Photometric Measurements in the Field

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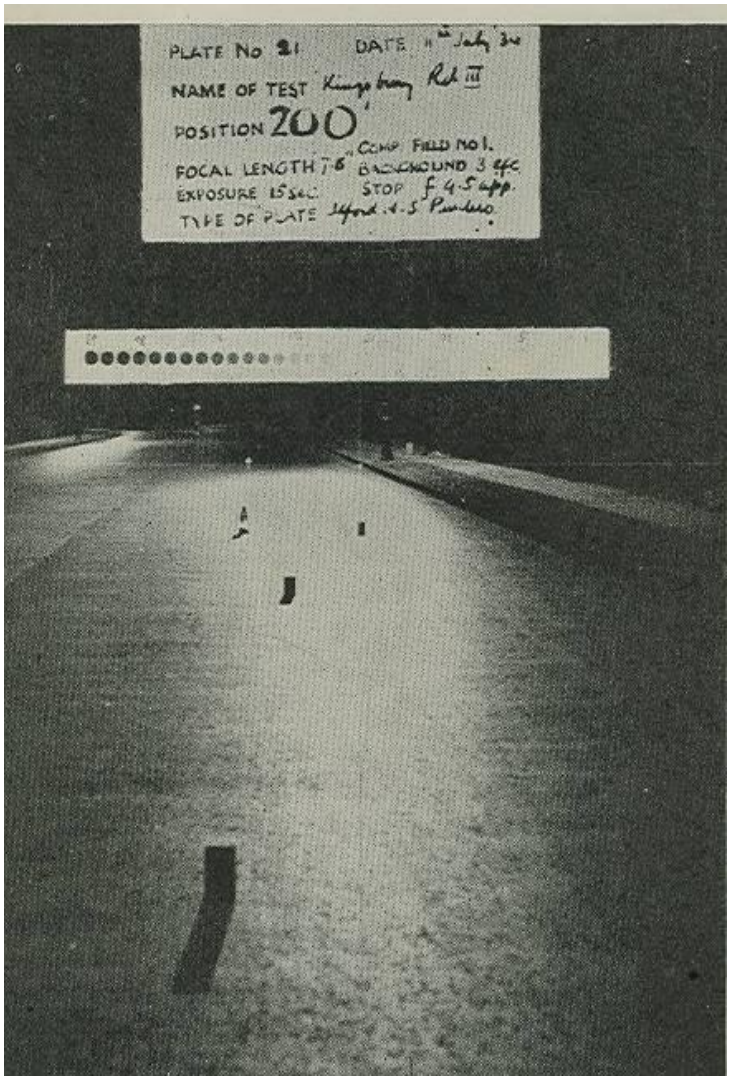
Photometric Measurements in the Field

- Traditional Methods
  - Luminance Meters
- Current Methods
  - CCD Photometry
- Future Considerations
  - Image Processing

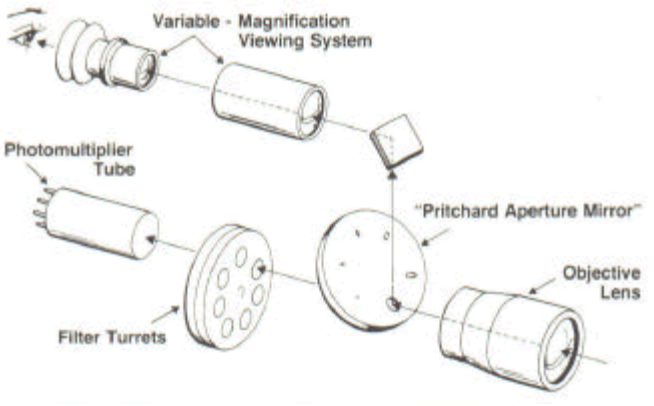
Early Pavement Luminance Measurement

- Waldram began researching luminance in 1934
- Using Photographic plates and a scaling system of known reflectance, luminance was able to be measured.
  - Image is from July 3rd, 1934



Traditional Equipment

- The development of high accuracy portable luminance meters allowed field measurements to be taken
- Pritchard developed an imaging system which remains one of the highest accuracy and reliable systems in use
  - Self Calibrating
  - Many Optics Options
    - Cassegrain Objective
    - Wide Angle Lenses



Field measurement

- The field measurement process is relatively simple:
  - Typically, the instrument is located at the prospective observer location and the optic is then located and the luminance is measured.

