Imperial College London

Relationships between fatalities and usage of level crossings in Great Britain

Andrew Evans

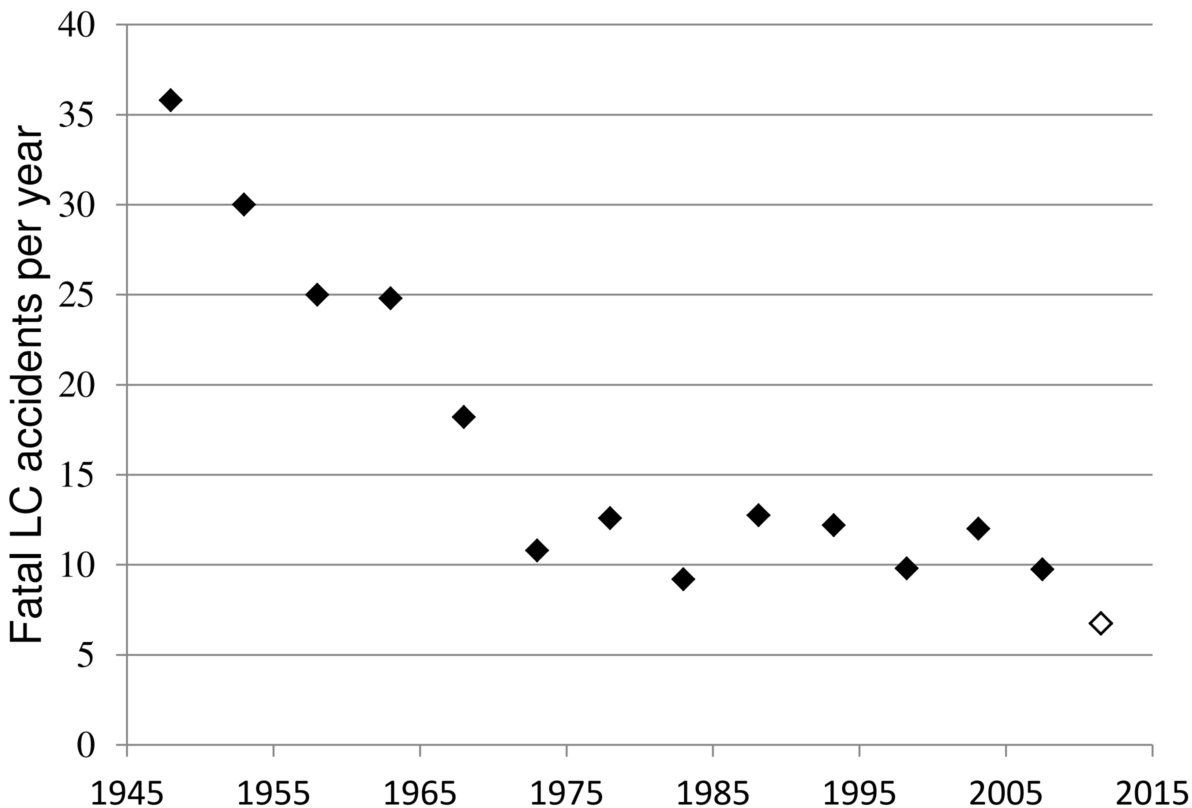
GLXS 2014, University of Illinois, Urbana-Champaign,
3-8 August 2014

Outline

- A little background
- LC types; LC users; LC traverses; LC fatalities
- Data, ratios and risks
- How much is owed to the retention of railway-controlled crossings in Britain?
- How do LCs affect the fatality risks of typical car and walk journeys?
- Conclusions

A little background

Figure 1: Fatal level crossing accidents per year: Great Britain 1946-2013



Long-term trend in fatal LC accidents

- Figure 1 (previous slide) shows fatal LC accidents per year in ~5-year intervals in 1946-2013
  - Accidents fell from about 35 per year in 1946-50 to about 11 per year in 1975
  - Then remained flat for 35 years at about 11 per year until 2009
  - Latest accident frequencies for 2010-2013 show a statistically significant reduction on flat period
- Despite non-improvement in 1975-2009, GB has one of the best LC safety performances
  - about 0.02 fatalities per million train-km compared with an EU average of about 0.08

