ACTIVITY REPORT
DIVISION 1
VISION AND COLOUR

January 2011

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This report presents an overview of the status of CIE Division 1 - Vision and Colour since the last Activity Report that was issued in January 2010. The annual meeting of Division 1 was held on 17 and 18 June 2010 at Princeton University, Princeton, New Jersey, USA. Eight countries were officially represented and 30 people were present.

The following Technical Committees met in Princeton:
- TC1-56 Improved colour matching functions
- TC1-63 Validity of the range of CIEDE2000
- TC1-69 Colour rendition by white light sources
- TC1-71 Tristimulus integration
- TC1-74 Methods for re-defining CIE D-Illuminants

The following activities were closed in Princeton:
- TC1-54 Age-related change of visual response
- TC1-56 Improved colour matching functions
- R1-19 Specification on individual variation in heterochromatic matching
- R1-43 Standard deviate observer

And the following activities were started in Princeton:
- TC1-81 Validity of formulae for predicting small colour differences
- TC1-82 Calculating colour matching functions as a function of age and field size
- R1-51 Reconciling Maxwell vs maximum saturation colour matches
- R1-52 Spectral data interpolation

The following publications have appeared during 2010:

CIE 191:2010, Recommended System for Mesopic Photometry Based on Visual Performance, from TC1-58

CIE 192:2010, Practical Daylight Sources for Colorimetry, from TC1-44

A summary of the status of each of the Technical Committees in Division 1 is included in this report together with summaries from the Reporters and Liaisons. The reports are grouped such that the Vision Section precedes the Colour Section which is followed by the Liaison reports.
VISION SECTION: TECHNICAL COMMITTEES

TC1-36 (V) Fundamental Chromaticity Diagram with Physiologically Significant Axes

Established: 1991
Terms of Reference: To establish a chromaticity diagram of which the coordinates correspond to physiologically significant axes.
Chairman: F Viénot FR
Members: D MacLeod US, JD Mollon GB, JD Moreland GB, Y Nakano JP, J Pokorny US, LT Sharpe DE, A Stockman GB, A Valberg NO, PL Walraven NL, J Wold NO
Consultants: H Scheibner DE, P Trezona GB, and H Yaguchi JP

1) Part I of the publication 170-1:2006: 1, entitled “Fundamental Chromaticity Diagram with Physiological Axes - Part 1” was published in 2006.

2) Part II is being prepared and consists of chapters 6 and 7.

Chapter 6 “Photometric aspects; the choice of the spectral luminous efficiency functions \( V_F(\lambda) \) and \( V_{F10}(\lambda) \)” was approved at the end of 2009. The spectral luminous efficiency functions are defined as weighted sums of the fundamentals \( \lambda(l) \) and \( \lambda(m) \).

TC1-36 is working on chapter 7 “Development of 2-dimensional fundamental chromaticity diagrams.” The first diagram will be a MacLeod-Boynton diagram, of the form:

![Diagram](image)

The other diagram consists of deriving the \( x_F, y_F \) fundamental chromaticity diagram. The goal is to derive the \( x_F, y_F \) fundamental chromaticity diagram in a similar way as the 1931 \( x,y \) chromaticity diagram was derived. The constraint that the equi-energy white should have equal \( X_F, Y_F, Z_F \) tristimulus values is still applicable.

What is needed, is a linear transformation of the colour-matching functions of the form

\[
\begin{pmatrix}
    x_F \\
    y_F \\
    z_F
\end{pmatrix} = M \cdot \begin{pmatrix}
    \Gamma \\
    \bar{m} \\
    \bar{s}
\end{pmatrix}
\]
The establishment of \( \bar{y}_F \) is already fixed in Chapter 6. Considering that \( \bar{z}_F \) is to be proportional to \( \bar{x}_F \), and that the equi-energy white should have equal \( X_F, Y_F, Z_F \) tristimulus values, the establishment of \( \bar{z}_F \) is straightforward. Remembering that in the CIE 1931 chromaticity diagram, the \( y \)-axis is almost tangent to the spectrum locus, which means that the local minimum of the \( \bar{z}_F \) has to be fixed in some way. A presentation by J.-H. Wold was given at the ISCC meeting in Princeton, June 16, 2010, who has examined a number of solutions. His proposal to TC 1-36, after exchange by email with Stockman, Walraven and Viénot, consists of a least squares optimisation of \( x_F, y_F \) and \( z_F \) relative to CIE \( x, y \) and \( z \), under the constraint \( x_{F,min}=x_{min} \) (and similar for the 10 deg field). Work is in progress.

Chapters 6 and 7 will form part II of the TC report when it is completed.

3) TC 1-36 proposes a modification of the ILV definition of the chromaticity coordinates. A new definition of “chromaticity” and “chromaticity coordinates” was proposed for discussion by M. Brill at the Princeton meeting. Françoise Viénot will contact Sharon McFadden (TC1-64) to modify the definition of chromaticity coordinates.

<table>
<thead>
<tr>
<th>ILV, 1987 edition</th>
<th>TC 1-36 proposal (changes are underlined)</th>
<th>M. Brill's proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>chromaticity coordinates ratio of each of a set of three tristimulus values to their sum</td>
<td>chromaticity coordinates ratio of each of a set of tristimulus values to their sum</td>
<td>chromaticity---a representation of the tristimulus values of a light with only two numbers, computed so as to suppress the absolute intensity of the light. The two numbers (called chromaticity coordinates) define a space (called chromaticity space) in which any additive mixture of two lights lies on a straight line between those two lights.</td>
</tr>
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</table>

NOTE 1 – As the sum of the three chromaticity coordinates equals 1, two of them are sufficient to define a chromaticity.

NOTE 2 – In the CIE standard colorimetric systems, the chromaticity coordinates are represented by the symbols \( x, y, z \) and \( x_{10}, y_{10}, z_{10} \).

6) Because TC1-36 should close as soon as possible and because of a lack of experimental data, Viénot, at the Princeton meeting, refused to extend TC1-36 terms of reference to derive a chromaticity diagram continuous in terms of age and field size.

A new TC was established in Princeton, 2010:
TC1-82 (V)  The calculation of colour matching functions as a function of age and field size
Chairman: Jan-Henrik Wold
Terms of reference:
1. Following on from CIE Technical Report 170, to recommend a procedure for calculating XYZ-like colour matching functions from cone fundamentals, as a function of age and field size.
2. To deliver a computer programme for the calculations.
Members: Viénot, Fairchild, Fairman, Brill, Richter, Farup, Li, Yamauchi.

TC1-37 (V)  Supplementary System of Photometry
Established: 1992
Terms of Reference: To recommend a system of photometry to assess lights in terms of the comparative brightness relationships at any level.
Chairman: K Sagawa JP  

No report.

TC1-41 (V) Extension of $V_M(\lambda)$ Beyond 830 nm  
Established: 1993  
Terms of Reference: To write a report on the feasibility of the extension of $V_M(\lambda)$ beyond 830 nm, including modification of $V_M(\lambda)$ in the 660-780 nm region of the spectrum.

Chairman: PL Walraven NL  
Members: DH Sliney US and JJ Vos NL

No report.

TC1-42 (V) Colour Appearance in Peripheral Vision  
Established: 1993  
Terms of Reference: To prepare a technical report on color appearance zones for colored lights in terms of unique hues in peripheral vision.

Chairman: M Ayama JP  

No report.

TC1-58 (V) Visual Performance in the Mesopic Range  
Established: 2000  
Terms of Reference: To define mesopic visual performance and related terms.  
To investigate performance based photometry in the luminance region below approximately 10 cd m$^{-2}$.  
To propose a model for the basis of performance based mesopic photometry.

Chairman: L Halonen FI, M Puolakka FI  

This TC has completed its work and the outcome was published as CIE 191:2010, ‘Recommended System for Mesopic Photometry Based on Visual Performance’ in September 2010. Thus the TC1-58 will be closed at the Sun City meeting of CIE D1 in July 2011.

TC1-60(V) Contrast Sensitivity Function (CSF) for Detection and Discrimination  
Established: 2001  
Terms of Reference: 1. To specify a baseline achromatic CSF with its reference conditions and reference observer  
2. To specify CSF extensions based on discrimination thresholds, as well as chromatic CSFs for both detection and discrimination.

Chairman: E. Martinez-Uriegas ES  
Members: D Alleyson FR, M. Artigas Verdes ES, C-C Chen US, M Fairchild US, RV Klassen US, L MacDonald GB, S McFadden CA, Chaker Larabi FR, E Peli US,
AB Watson, S Wuerger HU, H Yaguchi JP.

The chairman of this TC is ill and unable to continue with the work. The DD and DS have been active in trying to encourage one of the members of the TC to write the final technical report, so far without success.

**TC1-67 (V) The Effects of Dynamic and Stereo Visual Images on Human Health**

*Established:* 2005

*Terms of Reference:* To write a technical report on the physiological and psychophysical effects of dynamic and stereo visual images in terms of photosensitive seizures, visually induced motion sickness and eyestrain.

*Chairman:* H Ujike JP

*Members:* Not known

No report.

