Seeing With Headlights

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"You can't see worth a damn at night" (Paul Olson)

- Day/night illumination ratio: 10^5
- Pedestrian visibility distance
  night: 150 - 250 feet
  day: 1000's of feet
- Distance required to respond and stop from 55 mph: 265 feet

Night drivers have little time to respond to obstacles

- Best data on PRT gives means of 1.1 to 1.5 seconds
- 85th percentile values of 1.3 to 1.8 seconds.
- Glance durations can range from 0.5 to 1.5 seconds (IP tasks, mirror looks, looks to the side, etc.)
- Effective response latency of 2.5 or more sec

Over-driving Headlights

- Headlamps provide enough light for primary driving task of lane-keeping
- Low visibility obstacles are extremely rare and thus not expected
- Driver’s (and pedestrians) over-estimate visibility
- Result: we over-drive headlights *WRT* obstacles but not lane-keeping.

PCDETECT

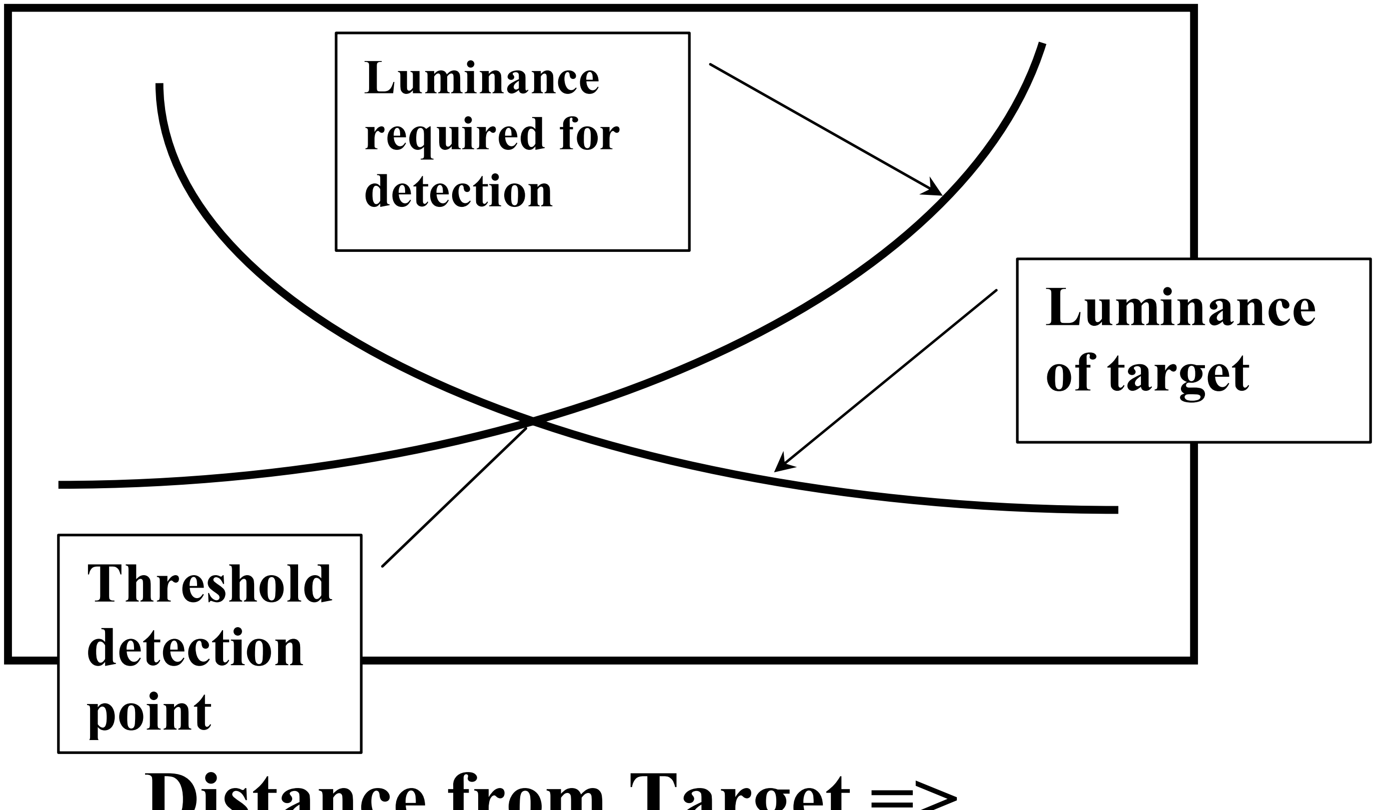
- Headlamp seeing distance program developed at Ford
- Based on Blackwell data and formulations
- Estimates seeing distance as influenced by human, environmental and lighting parameters
- Validated in early 70’s in field studies

