Lighting and Safety

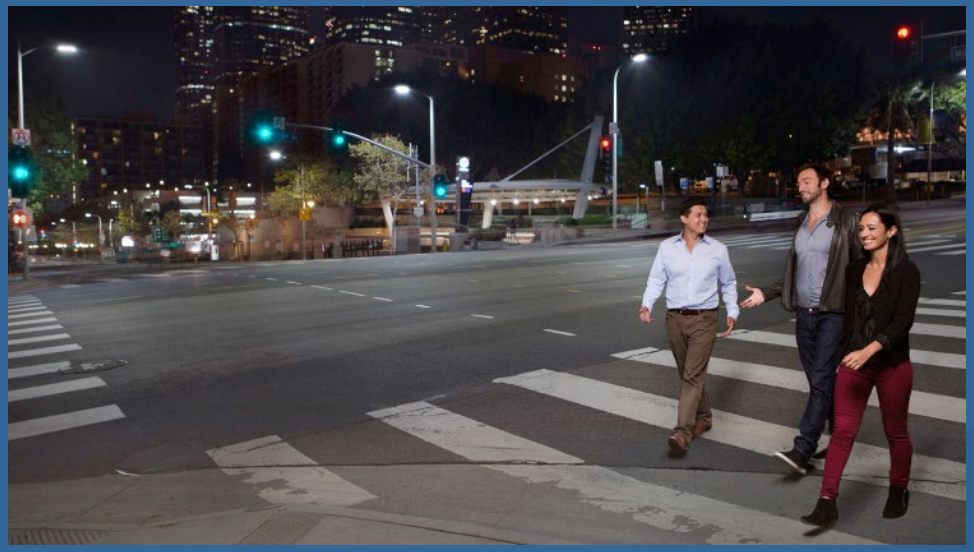
Don McLean – DMD and Associates Ltd

Introduction

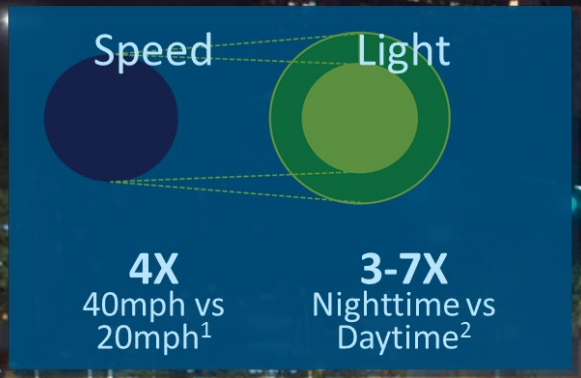
- Gap (or disconnect) exists between traffic safety engineers and those designing street lighting.
- Many safety oriented reports and studies simply define ***"improved lighting"*** in general as one of many safety improvements.
- Can the way we design lighting improve safety? ***Vision Zero***
- Will focus on three areas related pedestrians and cyclists:
  - Crosswalks
  - Bike lanes
  - Security

Why Light - General Info

- Reduces glare effects from oncoming vehicle headlamps
- Improves visibility for drivers
- Improves visibility for pedestrians and cyclists
- Provides a level of comfort and feeling of security



Lighting and Safety



Total Fatalities and Pedestrian Fatalities in Traffic Crashes, 2007–2016

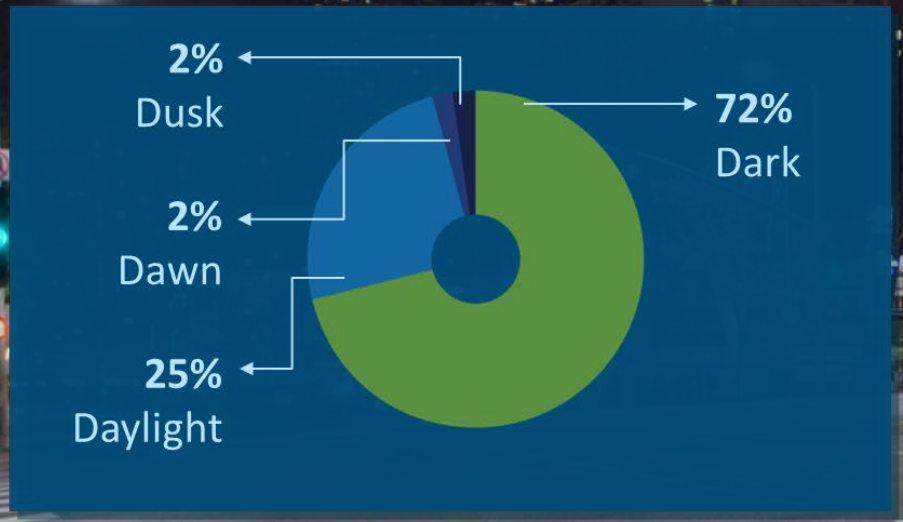
Year	Total Fatalities	Pedestrian Fatalities	Percentage of Total Fatalities
2007	41,259	4,699	11%
2008	37,423	4,414	12%
2009	33,883	4,109	12%
2010	32,999	4,302	13%
2011	32,479	4,457	14%
2012	33,782	4,818	14%
2013	32,893	4,779	15%
2014	32,744	4,910	15%
2015	35,485	5,495	15%
2016	37,461	5,987	16%

Source: Fatality Analysis Reporting System (FARS) 2007–2015 Final File, 2016 Annual Report File (ARF).

