International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

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INTERNATIONAL YEAR OF LIGHT 2015

28th CIE SESSION

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PROCEEDINGS

Volume 2

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The Presidents of the CIE

1913	T. Vauthier	France
1921	E.P. Hyde	USA
1927	C.C. Paterson	United Kingdom
1931	A.R. Meyer	Germany
1935	Ch. Fabry	France
1939	N.A. Halbertsma	Netherlands
1951	W. Harrison	USA
1955	J.W.T. Walsh	United Kingdom
1959	I. Folcker	Sweden
1963	L. Schneider	Germany, Fed. Rep.
1965	I. Folcker	Sweden
1967	D. Vermeulen	Netherlands
1971	W.R. Stevens	United Kingdom
1975	S.K. Guth	USA
1979	J.B. de Boer	Netherlands
1983	G. Wyszecki	Canada
1985	A.M. Marsden	Hong Kong
1987	H. Bodmann	Germany, Fed. Rep.
1991	R.C. Aldworth	United Kingdom
1995	J. Hsia	USA
1999	H.A. Löfberg	Sweden
2003	W. v. Bommel	Netherlands
2007	F. Hengstberger	South Africa
2011	A.R. Webb	United Kingdom

Objectives of the CIE

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

The work of the CIE is carried out by Technical Committees, organized in seven Divisions. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.

A plenary session is held every four years at which the work of the Divisions and Technical Committees is reported and reviewed, and plans are made for the future. The CIE is recognized as the authority on all aspects of light and lighting. As such it occupies an important position among international organizations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par Comités Techniques, organisés en sept Divisions. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.

Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationales Forum für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Messtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird durch Technische Komitees geleistet, die in sieben Divisionen organisiert sind. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtanwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind auf der ganzen Welt anerkannt.
Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

CIE Administrative Bodies

BOARD OF ADMINISTRATION

President of the CIE:	Ann Webb
President-Elect:	Yoshihiro Ohno
Vice-President Publications:	Teresa Goodman
Vice-President Standards:	Axel Stockmar (2011–2014), Ad de Visser (2014–2015)
Vice-President Technical:	Yoshihiro Ohno
Vice-President:	Cui Yiping
Vice-President:	Marc Fontoynont
Vice-President:	Axel Stockmar (2014–2015)
Vice-President:	Ramani Venkataramani
Secretary:	Yoshiki Nakamura
Treasurer:	Lorne Whitehead

Division 1	Vision & Colour	Director:	Ronnier M Luo
Division 2	Physical Measurements	Director:	Peter Blattner
Division 3	Interior Lighting	Director:	Jennifer Veitch
Division 4	Lighting for Transport	Director:	Ad de Visser (till 2014) Ronald B Gibbons
Division 5	Exterior Lighting	Director:	Peter Schwarcz
Division 6	Photobiology	Director:	John O'Hagan
Division 8	Image Technology	Director:	Po-Chieh Hung

DIVISION DIRECTORS COMMITTEE

Chair: Yoshihiro Ohno — Members: Division Directors

FINANCE COMMITTEE

Chair: Lorne Whitehead — Members: Peter Dehoff (Internal Auditor), Martina Paul, Ann Webb

PERSONNEL COMMITTEE

Chair: Ann Webb — Members: Yoshiki Nakamura, Lorne Whitehead

CENTRAL BUREAU

General Secretary:	Martina Paul
Technical Manager:	Peter Zwick
Office Manager:	Leo Trausnith
IT & Social Media :	Lena Doppel

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WELCOME ADDRESSES

Message from the incoming President, Dr. Yoshi Ohno

THE CIE – STARTING ITS NEW CENTURY IN THE MIDST OF LIGHTING REVOLUTION

The renewed CIE Board of Administration started at the 28th Session of the CIE in Manchester with changes of several officers. I humbly accepted the honour of serving as the new President of CIE, the prestigious international organization with one hundred years' history. We also had a big change in Central Bureau, with the change of General Secretary of CIE. We thank Ms. Martina Paul, who served in the position since 2007, taking strong initiatives in numerous improvements and reforms of CIE in the past eight years. We now welcome a new General Secretary, Ms. Kathy Nield, who moved from New Zealand's National Metrology Institute and who was also the President of New Zealand's NC of CIE.

The CIE celebrated its Centenary just a few years ago in 2013 and is starting its new century of existence. In its long history the CIE has been well established as the international scientific body for light and lighting, publishing numerous Technical Reports. In recent years CIE has also established its position as the international standardizing body for light and lighting, publishing many International Standards, as recognized by the ISO. CIE has recently established an official liaison with the International Committee for Weights and Measures (CIPM) to cooperate developing standards on quantities and units. CIE also started a new structure of cooperation with ISO (TC274) for developing standards for lighting applications. CIE aims to improve its financial position after revising the dues this year first time since 2001 thanks to cooperation and understanding of the NCs; other initiatives including symposia, tutorials, and publication strategies will also aid in bringing in extra revenues.

It is my goal for the quadrennium 2015 – 2019 to keep the strong activities of CIE going as has been established, continue working to speed up CIE work, and then make further improvements to adapt better to the needs brought about by changes in lighting. The world of lighting is changing as the LED revolution unfolds. While LED lighting products are being adopted rapidly in many applications, there are still many issues on quality of LED lighting products, and improved or new lighting metrics and recommendations are in urgent need. In some cases, the old metrics are not sufficient for LED products (e.g. colour rendering, glare); in other cases, LED products create new problems (e.g. flicker) or new effects (white light in street lighting). There also arise many questions on the photobiological safety and non-visual effects of LED products. Further, new technologies are constantly being developed and the style of lighting is changing (e.g. colour-tunable luminaires, adaptive lighting controls, and health applications). Also, with the efficacy of LED products significantly increased recently, lighting manufacturers are looking for high lighting quality in many aspects, thus metrics are increasingly important. These create challenges for the CIE to tackle the needs arising from various changes and to respond quickly in order to meet industry needs while ensuring scientific excellence in our work.

To better address the recent fast-changing needs, it is a continuing goal of the CIE to speed up its work. CIE recently started producing new types of publications. One is the Technical Note (TN) series, a publication type that can be developed quickly, to provide guidance to industry on urgent questions or issues. TN 001, on colour difference specification for light sources, published last year is the first one of this series. Three TNs have been published so far and several more are in progress.

CIE also published in 2015 a position statement on the non-visual effects of light, which is the first of its kind. CIE Position Statements are web based publications that issue CIE's official opinions on given topics. These are developed quickly to respond to incorrect viewpoints that misrepresent the CIE's position or to a specific concern from the industry on given topics.

The CIE has, as its basic structure, seven Divisions, which are the driving force of all CIE technical activities. However, there are often issues which span across the Divisions, as such in the past, TCs with similar subjects were formed in different Divisions, and the cooperation between Divisions was not efficient. CIE recently created a new structure, Joint TCs (JTCs),

in which members from multiple Divisions and/or from other organizations cooperate on CIE efforts. This provides with horizontal work across the Divisions, making inter-CIE Divisional work more effective and efficient. For example, JTC-1 for mesopic photometry is a collaboration of Divisions 1, 2, 4, and 5, and with an external outreach, JTC-2 is a collaboration between CIE and CCPR (Consultative Committee of Photometry and Radiometry) and JTC-3 between CIE and WMO (World Meteorological Organization). Overall seven JTCs have been formed to-date and it is anticipated that JTCs will play key roles in coming years.

CIE standards have been mainly of a fundamental nature in the past. Now a new type of standard has been added – test methods for products. There are strong needs for international test methods for LED lighting products, for global harmonization of accreditation of testing laboratories and for regulations for lighting products. CIE S025 lays out test methods for LED lighting products, and was published this year as the first of this kind of standard. We plan to produce more of such standards with expectation that such standards will increase CIE's relevance to the industry.

The CIE Board is also developing Research Strategies, which identify the areas of research needed by the industry and relevant community, as proactive planning for future CIE standards and technical reports. Such research topics will be publicized, thereby CIE will encourage academia and research institutes to prioritize research on such topics that best meets industry needs. Resulting research is expected to contribute to the technical work of the CIE, leading to timely completion of CIE publications.
Finally, I would also like to strengthen communication with National Committees so that we can share the difficulties they may have, with the hope that we can assist them in their growth and sustainability and possibly improve CIE activities and operation taking into account their needs and opportunities.

I look forward to working next four years with the new Board, NCs and General Assembly, and all those active in CIE, towards meeting these goals and making CIE an even better organization to serve the community of light and lighting, marking the first full quadrennium in CIE's new century.

Opening Ceremony, CIE 2015, University of Manchester

The Opening Ceremony began with a film about CIE and the history of lighting commissioned by CIE-UK.

The Lord Mayor of Manchester, Paul Murphy, OBE, welcomed delegates to Manchester.

President's Opening Address

Ladies and Gentlemen, Welcome to Manchester!

Thank you to our Lord Mayor for his kind words, and also for the opportunity to enjoy the splendours of the Town hall last night as the setting for our welcome reception. I hope you all enjoyed your time there.

Today we are at my home institution, my place of work. I am Professor and Associate Dean in the Faculty of Engineering and Physical Sciences, here at the University of Manchester. The University's origins are closely linked to that of the city, beginning on the one hand with the Manchester Mechanics Institute, founded in 1824, which then became UMIST. Parallel to that Owen's college was founded in 1851, and grew to need new premises (across the road) designed by the same architect as responsible for the Town hall. In 1880 Owen's college became England's first civic university, the Victoria University of Manchester. After weaving in and out of each other for more than a century, in 2004 VUM and UMIST joined forces to become simply "The University of Manchester". Today we are the country's largest university with approximately 40,000 students, though you won't see many of them as the teaching year has finished, enabling us to use the facilities for other things. I hope you enjoy your time on our city campus – this is where the atom was split, where Baby, the first stored programme computer was invented, and where graphene was discovered. Beyond the merely academic the University offers to visitors the Manchester Museum (just across the road), the newly remodelled Whitworth Art Gallery (about one km up Oxford Road), and if you fancy a trip to the Cheshire plain, there is the Discovery Centre at Jodrell bank where the Lovell telescope is based – built in 1957 this remains one of the biggest and most powerful radio telescopes in the world.

I'm really proud that you are all here at my institution, but the man that both you and I have to thank for that is Nigel Pollard. Nigel will be known to many of you for his work in CIE, as a previous Director of Division 5, and his expertise in lighting design. Today he is the chairman of CIE-UK, and having retired from the lighting business he thought he needed something else to occupy his time, so on behalf of CIE-UK he took on the task of organising this 28th Quadrennial Session. To tell you a little more about it, I give you Nigel Pollard.

Welcome by the Chair of CIE-UK, Nigel Pollard

President's Introduction for Professor Lars Chittka

Our guest speaker this morning is Professor Lars Chittka from Queen Mary University, London, where he is Professor of Sensory and Behavioural Ecology. Professor Chittka began his research career as a student in Berlin, then moving to Stony Brook University, followed by Wurzburg University, before settling at Queen Mary's, London, where he founded and directed the new Department of Psychology. Amongst other accolades, he is a recipient of the Royal

Society Wolfson Research Award, an ERC Advanced Grant and the Lesley Goodman Award of the Royal Entymological Society.

If you are wondering what that has to do with CIE, the clue is on page one of your brochure, and on your badge. You walked on it last night at the Town Hall and can find it on litter bins and bollards around campus; As a further clue your Local Organising Committee call Professor Chittka “The Bee man”.

His first paper developed a formal model that allowed assignment of numerical values to bee colour perception and, using this model, he demonstrated that the bees’ trichromatic colour vision system is optimal for coding flowers, then going on to explore the significance of UV signals in this process. Now I am starting to use words that sound more familiar to you, so here to explain why CIE needs to know about bees and their vision is Professor Lars Chittka.

There followed a guest lecture by Professor Lars Chittka

President’s Awards Ceremony

We now come to a part of our opening ceremony where we honour our own.

The CIE Distinguished Service Awards are presented once a Quadrennium and the recipients become Life Members of CIE. This entitles the holder to:

i. Citation and presentation of the Pin by the President at a Quadrennial Session (at Opening or Closing Ceremony),

ii. A complete electronic set of CIE Publications (with yearly updates),

iii. Free admission to CIE Sessions and other technical meetings (e.g. Symposia),

iv. Citation printed in the Golden Book of the CIE and in CIE NEWS.

The nominations for the awards are the prerogative of the three Presidents: Past, Present and Future, and these are then approved by the Board.

I am going to tell you about each award, and then its recipient, before asking that person to come onto the stage to receive the award.

The first of our awards is the Wyszecki Gold Pin for exceptional contribution to fundamental research connected with a CIE publication in the field of fundamental research in the past Quadrennium.

The award goes to Peter Blattner.

Dr Blattner is Head of the Optics Laboratory at the Swiss Federal Institute of Metrology (METAS). His main activities include primary realization of optical power measurements using cryogenic radiometers, development of calibration facilities for optical radiometers, photometers, and optical filters, and active contributions to various standardization organizations and experts groups in the field of photometry and radiometry.

One of those standardization organizations is of course CIE where Peter is our current Director of Division 2.You will remember that the Wyszecki award must be associated with a CIE publication from the last 4 years, and in Peter's case we had more than one to choose from, but his primary achievement was S 023 (Characterization of the Performance of Illuminance Meters and Luminance meters) for which he was TC Chair. In addition he made very significant contributions to S 025 (Test method for LED lamps, LED Luminaires and LED Modules). With typical modesty he points out that all the work was done by many people from all over the globe – which is true, our Statutes demand broad international membership in our committees – but someone has to get everyone else working. So when Peter said "My main input was to find consensus between the different communities (NMIs, instrument manufacturers and testing-/calibration laboratories)" I would respond that that is a tremendously difficult job very well done, and only possible because of his own expertise and the high regard in which he is held.

While the Wyszecki Gold Pin has to be linked to a publication, the awards overall are for Distinguished service, so I would also like to remark that as DD2 Peter has firmly embedded the Code of Practice for Technical Committees in Division 2, leading by example, and thus helped to bring other TC reports to fruition. He also initiated, organized and contributed to two very successful CIE symposia (Bled 2013 and Vienna 2014) on the topic of measurement uncertainties, bringing together academia, NMIs and industry. All this represents an immense contribution to CIE, so Peter, please come to the stage to receive your richly deserved award

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The next award is the Waldram Gold Pin for exceptional contribution in research in Applied Illuminating Engineering. Like the Wyszecki award it must be associated with a CIE publication from the last Quadrennium, but this time for applied work.

The award goes to Steve Fotios for his work on CIE 206 (The effect of spectral power distribution on lighting for urban and pedestrian areas).

Steve began life as a building services engineer, before studying for an engineering degree here at what was UMIST. After a year determining that he was not destined for life as a school teacher he returned to UMIST for a PhD and as a lecturer. He says that at the start he was not aware of the needs for research in lighting, which may explain why, 20 years later, he is still looking for an answer to his PhD question. This continuing curiosity led to CIE report CIE 206 and onwards to CIE 212 in 2014. ("Guidance towards best practice in psychophysical procedures used when measuring relative spatial brightness"), while his PhD was on spatial brightness under lamps of different SPD. Again we have an award winner who has more than one recent CIE publication to his name.

Steve left UMIST with his doctorate, and after moving to Scotland and back he is now Professor of Lighting and Visual perception at the University of Sheffield, just over the Pennines from here.

In promoting the study of pedestrians needs when considering data for road lighting guidance Steve has developed new techniques for discovering what pedestrians want to look at, and to measure the effect of lighting on interpersonal judgement – that rapid friend or foe assessment that we all make, going about our business on a dark winter's night.

Steve has also established the LumeNet research methods workshop for students, to explore daylighting and broader lighting issues, in alternate years, and has gained the funding to make these workshops free to attendees, one aspect of his championing of young researchers.

Steve, for all your efforts in lighting research and particularly for your contribution within CIE, please come and receive the Waldram Gold Pin.

Our final award is for Distinguished Services in Organization or Administration. The De Boer Gold Pin is for long lasting exceptional contribution to building the international reputation of the CIE and is awarded this year to Teresa Goodman.

Teresa graduated from Imperial College London with a degree in Physics and took up a position at NPL, the National Physical Laboratories, in the Earth Observation, Climate and Optical Radiation Group, where she is now Principal Research Scientist, responsible for leading work on optical radiation scales and standards. She currently leads NPL's work on realising, maintaining and disseminating the UK's optical radiation scales and standards for measurement of the properties of sources, detectors and materials. She has a particular interest in the human perception of light and colour in particular linking the physical properties of materials with complex perceptual attributes such as 'naturalness'. She also led NPL's research on mesopic photometry – this provided one of the key inputs to the CIE system for mesopic photometry (published as CIE 191:2010).

That is not her only CIE publication. Teresa has contributed to a large number of CIE publications over the years, and on a range of topics, to such an extent that she was certainly a consideration for the Wyszecki award, and even an outside contender for the Waldram gold pin – she contributed to both the publications cited for those awards.

But that is not all. She has served two terms as Associate Director of Division 2, followed by two terms as Director of Division 2. She is just now completing 2 terms as Vice President Publications, and is the Secretary elect for the coming term. I hope you are counting and are good at maths – that will make a grand total of 7 terms or 28 unbroken years as a CIE Officer, and 20 years as a member of the Board of Administration.

It is her current role as VP Publications that is especially pertinent to the terms of the De Boer award for building the international reputation of CIE, because it is our publications that most widely represent us the world's lighting community. The work began back in Division 2. It was Teresa's initiatives, first in the test bed of D2 and later extended across all Divisons, that have led to our Code of Procedure to help and encourage TCs to increase their speed and efficiency and deliver their reports in a timely fashion, something that is good for TC members, good for CIE and good for the lighting community. She also undertook a complete revision of the International Lighting Vocabulary, a huge task, and established the eILV, making searchable terms available to all.

Teresa, for your unstinting efforts to improve the quality of all CIE publications, as well as writing a good number of them, and for your selfless service over so many years, I am absolutely delighted to present you with the De Boer Gold Pin

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I don't want in any way to dampen the mood, but I do have one thing to add.

Sadly, we have recently lost the last recipient of the De Boer award. Janos Schanda, who was well known to so many of you, passed away earlier this year. Janos has already been remembered at the General Assembly and for anyone else who would like to share their memories of him there will be a short presentation during the Division 1 meeting, which was of course his home Division. All are welcome.

End of Opening Ceremony

OFFICERS' REPORTS

President's Report to the General Assembly

Manchester Town Hall, 28th June, 2015

Ann R. Webb

At the end of my term I would like to look back at the view I had of CIE 4 years ago, the tasks I envisaged for the organization, and the progress that has been made on those tasks by the Board of Administration and the Central Bureau. At my presentation is South Africa (CIE and the Art of Successful Lighting), the actions I saw as necessary to move CIE forward were:

- Speed up
- Use technology
- Publish with credit
- New (young) blood
- Network
- Relax self-imposed barriers
- Remain solvent

Let us evaluate the success of those actions within the context of CIE's main business.

Publications – our publications are the means by which we disseminate our work to the world, they are the foundation of CIE's reputation for rigorous science, and also provide us with a modest income stream. However, we had too many long-standing and very slow or inactive Technical Committees (TCs), leading to frustration from those awaiting reports. Thus, the Code of Procedure for TCs has been introduced during this term, and after a 4-year period of grace it is now being rigorously enforced.

As part of the support for TCs and TC Chairs, CIE now offers TCs two valuable tools to assist in their work. There is the Collaboration Tool (CollTool) where documents can be stored and messages/discussion threads circulated, and WebEx that allows for online (video) conferencing. WebEx TC meetings can be booked through the Central Bureau if desired, but all TCs must use CollTool as a document store accessible to all TC members.

CIE publications now have an author list, composed of those who made a significant input to the document, and a list of contributors who are other members of the TC that played an advisory role but were not heavily involved in writing the report. Completely inactive TC members are not represented, and should have been removed from TC membership. In addition, work is progressing to enable CIE publications to be represented in suitable citation indices.

Finally, we now have a number of Joint TCs (JTCs) that work across the boundaries between one or more Divisions, or with outside organizations (e.g. a TC report with the World Meteorological Organization was recently published).

Progress in: Speed, Use of Technology, Publish with Credit, Relaxing self-imposed barriers.

Research/Standardization – In the fast moving world that is the development of new lighting technologies, at this time solid state lighting, there is a demand for standardization. However, the speed of development is at odds with the rigorous research and certainty that is the hallmark of CIE work. This tension was explored in a Strategy Workshop with the Board and CIE stakeholders in November 2012. An agreed solution was to identify "Priority Projects" of high importance to both CIE and Industry and establish some financial support for the project (either underpinning research that could be completed quickly, or time and resource for the TC to write a document in a short time frame). To date no Priority Project has been established, but the concept remains.

A major advance for CIE has been the establishment of ISO/TC 274 on Light and Lighting, chaired by the General Secretary of CIE. This gives CIE more control of Lighting standards within ISO, and the support of the ISO system, while also leaving us freedom to publish stand-alone standards that do not fall within the ISO remit. It is an opportunity to retain prominence in lighting standards, provided that CIE is active. The current General Secretary and VP Standards have worked hard to establish a good working relationship within ISO/TC 274 and it is up to the new Board and GS to continue with this work.

