Intelligent Warning Beacon Design for Maximizing Worker and Driver Safety

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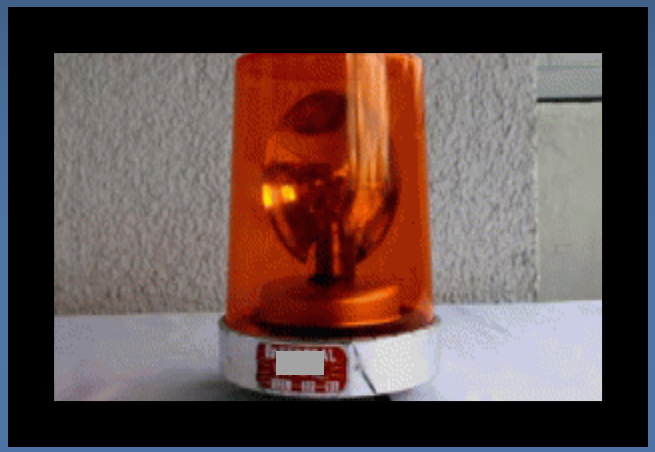
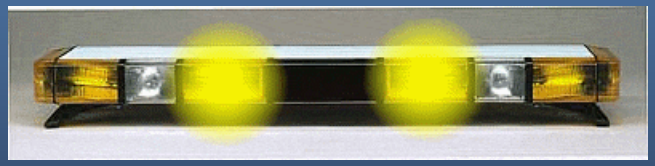
Warning beacons…

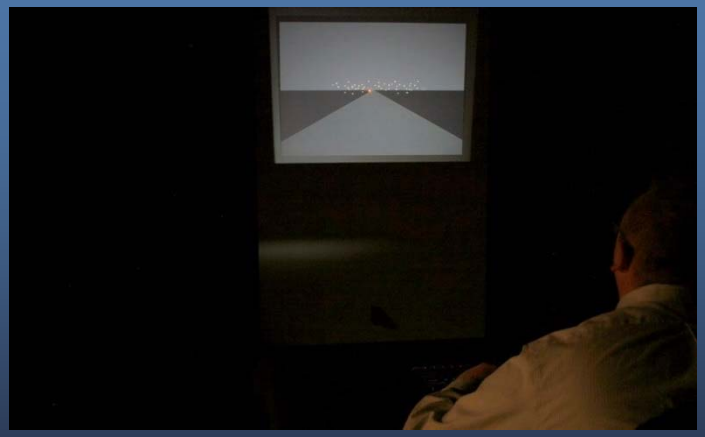
- …are a primary line of defense for the protection of **front line service workers**
- Service workers in construction, transportation and utilities make up **13% of U.S. work force but are involved of 36% of workplace fatalities** (NIOSH 2009)
  - Improved beacon design could help prevent more than 5200 injuries annually in the U.S. (Cook 2000)

