Discussion Paper

Cross Modal Safety Comparisons

Purpose

There has been a long standing interest among various transport safety organisations, researchers, other stakeholders and the public concerning the relative safety of various transport modes. Questions are often posed along the lines: on average, is travel in a light aircraft safer than a typical journey in a private car? or - what is the safety difference between motorcycle riding and driving a car ? Consideration of relative transport safety risks also has potentially important policy implications, particularly where contingent resource allocation or risk management decisions are involved. In an attempt to address the core substance of these questions this Discussion Paper explores some of the main issues associated with the development of comparative safety measures across various transport modes and compares the results available from Australian and other studies.

Overview

1 Comparisons of relative safety rates between different transport modes are difficult due to the paucity of, and cost associated with, collecting reliable underlying risk exposure statistics. Such exposure information is usually gathered as a result of surveys covering detailed travel patterns for individual people. Also, using a single safety risk measure such as fatalities per 100,000 population, can produce widely different and often misleading inter modal results.

2 While the number of fatalities recorded over time in each transport mode is readily available, there is very limited data on consistent risk exposure levels across modes. This lack of consistent risk exposure data leads to difficulties in making reliable comparisons. For example, accurate risk exposure for aviation is collected most reliably on an hours flown basis while for road travel, distance travelled is generally used.

3 Some safety risk exposure measures cannot be applied to all modes (eg, pedestrian activity and pedal cycling cannot be measured in terms of registered vehicles).

4 Nevertheless, comparisons have been made in this paper, drawing on the best available data. The results are considered to **be very broadly comparable**. The ATSB intends to update and augment this paper (eg to include marine and the results of comments on this paper) as future data becomes available.

5 These comparisons, summarised in table 1, find:

a. High capacity regular public transport (RPT) travel (airline travel) is the safest form of transport while general aviation is significantly less safe than car travel;

b. Bus and rail are the safest forms of land transport having very similar safety rates;

c. Motorcycling is the least safe form of transport.

Introduction

In order to compare the relative safety of different modes of transport the safety rates of each mode need to be expressed in common terms. While information on the numerator for such calculations, usually fatalities, is readily available, consistent and reliable risk exposure statistics are not. This is so largely because risk exposure data sources for different modes typically provide accurate records of activity in disparate terms. For example, the most accurately recorded measure of travel activity for road motor vehicles is vehicle kilometres while the most accurate measure for aviation is flight hours. An approach in this case is to convert aircraft hours flown to aircraft kilometres flown by converting hours to distance, so at least we can begin to compare road vehicles and aircraft on a distance travelled basis. Then there is the question of risk weighting per passenger. For example, how to get appropriate and accurate passenger risk data for a train and a bus per kilometre when the average bus may carry 20 to 30 passengers and the train several hundred?

Seven measures of exposure to risk have been identified as being relevant to most transport modes:
- vehicle kilometres travelled;
- passenger kilometres travelled;
- number of vehicle trips/departures;
- vehicle hours travelled;
- passenger hours travelled;
- number of registered vehicles; and
- passenger trips/departures.

Fatality rates per 100,000 population are often used as a measure of the accident rate of motor vehicle use. This simple population measure however does not fully take into account the risk of exposure. The exposure aspect can perhaps most clearly be seen when comparing a mode between countries. As an example, in 1996 Australia had a road fatality rate of 11 per 100,000 population and 2 per 10,000 motor vehicles. By contrast Tonga had a marginally better road fatality rate of 10 per 100,000 population but a much worse fatality rate per 10,000 motor vehicles of 52.[1] This illustrates that the use of a single measure may provide quite misleading results.

No single measure of travel risk exposure is considered ideal in all circumstances and it is possible that the best information is a comparison of the trends across various measures of exposure, perhaps on a weighted basis. Lack of data, however, often restricts the types of comparisons possible.

Available Data in Australia and overseas

Producing comparisons over several measures of exposure requires significant data collection. Appendix B examines the type and methods of data collection relevant to cross modal comparisons in Australia and some other countries.

Travel surveys are regularly conducted for the greater metropolitan areas of Sydney and Melbourne and it may be possible to combine and expand these to cover the entire Australian population to provide detailed safety exposure data. Such an expansion would be dependent on costs and funding.

