Challenges in Automotive Display Standards

2005 CORM

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and
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Standards

- SAE (Society for Automotive Engineers)
  - *SAE J1757 Vehicular Flat Panel Display Metrology Committee*
    - Chair: Silviu Pala
- ISO (International Organization for Standardization)
  - *ISO TC22 SC13 WG8: 15008 Road Vehicles — Ergonomic Aspects of Transport Information and Control Systems — Specification and Compliance Proceedings for In-Vehicle Presentation*
    - This is the older version of J1757 than presently under consideration.

Notable Display Requirements

- **Temperature: -40°C to 85°C**
  (105°C to 115°C under hood)
- **Daytime Luminance: 100 cd/m^2 to 300 cd/m^2**
- **Night Dimming: 15 % ± 5 % of daytime luminance**
  (in 8 to 100 steps to almost zero)
- **Letter Height: 5 mm**
  (7” [17.8 cm] navigation display with 640 x 480 pixel array)
  (pixel pitch 0.3 mm to 0.5 mm/px)

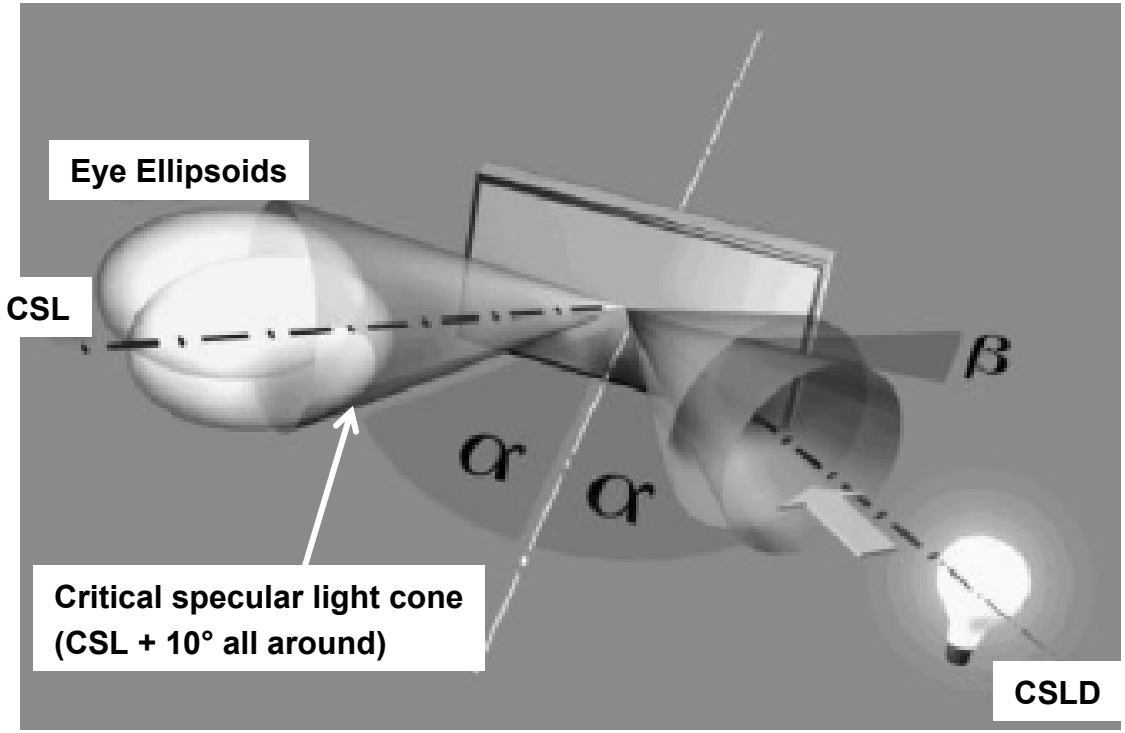
SAE J17857 Content

- Reflection Measurements
- Luminance Uniformity
- Color Uniformity

New Directions:

- Daylight-Source
- Composite Metrics
- Efficiencies & "Bang-for-the Buck" Metrics

Defining Terms



CSL — critical specular line (center of eye ellipsoids)

CSLD — critical specular light direction

Reflection Measurements

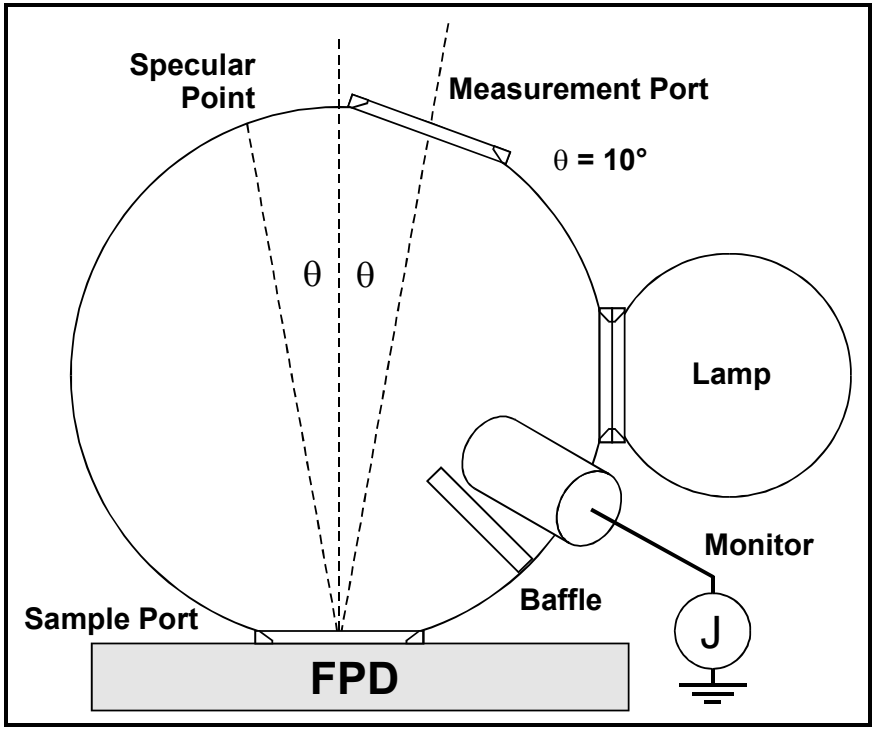
- Things not desired:
  - multiple complicated measurements (if at all possible),
  - scaling of reflection measurements, and
  - mathematics or calculations (if avoidable).