Progress in: Networking, Speed, Relaxing Barriers

Collaborations and Connections – CIE has been extending and strengthening its links with other organizations over the past 4 years. In 2013 in Paris you will remember that we signed two new MoU with Global Lighting Association (GLA) and International Association of Lighting Designers (IALD), and as the previous item shows, we are working much more closely with ISO.

Working more broadly, we have also become Scientific Associates within the International Council for Science (ICSU), giving us links to a wide range of other International Scientific Unions. We know that this membership is a benefit to at least one of our NCs, and hope it will assist others, in addition to being a benefit for CIE in general.

We have also joined STM, a global trade association of academic and professional publishers to enable us to gain additional expertise and advice on publication strategies and technologies to further enhance our publications and their visibility.

In this International Year of Light, we took on Gold+ sponsorship of IYL and I had the honour of representing CIE at the 2-day Opening Ceremonies at UNSECO in Paris, as well as the UK launch at St James's Palace, London. The IYL has also brought further collaborations with BIPM and IAU.

Finally, we should not forget our internal connections, remembering that we have polled our members through a NC questionnaire, and have welcomed new ANCs within this term.

Progress in: Networking, New Blood, Relaxing Barriers, Use of technology (future potential)

Representing CIE - On a personal note, as President, I have attended all the major CIE meetings during this term: starting with the Quadrennial Session in Sun City (2011), then the Centenary celebrations at the mid-term in Paris (2013), and in the intervening years conferences from our Lighting Quality and Energy Efficiency series in Huangzhou, China (2012) and Kuala Lumpur, Malaysia (2014). I have also had the great pleasure of joining a number of National events amongst our member countries, in Romania and Sweden (as President Elect), then China, USA, Taiwan, Netherlands, UK, France and Turkey. I thank you all for the opportunity to spend time with you, and apologize for the invitations that I could not accept.

Finances – staying solvent is the only action from my list that I have not yet addressed, although of course publications and successful conferences and symposia (which accounts for all those held this term) contribute to our revenue.

During this term there has been a risk, though by no means an inevitability, that CIE would enter a downward financial spiral. By that I mean that our income would be insufficient for us to make the advances and provide the services to our members that would keep the organization vibrant and up to date. With that comes the danger of less activity, less support for member NCs, less output, leading to less revenue, and so on.

There have been many efforts to combat this risk, including such diverse tasks as clarifying the Statutes and By-laws on membership and dues payment, and moving the Central Bureau

Office to smaller but more modern, better serviced and cheaper premises. I hope you agree that there has not been a decline in service, nor in activity, but despite all efforts at cost saving, prices have gone up in the last 10 and more years while NC dues have not. We have reached the point where dues need to increase, and that will be a major discussion point later in this meeting.

Summary – looking at the list with which I started, we have made progress on all points, some more than others, but I am very positive that CIE is in good shape to move forward into its second century and tackle the challenges of SSL technology and whatever comes next with as much success as it did the first electric lighting.

It has been a unique term – we have had our 100th birthday and all the celebrations that that entailed. We have a new logo to take us forward, and now we are at the centre of the International Year of Light, something that could not have been foreseen back in 2011. I thank you for the honour and pleasure of being your President for the last 4 years. It was not without its challenges, but I was well supported and I must thank, for myself and on your behalf, the fantastic team of dedicated people that make up the Board of Administration and the Central Bureau – it has been a true privilege to work with you all.

Sadly we have to say goodbye to a central figure in our organization. Martina Paul, who has held the post of General Secretary for the past 8 years, is now leaving us. She took the role as an “instrument for change” and has done a fantastic job of turning the Central Bureau into a really professional outfit, and pushing forward many of the changes I have just discussed. Let us show Martina our appreciation for the immense amount of work that she has given to CIE during her period as General Secretary.

We are not, however, without a General Secretary. Together with your Personnel Committee I led an international search for a new General Secretary, and it is my pleasure to introduce you to Kathy Nield, who will take on the role from July 1st, 2015. Martina will retain an advisory role for one month to ensure a smooth hand over.

Thank you once again for the opportunity to be President of CIE.

Report Concludes.

Quadrennial Report 2011 – 2015 of the Vice-President Technical

Yoshi Ohno

1 Division Directors Committee

One of the main roles of VPT is to chair Division Directors committee (DD committee), which consists of all Division Directors (DDs), VP-Technical (VPT), VP-Publication (VPP), VP-Standards (VPS), and Technical Manager (TM). The DD committee met biannually, and discussed various technical-related matters. General Secretary and President also often joined. Much of the work reported below were discussed at DD committee meetings before discussion/approval by Board of Administration (BA) and work was done with strong support by the Central Bureau (CB).

2 CIE Conferences

Another major responsibility of VPT is to chair International Scientific Committee (ISC) for CIE conferences. In 2010, CIE started Lighting Quality and Energy Efficiency (LQ & EE) Conference series, held in the years in between CIE Sessions, thus CIE had major scientific conferences every year in the last quadrennium. The ISC was formed and worked for the following conferences in 2011 – 2015, responsible for developing scientific programs.

- 2012 LQ&EE (2nd) Hangzhou, China (120 papers submitted)
- 2013 CIE Centenary and Midterm in Paris (240 papers submitted)
- 2014 LQ & EE (3rd) in Kuala Lumpur, Malaysia (157 papers submitted)
- 2015 28th Session of the CIE in Manchester (348 papers submitted)

The ISC members consisted of all DDs (in most cases), TM, and additional members selected by DDs and from local organizing countries. Developing scientific programs in these conferences have been major efforts by the ISC. All these conferences were held very successfully. DD committee recently discussed that, after the 4th LQ & EE 2016 in Melbourne, it will be time to change this conference series, possibly with new name/ format for more focused topics.

3 CIE Symposia and Workshops

The following CIE Symposia and Workshops were held since 2011. These symposia were organized by the Divisions, supported by Central Bureau.

- CIE Lecture on Photometry, Colorimetry, Metrology and Standard for SSL, Sep. 16–18, 2012, Hangzhou, China (D1, D2)
- CIE Introductory Tutorial & Workshop on Mesopic Photometry, 24–25 January 2012, Vienna, Austria (D1, D2)
- CIE Expert Workshop on Advanced Methods for Photometry, 8–9 October, 2013, Bled, Slovenia (D2)
- CIE Expert Symposium on Measurement Uncertainties in Photometry and Radiometry for Industry, September 2014, Vienna, Austria (D2)

4 Collaboration with Partner Organizations

Starting 2012, DD meeting functioned as a hub for collaboration with partner organizations, inviting the leaders of ISO Conformity Assessment, IEC CAS (Conformity Assessment Scheme), CEN TC169 Light and Lighting, IEA 4E Solid State Lighting Annex.

CIE, at CB level or at Division level, had collaborations with

- ISO/TC 274 (Light and Lighting): chaired by CIE General Secretary (GS), M. Paul.
- CEN/TC 169 (Light and Lighting) WG7 (Photometry): collaboration with TC 2-71 on test method for LED lamps, luminaires and module (CIE S 025 and EN 13032-4 published)
- IEC/TC34 (Lamps and related equipment): cooperation on LED terminology (TC2-66 and IEC 62504), colour difference specifications (TN 001), and coordination in revision of IEV/ILV.
- IEC/CAS (Conformity Assessment Schemes): possible collaboration on conformity assessment for IEC/CIE 62471 and CIE S 025.
- GLA (Global Lighting Association): communication on standards strategies and Priority project.
- CCPR (Consultative Committee of Photometry and Radiometry): JTC-2 (CIE-CCPR) (Principles Governing Photometry), chaired by VPT, was jointly established, for implementing CIE 191 mesopic photometry to the SI.
- IEA (International Energy Agency) 4E SSL Annex – Communiqué between CIE and SSL Annex signed Feb. 2014, on cooperation for testing and accreditation support and promotion of CIE test method S 025 (SSL Annex Task 1 in Phase II).
- IEEE PAR1789 on LED flicker (DD3, VPT participates) - related to TC1-83, R 2-52, D3, D6)
- ISO/TC12 (Quantities and Units) WG19 on harmonization of ISO 80000-7 with ILV and JTC-2 draft.

5 JTC (Joint TC)

As the technical issues were becoming cross-Divisional, a new structure of committee, JTC, was established in 2011. There are two types of JTCs:

- Joint TCs within CIE (collaboration between Divisions)
- Joint TCs with CIE and other organizations

Operation procedures for JTCs were developed and written in the Code of Procedure. The formation of JTC has been very successful. Seven JTCs were formed in the last quadrennium:

• JTC-1 (D1/D2/D4/D5)	Implementation of CIE 191:2010 Mesopic Photometry in Outdoor Lighting (Chair: Stuart Mucklejohn, GB)
• JTC-2 (CIE-CCPR)	Principles Governing Photometry (Chair: Yoshi Ohno, US)
• JTC-3 (CIE-WMO)	Rationalising UV Units (Chair: Richard McKenzie, NZ, completed)
• JTC-4 (D3/D6)	Visual, Health, and Environmental Benefits of Windows in Buildings during Daylight Hours (Chair: Martine Knoop, DE)
• JTC-5 (D2/D6-IEC)	Review of IEC 62471/CIE S009 (Chair: John O'Hagan, GB)
• JTC-6 (CIE-ISO)	Energy Performance of Lighting in Buildings (Chair: Soheil Moghtader, DE)
• JTC-7 (D3/D1)	Discomfort caused by glare from luminaires with a non-uniform source luminance (Chair: Naoya Hara, JP)

The following two JTCs were being established.

- JTC-8 (D1/D2/D3/D4/D5/D6/D8) Terminology in light and lighting (Chair: Peter Zwick, AT)
- JTC-9 (D1/D2/D3/D6) Quantifying ocular radiation input for non-visual photoreceptor stimulation (Chair: Luc Schlangen, NL)

6 Technical Notes

To address urgent needs in the industry quickly, CIE established a new type of CIE publication – Technical Note (TN). TNs have faster approval process and provided with free download from CIE website. The following TNs were published or approved during last term as below, and five more TCs are being developed.

- TN 001:2014 Chromaticity Difference Specification for Light Sources (Authors: Y. Ohno, P. Blattner)
- TN 002:2014 Relating Photochemical and Photobiological Quantities to Photometric Quantities (Author: P. Blattner)
- TN 003:2015 Report on the First International Workshop on Circadian and Neurophysiological Photometry, 2013 (DR 6-42) approved (in print) (Author: L. Price)

7 Monthly Technical Coordinators Meeting

- VPT, VPP, and TM met monthly on WebEx, and reviewed the progress of all the draft technical reports and standards that have been submitted for ballot stages to CB (CD stage and after).
- Delay of preparation of a new draft will be noted and notified to the TCC, which will keep the approval process without significant delay.
- Any difficult problems after ballot are discussed by Review Panel, which consists of VPT, VPP, TM, DD, and TCC.

8 Test Method standards for lighting products

CIE started developing test method standards for lighting products, to increase relevance to the industry, especially with solid state lighting community, and to meet the industry needs more directly.

- Work was done in communication with IEC (TC 34), which develops products performance standards.
- TC 2-71 was established in 2011, chaired by VPT, published the first CIE standard of this kind, CIE S 025 Test method for LED lamps, LED modules, and LED luminaires, in March 2015. Work was done in collaboration with CEN/TC 169/WG 7 that developed a CEN standard harmonized with this CIE standard. This will be a major international standard to be used by solid state lighting community worldwide.
- More test method standards are planned – LED packages, OLED products, etc.

9 International Year of Light

CIE organized the Global Open Lab Day (IYL-GOLD). During the weeks of May 9 to May 25, 2015, laboratories around the world dealing with light, lighting, optical radiation, laser, and other light- related topics, opened their doors to the general public, demonstrating what measuring light is about and why it matters. This included National Metrology Institutes (NMIs); industrial laboratories; universities; and public testing laboratories. 48 labs from 21 countries participated.

10 Research/Standards strategies

Since ISO/TC 274 was established, it was necessary to clarify what standards are developed by CIE or by the ISO/TC. For this purpose, DD committee developed first draft of CIE Standards Strategies, in a form of a large table in EXCEL sheet, for input to ISO/TC 274 in late 2013. Since then, DD committee is updating the table for internal purposes of CIE activities, especially with consideration of fast developments of solid-state lighting.

Goal: CIE to increase relevance to the stakeholders. Ensure and speed up CIE work to meet the stakeholders' needs.

In 2015, we are broadening its scope as research strategies because standards work often delays due to lack of research. We initiated Questionnaire to DDs.

Actions planned:

1) Each Division's research/standards strategies will be developed.
2) CIE's research/standards strategies will be developed.
3) Promote the topics of research/standards needed for CIE work (post them on CIE website and other places)
4) Interact with the stakeholders asking for their inputs on CIE's research/standards strategies. (GLA + more)

The current high priority topics includes below:

- New colour fidelity index and colour preference metric (D1)
- Flicker (metrics, effects on health and well-being) (D1 – D6)
- Glare evaluation of LED products (D1– D5)
- Energy performance of buildings (D3, work with ISO/TC 274)
- Mesopic photometry implementation (D1 – D5)
- Photobiology and non-visual effects (D6, D3, D2)
- Application related measurement standards (D2)
- Test methods for lighting products (D2)
- Interior lighting standards with multiple metrics (D3)
- Climate-based daylighting metrics (D3)
- Appearance measurement (D1 – D4)

Divisions will plan to start work on these topics strategically. Many topics (e.g. flicker, flashing light, glare, appearance measurement) are across Divisions, and will be suitable for new JTCs. It is proposed to establish a new structure for a group to discuss the needs and state of research of a specific topic, before a TC can be established. (Note that a reportership is normally a person assigned, not a group).

11 Other discussions

The following points were raised at recent DD meetings to improve CIE technical activities further.

- On-line Division meetings (done by D3, D6) may be more utilized.
- Improvements of Collaboration Tool are desired.
- There is a wish to have CIE proceedings papers to be registered in the EI database.

- ISO/TC 274 and relationship with CIE work need to be explained more widely.
- Further speed up approval process for CIE standards/technical reports (e.g. one ballot (WD) may be sufficient by TC members).

12 Future CIE meetings

CIE Conferences:

- CIE 2016 LQ&EE conference, Melbourne, Australia, March 3-5, 2016.
- CIE 2017 Midterm Session, Jeju, Korea, October 2017.

CIE Symposia:

- CIE Tutorial and Expert Symposium on CIE LED measurement standard S025, Braunschweig, Germany, Nov. 25-26, 2015 (D2)
- CIE Expert Symposium on Appearance Measurement, Aug. 30 – Sep. 1, 2016 (D1,D2)
- CIE Workshop on Research Methods for Effects of Lighting (D3)

Acknowledgment

VPT and DD committee members thank Technical Manager Peter Zwick for his very hard work and thorough support on our technical programs and management, and also General Secretary Martina Paul for her initiatives on many administrative improvements that benefitted our technical work, and Office Manager Leo Trausnith for his support on Collaboration tool and general support.

Quadrennial Report 2011 – 2015 of the Vice-President Publications

Teresa Goodman

1 Introduction

CIE publications can be divided into 3 categories:

those that are subject to a formal voting procedure such as Technical Reports, Standards and Technical Notes (the latter were introduced during this Quadrennium, with the first being published in July 2014);

those that record CIE sessional meetings, conferences and symposia, which are published as CIE Proceedings; and

those that act as a dissemination and knowledge sharing interface for all those interested in the work of the CIE, such as the CIE website and the CIE Newsletter.

This report summarizes the developments that have taken place over the past few years in relation to CIE publications policy and procedures. It also gives details of publications in the first two categories above that have been produced since the 2011 Session in Sun City, South Africa and provides a summary of information relating to the sales of these types of publication over the past 8 years.

2 Codes of Procedure

Publications, in all their various forms, are arguably the most important output of the work of the CIE and its Divisions and Technical Committees. The reputation of the CIE is therefore inextricably linked with the excellence of these publications, particularly Technical Reports and Standards, and maintaining and enhancing their quality, timeliness and relevance is therefore a major concern. To this end, there has been a focus during the past two quadrennia on improving and streamlining the Codes of Procedure for Divisions and Technical Committees, to help ensure that the efforts of those involved are not only used to best effect but are also properly acknowledged. These are available from the CIE website and cover the whole lifetime of a TC, from the initial establishment (membership, terms of reference, work plan etc.) right through to the final publication of a CIE Technical Report, Technical Note or Standard (voting, symbols and notation, publication numbering etc.). Particular points to note are:

Processes and the associated flowcharts have been revised to clarify responsibilities, timescales, voting requirements etc. for each stage of preparation of each type of publication

An independent review panel has been introduced which TCCs can call upon to help with solving issues around achieving unanimity in TCs working on Technical Reports and Notes

‘Rules’ have been set out to ensure consistency of presentation (notation, layout, use of quantities and units, etc.)

Procedures for ensuring proper recognition of those making ‘real’ contributions to Technical Reports have been introduced.

A new form of publication has been introduced – CIE Technical Note – as a means of disseminating information of fundamental importance to CIE members and other stakeholders as quickly and widely as possible. These are available for free download from the CIE website.

Following an initial implementation period, the new Codes of Procedure are now being rigorously enforced and it is hoped that this will support TCs in completing their work more quickly, whilst maintaining (and indeed enhancing) the technical quality of all the CIE's published outputs.

3 International Lighting Vocabulary (ILV)

The revised ILV was published immediately following the Quadrennial Meeting in July 2011 and shortly afterwards was made available as an electronic version (the eILV), which allows individual terms to be viewed and downloaded free of charge. It is hoped that this will encourage the use of CIE definitions as widely as possible by all stakeholders, not just those directly involved with the CIE. Discussions are underway with IEC for publication as a joint standard and this should appear in the next couple of years. In addition, a new TC (under Technical Manager Peter Zwick) has now been set up to handle any necessary revisions; it is hoped these will be made on a regular basis to avoid the need for wholescale revisions in the future.

4 New publications produced

New Technical Reports, Technical Notes, Standards and Proceedings published during this Quadrennium (July 2011 – June 2015) are listed in Tables 1 to 4 below:

Table 1 – New CIE Technical Reports, July 2011 – June 2015

Publ. No.	Title
CIE 198:2011	Determination of Measurement Uncertainties in Photometry
CIE 198-SP1:2011	Determination of Measurement Uncertainties in Photometry - Supplement 1: Modules and Examples for the Determination of Measurement Uncertainties
CIE 199:2011	Methods for Evaluating Colour Differences in Images
CIE 200:2011	CIE Supplementary System of Photometry
CIE 201:2011	Recommendations on Minimum Levels of Solar UV Exposure
CIE 202:2011	Spectral Responsivity Measurement of Detectors, Radiometers and Photometers
CIE 173:2012 (including Erratum 1)	Tubular Daylight Guidance Systems
CIE 203:2012 (including Erratum 1)	A Computerized Approach to Transmission and Absorption Characteristics of the Human Eye
CIE 204:2013	Methods for Re-defining CIE D Illuminants
CIE 205:2013	Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems
CIE 206:2014	The Effect of Spectral Power Distribution on Lighting for Urban and Pedestrian Areas
CIE 207:2014	Sensitivity of Human Skin to Ultraviolet Radiation, Expressed as Minimal Erythema Dose (MED)
CIE 208:2014	Effect of Stimulus Size on Colour Appearance
CIE 209:2014	Rationalizing Nomenclature for UV Doses and Effects on Humans
CIE 210:2014	Photometry Using $V(\lambda)$-Corrected Detectors as Reference and Transfer Standards
CIE 211:2014	Colour Appearance in Peripheral Vision
CIE 212:2014	Guidance towards Best Practice in Psychophysical Procedures Used when Measuring Relative Spatial Brightness
CIE 213:2014	Guide to Protocols for Describing Lighting
CIE 214:2014	Effect of Instrumental Bandpass Function and Measurement Interval on Spectral Quantities
CIE 215:2014	CIE Standard General Sky Guide

Table 2 – CIE Technical Notes, July 2014 – June 2015

Publ. No.	Title
TN 001:2014	Chromaticity Difference Specification for Light Sources
TN 002:2014	Relating Photochemical and Photobiological Quantities to Photometric Quantities
TN 003:2015	Report on the First International Workshop on Circadian and Neurophysiological Photometry, 2013

Table 3 – New CIE Standards, July 2011 – June 2015

Publ. No.	Title
CIE S 021/E:2011	Vehicle Headlighting Systems Photometric Performance - Method of Assessment
CIE S 017/E:2011	ILV: International Lighting Vocabulary
ISO 11664-3:2012(E) /CIE S 014-3/E:2011	Joint ISO/CIE Standard: Colorimetry — Part 3: CIE Tristimulus Values
ISO/CIE 11664-6:2014(E)	Joint ISO/CIE Standard: Colorimetry — Part 6: CIEDE2000 Colour-Difference Formula
ISO/CIE 19476:2014(E)	Joint ISO/CIE Standard: Characterization of the Performance of Illuminance Meters and Luminance Meters
CIE DIS 024/E:2015	Light Emitting Diodes (LEDs) and LED Assemblies – Terms and Definitions
CIE S 025/E:2015	Test Method for LED Lamps, LED Luminaires and LED Modules

Table 4 – New CIE Proceedings, July 2011 – June 2015

Publ. No.	Title
CIE 197:2011	Proceedings of the 27th Session of the CIE, 9-16 July 2011, Sun City, South Africa
CIE x037:2012	Proceedings of CIE 2012 Lighting Quality & Energy Efficiency, September 2012, Hangzhou, China
CIE x038:2013 (including Addendum 1)	Proceedings of the CIE Centenary Conference “Towards a New Century of Light”, 15-16 April 2013, Paris, France
CIE x039:2014	Proceedings of CIE 2014 Lighting Quality & Energy Efficiency, April 2014, Kuala Lumpur, Malaysia
CIE x040:2014	Proceedings of CIE Expert Symposium on Measurement Uncertainties in Photometry and Radiometry for Industry, September 2014, Vienna, Austria

5 Publication sales

Figures 1 to 9 below summarize some of the key information relating to publication sales. Further details are available upon request. The following observations and conclusions can be drawn, based on these Figures and the results of a more detailed analysis of the sales data over the past 8 years:

- The number of publications sold fluctuates significantly from year to year; no consistent trends are apparent
- The total income over this Quadrennium (2011-2015) was 35 % higher than the previous one, despite the fact that the total number sold was 9 % lower (note that changes in the pricing policy for publications, coupled with the discounts offered to NC members, mean that there is not a direct correlation between the income from sales and the number of publications sold each year)
- The top sellers each year are mixture of new publications and older ‘key’ publications
- A small number of countries show particularly strong sales but this is coupled with broad take-up of CIE publications across a wide geographical base

- It is notable that for some countries a large proportion of the sales made are to non-members, indicating that there is potential for these NCs in particular to encourage membership through publicising the high discount (66.7 %) available to members
- Detailed sales data is available for NCs to help them target membership drives etc.