**TC1-78 (V) Evaluation of Visual Performance in the Real Lit Environment**

*Established:* 2009

*Terms of Reference:* To investigate and report on current research on visual performance that relates to psycho-physical and physiological measurements in the real lit environment, and to produce a plan for future work.

*Chairman:* Monica Billger SE

*Members:* Steve Fotios GB, Frédéric Leloup BE, M. Ronnier Luo GB, Barbara Matusiak NO, Yoshiki Nakamura JP, Wouter Ryckaert BE, Monica Säter SE, Jan Wienold DE

Interested but pending: Mark Rea US, Dragon Sekulovski NL, Ingrid Vogel NL

No report.

**TC1-79 (V) Limits of Normal Colour Vision**

*Established:* 2009

*Terms of Reference:* 1. To document the correlation between performance on colour matching, colour discrimination, colour naming, and colour deficiency tests and factors such as variation in the peak spectral sensitivity of the M and L cones, density of the lens, density of macular pigment, variation in the optical density of the cones, L to M cone ratio, rod intrusion, illumination level, stimulus size, gender, stimulus duration and identify any substantive gaps in the existing literature.

2. Using the above database, develop a model or models that will allow the prediction of the effect of the above factors on colour discrimination, colour matching, and colour naming performance.

*Chairman:* John Barbur UK

*Members:* Members are being sought

No report.

**TC1-80 (V) Research Methods For Psychophysical Studies Of Brightness Judgements**

*Established:* 2010

*Terms of Reference:* 1. To document the correlation between performance on colour matching, colour discrimination, colour naming, and colour deficiency tests and factors such as variation in the peak spectral sensitivity of the M and L cones, density of the lens, density of
macular pigment, variation in the optical density of the cones, L to M cone ratio, rod intrusion, illumination level, stimulus size, gender, stimulus duration and identify any substantive gaps in the existing literature.

2. Using the above database, develop a model or models that will allow the prediction of the effect of the above factors on colour discrimination, colour matching, and colour naming performance.

Chairman: Steve Fotios
Members: Peter van der Burgt NL, Michelle Gauthier CN, Peter Hanselaer BE, Kevin Houser US, Sandra Mende DE, Yoshiki Nakamura JP, Keith Niall CN, Osvaldo da Pos IT, Monica Säter SE, David Simmons GB, Jan Vanrie BE, Agnes Vidovszky-Nemeth HU, Martijn Withouck BE

The first meeting was held at the 2nd CIE Expert Symposium on Appearance (September 2010, Ghent, Belgium). There are 14 members, including the chairman, and these have backgrounds in both lighting and psychology: further members are being sought.

Progress to date:
– Definition of spatial brightness.
– Classification of the four main experimental procedures that have been used in previous research of spatial brightness.

Current activity; a draft report of the four main experimental procedures was circulated, describing the potential problems of these procedures and how they can be overcome. Following feedback this will be re-circulated.

This TC has yet to decide whether it will be meeting during the 27th Session in Sun City.

TC1-82 (V) Calculation of Colour Matching Functions as a Function of Age and Field Size
Established: 2010
Terms of Reference:
1. Following on from CIE TR 170, to recommend a procedure for calculating XYZ-like colour matching functions from cone fundamentals, as a function of age and field size.
2. To deliver a computer programme for the calculations.
Chairman: Jan Henrik Wold NO
Members: C F Andersen NO, M Brill US, M Fairchild US, H Fairman US, I Farup NO, C Li CN, K Richter DE, F Viénot FR, M Withouk BE, Y Yamuchi JP

Two committee members have had two meetings in which an orientation and information package to the TC members has been prepared. The plan is to distribute this to the members by the beginning of January 2011.

VISION SECTION: REPORTERS

R1-36 (V) Action Spectra for Glare
Established: 2004
Terms of Reference: To summarize the literature on the subject and make recommendation
Reporter: J Fekete HU

Introduction
As is well known, humans obtain approximately 90% of information by means of visual perception. Good visibility is highly important when driving a motor vehicle. At night,
and in mesopic conditions, poor visibility conditions result in a lack of information for drivers. Visual information decreases with decreasing luminance level producing more (fatal) accidents during the night-time.

In rural environments, car drivers have to rely on car-headlamp lighting to see on the road but, with higher headlamp intensity, also the glare produced in the eyes of the approaching driver increases.

Human night vision is a complex phenomenon and the design of efficient light sources represents a very challenging field. Road lighting levels at night fall into the mesopic region, where the behaviour of the eye is not well characterised and measurement scales have not yet been agreed internationally. To recognize obstacles under mesopic circumstances, the values of brightness and colour contrast between the background and obstacle is essential. If there is a glaring light source in the field of vision, this will destroy the perception of contrast.

Light from vehicle headlamps embraces different areas in the different degree, and contributes decisively to more safety and security. It also plays a decisive role in the reduction of accidents and try to ensure the safety traffic at night-time. The primary purpose is to support driver vision while driving in conditions of reduced visibility. Vehicle headlights should be built to deliver optimum illumination in mesopic circumstances, but this is not always achievable. Because of the relatively high luminous intensities that are produced by headlamps, they can also become significant sources of glare to drivers viewing these sources from oncoming vehicles. Glare is visibility-reducing (disability glare), and potentially annoying (discomfort glare). Discomfort glare is a feeling of disturbance caused by high luminances in the field of view. Discomfort glare does not straightforwardly weaken the visibility of objects, but nevertheless is capable of influencing driving performance and the ability of the eyes to gather visual information is reduced.

The present report summarizes literature data on interrelationship between visibility and produced glare.

Papers presented during the past year

MODEL AND METHOD FOR ASSESSING HEADLAMPS VISIBILITY BENEFITS AND CAUSED GLARE

There are some researchers who try to create a kind of model to determine what sort of phenomena take place when a car runs on the highway at night with a different headlamp systems.


This article presents a method for assessing the visibility benefits of roadway lighting. The authors used photometrically accurate lighting software and a model of visual performance to evaluate realistic roadway lighting and driver scenarios. The software and model generated a great deal of data, both virtual photometric quantities and values of relative visual performance. The authors describe their method used to simplify these data, with the goal of offering practical insights about the value of different fixed roadway lighting systems. After a discussion of the implications of their findings, they concluded that it is important to illuminate both high-speed and low-speed intersections, to provide high illumination for older drivers on high-speed roadways with intersections, and to consider incorporating photosensor-based control of lighting in highly developed areas.

The approach used in this article enables officials responsible for public cost and public safety to make more sophisticated and rational decisions about roadway lighting.


Light quantities based on the photopic luminous efficiency function do not predict brightness perceptions of lighted outdoor scenes such as streets, parking lots and plazas. This paper summarises a series of experiments conducted using scale-model
outdoor scenes illuminated by different light sources to assess judgements of brightness. From the results and from previously published literature on the relative increase in short-wavelength spectral sensitivity for brightness, a tentative model for brightness perception of outdoor scenes is proposed. The model can serve as a starting point for efficiently testing future hypotheses regarding brightness perception in lighted outdoor scenes.

The authors summarize the development and initial deployment of a system that can be mounted along an intersection, curve, drive-in, or parking facility to efficiently gather relevant data about headlamp patterns that might relate to glare or visibility. The system can run autonomously to collect many vehicles per data collection period. The system includes a range finder to capture information when an approaching vehicle is at a specific location, a digital camera to store images of oncoming headlamp position (i.e., mounting height), two arrays of light sensors to measure the vertical headlamp illumination profile (e.g., angular position of headlamp beam cut-off or maximum luminous intensity), and a color-calibrated illuminance meter at the angular location of an oncoming driver's eyes. From the headlamp mounting height data and the vertical cutoff location data, an estimate of the headlamp aim distribution can be made. Further, the data provide an estimated distribution of light levels reaching drivers' eyes from oncoming vehicles. The results of the authors initial data collection are presented.

Statistical Models for the Effects of Dirt on Headlamp Beam Patterns. Michael J. Flannagan, Yoshihiro Fujiyama, Umtri-2010-33 pp. 1-35
See also part in CLARITY OF HEADLAMP

ASSESSMENT OF DIFFERENT HEADLAMP PERFORMANCE
There have been a variety of approaches to the evaluation of automotive headlighting

Ambient lighting from various head light patterns influences the visibility of differing pedestrian targets. In this article halogen, high intensity discharge headlight patterns, and high beam headlight beam patterns are investigated; as well as how each of them interacts with road lighting to influence pedestrian visibility. In the experiment rural, urban and suburban areas are all considered.
In real world driving conditions, illumination from vehicle headlamps and, when present, from fixed roadway lighting combines to provide visibility for the driver. In this article they analyses of visibility along a representative roadway intersection scenario with median and market-weighted headlamp beam patterns including halogen and high intensity discharge headlamp beam patterns, and high beam headlamp beam patterns. Also investigated are interactions with the spatial extent of roadway lighting, either as part of a continuous lighting system or as a single roadway luminaire at the intersection junction, and the role of ambient illuminance from urban environments. They found that the results of the analyses show the large influence of ambient illuminance from urban areas on the visibility of relevant targets, and show differential advantages of different headlamp beam patterns for different target locations where pedestrians might be encountered.