Example Measurement Process

- For the Enhanced Night Visibility Project performed at VTTI every experimental object (Pedestrians, Tire Treads, Bicycles) were photometered at every station (6 in total) under every lighting condition (12 in Total)
- These were measured in Clear Rain, Snow and Fog conditions

ENV Measurement Process

- Each object was measured multiple times to assess the foreground and the background at each of the measurement stations
- This was performed for multiple measurement distances to establish the change in luminance and illuminance by vehicle distance
- The Pritchard Telephotometer was located in the driver seat of the experimental vehicle
- The photometer operator was in the rear seat leaning over the seat back to aim the meter
- A second operator was recording the measurements
- In all over 4100 luminance measurements were made

Vision Enhancement System

12 Configurations

- Halogen Low Beam (HLB)
  - HLB + Hybrid UV-A
  - HLB + 3 UV-A
  - HLB + 5 UV-A
- High Intensity Discharge (HID)
  - HID + Hybrid UV-A
  - HID + 3 UV-A
  - HID + 5 UV-A
- High Output Halogen
- Halogen High Beam
- Halogen Low Beam – Lower Profile
- Infrared Thermal Imaging

Object Type

- Perpendicular Pedestrian
  - White clothing
  - Black clothing
- Parallel Pedestrian
  - White clothing
  - Black clothing
- Cyclist
  - White clothing
  - Black clothing
- Static Pedestrian
  - White clothing
- Tire Tread
- Children's Bicycle

Black Clothed Pedestrian

Black Clothed Cyclist

White Clothed Cyclist

White Clothed Pedestrian

Children's Bicycle

Tire Tread

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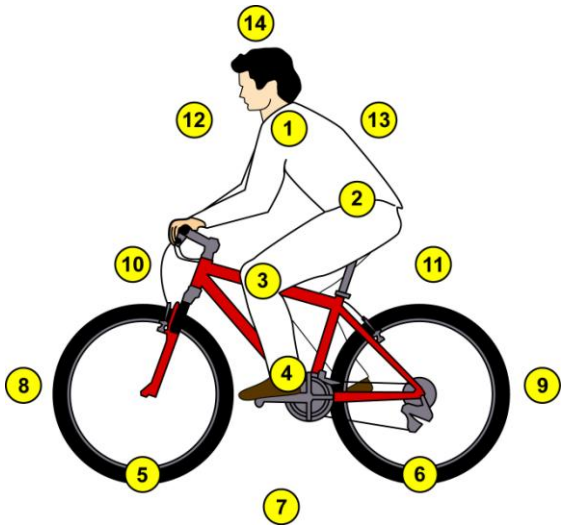
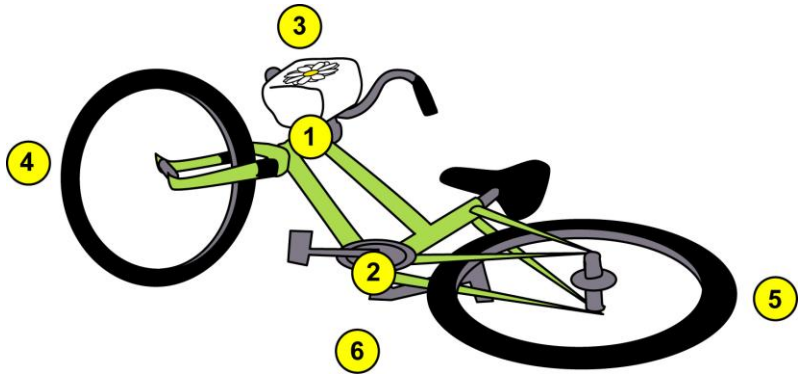
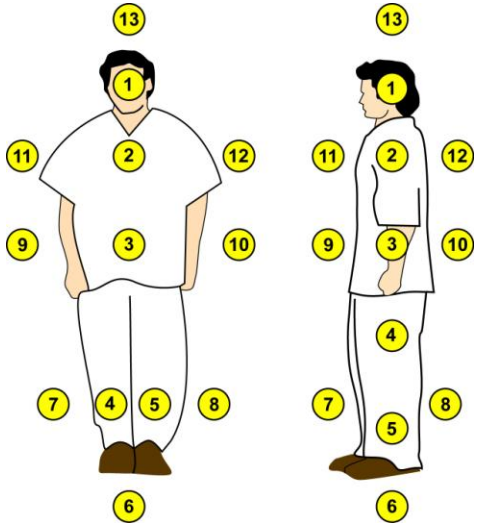
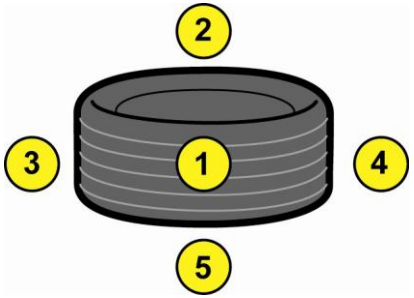
Measurement Locations









