Bright, Chromatic and Distinct
-
Perception and Detection of LED-based Airfield Lighting

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Sara Bergsten, PhD, Optical Designer

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Outline

- Perception of LED-based versus Halogen lamp lighting
  - Bright
  - Chromatic
  - Distinct

- Detection of LED-based ligthing
  - near-infrared region — Night Vision
  - mid-infrared region — Enhanced Flight Vision Systems
  - far-infrared region — Thermal Imaging, FLIR

- Discussion and Conclusion

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Bright

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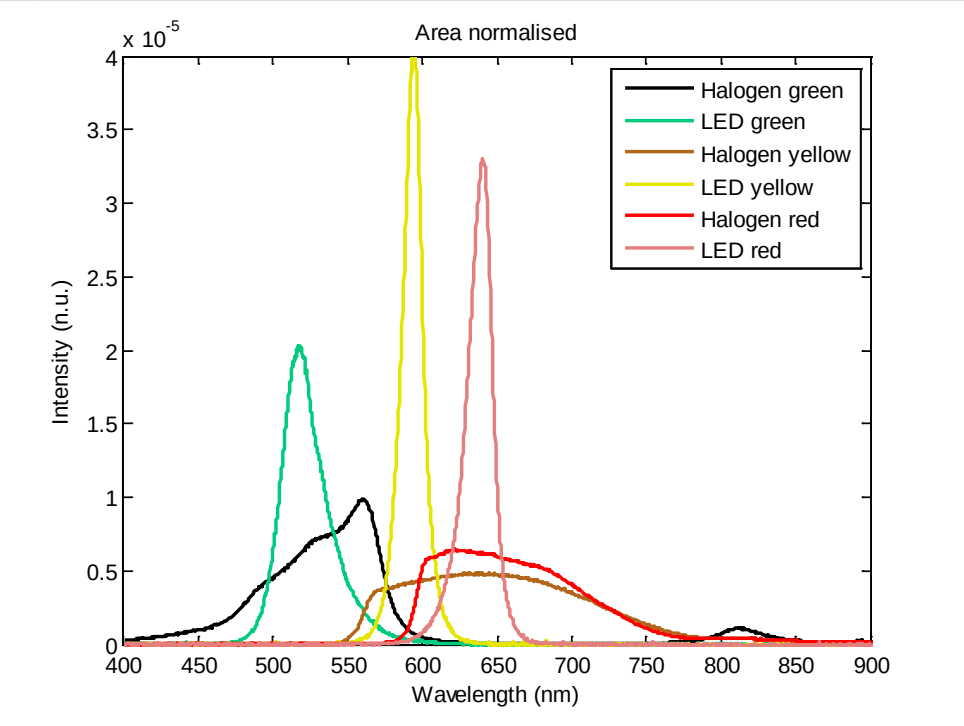
Bright

- Helmholtz-Kohlrausch effect
  - Described by Kohlrausch in 1947

- *"As a stimulus becomes more chromatic at constant luminance, it appears brighter"* Fairchild, M. *Colour Appearance Models*, First Edition, Addison-Wesley, Massachusetts (1998)



* Not corrected for detector spectral response

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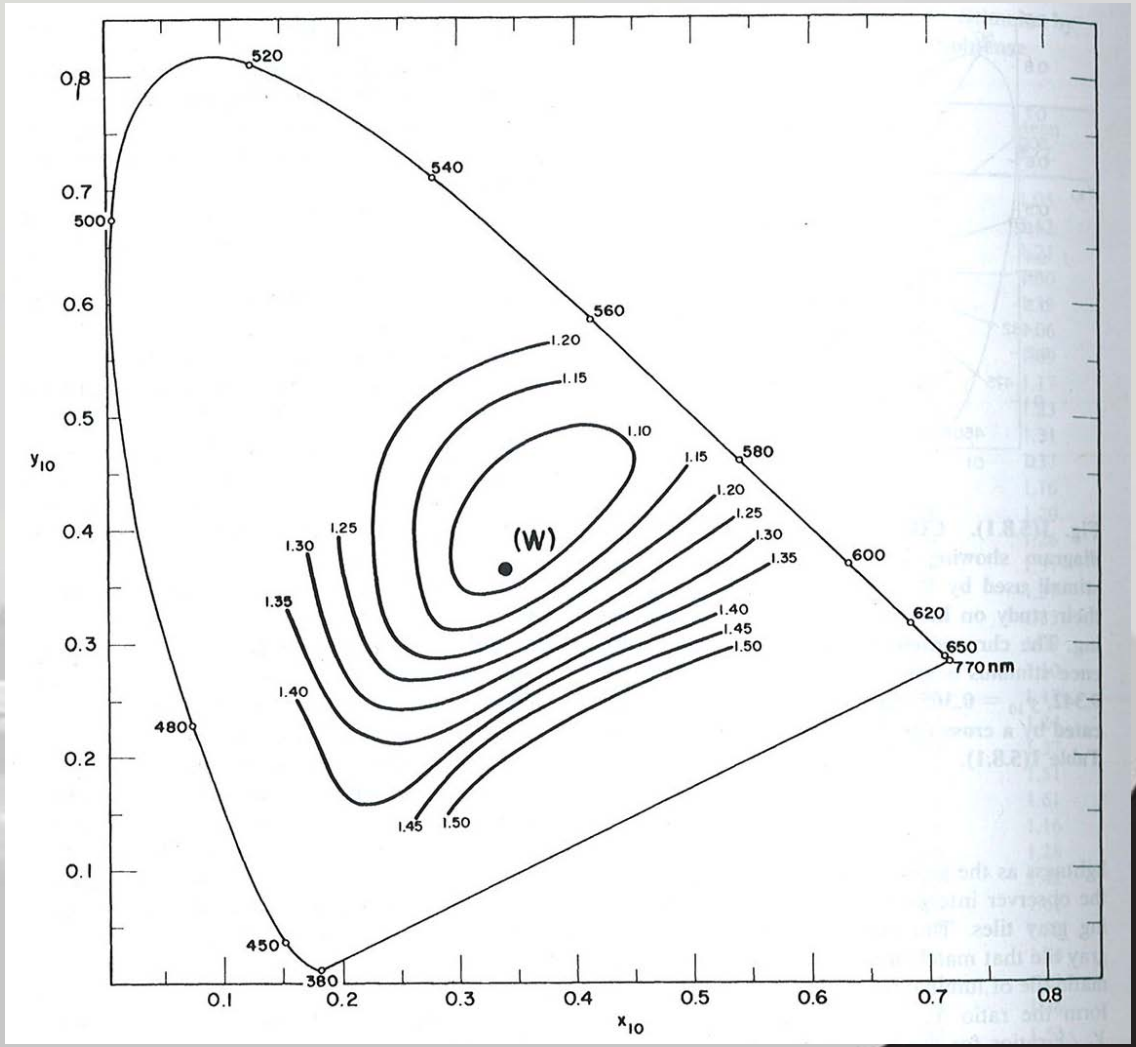
Bright