Notable points about LCs in Great Britain

- GB has fewer LCs per 100 route-km than EU average (41 vs 52)
- GB makes widespread use of “railway-controlled” LCs, operated by railway staff and interlocked with the signals
  - According to information from the ERA, this type is little used elsewhere in Europe, apart from Ireland
- GB has a higher proportion of passive LCs than EU average (76% vs 51%)
- GB has a higher proportion of fatalities who are pedestrians than EU average (70% vs 40%)

LC types; LC users; LC traverses; LC fatalities

Level crossing types

- Primary classification of LCs is three-way:
  - Railway-controlled (already mentioned) (12%)
  - Automatic, with active warning or protection operated by approaching trains, but not interlocked with signals (12%)
  - Passive, with no indication of approaching trains (76%)
- All railway-controlled LCs are used by both vehicles and pedestrians
- Automatic and passive LCs are further subdivided into those open to both vehicles and pedestrians, and those open to pedestrians only (footpath crossings)
- This makes a 5-way classification of LCs

Level crossing users

- This presentation is concerned only with the road-side users of LCs
  - Train occupants are also important but not the subject here
- Road users of LCs are classified into:
  - Pedestrians and cyclists (taken together)
  - Occupants of road vehicles (ORVs)
- People on stations who have left trains or who intend to board trains are counted as pedestrians

Level crossing traverses

- A “traverse” is a single crossing of an LC by a road user. There are pedestrian-traverses and ORV-traverses
- Network Rail (NR) periodically carries out counts of pedestrian-traverses and vehicle-traverses at all LCs. Main purpose is as input to LC risk models
- NR includes results in a public LC database. (I warmly acknowledge this initiative)
- I have converted vehicle-traverses to ORV-traverses by multiplying by 1.56 (average vehicle occupancy)
- Some counts are inaccurate, but are assumed reasonable overall