Lack of lighting is one of the primary factors of pedestrian fatalities

University of Michigan's Transportation Research Institute suggests pedestrians are from 3X to 6.8X more vulnerable at night than in the daylight[1]

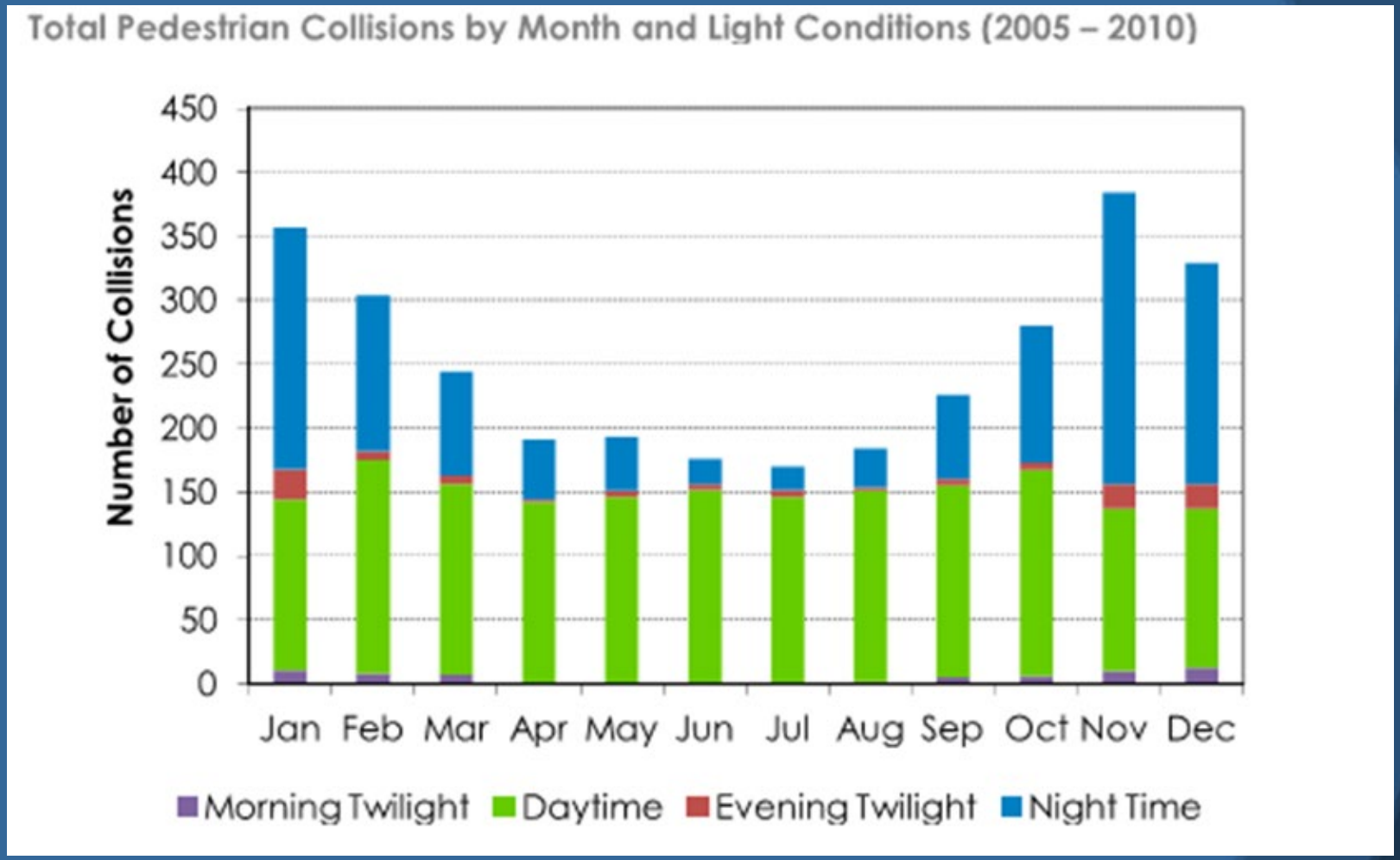
Lighting and Safety



Nearly 3 out of 4 pedestrian fatalities occur at night.