- Wyszecki 1964



Wyszecki & Stiles, Color Science, Second Edition, 1982

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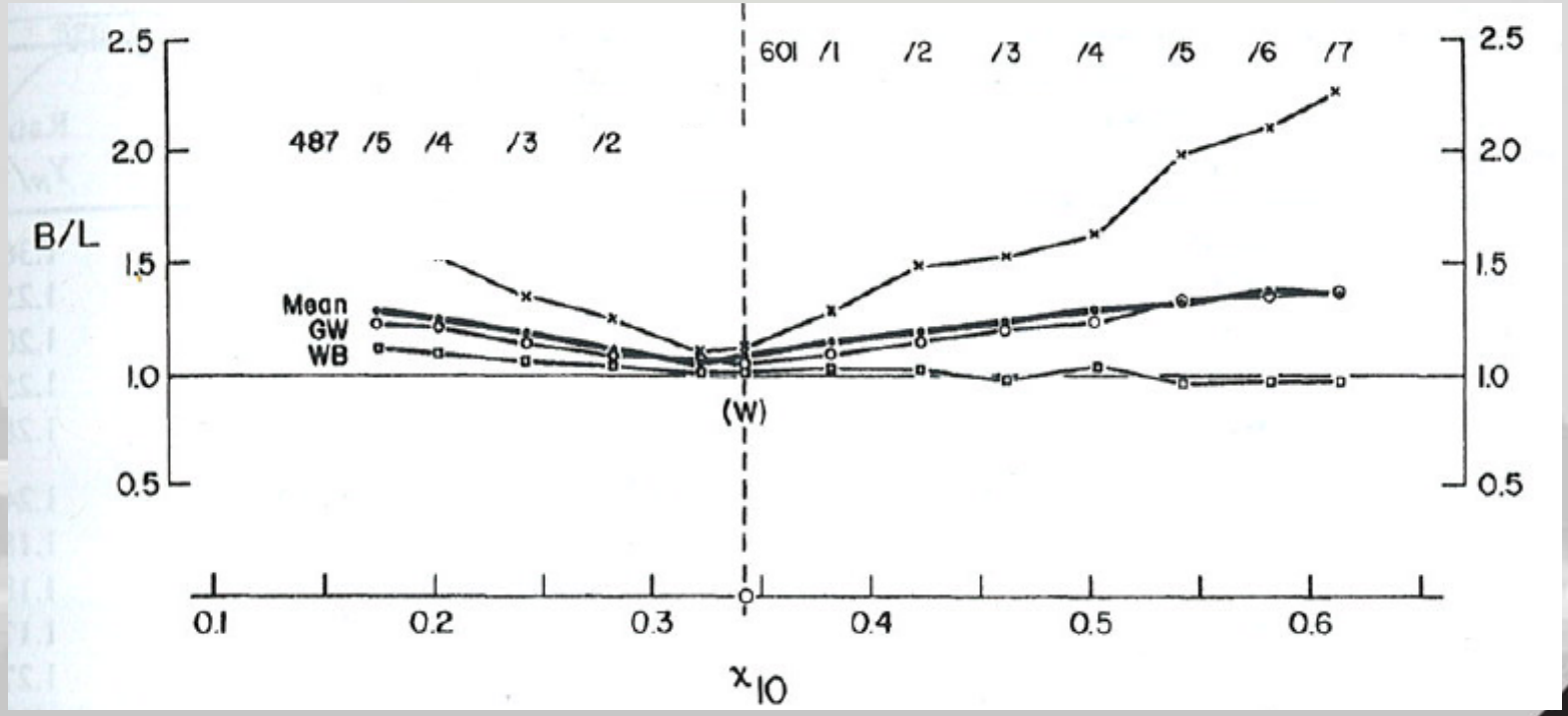
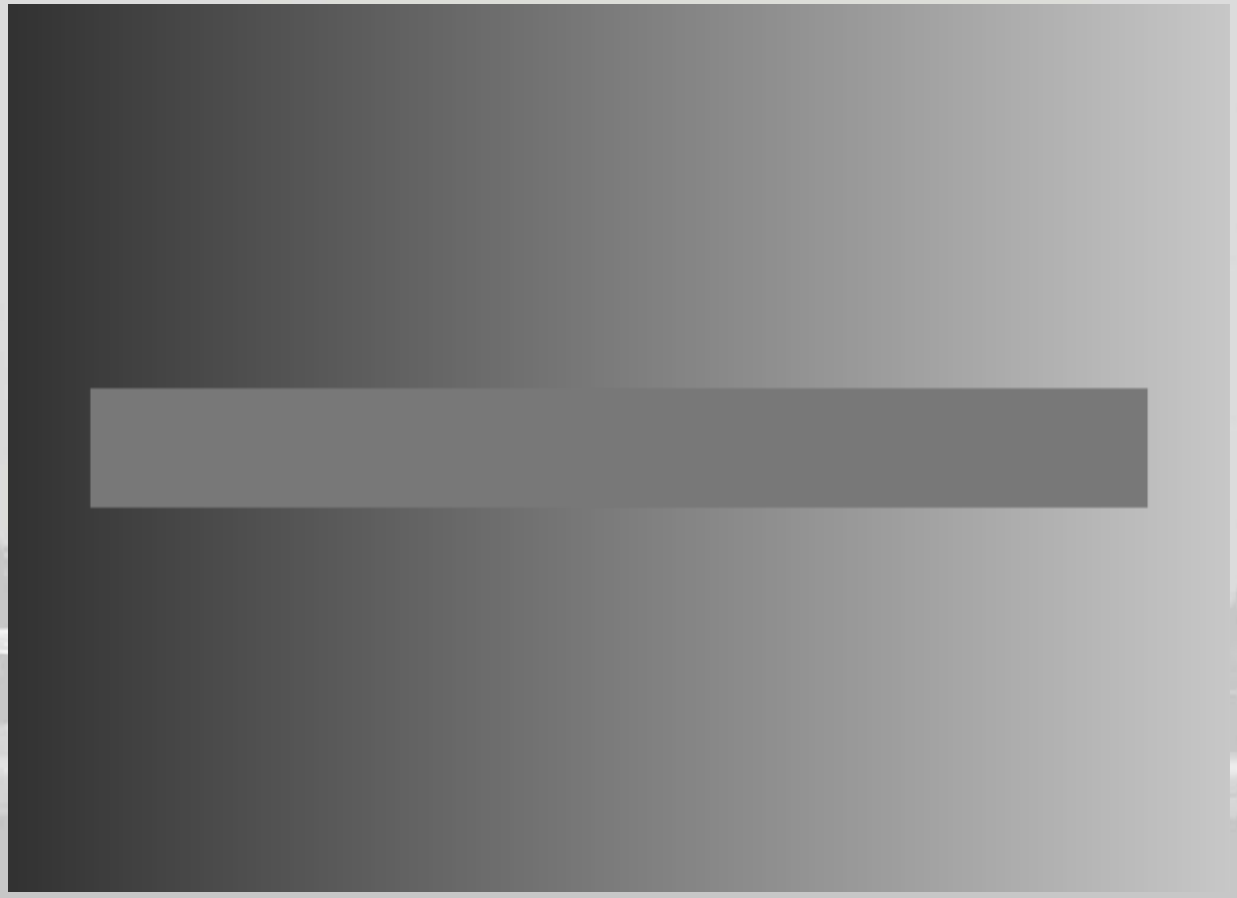
Bright

- Increasing variance with distance from reference
- Large variance between individuals



Wyszecki & Stiles, Color Science, Second Edition, 1982

Optical Illusions



Simultaneous Contrast Illusion
The brightness is adjusted to the sorroundings

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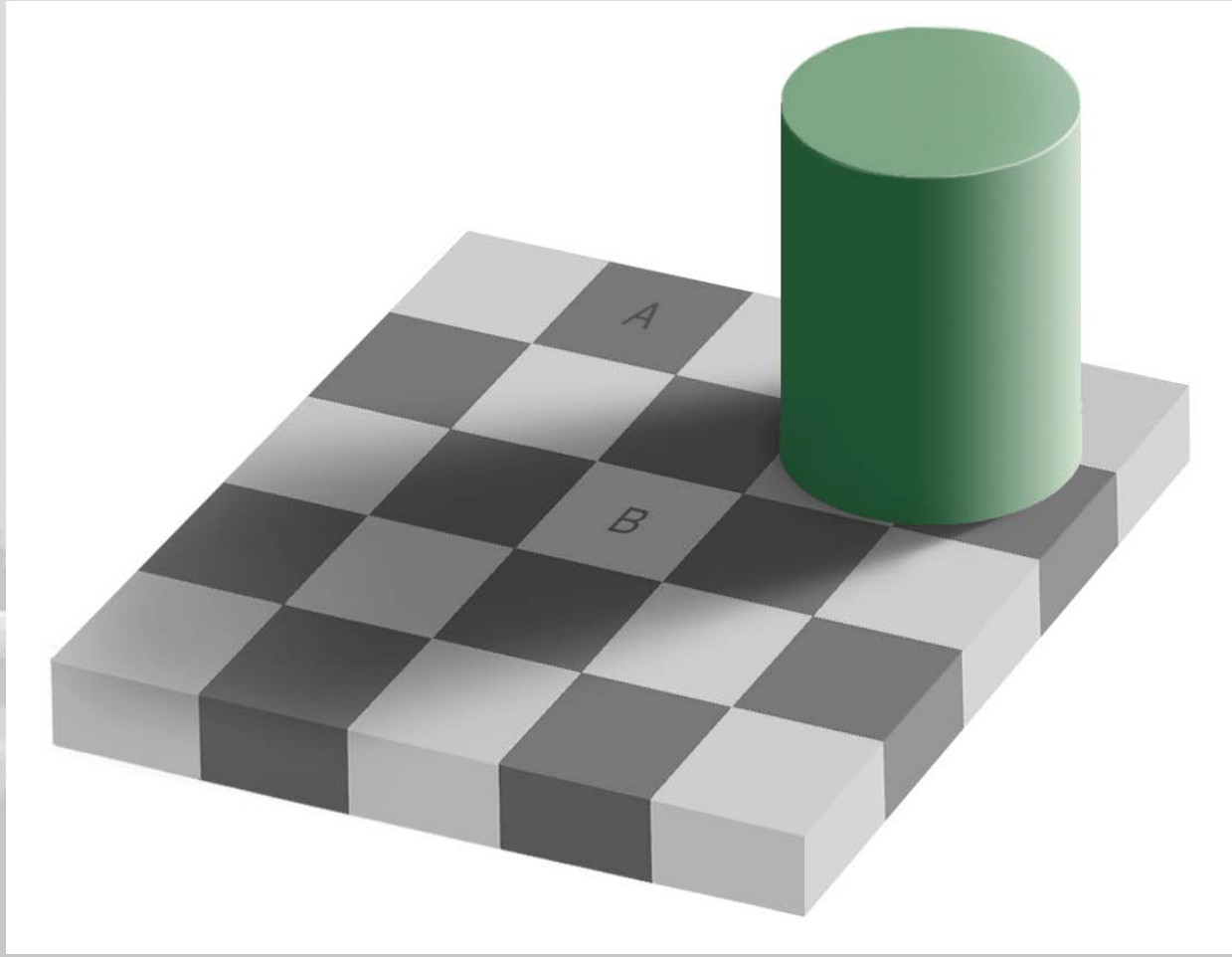
Optical Illusions



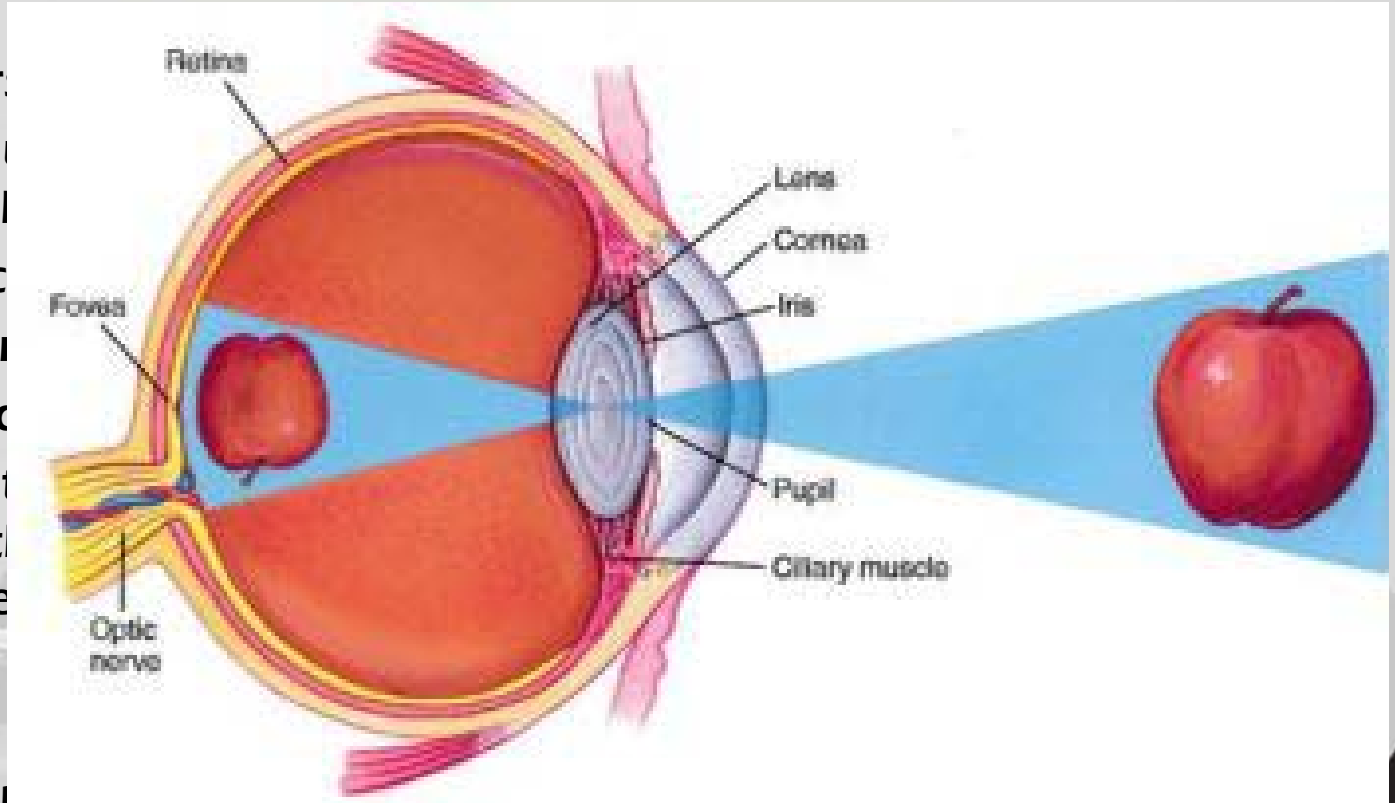
Same colour illusion
A and B have the same shade of grey