    (Groan!)
- Things desired:
  - a minimum number of measurements (one, if possible),
  - to get it done quickly,
  - measure using actual levels of light encountered, and
  - to see what it looks like to eye under actual light levels.

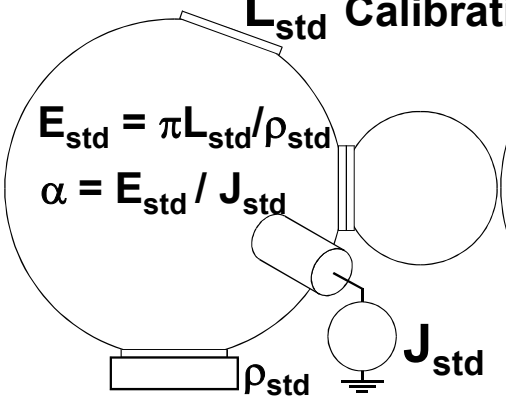
Diffuse reflectance measurement — if detached display

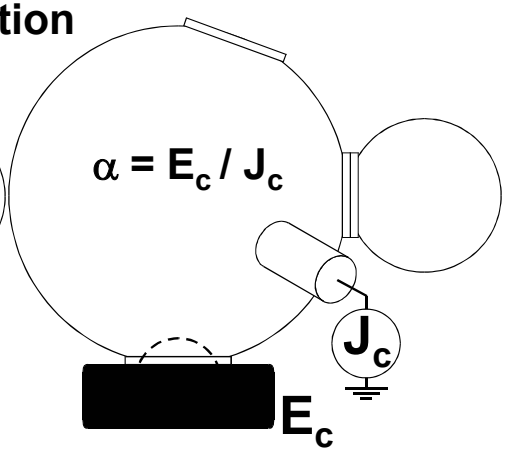
$$\beta_{d/\theta} = \rho_{\theta/d}$$

Sampling-sphere method



L_{std} Calibration





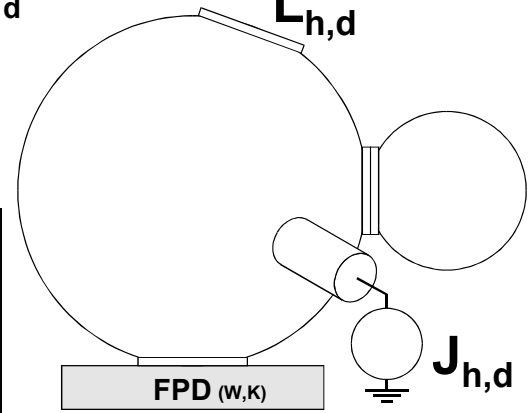
$E_h = \alpha J_h$, $E_d = \alpha J_d$

$\beta_W = \pi(L_h - L_W)/E_h$

$\beta_K = \pi(L_d - L_K)/E_d$

$$C = \frac{\frac{\beta_W E_0}{\pi} + L_W}{\frac{\beta_K E_0}{\pi} + L_K}$$

$L_{h,d}$



$L_{W,K}$ for full-screen white, black in darkroom.

$L_{h,d}$, etc. for full-screen white, black with sphere.

C = contrast under design ambient illuminance E_0.

Ambient Contrast [FPDM 308-2]

$C = \beta_W/\beta_K$ for reflective displays

Photodiode monitor is photopic, baffled to avoid direct rays from source or display.

ROBUSTNESS — Can we quantify it? Maybe…

M = measurement result

x_i = setup parameters of the apparatus (angles, distances, diameters, radii, source uniformities, luminances, etc.)

δx_i = allwed or anticipated uncertainties in x_i (how sloppy you anticipate you will be)