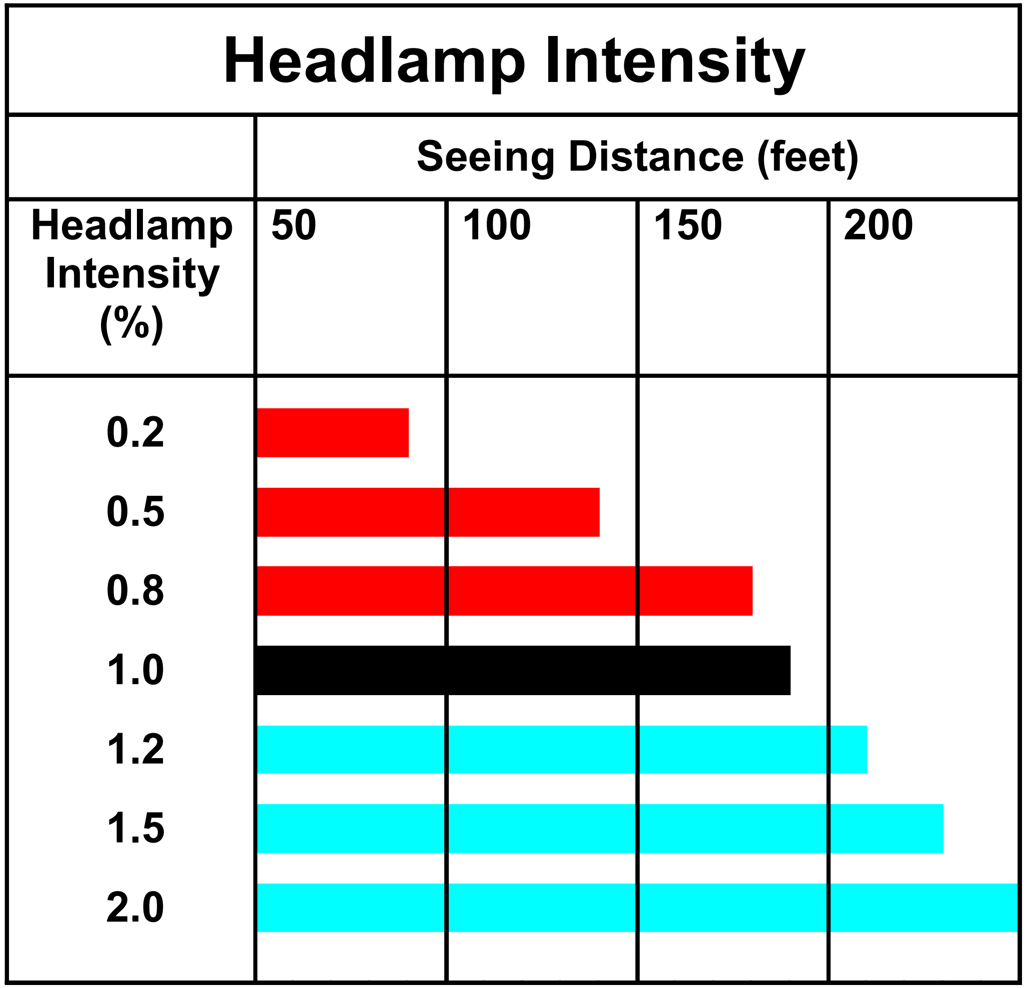
Base Conditions	
Headlamps	Taurus low beams
Headlamp height	Two feet above ground
Headlamp aim	Correct
Glare from opposing cars	None
Driver age & contrast sensitivity	35, 50^{th} Percentile
Alertness	“Normal”
Target type, size	Pedestrian, 5.8-feet tall