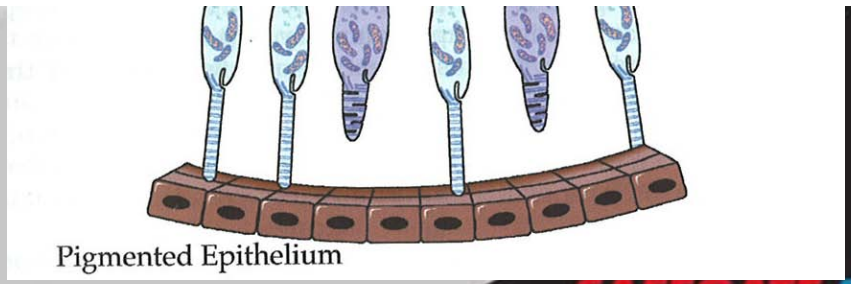
Optical Illusions

Opponent colour theory
Automatic gain control

Human Vision

- Absorbance in
  Cone Receptor
- Signals picked
  different cells,
- Connected in c
  - Contrast e
  - Visual proc
- Ganglion cells
  the signals to t
  where they are
- Complex steps
  functions => Op
  illusions





Fairchild, M. *Colour Appearance Models*, (1998)

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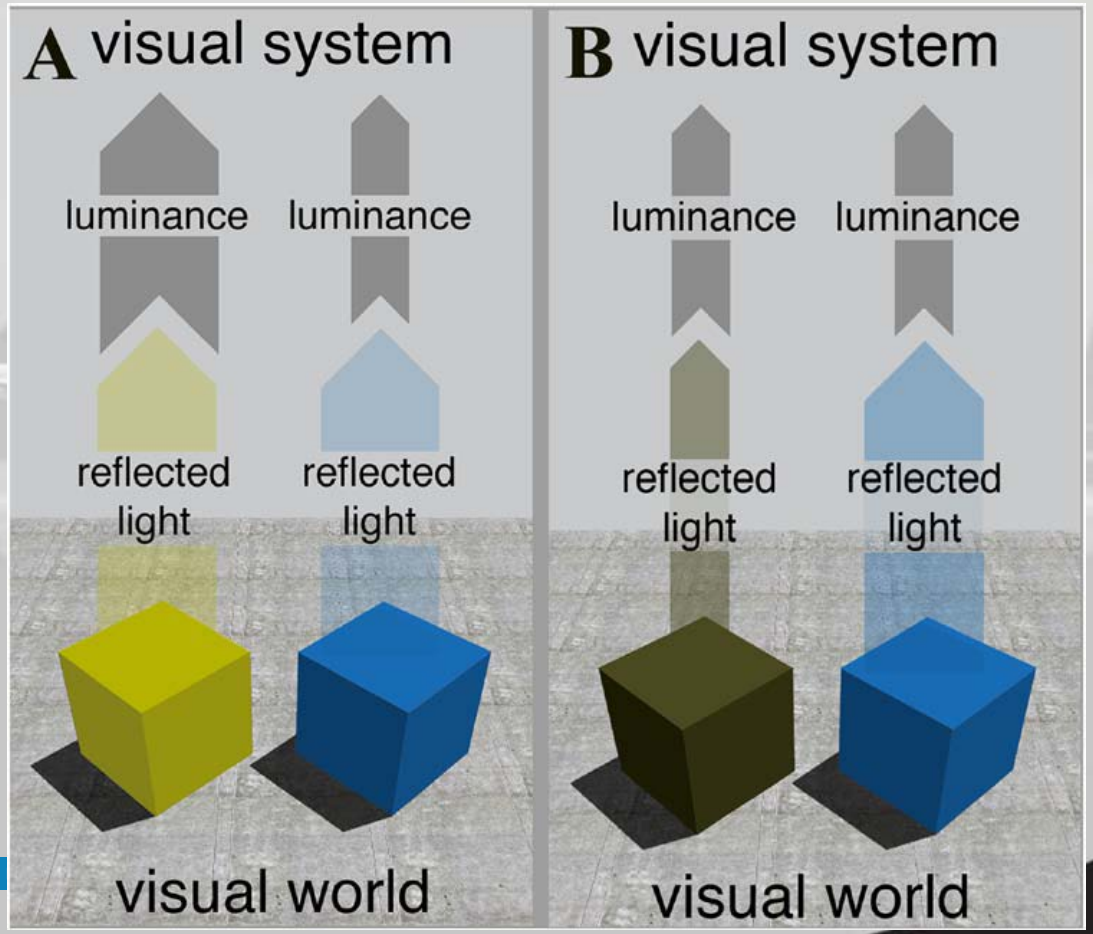
Bright

PLoS one
accelerating the publication of peer-reviewed science

The Brightness of Colour

David Corney[1], John-Dylan Haynes[2], Geraint Rees[3,4], R. Beau Lotto[1]*

1 UCL Institute of Ophthalmology, London, United Kingdom, 2 Bernstein Centre for Computational Neuroscience Berlin, Berlin, Germany, 3 UCL Institute of Cognitive Neuroscience, London, United Kingdom, 4 Wellcome Trust Centre for Neuroimaging, University College London, London, United Kingdom



Published 2009
www.plosone.org

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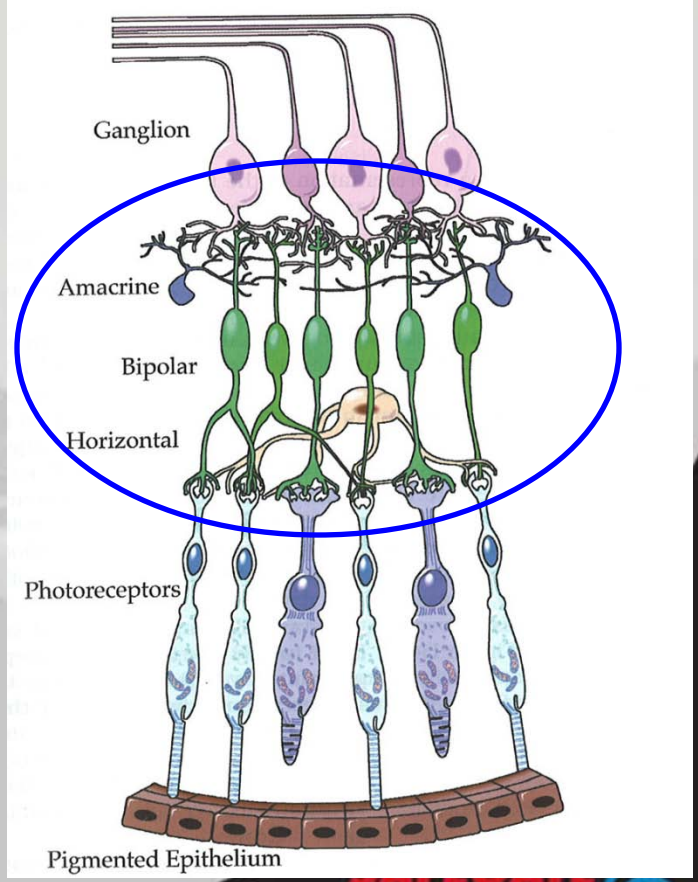
Bright

"The Helmholtz-Kohlraush effect and other "Optical illusions" cannot be explained in fully since the physiology and function of many of the visual receptors and transmitting cells are unknown"

Prof. Almut Kelber, Lund Vision Group,
Department of Cell and Organism Biology
Lund University