SPECTRAL POWER DISTRIBUTION OF CAR HEADLAMPS
The main concern of car headlamp manufacturers is to provide better visibility. Unfortunately, by increasing the luminous intensity of the headlamp the risk of increasing discomfort glare for the other road users increases. One possibility to increase visibility and decrease glare could be the selection of a spectral power
distribution for the headlamp such that it emits in wavelength regions (if such regions exist) where luminous sensitivity is high, and glare sensitivity is low.

During the last fifteen years gas discharge lamps (HID) have become popular and in the future we will meet LED headlamps too. These modern light sources have radically different spectral power distributions compared to that of the traditional incandescent lamp. Lamp SPD (Spectral Power Distribution) can have considerable impact on a driver’s visual performance. Therefore, researchers investigated some types of headlamps and carried out comparative examination (TH, HID, LED) to established maximum visibility and minimum of glare.

There are very few investigations on best spectrum for mesopic visibility and even less data on the spectrum of discomfort glare. Some authors have studied these two perceptions and came to the conclusion that it is not enough to optimise for the combined photopic and scotopic luminosity functions but the chromatic components have to be taken into consideration too. They tried to determine optimum SPD for mesopic conditions providing good visibility and low glare will be described.


Different retinal eccentricities of the incremental target and different spectral power distributions of the background lead to different relative contributions of the different retinal mechanisms of detection in the mesopic range.

In this task spectral sensitivity functions for the threshold detection of mesopic incremental targets were compared for different target eccentricities (10, 20, and 30°) and for different mesopic backgrounds (0.1, 0.5 and 1.0 cd m⁻²). Relative responsivities of achromatic mechanisms (L + M and rods) and chromatic mechanisms (S and |L–M|) were estimated for each eccentricity and background.

The authors found that chromatic mechanisms contribute significantly to detection but their effect is lower at 30°. In this research a new contrast metric ($C_{\text{CHC2}}$) is introduced to account for the selective adaptation of the photoreceptors and the effects of the chromatic mechanisms i.e. broadening of the range of spectral sensitivity with multiple local maxima and yellow sub-additivity of detection performance. The $C_{\text{CHC2}}$ metric is compared with the achromatic contrast metric of the MOVE model (CMOVE). For the same target, $C_{\text{CHC2}}$ generally predicts a higher visibility level than CMOVE. However, in accordance with visual observations, for grey or yellowish incremental targets appearing at the eccentricities of 20 and 30°, the visibility predicted by $C_{\text{CHC2}}$ is less than the visibility predicted by CMOVE.


The main concern of car headlamp manufacturers is to provide better visibility. Unfortunately by increasing the luminous intensity of the headlamp the risk of increasing discomfort glare for the other road users increases. One possibility to increase visibility and decrease glare could be the selection of a spectral power distribution for the headlamp such that it emits in wavelength regions (if such wavelengths exist) where luminous sensitivity is high, and glare sensitivity is low. For this – in the opinion of researchers – the spectral discomfort glare sensitivity of humans under low photopic conditions has to be determined.

In this project spectral discomfort glare sensitivity was determined using ten young observers, requesting the observers to select medium glare settings of monochromatic radiations based on the de Boer glare rating scale, both at near-foveal and 10° extra-foveal directions of the 2° large glare source. The authors investigated that whether would be possible to construct the discomfort glare sensitivity spectrum by a simple additive superposition of the photopic luminous efficiency function and a short wavelength cone sensitivity function. They found that...
the spectral discomfort glare sensitivity function could not be described by a simple addition of the photopic spectral luminous efficiency function and the short wavelength cone fundamental, but that the contribution of the chromatic channels of human vision may also have to be considered.

In this research the human visual system spectral glare sensitivity has been determined for near foveal vision, 10° and 20° para-foveal directions. In all cases the spectral glare sensitivity curve could be superposed from the rod spectral sensitivity and the three cone spectral sensitivity curves: the luminance and the two opponent channels signal.
Experiments have shown that the so determined glare spectral sensitivity is non-additive, thus the influence of white lights can not be simply calculated from the spectral components of the lights. A multi-spectral light of smaller power will produce equal glare as an approximately 30% higher monochromatic light of the same colour.
From the performed experiments one can state that the discomfort glare sensitivity spectrum is not a simple function where one of the visual mechanisms dominates, but both the cone and the rod receptors play important roles. For the cone contribution both magnocellular and parvo-, conio-cellular channels seem to contribute. Due this complex mechanism the spectral responsivity curve determined by measuring glare sensitivity at single wavelength produces non-additivity.

CLARITY OF HEADLAMPS
Although the effects of dirt on headlamp performance have been of interest for many years, additional data concerning the levels of dirt on headlamps in actual use would be helpful in better understanding the effects of dirt and the potential benefits of countermeasures, including headlamp cleaning systems.

Statistical Models for the Effects of Dirt on Headlamp Beam Patterns. Michael J. Flannagan, Yoshihiro Fujiyama, Umtri-2010-33 pp. 1-35
In this report, the authors describe a simple statistical model that predicts the photometric effects of dirt based on measures of the surface gloss of headlamps. Using the model, the light output at various points in the beam pattern of a dirty headlamp can be approximated reasonably well by simple functions of two variables: the light output at those specific points in the clean state, and a measure of overall dirt level based on gloss. In addition to describing the model, this report uses the model to quantify variations in the properties of artificial dirt that illustrate how the range of natural dirt may affect headlamp performance. Specifically, some forms of dirt probably cause relatively high levels of light scattering while others probably cause relatively high levels of light absorption. For two types of artificially applied dirt – salt and carbon dust – the model developed here works well in predicting the effects of dirt on light at a variety of test points. It appears to provide an adequate basis to use simple measurement of surface gloss as a surrogate for more comprehensive photometric measurements of the effects of dirt on headlamp beam patterns. In a separate report – according to authors – they will apply the model to a set of gloss data collected in the field from a fleet of vehicles during a period of just over one year. This should provide an assessment of the likely effects of headlamp dirt over a range of real-world conditions, including seasonal effects.

R1-37 (V) Definition of the Visual Field for Conspicuity
Established: 2004
Terms of Reference: To summarize the literature on the Visual Field for conspicuity and make a recommendation for terms of reference for a Technical Committee.
Reporter: N. Itoh JP

No report.
R1-40 (V)  Scene Dynamic Range
Established: 2006
Terms of Reference: To investigate the concept of scene dynamic range, the appearance of colors brighter than the adapted white, and adaptation to the dynamic range when viewing, and make recommendations regarding work to be done by the CIE.
Reporter: J Holm US

No report.

R1-49 (V)  Above-threshold Pulsed Lights
Established: 2009
Terms of Reference: To review methods for photometric prediction of the brightness and colour of supra-threshold pulsed signal lights.
Reporter: Ian Tutt GB & Dennis Couzin US

The General Lighthouse Authorities (GLAs) have agreed to pay for research into supra-threshold flashing light perception at the University of Leeds. A meeting was held in Leeds in December 2010 to discuss the experimental methods and equipment. A design will be prepared by March 2011 with experiments beginning thereafter. Research is due to continue until 2014 to cover many aspects of different flash profiles, colour and background experienced in the marine environment. See the L1-8 report below.

R1-51(V)  Reconciling Maxwell vs Maximum Saturation Colour Matches
Established: 2010
Terms of Reference: 1. To examine the CIE TR 185 rod-cone model.
2. To examine the viability of the uniqueness of stimulus C for a Maxwell match.
3. To examine the hypothesis of pigment-bleaching distinction between the matching methods.
4. To examine in u’v’ space the Wyszecki & Stiles reported discrepancy of the spectrum loci to assess the significance of the difference.
5. To consider the recommendation of a new TC to carry out further study.
Reporter: Michael Brill US

To accomplish Task 4 requires transforming the rg coordinates in Wyszecki & Stiles Fig. 4(5.6.6) to u’v’ coordinates. In a strict sense this is impossible, because rg represents color matching for a single observer, not for a CIE Standard Observer. However, a plausible computation can be done using an algorithm reported in M. H. Brill, ‘Transformation of primaries using four chromaticity points and their maps’, Color Res. Appl. 33 (2008), 506-508. The four chromaticity points are the experiment’s monochromatic primaries and the D65 illuminant, the rg coordinates of all of which are reported by Wyszecki and Stiles, and all of which are represented for the CIE 1964 Standard Observer. Based on transformation from (r,g) to (x,y) and thereafter to (u’,v’) using these known values, I found that the 488-nm stimulus (which has a particularly large Δr = 0.35) gives Δu’v’ = 0.013. Although much reduced relative to rg distance, it is still significant relative to say, the nominal “jnd” of 0.004 in u’v’. Further representative values will be included in the final report of this activity. It seems likely that the alarming Maxwell/Maximum-Saturation discrepancy reported by Wyszecki and Stiles is not nearly so large as one might gather from Fig 4(5.6.6), but places a significant limit on the applicability of Grassmann’s laws.
COLOR SECTION: TECHNICAL COMMITTEES

TC1-27 (C) Specification of Color Appearance for Reflective Media and Self-Luminous Display Comparison

Established: 1990
Terms of Reference: To study and make recommendations for the specification of a color appearance match between a reflective image and a self-luminous display image.
Chairman: PJ Alessi US
Consultants: RWG Hunt GB, Y Nayatani JP, MR Pointer GB

Awaiting final report from CB.