[1] Jacobs, G, et al; 2000; *Estimating global road fatalities*; DFID; London.

Initial Attempts at cross modal safety comparisons for Australia

Tables 1-6 detail those cross modal safety comparisons which are possible with currently available data. (Tables 4 – 6 are in Appendix A)

Table 1 – Fatalities per passenger distance travelled – normalised to car occupant = 1.0

	1985/86 from Table 5	1993 from Table 6	Braithwaite 1960s[2]	Braithwaite 1988[3]	Dick Smith 1992[4]	UK[5] 1990-99
Air						
- High Capacity RPT	0.00	0.00	0.03	0.00	0.01	0.01
- Low Capacity RPT	0.00	0.33			0.22	
- General Aviation (fixed wing)	6.22	6.83	5.52	4.15	6.27	
Road						
- Car occupant	1.00	1.00	1.00	1.00	1.00	1.00
- Motorcycles	24.18	26.67	12.15	15.99	10.29	31.52
- Bus passengers	0.18	0.17	0.18	0.05		0.12
Rail						
- Passenger fatalities	0.23	0.17				0.15
- Pedestrians	15.36					18.79
- Cyclists	4.04					13.33

The most comprehensive inter-modal comparisons are presented in Table 1 which examines risk in relation to passenger distance travelled. In each case the safety rate has been stated as a ratio in comparison with car occupant safety, where car occupant safety is standardised to 1.0. Tram data is likely to be similar to bus and train. Ferry data is not available but is also expected to be similar to bus and train.

Table 4 in Appendix A provides the most detailed collection of comparisons of cross modal safety able to be produced for any time in the last 20 years and is based on the Day-To-Day Travel in Australia 1985–86 report[6], combined with aviation statistics for the same period. Table 5 is based on Table 4 but normalises all data by comparing it with the rate of fatalities of car occupants. Table 6 provides data for 1993 with notes on its assumptions.

Low Capacity RPT involves relatively low volume and low occurrences of fatal accidents and this means that one or two accidents can significantly affect the safety rating of such modes. During the period 1991-2000 charter flying accounted for 25.9% of GA flight hours and 22.2% of GA fatalities. Some parts of GA are particularly risky such as aerial agriculture involving mustering and spraying.

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[2] Braithwaite, G.R.; 2001; *Attitude or latitude?: Australian aviation safety*; Ashgate; p.140.
[3] op. cit.
[4] Smith, D.; April 1992; "Why not a safety rating?" *Aerospace*; p. 10.
[5] http://www.transtat.dtlr.gov.uk/tables/tsgb00/1/10600.htm
[6] Adena, M.A. & Montesin, H.J.; 1988; *Day to Day Travel in Australia 1985-86*; CR 69; Instat and FORS.

Tables 2 and 3 below set out the latest available comparable data for air and road modes.

Table 2 - Cross Modal Fatality rates (Fatalities per 1000 registered vehicles)- 1999[3]

Air	
- High Capacity RPT	0.0
- Low Capacity RPT [1]	1.1
- General Aviation (fixed wing)	3.6
- General Aviation (helicopters)	9.2
Road	
- Drivers	0.1
- Drivers and passengers	0.1
- Motorcycles	0.5
- All motorised vehicles	0.1
- Bus passengers [2]	0.2

(1) There are an average of 1.7 fatalities (1991-2000) per year in Low Capacity RPT. An average over a large period of time is required as Low Capacity RPT fatalities occur in this mode approximately once every three years.

(2) The number of bus passenger fatalities varies greatly from year to year. This figure is based on average fatalities 1990-1996 and the number of bus registrations in 1999 – the best available figures.

(3) Fatalities per 1000 registered vehicles is the most reliable figure for Australia, as both fatalities and vehicle registrations are recorded. There is no comparable data for rail, pedestrians, bicyclists as registered vehicles has no useful meaning for these modes. Marine data is not available at this time.

Table 3 - Cross Modal Fatality rates (fatalities per 100 million vehicle kilometres)- 1999

Air	
- High Capacity RPT	0.0
- Low Capacity RPT	1.6
- General Aviation (fixed wing) [1]	8.5
Road	
- Drivers	0.5
- Drivers and passengers	0.7
- Motorcycles	17.5
- All motorised vehicles	1.0
- Bus passengers [2]	0.7

(1) Deaths in fixed wing GA aircraft divided by hours flown multiplied by approximate average speed for each aircraft type.