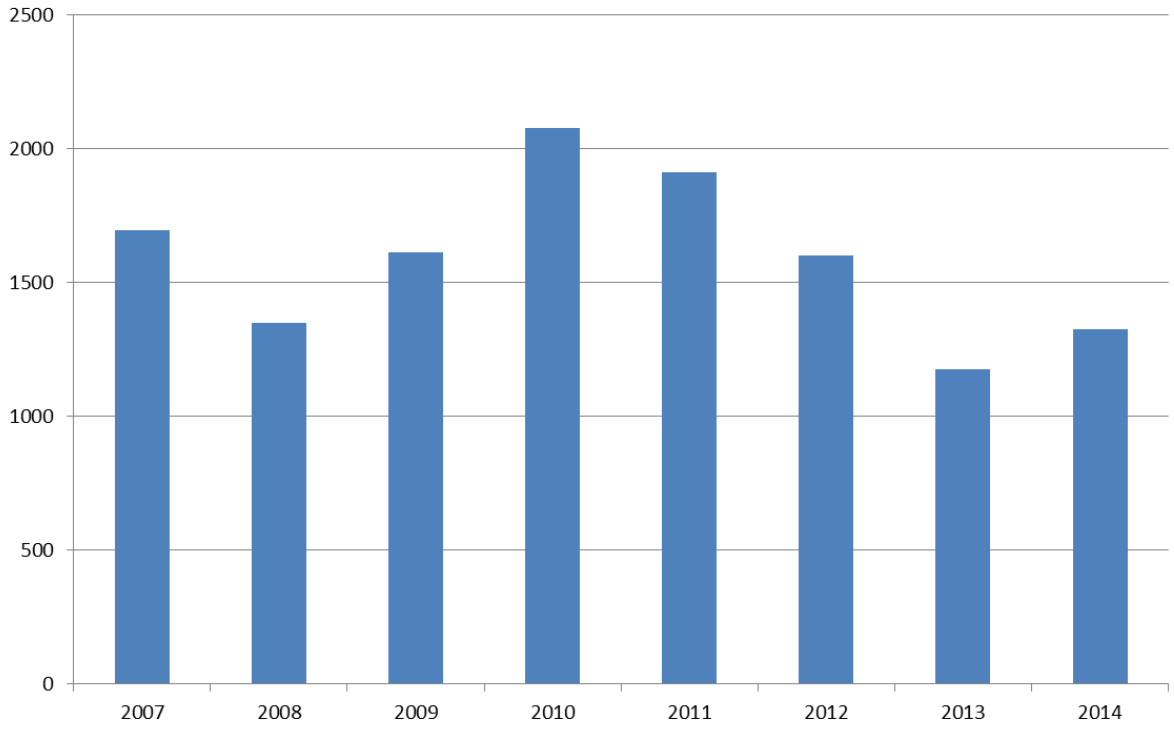


Figure 1 – Total number of publications sold, by year

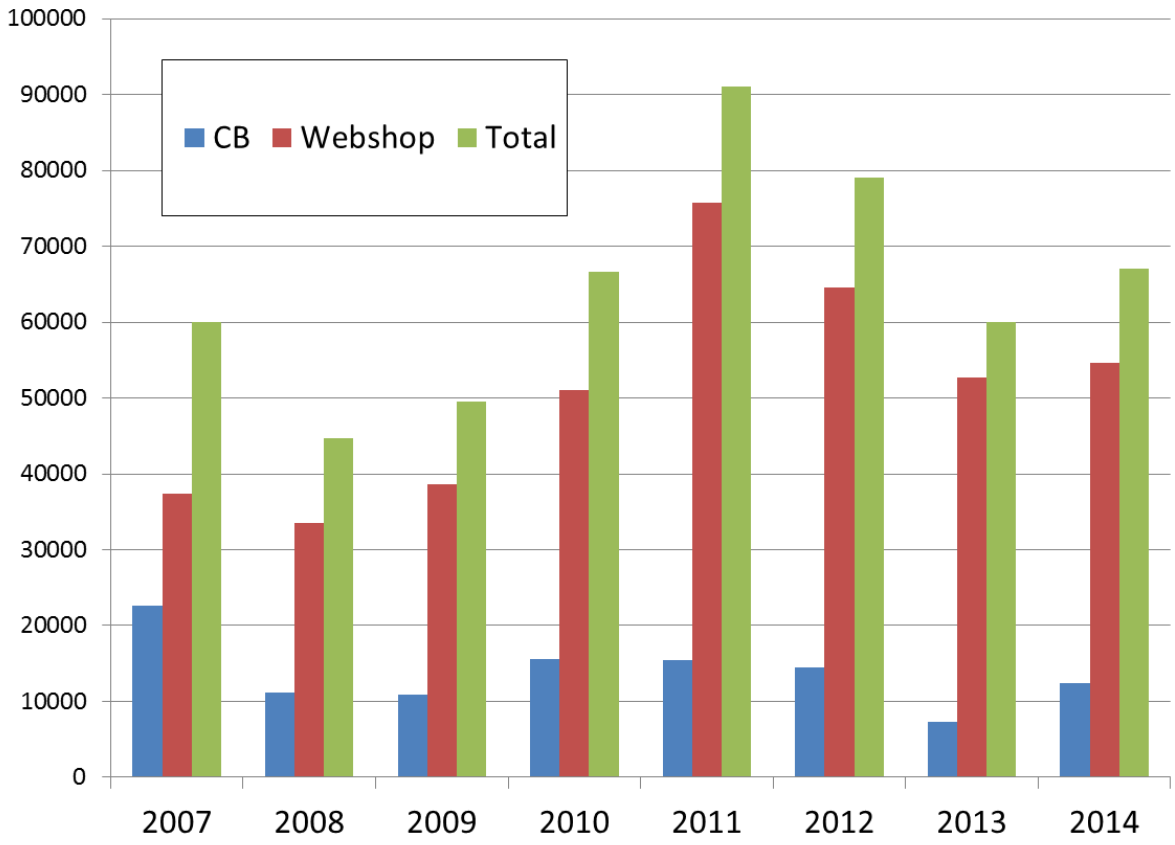


Figure 2 – Income from publications sold, by year

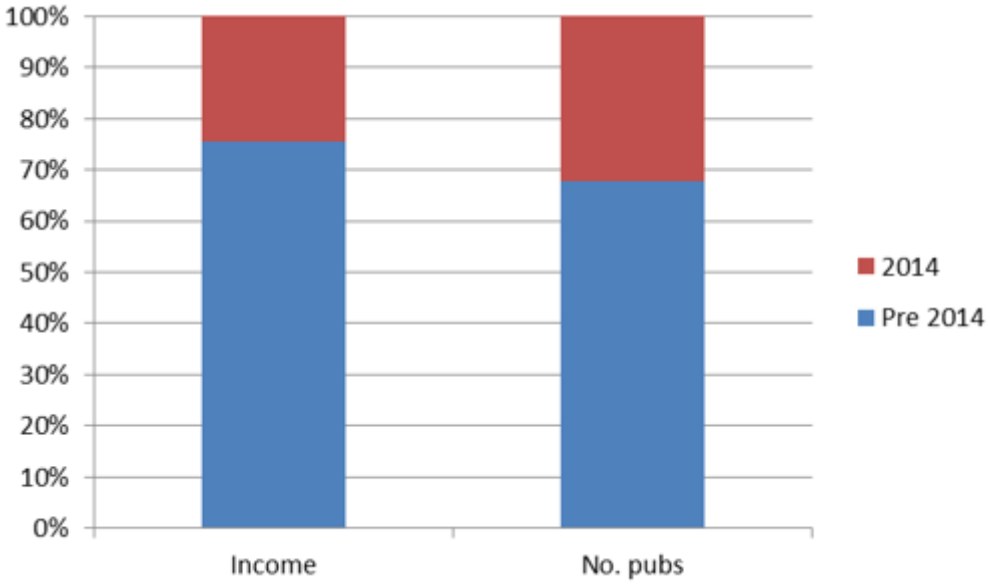


Figure 3 – Proportion of 'old' vs 'new' publications sold in 2014

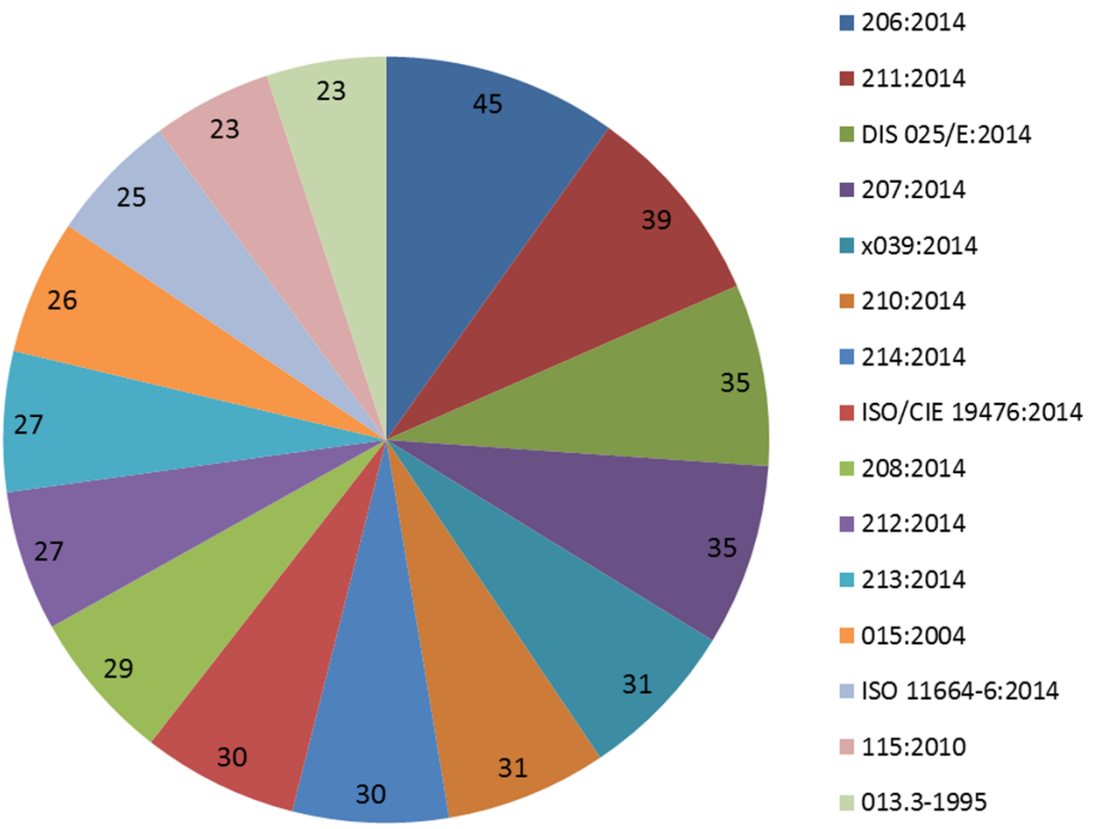


Figure 4 – Top selling publications in 2014 (by number)

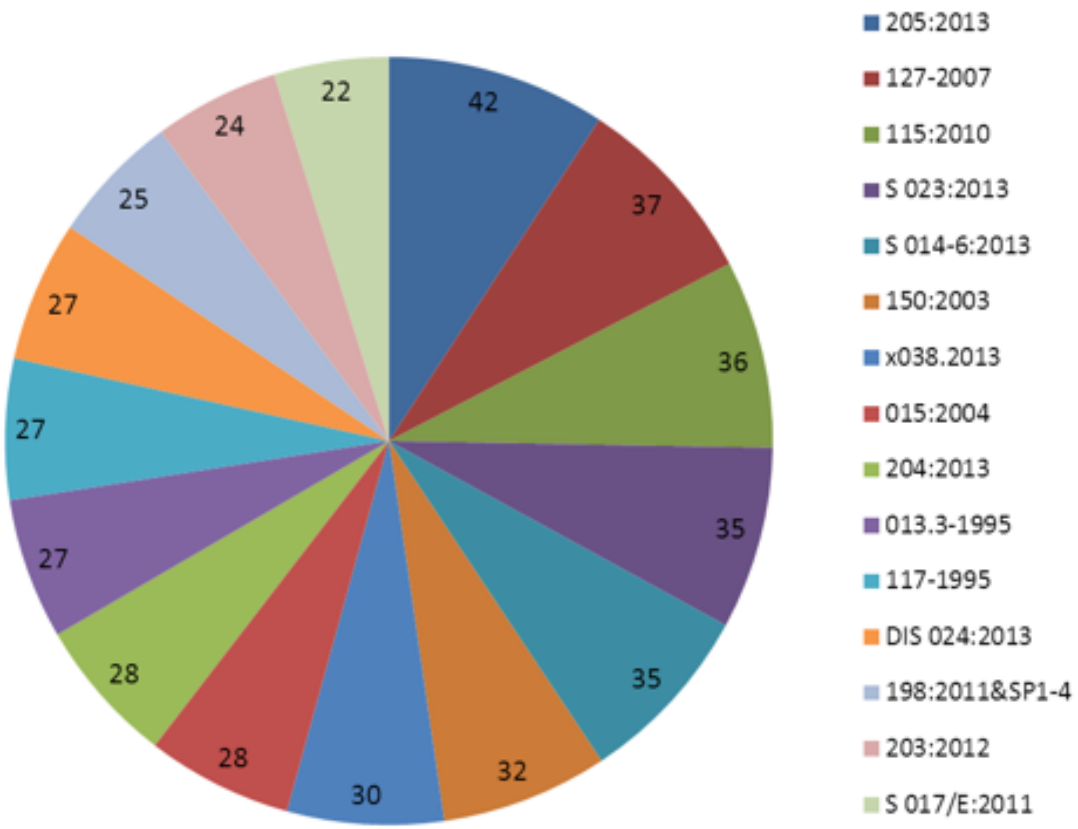


Figure 5 – Top selling publications in 2013 (by number)

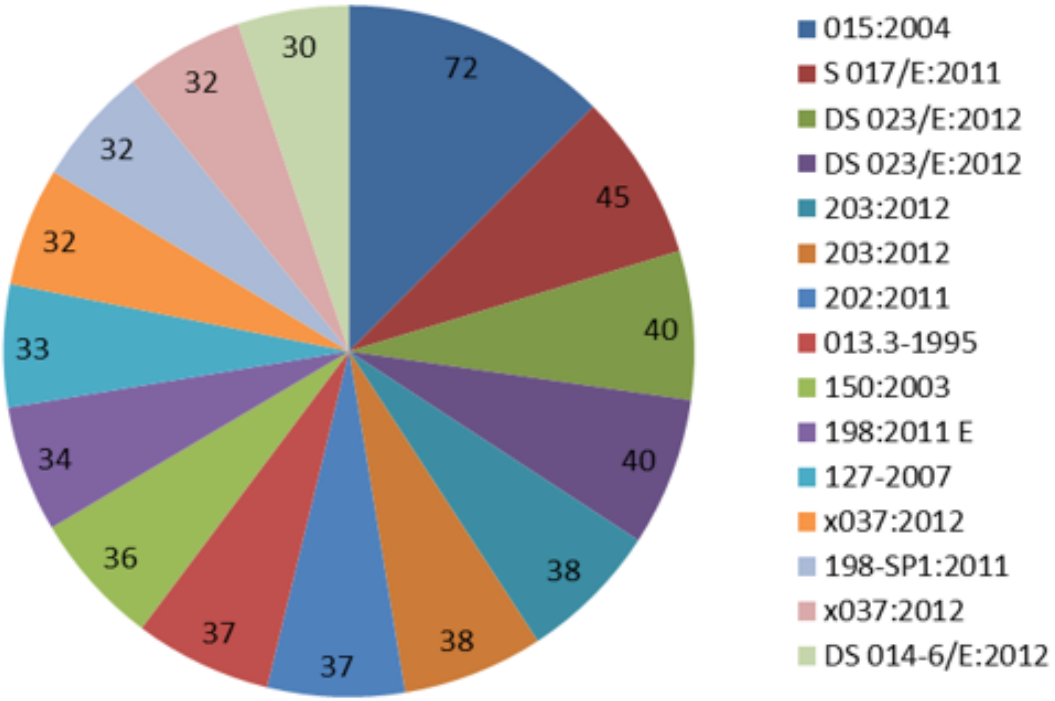


Figure 6 – Top selling publications in 2012 (by number)

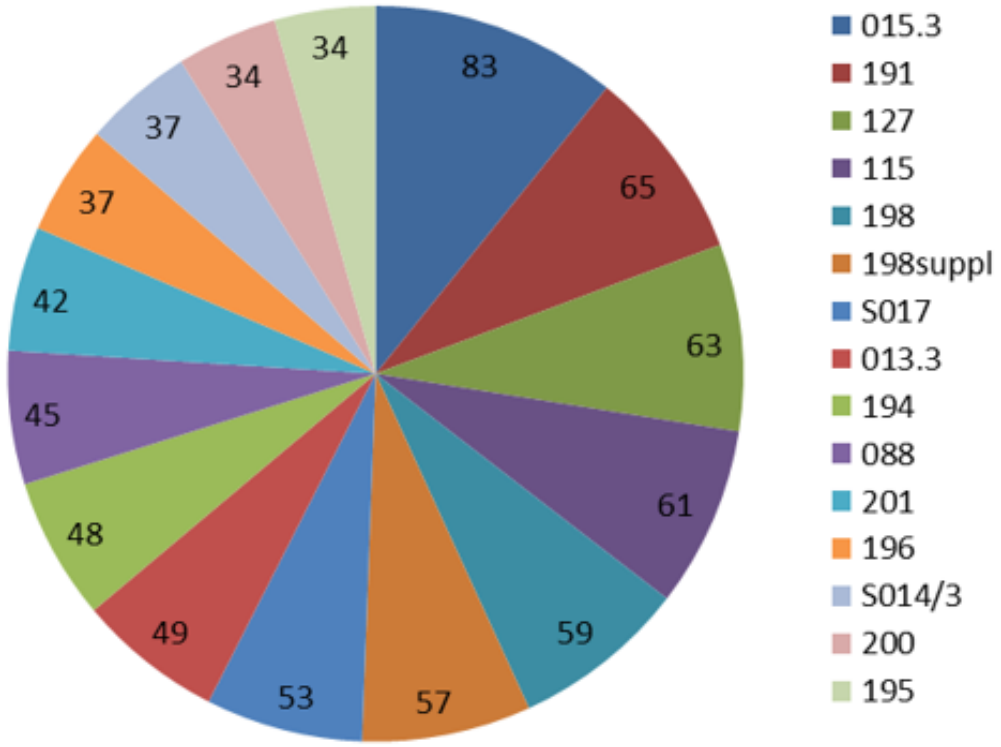


Figure 7 – Top selling publications in 2011 (by number).