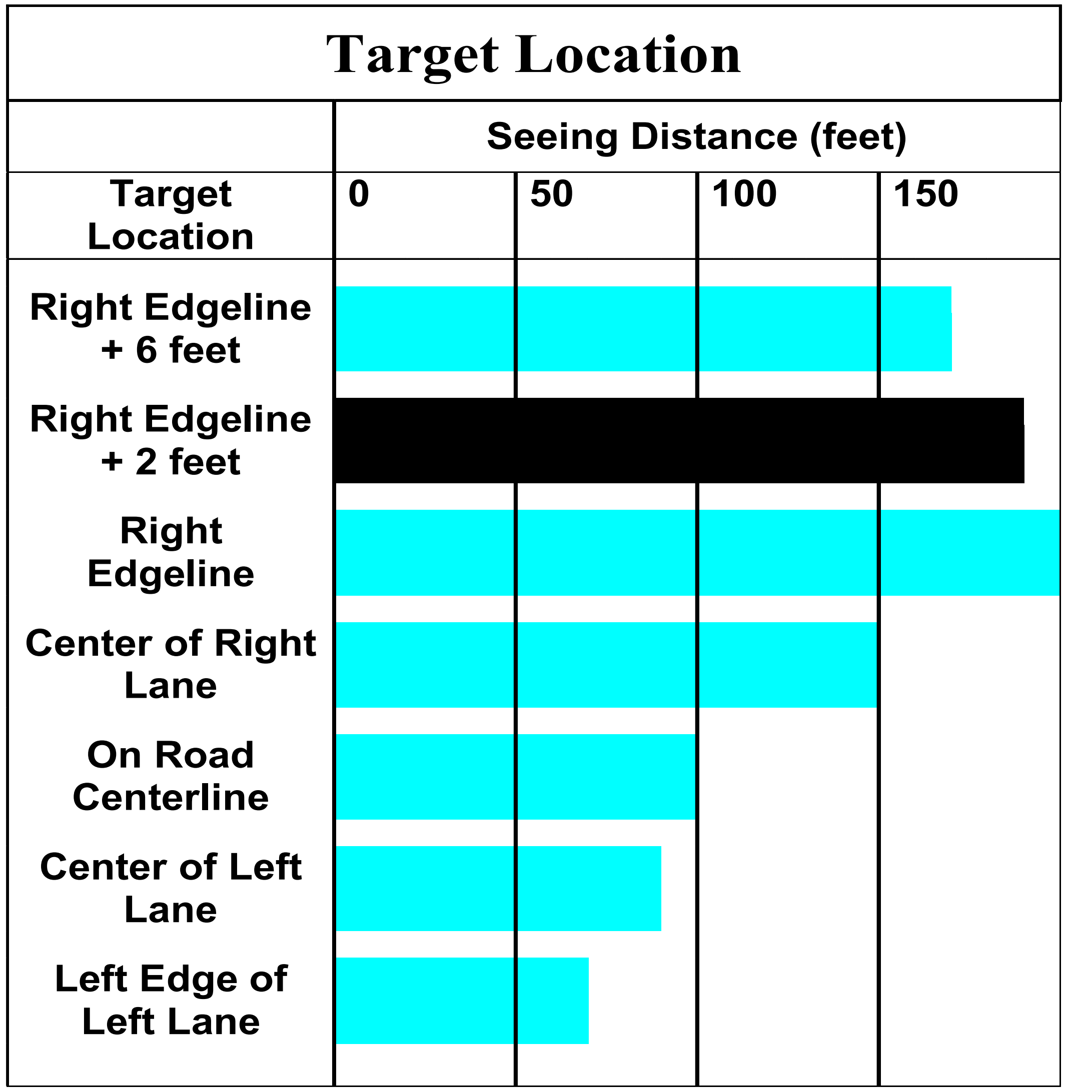
Base Conditions

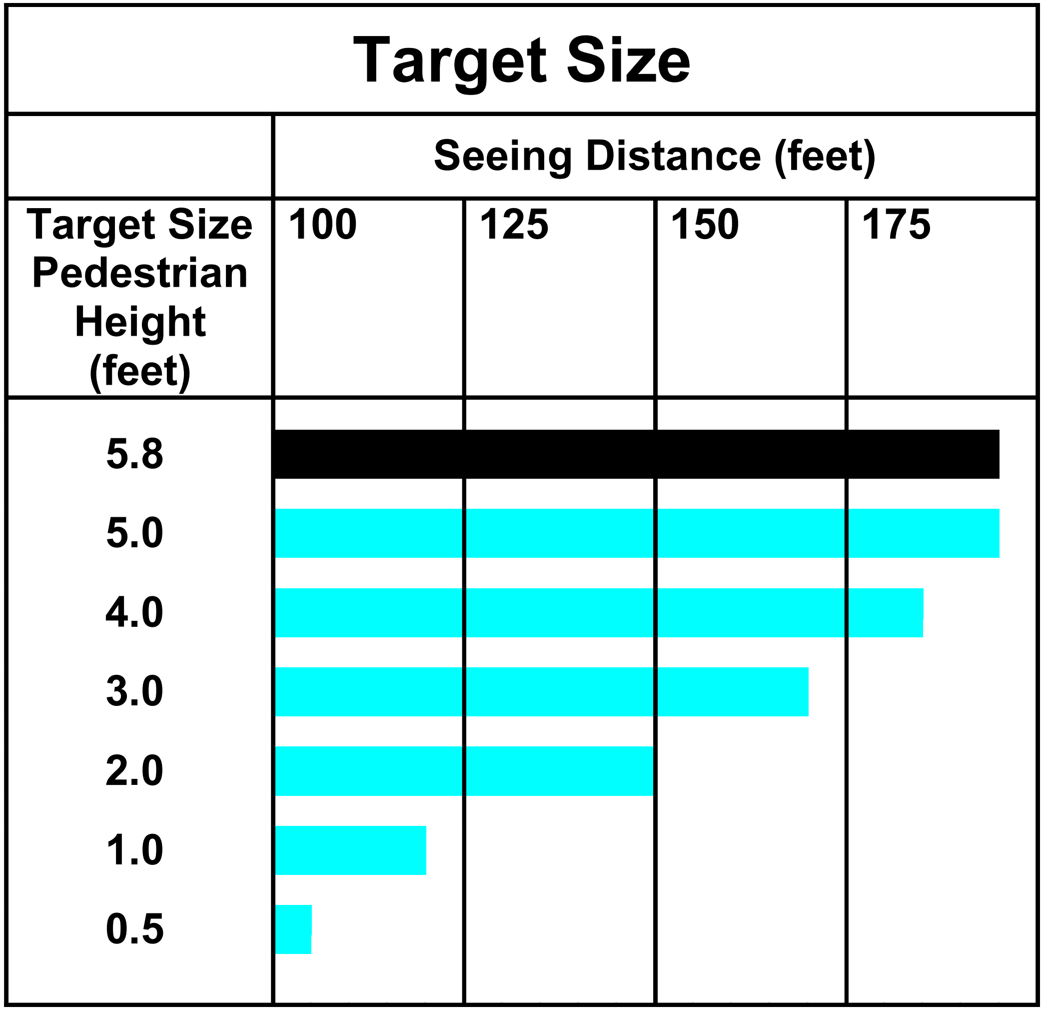
Target location	2 feet right of right lane edge
Target reflectance	8%
Pavement reflectance	6%
Ambient illumination	0.001 FL
Road type	Two 12-foot lanes
Geometry	Straight and level
Windshield transmittance	80%