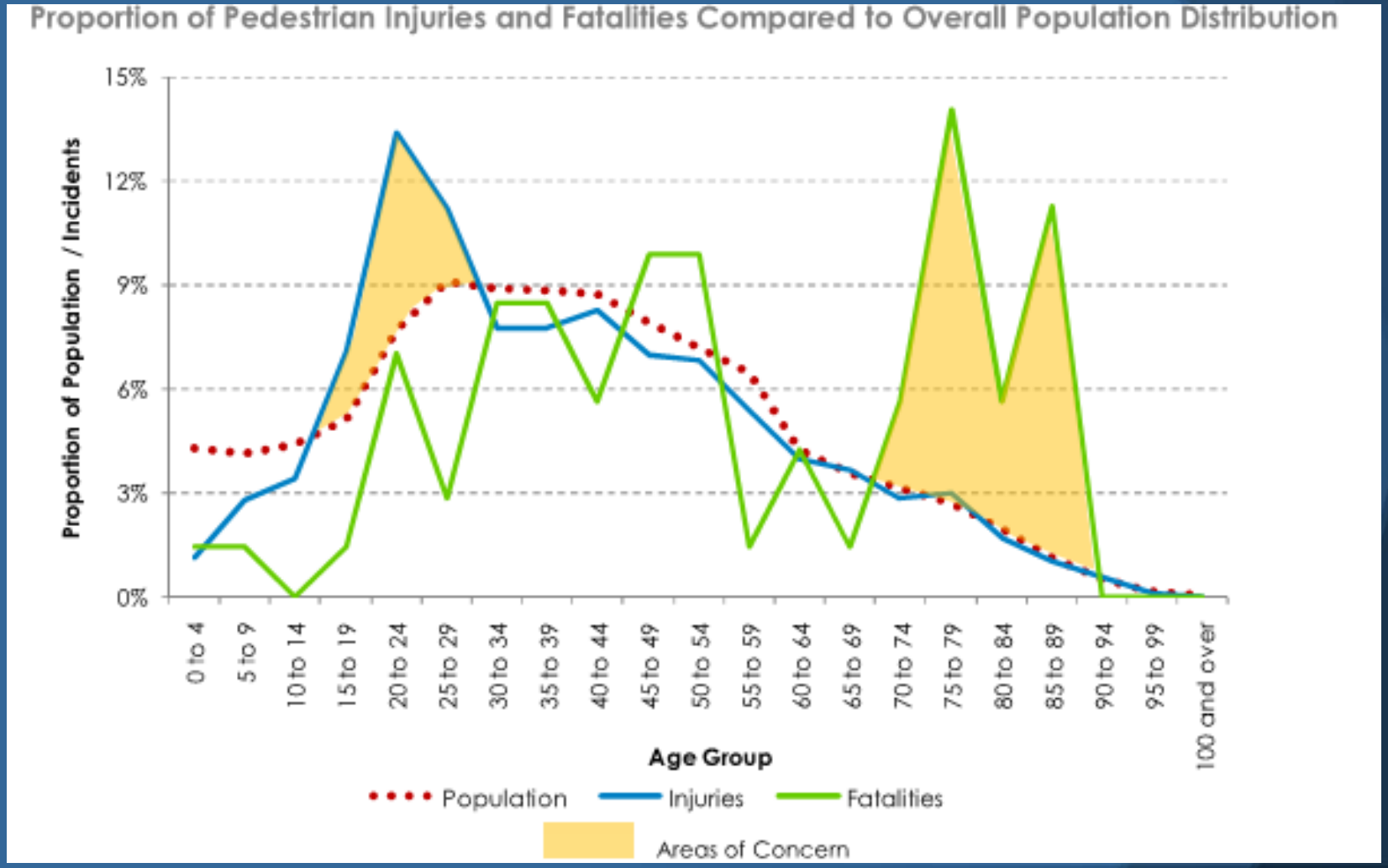
New York Department of Transportation, 2014

Pedestrian Collision – Seasonal Factors



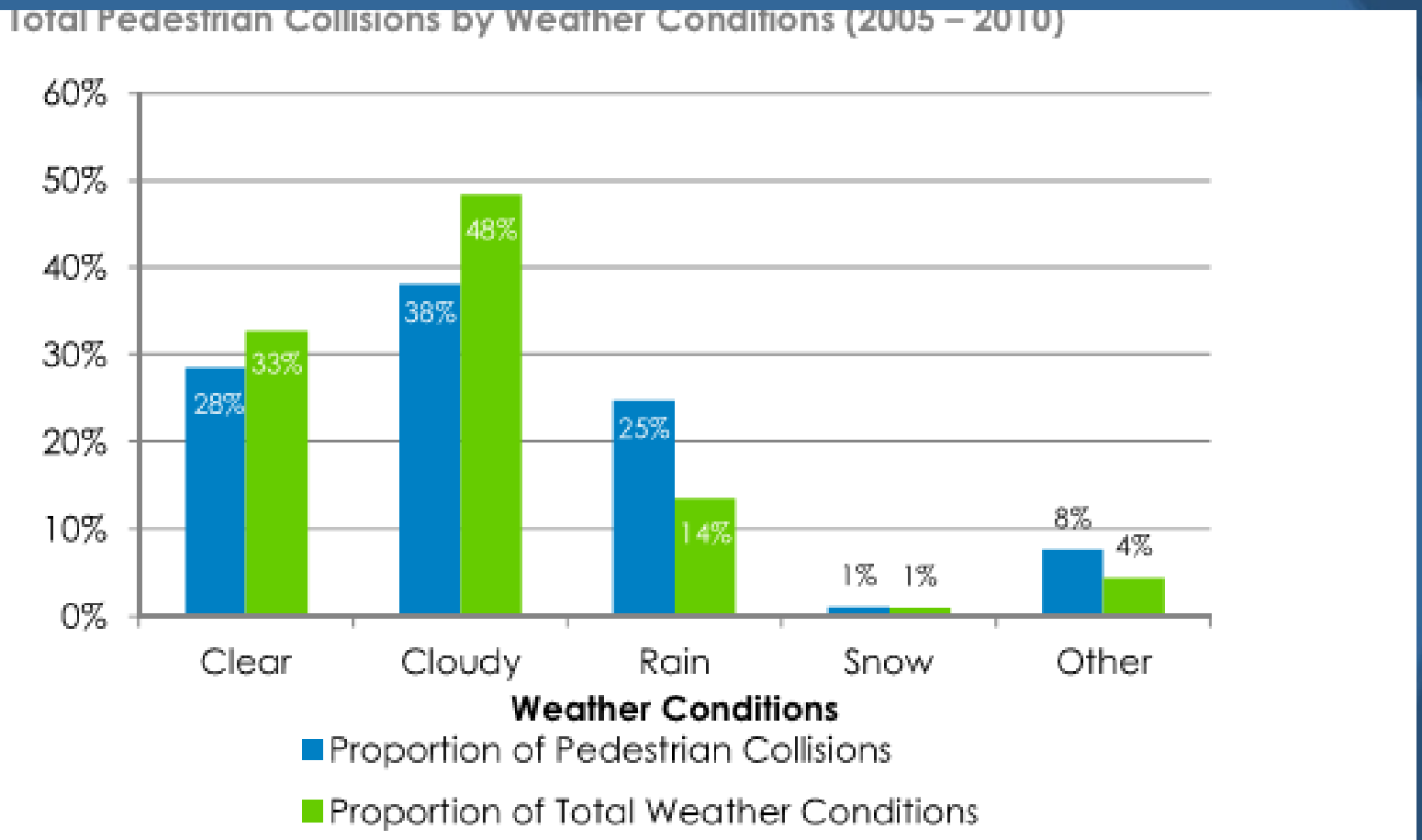
City of Vancouver Pedestrian Safety Study - 2012