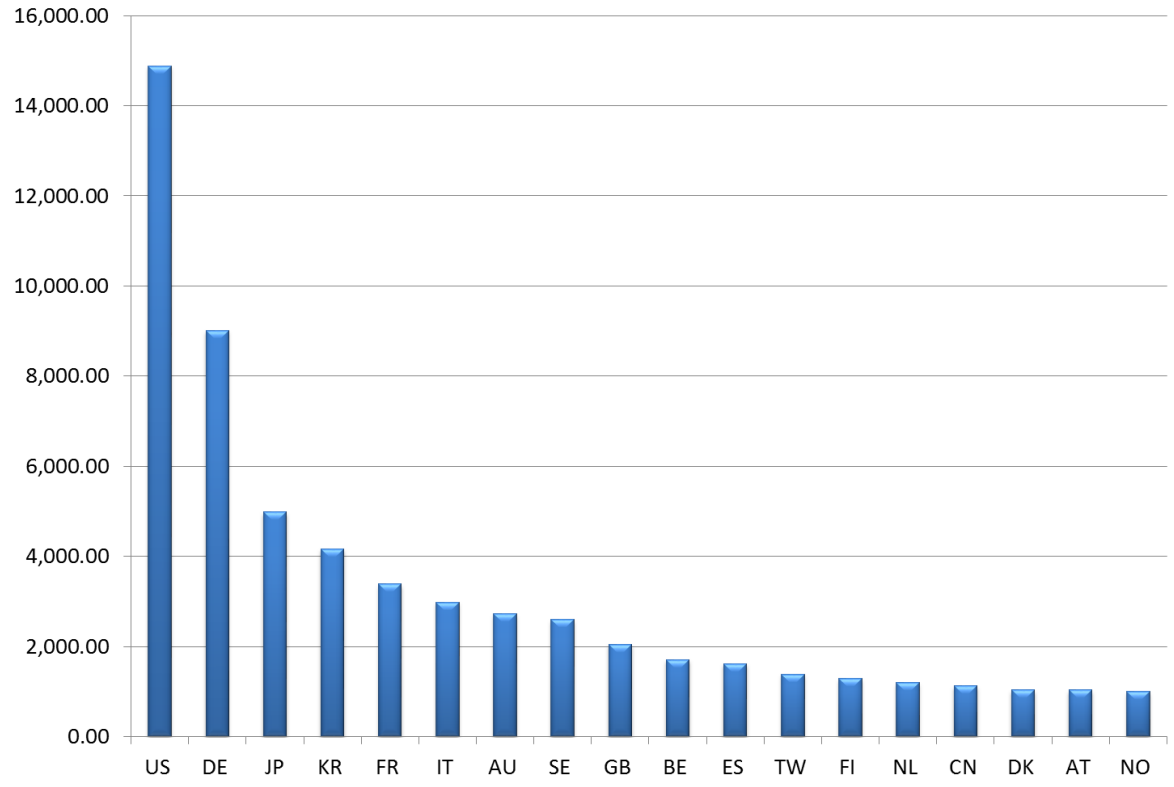


Figure 8 – Value of sales by country (in EUR, > € 1 000 only shown)

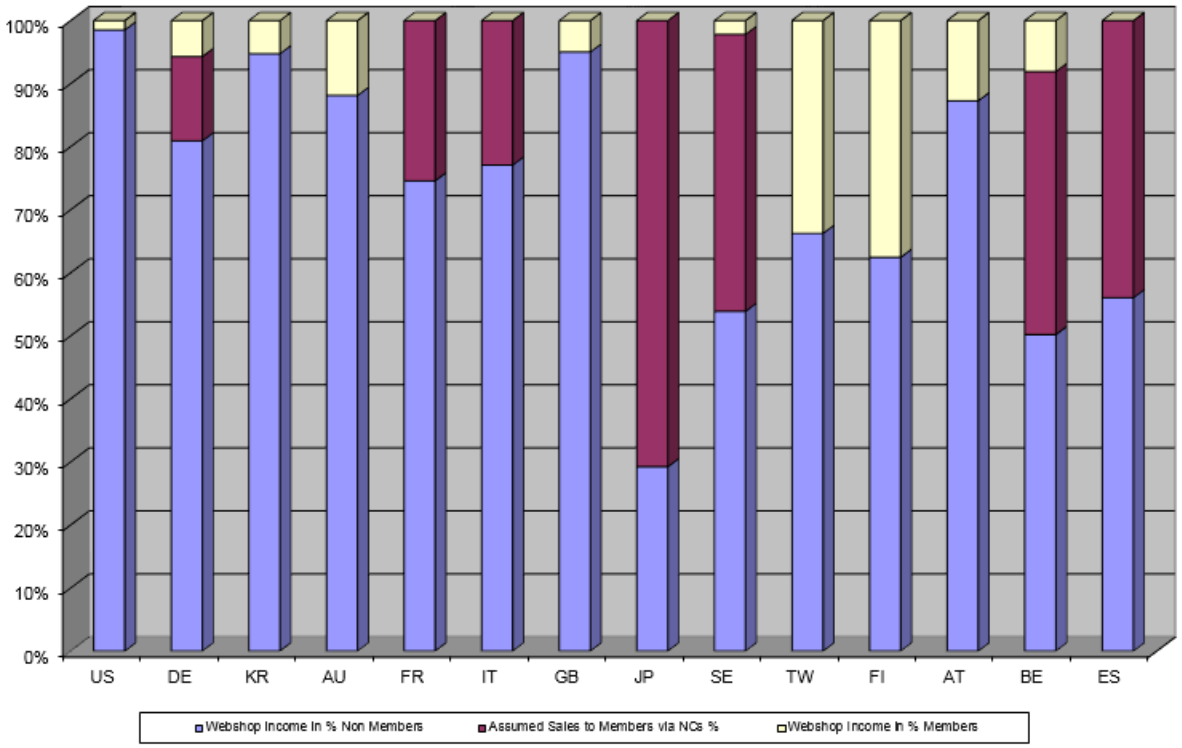


Figure 9 – % sales by category for countries buying more than € 900 of publications via the webshop in 2014

6 CIE website

The address of the main CIE website is

http://www.cie.co.at

It has been extensively overhauled to give it a more modern look and feel, and now also hosts all of the Divisional websites as well as providing links to the NCs and to the collaboration tool.

Acknowledgements

I wish to acknowledge with gratitude the many efforts of Technical Committees, Reporters and Divisions in producing the technical output of the CIE, and also the long hours Division Editors and the CIE Technical Manager Peter Zwick spend on scrutinising the submitted texts to ensure CIE's reputation for the high quality of its publications is maintained. I also wish to thank the CB Office Manager, Leo Trausnith, for his hard work and diligence in the final production and marketing of the publications and in preparing the publication sales data.

Quadrennial Report 2011 – 2015 of the Vice-President Standards

Ad de Visser, NL

Cooperation with international standards organizations

Three bodies are responsible for the planning, development and adoption of International Standards: ISO (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of IEC (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of ITU (International Telecommunication Union).

ISO

The International Organization for Standardization (ISO) has recognized the International Commission on Illumination (CIE) as an international standardizing body.

These working arrangements between the CIE and ISO aim to strengthen the development of International Standards and to avoid duplication of work on standards related to light, lighting, colour and vision (i.e. light sources, photometry and colourimetry, lighting design, illuminating engineering).

In 2012, ISO established the committee ISO/TC 274 with the scope: Standardization in the field of application of lighting in specific cases complementary to the work items of the CIE and the coordination of drafts from the CIE, concerning vision, photometry and colourimetry, involving natural and man-made radiation over the UV, the visible and the IR regions of the spectrum, and application subjects covering all usage of light, indoors and outdoors, energy performance, including environmental, non-visual biological and health effects.

An addendum of a working arrangement was attached in 2014; a copy is attached to this report.

Further progress with and in ISO/TC274 is under a separate topic in this general assembly meeting.

IEC

IEC develops and publishes standards in the complete domain of electro technology. Certain fields of activity of the IEC and the CIE overlap, such as the vocabulary and the CIE S 025/E:2015 *Test Method for LED Lamps, LED Luminaires and LED Modules*, which aims in particular to cover measurement methods for testing the compliance of LED devices with the photometric and colorimetric requirements of LED performance standards issued by IEC/TC 34 “Lamps and related equipment”.

CIE invited IEC/TC34, ISO management and other international partner organization representatives to participate to the first day of a CIE BA strategy workshop in Manchester in 2012.

IEC/TC34/AG2 invited CIE and ISO/TC274 representatives to a Lighting systems workshop in Berlin in 2014.

The Coordination committee of ISO/TC274 with CIE invited the IEC/TC34 liaison officer at management level for further coordination.

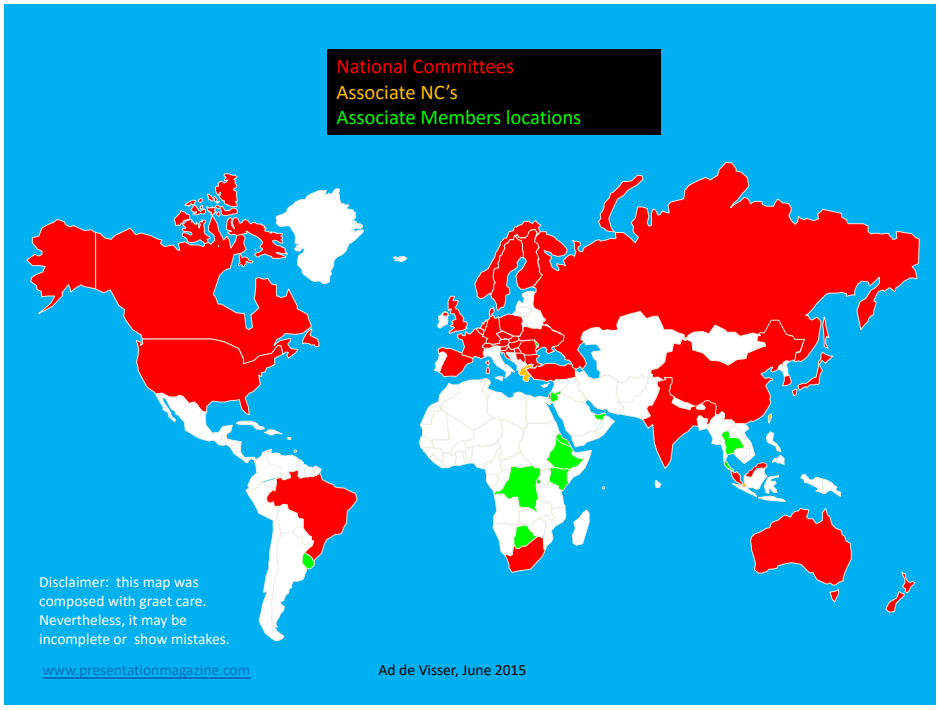
Compliance testing

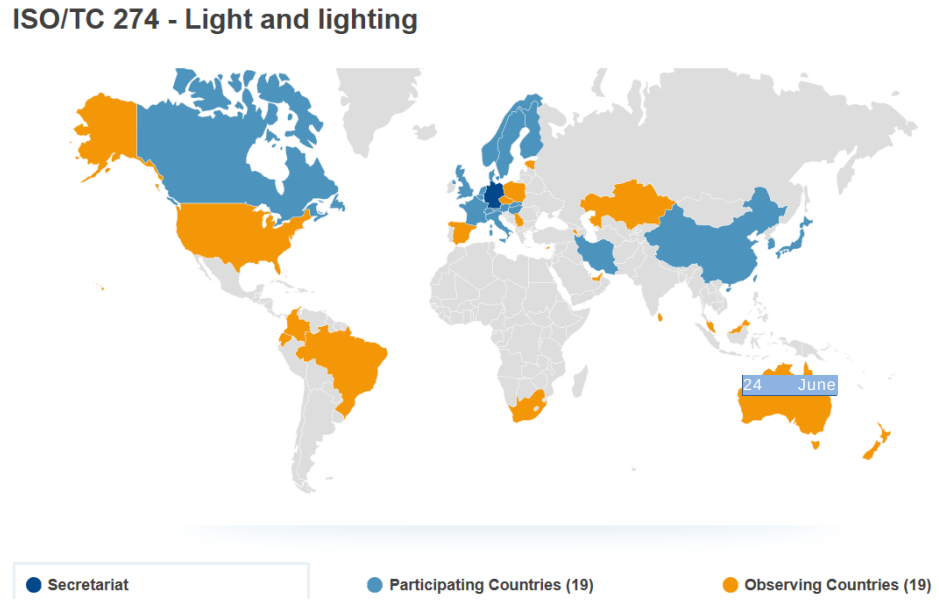
CIE is discussing the use of CIE standards in commercial IEC Conformity Assessment.

CIE National Committees and National Standards Bodies being member of ISO and IEC

CIE members should be aware of participation of national standards bodies in their country represented in ISO or IEC (and CEN/TC169) committees in the field of lighting. This is important in relation to where experts can contribute to the technical work and because of voting. National Committees of CIE are not necessarily covering the same countries as countries that are participating or observing members of ISO or IEC.

CIE





Country	CIE National Committee	ISO Participating Countries	CIE Associate National Committees	ISO Observing Countries
Armenia				x
Australia	x	per 24 June 2015		~~x~~
Austria	x	x		
Belgium	x	x		
Brazil	x			x
Canada	x	x		
China	x	x		
Colombia				x
Croatia	x			
Cyprus				x
Czech Republic	x			x
Denmark	x	x		
Germany	x	x		
Ecuador				x
Estonia				x
United Arab Emirates				x
Finland	x	x		
France	x	x		
United Kingdom/ Great Britain	x	x		
Greece			x	
Hong Kong	x			
Hungary	x	x		
Israel	x			
Italy		x		
India	x			
Iran, Islamic Republic of		x		
Japan	x	x		
Kazakhstan				x
Korea, Republic of	x	x		
Malaysia	x			x
The Netherlands	x	x		
New Zealand	x			x
Norway	x	x		
Poland	x			x
Romania	x			
Russian Federation	x			
Serbia	x			x
Singapore			x	x
Slovenia, Republic of	x			
Slovak Republic	x	x		
South Africa	x			x
Sri Lanka				x
Spain	x			x
Sweden	x	x		
Switzerland	x	x		
Chinese Taipei (Taiwan)			x	
Ukraine	x			
USA	x			x

Cooperation with regional standards organizations

CEN/TC169

Many experts are involved in both CIE and CEN/TC169. This results in harmonization bottom-up.

Coordination of work items

ISO/TC274/CoCo

The Coordinating Committee of ISO/TC274 coordinates new work items for ISO/TC274 and new work items on standards for CIE. This committee also keeps an eye on new work items in ISO itself since many committees have a scope covering lighting in particular fields.

ISO/TC22/SC8	Road vehicles/ Lighting and light-signalling
ISO/TC 22/SC 35	Road vehicles/ Lighting and visibility
ISO/TC159	Ergonomics
ISO/TC163	Thermal performance and energy use in the built environment
ISO/TC203	Technical energy systems
ISO/TC205	Building environment design
ISO/TC206	Fine ceramics
ISO/TC217	Cosmetics

A similar coordination is worked on with IEC/TC34 in particular for the scope of CIE Division 2 and the Lighting Systems. Coordination with CEN/TC169 is not possible in this group since this is a regional organization and member of ISO, where the Vienna agreement applies (new work item proposal on ISO level first; if no interest, then regional level or national level allowed). Nevertheless, there are cooperation officers vice versa.

Liaison/cooperation officers

Contacts at organizational level are maintained by the SGs of the respective organizations. Next to these SGs the following liaison officers can be noted; the list may not be complete but is intended as illustration of cooperation at technical level.

From		To	Title
CIE		ISO/TC274	Light and lighting
CIE		IEC/TC34	Lamps and related equipment
CIE/D2		IEC/SC34A/PRESCO	PREparation of Standards COmmission
CIE/D2		IEC/SC34D	Luminaires
CIE/D6		IEC/TC76	Optical radiation safety and laser equipment
CIE/D8		IEC/TC100	Audio, video and multimedia systems and equipment
IEC/TC34		CIE	Lamps and related equipment
ISO/TC274	Light and lighting	ISO/TC163	Thermal performance and energy use in the built environment
ISO/TC274	Light and lighting	ISO/TC205	Building environment design
ISO/TC274	Light and lighting	IEC/TC34	Lamps and related equipment
ISO/TC274	Light and lighting	CIE	
ISO/TC274	Light and lighting	CEN/TC169	Light and lighting
ISO/TC159/SC4	Ergonomics of human-system interaction	ISO/TC274	Light and lighting
ISO/TC159/SC5	Ergonomics of the physical environment	ISO/TC274	Light and lighting
ISO/TC205	Building environment design	ISO/TC274	Light and lighting
IEC/TC34	Lamps and related equipment	ISO/TC274	Light and lighting
CIE		ISO/TC274	Light and lighting
CEN/TC169	Light and lighting	ISO/TC274	Light and lighting

Vocabulary

IEC and the CIE have existing joint publications in the area of lighting vocabulary. A project to review this standard did not succeed. Both IEC and CIE have their own electronic vocabularies. IEC and CIE cooperated in the field of LED terminology on working group level.

The revision of ISO80000 in ISO/TC 12/WG 19 (Quantities and units/Revision ISO 80000 Quantities and units) is harmonized with the ILV. A task force within CIE, initially consisting of VPT, VPP, DD1, DS1, DD2, DS2, TM and ADD2 (also leader of the WG) has been initiated to address inconsistencies in these deficiencies in the ILV. A first meeting was scheduled for 2014-12-09.

Acknowledgement

Most of the results of the past four years would not have been possible without the enthusiastic engagement of Martina Paul, the CIE General Secretary, and the staff of the Central Bureau, in particular the CIE Technical Manager Peter Zwick.

Many thanks to Axel Stockmar, VPS for 2011-2014, for reviewing this report.

ISO/TC 274

Agreement on
Working arrangements between the ISO/TC 274 "Light and Lighting" and the International Commission on Illumination

1. Background

The International Organization for Standardization (ISO) has recognized the International Commission on Illumination (CIE) as an international standardizing body for the purpose of Council resolution 19/1984 (superseded by Council resolution 42/1999) through ISO Council Resolution 10/1989.

These working arrangements between the CIE and ISO aim to strengthen the development of International Standards and to avoid duplication of work on standards related to light, lighting, colour and vision (i.e. light sources, photometry and colorimetry, lighting design, illuminating engineering).

In 2012, ISO established the committee ISO/TC 274 with the scope: *Standardization in the field of application of lighting in specific cases complementary to the work items of the International Commission on Illumination (CIE) and the coordination of drafts from the CIE, in accordance with the Council Resolution 19/1984 and Council Resolution 10/1989 concerning vision, photometry and colorimetry, involving natural and man-made radiation over the UV, the visible and the IR regions of the spectrum, and application subjects covering all usage of light, indoors and outdoors, energy performance, including environmental, non-visual biological and health effects*.

2. Scope of application

Subject to their respective rules and procedures, and within the limits of their responsibility and available resources, CIE and ISO will regularly share with each other relevant information regarding their respective work programmes in standardization, such as new work items, and facilitate active participation and substantive contribution to each other's relevant meetings, appropriate workshops, seminars, working party or expert group meetings addressing standards issues associated with lighting.

This cooperation includes and encourages the active participation of CIE as a liaison organization in ISO/TC 274 and other relevant ISO committees (TC, SC or PC) as well as reciprocal participation by ISO/TC 274 in relevant CIE Divisions and Technical Committees (TC).

Noting that ISO/TC 274 and CIE are involved in similar areas, the focus on future standardization work shall be as follows:

- **CIE** develops the **fundamental and basic standards** in all domains covered by its scope (Colour & Vision, Photometry, Interior Lighting, Exterior Lighting, Lighting for Transport and Street Lighting, Photobiology and Photochemistry) (see Figure 1).

- **ISO** develops **standards which apply fundamental and basic standards** of CIE in lighting situations (such as Interior Lighting, Exterior Lighting, Lighting for Transport and Street Lighting, building environment, etc.) of all domains covered by its scope (see Figure 1).

Figure 1 – Visualization of the concept of complementary

ISO/TC 274 and CIE agree on the following principles of cooperation.

3. Working arrangements

Each organization will inform the other of any new work item in standardization via the respective Central Secretariats. The proposer shall be encouraged to indicate in the proposal the envisaged route of collaboration.

CIE Central Secretariat and the secretariat of ISO/TC 274 start a call to the relevant bodies of the organizations if there is an interest of the other in the project.

A Coordination Committee consisting of

- ISO/TC 274 Secretary,
- ISO/TC 274 Liaison Officer to CIE(/IEC),
- CIE Vicepresident Standards,
- CIE Liaison Officer to ISO/TC 274(/IEC),
- (IEC Liaison Officer to CIE/ISO/TC 274),
- (One Representative representing the relevant IEC/TCs),
- Appropriate advisors upon invitation and/or representatives of another ISO or IEC committee,

and chaired by the Chairperson of ISO/TC 274 in a neutral manner shall be installed.

It proposes, depending on the feedback of the other organization, one of the routes for collaboration together with the allocation to the relevant body (ISO/TC 274 or CIE committee) as leader of the work.

The allocation of work between CIE and ISO/TC 274 for potentially overlapping areas will be set out as required in schedules or programmes which, when agreed by the relevant parties, will form addenda to this agreement.

Additional tasks of the coordination committee are e.g.:

- Day-to-day management (e.g. coordination of NWIP, etc.)
- Discussions on general topics related to cooperation between ISO/TC 274, CIE (and IEC)

The 3 routes for collaboration are:

Route 1 – Informative relation

One organization is fully entrusted with a specific work area and keeps the other fully informed of all progress.

Route 2 –Collaborative relation

One organization takes the lead in the activities, but the work sessions and meetings may receive delegates from the other who have observer status and who ensure the technical liaison with the other organization. These delegates could also make written contributions where considered appropriate during the progress of this work.