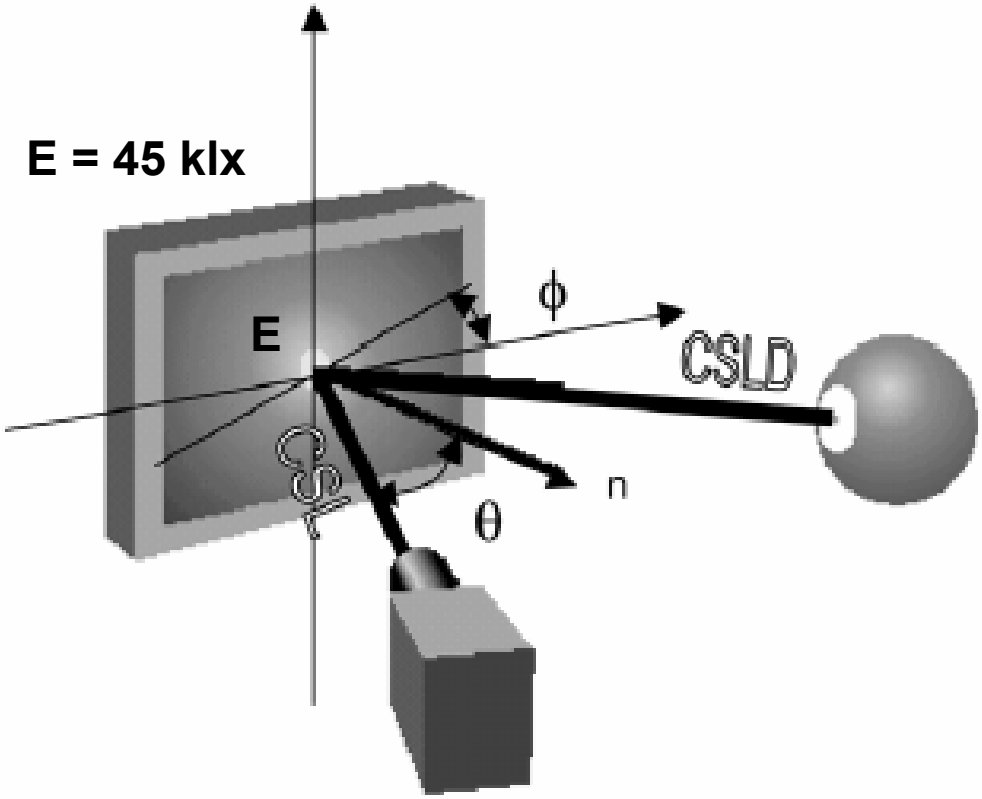
u = uncertainty in the measurement result that you will tolerate by the change δx_i in parameter value (e.g., 0.5 %, 1 %, 2 %, etc.)

$$Q_i = \left| \frac{1}{Mu} \frac{\partial M}{\partial x_i} \delta x_i \right|$$

If any $Q_i \geq 1$ then there may be a problem with robustness associated with that x_i; that is, reproducibility may well be difficult without significantly decreasing the size of δx_i. The robustness Q of the apparatus using the entire set of parameters might be defined:

$$Q = \left| \frac{1}{Mu} \right| \sqrt{\sum_i \left(\frac{\partial M}{\partial x_i} \right)^2 (\delta x_i)^2}$$