LUND UNIVERSITY
Faculty of Science



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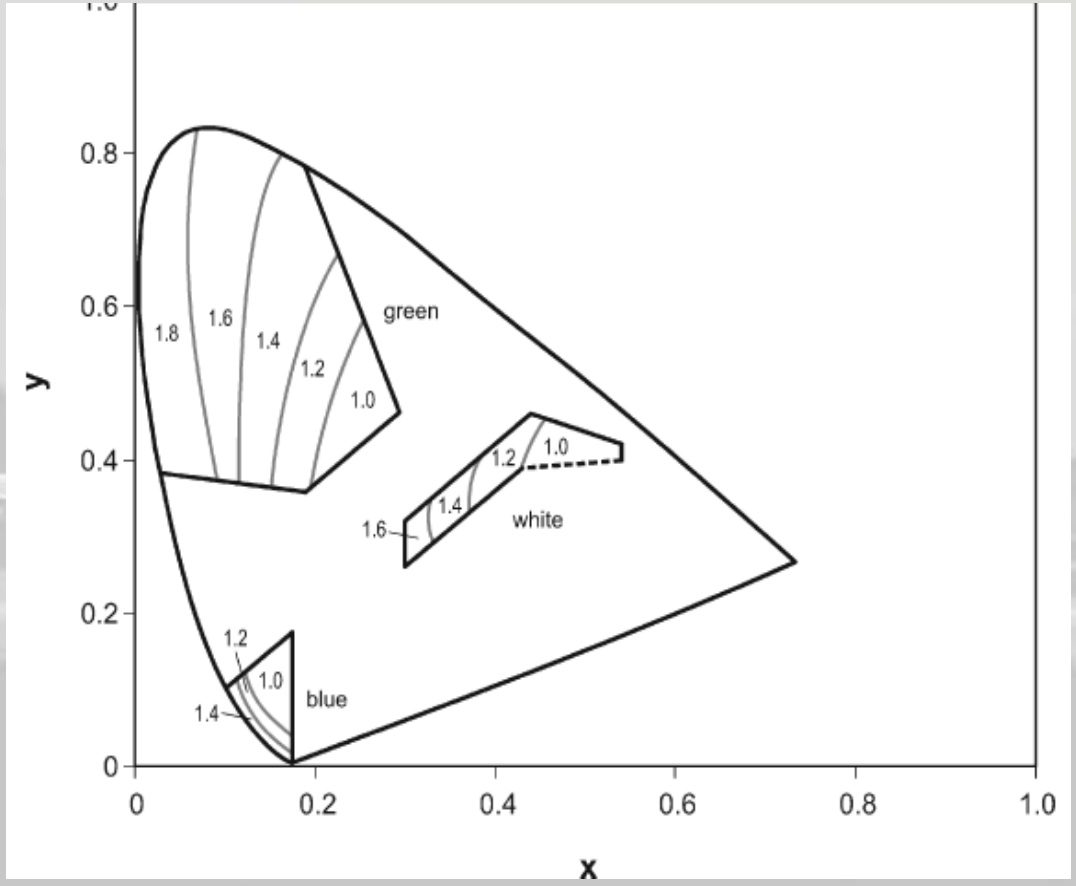
Bright

- FAA investigations, Lighting Research Center www.lrc.rpi.edu
- Blue, Green and White LED versus halogen



Bullough J.D., Yuan Z. And Rea M.S, *perceived Brightness of Incandescent and LED Aviation Signal Light,* Aviation, Space and Environmental Medicine, 78 (9), 2007

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Chromatic

- Colour resolution

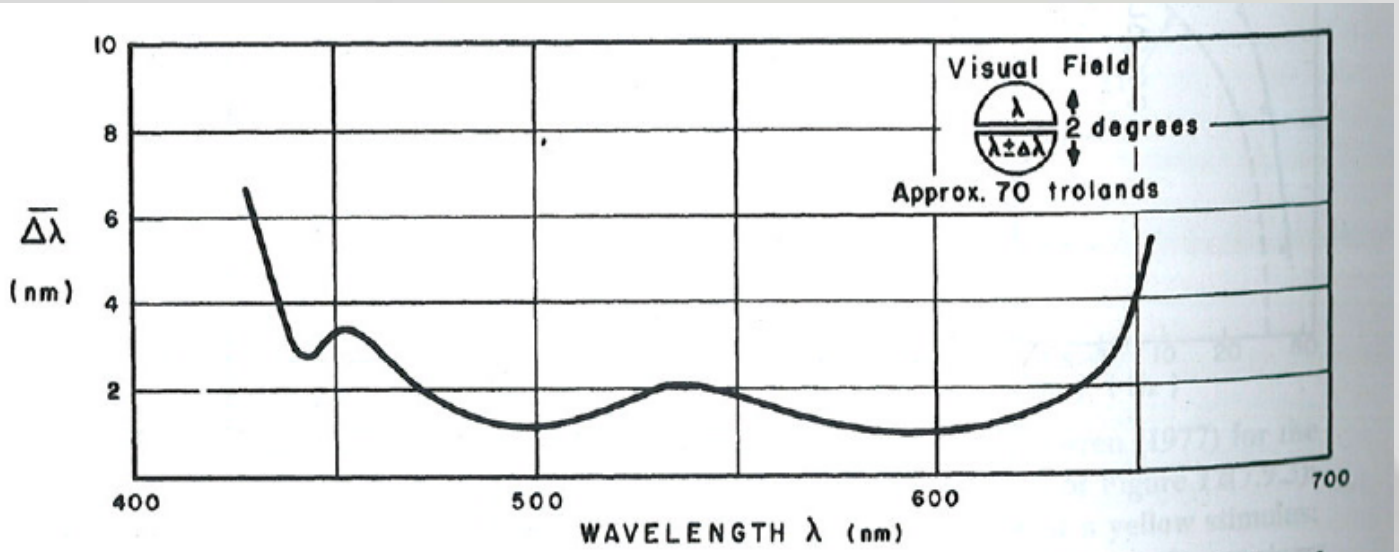
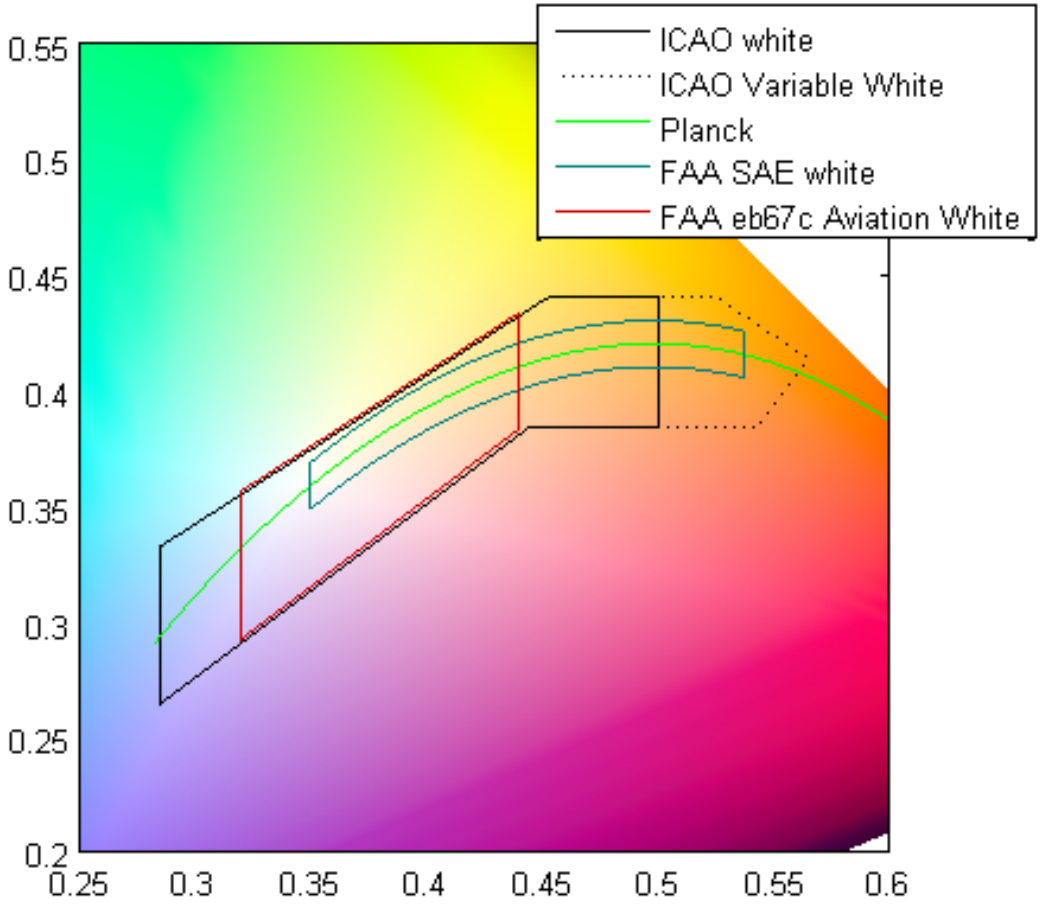


Fig. 1(7.10.2). Wavelength discrimination curve based on observations made by Wright and Pitt (1934).

Wyszecki & Stiles, Color Science, Second Edition, 1982

Vision

- Colour differences are visible
- New specifications in EB67C



Distinct

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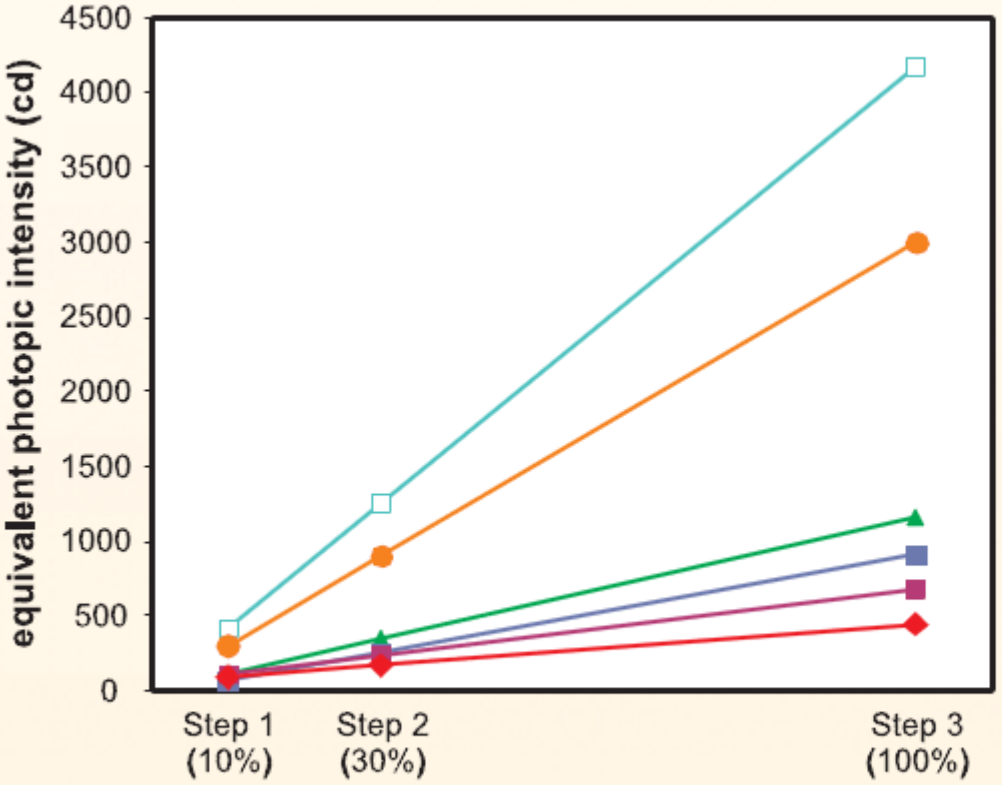
Distinct



The average minimum intensity of LED-based RGLs could be reduced by approximately 60% from the current recommended values.