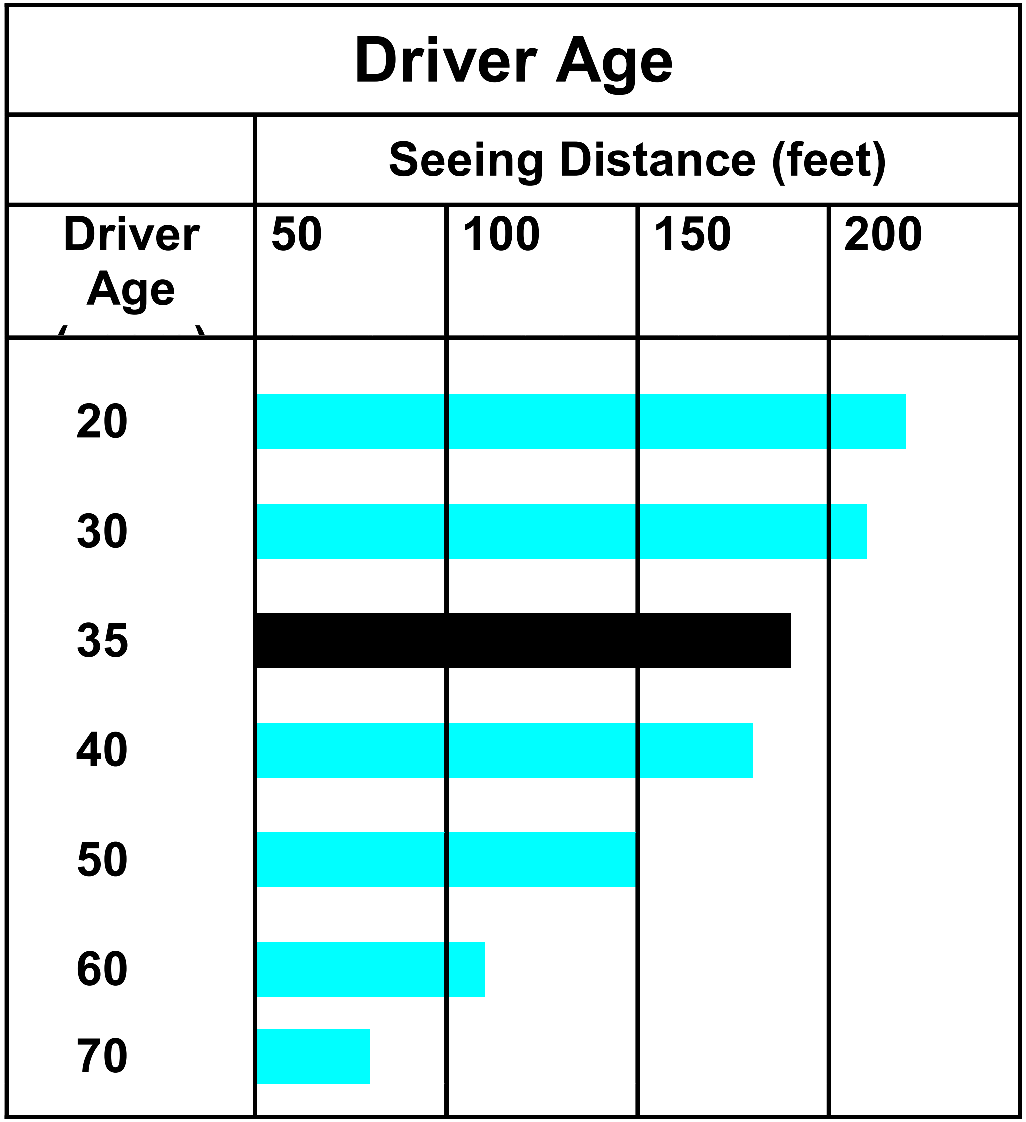
Luminance


Luminance required for detection
Luminance of target
Threshold detection point
Distance from Target =>

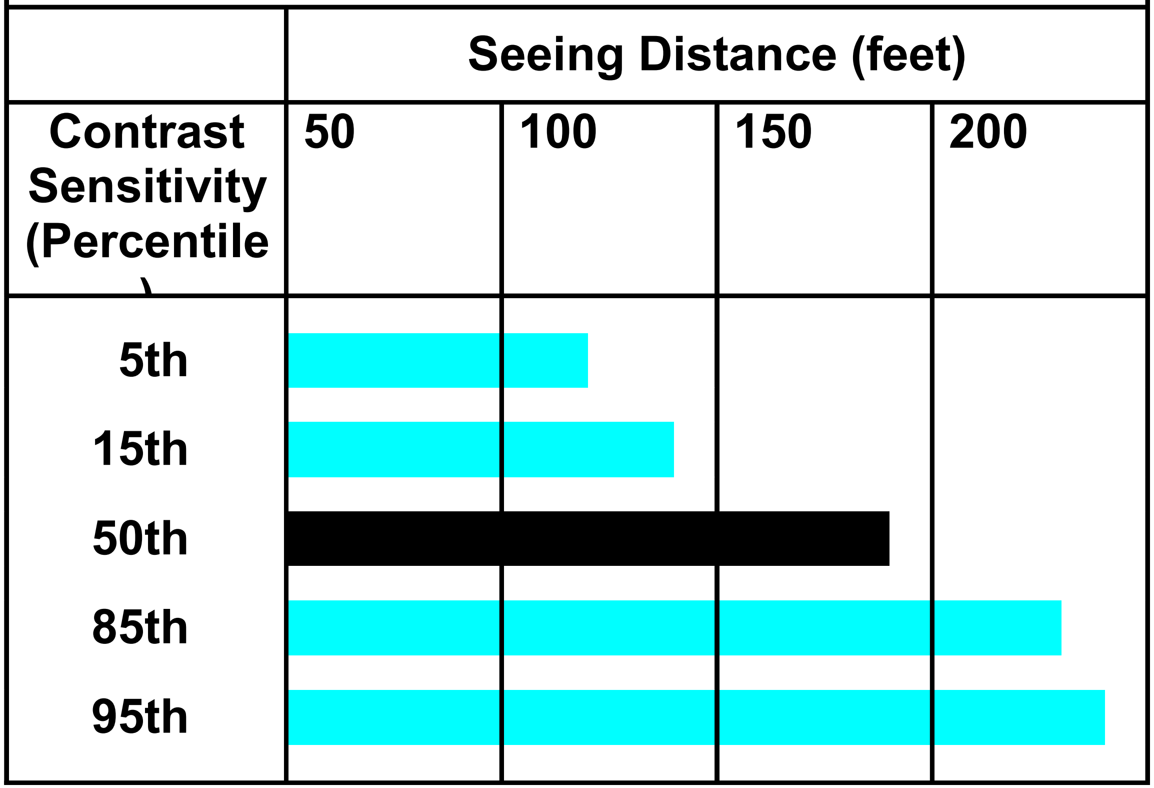

Headlamp Intensity
Seeing Distance (feet)
Headlamp Intensity (%)
50
100
150
200
0.2
0.5
0.8
1.0
1.2
1.5
2.0