TC1-44 (C) Practical Daylight Sources for Colorimetry

Established: 1995
Terms of Reference: 1. To compare existing daylight simulators for color measuring instruments and colour matching booths.
2. On the basis of this intercomparison, to recommend practical methods for simulating daylight sources.
Chairman: R Hirschler HU

The technical report CIE 192:2010: ‘Practical Daylight Sources for Colorimetry’, has been published, and the TC will be closed in Sun City.

This publication discusses the state-of-the-art of practical daylight sources for colorimetry. It provides information on these lamps and devices used for illumination in the visual evaluation and instrumental measurement of non-fluorescent and fluorescent specimens.

Suppliers of lamps, booths and spectrophotometers provided some of the data on daylight sources. TC members and advisors at four institutions measured the rest. These institutions are the University of Derby (UK), the Hong Kong Polytechnic University (Hong Kong, China), the University of Pannonia (Veszprém, Hungary) and SENAI/CETIQT (Rio de Janeiro, Brazil).

The report concludes from these data that practical daylight sources are commercially available that satisfy the criteria of the relevant national and international standards for both visual evaluation and instrumental measurement. Filtered tungsten, filtered xenon and fluorescent lamps currently provide the best results for visual evaluation. Pulsed filtered xenon provides the best results for instrumental measurements. Light-emitting diode (LED) sources may appear as viable alternatives for both applications in the not too distant future.

Standardization of any particular source as “best representing daylight” is not recommended. There are significant differences between the spectral properties of the sources currently used in visual evaluation and the sources used in instrumental measurement. These differences produce large differences in the rendering of colours of specimens, especially fluorescent specimens.
TC1-55 (C) Uniform Color Space for Industrial Color Difference Evaluation
Established: 1999
Terms of Reference: To devise a new uniform color space for industrial color-difference evaluation using existing experimental data.
Chairman: M Melgosa ES
Advisor: R Huertas ES

Dr. Robert Hirschler (Hungary) and Dr. Tetsuya Sato (Japan) have joined this TC as new members. A report was submitted to CIE Meetings in Princeton (USA). The next two paragraphs summarize the main contents of this report.

Regarding the relationship between perceived and computed color-differences, it can be stated that the STRESS index (Journal Optical Society of America A, 24, 1823-1829, 2007) is increasingly employed by different researchers, and seems to be an appropriate tool to assess the merit of different color-difference formulas. Four new experimental datasets (Wang & Xu, NCSU Global, RIT Combined, RIT Original Pairs) have been analyzed: similar results were found for the 5 formulas tested (OSA-GP Euclidean, CAM02-UCS, CAM02-SCD, DIN99d, and CIEDE2000) using these datasets. The same can be stated using these formulae to test 4 additional experimental datasets (Tremeau, Wang Hans, Witt1, Witt2) with color pairs having very small color differences (average $\Delta E_{ab}$ below 1.9), although the STRESS values were slightly higher for most of these last datasets.

Main items in our future work are as follows: 1) To analyze the LCAM dataset (M. Vik, 2004) including 284 textile pairs around 9 centers, 87 observers (5 replications), gray scale method. 2) To test some IPT models developed by Dr. Berns (RIT), using available datasets. 3) Discussion on which criteria will be considered to propose (if the case) a new color space for industrial color-difference evaluation, in addition to achieve significantly lower STRESS values than those found using CIEDE2000. 4) If it is not possible to achieve a significantly better model than CIEDE2000, the STRESS method and the results achieved from current available datasets can be reported as the final outcome of the work carried out by this TC.

TC1-57 (C) Standards in Colorimetry
Established: 2000
Terms of Reference: To prepare a series of CIE/ISO/IEC Standards that describe:
1. The method of calculating CIE tristimulus values and chromaticity coordinates
2. A uniform colour space and its associated metrics
3. A formula for industrial colour difference evaluation
Chairman: AR Robertson CA
TC 1-57 is responsible for preparing four CIE Standards, as follows:

S 014-3 Colorimetry – Part 3: Calculation of CIE tristimulus values
S 014-4 Colorimetry – Part 4: CIE 1976 L*a*b* colour space
S 014-5 Colorimetry – Part 5: CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram
S 014-6 Colorimetry – Part 6: CIEDE2000 colour-difference formula

Part 4 (CIE 1976 L*a*b* colour space) has been approved and was published in September 2007 as CIE Standard S 014-4/E:2007. It has also been approved by ISO and published as ISO 11664-4:2008(E).

Part 5 (CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram) has been approved and was published in March 2009 as CIE Standard S 014-5/E:2009. It too has been approved by ISO and has been published as ISO 11664-5:2009(E).

Part 3 (Calculation of CIE tristimulus values) was approved by TC 1-57 in June 2009 and by Division 1 and the Board of Administration in December 2009 with minor revisions. A revised draft was sent to National Committees for comments as DS 014-3.2/E:2010 in March 2010. The comments of the NCs were received by the TCC in December 2010. The TCC has drafted responses which are currently being reviewed by the TC.

The final work of the TC is Part 6 (CIEDE2000 colour-difference formula). The TCC prepared a first draft and sent it to the TC for review in October 2010. A second draft is being prepared for liaison members to solicit comments from their ISO or IEC Committees or Working Groups. As in the past, three months will be allowed for this consultation process.

TC1-61 (C) Categorical Color Identification
Established: 2001
Terms of Reference: To prepare a report describing a color categorization map for the photopic and mesopic illumination levels.
Chairman: T Ishida JP

The first draft report was written and circulated to TC members in June 2010. Revision of the report is currently in progress based on input from the members.

TC1-63 (C) Validity of the Range of CIE DE2000
Established: 2003
Terms of Reference: To investigate the application of the CIEDE2000 equation at threshold, and to CIELAB colour differences greater than 5 units.
Chairman: K Richter, DE

At the CIE meeting in Princeton 2010 it was decided that TC1-63 should now write a Technical Report.

The publication of the PhD thesis of Kittelmann in 2010 with both scaling and threshold results supports the writing of this report; see the summary and full text (132 pages, 9,8 MB, only in German) at http://opus.kobv.de/tuberlin/volltexte/2010/2634/

The threshold results lead to a transfer (Index t) of both the CIELAB formula and the CIEDE2000 formula for thresholds:

\[ L^*t = L^* \]
\[ a^*t = a \ a^* \]
\[ b^*t = b \ b^* \]

For a=b=1 this is the usual CIELAB formula. The CIELAB formula produces according to the summary (page 107) the stress value \( S100 = 54 \) (= 100 - S of CIE TC1-55). The CIELAB formula with the optimized parameters \( a=0,515 \) and \( b=0,153 \) produces the stress value \( S100 = 80 \). In summary for CIELAB: The read-green weighting factor decreases to about 1/2 and the yellow-blue weighting factor decreases to 1/6. (The weighting factor of \( L^* \) is not changed).

The CIEDE2000 formula uses the parameters \( 1/KC \) and \( 1/KH \) as weighting factor for chroma and hue. The CIEDE2000 formula produces according to the summary (page 107) the stress value \( S100 = 60 \). The CIEDE2000 formula with the optimized parameters \( KC= 2,05 \) and \( KH= 3,18 \) produces the stress value \( S100 = 74 \). In summary for CIEDE2000: Both the chroma and hue weighting factor decreases to 1/3.

2. Model for threshold and new TC1-81
A model to describe experimental threshold results of Kittelmann and others is necessary. Therefore a new CIE TC1-81 was created in 2010 with the title: Validity of Formulae for Predicting Small Colour Differences. TC1-81 will try to solve the problems which seem to depend mainly on field size. There are only 12 S-cones/degree. There are about 16 times more M-cones and 32 times more L-cones compared to S-cones. Therefore around 0,4 degree the yellow-blue discrimination is highly reduced and leads to the so called small field tritanopia below 0,2 degree viewing angle. In the threshold experiments of Kittelmann (2010) the observer looks at the border of a 2 degree sample pair. The detection of the threshold may depend on a smaller field size, for example only 0,4 degree. The reduction of discrimination in the yellow-blue direction by a factor 6 (see the weighting factors in the CIELAB formula above) is in agreement with this assumption.

The content of the proposed Technical Report of TC1-63 is as follows:

Terms of reference
1. Test charts and CIELAB data for the study of large colour differences
2. Results from different countries (CZ, DE, ES, GB)
3. Standard deviation and correlation in terms of stress values
4. Results for small colour differences (Kittelmann, Witt, Melgosa, Luo)
5. Standard deviation and correlation in terms of stress values
6. Discussion of the results
7. Summary
8. References

A special face-to-face meeting of members of TC1-55 and TC1-63 in February 2011 in Berlin will discuss the main content of the proposed Technical Report and some present and future work of TC1-55 and TC1-81.