Level crossing fatalities

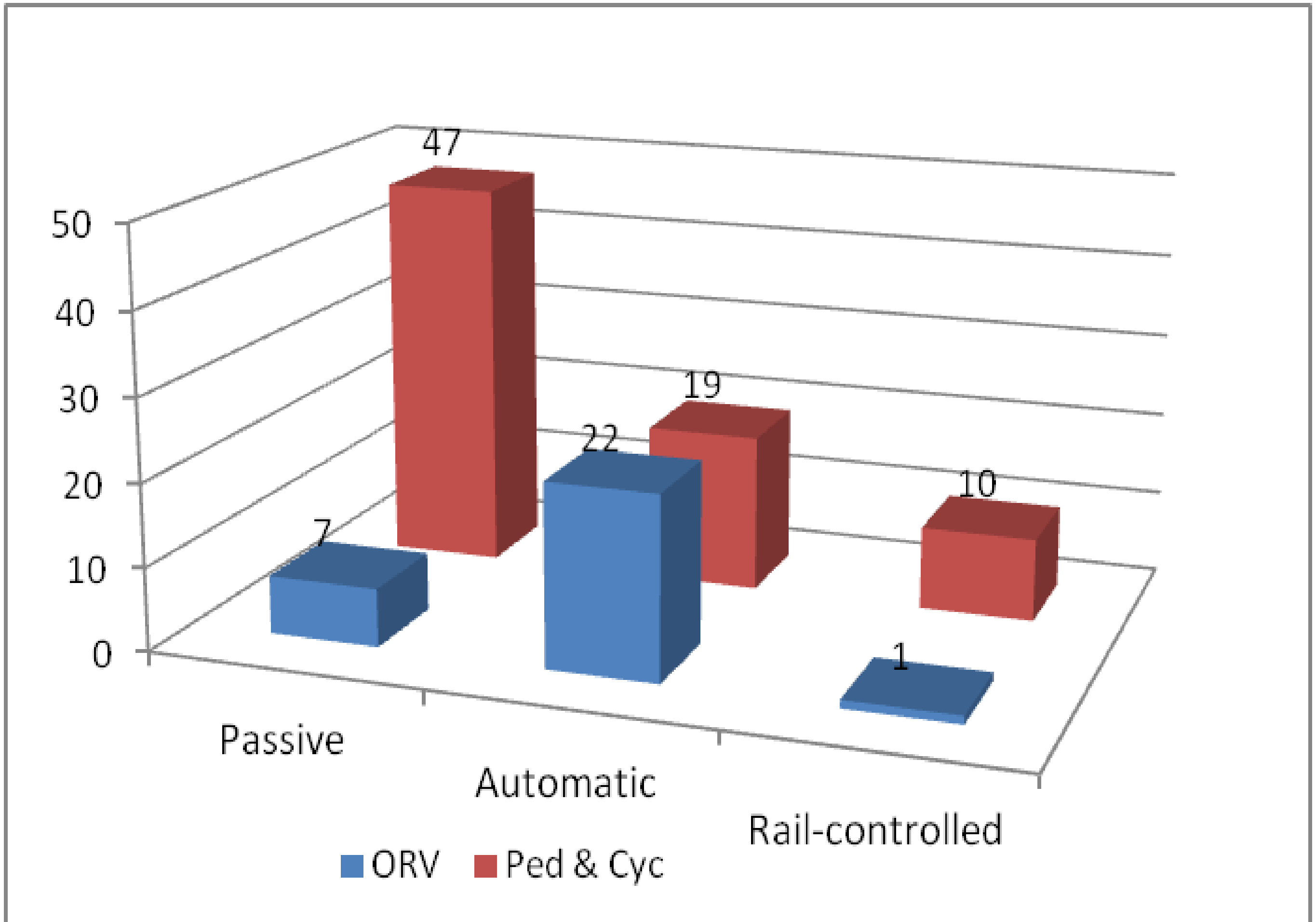
- The measure of harm to road users at LCs is taken to be fatalities
- These are here measured by the observed fatalities in the 11 years 2003-2013
- Train occupant fatalities are excluded because the focus here is on road users

Data, ratios and risks

Table 1: fatalities to road users at LCs: 2003-2013

Crossing Type	*Ped/Cyc Fatalities*	*ORV Fatalities*	*All Fatalities*
Rail controlled	10	1	11
Automatic			
Veh & Foot	14	22	36
Footpath only	5		5
All	19	22	41
Passive			
Veh & Foot	13	7	20
Footpath only	34		34
All	47	7	54
All crossings	76	30	106

Fig 2: Road user fatalities at level crossings: Great Britain national system: 2003-2013



Level crossing fatalities

- Table 1 and Figure 2 (above) give actual fatalities in the 11 years 2003-2013
- The total of fatalities is 106, or 9.9 per year
  - In addition to the 106 road user fatalities, there were 6 train occupant fatalities in 2004. These are excluded because of the focus here on road users
- The numbers are (fortunately) small. So there is substantial statistical uncertainty
- Of the 106 fatalities, 72% were pedestrians and 28% ORVs. 10% were at railway-controlled LCs, 39% were at automatics; 51% at passives.

Table 2: Crossings and traverses (000s per day)

Crossing Type	*No of Crossings*	*Ped/Cyc Traverses*	*ORV Traverses*	*All Traverses*
Rail controlled	798	490	3671	4161
Automatic				
Veh & Foot	704	74	1593	1667
Footpath only	93	8	0	8
All	797	83	1593	1676
Passive				
Veh & Foot	2345	7	25	32
Footpath only	2805	84	0	84
All	5150	92	25	117
All crossings	6745	665	5289	5954

Imperial College London

Figure 3: LC traverses per day by road users: Great Britain national system: 2013