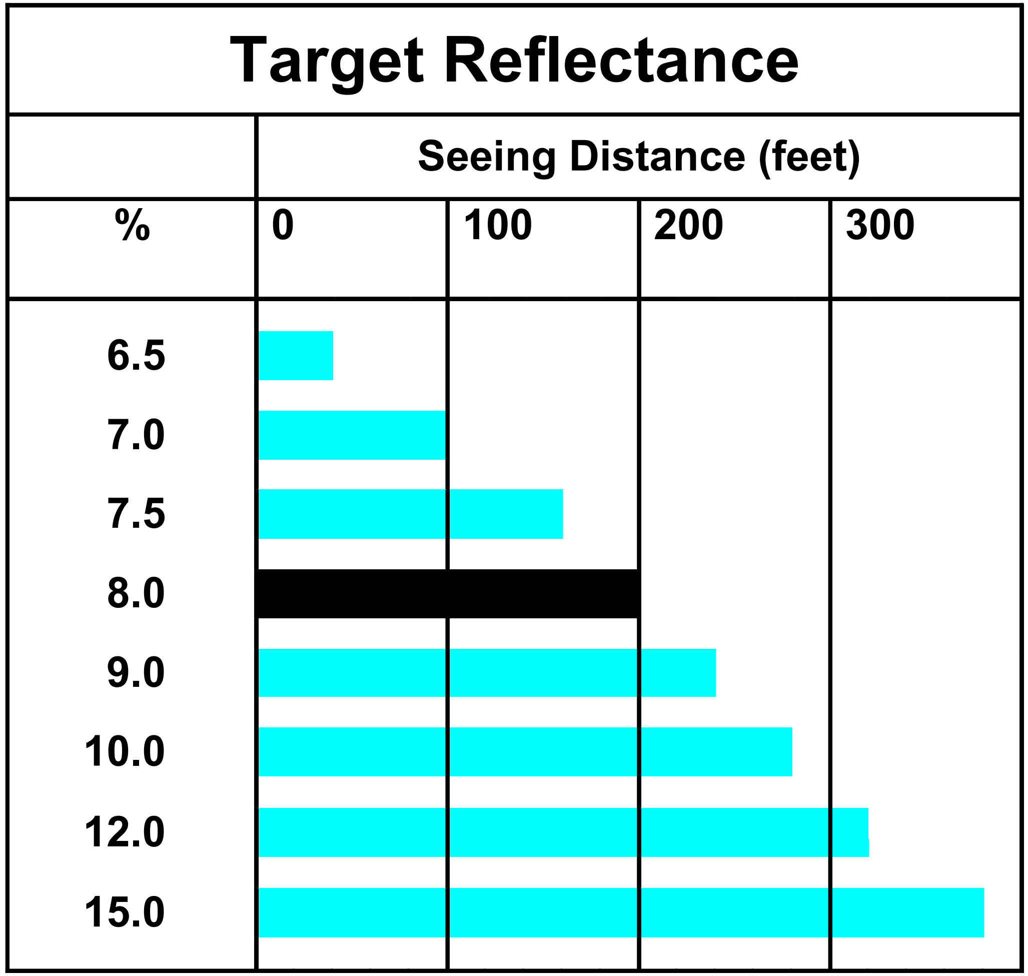

Target Location
Seeing Distance (feet)
Target Location
0
50
100
150
Right Edgeline + 6 feet
Right Edgeline + 2 feet
Right Edgeline
Center of Right Lane
On Road Centerline
Center of Left Lane
Left Edge of Left Lane