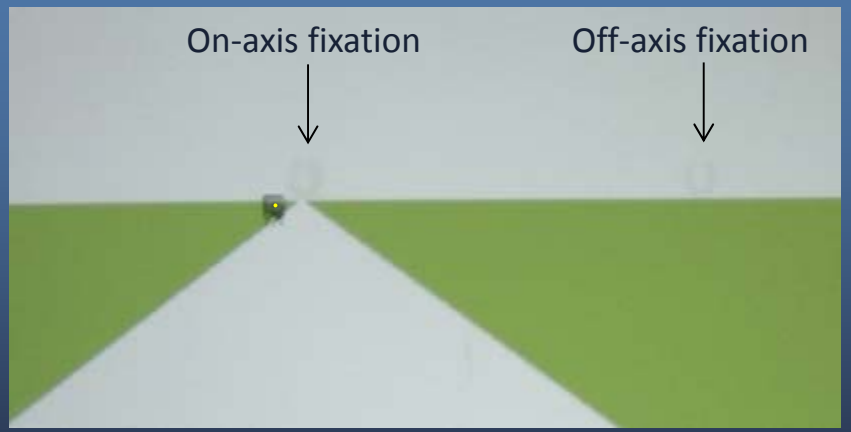




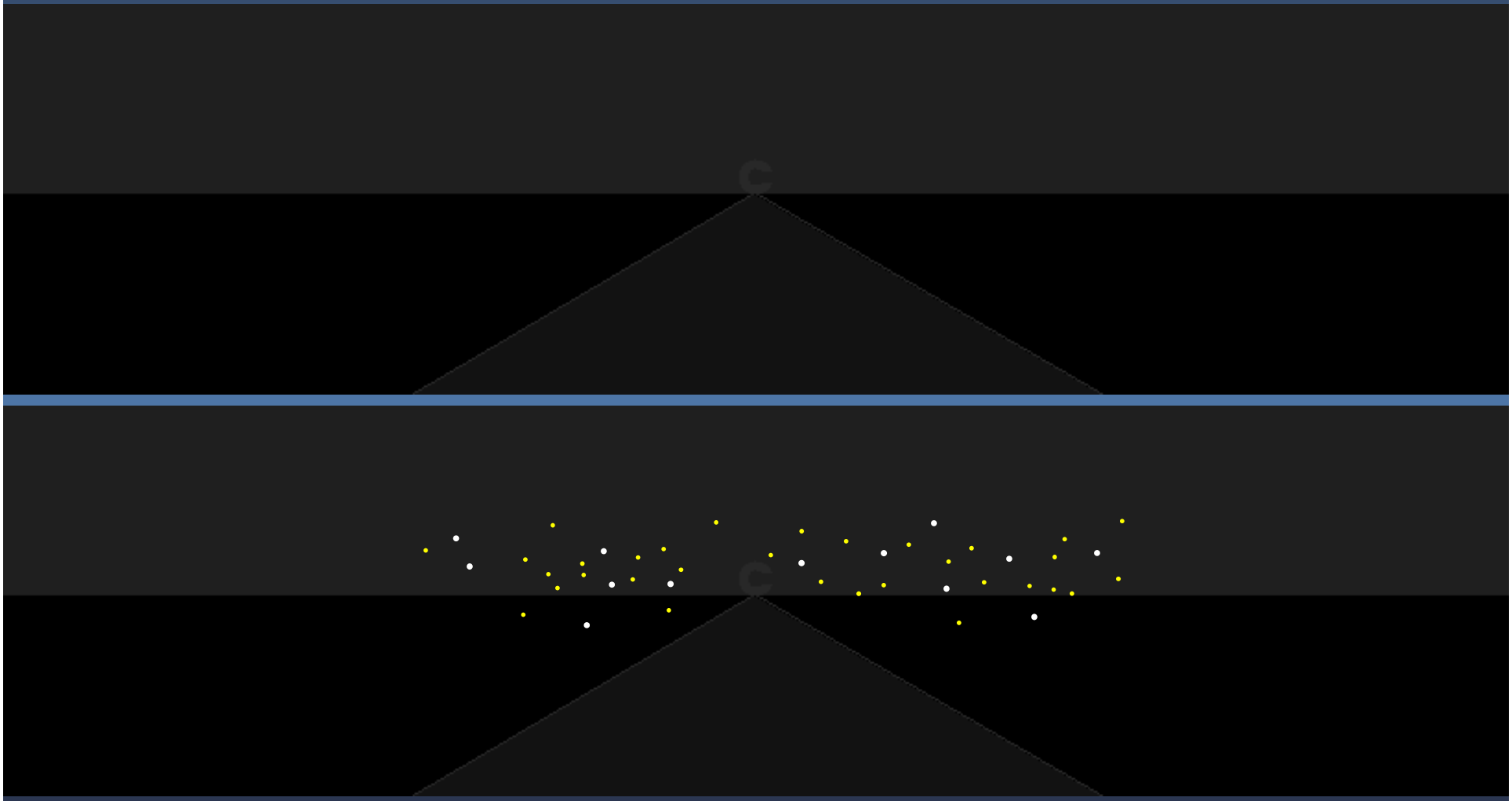
Luminous intensity requirements

- Intensity
  - Warning beacons need to be bright enough to be seen, during daytime and nighttime, but not so bright that they cause glare
  - Laboratory experiments were conducted to measure response times to flashing warning beacons and impacts on hazard visibility
  - Participants viewed a target near or away from a simulated truck with a warning beacon with adjustable peak intensity (80, 180, 530 candelas)