(2) The number of bus passenger fatalities varies greatly from year to year. This figure is based on average fatalities 1990-1996 and the number of bus registrations in 1999 – the best available figures.

The main difficultly with fatalities per vehicle kilometre is that aircraft activity tend to be measured in flight hours rather than distance. The exception is that RPT revenue passenger kilometres are recorded. Use of this figure is difficult, however, because it does not include air crew or other non-paying passengers. An allowance for aircrew has been estimated.

Conclusions

Three comparisons based on passenger-based activities provide meaningful information that can be compared across all modes. These are passenger distance travelled; hours travelled; and number of trips. The value of each of these measures needs further consideration. As demonstrated by Table 1, most studies to date have focussed on passenger kilometres.

No deaths have been recorded for High Capacity airline travel in Australia since the 1960s and none involved jet aircraft and it will therefore remain the safest form of transport regardless of the exposure measure used, so long as no fatal accidents occur in this sector. Comparisons between other modes of transport may vary depending on the type of journey to be made. On the basis of number of trips (column 7 of Table 4) it would appear that there is no difference in the safety of pedestrians and car passengers. However on the basis of distance travelled, the safety of car passengers is much higher than that of pedestrians. This suggests that walking over a short distance is safer but that the greater the distance the greater the risk. Such an analysis ignores other factors such as the proportion of pedestrians killed who are under the influence of alcohol (estimated to be in the order of 45%)[7] which distort the risks faced by non-intoxicated pedestrians.

This discussion paper concludes that in the absence of regularly conducted detailed travel surveys, it is difficult to compare the relative safety of various modes of transport. These difficulties notwithstanding, trends across safety indicators suggest certain modes of transport are clearly more dangerous, for example, motorbikes. The other **key finding of the paper is the significant degree of consistency shown in Table 1 among the results of Australian researchers**. Table 1 also suggests that the relative safety of different modes of transport in Australia is broadly in line with the UK. The exception is that cycling in Australia appears significantly safer than in the UK. This may reflect the lower kilometres travelled for bicycles and all modes of land transport, other than rail, per person in the UK.[8] A comparison based on a different measure such as fatalities per trip may provide a more accurate picture of safety. The large number of factors which will affect the safety of any one journey cannot be accounted for without the sort of detail which can only be collected with a higher error rate. Factors outside the physical safety of the journey which can be expected to influence decisions about travel include time and cost (financial, environmental and social).

The ATSB would be grateful to receive[9] additional data and technical suggestions that could be incorporated in future versions of this discussion paper. The Bureau intends to update and augment the paper as further data becomes available.

[7] FORS Monograph 14, 1997, *Alcohol and Pedestrian Fatalities*.
[8] Based on UK http://www.transtat.dtlr.gov.uk/tables/tsgb01/1/10401.htm & figures from Day-to-Day Travel in Australia 1985-86 CR 69.
[9] Comments can be emailed to stats@atsb.gov.au or sent to the Team leader, Safety Statistics, ATSB, PO Box 967, Civic Square ACT 2608.

Appendix A

Table 4 - Cross Modal Fatality Rate Comparisons 1985/86

		Fatality Rates						
		1	2	3	4	5	6	7
Air		(G)	(F)	(E)	(D)&(E)	(E)&(F)	(E)	(E)&(F)
- High Capacity RPT		0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Low Capacity RPT		0.00	0.00	0.00	0.00	0.00	0.00	0.00
- General Aviation (fixed wing)		13.45	6.53	15.37	2.75	1.34	6.49	7.46
- General Aviation (helicopters)				13.02	3.44	1.67	14.95	6.32
Road		(B)	(A)	(H)	(H)	(A)	(B)	(A)
- Car drivers (I)		0.98	0.99	0.10	0.33	0.33	0.13	0.10
- Car passengers		0.66	1.15			0.44	0.09	0.17
- All car occupants		1.64	1.05			0.37	0.22	0.12
- Motorcycles		17.75	25.38	2.74	8.84	8.84	1.15	2.74
- All motorised vehicles		2.08	1.54			0.53	0.33	0.19
- Bus passengers (J)		1.26	0.19			0.04	0.86	0.02
Rail								
- Passenger fatalities			0.24			0.07		0.04
- All Rail fatalities			0.93			0.28		0.15
Pedestrians			16.12			0.68		0.17
Cyclists		4.24	4.24	0.10	2.82	0.42		0.10