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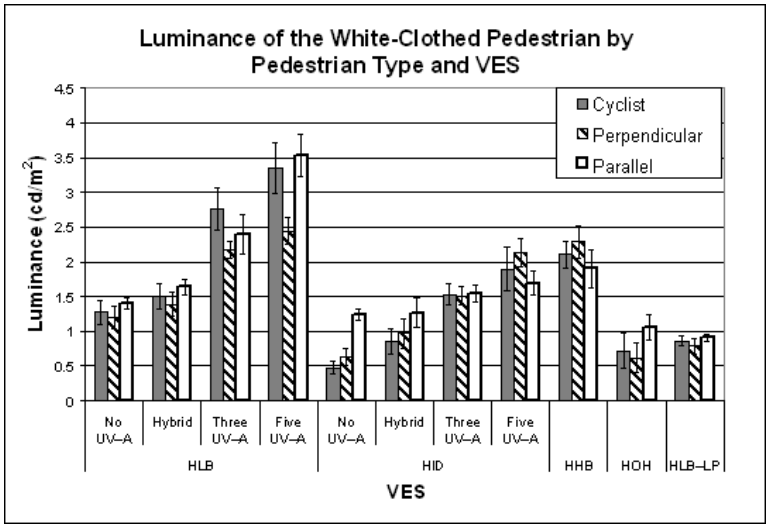
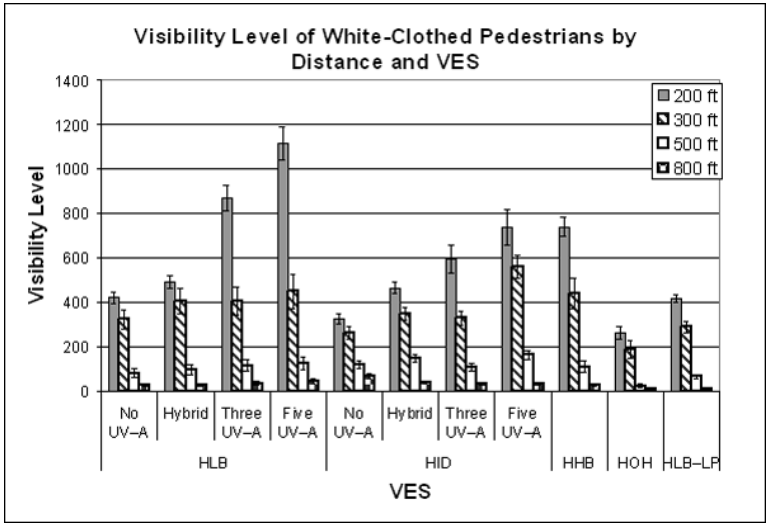
Results

- From this data, contrast, reflectance, fluorescence, Visibility Level and Weber Ratio were all able to be calculated
- These results were then able to be compared and correlated to the human factors testing results
  - Weber Ratio appeared to provide the highest correlation at threshold





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Issues with the Traditional Methods

- Equipment
  - Many luminance meters have high uncertainties
  - The Pritchard is bulky and difficult to use in the field as it requires more electricity than can be provided by the vehicle
- Time
  - A single measurement system is time consuming to use to develop comprehensive measurements
  - The ENV testing process took four weeks of staff and resource time