Pedestrian Collisions - Age Factors



City of Vancouver Pedestrian Safety Study - 2012

Pedestrian Collisions – Weather Factors



Note: 'Other' represents a combination of weather conditions

Pedestrian Collisions – Speed Factors

Table 1: AASHTO Stopping Sight Distance (Wet Pavement)							
Stopping Sight Distance M (Ft) by Percent Grade (%)							
		Downgrade			Upgrade		
Traffic Speed km/h (mph)	0	3	6	9	3	6	9
35 (20)	35 (115)	35 (116)	40 (120)	40 (126)	35 (109)	35 (107)	35 (104)
40 (25)	50 (155)	50 (158)	50 (165)	55 (173)	45 (147)	45 (143)	45 (140)
50 (30)	60 (200)	65 (205)	65 (215)	70 (227)	60 (200)	60 (184)	55 (179)
60 (35)	80 (250)	80 (257)	85 (271)	90 (287)	75 (237)	70 (229)	70 (222)
65 (40)	95 (305)	95 (315)	100 (333)	110 (354)	90 (289)	85 (278)	80 (269)
75 (45)	110 (360)	115 (378)	120 (400)	130 (427)	105 (344)	100 (331)	100 (320)
80 (50)	130 (425)	135 (446)	145 (474)	155 (507)	125 (405)	120 (388)	115 (375)
90 (55)	150 (495)	160 (520)	170 (553)	180 (593)	145 (469)	140 (450)	135 (433)
100 (60)	175 (570)	185 (598)	195 (638)	210 (686)	165 (538)	160 (515)	150 (495)
105 (65)	200 (645)	210 (682)	220 (728)	240 (785)	190 (612)	180 (584)	170 (561)
115 (70)	225 (730)	235 (771)	250 (825)	275 (891)	210 (690)	200 (658)	195 (631)
120 (75)	250 (920)	265 (866)	285 (927)	305 (1003)	235 (772)	225 (736)	215 (704)

Source: A Policy on Geometric Design of Streets & Highways, AASHTO, Washington DC, 2004. Chapter 3 Elements of Design.

The speed and distance columns only correspond to their metric or English equivalent, i.e., if determining the SSSD for a posted speed in kilometer per hour (km/h), use the value shown in m, if using miles per hour (mph), use the value shown for ft.

Human Factors (AGE)

- % of older drivers is increasing. We are living longer!
- 20/20 vision can be reduced to 20/40 at night.
- Contrast sensitivity is reduced with age.
- Older drivers are more susceptible to glare
- Glaucoma can reduce peripheral vision.