TC1-64 (C) Terminology for Vision, Color, and Appearance
Established: 2003
Terms of Reference: To monitor the terminology requirements of Division 1 including the revision of the present ILV terms and the addition of new terms.
Chairman: S. McFadden CA
Members: EC Carter US, O da Pos IT, MR Pointer GB, J Schanda HU, Manuel Melgosa
A revised list of proposed Division 1 terms and definitions was distributed to the members. Comments were received from two additional members. In addition, members commented on the definitions of LED terms being developed by TC2-66. Their comments were collated by the Chair and submitted to TC2-66. At the request of the Central Bureau, the Chair collated comments on several issues raised during the National Committee ballot for the ILV. Unresolved issues will be addressed by TC1-64 prior to the next ILV revision.

TC1-68 (C) Effect of Stimulus Size on Color Appearance
Established: 2005
Terms of Reference: To compare the appearance of small (<2°) and large (>20°) uniform stimuli on a neutral background.
Chairman: Peter Bodrogi HU
Advisor: G Derefeldt SE

A technical report is being prepared and is expected to be ready by the time of the 27th session.

TC1-69 (C) Color Rendition by White Light Sources
Established: 2006
Terms of Reference: To investigate new methods for assessing the color rendition properties of white-light sources used for illumination, including solid-state light sources, with the goal of recommending new assessment procedures.
Chairman: Wendy Davis (US)

Working Plan:
1. Agree on some basic criteria for a new metric (or system of metrics) such that it (or they) could be developed to be scientifically sound, acceptable to lighting industry, and useful.
2. Solicit, share, and discuss proposals for new assessment procedures for colour rendition properties of white light sources.
3. Evaluate proposed assessment procedures with visual experiments and compatibility with basic criteria (in #1).
4. Recommend a new metric (or system of metrics) based on evaluation (in #3).
5. Prepare a CIE Technical Report on recommended new metric (or system of metrics), including calculation procedures and justification for recommendation.

Following the four-month period for individual TC members to study and evaluate the submitted research reports and metric proposals (see 2009 annual report), the
dedicated month-long discussion period began in mid-January. As part of these discussions, the TC held a web meeting in early February. The discussion was very active via e-mail, but it appeared that a consensus would not be reached during the allotted time. So, the TC members chose to extend the discussion/decision-making time. In March, a small group of TC members and other interested people met at the CIE Lighting Quality and Energy Efficiency meeting in Vienna, Austria.

In June, the committee officially met in Princeton, NJ, USA at the Joint Meeting of ISCC/ASTM E12/CIE Division 1. Eleven TC members and numerous others were in attendance. Brief presentations were given by Ronnier Luo, Janos Schanda, Francoise Vienot, Klaus Richter, Kevin Smet, and Yoshi Ohno. One of the primary goals of the meeting was to strategize on how the group could build consensus. A proposal was made that the TC report recommend two different metrics (CRI-CAM02UCS and CQS), with the intent that the users/marketplace would ultimately adopt one more strongly than the other. There were no objections to that idea, so it was decided that the idea would be brought to the rest of the members via e-mail following the meeting. Also at the Princeton meeting, it was agreed that the Memory CRI, which has strong support but also challenges for widespread immediate acceptance as a color rendering metric, would be taken up in a new TC to be formed after the conclusion of TC 1-69. Ronnier Luo suggested holding another TC meeting at the CIE Expert Symposium on Appearance in Gent, Belgium in September and offered to chair the meeting.

Following the meeting, e-mail discussion of the dual-recommendation proposal was initiated. There were some objections and one member wanted to begin working on a new metric proposal. Since this plan deviated so strongly from all of the previously agreed-upon timelines, a vote was taken on how to proceed. The voting was completed in mid-July. Of the voting members, 60% (18/30 votes) agreed to wait longer in the hopes of reaching consensus, while the other 40% (12/30 votes) wanted to write the report with the dual-metric recommendation and allow the inclusion of dissenting opinions in the document. The TC chair reiterated the time-sensitive nature of this committee's work and insisted that a draft of the report must be ready by the South Africa meeting (July, 2011), which means a decision should be made by the end of January, 2011.

A small meeting was held in Gent, Belgium in September, chaired by Ronnier Luo. Presentations were given by Ronnier Luo, Janos Schanda, and Peter Bodorogi. Kevin Smet gave a demonstration of the Memory Color Rendering Index.

Previously, two separate groups (non-TC members) approached the TC chair about presenting their ideas to the committee after the original metric proposal deadline (see 2009 annual report). At that time, the TC chair chose to enforce the timeline and did not permit them to do so. However, after the results of the voting indicated that members wanted more ideas before making a decision, the TC chair contacted these two groups and offered them the opportunity to submit their proposals to the TC for consideration. One proposal was introduced in October and another in November. These proposals generated little discussion. Overall, there has been very little TC activity for last quarter of 2010.

TC1-70 (C) Metameric Samples for Indoor Daylight Evaluation
Established: 2007
Terms of Reference: To investigate the derivation of a set of metameric samples to enable the evaluation of indoor daylight simulators
Chairman: B Kránicz HU

No report.
TC1-71 (C)  Tristimulus Integration
Established: 2007
Terms of Reference: To investigate methods for computing weighting tables for the calculation of tristimulus values from abridged data.
Chairman: C Li CN

No report.

TC1-72 (C)  Measurement of Appearance Network: MApNet
Established: 2007
Terms of Reference: 1. To establish a network of those interested in the measurement of visual appearance.
2. The network shall be under the direction and guidance of a group of at least four Technical Leaders each responsible for a particular aspect of the subject.
3. Each Technical Leader shall provide substantial periodic reports in a form that might be published.
4. A second Expert Symposium on Appearance shall be organised at an appropriate time within the next 4 years.
5. A database of relevant published work shall be maintained.
6. Consideration shall be given to the establishment of separate Technical Committees when appropriate.
Chairman: MR Pointer GB

The 1st CIE Expert Symposium on Appearance was held in Paris in 2006 and it was recognised at that meeting that an important group of people were missing from the attendees: lighting designers and practitioners. Thus, the 2nd Expert Symposium aimed to correct this omission and invite those active in CIE Division 3 Interior Environment and Lighting Design to participate. 78 abstracts were submitted and these were given as 36 presentations of 15 minutes each plus 42 posters, all in two and a half days! Over 135 delegates attended the event representing 22 countries.

To introduce the symposium Monica Billger from the Department of Architecture, Chalmers University of Technology, Sweden discussed issues to do with lighting quality in the real environment pointing out that there is no accepted definition of lighting quality, the quality of lighting usually being expressed in terms of specific luminance levels, or distributions, in the workplace, the home, etc.

There followed six sessions, each chaired by an expert in the respective field: Colour Appearance (Ronnier Luo), Measurement and Instrumentation (Mike Pointer), Gloss and Texture (Françoise Viénôt), Luminance and Glare (Terry McGowan), Luminance Based Design (Yoshiki Nakamura), and Lighting Comfort (Steve Fotios).

This was both an enjoyable and a successful symposium. Invitation are being sought to organise the 3rd Expert Symposium on Appearance, perhaps during 2012, or maybe 2014.

The concept of a network of people interested in all aspects of appearance has not really worked and it is proposed that this TC be shut at the 2011 meeting on D1. There are many aspects of appearance that, at some time in the future, would warrant the attention of CIE, but perhaps it is too early in the development of the science to propose new TCs in this area.
TC1-73 (C) Real Colour Gamut
Established: 2007
Terms of Reference: To recommend a gamut representative of real (non-fluorescent) surface colours and defined by associated spectral reflectance data.
Chairman: C Li CN
Observers: Ellen C Carter US, Siu-Kei Tin

A draft (version 0) report was prepared by the chair and was distributed to members. In the report, the existed gamuts were reviewed. They are:
- Pointer Gamut (MP)
- ISO TC 130 Gamut of Surface Colours (1998)
- Hewlett Packard's Printer Gamut (HP)
- PhotoGamut RGB (RGB)

Figure 1 shows the comparison of the gamuts of MP, HP, RGB and ISORCG in L* vs C* with hue=0. It can be seen that the ISO gamut is the largest. The gamut of Pointer is the smallest for L* less than 40 and the RGB is smallest for L* greater than 40.

Figure 2 shows the gamuts of Pointer (black) and ISO RCG (blue) against real data (read). It can be seen that the ISO gamut is larger than it should be in certain parts because there is a large gap in certain parts between the boundary and real data. For hue being 300, only two points of the Pointer gamut were left. This is because original coordinates of Pointer gamut is defined under C/2°. The gamut of ISO is defined under D50/2°. For the comparison, the coordinates were transformed from C to D50 using CAT02. After the transformation, more original data with hue being 300 were shifted to other hue range less than 295° or greater than 305°.
In summary,

1. Define gamut in terms of coordinates under a particular illuminant is not enough.
2. The current available gamuts do not represent available data well.
3. Hopefully this TC can derive a new gamut which represents available data well and is defined in terms of reflectance functions.
4. The time scale can be anticipated within the next two years.