Such observers should have the right to intervene in the debate but have no right to vote. The full flow of information is oriented through this liaison.

Under Routes 1 and 2, publications can be further proposed by the lead organization to the other as joint ISO/CIE standard. The proposal shall be received by the relevant Central office/Secretariat, who shall take the following actions:

assess in consultation with the Coordination Committee if a committee is competent for the subject covered by the proposed document from the other organization;

ascertain that there is no evident contradiction with other International Standards;

distribute the proposed document as an enquiry draft if the publication fall within the scope of an existing committee, or as a final draft International Standard if appropriate (e.g. in case of already published standards which should become a Joint standard).

Comments received should be dealt with by the Coordination Committee and appropriate advisors of the relevant committee(s).

Route 3 – Integrated liaison

Joint Working Groups ensure integrated meetings for handling together the realization of standards under a principle of total equality of participation.

Joint Working Groups between technical committees of the two organizations shall operate in accordance with 1.12.6 of the ISO/IEC Directives, Part 1.

For standards developed following the integrated route, the different approval stages in the development shall be carried out in parallel in both ISO/TC 274 and CIE. The committee/organization with the administrative responsibility (“Lead”) for the project shall submit drafts for all stages to the other organization two weeks prior to the circulation date.

When the enquiry draft has not fulfilled the approval criteria in one of the organizations, then:

- the officers of the committees involved in the joint working group may select one of the options given in 2.6.4 c) of the ISO/IEC Directives, Part 1, or

- in exceptional circumstances, if agreed between ISO/TC 274 and CIE committees involved in the joint working group and the offices of the respective CEO, the project may proceed as a single logo standard of the organization in which the enquiry draft was approved. The joint working group is automatically disbanded.

If the final draft International Standard is not approved in accordance of the conditions in 2.7.3 of the ISO/IEC Directives, Part 1, then:

- the committees involved in the joint working group may select one of the options given in 2.7.7 of the ISO/IEC Directives, Part 1, or
- in exceptional circumstances, if agreed between ISO/TC 274 and CIE committees involved in the joint working group and the offices of the CEO, the standard may be published as a single logo standard of the organization in which the final draft International Standard was approved. The joint working group is automatically disbanded.

Standards developed following the integrated route via a joint working group between ISO/TC 274 and CIE are published under a joint reference ISO/CIE. The standard carries the logo of both organizations. The International Standard contains each organization's foreword. Each foreword will identify all the committees responsible for the development.

The maintenance procedures to be used for standards developed following the integrated route will be those currently applied in the organization which has the committee with the administrative responsibility.

If there is a reason, during the development of the project, to change from one route to another, a resolution shall be taken by both technical committees concerned and submitted to the Coordination Committee for information.

Cooperation of secretariats

The secretariats/responsibles of the respective committees from ISO/TC 274 and the CIE concerned shall cooperate on the implementation of this agreement. There shall be a complete information flow on on-going work and availability on demand to each other of working documents, in accordance with normal procedures.

The organizations shall strive to coordinate and address matters using the above working arrangements. Any unresolved issues shall be forwarded to the coordination committee for further treatment.

Quadrennial Report 2011 – 2015 of the Treasurer

Lorne Whitehead, CA

Overview of the financial affairs of the CIE during the quadrennial period 2011 - 2015

This unaudited summary supplements the audited financial statements. Those interested in financial details are advised to consult the CIE audited financial statements, which are available upon request.

Since the CIE is a not for profit society, it should not generate long-term profits, but of course it must maintain a sufficiently positive financial position to remain solvent at all times, despite the normal timing variations of income and expenses and occasional unexpected costs. For these reasons it is prudent for the CIE cash position (the sum of our cash and reserves) to represent at least 9 month of total revenue. This means that our cash and reserves should generally exceed €300,000 in today's currency.

Figure 1 summarizes the approximate evolution of the CIE financial position over the preceding two quadrennial periods.

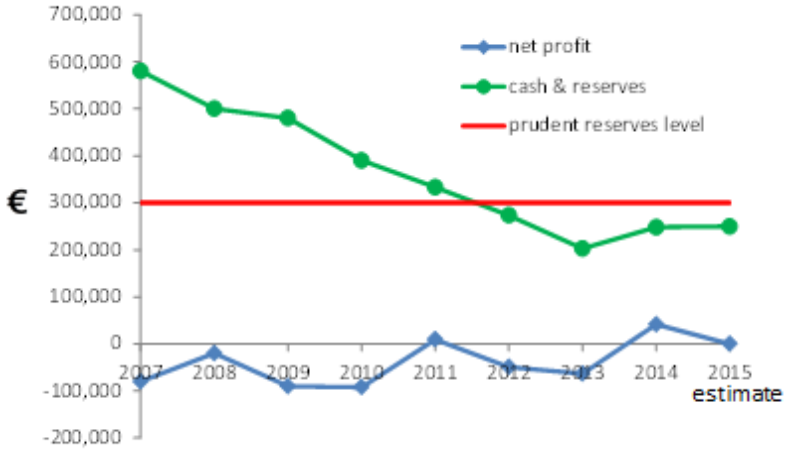


Figure 1 – Approximate, unaudited, summary information derived from the audited CIE Financial Statements. The green curve depicts the approximate sum of cash and reserves. The red line represents a prudent minimum level for this sum. The blue curve shows the net change in the sum of cash and reserves in each year, which is approximately the net profit.

As can be seen in Fig. 1, during the preceding quadrennial period from 2007 to 2011, there was a significant diminishment of the CIE cash and reserves position. It had been reported that the significant annual losses during that past period represented investments that were expected to yield significant revenue improvement for the CIE in the subsequent period now just completed. Unfortunately, it became clear in 2011 that the anticipated revenue increases were unlikely to be forthcoming, and as a result the Treasurer, President, and General Secretary, with the support of the Board of Administration, embarked on a program of prudent cost control, returning the organization to a small profit in 2014 and break-even in 2015. Without that cost control program, the CIE cash position would have been seriously depleted, which in turn could have caused serious problems.

While the cost control program was necessary, it was also not seen as a long term solution, since the CIE has had to delay various improvements that are needed for long term success. These include a new web-site, and possible additional modern services for CIE stakeholders. For this reason, during 2015, the CIE leadership embarked on a communication exercise with the CIE National Committees, to explain that, due to inflation, the purchasing power of the CIE National Dues had been significantly diminished over the last decade. It was agreed that a series of four successive dues increases, each of 6 %, would be applied for years 2016, 2017, 2018, and 2019. We are optimistic that this will enable to the CIE to maintain a suitable level of cash and reserves and also make the modest investments required to maintain relevance and viability in the years ahead.

Anyone wishing to deeply study the CIE's financial activities are advised to review the organization's financial statements, which received an unqualified report from the CIE auditors in each of the years in the quadrennial period.

In reviewing these results, perhaps the most apparent feature is overall stability. Although the CIE National Dues are slightly insufficient to properly cover CIE costs, the organization's financial performance has been quite stable during the recent quadrennial period. Our cost of operations has been controlled at slightly above € 400 000, and national dues have steadily covered about 60% of this cost each year. Revenues from publications and conferences are more variable from year to year, but there is no large overall trend and on average they have covered about 35% of the cost of operations. By restricting the average shortfall over the past quadrennial period to about 5% per year, the CIE has remained financially viable, and the planned increase in dues during the next quadrennial period is expected to help ensure the long term continue financial viability of the CIE.

As I conclude my period as CIE Treasurer, I would like to sincerely thank all of my colleagues within the CIE for their cooperation and assistance as I carried out this work. As I hand over this responsibility to my successor, Mr. Richard Distl, I wish to thank him for accepting this task, and offer my continued support.

Report 2007 – 2015 of the General Secretary

Martina Paul, AT

I had the honour and the pleasure to chair the CIE Central Bureau for eight years. As many of the strategies, projects and results can only be read when seen as part of the big picture I will draw a detailed sketch of what has been the major achievements – apart from the day-to-day business - of the Central Bureau from August 1, 2007 till June 30, 2015. Regulations, legal, statutory and procedural ones form the frame in which the management of the organization takes place.

Therefore this report will use this framework as starting point and from there will describe the tasks and related results which have been achieved by great people, in particular to mention Dr Peter Zwick, Technical Manager, and Leo Trausnith, Office Manager, but not forgetting numerous others who were part of a truly professional and committed team, striving for excellence in all its operations.

The Legal and Statutory Framework for the CIE General Secretary and the Central Bureau

The Statutes delegate the

- External Representation (together with CIE President)
- Chairing CB and the
- Responsibility for professional management of CB

to the General Secretary whose legal duties are defined by various regulations which entitles and obliges him/her to mainly ensure

Legal and tax compliance in a variety of fields

Legal compliance:

a) Association Law
b) Trade Law
c) Labour Law
d) Social Insurance Law

Tax compliance:

- Payroll related taxes
- Corporation taxes
- Timely payment of these taxes

a. Association Law:

- Acting with due diligence in accordance with the Statutes, the ByLaws and the Code of Procedure
- Safeguarding the maintenance of these rules and notifying decision making bodies in case of their violation

b. Trade Law/Corporation Taxes:

- Maintaining an accounting system in compliance with internationally recognized standards
- Maintaining an appropriate internal financial control system
- Managing Director of CIE Scientific Services

c.+d. Labour Law/Social Insurance Law/Payroll related taxes

- Maintaining and supervising adequate workhours recording systems
- Setting up proper contracts with staff and contractors
- Supervising and coaching of staff and contractors
- Supervising payroll accounting and setting up a proper system

To paint a clearer picture of what the CIE Central Bureau and the General Secretary are supposed to accomplish the tasks of CIE Central Bureau and the General Secretary are herewith summarized as such:

1) Central Bureau is the main operational unit of the CIE.
2) General Secretary is the Chair of the Central Bureau and the interface from CB to the CIE Board of Administration as ex-officio Board Member.
3) CB and GS have to take care of Safeguarding Procedures
4) GS is responsible for
    a. Safeguarding legal and tax compliance of the CIE
    b. Implementing Board Decisions and Strategic Development
    c. Organizing (administrative) meetings and other events
    d. Safeguarding publishing procedures
    e. Supervision and Responsibility for:
        - Administrative & Financial Day-to-Day Management
        - Staff
    f. External Representation and Stakeholder Coordination
    g. Strategy Development (as mandated by the Board of Administration)

Achievements 2007 – 2015

1. Central Bureau is the main operational unit of the CIE

Publications:

- 72 Publications comprising 11 338 pages
- 52 Technical Reports
- 11 Standards
- 9 Conference Proceedings
- A completely re-edited version of the International Lighting Vocabulary (ILV) including a searchable database with 1447 terms and definitions.

(further details can be obtained from the report of Vice-President Publications Teresa Goodman).

Conferences:

- 11 Conferences, Symposia and Tutorials with:
- 3 227 Participants attended
- 1 587 Abstracts received
- 1 351 Papers published

Measures:

- Outsourcing of Bookkeeping and Payroll Accounting
- Quarterly Dues Account Statements (and reminders) to National Committees
- Cost savings by
  - decreased number of employees by two thus permitting higher flexibility
  - Outsourcing services (IT, Web)
  - Establishing regular CIE e-Newsletter instead of printed CIE News (less expensive printing/copying machine – around 18 000 EUR less)

2. General Secretary is the Chair of the Central Bureau and the interface from CB to the CIE Board of Administration as ex-officio Board Member.

3. CB and GS have to take care of Safeguarding Procedures

4. GS is responsible for

a) Safeguarding legal and tax compliance of the CIE

Measures:

- Drafting new Statutes with external advise
- Coordinating Approval Process with BA and NCs
- Drafting final proposal with their input
- Governing the process to set up CIE Scientific Services GmbH with tax adviser and lawyer
- Managing the foundation of CIE Scientific Services to meet all legal and tax requirements
- Developing (together with former Treasurer, Johann Schleritzko) new publication pricing and NC crediting
- Installing compliant reporting and proper accounting
- Proposing two-signature system (till 2007 only GS signed off transfers)
- Setting up, governed by the Treasurer 2007 – 2011, Johann Schleritzko, an appropriate financial reporting system compliant with International Financial Reporting Standards (IFRS)
- Drafting the Associate Members Programme
- Designing a strategy for its implementation

b) Implementing Board Decisions and further Strategic Development

Measures:

- Re-negotiating royalty agreement with Thomson Reuters (raising royalties by 10%, late payment interests)

- Negotiating contract amendments with Thomson Reuters for new products (combined pdf-print publications, multi-licencing for single pdfs, subscriptions etc)
- Re-negotiating Royalty agreements with IHS (in progress)
- Setup Royalty contract with the German Beuth Verlag in 2011
- Initiating and Contracting Licences for Online Meetings as well as for Abstract Submission and Review
- New CIE Website
- Offering regular training sessions to TCCs and Divisions
- Negotiating use of IEC collaboration tool for free, implementing its mandatory use
- Installing Communication Routines between Board and National Committee
- Starting process to include publications (Proceedings and Technical Reports) in Citation Indices. Some proceedings are now included in the Citation Index.

Business Models

- Conference Format “Lighting Quality & Energy Efficiency” and related “Franchising” model
- Development of Business Plan and related activities such as Trainings

c) Organizing (administrative) meetings and other events

d) Safeguarding publishing procedures

Measures:

- Proposed new drafting procedures for publications to the Board of which 90% are now included in the Code. Main achievements: Installing “Process Owners” (responsibilities), deadlines, avoiding loops in the process as much as possible
- Proposed a new structure for the Codes and the Bylaws (there were actually two Codes existing and Bylaws and Codes were not consistent with each other)

e) Supervision and Responsibility for:

- **Administrative & Financial Day-to-Day Management & Staff**

Measures:

- Setup a process manual for CB to ensure that each and every process step is transparent. Process manual undergoes an annual review to re-call procedures, to check if they are still up-to-date and appropriate and to improve them if necessary.
- Personnel Manual as well as Standard Contracts established
- Salary Scheme implemented
- New CB Team (2008: Technical Manager, 2011: Office Manager)

f) External Representation and Stakeholder Coordination

Measures:

- Recognition of CIE as partner. ISO accepted CIE work items to be included in the official monthly announcements of ISO/IEC work programmes
- Four Memoranda of Understanding with Lighting Designers (PLDA, IALD) and Lighting Industry (GLA) as well as the City Lighting Network (LUCI)

- Ensuring coordination with the regulators via the IEA and acceptance of CIE Measurement Standard CIE S 025:2014 as part of governmental regulations
- Negotiating and partnering in the process with a variety of stakeholders in particular DIN, the German Standardization Body, of setting up an ISO/TC which resulted in the foundation of ISO/TC 274 “Light and Lighting”
- Chairing ISO/TC 274
- Coordination with partner organizations such as BIPM, ISO, IEC, PLDA, IALD, GLA
- Membership within ICSU (International Council of Scientific Unions) and STM (Association of Scientific, Technical and Medical Publishers)
- Installing close cooperation with the IAU (International Astronomical Union)
- Representing CIE and the ISO/TC as invited speaker at various international lighting conferences worldwide

All these would not have been possible without the support of the members, the National Committees, the Supportive Members, the commitment of the Technical Committee Chairs and contributors and a forward looking Board of Administration, above all the two Presidents which I served, Dr Franz Hengstberger (2007 – 2011) and Prof Ann R Webb (2011 – 2015).

QUADRENNIAL REPORTS OF THE DIVISIONS

Division 1: Vision and Colour
Quadrennial Report 2011-2015

Ronnier Luo, GB/CN (DD)

2015-07-20

1 Terms of Reference

To study visual responses to light and to establish standards of response functions, models and procedures of specification relevant to photometry, colorimetry, colour rendering, visual performance and visual assessment of light and lighting.

2 Division Officers

2011-2015:	Director:	Ronnier Luo (GB)
	Associate Director (Vision):	Miyoshi Ayama (JP)
	Associate Director (Colour):	Ellen Carter (US)
	Secretary:	Michael Pointer (GB)
	Editor:	Phil Green (GB)
2015-2019:	Director:	Youngshin Kwak (KR)
	Associate Director (Vision):	Nana Itoh (JP)
	Associate Director (Colour):	Ellen Carter (US)
	Secretary:	Li-Chen Ou (TW)
	Editor:	Phil Green (GB)

3 Division Meetings

2012: Taipei (TW), 2012-09-26 – 2012-09-27
(This meeting was held in conjunction with the AIC Interim Meeting *In Color We Live: Color and the Environment* at the Chinese Culture University, Taipei, Taiwan, 2012-09-23 – 2012-09-25. The CIE D1 meeting, which was held at the National Taiwan University of Science and Technology, included a *Color Science Symposium* on 2012-09-28.)
42 attendees including 12 national representatives

2013: Leeds (GB), 2013-07-05 – 2013-07-06
(This meeting was preceded on 2013-07-25 by a one-day workshop on *Colorimetry, Graphic Arts and Colour Management* the purpose of which was to explore areas of colour science that are of interest to ISO/TC 130 *Graphic Technology* and ICC – the International Color Consortium. The meeting was followed by the AIC Congress 2013 *Bringing Colour to Life*)
44 attendees including 18 national representatives

2014: Gaithersburg (US), 2014-06-16 – 2014-06-17
(This meeting was organized as part of a *Color, Light and Appearance Week* at NIST. The D1 meeting was followed by a one-day symposium organized by the ISCC – the Inter-Society Color Council – and a two-day meeting of ASTM – the American Society for Testing and Materials – Committee E12 *Color and Appearance*.)
40 attendees including 19 national representatives

2015: Manchester (GB), 2015-06-30
(This meeting was held as part of the 28th CIE Session)
62 attendees including 23 national representatives

4 Symposia and Workshops

No official CIE endorsed symposia were held within this reporting period.

5 Strategy 2011-2015 and beyond

A. What have we achieved?

- CIE Publication 15 revision near completion
- ISO/CIE colorimetry series completed: Illuminants, Observers, XYZ, uniform colour spaces of CIELAB and CIELUV, and colour difference equation:CIEDE2000.
- CIE 2006 Colorimetry: new spectral tristimulus values: variation with stimulus size and observer age
- CIE mesopic vision

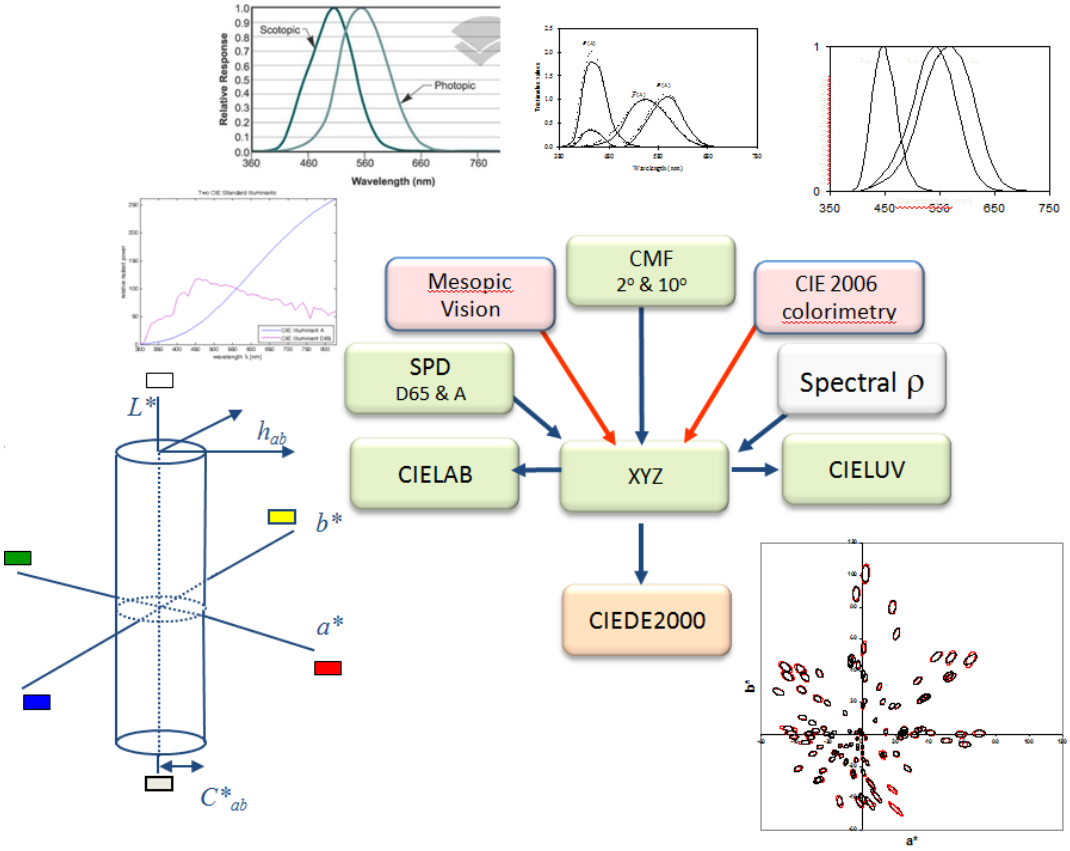
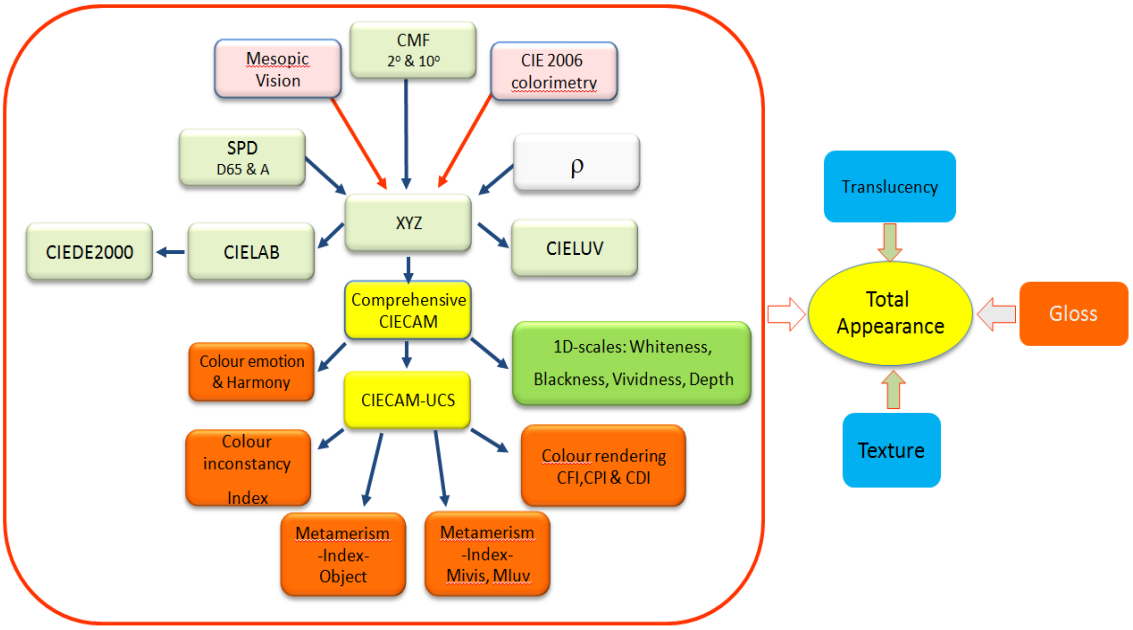


Figure 1 – Summary of what we have achieved

B. Road map for the future

B-1:Comprehensive colour appearance model and its associated colour space (yellow boxes)



The 1st stage extension (see yellow boxes) to develop a comprehensive colour appearance model based on CIECAM02 to predict the colour appearance under the viewing conditions of unrelated colours, variable stimulus size, mesopic region, and the 2nd stage extension (see green and orange boxes) to new correlates whiteness, blackness, vividness and depth, new colour rendering index, colour preference index, and colour discrimination index; metamerism index for object and light stimulus, colour inconstancy index and colour emotion and harmony indices.