Impacts on Eye as We Age – Lens

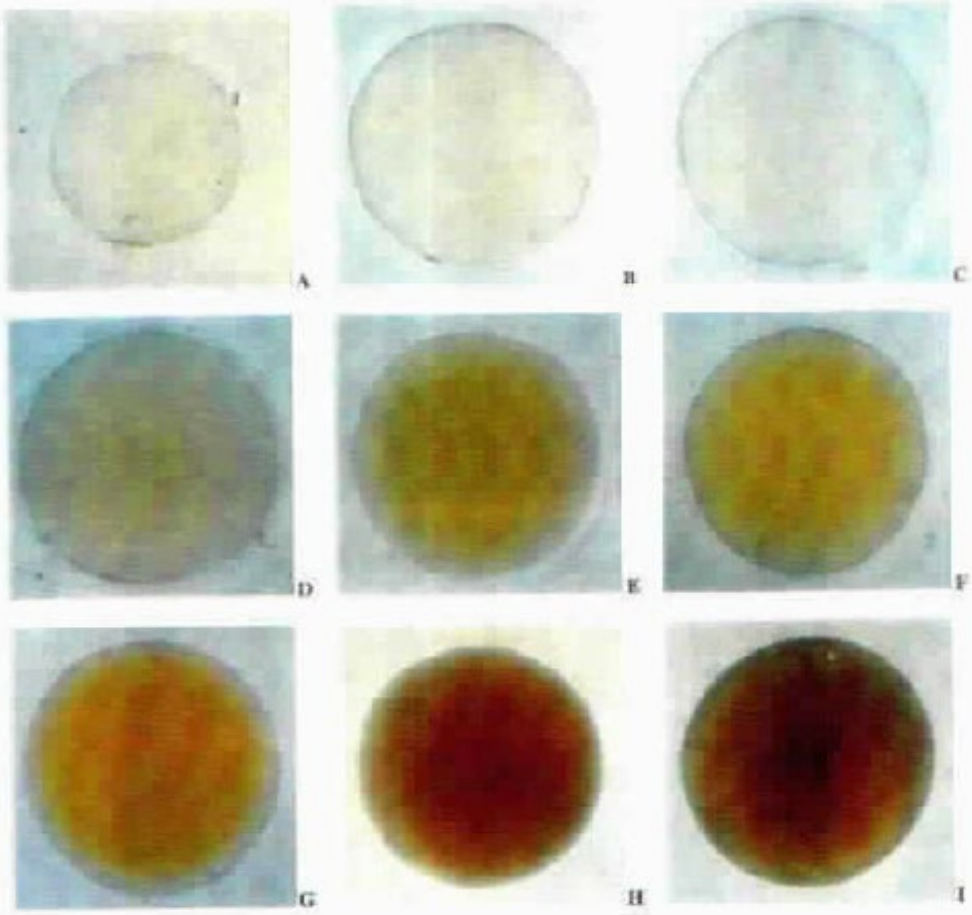
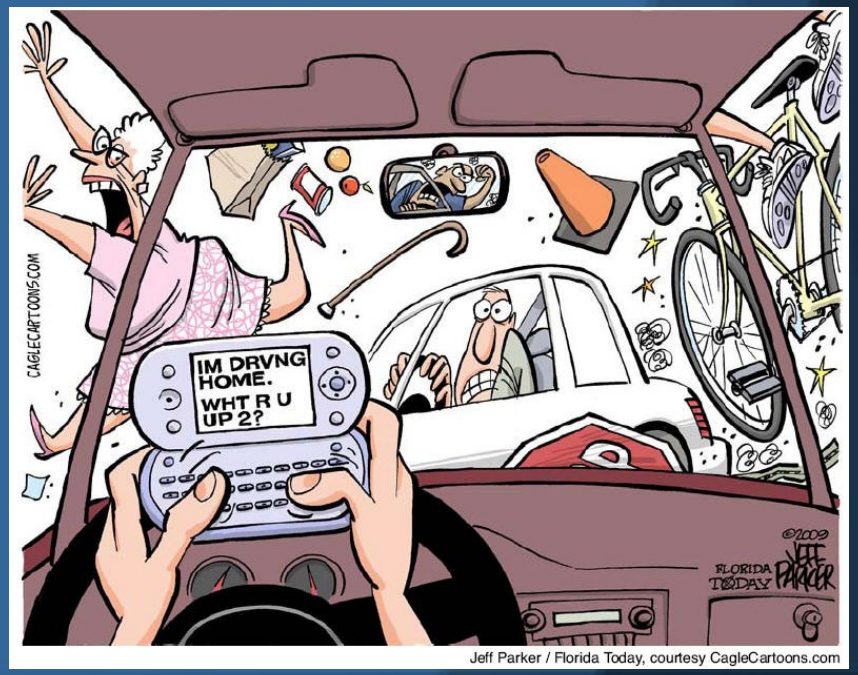


Fig. 3 Yellowing and transparency of the Human Lens from 6 month (A) to 8 years (B), 12 years (C), 25 years (D), 47 years (E), 60 years (F), 70 years (G), 82 years (H) and 91 years (I) of age.

Good news is lens can be replaced

Other Factors

- DATA - Distractions to Pedestrian and Drivers (phones, headphones, LED video display advertising signs).
- TECHNOLOGY – Collision avoidance systems, autonomous vehicles, headlights, etc.
- Climate change
- Stress and fatigue
- Impairments (drugs, alcohol)