Lighting Research Center, *FAA Runway Guard Lights,* Lighting Research Center, 2008, http://www.lrc.rpi.edu/resources/newsroom/pdf/2008/FAAGuardLightsR8511.pdf

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Perception of Led-based AFL

- The perceived brightness
  - LEDs appear brighter compared to Halogen lights when they have the same luminous intensity
  - The perceived brightness varies with wavelenght
  - The perceived brightness varies with the individual observer
- With the current colour requirements
  - different colours can be perceived
- Temporal behaviour affecting the perception of the light

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Detection of LED-based AFL

- Human vision limited in spectral range and sensitivity
  - Need enhanchement to see in dark environments
  - Fog , particles – scattering and absorption in visual range

- Changing from Halogen to LED-based AFL – consequences for
  - Military Airfields using Night Vision equipment
  - Detection systems for visualizing AFL through fog

- Technology
  - Night Vision Guidance 0.7-0.9 µm
  - Enhanched Flight Vision Systems 1-5 µm
  - Thermal Imaging 7.5-14 µm

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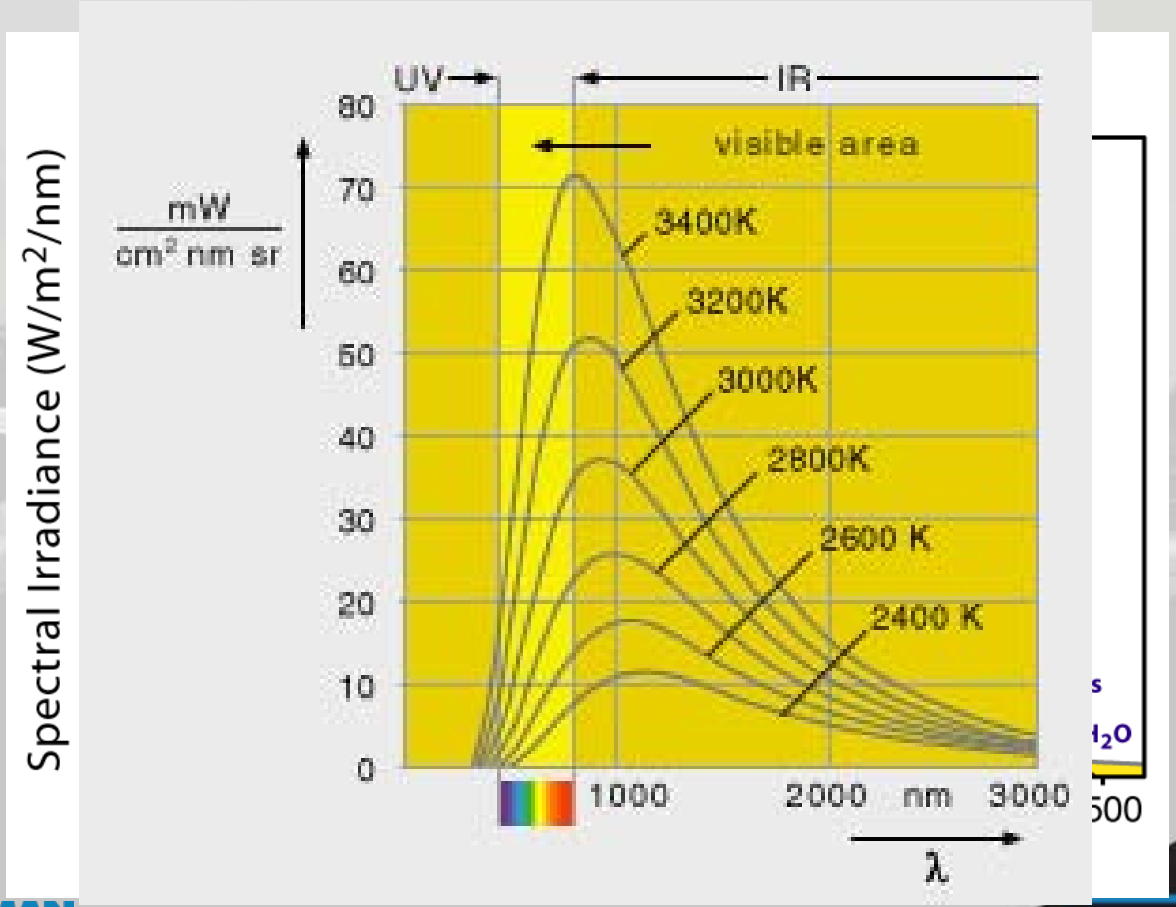
Night Vision

- Detection of solar radiation reflected from the moon
- AFL Halogen Lights, blackbody radiation from the filament



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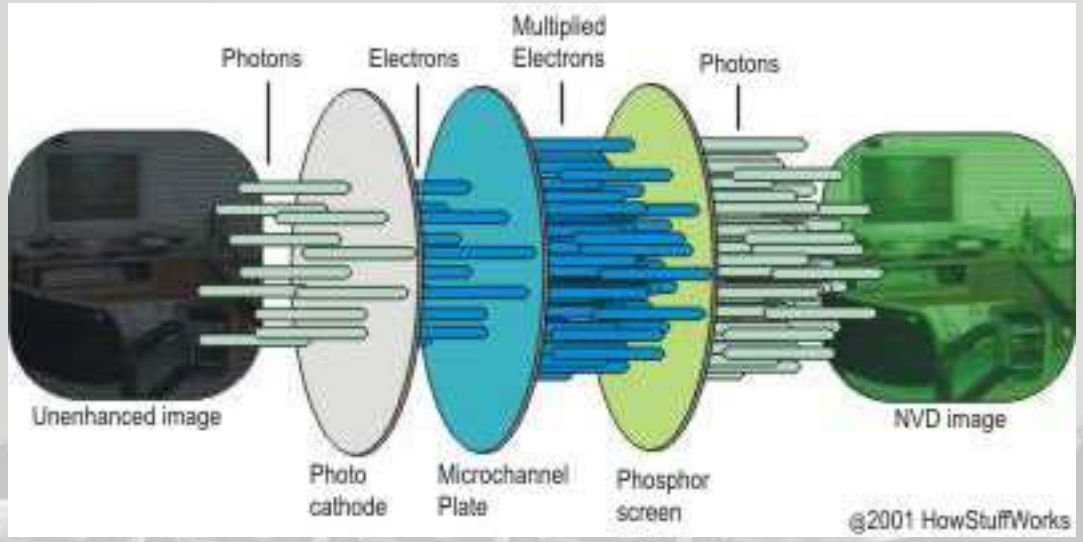
Night Vision

- Image intensifier tube



- Different generations of equipment
- Different photochatode, light intensifying capacity and other improvements

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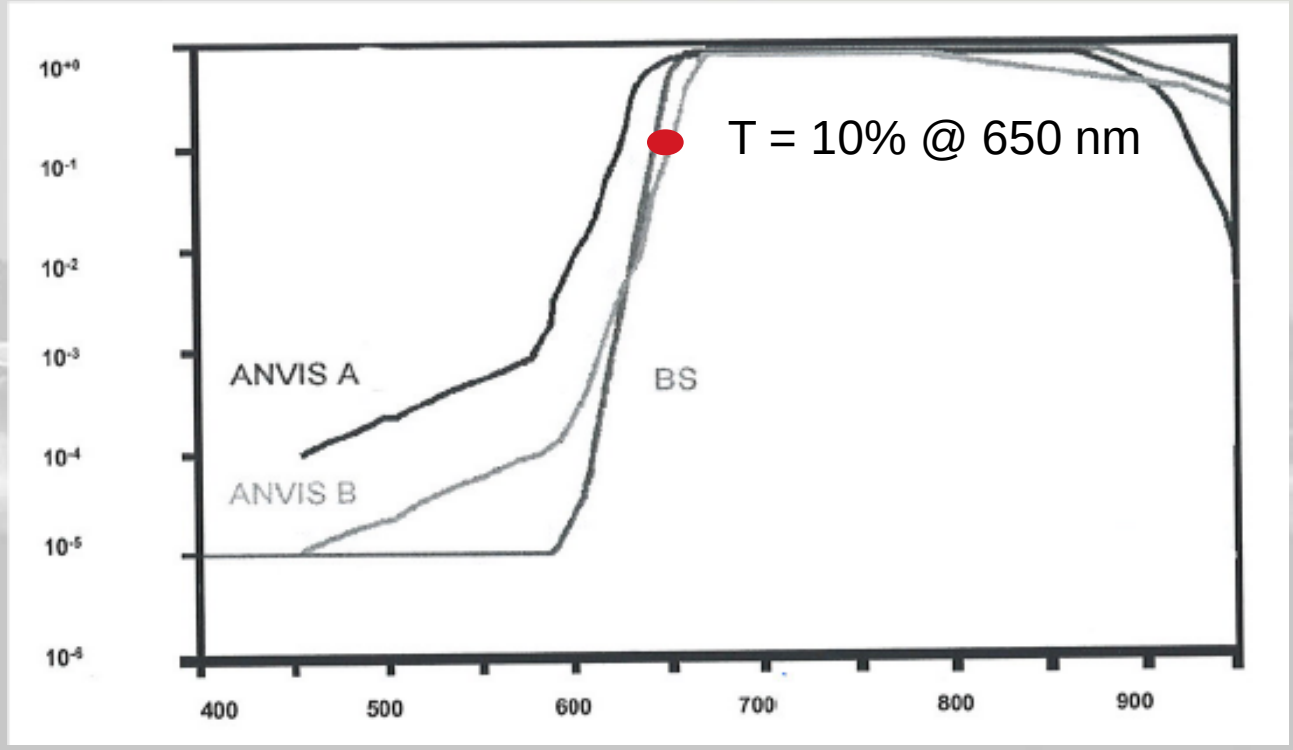
Night Vision

