OPUS

The Impact Of Adaptive Road Lighting On Road Safety

Bill Frith, Opus Research,
and Mike Jackett, Jackett Consulting

Road lighting for safety

- Road lighting is primarily a safety measure.
  - As stated by Austroads in 2004,
    - "Road authorities are primarily concerned with road lighting for its crash reducing potential, with any improved road utilisation or level of service being a secondary benefit."
- This is in accord with the Safe System Approach to road safety now adopted throughout Australia and New Zealand.
  - The ultimate goal of the safe system approach is a road system free of serious injury and death

But how effective a safety measure is road lighting?

- The literature generally associates improved road lighting with crash reduction (~30% reduction)
- In reports of before and after studies the prior and post levels of lighting are seldom stated.
- Under a Safe System Approach it is important to optimise the safety benefits of lighting in the context of our overall repertoire of road safety measures
- We now know how safety in urban New Zealand varies with the level of lighting

Adaptive lighting installations are those where lighting levels may be varied over time

- Adaptive lighting has been used , on a small scale, in a few places for a long time.
- This is because with legacy technologies it was difficult and expensive to change the lighting levels
- This has all changed since the advent of LED lighting.

Adaptive LED lighting has many advantages

- LED luminaires use much less energy than legacy technologies
- The light is much better directed, resulting in less light pollution
- Their light can be easily reduced or increased using computer controlled technology
- Hardware prices are dropping and are expected to continue to do so

The advent of LED road lighting has made adaptive lighting much more accessible

Normal lighting

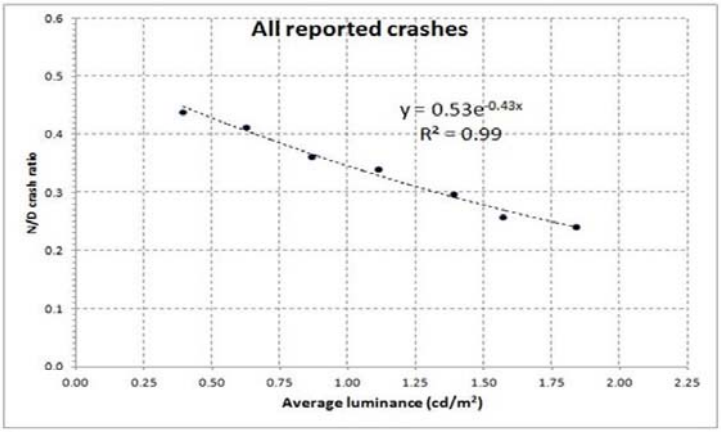
- is designed to a chosen subcategory of lighting according to national or local codes of practice
- stays unchanged during the period of darkness.

Adaptive lighting is appropriate

- where there is a need to vary the level of lighting at different times; for example off-peak, during better weather or worse weather, times when there are more or fewer crashes,
- when there are more vulnerable road users around or when there is more ambient light.
- An example is the adaptive lighting used around Eden Park at the rugby world cup

Here a higher or lower level of lighting can be selected from the range of subcategories available in National Standards.

In general any decrease in lighting levels can be expected to decrease safety and vice versa



http://www.sciencedirect.com/science/article/pii/S0386111212000325

This is very important with the arrival of adaptive LED lighting

- We now have in our grasp the ability to vary lighting levels virtually at will
- This ability, as with all new technology will become more affordable
- To move towards a safe system, we need to know the safety impact of the changes we are considering, whether they involve dimming or brightening road lighting
- Lighting decisions need to be made alongside with other safety measures so that overall system safety continues to increase, but with best use of the road safety dollar
- Safety should be considered in all road lighting decisions.

Adaptive LED Lighting

Decision making on how to use adaptive lighting varies internationally

- Decisions tend to be based on traffic volumes and perceived energy savings
- Decisions tend to be arbitrary, based on little hard evidence, and safety is often not explicitly or implicitly taken into account.
- None of the approaches found internationally have provision for the direct inclusion of crash information in the choice of lighting level
- Most only allow dimming rather than dimming and brightening
- New Zealand is fortunate that our road lighting standard allows for safety implicitly and also has flexibility to move to a higher as well as lower level of lighting as appropriate.

Normal lighting levels used in New Zealand at present

- Lighting for road safety purposes is classified into four sub categories V1, V2, V3 and V4.
- Its use on roads may be guided by the traffic volume
  - V1 corresponds to an average luminance of 1.5 cd/m^2,
  - V2 to an average luminance of 1.0 cd/m^2,
  - V3 to an average luminance of 0.75 cd/m^2
  - V4 to an average luminance of 0.5 cd/m^2
- The 2013 Auckland Transport guidelines for street lighting indicate that generally :
  - V1 is used on streets with daily volumes greater than 20000 vehicles,
  - V2 for 15000 to 20000
  - V3 for 5000 to 15000
  - V4 for 3500 to 5000.

Other Councils' guidelines may vary from these.