Jeff Parker / Florida Today, courtesy CagleCartoons.com

Visibility - Contrast

We need contrast to see objects

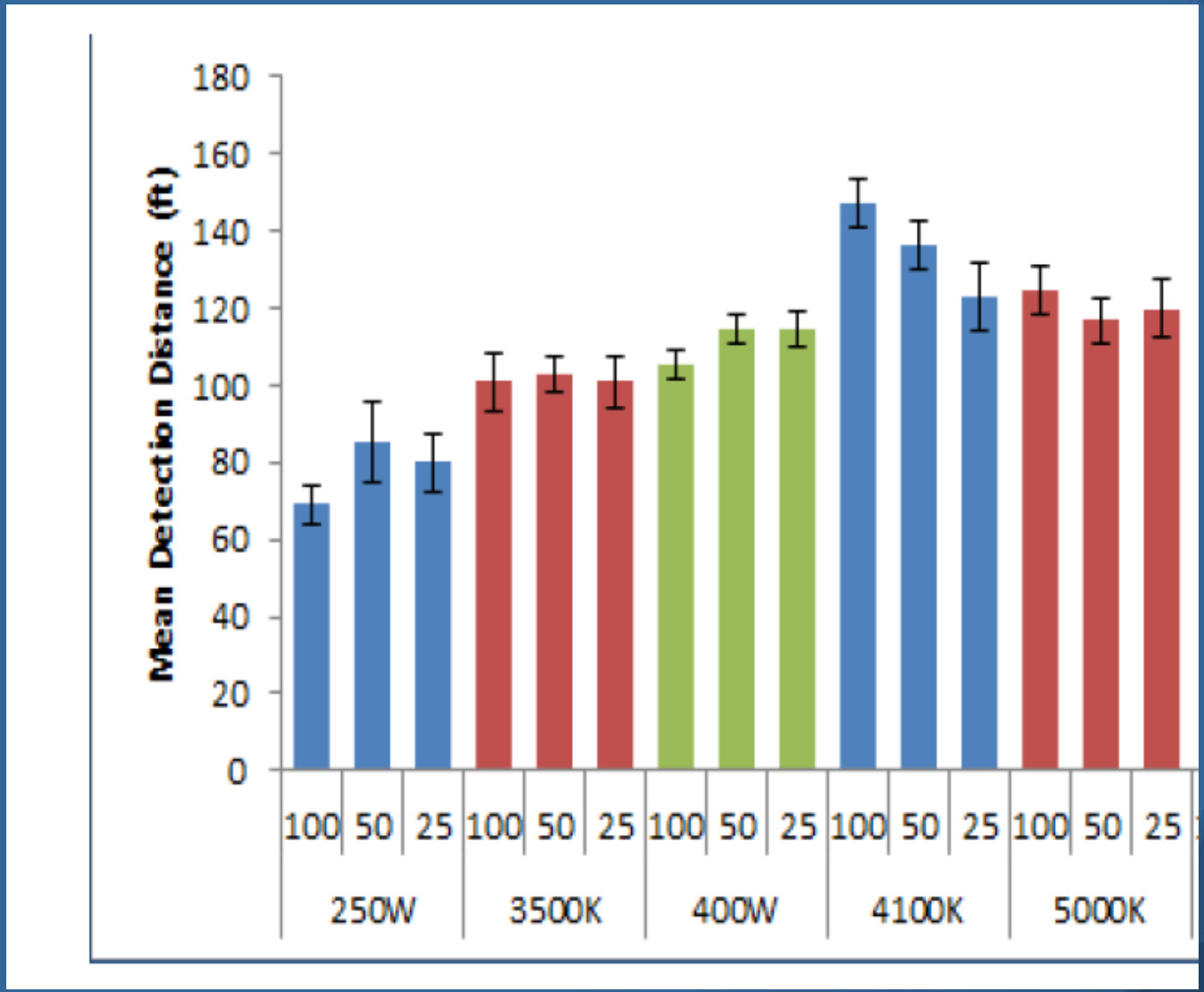
- Negative / Positive - Prefer positive

Figure 2-14 – Examples of Negative and Postive Contrast.

Color Contrast

Spectral Power Distribution of light sources is not considered when defining lighting levels

Object Detection Distance Study



2014 REPORT #E14-286 Seattle LED Adaptive Lighting Study

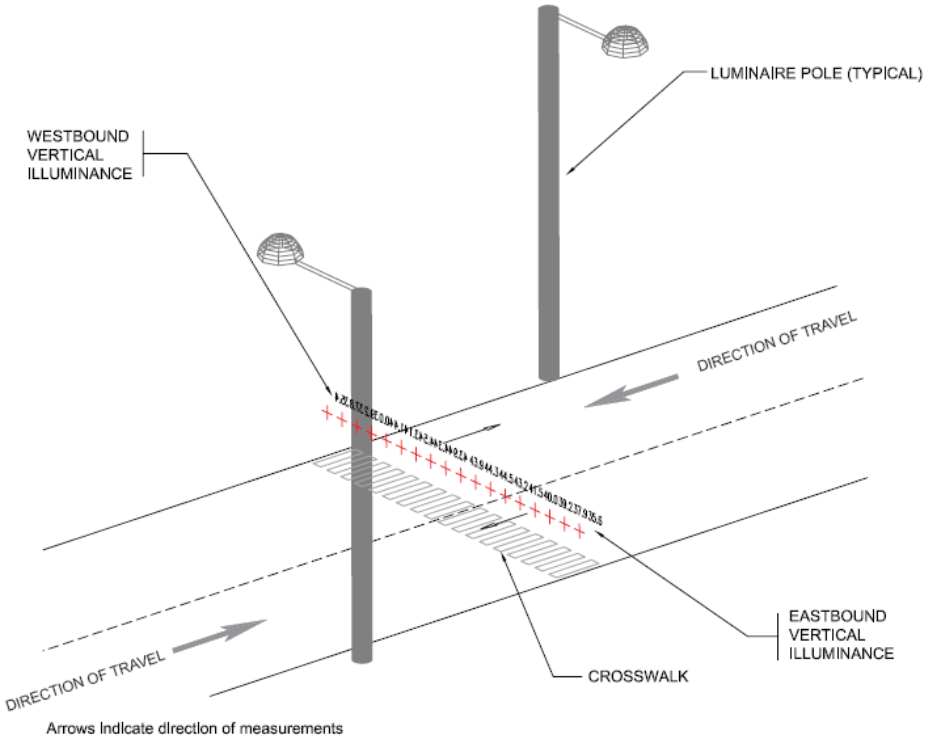
Crosswalks

- It was found that in Europe, a level of 40 vertical lx was used in all crosswalks. This level reduced nighttime vehicle to pedestrian crashes by 66% (FHWA PL-01-034)