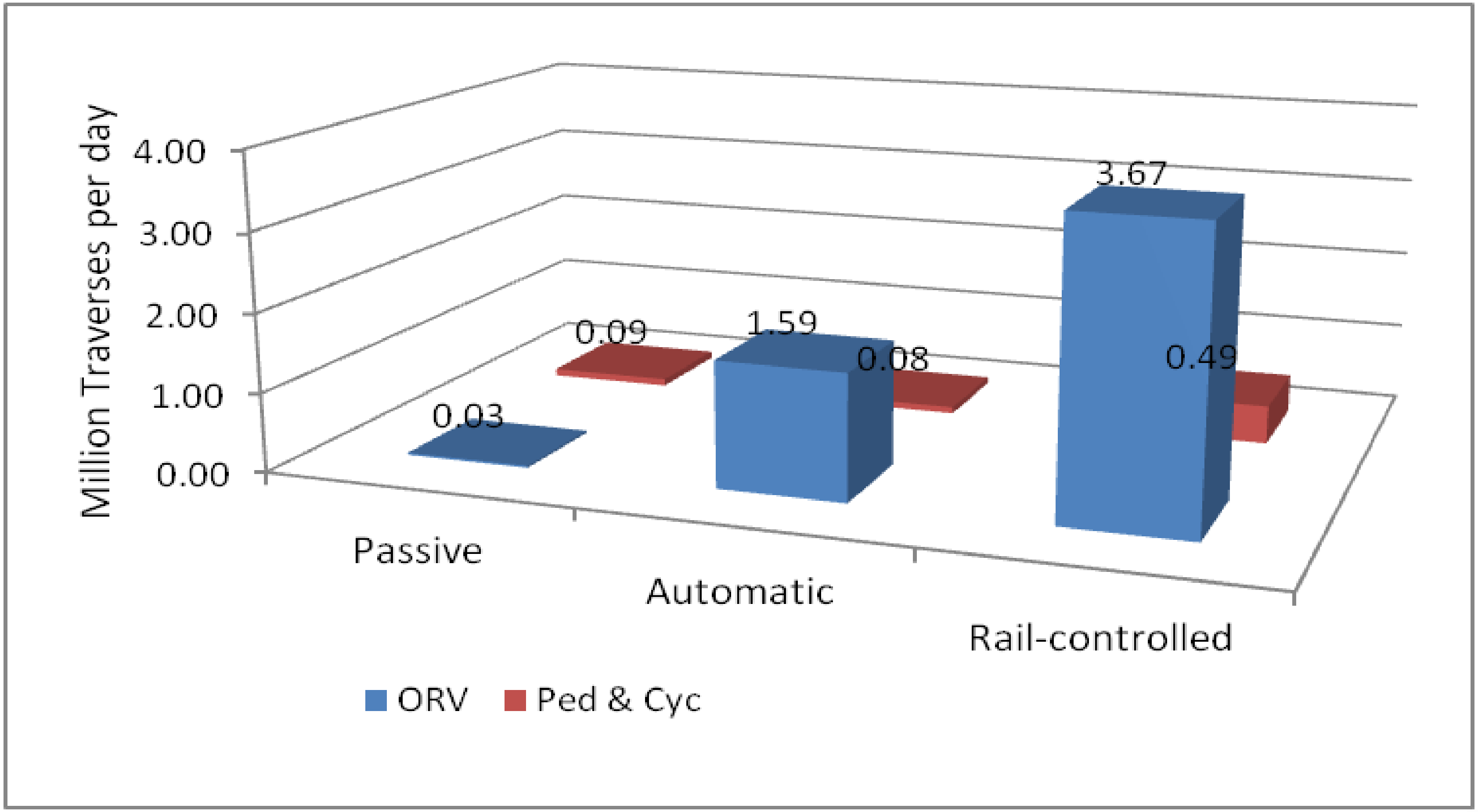


Table 3: Distribution of crossings and traverses

Crossing Type	*Crossings*	*Ped/Cyc Traverses*	*ORV Traverses*	*All Traverses*
Rail controlled	11.8%	73.8%	69.4%	69.9%
Automatic				
Veh & Foot	10.4%	11.2%	30.1%	28.0%
Footpath only	1.4%	1.3%		0.1%
All	11.8%	12.4%	30.1%	28.1%
Passive				
Veh & Foot	34.8%	1.1%	0.5%	0.5%
Footpath only	41.6%	12.7%		1.4%
All	76.4%	13.8%	0.5%	2.0%
All crossings	100.0%	100.0%	100.0%	100.0%