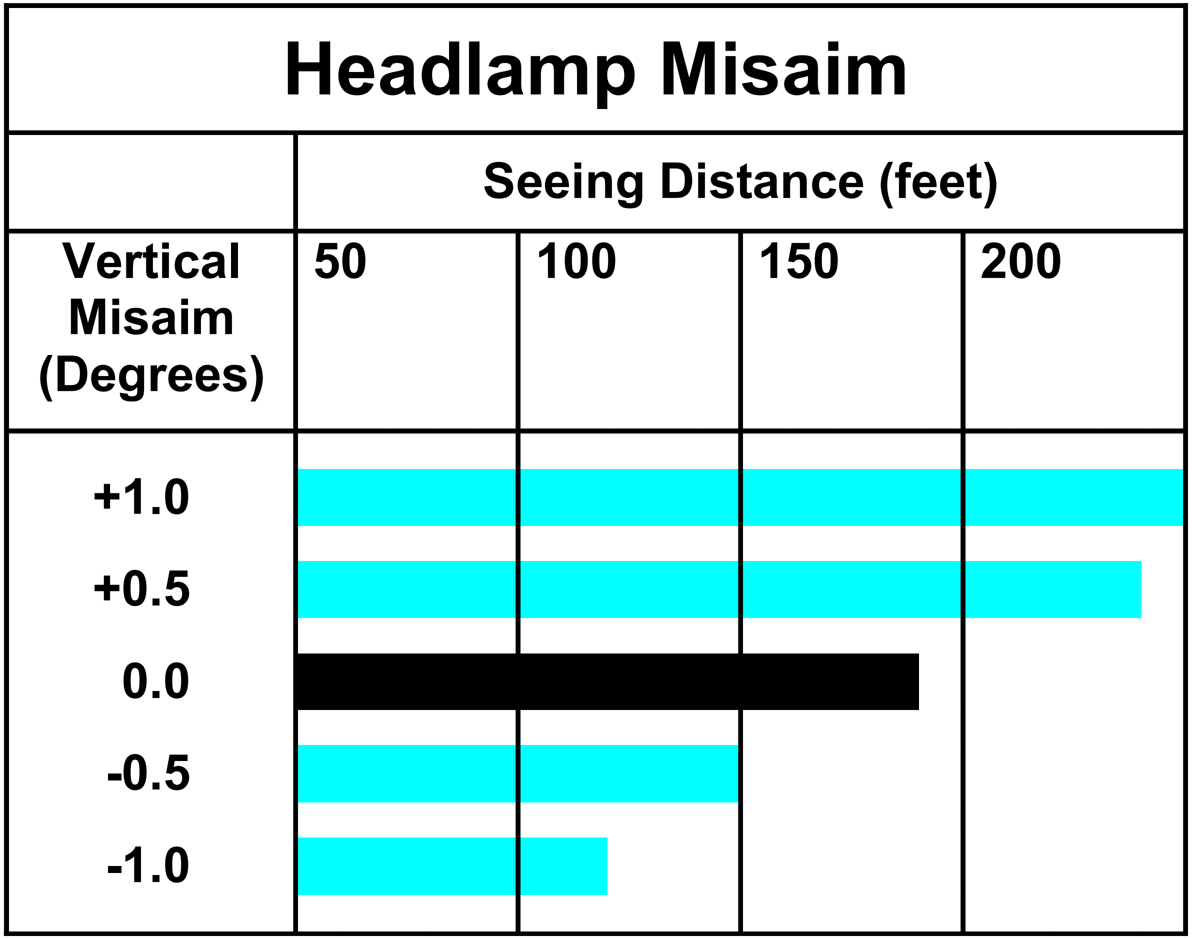

Target Size
Seeing Distance (feet)
Target Size Pedestrian Height (feet)
100
125
150
175
5.8
5.0
4.0
3.0
2.0
1.0
0.5