- A VTTI study defined lighting level of 20 vertical lux seems sufficient for crosswalks (FHWA-HRT-08-053)

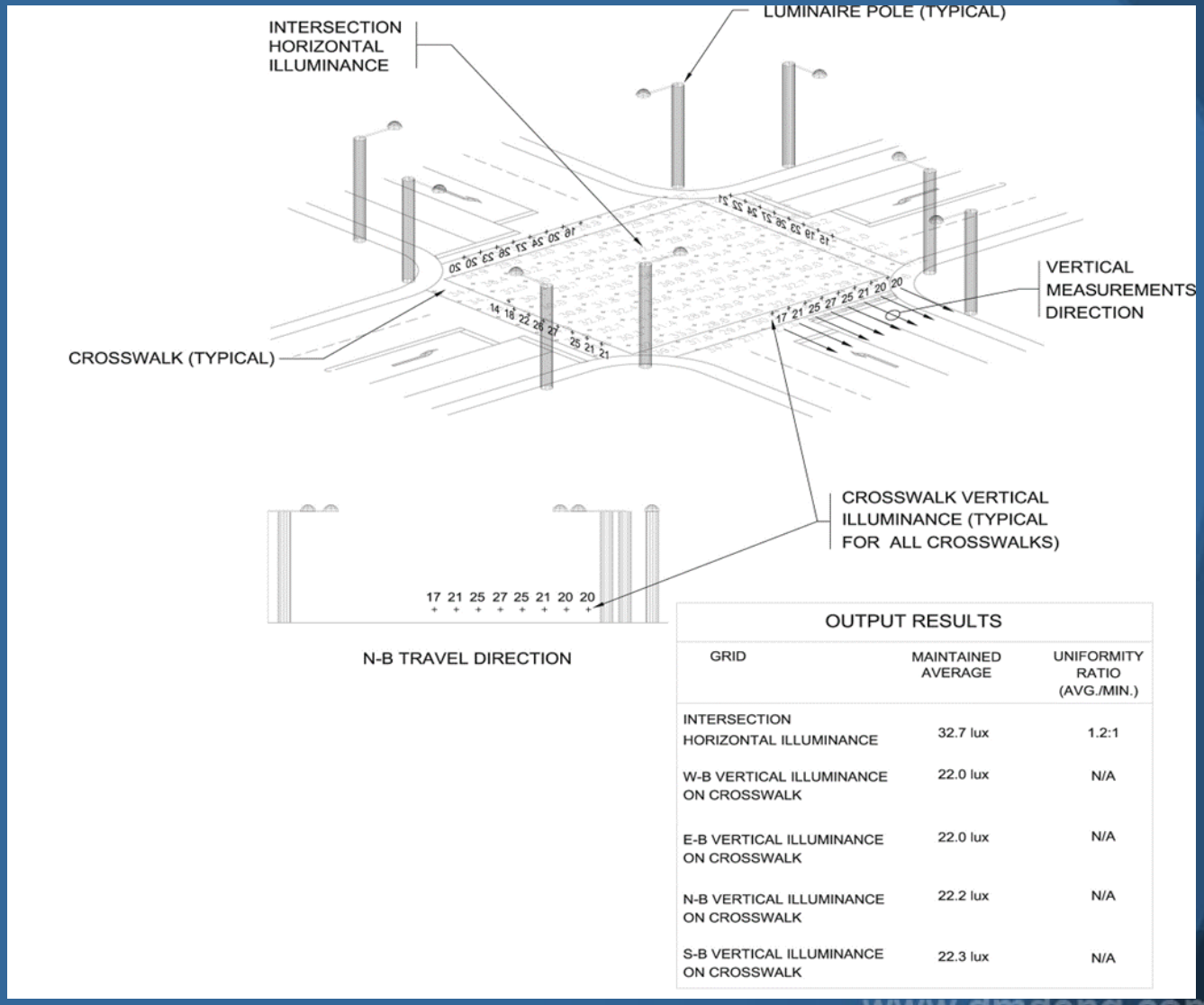
- Currently defined in IESNA RP-8-18

Crosswalk Lighting



OUTPUT RESULTS	
GRID	MAINTAINED AVERAGE
W-B VERTICAL ILLUMINANCE	41.1 lux
E-B VERTICAL ILLUMINANCE	41.1 lux

Intersections



OUTPUT RESULTS

GRID	MAINTAINED AVERAGE	UNIFORMITY RATIO (AVG./MIN.)
INTERSECTION HORIZONTAL ILLUMINANCE	32.7 lux	1.2:1
W-B VERTICAL ILLUMINANCE ON CROSSWALK	22.0 lux	N/A
E-B VERTICAL ILLUMINANCE ON CROSSWALK	22.0 lux	N/A
N-B VERTICAL ILLUMINANCE ON CROSSWALK	22.2 lux	N/A
S-B VERTICAL ILLUMINANCE ON CROSSWALK	22.3 lux	N/A