TC1-74 (C) Methods for Re-Defining CIE D Illuminants
Established: 2009
Terms of Reference: To investigate the issue of smoothing the values of the D illuminants such as described in CIE 15:2004 Appendix C and to propose the calculation methods for new definitions of the D Illuminants.
Chairman: Janos Schanda HU
Members: Hugh Fairman US, Robert Hirschler HU, Balázs Kránicz HU, Changjun Li GB, Yoshi Ohno US, Danny Rich US

A report was given at the Princeton meeting. A final chapter has been prepared to add to the report, but a complete draft has not yet been collated. It should be done early in 2011 so that a final meeting of the TC in Sun City may be able to approve the draft.

TC1-75 (C) A Comprehensive Model of Colour Appearance
Established: 2009
Terms of Reference: To derive colour appearance models that include prediction of the appearance of coloured stimuli viewed in typical laboratory conditions that 1) appear as unrelated colours, 2) are viewed under illumination down to scotopic levels and 3) include consideration of varying size of stimulus.
This TC is based on the previous research works by Dr. K. D. Xiao and Dr. C. Y. Fu. Dr. Xiao studied the change of colour appearance of the same colour having different sizes (2, 8, 19, 22, 44 and 50 degree of visual field). Dr. Fu investigated unrelated colours viewed under photopic and mesopic vision. The visual results included 4 illumination levels (0.1, 1, 5 and 60 cd/m$^2$) and three field sizes (0.5, 1, 2 and 10 degree).

The major progress of this TC was the writing of 3 journal papers, which were all accepted for publication by Color Research and Application$^1$. The major deliverable of this TC will be the extension of CIECAM02 to take into account these effects. This was more or less completed because these were reported in these papers.

However, the reverse model is still required to be developed. This will form the second stage of the TC work. In addition, the papers will also be distributed around the TC members for comments in terms of modelling.

TC1-76 (C) Unique Hue Data
Established: 2009
Terms of Reference: To study and report on unique hue data, including an analysis of the scatter of those data: this to include practical viewing conditions.
Chairman: Sophie Wuerger GB

No report.

TC1-77 (C) Improvement of the CIE Whiteness and Tint Equations
Established: 2009
Terms of Reference: To recommend improvements or modifications to the existing CIE Equations for Whiteness and Tint to extend their scope of application to a wider range of instrument conditions and white materials; e.g. various tints and levels of fluorescence.
Chairman: Robert Hirschler HU
Advisors: S H Amirshahi IR, R Harold US, S Rydefalk SE

The CIE Central Bureau has approved the establishment of this TC that was proposed at the 2009 meeting of CIE Division 1 in Budapest, Hungary. The draft working plan, currently being discussed within the TC is the following:

TC1-77 Improvement of the CIE Whiteness and Tint Equations
Draft Working Program

1. Preparation of textile, paper or other sample sets
Prepare textile, paper or other sample sets to be used in visual and instrumental evaluation of whiteness. The sample sets should sufficiently cover the whole area considered “white” by the current CIE limits and should also include samples which are visually considered “white” but fall outside the current limits.

2. Experimental work on measurement geometry
Develop a correction method for the transfer of calibration data obtained on 45:0 instruments in National Standardizing Laboratories to industrial instruments using d:0 or d:8 geometry.

3. Visual/instrumental evaluation under different light sources
Verify the validity of the current whiteness formula under different, light sources (D65/D50/ID65/ID 50/A/TL84/other). Recommend the necessary modification(s) in order to achieve sufficiently high correlation between visual and instrumental results under each of the illuminants/sources.

4. Practical calibration of spectrophotometers.
Verify the suitability of the Ganz-Griesser calibration method and formula for the “absolute” (instrument-independent) specification of whiteness. In case of positive results recommend to develop it into a CIE standard.

5. Extension of the CIE whiteness limits
The CIE whiteness formula establishes tint and whiteness limits; many commercial papers and possibly also textiles perceived as white fall outside these. Modify the CIE whiteness formula (e.g. by the introduction of a penalty function) to handle white materials at the vicinity of the upper CIE whiteness limit and also verify experimentally the tint limits modified in 2004.

6. Prepare a CIE Technical Report on the findings and make recommendations as described under items 2 to 5.

TC1-81 (C) Validity of Formulae for Predicting Small Colour Differences
Established: 2010
Terms of Reference: 1. To evaluate available formulae for small colour differences (<~2.0 CIELAB).
2. To define a visual threshold colour difference.
Chairman: Klaus Richter DE

1. Scaling and threshold: Stevens and Weber-Fechner law
The standard office display with the standard luminance reflection of 2,5% compared to the reference white display (100%) shows a basic problem between scaling and threshold (visibility). This is shown by 16 achromatic samples of the ISO test chart according to ISO 92421-306:20082.

The 16 samples look usually equally spaced for a gamma near 2 (Yw:Yn=88,6: 1,3 or 2,5, page 5 or 7). However, all Landolt rings produced by the 16 grey steps may be seen only at a gamma of about one (page 15) instead of a gamma of about two (page 5 or 7). Therefore the log visual response is a function of log luminance with the slopes of approximately 0,5 (Stevens law) and 1,0 (Weber-Fechner) law in the two cases. A model of Richter (2006) for the connection of both laws is shown in the paper3.

2. Linear metric for thresholds
It has been shown by S. L. Guth (Colour metrics, TNO, Driebergen, 1971, 82-98) that color thresholds can be described by linear chromatic response functions similar to the Hurvich and Jameson response functions, see Richter 20104. The Guth model has a very small yellow-blue chromatic response compared to the red-green response.

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2 http://www.ps.bam.de/ME15/10L/L15E00FP.PDF(16 pages, 1,8 MB)
3 http://www.ps.bam.de/BAMAT.PDF(11 pages, 200 KB)
4 http://130.149.60.45/~farbmetrik/CIE_TC1-63M_10.PDF(18 pages, 500 KB)
(compare the dependence on field size below). In addition a linear model is able to describe the Holtsmark-Valberg (1970) experiments of equal threshold for complementary optimal colours. This model includes a metric by CIE tristimulus values and it requires approximately the Weber-Fechner law in the White-Black direction for thresholds.

3. Yellow-Blue threshold and field size
For example for small field sizes of about 0.4 degree there are too few blue cones to produce a larger yellow-blue component. An example of this effect shows the DIN-test chart according to DIN 33872 6:2010. Any two neighbouring colors of the 9 colors between White and Yellow have a CIELAB color difference larger 5 (row 10, columns J to R). Still it is hard to distinguish neighboring color pairs (perhaps some size reduction by a factor 0.5 may be necessary). However, if the series is magnified by a factor 4 to about a viewing angle of 2 or more degrees all steps are distinguishable.

4. Weighting factors 1/2 and 1/6 in CIELAB to describe thresholds
The optimization of the CIELAB formula by Kittelmann (2010), see the report of TC1-63, describes his experimental threshold results by the weighting factors 1/3 and 1/6 for red-green and yellow-blue. This is similar compared to the above White-Yellow color series. In one model for this one can assume that for the two degree samples of Kittelmann still the threshold is determined by only a small part (0.4 degree) of the two degree border between two samples.

5. Opponent color pairs of image technology produce a yellow-blue component
A model which describes the low Yellow-Blue component comes from image technology. In image technology two opponent color pairs Orange-Cyan and Leafgreen-Magenta are used. The Cyan is the complementary colour to Orange. Therefore Orange covers the wavelength range 575nm to the end of the spectrum and Cyan the wavelength range from the beginning of the spectrum to 575nm. The Yellow component of both Orange and Leafgreen is by a factor 6 smaller compared to the Red-Green component. This relation describes the low discrimination in Yellow-Blue direction compared to a large discrimination in the Red-Green direction. The small Yellow-Blue component is produced without a contribution from the S-cones. If in addition a bluish D65 surround is visible then the surround may increase the Yellow-Blue component by a factor 3.

6. Nonlinear contribution of the S-cones
For scaling of the 2 degree sample field in a white surround a nonlinear contribution of the short wavelength cones is expected. The orientation of the threshold ellipses along the axis 575nm-475nm in the (x,y) chromaticity diagram is shifted towards the axis 537nm-450nm (maximum responses of M and S cones). This turn has been published for threshold and scaling data.

Summary
The goal of CIE TC1-81 to describe the threshold data of Kittelmann (2010), Witt, Luo and others and to determine a threshold value may be possible by an improved color vision model as function of field size. Not only the 2 degree samples size but also the smaller viewing size, for example 0.4 degree, may be in addition important to detect the threshold.