Crossings and traverses (1)

- Tables 2 and 3 and Fig 3 (above) give the numbers and distributions of crossings and traverses
- Some notable results:
  - There are about eight times as many ORV as pedestrian traverses
  - 70% of all traverses are at railway-controlled crossings; 28% at automatics and only 2% at passives
  - Pedestrians are the main users of passive crossings, accounting for 78% of traverses. Most footpath crossings are passive
  - Only 0.5% of ORV traverses are at passive crossings

Table 4: Traverses per crossing per day

Crossing Type	*No of Crossings*	*Ped/Cyc Traverses*	*ORV Traverses*	*All Traverses*
Rail controlled	798	615	4600	5215
Automatic				
Veh & Foot	704	105	2263	2368
Footpath only	93	91		91
All	797	104	1999	2103
Passive				
Veh & Foot	2345	3	11	14
Footpath only	2805	30		30
All	5150	18	5	23
All crossings	6745	99	784	883

Imperial College London

Crossings and traverses (2)

- Table 4 (above) divides the numbers of traverses by the numbers of crossings to give the mean numbers of traverses per day by each type of user at each type of crossing
  - The table shows that rail-controlled crossings are the busiest, with some 5,200 traverses per day
  - Next are the automatics with some 2,100 traverses per day
  - Least used are the passives with an average of only 23 traverses per day, of which 18 are pedestrians and 5 are ORVs
- The usage of individual crossings may be very different from these averages

Table 5: Distribution of pedestrian traverses per day at passive crossings

Pedestrians per day	Number of crossings	% of traverses in group
“Infrequent”	3069	1.7%
1 to 9	1329	5.7%
10 to 29	279	6.3%
30 to 99	225	15.4%
100 to 299	190	34.1%
300 to 999	52	28.3%
1000 to 2999	6	8.5%
3000 or more	0	0.0%
All	5150	100.0%

Pedestrian traverses at passive crossings

- Table 5 (above) shows the distribution of the numbers of pedestrian traverses at the 5150 passive crossings
  - The table shows that about 4,400, or 85%, of passive crossings have fewer than 10 pedestrian traverses per day. These account for only 7.4% of pedestrian traverses
  - At the other end of the scale, 248 crossings, or 4.8% of the total have 100 or more pedestrian traverses per day, and these account for 71% of pedestrian traverses
- Therefore a small proportion of passive crossings account for the majority of pedestrian usage

Table 6: Distributions between crossing types

Crossing Type	*Percent of Crossings*	*Percent of Traverses*	*Percent of Fatalities*
Rail controlled	11.8%	69.9%	10.4%
Automatic			
Veh & Foot	10.4%	28.0%	34.0%
Footpath only	1.4%	0.1%	4.7%
All	11.8%	28.1%	38.7%
Passive			
Veh & Foot	34.8%	0.5%	18.9%
Footpath only	41.6%	1.4%	32.1%
All	76.4%	2.0%	50.9%
All crossings	100.0%	100.0%	100.0%

Distributions between crossing types

- Table 6 (above) summarises the distributions of crossings, traverses and fatalities between crossing types
- The distributions are very different.
  - Railway controlled crossings account for 70% of the traverses but only 10% of the fatalities
  - Passive crossings account for only 2% of the traverses but 51% of the fatalities
- There are also large differences between pedestrians and ORVs
- Therefore we can expect large differences between fatalities per traverse. These are shown in Table 7 (below)