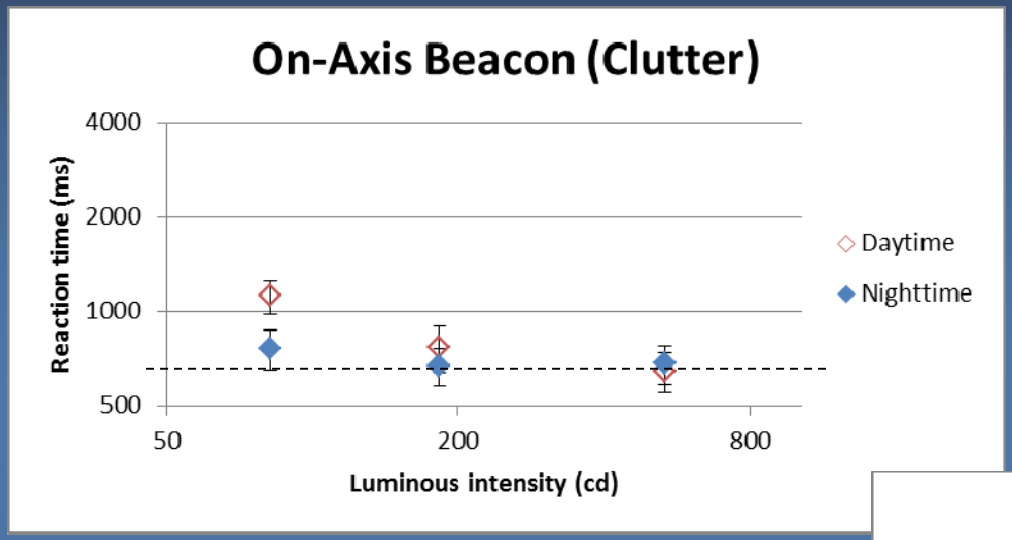




Cluttered vs. uncluttered backgrounds

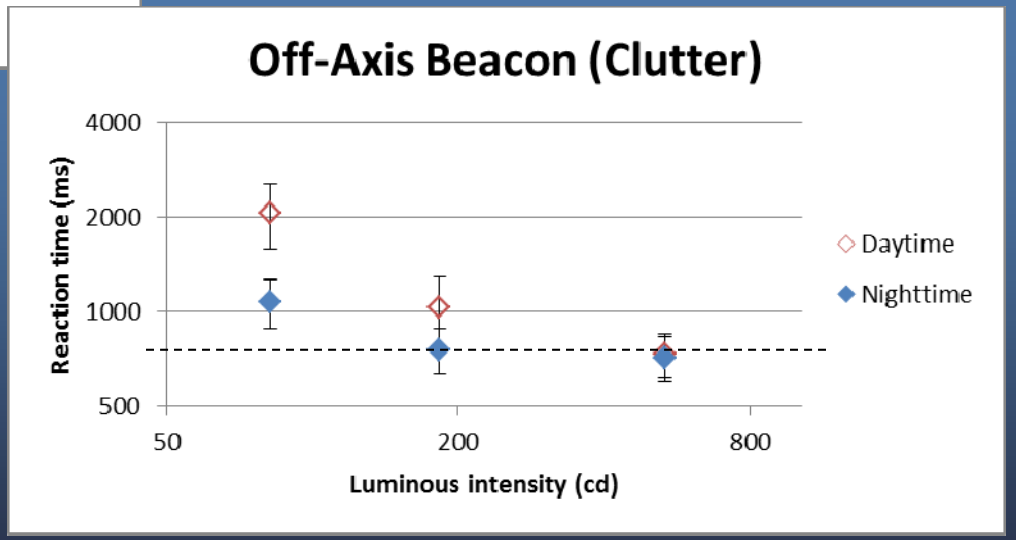


Response time vs. intensity

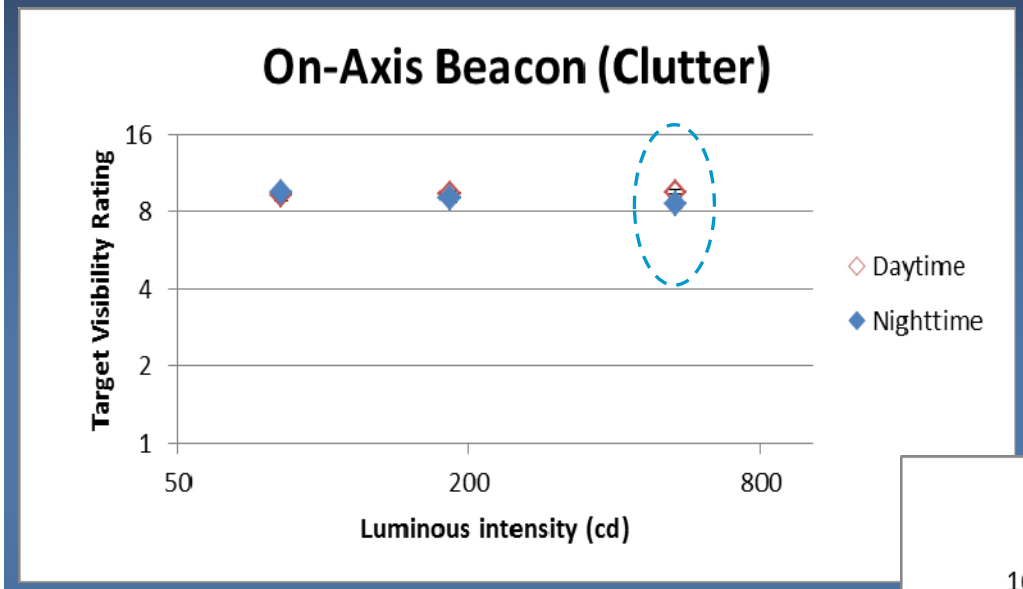