1. fatalities/100 million vehicle kilometres
2. fatalities/100 million passenger kilometres
3. fatalities/million vehicles trips
4. fatalities/100,000 vehicle hours travelled
5. fatalities/million passenger hours
6. fatalities/1000 registered vehicles
7. fatalities/million passenger trips

Note: no figures recorded for the 0-8 age groups in the travel survey (A). In 85/86 this age group accounted for approximately 7% of the population meaning an error of up to 7% is expected in the non-aviation statistics.
(A) Adena, M.A. & Montesin, H.J.; 1988; *Day to Day Travel in Australia 1985-86*; CR 69; Instat and FORS.
(B) ABS SMVU 1988
(C) Road Fatalities Australia: 2000 Statistical Summary except Rail fatalities which comes from an unpublished ATSB report using ABS data
(D) Air fatalities from BASI Survey of Accidents to Australian Civil Aircraft 1990
(E) Air Transport Statistics SURVEY OF HOURS FLOWN 1986
(F) Estimate of 2.06 for GA occupants based on the number of occupants in accidents 1991-1999
(G) Estimate of 204.6 km/h for GA aircraft including 10% adjustment for take off and landings. Based on 1999 figures but only accurate to an order of magnitude.
(H) By definition, driver-hours and trips must be equal to vehicle hours and trips. Similarly or within an allowable error for motorbikes, pedestrians and cyclists. Pedestrian & Cyclist vehicle km same presumption. Similarly fatalities for all car occupants/vehicle trips or vehicle hours can be estimated on the basis of driver trips and hours.
(I) Car includes station wagons, utilities and panel vans.
(J) The available data does not allow for the separation of passengers from all bus fatalities for 1985/86. Thus the average proportion of passenger fatalities for the period 1989 to 1997 (36.6%) was used to estimate the passenger deaths for 1985/86 (total deaths 99, average 49.5, estimated passenger deaths per annum 18.12).

Table 5 – Fatality Rate Comparisons - 1985-86 data normalised to car occupants = 1

		Fatality Rates						
		1	2	3	4	5	6	7
Air		(G)	(F)	(E)	(D)&(E)	(E)&(F)	(E)	(E)&(F)
- High Capacity RPT		0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Low Capacity RPT		0.00	0.00	0.00	0.00	0.00	0.00	0.00
- General Aviation (fixed wing)		8.21	6.22	97.85	5.15	3.63	29.80	60.10
- General Aviation (helicopters)				82.90	6.45	4.54	68.63	50.92
Road		(B)	(A)	(H)	(H)	(A)	(B)	(A)
- Car drivers (I)		0.60	0.94	0.67	0.62	0.90	0.60	0.84
- Car passengers		0.40	1.09			1.19	0.40	1.37
- All car occupants		1.00	1.00	1.00	1.00	1.00	1.00	1.00
- Motorcycles		10.84	24.18	17.45	16.55	24.03	5.26	22.08
- All motorised vehicles		1.27	1.47			1.45	1.51	1.53
- Bus passengers (J)		0.77	0.18			0.11	3.96	0.17
Rail								
- Passenger fatalities			0.23			0.19		0.31
- All Rail fatalities			0.89			0.75		1.20
Pedestrians			15.36			1.85		1.35
Cyclists		2.59	4.04	0.66	5.27	1.14		0.84

All notes as per Table 4.

Table 6 - Cross Modal Fatality rates (Fatalities per 100 million passenger kilometres) – 1993

Air	
- High Capacity RPT	0.0
- Low Capacity RPT (1)	0.2
- General Aviation (fixed wing)	4.1
Road	
- Private cars (2)	0.6
- Bus occupants	0.1
- Motorcyclists (3)	16.0
Rail	
- Passengers	0.1

(1) Low Capacity RPT fatalities are based on an average of two for the nine years 1992-2000 (inclusive). Estimate total passengers = 1.15 * Revenue passengers.
(2) This figure is an over estimate in that the source data includes fatalities of occupants of motor vehicles other than cars.
(3) Motorcycle rider numbers estimated at 1.1 per vehicle on basis of fatal and serious accident data. Based on data for 1999.