In the following the notation V for visual with an integer wavelength number is used. Two log visual response curves V537 [M-cone] and V612 (Orange) of parabolic shape sum up to the elementary Yellow response curve V575 of the same parabolic shape. In other words: the response curve V612 (Orange) is the difference of the response curves

http://www.ps.bam.de/De16/10L/L16e00NP.PDF
VS37 \([L\text{-cone}]\) and VS75. Similar VS75 is the difference between VS50 \([V(\lambda)]\) and VS63 \([L\text{-cone}]\). The paper of point no. 2 includes some more information. The very similar shape of VS37 \([L\text{-cone}]\) and VS63 \([L\text{-cone}]\) and the distance of only 25nm on the wavelength scale allow to use both either a log or linear summation to calculate VS50 \([V(\lambda)]\). The difference is less than 1% at 400 nm and 700 nm. This is small compared to the office tristimulus value \(Y=2.5\) of black. Therefore the other visual responses VS75 \([\text{elementary Yellow}]\), VS612 \([\text{Orange}]\), and VS37 \([\text{Leaf green}]\) are approximately linear functions of the visual responses of VS37 \([L\text{-cone}]\) and VS63 \([L\text{-cone}]\). Therefore if there is no contribution of S-cones a linear model may describe threshold results to a high degree.

Final remarks
Some conflicts of the Kittelmann results with the results of TC1-55 may depend on the different field size and have to be discussed further. Any comments to this problem and to this activity report are welcomed. The chairman is looking for more active members in TC1-81. Especially active members of the former TC1-63 and TC 1-55 are invited and those who can produce threshold data as a function of field size.

COLOR SECTION: REPORTERS

R1-42 (C) Extensions of CIECAM02
Established: 2007
Terms of Reference:
To evaluate potential additions to CIECAM02 in liaison with Division 8 and to include:
- Those published in the literature;
- Extension to include unrelated colours;
- Extension of the range down to scotopic levels
Reporter: C Li CN

Repairing CIECAM02 is proving more difficult than we thought. There are no new results from TC8-11 this year.

R1-48 (C) Colour Emotion and Harmony
Established: 2009
Terms of Reference:
To review methods for relating the emotion and harmony responses to coloured stimuli with associated colorimetric measurement of those stimuli.
Reporter: Li-Chen Ou TW

A review report has been published during the CIE Division 1 meeting held in Princeton, July 2010 summarising recent findings and development of research in colour emotion and harmony.

In this report, a definition of colour emotion was given, as follows: “colour can serve as an emotion messenger, sending a communicative signal describing the affective quality of the colour itself or of the environment/product; colour emotion is a discipline investigating the relationship between colour and such affective quality”. Three underlying factors of colour emotion have been identified, i.e. hue-related, lightness-related and chroma-related, each modelled on the basis of CIELAB system.

Conventional theories of colour harmony were reviewed, with the following “principles” identified (note: these were based on each researcher’s own observation rather than empirical data): complementary hue, equal hue, equal chroma and equal lightness. Psychophysical models of colour harmony developed during the last decade were all based on similarity or dissimilarity in colour appearance attributes of each constituent colour.
Findings regarding psychophysiological responses to colour have shown strong impacts of reds (compared with other colours) according to electroencephalogram (EEG) and skin conductance (SC) measurements. However, the following question has been raised: when people look at a colour, do they respond directly to it or are various associations with that colour (i.e. cognitive responses) also elicited?

From the review results, the Reporter is looking to establish a new TC for addressing issues related to colour emotion and harmony as will be proposed in the next CIE meeting.

R1-50 (C) 3D Aspects of Visual Appearance Measurement
Established: 2009
Terms of Reference:
1. To review the activity of relevant organisations related to 3D vision, 3D image capture, 3D model storage and 3D display where these are relevant to visual appearance issues
2. To establish a database of key research articles, technology and terminology related to 3D aspects of visual appearance
3. To establish an international panel of experts able and willing to advise on 3D matters
4. To liaise with other CIE divisions

Reporter: David Simmons GB

No report.

R1-52 (C) Spectral Data Interpolation
Established: 2010
Terms of Reference: To review the methods, and make a recommendation for the interpolation of existing, highly structured source spectra, including the FL illuminants, for colorimetric calculations.

Reporter: Hugh Fairman US

No report.
LIAISONS

L1-1  AIC (Association International de la Couleur)

Liaison:  P J Alessi

The AIC 2010 meeting was held in Mar del Plata, Argentina from Tuesday October 12 to Friday, October 15 2010. It was organized by the Argentine Color Group. The topic was Color and Food: From the Farm to the Table. This was a very successful meeting with 202 participants from 26 countries. It featured 139 presentations including 90 posters, 42 oral papers, 4 invited lectures, 2 pre-congress seminars and 1 sponsor talk. Oral Sessions included Food Color and Appearance, Psychological Aspects of Food Color, Color in Food Packaging, Color in Food-Related Architecture, Food Chemistry and Colorimetry, Food Colorimetry, Color and Food in Arts and Culture, Color, Food Properties, and PFureferences, Color Design in Food Environments, Color and Food in Culture and Language, Food Lighting, and Color Imaging and Appearance. Proceedings of the conference are available in hardcopy with a CD-ROM included. If interested, please see http://www.aic2010.blogspot.com/

Future AIC Meetings are:

AIC 2011 (June 7-10) Interaction of Color and Light, Zurich Switzerland
AIC 2012 Color and Environment, Taipei, Taiwan
AIC 2013 12th Congress, Newcastle Gateshead, UK
AIC 2015 Color and Image, Tokyo, Japan

L1-2  CCPR (Comite Consultatif de Photometrie et Radiometrie), BIPM

Liaison:  M. Stock

The CCPR normally meets every two years at the BIPM in Sèvres, France, bringing together experts from its member NMIs (National Metrology Institutes). The last meeting of the CCPR took place from 17-18 September 2009. The CCPR working groups met from 6-9 July 2010 at the NPL in Teddington, UK.

The key comparison working group had organized a one-day workshop on key comparison analysis. The main themes were the use of mathematical modes to describe comparisons and the treatment of inconsistent data, which includes outliers. The Mandel-Paule method\(^6\) was considered as particularly well suited to deal with inconsistent data.

The key comparison working group has set up a schedule for the second round of key comparisons, which are the technical basis for the CIPM-MRA\(^7\) and which demonstrate the technical capabilities of the participating NMIs. The first comparisons to be repeated are for regular spectral transmittance (start in 2011) and for luminous intensity and luminous flux (start in 2012). The results of the completed key comparisons can be found in the key comparison data base, held at the BIPM\(^8\).

The members of the task group on the SI of the Strategic Planning Working Group have published a position paper on “Photometry, radiometry and the candela: evolution in the classical and the quantum world”\(^9\). This paper reviews the evolution of optical radiation measurements and its consequent impact on the definition of the candela. In

\(^7\) CIPM-MRA : Mutual Recognition Arrangement of the International Committee for Weights and Measures. For more information, see www.bipm.org/en/cipm-mra.
\(^8\) http://kcdb.bipm.org/appendixB
the context of the preparations for the redefinition of four of the seven SI base units (the kilogram, the ampere, the kelvin and the mole), planned for 2015, a discussion has begun within the CCPR if the candela definition should be reworded in terms of a photon intensity, without any clear conclusion up to now.

As a consequence of a workshop on "Physiological quantities and SI units", held at the BIPM in November 2009, the Strategic Planning Working Group has created a task group on terahertz radiation, which shall advise the CCPR on technical matters related to THz measurements requiring SI traceability.

The next meeting of the CCPR and its working groups will take place in March 2012 at the BIPM. General information on the work of the CCPR can be found on www.bipm.org/en/committees/cc/ccpr.

The following recent activities may be of interest to the CIE:

Liaison: J C Zwinkels

The following Standard: ISO 22891-2007 Paper - Determination of transmittance by diffuse reflectance measurement, has completed systematic review and, based upon the received comments, it is recommended to "Confirm this Standard but with correction of errors". One of the needed corrections is to clarify the CIE conditions for calculation of "luminance factor"

There are no other ISO TC6/WG3 Standards that are currently undergoing systematic review.

The committee draft CD 2469 Paper, board and pulps – Measurement of diffuse radiance factor to incorporate a means to ensure that the UV intensity is negligible below 300 nm has received many comments at the CD stage. There is concern not only about providing more details on the proposed 320 –nm cutoff filter for eliminating the UVB, but also several comments about terminology, including proposals to introduce "non-standardized terminology, such as "apparent diffuse reflectance factor". An extension of this project has been requested so that the comments received on the CD ballot can be fully discussed at the next WG3 meeting in Paris, May 2011.

CIE liaison activities: I provided Robert Hirschler, the Chair of TC 1-77 Improvement of the CIE Whiteness and Tint Equations, a copy of a recent TAPPI- Over the Wire article entitled “Whitest paper not necessarily the whitest” based on research being carried out at Innventia (Sweden) by a Ph.D. student, Sundsvall Gustafsson of Mid Sweden University; his dissertation is entitled “Whiteness and Fluorescence in Paper – Perception and Modeling”. This work includes application of CIECAM02-m2 on perceived whiteness and shows that the linear CIE Whiteness equation fails to predict perceived whiteness of highly white papers with a distinct bluish tint; an alternative non-linear whiteness equation was shown to give better correlation. The results of this research have a direct impact on the work of this TC.

The next meeting of ISO TC6 is scheduled for 23-27 May, 2011 in Paris, France.
Note – some titles of standards are paraphrased for brevity

ISO/TC 42/WG 18/20/22/23 (Digital photography and color) met in Cologne the 29th & 30th September 2010. The active projects in WG18, 20 & 23 and TC130 WG7 & 9 are reported as follows:

WG18, Digital photography
ISO 2721, Automatic exposure control
Is proposed to be revised, to limit the current standard method to film cameras and provide new information relevant to digital cameras (PL proposed to be from Germany).