B-2: Beyond colour

In addition to the colour specification and applications, total appearance should be the next phase. It can be divided into four parts: colour, surface texture, gloss and translucency.

C. Important tasks in lighting

Due to the rapid spread of LED lightings, the following tools are required.

- Standard LED illuminant in terms of spectral power distribution for colour specification
- Colour rendering (Colour Rendering Index + Colour Preference Index) to update the current outdated CIE-Ra
- White-perception locus in addition to the blackbody locus
- Whiteness index for LED lights as new quality indicator
- Whiteness for object colours to replace the present equations
- LED daylight simulator to revisit the present standard such as ISO 3664.

6 Administrative Matters and Communication

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7 Publications

7.1 Published

7.1.1 CIE Technical Reports

CIE 200:2011 CIE supplementary system of photometry

CIE 204:2013 Methods for Re-defining CIE D Illuminants

CIE 208:2014 Effect of Stimulus Size on Colour Appearance

CIE 211:2014 Colour Appearance in Peripheral Vision

CIE 212:2014 Guidance towards Best Practice in Psychophysical Procedures used when Measuring Relative Spatial Brightness

7.1.2 Joint ISO/IEC/CIE International Standards

ISO 11664-3:2012(E)/CIE S 014-3/E:2011 Colorimetry – Part 3: Calculation of CIE tristimulus values

ISO/CIE 11664-6:2014(E) Colorimetry – Part 6: CIE DE2000 colour difference formula

7.1.5 Reports by Reporterships

DR 1-47 Hue Angles of Elementary Colours

DR 1-54 Variability in Colour-Matching Functions

DR 1-55 Enhancement of Images for Colour Defective Observers

DR 1-56 Skin Colour Database

DR 1-57 Border between Luminous and Blackish Colours

DR 1-59 Calculation of Self-luminous Neutral Scale

7.2 Expected

TC 1-36 Fundamental Chromaticity Diagram: Technical Report Part 2

TC 1-55 Uniform Colour Space for Industrial Colour-difference Evaluation: Technical Report

TC 1-63 Validity of Range of CIEDE2000: Technical Report

TC 1-64 Terminology for Vision, Colour and Appearance: Technical Note

TC 1-75 A Comprehensive Colour Appearance Model: Technical Report

TC 1-76 Unique Hue Data: Technical Report

TC 1-81 Validity of Formulae for Predicting Small Colour Differences: Technical Report

TC 1-82 The Calculation of Colour Matching Functions as a Function of Age and Field Size: Technical Report

TC 1-83 Visual Aspects of Time-Modulated Lighting Systems: Technical Report

TC 1-84 Definition of the Visual Field for Conspicuity: Technical Report

TC 1-85 Update CIE Publication 15:2004: Technical Report

TC 1-86 Models of Colour Emotion and Harmony: Technical Report

TC 1-88 Scene Brightness Estimation: Technical Report

TC 1-89 Enhancement of Images for Colour Defective Observers: Technical Report

TC 1-90 Colour Fidelity Index: Technical Report

TC 1-91 New Methods for Evaluating the Colour Quality of White-Light Sources: Technical Report

TC 1-92 Skin Colour Database: Technical + Database

TC 1-93 Calculation of Self-luminous Neutral Scale: Technical Report

7.3 Review

7.3.1 Reviewed Publications

CIE 101:1993 Parametric Effects in Colour-Difference Evaluation

7.3.2 Status of Publications

Current:

CIE 075-1988 Spectral Luminous Efficiency Functions based upon Brightness Matching for Monochromatic Point Sources, 2° and 10° Fields

CIE 095-1992 Contrast and Visibility

CIE 101-1993 Parametric Effects in Colour-Difference Evaluation

CIE 118-1995 CIE Collection in Colour and Vision:

CIE 123-1997 Low Vision – Lighting Needs for the Partially Sighted

CIE 124-1997 CIE Collection in Colour and Vision, 1997

CIE 135-1999 CIE Collection 1999: Vision and Colour, Physical Measurement of Light and Radiation

CIE 141-2001 Testing of Supplementary Systems of Photometry

CIE 142-2001 Improvement to Industrial Colour-Difference Evaluation

CIE 145:2002 Correlation of Models for Vision and Visual Performance

CIE 146/147:2002 CIE Collection on Glare 2002

CIE 160:2004 A Review of Chromatic Adaptation Transforms

CIE 165:2005 CIE 10 Degree Photopic Photometric Observer

CIE 166:2005 Cognitive Colour

CIE 170-1:2006 Fundamental Chromaticity Diagram with Physiological Axes – Part 1

CIE 175:2006 A Framework for the Measurement of Visual Appearance

CIE 177:2007 Colour Rendering of White LED Light Sources

CIE 185:2009 Reappraisal of Colour Matching and Grassmann's Laws

CIE 191:2010 Recommended System for Mesopic Photometry based on Visual Performance

CIE 192:2010 Practical Daylight Sources for Colorimetry

CIE 195:2011 Specification of Colour Appearance for Reflective Media and Self-Luminous Display Comparisons

CIE 200:2011 CIE Supplementary System of Photometry

CIE 204:2013 Methods for Re-defining CIE D Illuminants

Under Review:

CIE 13.3:1995 Method of Measuring and Specifying Colour Rendering Properties of Light Sources (incl. CD-ROM CD008-1995)

Could be superseded by the results from TC1-90 and/or TC1-91.

CIE 15:2004 Colorimetry

Under revision by TC1-85.

CIE 51.2:1999 A Method for Assessing the Quality of Daylight Simulators for Colorimetry

Could be archived: superseded by ISO 23603:2005(E)/CIE S 012/E:2004

CIE 167:2005 Recommended Practice for Tabulating Spectral Data for Use in Colour Computations

Will be reviewed by TC1-85 as part of the update of CIE 15:2004.

CIE 184:2009 Indoor Daylight Illuminants

Will be reviewed by TC1-85 as part of the update of CIE 15:2004.

Superseded:

Archive:

CIE 78:1988 Brightness-Luminance Relations: Classified Bibliography Colorimetry

CIE 80:1989 Special Metamerism Index: Change in Observer

Now included in CIE 15:2004 Colorimetry

CIE 81:1989 Mesopic Photometry: History, Special Problems and Practical Solutions

CIE 86-1990 CIE 1988 2° Spectral Luminous Efficiency Function for Photopic Vision

CIE 87:1990 Colorimetry of Self-luminous Displays – A Bibliography

CIE 109-1994 A Method of Predicting Corresponding Colours under Different Chromatic and Illuminance Adaptations

CIE 116-1995 Industrial Colour-Difference Evaluation

8 Technical Committees (TCs)

8.1 Closed TCs

TC 1-37 Supplementary System of Photometry (Chair: Ken Sagawa, JP) closed in 2012

Produced CIE publication 200:2011

TC 1-42 Colour Appearance in Peripheral Vision (Chair: Miyoshi Ayama, JP) closed in 2014

Produced CIE publication 211:2014

TC 1-57 Standards in Colorimetry (Chair: Alan Robertson, CA), closed in 2013

Produced CIE standards:

S 014-3 Colorimetry – Part 3: Calculation of CIE tristimulus values. Also published as ISO 11664-3:2012(E)

S 014-4 Colorimetry – Part 4: CIE 1976 L*a*b* colour space. Also published as ISO 11664-4:2008(E)

S 014-5 Colorimetry – Part 5: CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram. Also published as ISO 11664-5:2009(E)

S 014-6 Colorimetry – Part 6: CIE DE2000 colour difference formula. Also published as ISO/CIE 11664-6:2013(E).

TC 1-60 Contrast Sensitivity Function (Chair: Eugene Martinez-Uriegas, ES), closed in 2012

The original TCC was taken seriously ill and unable to continue. The Division Secretary took over as interim Chairman at the 2011 meeting, to try to find a new TCC: this proved impossible.

TC 1-61 Categorical Colour Identification (Chair: Taiichiro Ishida, JP), closed in 2015

Non-compliant with the Code of Procedure – will possibly continue as a Reporter

TC 1-67 The Effects of Dynamic and Stereo Visual Images on Human Health (Chair: Hiroyasu Ujike, JP), closed in 2015

Closed for being non-compliant with the Code of Procedure. Will possibly continue as a Reporter.

TC 1-68 Effect of Stimulus Size on Colour Appearance (Chair: Peter Bodrogi, DE) closed in 2014

Produced CIE publication 208:2014

TC 1-69 Colour Rendition by White Light Sources (Chair: Wendy Davis, AU) closed in 2014

TCC emigrated from US: failed to write a Technical Report

TC 1-70 Metameric Samples for Indoor Daylight Evaluation (Chair: Balázs Kranicz, HU), closed in 2015

Lost contact with TCC.

TC 1-71 Tristimulus Integration (Chair: Changjun Li, CN), closed in 2015

Non-compliant with the Code of Procedure – will continue as a Reporter.

TC 1-73 Real Colour Gamuts (Chair: Changjun Li, CN), closed in 2015

Non-compliant with the Code of Procedure – will continue as a Reporter.

TC 1-74 Methods for Re-defining the CIE D Illuminants (Chair: Janos Schanda, HU), closed in 2013

Produced CIE publication 204:2013

TC 1-77 Improvement to CIE Whiteness and Tint Equations (Chair: Robert Hirschler, HU), closed in 2015

Non-compliant with the Code of Procedure: a proposal for a replacement TC was approved by the BA after the Manchester 2015 meeting.

TC 1-78 Evaluation of Visual Performance in the Real Lit Environment (Chair: Monica Billger, SE) closed in 2014

TCC unable to continue: efforts to find a new TCC failed

TC 1-80 Research Methods for Psychophysical Studies of Brightness Judgements (Chair: Steve Fotios, GB) closed in 2014

Produced CIE publication 212:2014

8.2 New and Closed TCs

TC 1-87 New Aspects of Colour Rendering (Chair: Mike Pointer, GB) started 2011, closed in 2012

This TC was established in 2011 to continue the momentum in the subject following the failure of TC1-69 to produce a Technical Report. In 2012 the TC subsequently recommended the formation of two new TCs: TC1-90 and TC1-91.

8.3 TCs in Progress

TC 1-36 Fundamental Chromaticity Diagram with Physiologically Significant Axes (Chair: Françoise Viénot, FR)

Part II of the Technical Report is near to the BA/D1 approval stage. Assuming approval is obtained the Central Bureau will proceed towards production and publication.

TC 1-55 Uniform Colour Space for Industrial Colour Difference Evaluation (Chair: Manuel Melgosa, ES)

The TC submitted a Technical Report to the Division in July 2015.

TC 1-63 Validity of the Range of CIEDE2000 (Chair: Klaus Richter, DE)

The TC is working on the final draft of its Technical Report.

TC 1-75 A Comprehensive Model of Colour Appearance (Chair: Ronnier Luo, GB)

This TC is waiting testing of the final models. Re-apply to have a new TC number.

TC 1-76 Unique Hue Data (Chair: Sophie Wuerger, GB)

This TC is ready for a TC ballot on a draft Technical Report.

TC 1-81 Validity of Formulae for Predicting Small Colour Differences (Chair: Klaus Richter, DE)

The TC is working on the final draft of its Technical Report.

TC 1-82 The Calculation of Colour Matching Functions as a Function of Age and Field Size (Chair: Jan Henrik Wold, NO)

The TC is progressing well with its task and hopes to complete by 2017. e-apply to have a new TC number.

8.4 New TCs

TC 1-83 Visual Aspects of Time-Modulated Lighting Systems (Chair: Dragan Sekulowski, NL)

ToR: To investigate and report on current research on the perception of visual artefacts of temporally modulated lighting systems, including flicker, the stroboscopic effect, and the phantom array effect.

Design methodology and gather data on the visibility of temporal artefacts.

Build a model for the visibility of temporal artefacts and their dependence on environmental, demographical and lighting parameters.

TC 1-84 Definition of Visual Field for Conspicuity (Chair: Nana Itoh, JP) opened in 2011

ToR: To define and classify functional visual fields for universal tasks and develop guidelines for the layout of visual information to increase the visibility of visual signs, displays and markings.

TC 1-85 Update CIE Publication 15:2004 Colorimetry (Chair: Janos Schanda†, HU) opened in 2011 - †Deceased

ToR: To update CIE Publication 15:2004 taking into consideration the current CIE/ISO standards on colorimetry and the work of TC1-36 Fundamental Chromaticity Diagram with Physiologically Significant Axes

TC 1-86 Models of Colour Emotion and Harmony (Chair: Li-Chen Ou, TW) opened in 2011

ToR: To recommend models of colour emotion and harmony based on existing psychophysical data obtained by different research groups or networks for applications in the colour design area.

TC 1-88 Scene Brightness Estimation (Chair: Yoshiki Nakamura, JP) opened in 2012

ToR: To investigate current research on brightness estimation methods using a calibrated luminance image of a real indoor scene.

To compare brightness estimations of real indoor scenes with those predicted.

To recommend a method to predict the brightness of specified regions of a scene from a luminance image of that scene.

TC 1-89 Enhancement of Images for Colour Defective Observers (Chair: Po-Chieh Hung, JP), started in 2012

ToR: To study, evaluate and recommend image enhancing techniques for colour defective observers and to provide a test procedure for the evaluation of those techniques.

TC 1-90 Colour Fidelity Index (Chair: Hirohisa Yaguchi, JP), started in 2012

ToR: To evaluate available indices based on colour fidelity for assessing the colour quality of white- light sources with a goal of recommending a single colour fidelity index for industrial use.

TC 1-91 New Methods for Evaluating the Colour Quality of White-Light Sources (Chair: Yandan Lin, CN), started in 2012

ToR: To evaluate available new methods for evaluating the colour quality of white-light sources with a goal of recommending methods for industrial use. (Methods based on colour fidelity shall not be included: see TC1-90)

TC 1-92 Skin Colour Database (Chair: Kaida Xiao, CN), started in 2013

ToR: To investigate the uncertainty in skin colour measurement and to recommend protocols for good measurement practice.

To tabulate skin colour measurements that accord with these protocols covering different ethnicity, gender, age and body location.

TC 1-93 Calculation of Self-luminous Neutral Scale (Chair: Robert Carter, US), started in 2013

ToR: To recommend a formula or computational method for an achromatic, neutral or grey scale for self-luminous (i.e. non-reflective) surfaces. (This computation complements CIE Lightness, L*, which serves a similar purpose for reflective surfaces.

8.5 Proposed TCs

TC 1-XX The Validity of the CIE Whiteness and Tint Equations (Chair: Robert Hirschler, HU)

Scope: Based on published and new experimental work the TC shall seek to recommend modifications to the existing CIE Whiteness and Tint Equations to extend their application to illuminants other than D65. Furthermore the TC shall review the restrictions imposed on the validity of the equations to samples that are measured on the same instrument at nearly the same time, and review the colorimetric limits hitherto set. If enough experimental data justify it, the TC may recommend modifications to the current CIE Equations for Whiteness and Tint.

8.6 Miscellaneous

TC 1-64 Terminology for Vision, Colour and Appearance (Chair: Sharon McFadden, CA)

This TC submitted a Technical Note to the Division in July 2015. The work of this TC will be merged with that of the new JTC 8 Terminology in Light and Lighting.

9 Reporterships (DRs)

9.1 Closed DRs

DR 1-40 Scene Dynamic Range (Jack Holm, US) closed in 2013

No report.

DR 1-49 Above Threshold Pulsed Lights (Malcolm Nicholson, GB) Closed in 2014

Report attached to Minutes of 2014 Division meeting.

DR 1-50 3D Aspects of Visual Appearance Measurement (David Simmns, GB) closed in 2013

No report.

DR 1-51 Variability in Colour-Matching Functions (Abhijit Sarkar, IN) closed in 2011

A report was published that recommended a TC might be useful in the future.

DR 1-55 Enhancement of Images for Colour Defective Observers (Po-Chieh Hung, JP), closed in 2012

A report was published that recommended a TC be formed: TC1-89.

DR 1-56 Skin Colour Database (Kaida Xiao, CN), closed in 2012

A report was published that recommended a TC be formed: TC1-92.

DR 1-57 Border between Luminous and Blackish Colours (Thorstein Seim, NO), closed in 2013

A report was published.

9.2 New and Closed DRs

DR 1-54 Variability on Colour-0Matching Function (Abhijit Sarkar, IN) started in 2011; report published in 2012.

DR 1-55 Enhancement of Images for Colour Defective Observers (Po-Chieh Hung, JP) started in 2011, report published in 2012, TC1-89 established.

DR 1-59 Calculation of Self-luminous Neutral Scale (Robert Carter, US), started in 2013

This Report produced a report that recommended establishing a TC: TC1-93. The Reportership was closed in 2013.

9.3 DRs in Progress

DR 1-42 Extension of CIECAM02 (Changjun Li, CN), started in 2011 to monitor the work of TC8-09.

DR 1-52 Spectral Data Interpolation (Danny Rich, US) to be closed in 2015.

The subject, as defined by the Terms of Reference, is deemed to be too complex to purse within CIE.

DR 1-53 Gloss Perception and Measurement (Frédéric Leloup, BE) started in 2011 to monitor published literature in the subject.

9.4 New DRs

DR 1-58 Liaison with ISO/TC130 Graphic Technology (Phil Green, GB), started in 2012

ToR: To investigate and respond to ISO/TC130 Graphic Technology on matters concerned with colorimetric calculations.

DR 1-60 Future Colour-difference Evaluation (Guihua Cui, CN), started in 2013

ToR: To report on publications that relate to colour-difference evaluation and uniform colour spaces.

DR 1-61 Source Whiteness Metric (Aurelian David, US), started in 2014

ToR:

1. To review the literature on the impact of white objects containing Fluorescent Whitening Agents.
2. To report on the activity of the IES (Illuminating Engineering Society of North America) Whiteness Group which will propose a metric for the whiteness-rendering capability of light sources.

DR 1-62 Typical LED Spectra (Sophie Jost, FR), started in 2015

ToR:

1. To collect available LED spectra.
2. To analyse the difference among the spectra with the aim of finding possible typical spectra for various classes, e.g. cool white, warm white.

9.5 Proposed DRs

DR 1-63 Tristimulus Integration (Changjun Li, CN)

ToR: To investigate methods for computing weighting tables for the calculation of tristimulus values from abridged data.

To continue the work of the now closed TC1-71. The formation of this Reportership was approved at the Manchester 2015 Division meeting.

DR 1-64 Real Colour Gamut (Changjun Li, CN)

ToR: To investigate the derivation of a gamut representative of real (non-fluorescent) surface colours and defined by associated spectral reflectance data.