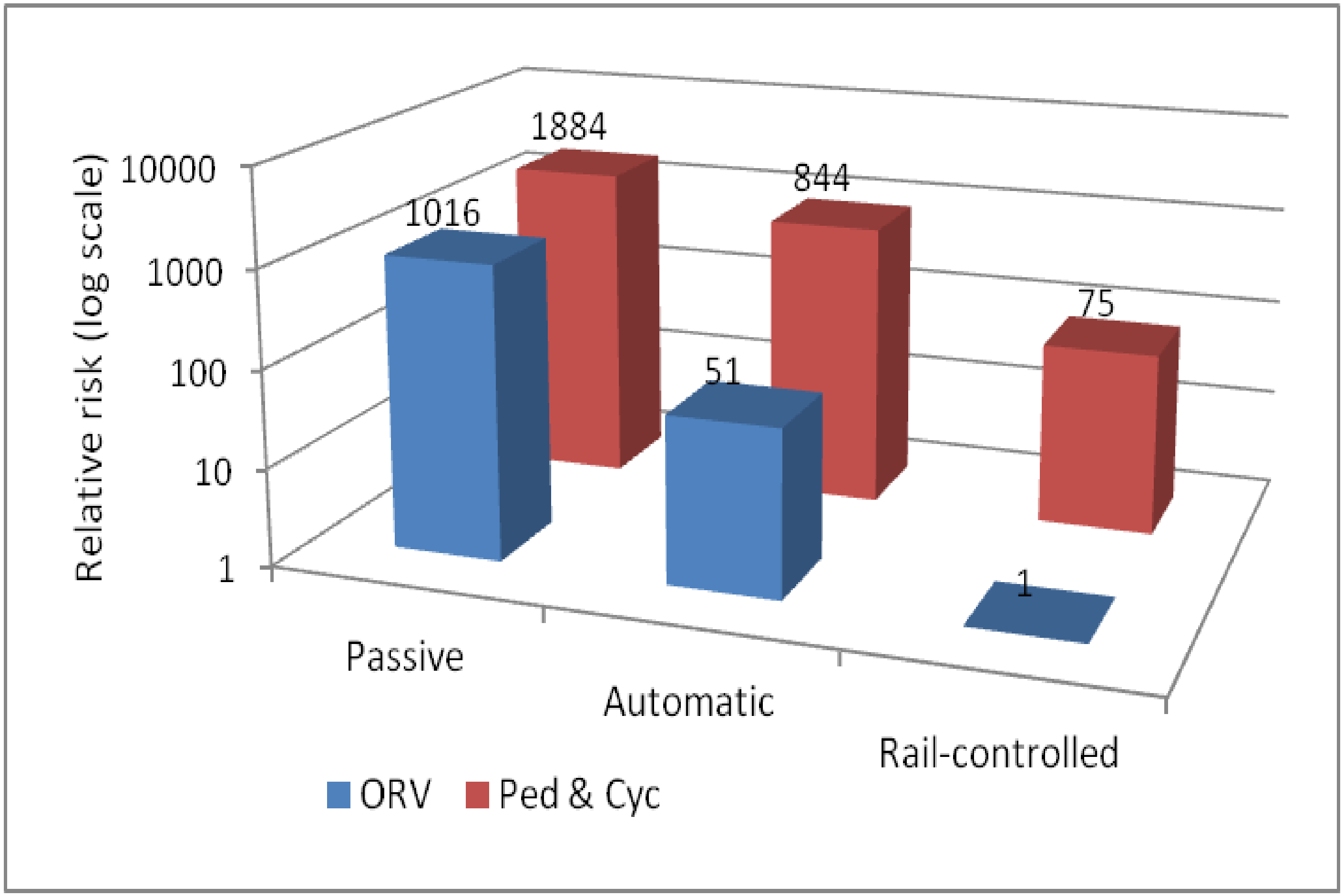
Table 7: Fatalities to road users per billion traverses

Crossing Type	*Ped/Cyc Fatalities*	*ORV Fatalities*	*All Fatalities*
Rail controlled	5.1	0.1	0.7
Automatic			
Veh & Foot	47.0	3.4	5.4
Footpath only	147.4		174.4
All	57.3	3.4	6.1
Passive			
Veh & Foot	451.4	69.0	153.5
Footpath only	100.3		100.3
All	127.8	69.0	115.1
All crossings	28.5	1.4	4.4