- Standards for filters
  - USA US-MIL-L-85762
  - BS British standard



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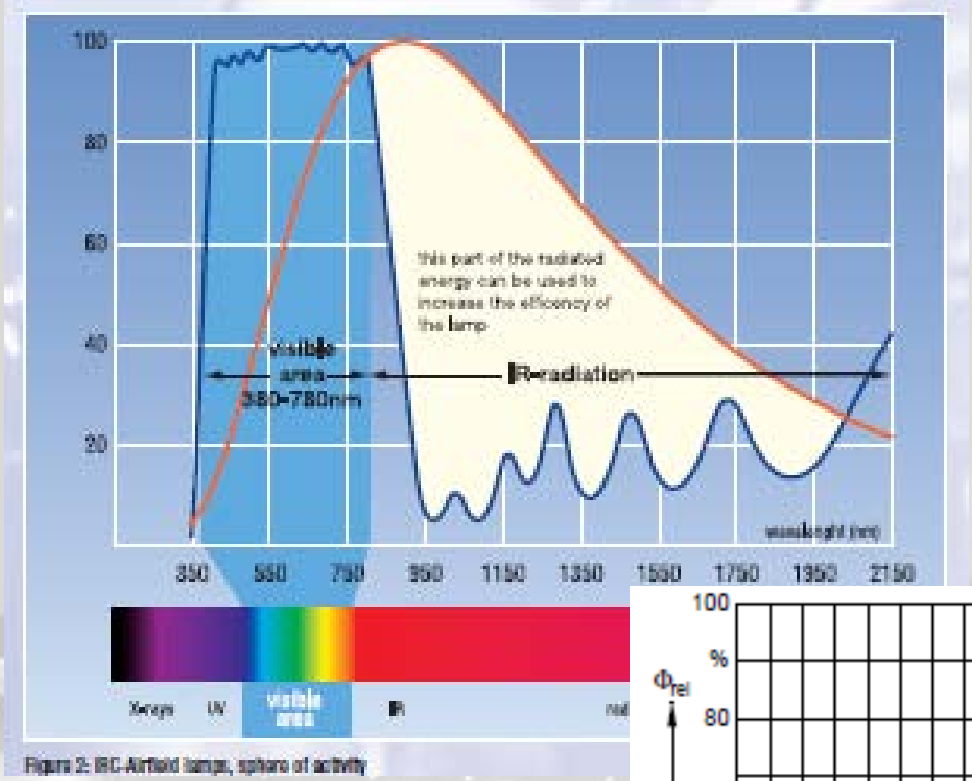
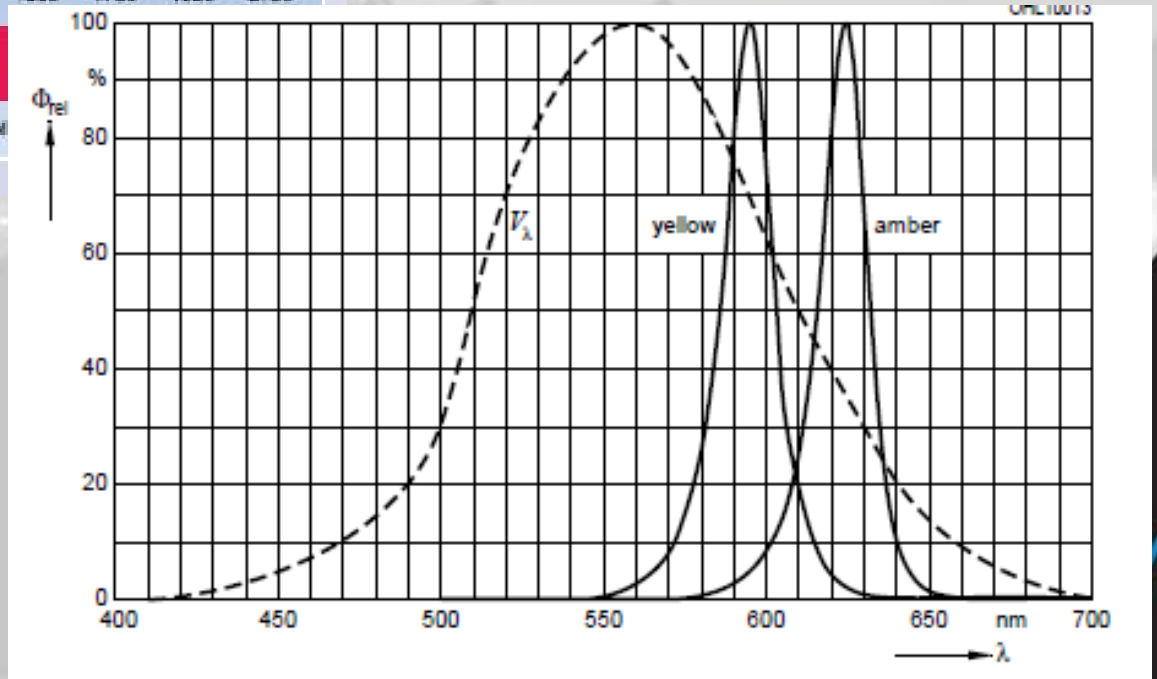
Night Vision Guidance



625 nm



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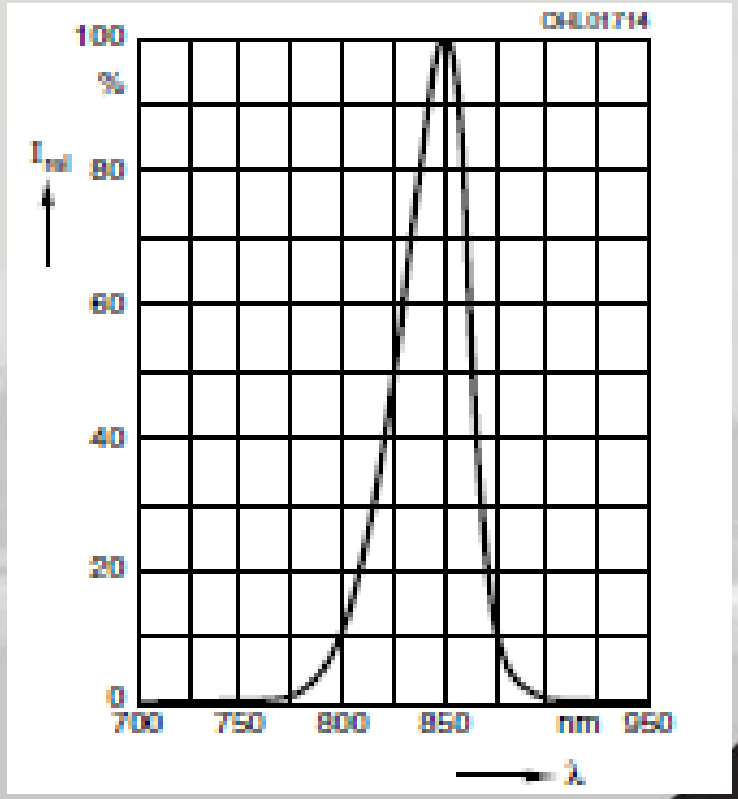
Night Vision Guidance

- Possible Plug-Ins for Night Vision
  - Insert NIR diode
    - 1-3 W at 850 nm



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Night Vision

- Difficult to set up standards
  - Many different NVG equipments with different filters and intensifying magnitudes
  - Vision is different among individuals
- Night Vision Compatible - The NIR plug-in intensity must be controllable