To continue the work of the now closed TC1-73. The formation of this Reportership was approved at the Manchester 2015 Division meeting.

10 Liaisons

10.1 Official Liaisons

L1-01	Paula Alessi	AIC to CIE D1
L1-02	Michael Stock	CCPR to CIE D1
L1-03	Joanne Zwinkels	ISO /TC 6/3 Paper – Optical Properties to CIE D1
L1-04	Ronnier Luo	ISO/TC 38/SC 1 Textiles: Color Fastness to CIE D1
L1-05	Klaus Richter	ISO/TC 42 Photography to CIE D1
L1-06	Danny Rich	ISO/TC 130 Graphic Technology to CIE D1
L1-07	Hirohisa Yaguchi	ISO JTC 1 SC28 Office Equipment to CIE D1
L1-08	Malcolm Nicholson	IALA to CIE D1
L1-09	Ken Sagawa	ISO/TC 159/WG 2 Design Issue for Elderly and Disabled People to CIE D1
L1-10	Jack Ladson	CIE D1 to ISO/TC 42 Photography

10.2 Informal Contacts

CIE Division 1 has a mailing list comprising:

5 Officers

24 TC Chairman

7 Reporters

10 Liaisons

37 Country Representatives

63 Associates

11 Future Activities

2016: The Division will meet in association with Expert Symposium on Appearance, 2016-08-29 – 2016-09-02, Prague, Czech Republic

2017: The meeting will be held in association with the AIC Congress, 2017-10-16 – 2017-10-20, to be held in Jeju, Korea. This will also be the time and location of the 2017 CIE Mid-term Meeting.

Division 2: Physical Measurement of Light and Radiation
Quadrennial Report 2011-2015

Peter Blattner, CH (DD), Tony Bergen, AU (DS)

2016-03-20

1 Terms of Reference

To study standard procedures for the evaluation of ultraviolet, visible and infrared radiation, global radiation, and optical properties of materials and luminaires.

To study optical properties and performance of physical detectors and other devices required for their evaluation.

2 Division Officers

2011-2015:

Director:	Peter Blattner (CH)
Associate Directors:	Joanne Zwinkels (CA)
	Hiroshi Shitomi (JP) [2012-2015]
	Armin Sperling (DE) [2013-2015]
	Guy Vandermeersch (BE) [2011-2013]
	Georg Sauter (DE) [2011-2013]
Secretary:	Armin Sperling (DE) [2011-2013]
	Tony Bergen (AU) [2013-2015]
Editor:	Jim Gardner (AU)

2015-2019:

Director:	Peter Blattner (CH)
Associate Directors:	Joanne Zwinkels (CA)
	Hiroshi Shitomi (JP)
	Armin Sperling (DE)
Secretary:	Tony Bergen (AU)
Editor:	Jim Gardner (AU)

3 Division Meetings

2011: Sun City (ZA), 2011-07-14 – 2011-07-15
(meeting held in conjunction with the 27th CIE Session)
60 attendances including 19 national representatives

2012: Hangzhou (CN), 2012-09-22
(meeting held in conjunction with the 2012 CIE Lighting Quality and Energy Efficiency Conference)
74 attendances including 17 national representatives

2013: Paris (FR) 2013-04-17
(meeting held in conjunction with the 2013 CIE Midterm Session)
61 attendances including 25 national representatives

2014: Kuala Lumpur (MY) 2014-04-28
(meeting held in conjunction with the 2014 CIE Lighting Quality and Energy Efficiency Conference)
51 attendances including 24 national representatives

2015: Manchester (GB), 2015-06-30 and 2015-07-04
(meeting held in conjunction with the 28th CIE Session)
82 attendances including 23 national representatives

4 Symposia and Workshops

2013: CIE Expert Workshop on Advanced Methods for Photometry
Joint Conference between CIE Division 2 and Slovenia Lighting Society
Accompanied by CIE Division 2 Technical Committee Meetings
Bled (SI), 2013-09-07 – 2013-09-09

2014: CIE Tutorial and Expert Symposium on Measurement Uncertainties in Photometry and Radiometry for Industry
Accompanied by CIE Division 2 Technical Committee Meetings
Vienna (AT), 2014-09-11 – 2014-09-12

5 Strategy 2011-2015

During the first half of the quadrennial focus was given on implementing the Code of Procedure. A review of the TC activities was made and few TCs were closed or transferred into reporterships because of lack of progress over several years. On the technical level the TCs were classified according to their scope into four categories:

- Fundamentals: this includes consideration on basic photometry and definitions (i.e. JTC 2, TC 2-65, …), measurement uncertainty (i.e. TC 2-72, …) and general characterization technics (i.e. TC 2-29, TC 2-60, …).
- Instruments: this includes characterization of array spectrometer (TC 2-51), imaging luminance measurement devices (TC 2-59), near field goniophotometer (TC 2-62), goniophotometer (TC 2-78), and many more.
- Products: LEDs (TC 2-71), AC-LEDs (TC 2-76), OLEDs (TC 2-68) and many more
- Application: Guide for Photometric Field Measurement (DR 2-74), Automotive Lighting (TC 2-67)

In the past CIE Division 2 was very active for the first two categories. Due to the technological change of lighting products CIE D2 decided to put additional effort into the characterization and of products. As a result the first international agreed measurement standard of LEDs was published in 2015. In 2012 D2 management decided to increase impact of CIE by proposing various workshop and tutorials (see list chapter 4). All of the arranged workshops and tutorials were great technical, scientifically and financial successes. Further events are planned in 2015 and 2017.

Beginning 2015 CIE BA decided to start a CIE research strategy. Division 2 has discussed different topics and proposed 3 items to the Board. This work is still ongoing and a general CIE strategy will be published mid-2016.

6 Administrative Matters and Communication

All communications to the Division, the publication of D2 meeting documents and Division ballots are done using Collaboration Tool. In the period 2011-2015 about 40 D2 ballots were conducted and 35 communiqués were sent out to the division. Ballots on critical items (e.g. creation of new TCs) are carried out in two steps: a commenting/discussion phase (typical 1 months) and a Yes/No/Abstain ballot (2 weeks).

Furthermore, the D2 Division Associate room includes about 210 people interested in D2 activities. About 30 communiqués were sent out to D2 Division Associate room. All TCs in Division 2 are using the Collaboration Tool. At least the draft of the publications, the status reports, the primary data, the meeting documents and minutes of the meetings have to be collected in the Collaboration Tool.

7 Publications

7.1 Published

7.1.1 CIE Technical Reports

CIE 198:2011	Determination of Measurement Uncertainties in Photometry
CIE 198-SP1:2011	Determination of Measurement Uncertainties in Photometry - Supplement 1: Modules and Examples for the Determination of Measurement Uncertainties
CIE 202:2011	Spectral Responsivity Measurement of Detectors, Radiometers and Photometers
CIE 210:2014	Photometry Using V(λ)-Corrected Detectors as Reference and Transfer Standards
CIE 214:2014	Effect of Instrumental Bandpass Function and Measurement Interval on Spectral Quantities

7.1.2 CIE Standards

CIE S 025/E:2015	Test Method for LED Lamps, LED Luminaires and LED Modules

7.1.3 Joint ISO/IEC/CIE Standards

ISO/CIE 19476:2014(E) (CIE S 023/E:2013)	Characterization of the Performance of Illuminance Meters and Luminance Meters

7.1.4 CIE Draft Standards

DIS 025/E:2014	Test Method for LED Lamps, LED Luminaires and LED Modules
DIS 024/E:2015	Light Emitting Diodes (LEDs) and LED Assemblies – Terms and Definitions

7.1.5 CIE Technical Notes

TN 001:2014	Chromaticity Difference Specification for Light Sources
TN 002:2014	Relating Photochemical and Photobiological Quantities to Photometric Quantities

7.2 Expected

The following publications are expected within the next year:

TC 2-29	Measurement of Detector Linearity Technical Report
TC 2-47	Characterization and Calibration Methods of UV Radiometers Technical Report
TC 2-49	Photometry of Flashing Light Technical Report

TC 2-51 Calibration, Characterization and Use of Array Spectroradiometers
Technical Report

TC 2-59 Characterization of Imaging Luminance Measurement Devices
Technical Report

TC 2-66 Terminology of LEDs and LED Assemblies
Standard

TC 2-68 Optical Measurement Methods for OLEDs used for Lighting
Technical Note

TC 2-71 TG2: Technical Note on CIE Standard on test methods for LED Lamps, luminaires and modules

7.3 Review

7.3.1 Reviewed Publications

The status of all publications were reviewed in 2012. Since then the review of status is done according to the Code of Procedure (i.e. every 5 years for technical reports and 3 years for standards).

7.3.2 Status of Publications

Current:

CIE 089:1991	Technical Collection 1990
CIE 114-1994	CIE Technical Collection in Photometry and Radiometry (1994):
CIE 130-1998	Practical Methods for the Measurement of Reflectance and Transmittance
CIE 038 -1977	Radiometric and Photometric Characteristics of Materials and their Measurement
CIE 043 1979	Photometry of Floodlights
CIE 044-1979	Absolute Methods for Reflection Measurements
CIE 046-1979	A Review of Publications on Properties and Reflection Values of Material Reflection Standards
CIE 054.2-2001	Retroreflection: Definition and Measurement
CIE 059-1984	Polarization: Definitions and Nomenclature, Instrument Polarization
CIE 076-1988	Intercomparison on Measurement of (Total) Spectral Radiance Factor of Luminescent Specimens
CIE 122-1996	The Relationship between Digital and Colorimetric Data for Computer-Controlled CRT Displays
CIE 127:2007	Measurement of LEDs
CIE 149:2002	The Use of Tungsten Filament Lamps as Secondary Standard Sources
CIE 153:2003	Report on an Intercomparison of Measurements of the Luminous flux of High-pressure Sodium Lamps
CIE 176:2006	Geometric Tolerances for Colour Measurements
CIE 179:2007	Methods for Characterising Tristimulus Colorimeters for Measuring the Colour of Light
CIE 182:2007	Calibration Methods and Photoluminescent Standards for Total Radiance Factor Measurements
ISO 23539:2005(E)/CIE S 010/E:2004	Photometry – The CIE System of Physical Photometry

ISO 11664-1:2007(E)/CIE S 014-1/E:2007	Colorimetry - Part 1: CIE Standard Colorimetric Observers
ISO 11664-2:2007(E)/CIE S 014-2/E:2006	Colorimetry - Part 2: CIE Standard Illuminants for Colorimetry
CIE 121-SP1:2009	The Photometry and Goniophotometry of Luminaires – Supplement 1: Luminaires for Emergency Lighting
CIE 198:2011	Determination of Measurement Uncertainties in Photometry
CIE 198-SP1:2011	Determination of Measurement Uncertainties in Photometry – Supplement 1: Modules and Examples for the Determination of Measurement Uncertainties (4 Parts)
CIE 202:2011	Spectral Responsivity Measurement of Detectors, Radiometers and Photometers

Under Review:

CIE 063-1984	The Spectroradiometric Measurement of Light Sources
CIE 065-1985	Electrically Calibrated Thermal Detectors of Optical Radiation (Absolute Radiometers)
CIE 070-1987	The Measurement of Absolute Luminous Intensity Distributions
CIE 084-1989	Measurement of Luminous Flux
CIE 121-1996	The Photometry and Goniophotometry of Luminaires
CIE 085-1989	Solar Spectral Irradiance
CIE 018.2-1983	The Basis of Physical Photometry, 2nd ed.
CIE 105-1993	Spectroradiometry of Pulsed Optical Radiation Sources

Superseded:

CIE 053-1982	Methods of Characterizing the Performance of Radiometers and Photometers
CIE 064-1984	Determination of the Spectral Responsivity of Optical Radiation Detectors
CIE 069-1987	Methods of Characterizing Illuminance Meters and Luminance Meters: Performance, Characteristics and Specifications ….. …..

8 Technical Committees (TCs)

8.1 Closed TCs

TC 2-28 Methods of characterizing spectrophotometers (Chair: Teresa Goodman, GB), closed in 2013

Reason for closure: Many parts of the draft were out-of-date and, while it contains much useful information, needs a lot of work to being it up-to-date and complete. Closed without report and transferred to Reportership DR 2-64, Teresa Goodman, GB.

TC 2-32 Measuring Retroreflectance of Wet Horizontal Road Markings (Chair: N. Johnson, US), closed in 2013

Reason for closure: Many parts of the draft were out-of-date and, while it contains much useful information, needs a lot of work to being it up-to-date and complete. Closed without report.

TC 2-53 Multi-Geometry Colour Measurements of Gonio-apparent Materials and Metrics for Evaluation (Chair: G. Rösler, DE), closed in 2013

Reason for closure: Many of the TC members believed that the draft is outdated or that the needs of industry have changed. Needs a lot of work to being it up-to-

date and complete. Closed without report and transferred to Reportership DR 2-64, Gaël Obein, FR.

TC 2-56 CIE/ISO standard on retroreflection measurements (Chair: Cameron Miller, US), closed in 2013

Reason for closure: Lack of progress. Closed without report.

TC 2-40 Characterizing the Performance of Illuminance and Luminance Meters (Chair: Peter Blattner, CH), closed in 2014

Reason for closure: Standard published as CIE S 023/E:2013 Characterization of the Performance of Illuminance Meters and Luminance Meters.

TC 2-48 Spectral Responsivity Measurement of Detectors, Radiometers and Photometers (Chair: George Eppeldauer, US), closed in 2014

Reason for closure: Report published as CIE 202:2011 Spectral Responsivity Measurement of Detectors, Radiometers and Photometers.

TC 2-70 Standards for the Measurement of Reflectance and Transmittance Properties of Materials (Chair: Danny Rich, US), closed in 2015

Reason for closure: Lack of progress. Closed without report.

8.2 in Progress

TC 2-29 Measurement of Detector Linearity (Chair: George Eppeldauer, US), started in 1988

Progress Report: Nearing publication, under CB control.

TC 2-47 Characterization and Calibration Methods of UV Radiometers (Chair: Armin Sperling, DE), started in 1998

Progress Report: Nearing publication, under CB control.

TC 2-49 Photometry of Flashing Light (Chair: Yoshi Ohno, US), started in 1998

Progress Report: Nearing publication, under CB control.

TC 2-50 Measurement of the Optical Properties of LED Assemblies (Chair: Richard Distl, DE), started in 1999

Progress Report: Should be ready to begin publication process within the next year.

TC 2-51 Calibration of Multi-Channel Spectrometers (Chair: Richard Young, DE), started in 1999

Progress Report: Should be ready to begin publication process within the next year.

TC 2-59 Characterization of Imaging Luminance Measurement Devices (Chair: Udo Krüger, DE), started in 2004

Progress Report: Preparing to begin publication process and hand over to CB control.

TC 2-62 Imaging-Photometer-Based Near-Field Goniophotometry (Chair: Vacant), started in 2007

Progress Report: Should be ready to begin publication process within the next two years.

TC 2-63 Optical Measurement of High-Power LEDs (Chair: Yuqin Zong, US), started in 2008

Progress Report: Should be ready to begin publication process within the next year.

TC 2-64 High speed Testing Methods for LEDs (Chair: Günther Heidel, DE), started in 2008

Progress Report: Should be ready to begin publication process within the next year.

TC 2-65 Photometric Measurements in the Mesopic Range (Chair: Teresa Goodman, GB), started in 2009

Progress Report: Preparing to begin publication process of two technical notes and hand over to CB control.

TC 2-66 Terminology of LEDs and LED Assemblies (Chair: Vacant, was Janos Schanda, HU), started in 2009

Progress Report: Nearing publication, under CB control.

TC 2-67 Photometry of Lighting and Light-signalling Devices for Road Vehicles (Chair: Thomas Reiners, DE), started in 2010

Progress Report: In progress.

TC 2-68 Optical Measurement Methods for OLEDs used for Lighting (Chair: Vacant, was Thorsten Gerloff, DE), started in 2010

Progress Report: In progress. Preparing a technical note for publication.

TC 2-69 CIE Classification System of Illuminance and Luminance Meters (Chair: Peter Blattner, CH), started in 2010

Progress Report: In progress.

TC 2-71 CIE Standard on Test Methods for LED Lamps, Luminaires and Modules (Chair: Yoshi Ohno, US), started in 2011

Progress Report: Should be ready to begin publication process of a technical note on uncertainties within the next year.

8.3 New TCs

TC 2-72 The Evaluation of Uncertainties in Measurement of the Optical Properties of Solid State Lighting Devices, including Coloured LEDs (Chair: Georg Sauter, DE), started in 2011

ToR: To expand the supplements to CIE 198-2011 to include further principles and examples for evaluation of the uncertainties associated with the measurement and testing of LEDs and other solid state lighting devices. Examples include distribution photometry, spectral measurement and derived quantities, goniospectroradiometry and other priority measurements as advised by industry.

TC 2-73 Measurement of Quantities Relating to Photobiological Safety of Lighting Products (Chair: Tongsheng Mou, CN), started in 2011

ToR: To prepare a technical report for the measurement of optical radiation related to photobiological safety of lighting products, focusing on LED products.

TC 2-74 Goniospectroradiometry of Optical Radiation Sources (Chair: Jiangen Pan, CN), started in 2011

ToR: To prepare a technical report on goniospectroradiometry to summarize measurement principles for evaluating radiometric, photometric and colorimetric quantities and related traceability.

TC 2-75 Photometry of Curved and Flexible OLED and LED Sources (Chair: Hsueh-Ling Yu, TW), started in 2011

ToR: To prepare a CIE recommendation on methods for the characterization of photometric and colorimetric quantities of curved and flexible sources especially for OLED and LED including traceability.

TC 2-76 Characterization of AC-Driven LED Products for SSL Applications (Chair: Pei-Ting Chou, TW), started in 2011

ToR: To prepare a technical report on the measurement of characteristic quantities of AC driven LED products, including operational conditions, and photometric quantities focused on those influenced by the effect of flicker.

TC 2-77 Fundamental Concepts (Chair: Tony Bergen, AU), started in 2013

ToR: To facilitate informal collaboration and sharing of ideas on fundamental concepts in photometry, radiometry and colorimetry, with a special focus on dedicated activities at D2 division meetings.

TC 2-78 The Goniophotometry of Lamps and Luminaires (Chair: Tony Bergen, AU), started in 2013

ToR: To update CIE 121-1996, CIE 070-1987 and the relevant parts of CIE 084-1989 and combine these into the one technical report, incorporating new techniques and the absolute goniophotometry of lamps in their own right.

TC 2-79 Integrating sphere photometry and spectroradiometry (Chair: Dong-Hoon Lee, KR), started in 2013

ToR: To create a technical report on the photometry and spectroradiometry of sources in integrating spheres by updating the relevant parts of CIE 084-1989 and incorporating new techniques and practices.

TC 2-80 Spectroradiometric measurement of light sources (Chair: Richard Young, DE), started in 2013

ToR: To specify current procedures for the spectroradiometry of continuous, line and mixed sources of optical radiation. Such procedures apply to measurements of irradiance, radiance and radiant flux in the near ultraviolet, visible and near infrared regions of the spectrum.

8.4 Proposed TCs

TC 2-81 Update of CIE 065:1985 (Absolute Radiometers) (Chair: Marek Smid, CZ)

ToR: To update the existing CIE 065-1985065-1985 on the operating principle of absolute detectors of optical radiation.

TC 2-82 Revision of CIE S014-2 (Chair: Peter Csuti, HU)

ToR: To revise CIE Standard S014-2 (CIE Standard Illuminats) to include Iluminant D50

9 Reporterships (DRs)

9.1 Closed DRs

DR 2-32 Visual Appearance Measurement (Mike Pointer, GB), closed in 2012

DR 2-39 Display measurement standard - liaison with ICDM (K Vassie), closed in 2012

DR 2-46 Photobiological Safety Measurement of Lighting Products (Tonsheng Mou, CN), closed in 2012 due to a new TC being proposed.

DR 2-45 Measurement of the Illumination Uniformity for Critical Applications (Meena Lysko, ZA), closed in 2013 due to inactivity.

DR 2-33 Measurement of Laser-Based Projection Displays (Tongsheng Mou, CN), closed in 2015 due to the reporter concluding that the subject matter was not relevant for CIE D2.

9.2 New and Closed DRs

DR 2-49 Standardization of broad-band UV measurements (George Eppeldauer, US), started in 2011

ToR: To investigate the needs and feasibility for standardized spectral responsivities and spectral distributions of UV sources for uniform and reproducible calibration of broadband UV meters.

Closed in 2015 due to a new TC being proposed.

DR 2-50 Metric for Comparison of Luminous Intensity Distributions (Tony Bergen, AU), started in 2011, transferred to Udo Krüger, DE in 2012.

ToR: To investigate the need for recommended calculation methods for comparing luminous intensity distributions, resulting in a metric that can be used as a quality index. The report shall include results of comparisons undertaken in multiple laboratories using a variety of types of lamps and luminaires.

Closed in 2015 due to the work being completed.

DR 2-51 Characterization and Measurement of LED Lighting Sources with Dynamic Control (Jian Ping Wang, CN), started in 2011

ToR: To prepare a CIE recommended methods for characterization and measurement of LED lighting sources with dynamic control, including power consumption, optical performance and photobiological effects relating with healthy issues.