When viewed at **night** (on- or off-axis), asymptotic response time occurred at 180 candelas

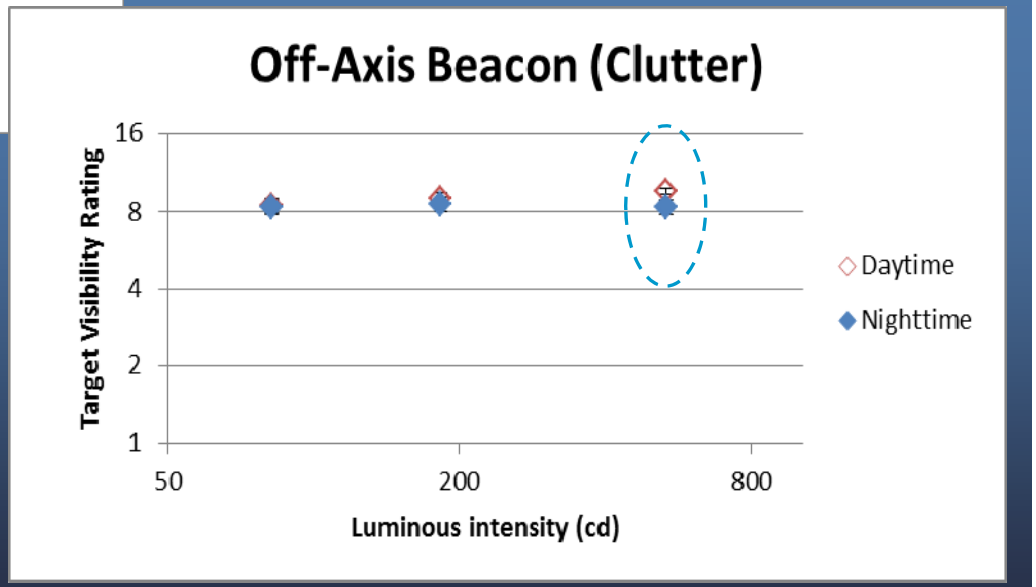
When viewed in **daytime** (on- or off-axis), asymptotic response time occurred at 530 candelas