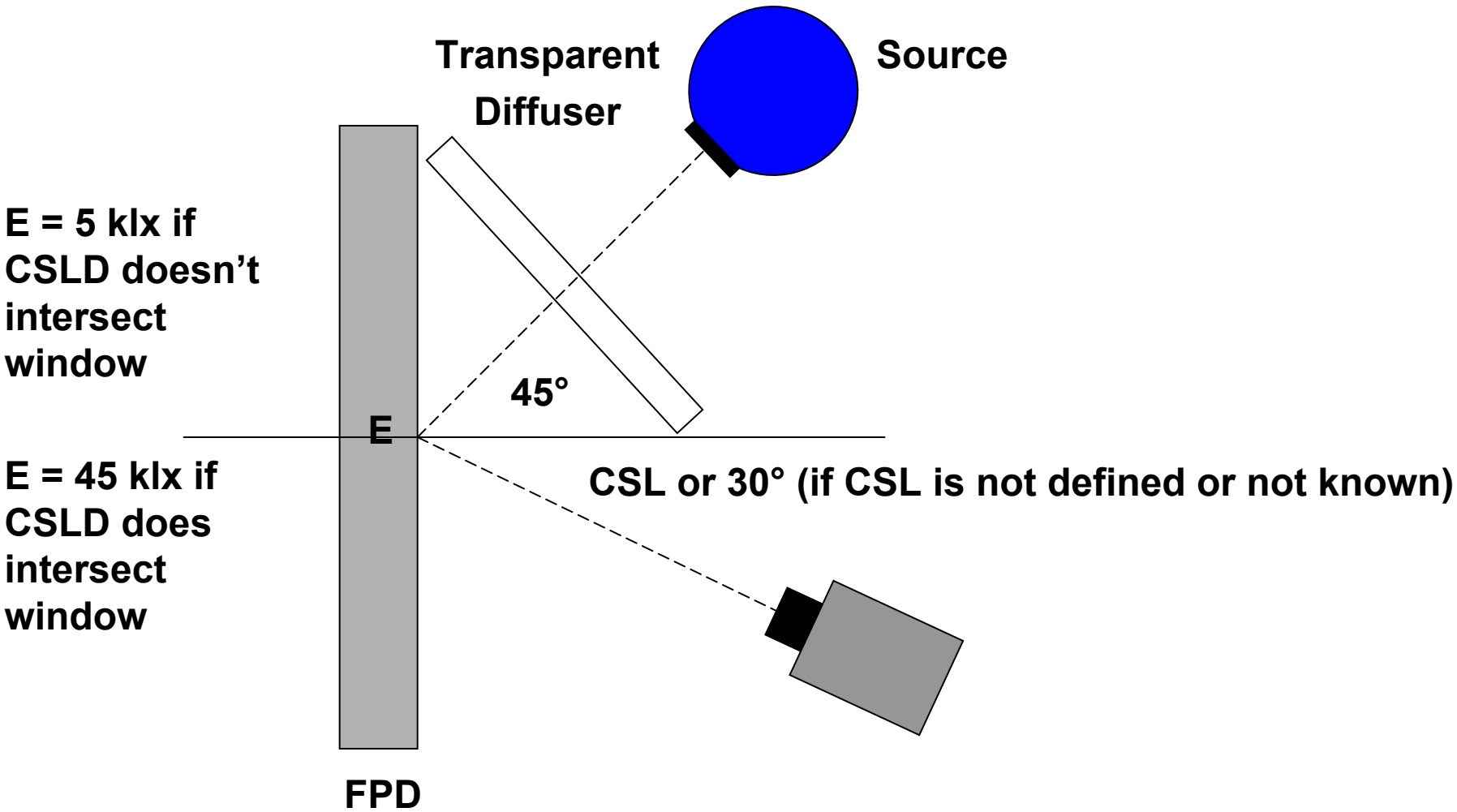
If CSLD intersects a window…



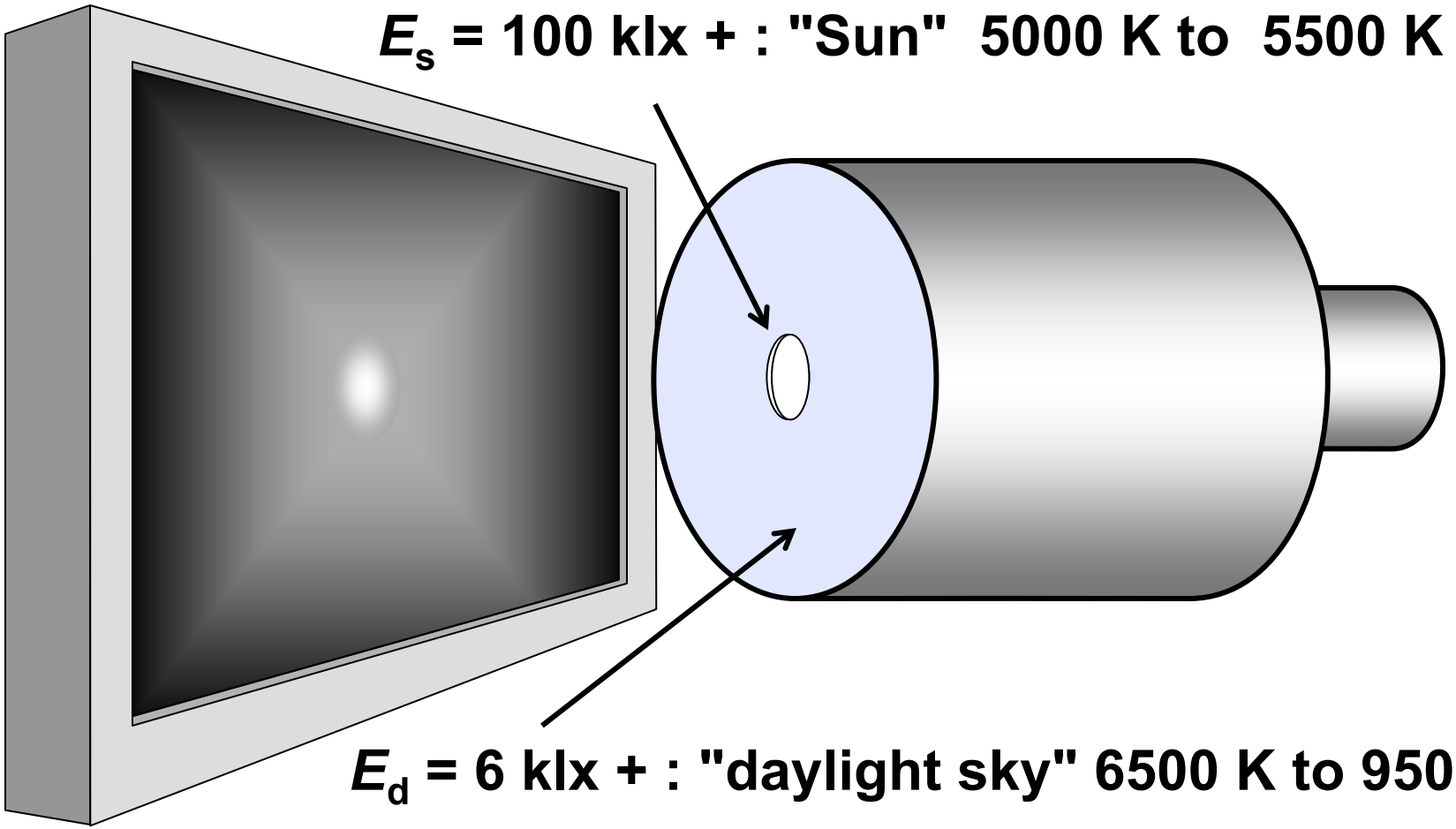
This is an attempt to simulates looking at the display with the sun's disk in the specular direction.

Problem: Source/detector geometry needs careful specification that is not currently present in the standard. If the display has a non-trivial haze component, this measurement is highly sensitive to geometry!

Using a transparent diffuser



New: Daylight-Source



Have no idea how to provide this… may not be remotely possible or even wise. If display has a non-trivial haze component this may be a terrible (non-robust) measurement!

New: Composite Metrics

Metric Type		Examples	Comments
Basic Metrics	Fundamental Metrics	*H, V, P, Φ, L, etc.*	These are fundamental measured quantities for which a single measurement is made.
	Derived Metrics	$C = L_W/L_K$, $A = HV$, $\eta = \Phi/P$	These are simple combinations of fundamental metrics that are commonly understood and employed.
Composite Metrics		$G = G_0 \prod_{n=1}^{N} \left(\frac{Q_n - q_n}{T_n} \right)^{m_n}$ (next slide)	These are non-trivial combinations of a number of basic metrics that suggest an appropriate measure of quality for a specific task.

New: Efficiencies

Luminous Efficacy of a Source: $\eta = \Phi_W / P_W$

Only care about light hitting eye ellipsoids.

Frontal Luminance Efficiency: $\varepsilon = L_W / P_W$

No difference between large or small display

Frontal Intensity Efficiency: $\xi = A L_W / P_W$ "$= I_W / P_W$"

Credits large and efficient displays, but no contrast reward.