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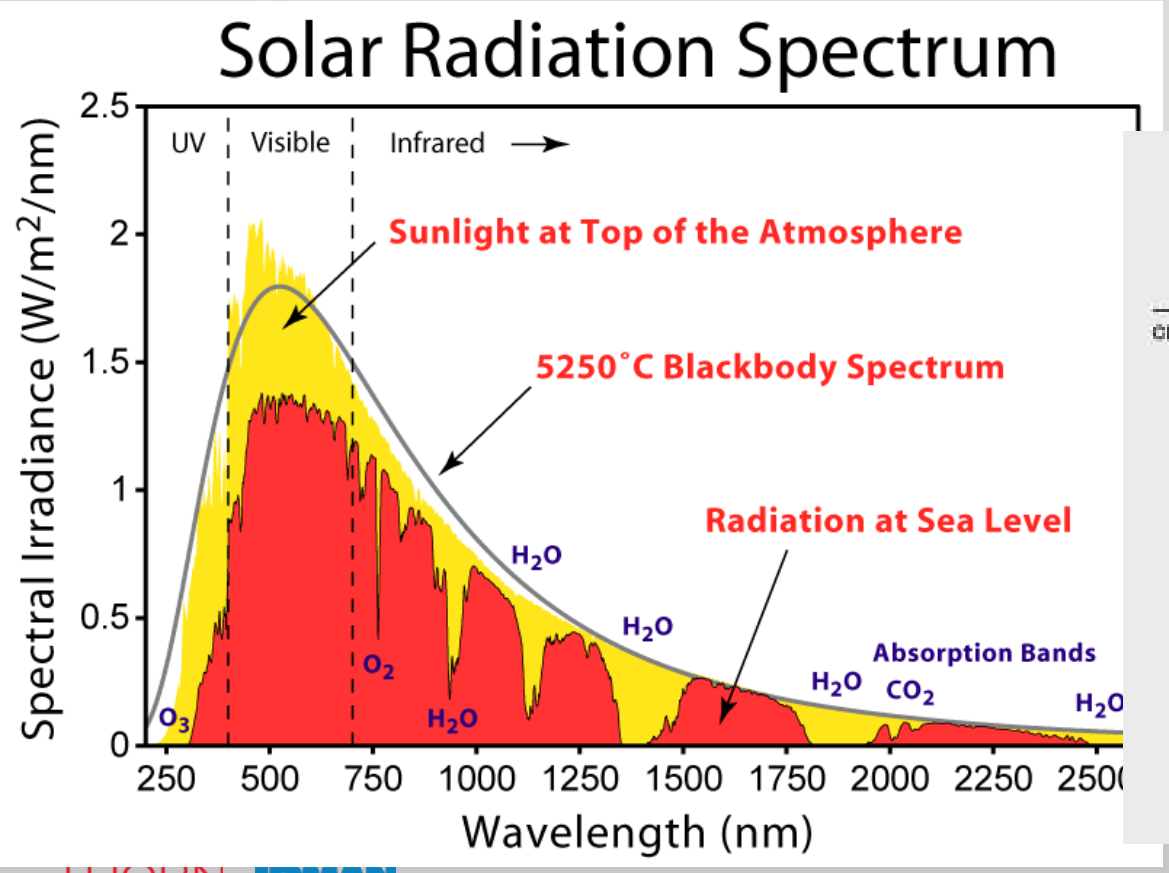
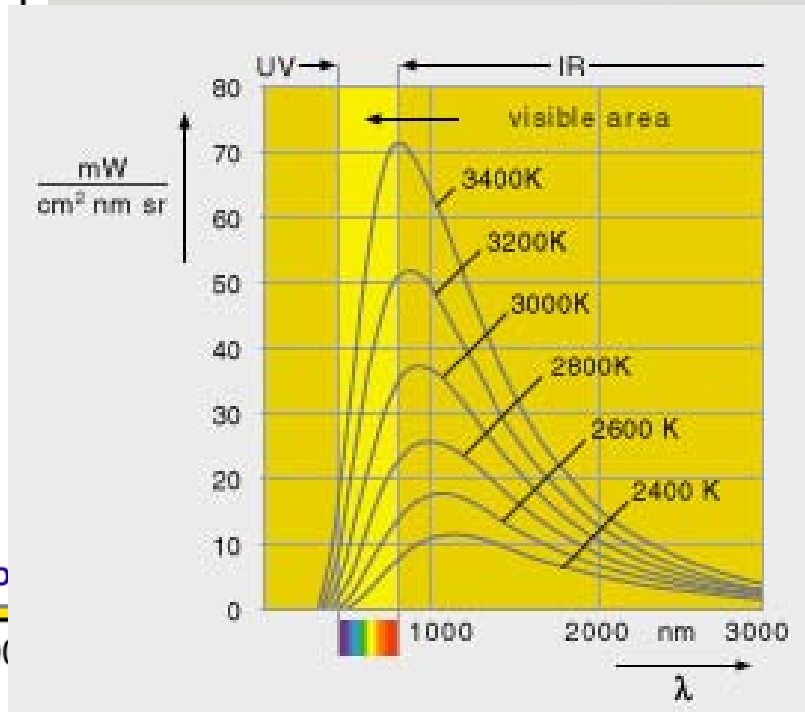
Enhanced Flight Vision Systems

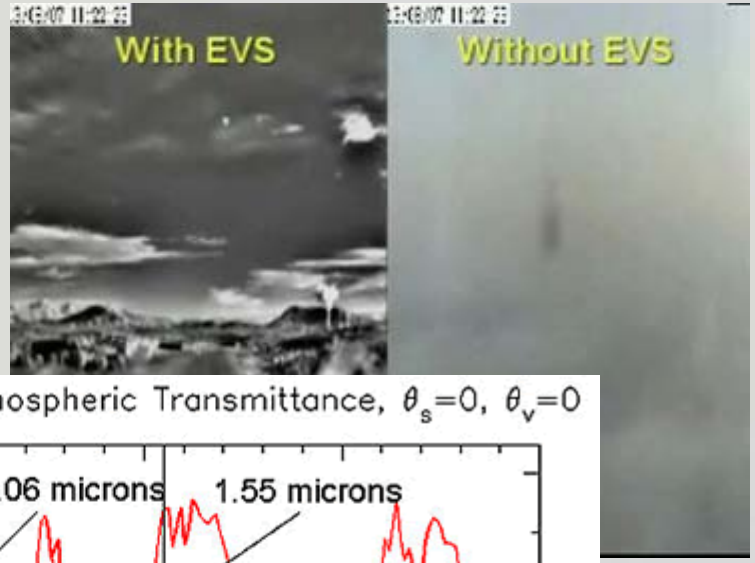
- Imaging of mid infrared light
  - Reflected light from the sun 1-5 μm
  - IR light emitted from halogen–based AFL

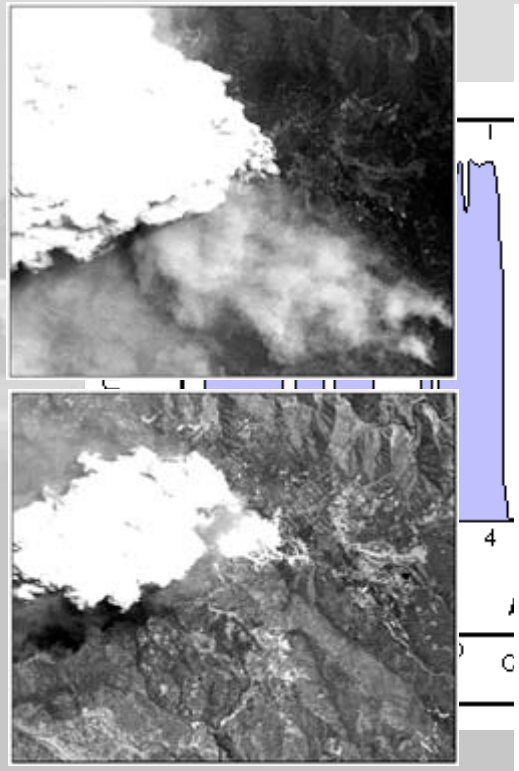


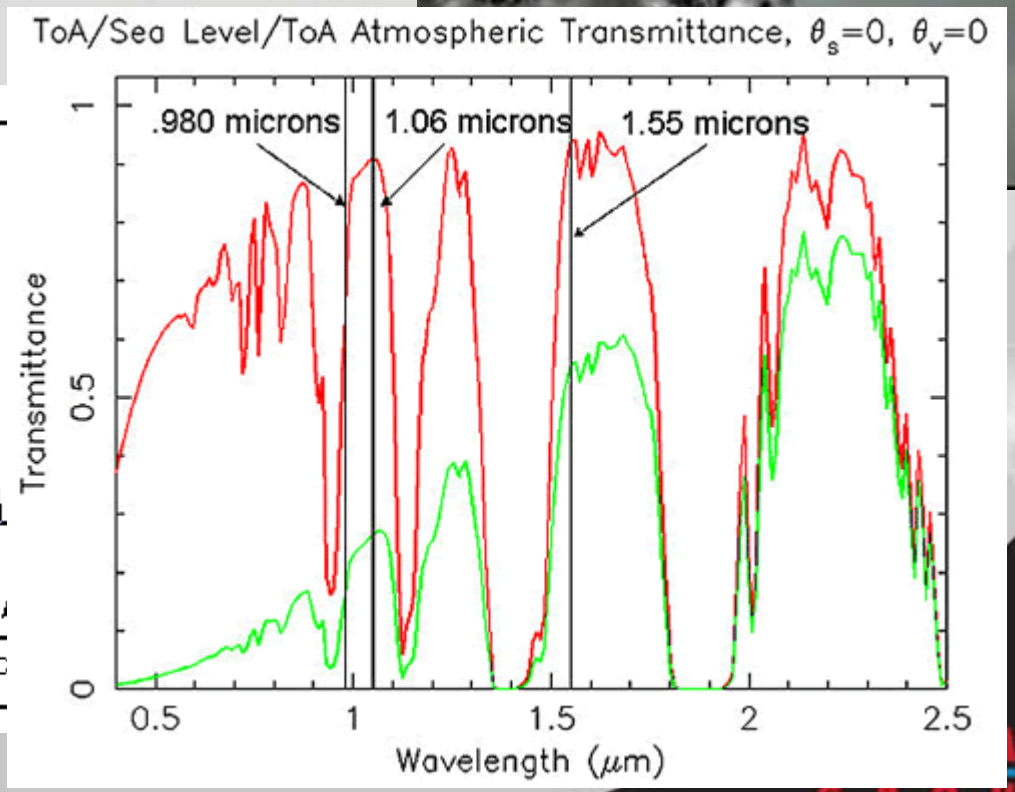


Enhanced Flight Vision Systems

- Detection of Mid-infrared emission
  - Reduced absorption
  - Reduced Mie scattering