Hazard visibility vs. intensity

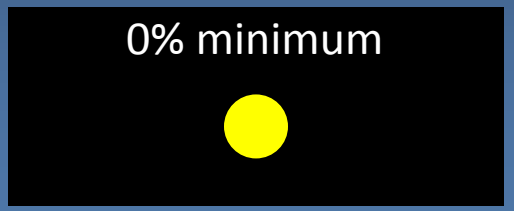


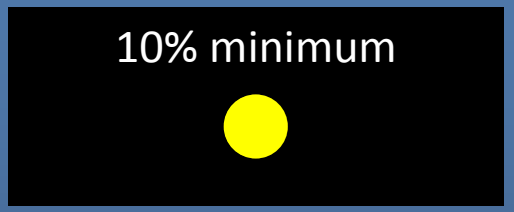
- Hazard visibility during **daytime** was unaffected by the warning beacon for all intensities investigated
- Hazard visibility at **night** was reduced slightly by the warning beacon at the highest peak intensity (**530 candelas**)
  - Reliable ($p<0.05$) interaction between peak intensity and ambient level

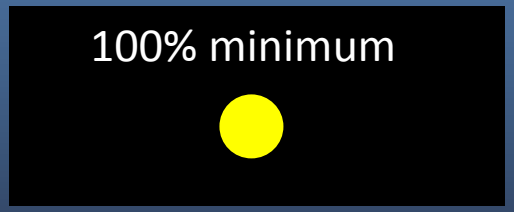


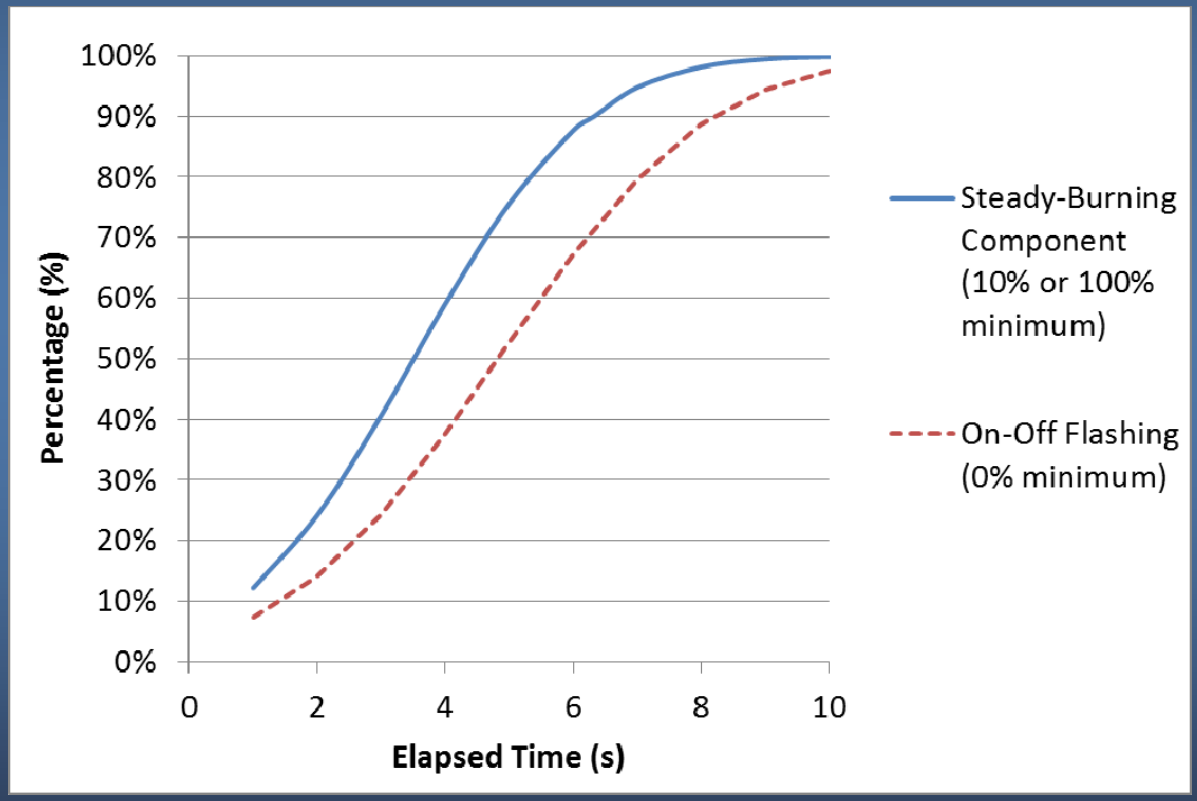
Amount of modulation

Closure detection is impacted by the amount of modulation









Toward the next generation of warning beacons

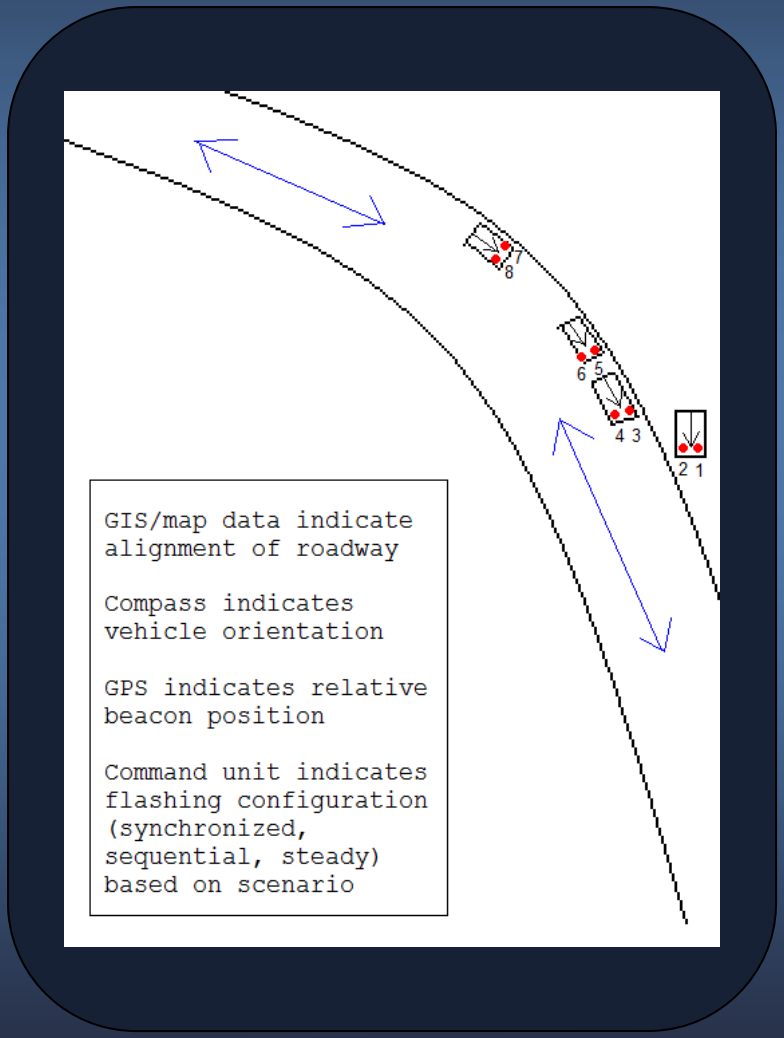
- The Lighting Research Center is developing intelligent functionality to provide visually effective guidance using warning beacons, potentially including:
  - GPS and clock functionality for positioning and timing
  - Modified color and chromaticity
  - Intensity control based on ambient light level
  - Optical distributions to reduce visual noise in fog/snow
  - Polarization of light to control reflections from wet pavement

A roadway incident scene today

Photo: http://bangordailynews.com/2013/03/19/news/bangor/route-9-closed-for-accident-bangor-hydro-truck-also-hit-dispatcher-says/

Making use of available data

- Ambient light sensor adjusts intensity based on day/night condition
- GPS/map data provide beacon positions relative to roadway
- Master control unit sets flash configuration based on scenario



A roadway incident scene tomorrow?

Photo: http://bangordailynews.com/2013/03/19/news/bangor/route-9-closed-for-accident-bangor-hydro-truck-also-hit-dispatcher-says/

Planned field investigations

- Following human factors research to develop preliminary warning beacon specification, prototype units will be field tested in collaboration with Pennsylvania State University

Thank you!

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