Traditional Mindset

- Traditional thinking is that you aim the photometer at an object and get a measurement
  - Objects do not have a single luminance but a range of luminance and contrasts which are not captured by traditional means
- New technologies allow us to consider these variations in a much broader scale

New Technologies

- The greatest development in photometry may be the use of CCD technology to allow us to consider the entire scene rather than just a single component of it
- FHWA owns a Radiant Imaging Prometric CCD Photometer which is used by VTTI and TTI for visibility research
  - 1024x1024 16 bit full color CCD
    - 1,000,000 measurements vs. 1 with a conventional photometer

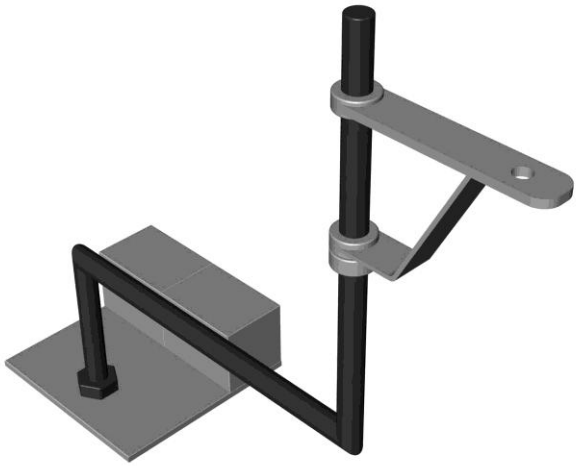
CCD System

- Calibration
  - The CCD array has a field calibration applied for each pixel
  - This field calibration changes with each lens and aperture used
  - The impact of the exposure time is assumed to be linear.
- Sensitivity
  - The array is sensitive to a wide range of luminance
    - Adjusting the exposure time allows for an infinite capture
  - The 16 bit capability in the CCD limits the max\min ratio of luminance in the image to 1:64000 (1:40000 functionally)
- Communication and Power
  - Initial systems required a desktop PC and a 17inch screen
  - New USB2 versions allow for Laptop Usage
  - Requires 110 volt power for the Camera
    - Current requirements are low enough for the use of a 300 Watt in-vehicle inverter

In Vehicle Usage

- The CCD system can be placed in the vehicle and then used from the passengers seat
  - Images show an earlier version with desktop PC and tripod
  - Two vehicles were required because of the power requirements