Fatalities per billion traverses

- Table 7 estimates the risks to road users at LCs by dividing the numbers of fatalities in Table 1 by the numbers of traverses in Table 2
- The bottom line shows that the risk per traverse to pedestrians is about 20 times greater than the risk to ORVs (28.5 vs 1.4)
- Cross-cutting this, railway-controlled crossings are about one order of magnitude safer than automatic crossings
- In turn, automatic crossings are about one order of magnitude safer than passives
- Thus there are about three orders of magnitude between the safest (ORVs at rail-controlled) and the riskiest (pedestrians at passives) traverses

Figure 4: Relative fatality risk per traverse (Rail-controlled ORV traverse = 1)



Relative fatalities per traverse

- Figure 4 (above) shows relative fatalities per traverse, with the lowest risk (ORVs at rail-controlled crossings set to 1 and the risk of other traverses measured relative to this.
- Note the logarithmic scale

How much is owed to the retention of railway-controlled crossings?

Railway-controlled crossings

- Britain appears to be unusual in Europe in retaining a large number of railway-controlled LCs
- Most other countries have switched to automatics
- We can estimate how many fatalities might occur in Britain if automatics replaced rail-controlled LCs by assuming:
  - The same numbers of traverses would be made
  - The fatality rates for automatics would apply to what are now rail-controlled
- This would raise fatalities from about 10 to about 22 per year.
- GB would still be among the good European performers

How do LCs affect the fatality risks of typical car and walk journeys?

Level crossing risk in the context of road risk

- It is desirable to place level crossing risk in the context of road risk – but difficult to do
- The most frequent method is to estimate LC fatalities as a proportion of road fatalities – typically about 1% – but this seems to miss the point
- Better to have something reflecting the user's viewpoint

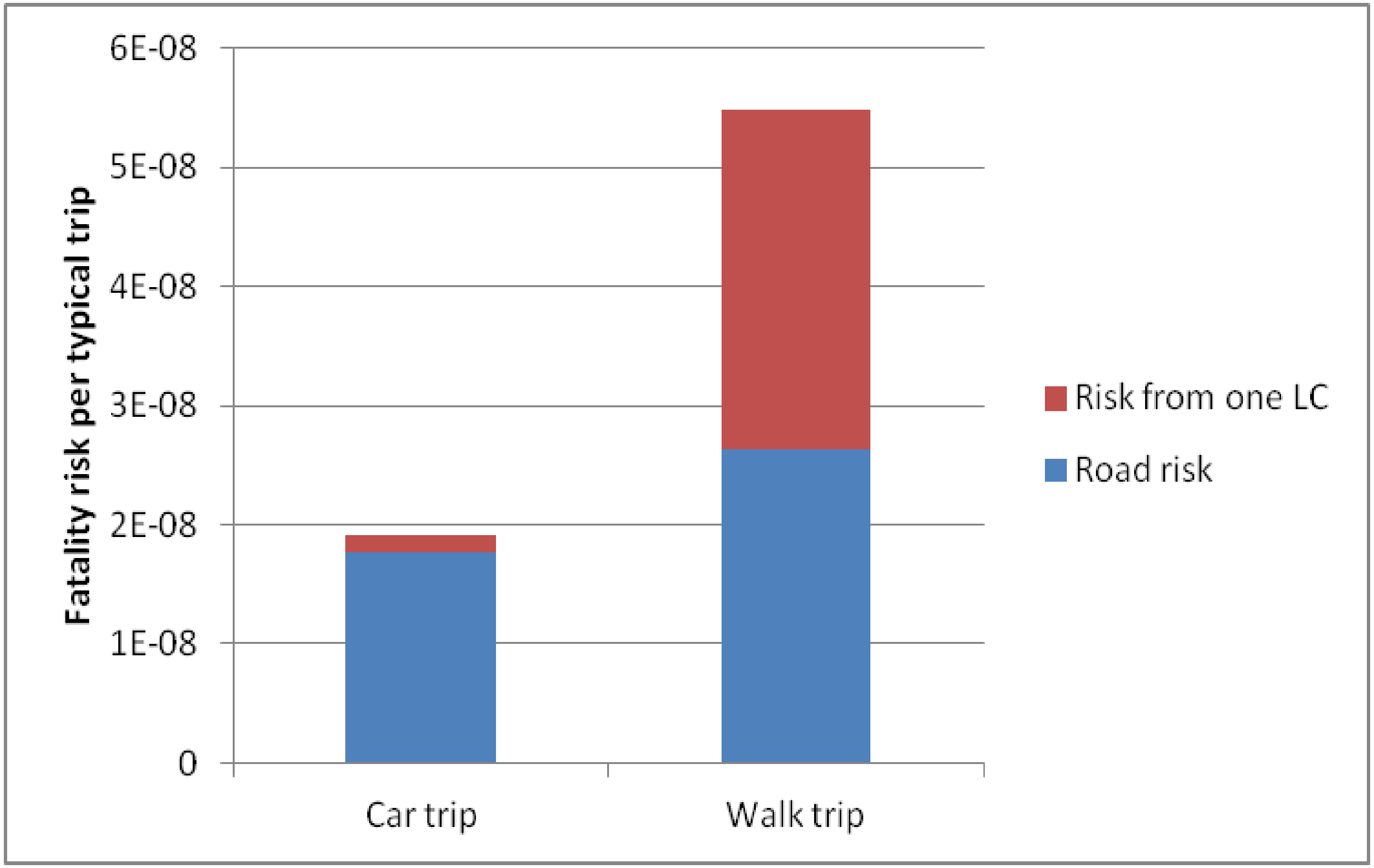
Level crossing risk in the context of road risk