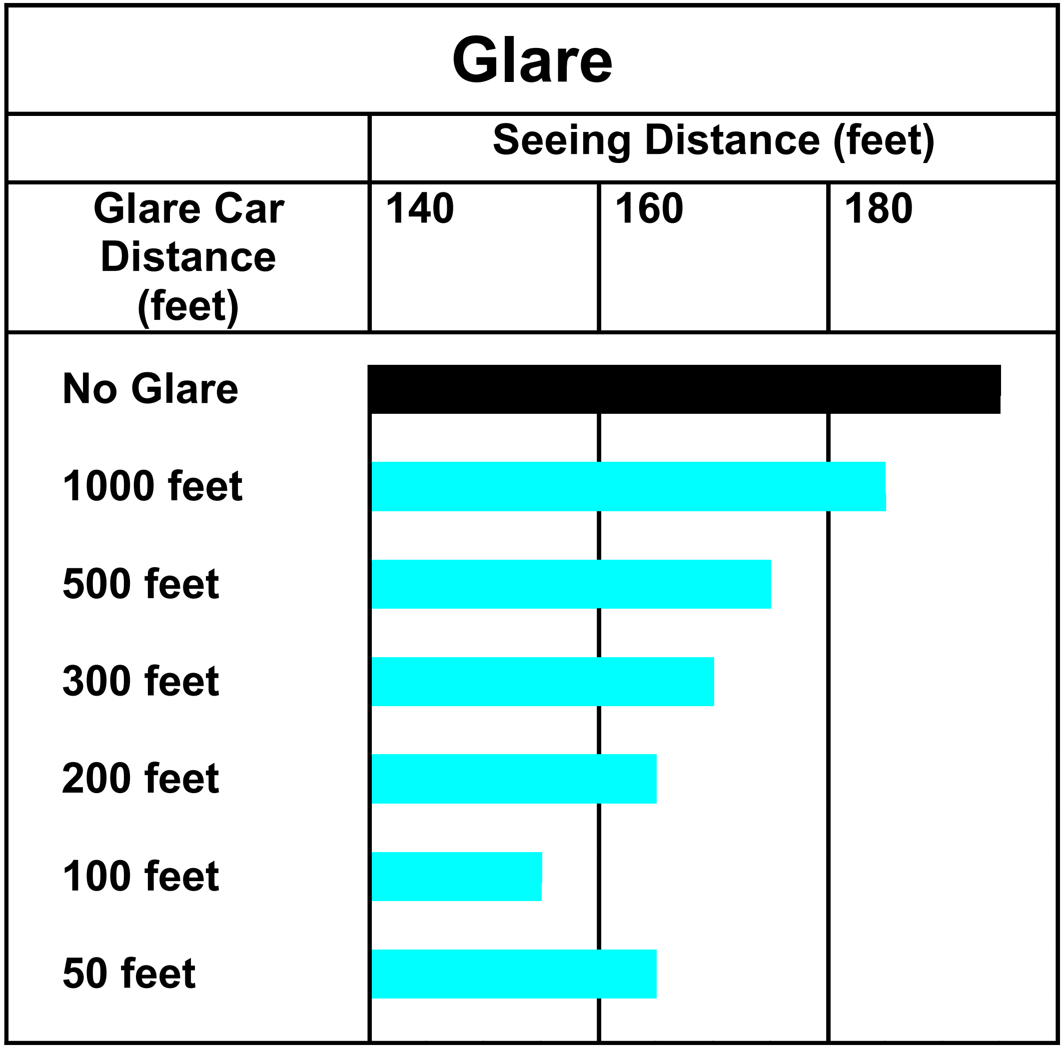

Driver Age
Seeing Distance (feet)
Driver Age
50
100
150
200
20
30
35
40
50
60
70

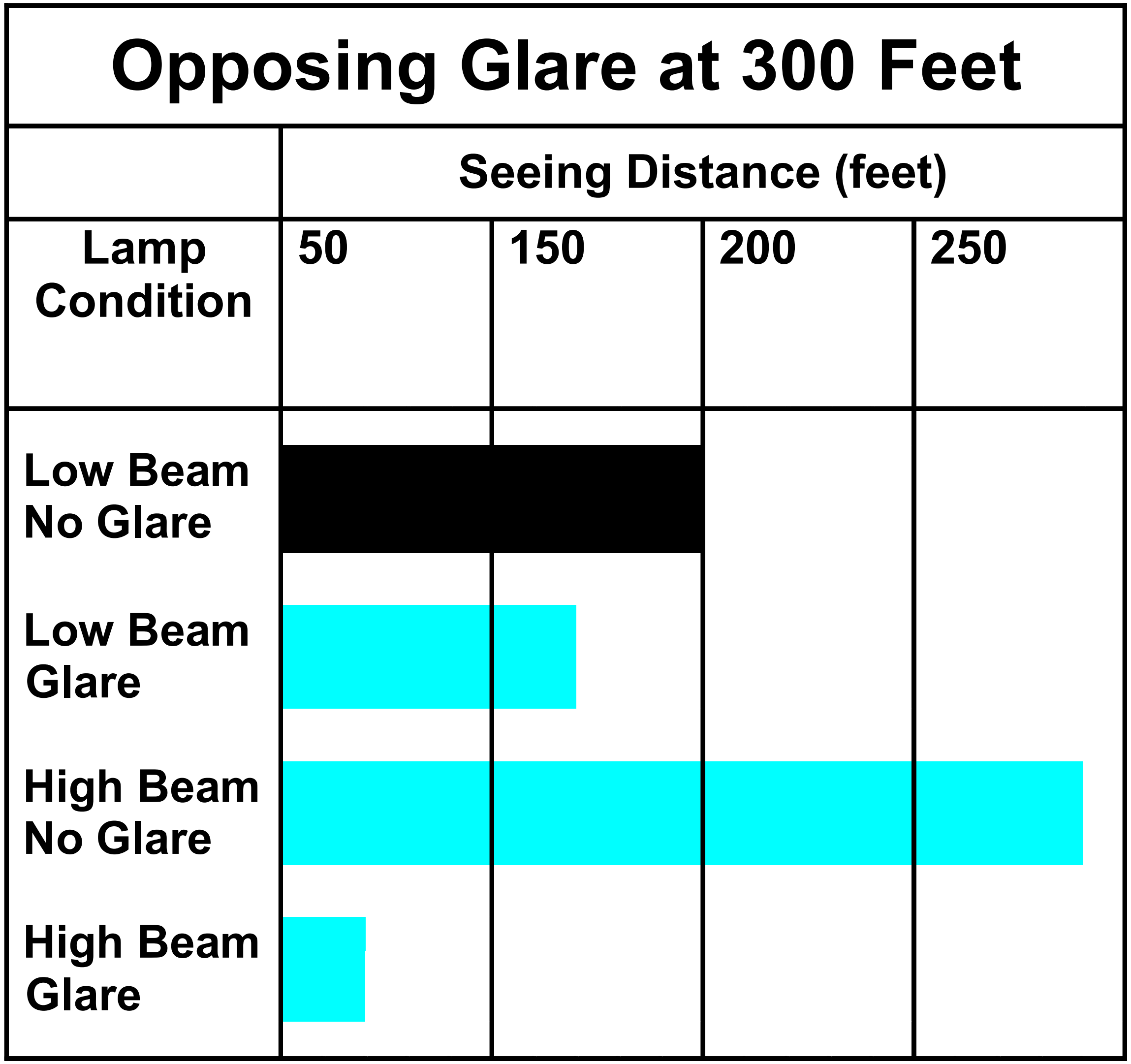
Contrast Sensitivity




Target Reflectance
Seeing Distance (feet)
%
0
100
200
300
6.5
7.0
7.5
8.0
9.0
10.0
12.0
15.0