The Auto-Pod ™

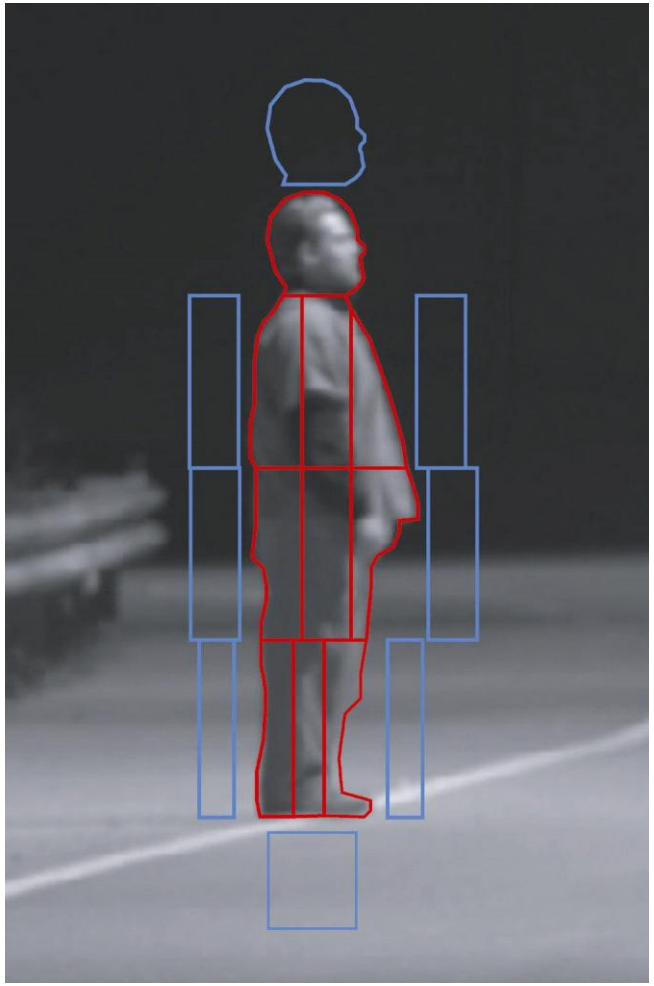


- The Auto-Pod ™ was developed to allow the driver to be sitting their seat with the camera in the typical observer location
- The vehicle can be driven with the camera installed
  - Only by staff members on a closed course

Analysis Software

- The images can be analyzed post-hoc using the software provided with the system

Analysis Options



- The system allows for individual assessment of each pixel as well as the consideration of areas
  - The object can be subdivided and considered in each case individually
  - In this example, red areas indicate the foreground (Object) measurement and the blue are background

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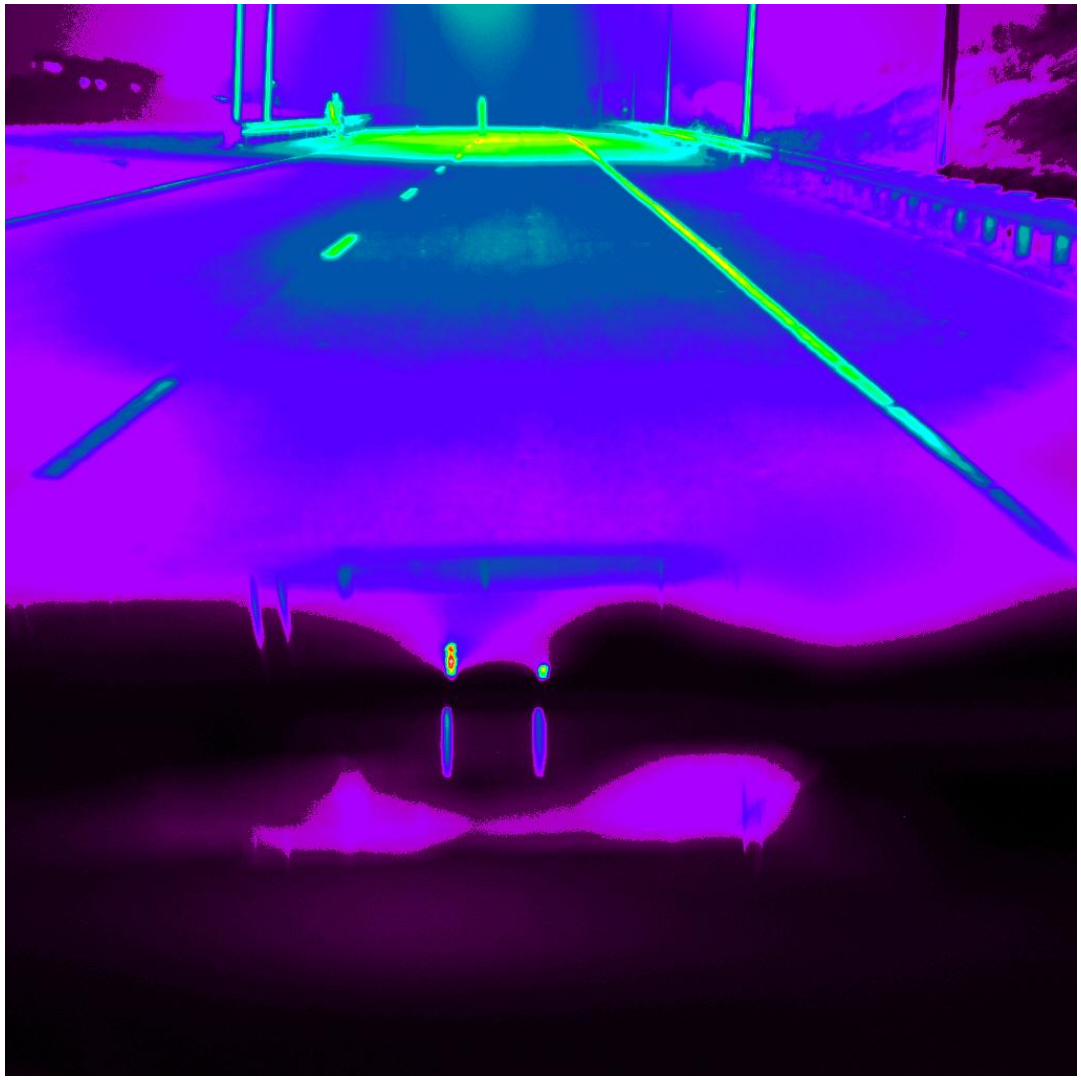
Luminance Zones



