life is precious and can therefore never be ethically traded off against traffic mobility;*
2. *No person should be placed in*

harm's way simply because of poor policy, poor planning, poor maintenance or poor procedures; and

3. *Each of us must drive to actively protect other road users and especially those road users who find themselves vulnerable (e.g., those involved in an incident, those who assist and protect, cyclists and pedestrians!)*⁵

These principles are entirely consistent with Safe System principles. We need to turn up the volume for voices such as SARAH. Were road safety professionals to work more collaboratively in advocating for change, we would hear a chorus of demands in our rural – and urban – communities for increased and improved investments in road safety. In Australia and New Zealand, the Australasian College of Road Safety⁶ provides a voice of road safety researchers and practitioners. However, the voices of civil libertarians calling for higher speed limits and fewer speed cameras appears to be louder.

Conclusions

Despite all the technical knowledge we have amassed about road safety, Australian road authorities continue to treat safety – at best – as one of a number of competing corporate objectives. Instead of embracing the primacy of road safety, they carry out improvements to road safety only to the extent that budgetary allocations allow. We need to question the values that underpin those budgetary decisions. Until we begin to hear loudly voiced demands for making roads survivable, Australia will continue to fail to meet its Safe System objectives.

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⁵ See more information about SARAH at <http://www.sarahgroup.org/background/who-is-sarah/>

⁶ See more information about the Australasian College of Road Safety at <http://acrs.org.au>

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People Cities. The life and legacy of Jan Gehl

Annie Matan
Peter Newman

Island Press, Published 28.2.17, 978-1-61091-714-8, Hardback £30.00
192 pages, 150 photos, 20 illustrations

This is a book about how to organise our cities so that they are people-focussed and not designed to promote cars, lorries, noise, pollution and danger. The current paradigm is to organise around the nasty, dirty option (vehicles are far more important than people) and Jan Gehl has shown us exactly how to create high quality living environments around people and nature and encourage human scale activity in cities.

This is a delightful book. It straddles several important publishing categories and disciplines. It is an impressive "how to do it" manual for any professional involved in traffic and transport planning, architecture and urban design. It should be a compulsory learning manual (with a test) for any aspiring politician (councillor, Member of Parliament, assembly member at any level in any country). It should be interrogated for its lessons whenever a planning application for a new supermarket, retail centre, office block or housing development is under discussion. It should be compulsory for all those who have responsibility for bus stations and rail stations anywhere in the world and the routes to and from those hubs. It should be a public health manual, if public health still exists as a professional body, with a real interest in getting involved in the way people move around, walk, cycle or are just active in public space.

Jan Gehl has set a high standard for getting all these right and has produced books and consultancy reports to convert the general into the specific in Oslo, Odense, Stockholm, Perth, Melbourne, Copenhagen, Edinburgh, Aberdeen, London and many more locations.

The book is rather special in that it is about Jan Gehl and his impressive and distinctive contribution to the creation of "vibrant human-scale cities".

The book is a lively, optimistic and energetic celebration of Jan Gehl's contribution to creating better cities and promoting a calmer, healthier more civilised life.

It is for another book and another author to stray into the rather obvious question that has to be asked. Given the richness of Gehl's work and his very clear guidance on how to make things so much better, why are things so dreadful in so many places? My routine walking journeys in London are a pollution-soaked, traffic danger hell. Just try (or better still don't try) to walk down Euston Rd between Euston station and King's Cross past the British Library. Try walking down Gower St or Pentonville Rd or York Way. Try walking from Hereford railway station to the Cathedral and discover the delights of the nightmare junction that has to be crossed to enter the pedestrian area. Try walking any distance at all in Oldham with its brutal, dystopian highways and traffic sewers. Try walking on King St in Ludlow or on a pedestrian pavement that is not wide enough for two people to walk side-by-side in Church Stretton (Shropshire). Jan Gehl is a beacon of good design and this book does a magnificent job in making this glaringly obvious but decision-takers are well and truly stuck with no interest whatsoever in Gehl-world and a deep commitment to making things worse.

John Whitelegg