Thinking in terms of a composite metric…

Contrast Weighted Frontal Intensity Efficiency:

$$\kappa = (A L_W / P_W)(C/100)$$

Credits large, efficient, high-contrast displays.

C may be ambient contrast…?

THANKS FOR LISTENING!

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But, if there is time…

NIST

FLAT PANEL DISPLAY LABORATORY

Tips on Buying a New FPD

WARNING!!!

READING OR LISTENING TO THE FOLLOWING MATERIAL MAY CAUSE PERMANENT DAMAGE TO YOUR PRESENT ABILITY TO ENJOY PRACTICALLY ANY IMAGE ON ANY DISPLAY SCREEN. LEARNING THE FOLLOWING GUIDELINES WILL CAUSE YOU TO SEE SOME OF THE SUBTLE DIFFERENCES IN DISPLAYS SO THEY NO LONGER LOOK ALL ALIKE.

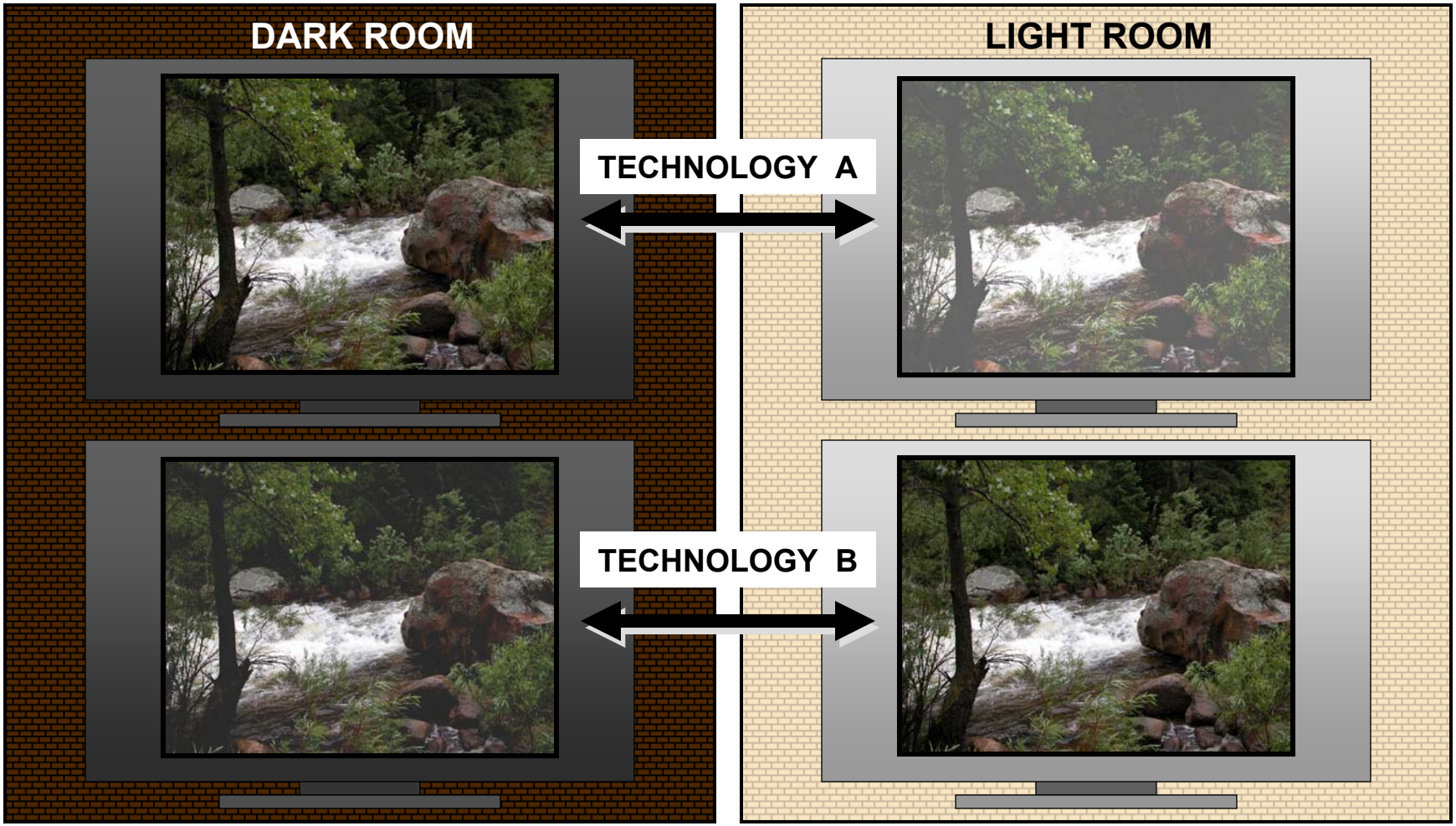
BE CAREFUL! PROCEED AT YOUR OWN RISK!

IF YOU ALREADY HAVE PURCHASED A NEW DISPLAY, ABSORBING THIS MATERIAL MAY NOT BE THE WISEST THING TO DO. YOU HAVE A FEW SECONDS TO LEAVE THE ROOM.

YOU'VE BEEN WARNED!

PROPER AMBIENT

Some displays will perform best in a very dark surround. Some will perform best in a bright surround. Attempt to evaluate the display in the environment into which you intend to place it.



- **LOOK AT THE BLACKS !!!!!**

  Most displays exhibit sufficient brightness or you wouldn't consider them in the first place. Often the real test of the display is how it shows its blacks when it is placed in an environment similar to your home. Consider both large-area blacks and small-area blacks. Some displays will show wonderful blacks in a bright environment, but those same blacks will be seen as dark gray when that display is placed in a dark room. Some displays will show wonderful blacks in a dark room, but they will be washed out by reflections in a bright room.