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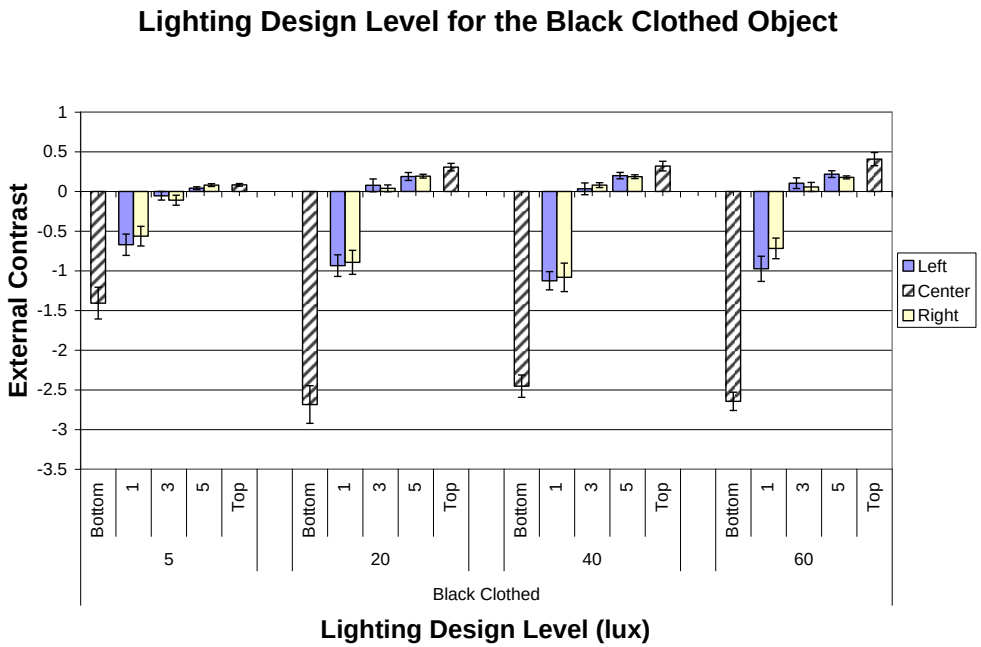
Contrast Consideration

- Allows for a greater analysis of the actual lighting condition of all of the object and the background