Fatalities per passenger kilometre may provide the best cross modal comparison in terms of exposure. However there is considerable difficulty in obtaining reliable, accurate and well documented statistics on which to base such a comparison.

The publication *OECD in Figures,* published 2000, included figures for Australia in 1993 for passenger transport of billion passenger kilometres for rail, bus and car travel. Fatalities per 100 million passenger kilometres for 1993 can be derived from this data. However, the source of the OECD figures is unknown and an analysis of the OECD data combined with the km travelled by passenger car from the SMVU (1995 figures) gives a vehicle occupancy rate of 1.75. By comparison, Austroads Performance Indicators gives a figure of 1.25-1.30.

With regard to aviation, the accuracy of the GA fatalities per 100 million vehicle kilometres is such that the change in activity between 1993 and 1999 is less than the error factor. Thus 1999 figures can be used as a point of comparison. There is no accurate data for the average number of occupants of a GA trip. To provide an estimate, the number of occupants in aircraft involved in reported accidents for the years 1997 – 2001 inclusive was used to estimate the average number of occupants on any given GA trip. In this period 2020 people were on 979 GA aircraft involved in accidents giving an average occupant number of 2.06.

The average number of railway deaths per annum is estimated at 40. Three quarters of these are pedestrians and the remaining quarter are passengers. Under the *International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision (ICD-10), published by the World Health Organization accidents involving trains and motor vehicles are classified as motor vehicle accidents. The number of railway deaths is based on an ATSB draft working paper. Passengers include unauthorised persons such as "train surfers".

Appendix B
Current approaches to making cross modal safety comparisons in Australia and overseas.

In Australia the ATSB compiles data on fatalities for all modes of transport, the ABS surveys motor vehicle registrations and kilometres travelled, CASA records aircraft registrations and the AvStats unit in the Bureau of Transport and Regional Economics of the Department of Transport and Regional Services records flight hours. From this information reliable and consistent data is only available for fatalities per registered vehicle which is of little relevance for trains, bicycles and pedestrians. Estimates must to be made for any other exposure method (see below for two examples).

Two major travel surveys are conducted in Australia each year. The NSW Dept of Transport has conducted the Household Travel Survey (HTS) of the Greater Sydney Metropolitan Region (GSMR) since 1997. This survey covers all forms of transport, car, public transport, bicycle and walking. In Victoria the RMIT has conducted the Victorian Activity and Travel Survey (VATS) since 1994. VATS aims to provide information on personal travel and out of home activity in the metropolitan statistical district.

The most comprehensive travel survey of land transport to have been conducted Australia wide was the *Day-To-Day Travel In Australia 1985-86* survey prepared by Instat for FORS, a precursor of what is now part of the ATSB.

A search of the Internet identified a number of localised travel surveys such as: *1992 Southeast Queensland Household Travel Survey* and *1998 City of South Perth Travel Survey*.

The European Conference of Ministers of Transport (ECMT) releases data on tonne-kilometres of freight transport across rail, road, inland waterways and pipelines and passenger kilometres of passenger transport across rail, private cars and buses. This is based on data supplied by the member countries.

The UK has a National Travel Survey. This survey depends on travel diaries for 9000 households recording trips of more than 50 yards. The UK uses this information to publish passenger casualty rates by mode: 1990-1999 (Per billion passenger kilometres) (http://www.transtat.dtlr.gov.uk/tables/tsgb01/1/10601.htm). The UK Department of Transport, Local Government and Regions uses a number of other methods of comparison (http://www.local-transport.dtlr.gov.uk/transsaf/transsaf.htm). Despite this source of detailed data, air is only examined for passenger kilometres of revenue passengers on "world passenger carrying services of UK airlines for craft over 2,300 kilograms." (Accordingly, no GA figures are provided.)

The US Bureau of Transport Statistics (BTS) has a number of projects relevant to cross modal safety comparison. The BTS Transportation Safety Data Initiative (SDI) (http://www.bts.gov/sdi/) aims to improve their transport safety data and one of the Research Projects (#3) of the SDI is to "Develop common denominators for safety measures." The BTS also conducts the American Travel Survey and The National Household Travel Survey which have the potential to generate all the data required for meaningful cross modal comparisons.