Surround Lighting

- Surround is the area off the roadway (sidewalk, bike lane, etc)
- Solid State Luminaires have focused on tight optical controls to reduce light spill off the roadway. This creates a dark surround
- Current IESNA standards do not define “Surround Lighting”
- CIE 140:2000 and 115:2007 define a surround ratio of 0.5 to 1 (surround to road).
- Recent research shows significant object detection distance benefit for high vs low surround lighting

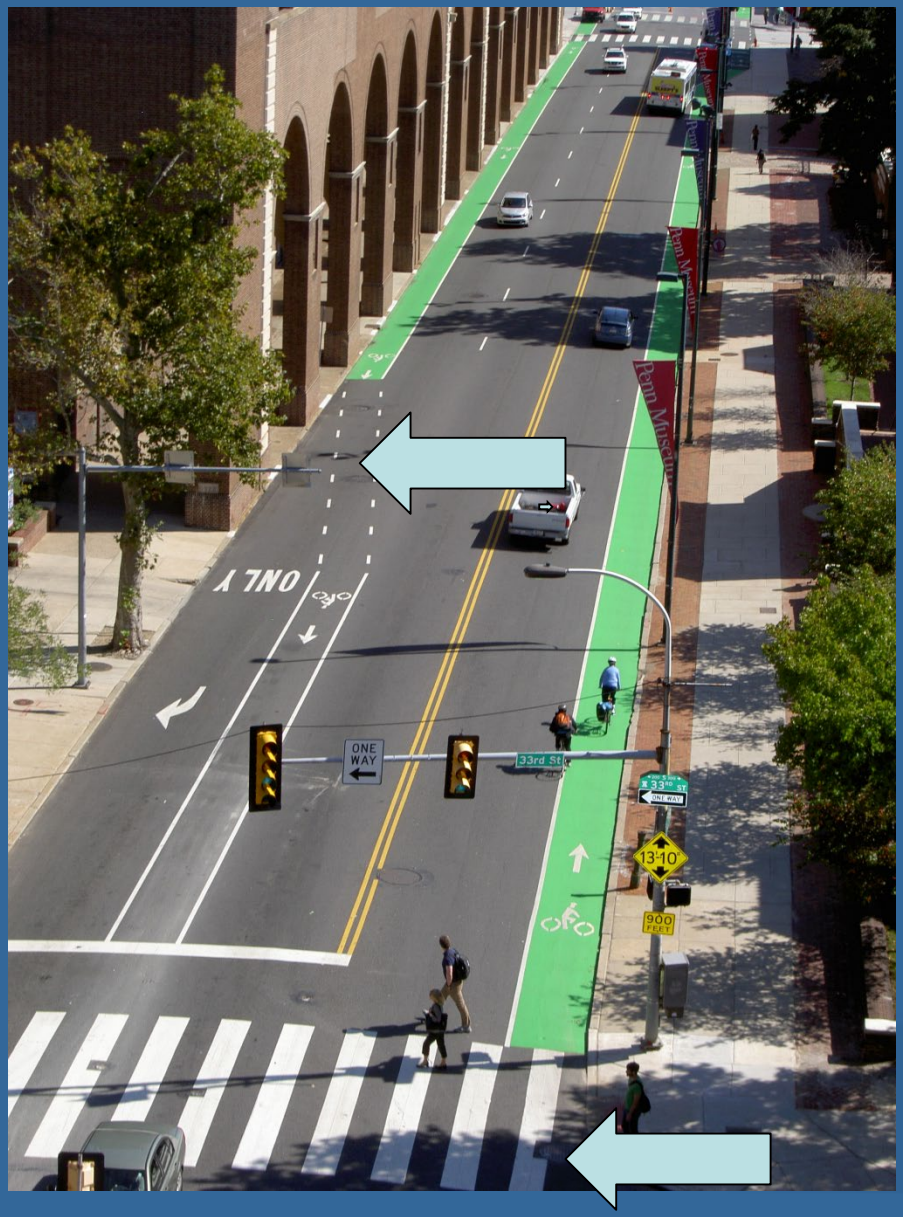
Bicycles

- 900+ cyclist fatalities and 35,000+ serious cyclist injuries (requiring hospitalization).

- The US has a much higher fatality and serious injury rates per kilometer cycled than comparable high-income countries.

The Centers for Disease Control and Prevention's injury statstics 2014,

Bicycles



- Conflict points
- Bike lanes and usages increasing
- Bikes at high risk
- Issues include distracting drivers, lack of visibility, etc
- Parking lanes a further issue

Bicycles

- Marked bike lanes are relatively new
- Lighting standards are currently very unclear and don’t deal with conflict points
- Some apply vertical sidewalk levels whereas some simply apply roadway levels to bike lanes
- Vertical levels maybe of benefit – **Research needed!!**

Security

Crime Prevention Through Environmental Design (CPTED)

- Natural surveillance key (park or lane vs street)
- Lighting can provide a feeling of safety and security
- Lighting can provide a false sense of security in isolated areas.
- Fight or Flight (need visibility)
- Surround surface reflectance can impact visibility.