We now know how lighting level impacts on crash risk

We can use this knowledge to estimate:

- Potential savings from utilising a higher and lower lighting level; and,
- Comparative savings if targeting lighting levels by crash risk compared to traffic volume

This concept was piloted in a case study using historical crash and flow data from the North Shore of Auckland

Traffic volume criteria and safety

- Crash rates per hour vary during the night.
- Notwithstanding lower traffic volumes, they still exceed weekly median levels in the small hours of Saturday and Sunday mornings
- This is related to the presence of high risk drivers who may be fatigued and or intoxicated
- It would appear sensible to use this risk information when setting adaptive lighting levels.

Risks per hour at "night-time"

Hour	Mon/Tue	Tue/Wed	Wed/Thu	Thu/Fri	Fri/Sat	Sat/Sun	Sun/Mon
6-7pm	2.4	2.9	3.3	4.0	4.7	2.5	2.3
7-8pm	1.8	1.8	1.7	2.3	2.1	1.4	1.7
8-9pm	0.9	1.4	1.8	1.8	2.2	1.8	1.8
9-10pm	1.1	0.98	1.8	1.6	2.7	1.9	0.9
10-11pm	0.7	0.9	1.7	1.5	1.9	1.5	0.9
11-12pm	0.6	0.7	0.9	1.3	1.6	2.0	0.6
12-1am	0.6	0.5	0.5	0.98	1.3	1.6	0.3
1-2am	0.3	0.4	0.7	0.6	1.8	1.9	0.2
2-3am	0.2	0.4	0.4	0.7	1.1	1.7	0.5
3-4am	0.5	0.3	0.2	0.6	1.0	1.4	0.4
4-5am	0.3	0.2	0.3	0.6	0.9	1.0	0.1
5-6am	0.5	0.6	0.8	0.5	0.7	1.3	0.4

Number of crashes per hour normalised such that the median cell is set to 1.0

Targeting lighting to risk

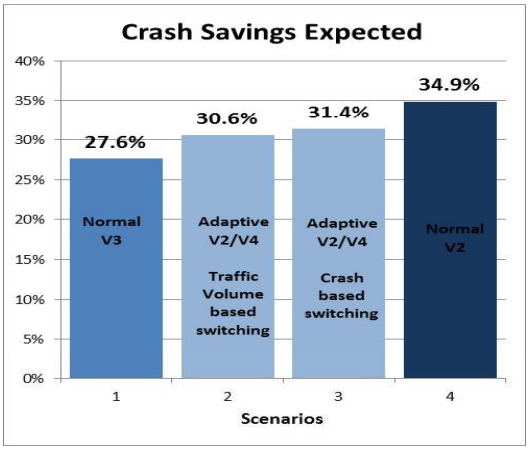
If a lighting installation can be varied to deliver more light at the periods with high crash numbers and less light at the periods with low crash numbers, then safety can be maximised for a given total nightly lumen output.

We tested 4 scenarios:

1. A single V2 level of lighting provided throughout the night.
2. A single V3 level of lighting provided throughout the night. This represents the norm for much State Highway lighting in NZ.
3. A V3 level is provided for 50% of the time and dimmed to V4 for the remainder. The high level is applied at the times with most crashes. This option lowers energy use while minimising the adverse effect on safety.
4. A V2 level is provided for 50% of the time and dimmed to V4 for the remainder. The high level is applied at the times with most crashes. This option uses the same energy as option 2 but achieves greater road safety savings.

Savings quoted are relative to having no lighting at all.

Results (compared to no lighting)



- The decision on lighting levels would involve consideration of the overall mix of road safety measures
- This is only a rough illustration- extra safety achieved by targeting to risk will differ with the situation.

Discussion

- Traffic volume works as a reasonable surrogate for crash frequency, except in some specific high risk times at the weekend and approaching the weekend.
- A case study found that without increasing energy output an increase in crash savings of some 14 % over V3 lighting could be achieved with a simple two step adaptive lighting scheme (one level above, one level below normal) targeting light levels according to traffic crash data.
- A smaller figure (11%) is applicable if light levels are targeted according to traffic volume data.
- The ready availability of detailed traffic volume data at most road lighting sites could provide a useful first step in selecting periods for high and low level lighting.
- This could then be supplemented by information on high risk times, using information similar to that in the crash frequency matrices used in the case study

Conclusions

- Adaptive road lighting, within a safe system context, can fine-tune our lighting conditions so that safety and environment benefits can be simultaneously realised at more optimal cost.
- As a simple guide urban arterial network lighting should be at higher levels during the dark periods from dusk Friday evening through to sunrise Sunday morning
- As more sophisticated adaptive technology becomes available, weather related changes in lighting could be incorporated, giving greater light to those times when weather is bad
- Guidelines to aid decisions on raising /lowering the level of lighting using adaptive LED technology would be helpful to practitioners

Acknowledgement

- The NZTA provided the funding for this work