Darkness of small-area blacks is very important.

- **REFLECTION PROPERTIES**

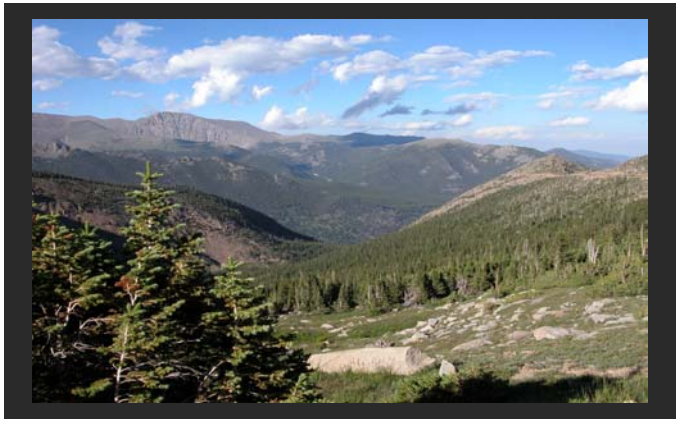
  Some displays will reflect light so that you can see the distinct reflected image of the source because they have a strong specular component. Other displays will diffuse the light so that you just see a fuzzy ball of light instead of a distinct image of the source—a strong haze component. How large that fuzzy ball is will depend upon the microstructure of the surface treatment. This diffusing treatment is often called anti-glare or non-glare. Some displays will have both properties as well as a third Lambertian component. You will want to keep in mind your living-room lighting and window configuration when you examine candidate displays. Some displays will allow the mirror-like reflections but will reduce them considerably by using an anti-reflection coating. You can often recognize such coatings by the dim magenta, dim blue, or dim green reflections of lights.

- **PLACEMENT**

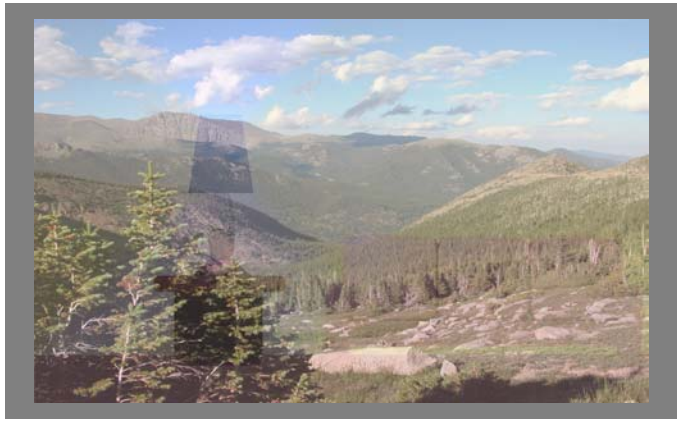
  Some of the problems with reflections can be reduced by placing the display so that you avoid seeing bright objects such as windows or lamps in its reflection.