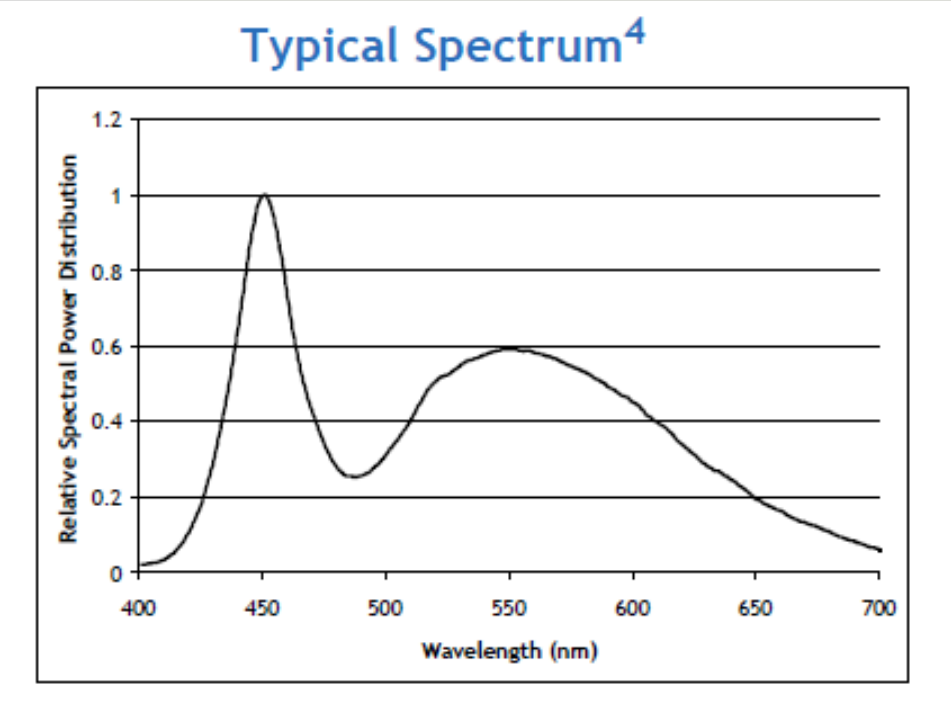






http://www.nrl.navy.mil/fpco/mrr/considerations.php

Enhanced Flight Vision Systems



White LED

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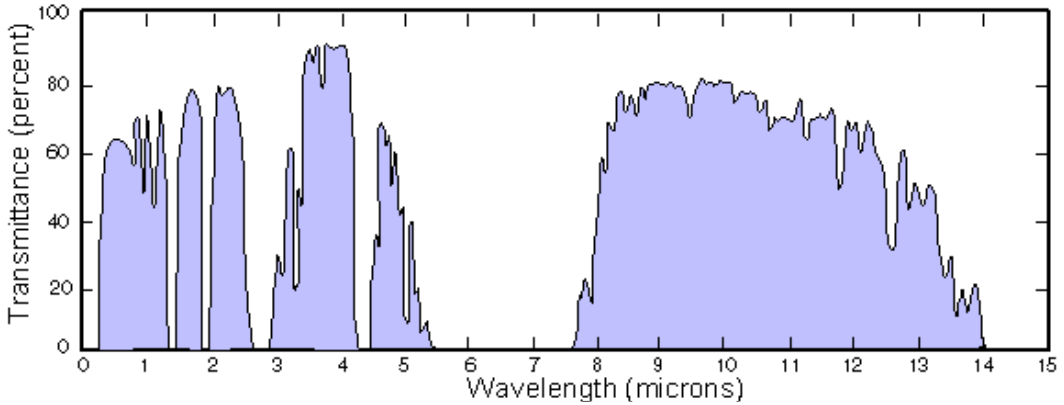
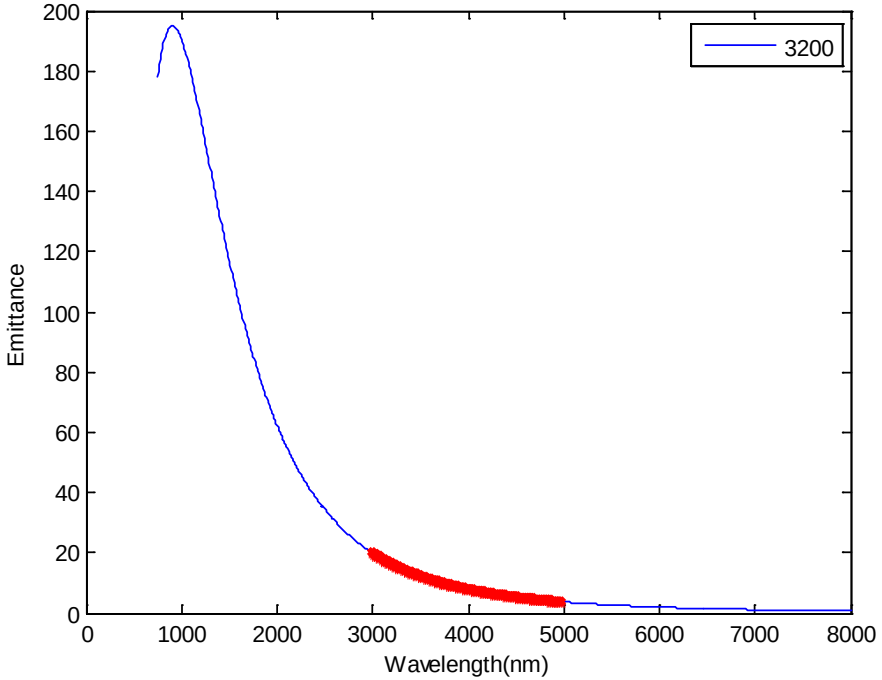
Enhanced Flight Vision Systems

- Possible Plug-Ins for EFVS
  - Wavelength range
  - Power
- Detectors
  - InGaAs 1.3-1.5 μm
  - InSb 1-5 μm
  - HgCdTe 3-5 μm
  - PbSe 1.5 – 5.2 μm
- Power
  - Blackbody radiation
  - 100 W filament, 70W IR
  - 3-5 μm 6 W





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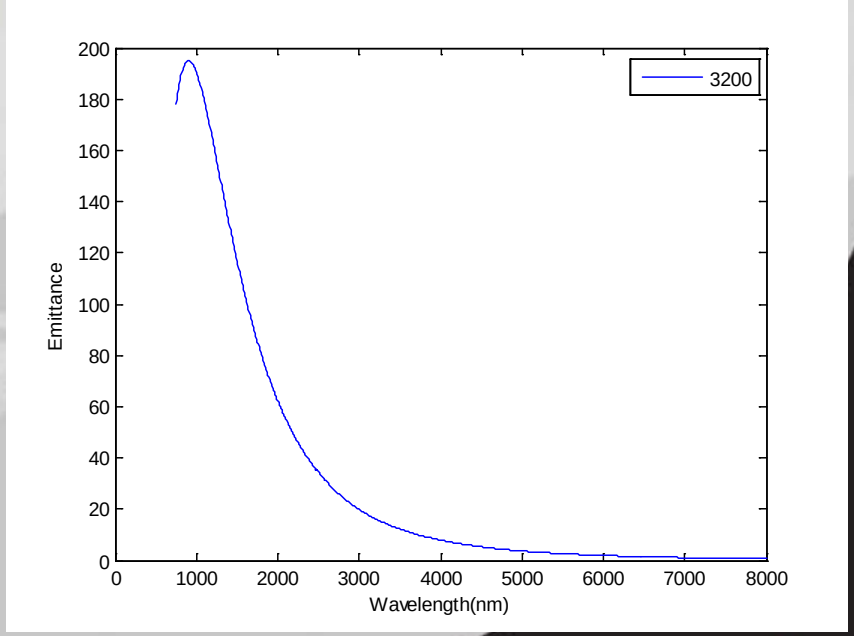
Enhanched Flight Vision Systems

- Possible Plug-Ins for EFV
  - Photonic crystal, mW, $$$, need optics
  - Kanthal filaments, mW, $$$, need optics
  - Laser diodes, eye safety, need optics

- Plan B
  - Halogen lights next to LED lights
  - Individually controlled
  - Only used when needed



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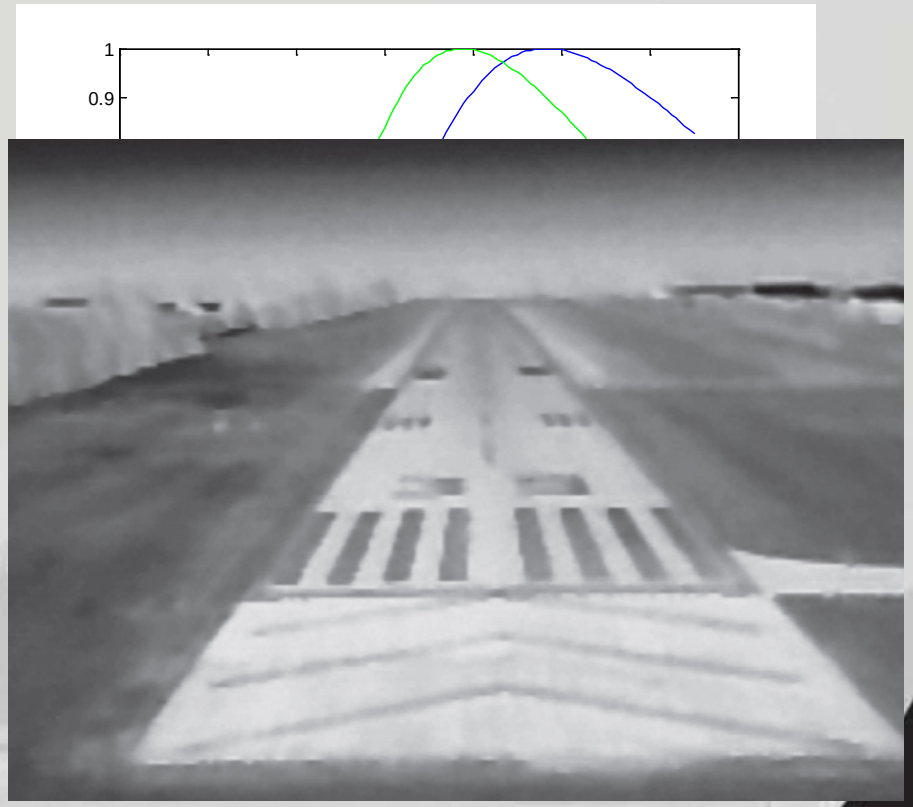
Thermal Imaging

- IR detection in > 4 µm
- EVS3 detection 7.5 – 13.5 µm



- Led fixtures warmer than surroundings
  - Comparable to halogen fixtures
- Emissivity of objects important

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Detection of LED-based AFL

- The purpose of the AFL system is to provide the visual guidance to the pilots, using their own eyes
- The industrialization and the change of world has driven the development of visual enhanchement systems for landing in darkness and fog
- The use and development of LEDbased AFL should not be affected by the demands from EFVS industry

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Conclusions

- LEDs are here to stay
- Discussions and trials with pilots required to get the right specifications
- Standardizing committees and Airports must take the lead on this
- We all have a common goal:
- Specifying and constructing a LED-based airfield lighting system that gives the pilot the right guidance in order to operate safely
- colour, brightness, beam angles, flash rate
  - Proper perception

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Thank you for your attention!

Safegate HQ in Malmö

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