ISO 12231, Vocabulary
Ed. 3 DIS approved unanimously with only minor editorial comments; it will proceed to publication after the PL addresses the comments from the ISO editor.

ISO 12233, Resolution measurements
Ed. 2 NP for CD has been prepared and will be circulated soon. This will be a technically revised standard with new normative methods.

ISO 12234-1, Removable memory and file formats
Ed. 3 CD approved with minor comments; DIS ballot being prepared. Includes more extensive metadata table and metadata persistence rules. Adds JPEG 2000 and will reference new CIPA/JEITA Exif & DCF standards.

ISO 12234-2, TIFF/EP file format
The task group for the development of the proposed 2nd Ed. of TIFF/EP was reconfirmed with the PL from Adobe. TIFF/EP is comprehensive to support many different use cases, including backward compatibility with current TIFF readers and support of Adobe DNG. Further, it has been requested to incorporate TIFF as needed to avoid the need for the normative reference to the TIFF 6.0 specification. It was reported that SMPTE intends to refer to ISO 12234-2 for their CinemaDNG specification, which uses TIFF files in an MXF wrapper. The NP ballot is currently out for vote.

ISO 15739, Noise and dynamic range measurement
Ed. 2 CD has been prepared and will be circulated for vote soon. The new edition includes significant cleanup work and technical clarifications, and a new method for visual noise measurements.

ISO 20462-3, Image quality ruler
Ed. 2 DIS ready to be circulated for vote. Adds softcopy quality ruler method.

ISO 15781, Shutter-lag measurements
The NP was approved and the CD has been prepared and will be balloted soon.

Mobile imaging group
This group will submit comments on current standards and proposals for new standards in the area of mobile imaging.

ISO TC130 JWG7, ISO 15076 series: ICC color management
Ed. 2 of ISO 15076-1 was published on 2010-11-26. It is the ISO version of the ICC color management standard. Edition 2 contains a number of editorial clarifications and technical additions from Edition 1, but is fully backward compatible.

ISO TC130 JWG9, ISO 12640-5, RIMM/ SCI D
The CD ballot just closed for this standard, but the results are not yet available. This standard provides a number of scene-referred images and associated information for testing color rendering.

JWG20 with ISO TC130, Graphic Technology, Digital camera color characterization
ISO/TR 17321-2, Considerations for determining scene analysis transforms
NP and DTR are currently out for vote.

JWG23 with ISO TC130, Extended color encodings
ISO 22028-2, ROMM RGB
NP approved to elevate this TS to IS. CD has been prepared and will be circulated for voting soon. Edition 2 (IS) contains additional editorial explanatory material, and one technical restriction on the allowed encoding values was removed. Otherwise it is identical to Edition 1 (TS).

ISO/TS 22028-3, RIMM RGB
NP and DTS are currently out for vote. Ed. 2 adds specifications for floating point RIMM (FP-RIMM) and clarifies and simplifies several sections, especially the white balance/adaptation requirements.

ISO/TS 22028-4, eciRGB
DTS approved unanimously with comments. Comment resolutions agreed in Cologne. PL will prepare publication draft for submission to ISO.

JWG25 with ISO TC130, Use of XMP for digital photography
ISO/PWI 12234-3, Electronic still picture imaging -- Removable memory – Part 3: Use of XMP
This new JWG has just been formed for preliminary work on this project. It was noted that Adobe has brought their XMP specification to ISO/TC 130 for fast-track standardization as ISO 16684.

Other WGs and projects
There are currently no active projects in JWG 22 as there is currently no collaborative work with IEC TC100. (JWG22 provides coordinated ISO TC42 and TC130 input to joint IEC/ISO color standards administered by IEC TC100/TA2.) This may change as IEC/ISO 61966-2-1 and IEC/ISO 61966-2-2 are coming up for review.

ISO TC42 WG5, Image Permanence, held meetings during the same week in Barcelona, but as these meetings were concurrent with the meetings listed above, I could not attend them and consequently they are not reported.

L1-6 ISO/TC130: Graphic Technology
Liaison: D C Rich

ISO TC 130 held its annual plenary meeting in Sao Paulo, Brasil, 16 October 2010.

Actions and plans of the Technical Committee that are of interest to the CIE
1. ISO TC 130 resolved to send a communication to the CIE concerning the series of documents starting with CIE Publication 51 and continuing through CIE S012 and finally ISO/CIE 23603. The ISO Technical Committee wishes to express their concerns over the number of variances between the recommendation and the final standard.
2. Withdrawal of the standard ISO 13656 Application of Reflection Densitometry and Colorimetry to Process Control or Evaluation of Prints or Proofs. This standard is now considered to be obsolete and no longer required.
3. Konica-Minolta reported to ISO TC 130 that they have designed and constructed a new color-measuring instrument that is fully compliant with ISO 3664 and ISO 13655 by providing an illumination system that is compliant with the M1 classification, that is a category BB D50 simulator.

No other actions or activities were planned or carried out that are of interest to CIE Division 1.

L1-7 ISO/IEC JTC1/SC28 Office Equipment
Liaison: K Richter

No report.

L1-8 IALA (International Association of Lighthouse Authorities)
Liaison: M. Nicholson and I. Tutt GB

IALA ANM and EEP Meetings
The IALA quadrennial conference in South Africa was a great success and the Proceedings are available on the IALA website http://www.iala-aism.org. IALA committee meetings took place in October 2010 when a new four-year work programme began. Work continues on the IALA Guidelines “on Conspicuity of Aid to Navigation Signal Lights at Night” and “on Light Sources used in Visual Aids to Navigation”. Most IALA documents can be freely downloaded by visiting the IALA website and clicking on the “Publications” tab, followed by choosing the type of document (e.g. “Recommendations”).

Expert Meeting on Conspicuity of Pulsed Lights
Unfortunately, the Japan Coast Guard expert meeting in Tokyo due in November 2010 was cancelled due to lack of funding. This was supposed to be a joint IALA-CIE meeting on the topic of signal light conspicuity.

General Lighthouse Authorities of UK & Ireland
The GLAs are still progressing with various projects calling for long-range LED signal lights. One approach taken was to consider putting an array of high power LEDs into an existing large optic (see picture below). This approach minimises replacement cost - some optics are two metres in diameter, several metres tall and at the top of a tall tower in the middle of the sea! It also preserves heritage by retaining existing optics, many of which are over one hundred years old. Long distance photometric measurements took place at Casquets Lighthouse (Channel Islands) in June 2010 which confirmed a nominal night time range of 19 nautical-miles from this 50W LED light source within the existing revolving optic.
An example of a high intensity LED marine signal light is shown in the picture below, under test on the light range.

The measurement of these lights is done at a distance beyond beam crossover. Measurements of luminous intensity against angle and time (these lights are flashing a rhythmic character) are carried out before installation. Spectroradiometric measurements are also carried out at this measurement distance to establish colour variations within the beam and within the flash.

The GLAs’ work on improving the efficiency and effectiveness of the Visual Aids to Navigation continues. Recent improvements in LED performance and efficacy are finding their way into the market at an alarming rate. Concerns are:

- Long projected life means that lumen maintenance figures are not known;
- Obsolescence may occur long before lumen degradation effects are quantified;
- There is a lack of standardisation in LED components;
- Effects of UV exposure, lightning and static on solid state light sources in prominent locations at sea are unknown.

These concerns raise questions about the procurement of spares and spares holdings.

GLA Study on Conspicuity of Marine Signal Lights
Flashing Lights at Supra-threshold
The GLAs have agreed to pay for research into supra-threshold flashing light perception at Leeds University. Part of the remit will be to repeat the 1933 brightness matching experiments of Toulmin-Smith and Green.

This research is due to begin in early 2011 and will hopefully continue until 2014.
A marine aids to navigation lights calculator, based on conspicuity information already known, has been made available to selected users of the R&RNAV website. A picture of the front panel of this software application is shown below.

As well as looking at the theoretical aspects of conspicuity, practical applications have been developed. The temporal and spatial separations of synchronised lights have been defined and the use of floodlighting lighthouse structures, using CIE Guidance, has been investigated with interesting results.

Figure 2 Left: Spatial separation is required with synchronised red and green lights to prevent colour mixing at narrow subtense angles. Right: A lighthouse floodlit with magenta.

Useful Links
http://site.ialathree.org/  
http://www.cil.ie/  
http://www.nlb.org.uk/  
http://www.trinityhouse.co.uk/  
International Association of Marine Aids to Navigation and Lighthouse Authorities  
Commissioners of Irish Lights  
Northern Lighthouse Board  
Trinity House
http://www.gla-rrnav.org/  General Lighthouse Authorities Research and Radionavigation Directorate

Author: Ian Tutt & Malcolm Nicholson  Date:  8th December 2010
Approved: Nick Ward  Date:  8th December 2010

L1-9  ISO/ TC159: Ergonomics
Liaison: K Sagawa JP

No report.