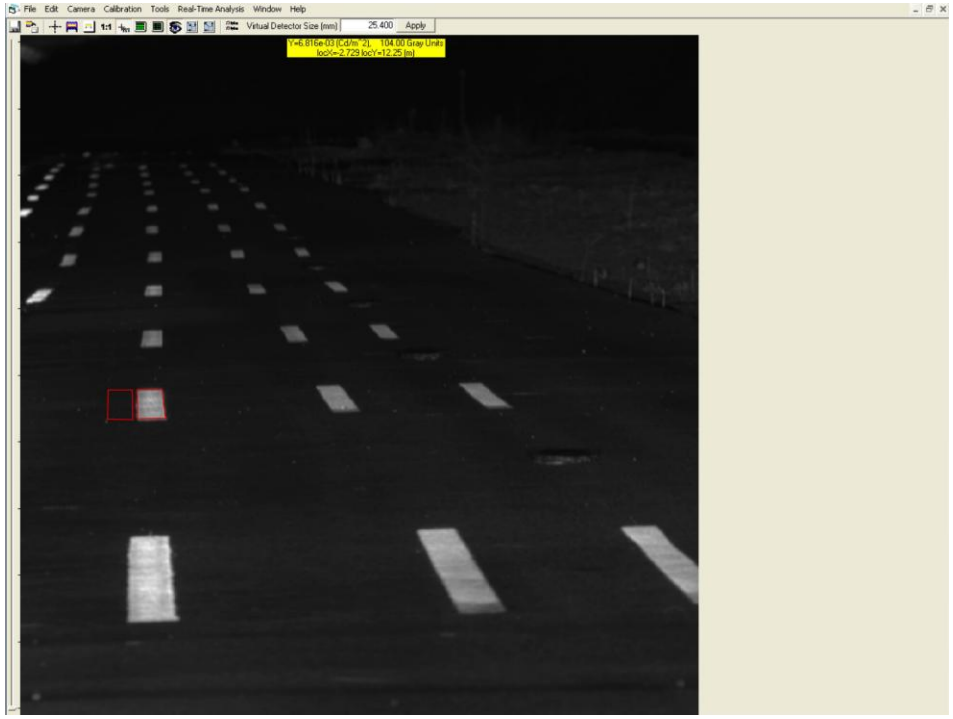
Example Projects

- Crosswalk Lighting
  - Each object used for the crosswalk lighting project was analyzed in terms luminance, contrast and Visibility Level
  - Was able to determine the impact of contrast at varying light levels and object heights and explain the impact of overhead lighting on the object visibility



Example Projects

- Wet Visibility of Pavement Markings
  - The luminance of the pavement markings at threshold was able to be determined for each participant as the rating were being performed
  - Used to establish the required retroreflectivity for detection.



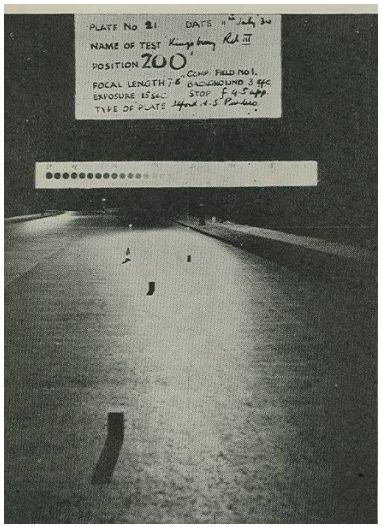
Examples

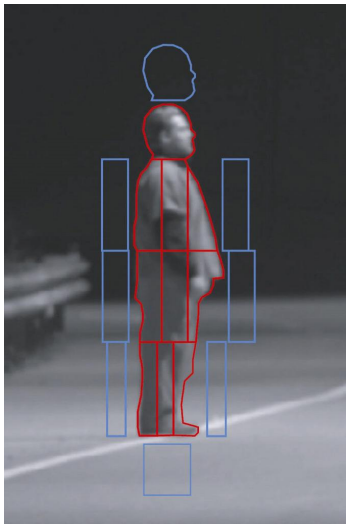
- Billboard Study
  - The luminance of a series of billboards within the City of Cleveland was investigated
  - The CCD photometer was mounted in a vehicle which was driven to various sites and images were taken from the shoulder of the road
  - In all Seventy Seven different images were taken within a period of 3 hours including the driving time

Benefits of the CCD Technology

- Speed
  - Results which required 4 weeks have been reduced to 2 nights of imaging and 4 days of post-hoc in office analysis
- Content
  - The data is rich with opportunities for greater understanding of the visual environment
- Analysis
  - The shape and the size of the detection field is determined in the software analysis and is not limited

Return to the Beginning





- One thing to note:
  - We have returned to the same system used in 1934 by Waldram
    - Photographic images

The Future

- Image Processing Techniques
  - We may be able to tap into different technologies for the analysis of the images to provide greater tools for visibility analysis
- Live Photometric Video
  - There is a need for a mobile photometer which takes live imaging video that can be analyzed for luminance
  - This tool could then be used for analysis of the visual scene as we really see it – in a dynamic environment

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Fourier Analysis

- Image Processing may unlock some of the keys to understanding the visual process in a dynamic environment

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Outlook

- New technologies are taking us beyond a single number/single measurement world
- We will soon be able to fully measure the luminance environment that we live in
- This should lead to an even greater understanding of the visual processes behind driving, walking and living