- Here is a suggestion
  - (1) Start by considering an average car journey (length 13.6 km) or an average walk journey (length 1.15 km) without a level crossing
  - (2) Estimate the ordinary road risk for such journeys
  - (3) Now suppose that the journeys involve traversing one level crossing. Calculate the additional risk
  - (4) Compare the additional risk with the road risk
- The calculations are outlined in Table 8

Table 8: Additional risk from presence of one level crossing on typical car or walk trip

	Car	Walk
Average road trip length: km	13.61	1.146
Road fatalities per 10^9 person-km	1.3	23
Road fatalities per single trip	$1.77*10^{-8}$	$2.64*10^{-8}$
LC fatalities per year 2003-2013	2.72	6.91
LC person-traverses per year (10^8)	19.31	2.43
LC fatalities per person-traverse	$0.14*10^{-8}$	$2.85*10^{-8}$
LC fatality risk as percent of road fatality risk per trip	8%	108%

Figure 5: Fatality risk of typical car and walk trips with one level crossing



Imperial College London

Level crossing risk in the context of road risk

- The conclusion is that the presence of the LC adds 8% to the risks of the car journey, but doubles the risk of the walk journey.
- However, because walk journeys are shorter, they are less likely to include an LC
- However, the additional risk for the walk journey would be higher if the LC were assumed to be a footpath crossing

Conclusions

Conclusions: fatalities per traverse

- The fatality risk per traverse to pedestrians and cyclists is about 20 times greater than that to ORVs
- Cross-cutting this, the relative orders of magnitude of fatalities per traverse at railway-controlled: automatic: passive crossings are roughly 1:10:100.
- That makes three orders of magnitude between the safest traverses (ORVs at railway-controlled crossings) and the least safe (pedestrians at passives)

Conclusions: railway-controlled crossings

- Railway-controlled crossings present a paradox
- On one hand, their safe operation depends on correct judgements and actions by staff
  - Therefore they are vulnerable to human error to some degree
- On the other hand, they have the best safety record, and make a major contribution to GB's good performance
- As railway operation becomes more centralised, it will be a challenge to replace them to match their current performance
- Not clear how widespread this type of crossing is internationally: little used elsewhere in Europe

Conclusions: passive crossings

- Most users of passive crossings are pedestrians
- Passive crossings present the highest risk per traverse among crossing types
- Passive crossings are numerous, but the majority see little use
- On the other hand, a small minority see substantial use
- It seems correct to focus improvement efforts on these

Thank you

a.evans@imperial.ac.uk
www.imperial.ac.uk/cts