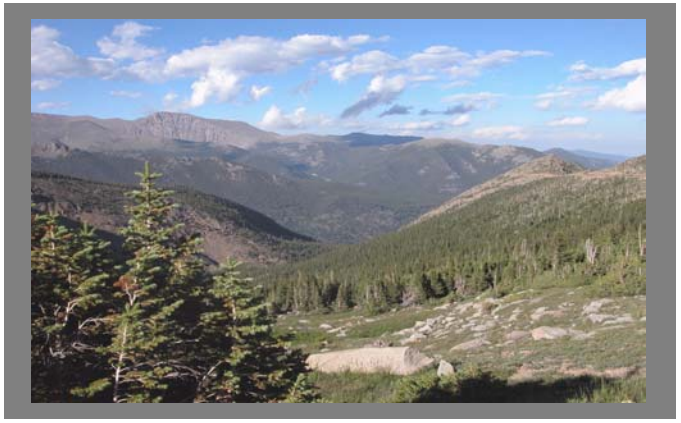
Light Living Room Effects on Image

Darkroom Image



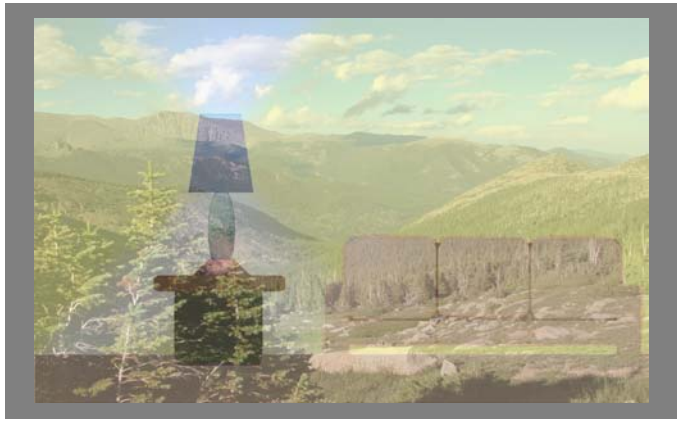
Specular & Lambertian with AR

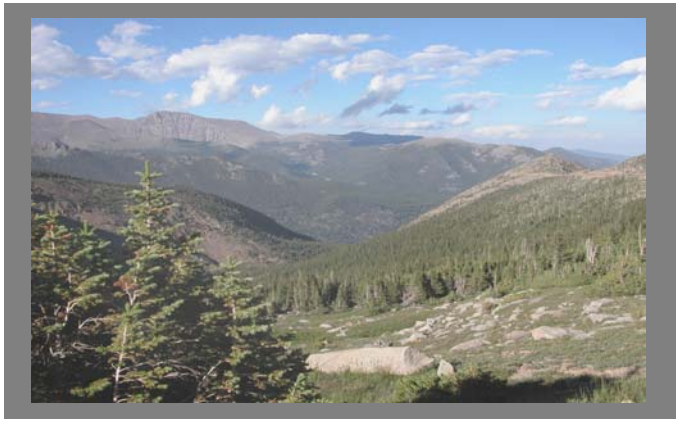




Haze only, with AR

Specular & Lambertian no AR





Haze only, no AR

- **SPECIFICATIONS**

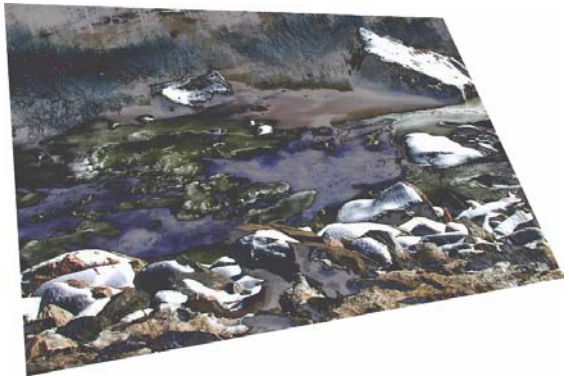
  Unfortunately, specifications claimed for displays cannot always be used to compare them. They may not employ measurement standards like the FPDM but use their own methods. Use and trust your eyes. What you see can be exactly what you get. Some displays will exhibit the same luminance when they show a small white area or fill the screen with white. Other displays will show a bright white small area but become much dimmer when displaying full-screen white. So when you evaluate the display, be sure to view a wide variety of scenes.

Contrast: 500:1
Luminance: 300 cd/m^2

Contrast: 500:1
Luminance: 300 cd/m^2

VIEWING ANGLE

The problems with viewing angle are gradually being eliminated. However, if you will have kids on the floor looking at the display while you sit on the sofa or if you have a room filled with people viewing the display from all different angles, then the display's viewing angle properties may be important to you. So, check it out. Move around and see what it does with the colors and especially the blacks. Some displays suffer most viewing-angle problems when viewed from the lower right or left. Often static images are useful in such evaluations.



STATIC IMAGES

Should you be able to view static images on the screen (if the display can be hooked up to a computer), then there are many images you can use, dark scenes, light scenes, but especially faces. Moving scenes may indicate motion artifacts, but generally don't give you enough time to consider the reflection properties, viewing angle properties, the whites (both small and large area), and the blacks (both small and large area).

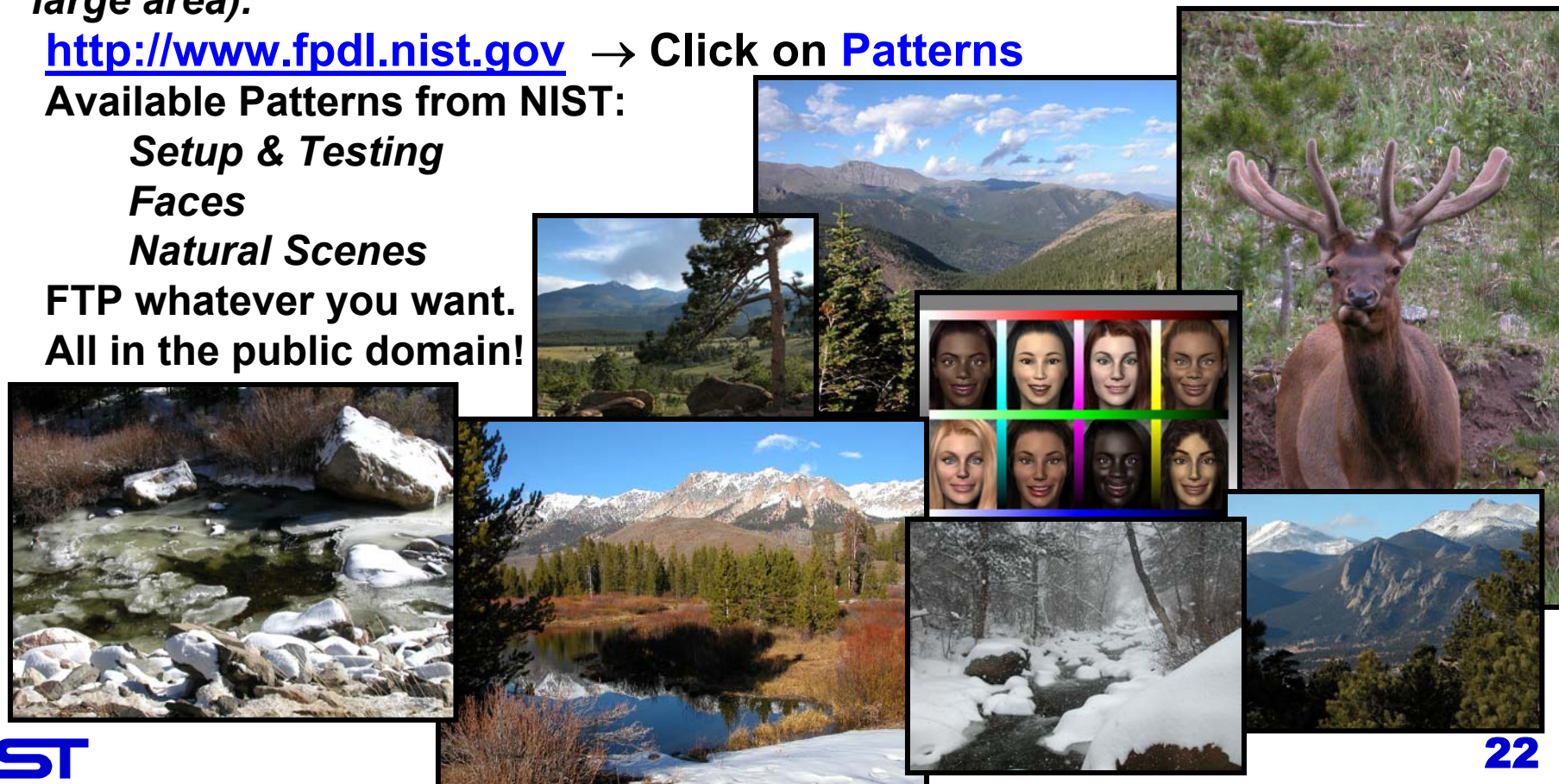
http://www.fpdl.nist.gov → Click on Patterns

