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Notes on Achieving Night Colour Tables with LCD Displays

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Colour tables for ECDIS were designed to maximize the ability to recognize chart information. Recognition is greatly impacted by the external lighting environment, and so unique colour tables were developed for bright and dark environments. These tables were developed using CRT's as the display, but were specified in absolute x,y,L colourimetric terms, as opposed to specific RGB values for driving a CRT. As such, they will translate to any display technology that is capable of achieving the range of colour used by a CRT

Of particular interest are flat panel LCD displays. These are dominating the display market currently, and high quality CRT displays are difficult to acquire. In 2001 I prepared a preliminary study (presented at the 13th CHRIS Meeting, 17-19 September, 2001, Athens, Greece) of the issues involved in using LCD displays for ECDIS application, and highlighted the difficulties with achieving correct colour due to the fact that this display type will not achieve a true black. I further recommended that the approach to achieve correct colour with LCD displays is to use the backlight or a neutral density filter to dim the display, while at the same time calculating new RGB values to give to the display for the night time colour set.

Since that time, flat panel displays have achieved darker black performance, and practical backlights offer substantial dimming capabilities, making the display much more suitable for night time viewing of chart information.

To apply the display to dark night viewing conditions, it is necessary to perform a calibration (or calculate the calibration) under the specific backlight illumination setting that will be used.

At this point it will be useful to review the process used to achieve the correct colour on a CRT or LCD:
- each colour in the S 52 colour table has a unique colour and luminance associated with it. These are specified in x,y,L coordinates, which are a universal specification of colour (CIE).

- to display a particular colour from the S-52 tables on a CRT or LCD display, luminance from each of the Red, Green and Blue (RGB) channels of the display ("guns" in CRT terms) is added in the correct proportions to provide that particular colour. The mathematics for computing the correct proportions is outlined in Annex B of S-52 Appendix 2.
- the key attributes of the display which must be known for this computation are the absolute colour of the pure red, green, and blue channels generated by the display and the luminance function of the display. This luminance function is the relationship between an R or a G or a B value input to the display on the connector input from the ECDIS computer, and the luminance output of that colour on the screen.

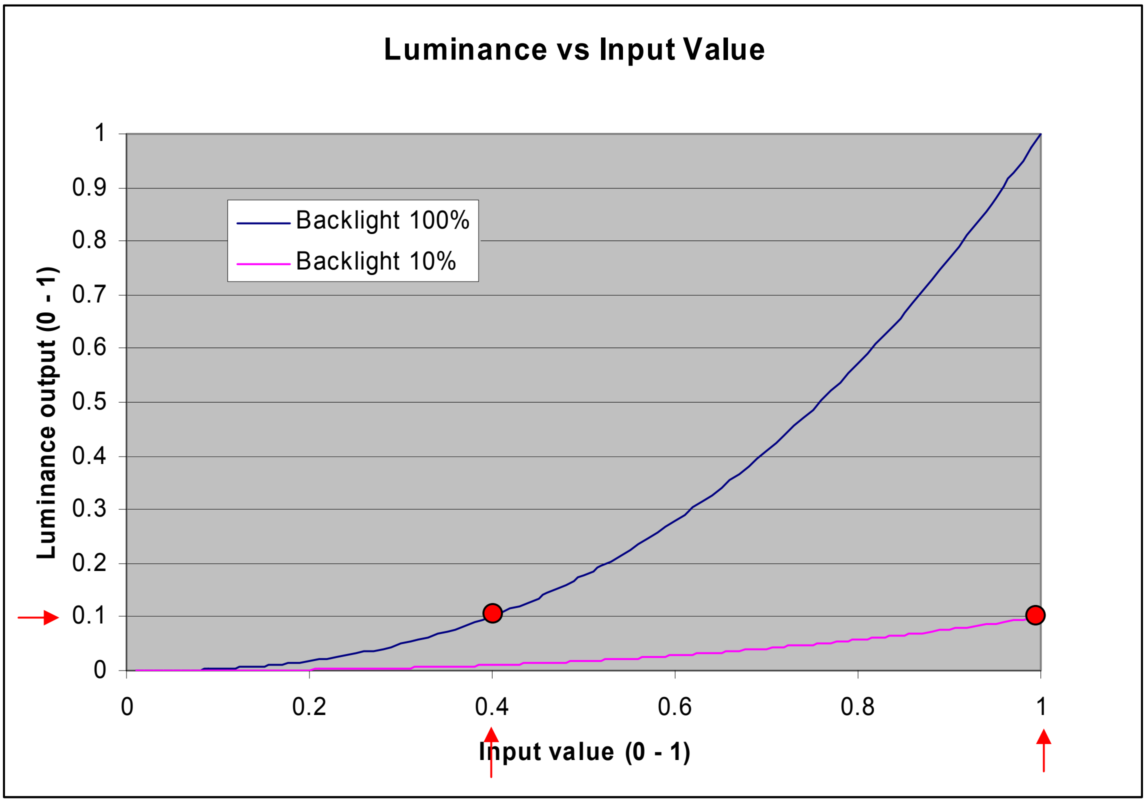
The process for displaying a colour flows as follows:

1. select the colour and luminance to be achieved in x,y,L coordinates (this is directly from the S-52 colour table.)
2. through calibration, determine the colour coordinates of each of the R, G, B channels of the display (the coordinates of the primary colours of the display).
3. through calibration, determine the luminance function, the relationship between input value at the display and luminance output on the screen from each of the R, G, B channels of the display,
4. Using the math from Annex B, and the data from 1, and 2 above, determine the theoretical required luminance of each of R, G, and B to achieve the correct colour.
5. Using the relationship from 3 above, determine the R, G, and B values that need to be input to the display to achieve the actual required luminance of each to give the correct colour on the screen.

As noted in my 2001 report, the LCD displays are capable of achieving a good calibration for bright day tables.

To achieve night tables, the display must be darker. In a CRT, this is achieved by reducing the signal levels on the input of the CRT. In a LCD, the darker colours are swamped by the inability of the display to achieve a dark black. To overcome this issue, variable intensity backlights are being employed in LCD displays. To display a darker colour, the backlight intensity is reduced, reducing the overall intensity of all colours on the display.

This affects the approach to achieving the correct colour on the display. When the backlight intensity is adjusted, the display intensity changes, independent of the signal levels that are being provided on the input of the display. This presents a problem for process step (3) above. For each new backlight intensity setting, there is a new relationship between input value to the display and luminance output on the screen.



Plot showing different input values to achieve same luminance – according to backlight setting.

The graph above shows a hypothetical display performance, with two different backlight settings - at 100% and at 10%. This graph can be used to determine the input value we would need to achieve a required luminance output at the two different backlight settings. If, for example our required luminance output is 0.1, then with the backlight set at 100%, we would provide an input to the display of 0.4. If the backlight is set at 10%, we would provide an input to the display of 1.0

Fortunately the relationship between the input to the display and the luminance output for different backlight settings is mathematically a linear relationship. This means that calibration measurements of input versus luminance output for only two reasonably well separated backlight settings are sufficient to compute the input versus luminance output for all other backlight settings.

To successfully use the variable backlight, the ECDIS system must know the backlight setting. Then it must send the correct input value to the display to obtain the luminance output required to give the correct colour on the screen.

From a practical point of view, this might be achieved by:

- Calibrate the display separately for each backlight setting, OR

- Calibrate the display for maximum backlight and one other backlight setting, and scale the input values according to the actual backlight setting using the mathematical model derived from the backlight setting calibration

Using this approach, it should be possible to achieve correct colourimetry at any known backlight setting.