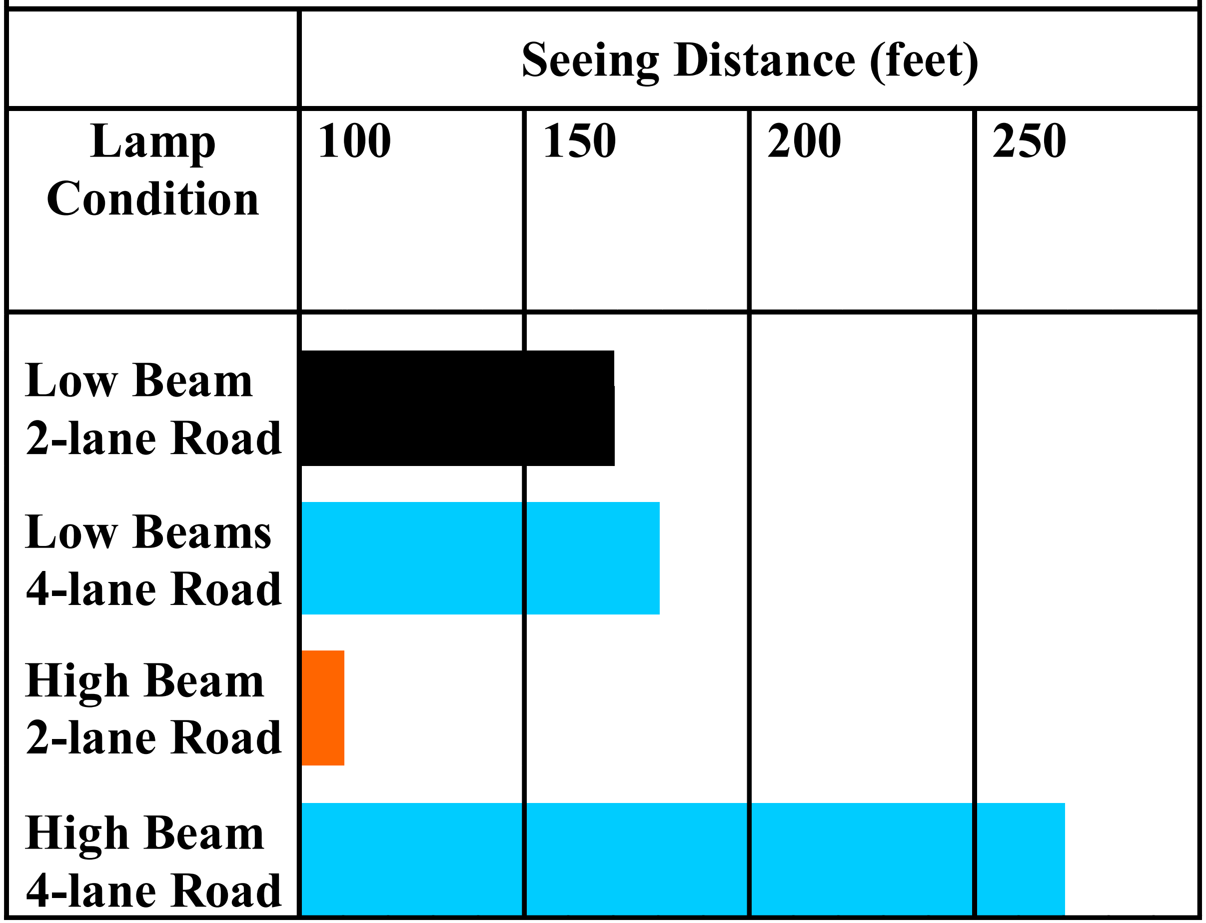

Headlamp Misaim
Seeing Distance (feet)
Vertical Misaim (Degrees)
50
100
150
200
+1.0
+0.5
0.0
-0.5
-1.0

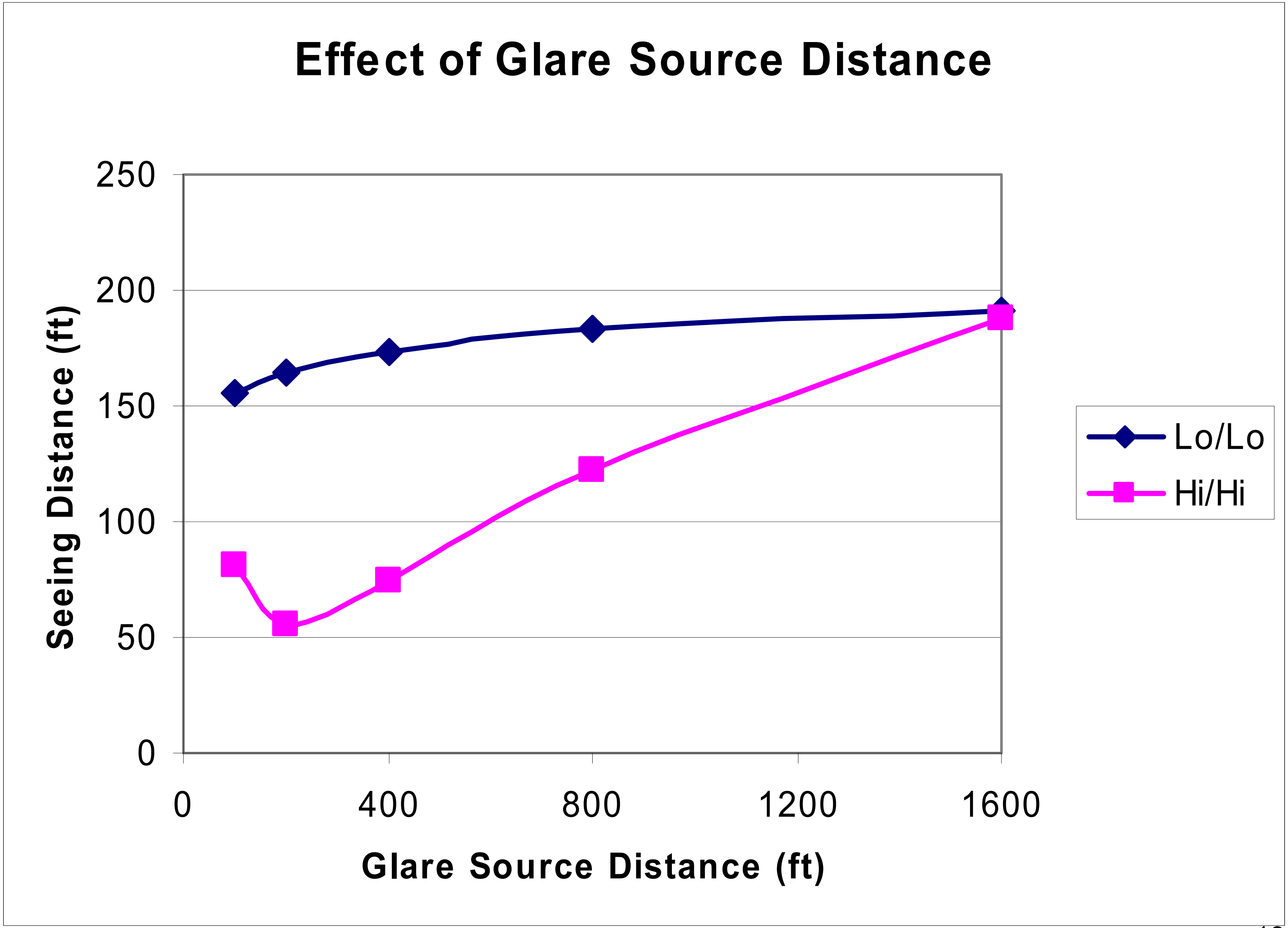

Glare
Seeing Distance (feet)
Glare Car Distance (feet)
140
160
180
No Glare
1000 feet
500 feet
300 feet
200 feet
100 feet
50 feet


Opposing Glare at 300 Feet
Seeing Distance (feet)
Lamp Condition
50
150
200
250
Low Beam No Glare
Low Beam Glare
High Beam No Glare
High Beam Glare

Opposing Glare

Road Width Effects




Effect of Glare Source Distance
250
200
150
100
50
0
0
400
800
1200
1600
Seeing Distance (ft)
Glare Source Distance (ft)
Lo/Lo
Hi/Hi

Closing thoughts

- High beams are better than low beams for pedestrian detection (but not all *that* much better).
- High beam glare is much worse than low beam glare.
- Even with high beams, drivers have little time to respond to pedestrians.

Closing thoughts

- Need a systems approach for evaluation
- Need to consider behavioral factors.
- Need to consider driver comfort:
  Pedestrian at risk extremely rare event
  Always-on high beams a constant irritation
- Alternatives:
  Better signaling and marking
  Smarter headlights