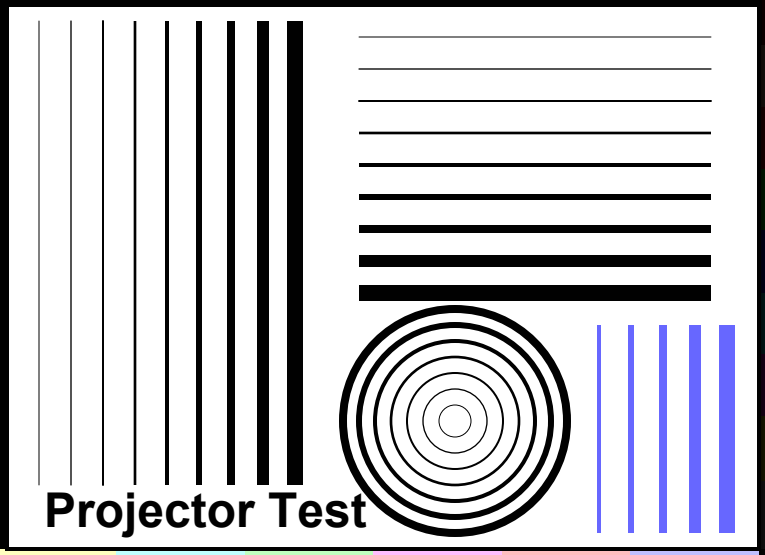
Available Patterns from NIST:

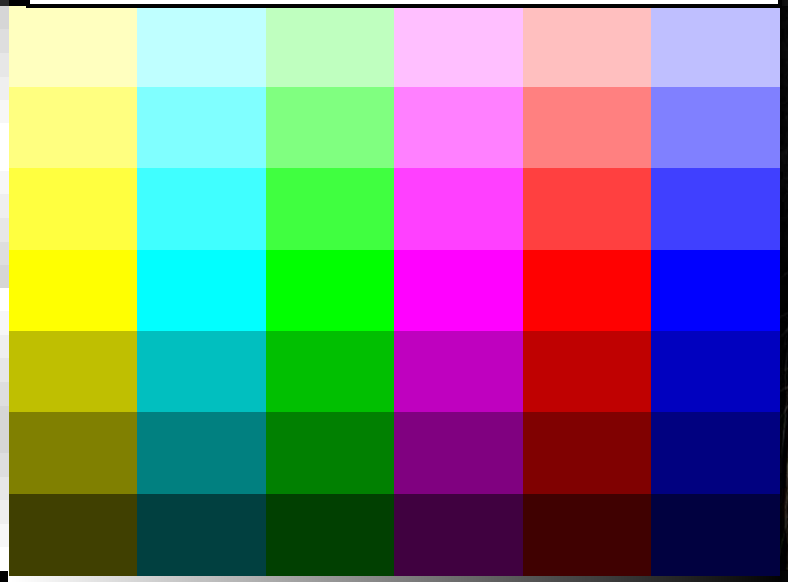
- ***Setup & Testing***
- ***Faces***
- ***Natural Scenes***

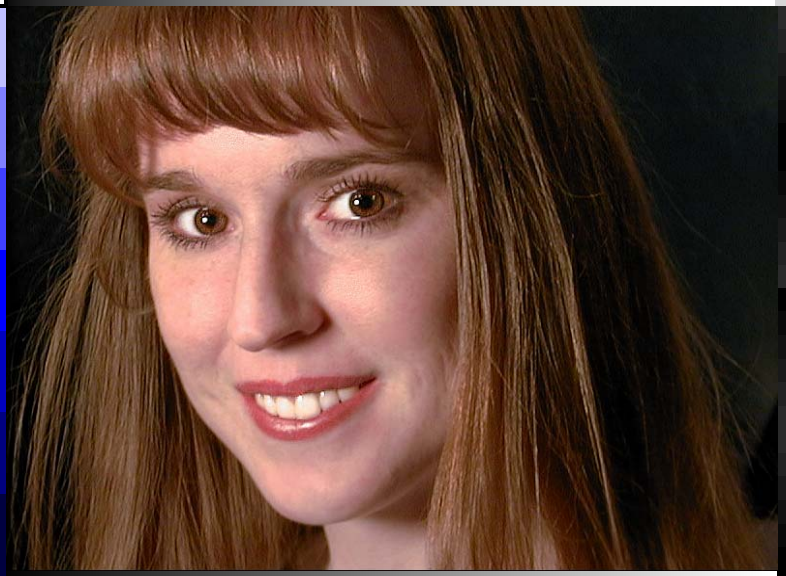
FTP whatever you want.

All in the public domain!









NISTSU01 Targets for Setting Up Displays

NIST