Closed in 2015 due to a new TC being proposed.

DR 2-53: Glare Rating Measurement by Image Luminance Measuring Device (ILMD) (Shau-Wei Hsu, TW), started in 2012

Closed in 2015 due to a new TC being proposed.

DR 2-54: Internal quantum efficiency measurement for SSL products (Cong Chen, CN), started in 2012

Closed in 2015 due to the work being completed.

DR 2-59 Recommendation on resolving problems with the definition of BRDF (Joanne Zwinkels, CA), started in 2012

Closed in 2015 due to the work being completed.

DR 2-62 Revision of D2 documents related to luminous flux and luminous intensity distribution (Tony Bergen, AU), started in 2012.

Closed in 2013 due to new TCs being proposed.

DR 2-63 Revision of CIE 63-1984 (Richard Young, DE), started in 2012.

Closed in 2013 due to a new TC being proposed.

DR 2-65 Multi-Geometry Colour Measurements of Effect Materials (Gaël Obein, FR), started in 2012.

Closed in 2013 due to a new TC being proposed.

DR 2-66 To prepare a TN on the colour difference of light sources (Yoshi Ohno, US), started in 2013.

Closed in 2015 due to a TN being published.

DR 2-67 To prepare a TN on relating photochemical and photobiological quantities to photometric quantities (Peter Blattner, CH), started in 2013.

Closed in 2015 due to a TN being published.

9.3 New DRs

DR 2-52 Flicker Measurement and Flicker Index Study on Solid State Lighting (Kuei-Neng Wu, TW), started in 2012

DR 2-55 Simple Practical Guide for Measurement Uncertainty Estimations (supplement to CIE 198) (Teresa Goodman, GB), started in 2012, transferred to David Chan, 2015.

DR 2-56 Monitoring Progress in Regional Metrology Organizations (RMOs) (Maria Luisa Rastello, IT), started in 2012.

DR 2-57 Monitoring Progress of IEC TR 62778 (Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires) (Hiroshi Shitomi, JP), started in 2012

DR 2-58 Standard lamps: availability of and alternatives to commercially available incandescent sources (Teresa Goodman, GB), started in 2012

DR 2-60 Discussion on the definition of Luminance/Radiance (Georg Sauter, DE), started in 2012, transferred to Teresa Goodman 2013

DR 2-61 Review of Published D2 Publications (Peter Blattner, CH), started in 2012

DR 2-64 Technical Note on Errors of Measurement in Spectrophotometry (Teresa Goodman, GB), started in 2013

DR 2-68 Measurement of light output degradation of LED light source (Pei-ting Chou, TW), started in 2013

DR 2-69 TN on the validation of a near-field goniophotometer (Roman Dubnicka, SK), started in 2014

DR 2-70 Guide for the Field Photometric Measurements for the Verification of Lighting Systems (Roman Dubnicka, SK), started in 2014

DR 2-71 Towards a CIE standard illuminant/source L (Tuomas Poikonen, FI), started in 2014

ToR: To investigate the advantages and disadvantages of moving towards the use of LED-based standard calibration sources for photometry taking into account the ability of LED manufacturers to realise specific spectral distributions. The impact on NMIs, testing laboratories and others in the photometric measurement community shall be outlined. In addition possible impact on the existent CIE division 2 technical reports and standards shall be reported.

DR 2-72 Towards a new CIE file format for luminous intensity distributions of luminaires (James Walker, US), started in 2014

ToR: To investigate the deficiencies of the photometric data file formats currently in use and the possibility for developing a harmonised global file format in a future TC with input from all stakeholders in the lighting industry.

DR 2-73 Colour Luminance File Format Specification (Udo Krüger, DE), started in 2015.

ToR: A Colour Luminance File Format Specification has to be worked out. This format should enable the data exchange between customers and between measurement programs and simulation programs as well. A proposal introduced by B. v. Blanckenhagen (Automotive Lighting, Germany) and M. Unland (Hella, Germany) (von Blanckenhagen & Unland, 2013) and supported by simulation program producers and instrument manufactures should be the basis of the work.

DR 2-74 Physical characterization of new visual effects in the field of appearance of materials (Alejandro Ferrero, ES), started in 2015.

ToR: To follow the innovation in the field of special visual effect created by industrials.

DR 2-75 TN on the use of “Accuracy” and related terms in the specifications of testing and measurement equipment (Tony Bergen, AU), started in 2015.

ToR: To consult with D2 and external experts and write a technical note regarding the improper use of terms such as “accuracy”, “error”, “tolerance”, “reproducibility” and “repeatability” in the specifications of testing and measurement equipment and instruments.

10 Liaisons

10.1 Official Liaisons

CIE Division 2 has liaisons to the following organizations:

No	Organization	Liaison Officers to CIE	Liason Officers from CIE
L2-1	CCPR - Consultative Committee of Photometry and Radiometry	Y Ohno to CIE	DD2 to CCPR
L2-3	ISO/TC 6 Paper, board & pulps	J Zwinkels	J Zwinkels
L2-4	IEC/TC 34: Lamps and related equipment	G Vandermeersch	
L2-5	ISO on reflectance and transmittance issues	D Rich	D Rich
L2-6	OIML (Organization of International Legal Metrology), TC 11 and TC 14	A. Sperling	
L2-7	IALA (International Association of Lighthouse Authorities)	M. Nicholson	M. Nicholson
L2-9	IEC/SC 34A MT PRESCO with special attention to TS 62504 (Terms and definitions for LEDs in general lighting)	P. Blattner (ad interim)	P. Blattner(ad interim)
L2-10	IEC/TC 110 WG5 regarding OLED Displays	T Mou	T Mou
L2-11	ISO/TC 12/WG 19	A. Sperling	A. Sperling

11 Future Activities

CIE Division 2 intends to continue to organize workshop, symposia and tutorials.

Division 3: Interior Environment and Lighting Design
Quadrennial Report 2011-2015

Jennifer A. Veitch, CA (DD)

2015-09-30

1 Terms of Reference

Division 3 of the CIE is concerned with factors which influence the satisfaction of the occupants of a building with their environment, including the effects of both daylighting and electric lighting.

Its objectives are to study and evaluate those factors to provide guidance on relevant design criteria, to study design techniques (including relevant calculations) for the interior lighting of buildings, to incorporate the findings and those of other CIE divisions into lighting guides for interiors in general or of particular types.

2 Division Officers

2011-2015:

Director:	Jennifer A. Veitch (CA)
Associate Director 1 (Daylighting):	Anna Pellegrino (IT)
Associate Director 2 (Electric Lighting):	Yasuko Koga (JP)
Secretary:	Martine Knoop (DE)
Editor:	Peter Thorns (UK)

2015-2019:

Director:	Jennifer A. Veitch (CA)
Associate Director 1 (Daylighting):	TBD
Associate Director 2 (Electric Lighting):	TBD
Secretary:	Martine Knoop (DE)
Editor:	Peter Thorns (UK)

3 Division Meetings

2012: WebEx, 08-Jun-2012
The meeting was held by WebEx with national representatives, liaison officers and TCCs only, following online discussion including the whole D3 roster.
21 attendees including 16 national representatives

2013: Paris, FR, 17-Apr-2013
The meeting was held in conjunction with the CIE Centenary conference.
52 attendances including 20 national representatives

2014: WebEx, 11-Jun-2014
The meeting was held by WebEx with national representatives, liaison officers and TCCs only, following online discussion including the whole D3 roster.
21 attendances including 15 national representatives

2015: Manchester, UK, 03-Jul-2015
The meeting was held in conjunction with the 28th Session of the CIE.
50 attendances including 19 national representatives

4 Symposia and Workshops

There were no symposia or workshops held during this quadrennium. An Expert Symposium on Research Methods for the Effects of Lighting has been approved by D3 and the BA. It is expected to be held in late 2017 (date and location to be determined). Although other Divisions have not asked to co-sponsor, participation from D1, D2, and D6 is expected as they had all expressed interest in the topic.

5 Strategy 2011–2015

Goals: faster delivery of useful documents with less administrative effort; new work to focus on a limited number of tasks with demonstrated value to the lighting community.

Tactics:

- Improved communications using electronic tools
- Routine reports of TCs, Rs, LOs, submitted 6 weeks before meeting and available online for review 3-4 weeks in advance.
- Meetings to focus on decisions and discussions for future plans, rather than repetition of routine reports.
- Executive members more active, to distribute the workload
- Active requests for input on strategic direction from opinion leaders to guide selection of new activities.

These goals were only partly achieved in this quadrennium. Division 3 established an invitation-only LinkedIn group in 2013 to encourage greater participation, but this was only marginally successful. Although there are 90+ members, only a handful participate regularly. We have had greater success using e-mails to elicit responses to specific topics.

Administrative effort remains high, partly in recent months because of the enforcement of Code of Procedure provisions. It is to be hoped that as these become more routine, the effort to enforce these policies will become less.

A sudden change to the Division executive in the winter of 2015 coupled with a flurry of calls for input to various discussions distracted D3 from its usual planning routine for the 2015 meeting. Nonetheless, D3 achieved much, as shown below.

6 Administrative Matters and Communication

D3 uses on line communication tools as much as possible: e-mail to the division roster for rapid turnaround and announcements, and CollTool for documents to be shared. Except for ballot documents and in-progress work that must be treated as confidential, the Division is open with its materials. All meeting minutes, including TC progress reports, are posted on the Division web page under the CIE page.

During this quadrennium we established a member-only discussion group on LinkedIn, to which anyone on the D3 roster may apply for membership. This was only partly successful in creating a forum for ongoing discussions, but has the advantage of persisting over time and of being more user-friendly than CollTool.

D3 also has established a template for TC reports, as of 2013, to be completed every 6 months. TCCs are asked to identify a small number of SMART goals: specific, measurable, achievable, realistic, and time-targeted subtasks leading to the completion of the work plan.

The system is only now becoming familiar to TCCs, but is expected to streamline work as people become more familiar with this way of working and as the ADDs become more adept in following up with the TCCs on goal achievement.

7 Publications

7.1 Published

7.1.1 CIE Technical Reports

CIE 205:2013: Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems

CIE 213:2014: Guide to Protocols for Describing Lighting

CIE 215:2014: CIE Standard General Sky Guide

7.1.2 Reports by Reporterships

DR 3-30 Daylight Systems Metrics - Evaluation of Daylight Systems and Products (M. Fontoynont)
Completed 2012

7.2 Expected

JTC 4 (D3/D6) Visual, Health, and Environmental Benefits of Windows in Buildings during Daylight Hours

3 Technical Notes, 1 Technical Report

JTC 6 (CIE/ISO) Energy Performance of Lighting in Buildings

Joint ISO/CIE Standard

JTC 7 Discomfort caused by glare from luminaires with a non-uniform source luminance

Technical Report

TC 3-44 Lighting for Older People and People with Visual Impairment in Buildings

Technical Report

TC 3-45 Luminance Based Design Approach

Technical Report

TC 3-46 Research Roadmap for Healthful Interior Lighting Applications

Technical Report

TC 3-48 CIE Standard Method of UF Table Calculation for Indoor Luminaires

Technical Report

TC 3-49 Decision Scheme for Lighting Controls for Tertiary Lighting in Buildings

Technical Report

TC 3-53 Revision of CIE S 008 Joint ISO*CIE Standard: Lighting of Work Places - Part 1: Indoor

Joint ISO/CIE Standard

TC 3-54: Revision of CIE 16-1970: Daylight

Technical Report

7.3 Review

7.3.1 Reviewed Publications

CIE 19.21:1981	An analytic model for describing the influence of lighting upon visual performance 2nd ed. Vol. 1
CIE 19.22:1981	An analytic model for describing the influence of lighting upon visual performance 2nd ed. Vol. 2
CIE 40:1978	Calculations for interior lighting: Basic method
CIE 49:1981	Guide on the emergency lighting of building interiors
CIE 52:1982	Calculations for interior lighting: Applied method
CIE 55:1983	Discomfort glare in the interior working environment
CIE 60:1984	Vision and the visual display unit work station
CIE 97/2:2005	Maintenance of indoor electric lighting systems
CIE 103/2:1993	Industrial lighting and safety at work
CIE 103/5:1993	The economics of interior lighting maintenance
CIE 108:1994	Guide to recommended practice of daylight measurement
CIE 110:1994	Spatial distribution of daylight – Luminance distributions of various reference skies
CIE 117:1995	Discomfort glare in interior lighting
CIE 147:2002	Glare from small, large and complex sources
CIE 157:2004	Control of damage to museum objects by optical radiation
CIE 161:2004	Lighting design methods for obstructed interiors
CIE 164:2005	Hollow light guide technology and applications
CIE 171:2006	Test cases to assess the accuracy of lighting computer programs
CIE 173:2012	Tubular daylight guidance systems
CIE 190:2010	Calculation and Presentation of Unified Glare Rating Tables for Indoor Lighting
CIE 196:2011	CIE Guide to Increasing Accessibility in Light and Lighting
CIE 205:2013	Review of lighting quality measures for interior lighting with LED lighting systems
CIE 209:2014	Rationalising nomenclature for UV doses and effects on humans
CIE 213:2014	Guide to protocols for describing lighting
CIE 215:2014	CIE standard general sky guide
CIE D006:1994	Automatic quality control of daylight measurement – Software for IDMP stations (computer program to Publ. CIE 108)
CIE S 008:2001	Lighting of indoor workplaces
CIE S 011:2003	Spatial distribution of daylight – CIE standard general sky

7.3.2 Status of Publications

Current:

CIE 016-1970	Daylight
CIE 19.21:1981	An analytic model for describing the influence of lighting upon visual performance 2nd ed. Vol. 1

CIE 19.22:1981	An analytic model for describing the influence of lighting upon visual performance 2nd ed. Vol. 2
CIE 40:1978	Calculations for interior lighting : Basic method
CIE 52:1982	Calculations for interior lighting : Applied method
CIE 55:1983	Discomfort glare in the interior working environment
CIE 110:1994	Spatial distribution of daylight – Luminance distributions of various reference skies
CIE 117:1995	Discomfort glare in interior lighting
CIE 147:2002	Glare from small, large and complex sources
CIE 157:2004	Control of damage to museum objects by optical radiation
CIE 161:2004	Lighting design methods for obstructed interiors
CIE 164:2005	Hollow light guide technology and applications
CIE 173:2012	Tubular daylight guidance systems
CIE 190:2010	Calculation and Presentation of Unified Glare Rating Tables for Indoor Lighting
CIE 196:2011	CIE Guide to Increasing Accessibility in Light and Lighting
CIE 205:2013	Review of lighting quality measures for interior lighting with LED lighting systems
CIE 209:2014	Rationalising nomenclature for UV doses and effects on humans
CIE 213:2014	Guide to protocols for describing lighting
CIE 215:2014	CIE standard general sky guide
CIE S 003:1996	Spatial distribution of daylight – CIE standard overcast sky and clear sky
CIE S 011:2003	Spatial distribution of daylight – CIE standard general sky

Current, under revision:

CIE 016-1970	Daylight
CIE S 008:2001	Lighting of indoor workplaces

Current requiring review & possible revision when resources permit:

CIE 103/2:1993	Industrial lighting and safety at work
CIE 103/5:1993	The economics of interior lighting maintenance
CIE 171:2006	Test cases to assess the accuracy of lighting computer programs

Under Review:

CIE 97/2:2005	Maintenance of indoor electric lighting systems
CIE 108:1994	Guide to recommended practice of daylight measurement

Withdrawn:

CIE 49:1981	Guide on the emergency lighting of building interiors
CIE 60:1984	Vision and the visual display unit work station
CIE D006:1994	Automatic quality control of daylight measurement – Software for IDMP stations (computer program to Publ. CIE 108)
CIE S 003:1996	Spatial distribution of daylight – CIE standard overcast sky and clear sky

8 Technical Committees (TCs)

8.1 Closed TCs

TC 3-25 Co-ordination of the IDMP and its data (Chair: N. Igawa, JP), closed in 2011

Closed because the TCC was due to retire, and because the activity did not fit the TC structure. It had no deliverable.

TC 3-34 Protocols for describing lighting (Chair: J. Veitch, CA), started in 1999, closed in 2015.

Closed following the publication of CIE 213:2014.

TC 3-39 Discomfort glare from daylight in buildings (Chair: W. Osterhaus, DK), started in 2002, closed in 2015.

Closed by BA following the Code of Procedure.

TC 3-42 Indoor Work Space Application Guide (Chair: K. Pero, CA) started in 2006, closed in 2011

This TC was closed because two successive TCCs had to resign from the post and there were no volunteers to take on the work. No progress had been made in five years.

TC 3-47 Climate-based daylight modelling (Chair: J. Mardaljevic, UK), started in 2008, closed in 2015.

This TC was closed by the BA because of Code of Procedure requirements not met, but with the agreement of the Chair. In his view, the science is not sufficiently advanced to permit the report to be completed in a reasonable time. A new TC will be formed when conditions permit.

TC 3-50 Lighting quality measures for interior lighting with LED lighting systems (Chair: M. Knoop, DE), started in 2010, closed 2014.

Closed following publication of CIE 205:2013.

TC 3-51 CIE Standard General Sky Guide (Chair: S. Darula, SK), started in 2010, closed 2015.

Closed following publication of CIE 215:2014.

8.2 New and Closed TCs

TC 3-52 Energy Requirements for Lighting in Buildings (Chair: S. Moghtader, DE), started in 2011, closed 2014.

Superseded by the creation of JTC 6 (CIE/ISO), which has taken on the work under the CIE-ISO memorandum of understanding.

8.3 TCs in Progress

TC 3-44 Lighting for Older People and People with Visual Impairment in Buildings (Chair: Yukio Akashi, JP), started in 2007.

To provide summary recommendations for the lighting provision for older people and people with visual impairment in buildings.)

TC 3-45 Luminance Based Design Approach (Chair: Yoshiki Nakamura, JP), started in 2007.

To determine suitable design factors and criteria for luminance based design, and to produce suitable tools to allow luminance based design to be performed and validated. This will involve a detailed literature search in the area of luminance based design and an examination of the tools for a luminance based design that have been developed or are currently available. The validity of the tools will be undertaken and compared to standard data.

TC 3-46 Research Roadmap for Healthful Interior Lighting Applications (Chair: Jennifer Veitch, CA), started in 2007.

The TC will review relevant CIE publications and the more recent scientific literature to identify the information that is needed before such lighting application may take place. The output will be a technical report which will describe a research roadmap intended to stimulate fundamental research into questions relevant to lighting applications. This technical committee follows from the publication of CIE 158:2004 and the two CIE expert symposia on light and lighting and health in 2004 and 2006.

TC 3-48 CIE Standard Method of UF Table Calculation for Indoor Luminaires (Chair: Peter Thorns, GB), started 2008.

To produce a CIE standard methodology for the calculation of utilization factor (UF) tables for indoor luminaires.

TC 3-49 Decision Scheme for Lighting Controls for Tertiary Lighting in Buildings (Chair: Peter Dehoff , AT), started 2009.

To offer guidelines in order to balance lighting quality, user comfort and energy efficiency in lighting controls solutions for tertiary lighting in buildings (i.e. for commercial, institutional and industrial buildings). To work on a decision scheme with focus on the user requirements (visual comfort, performance, personal control) to determine the most applicable control solution, including the consequences for possible savings. In this, it needs to be assumed that there are no technological or financial hurdles.

8.4 New TCs

TC 3-53 Revision of CIE S 008 Joint ISO*CIE Standard: Lighting of Work Places - Part 1: Indoor (Chair: Yasuko Koga. JP), started in 2012.

To review and, if necessary, revise S008/E:2001 (ISO 8995-1:2002): Joint ISO/CIE Standard: Lighting of Work Places - Part 1: Indoor [incl. Technical Corrigendum ISO 8995:2002/Cor. 1:2005(E)].

TC 3-54 Revision of CIE 16-1970: Daylight (Chair: Anna Pellegrino, IT), started in 2012.

To revise and update publication CIE 16-1970: Daylight in the light of the advances in technology and design since 1970.

TC 3-55 Metrics for Sunlighting and Daylight Passing through Sunshading Devices (Chair: Marc Fontoynont, FR), started 2012.

To propose a metric to assess contribution of sunlight to the daylighting a building, and to rate lighting contribution of daylight and sunlight passing through sunshading systems. The proposal should avoid performing long term climate based calculations, and be of interest both for building designers and manufacturers of window components.

JTC 4 (D3/D6) Visual, Health, and Environmental Benefits of Windows in Buildings during Daylight Hours (Chairs: M. Knoop, DE; F. Bisegna, IT), started in 2012.

To review the scientific literature in all relevant fields and to produce a concise document that identifies the values of windows in buildings. Examples of such values could the provision of light for visibility, ventilation, means of egress; aesthetic benefits, access to a view, and light for physiological functioning, including circadian rhythm regulation. If possible, based on this literature, the committee will propose preliminary criteria for daylighting metrics (the metrics being already under development by TC 3-47) to support these functions.

JTC 6 (CIE-ISO) Energy Performance of Lighting in Buildings (Chair: Soheil Moghtader, DE), started 2015.

To develop a ISO/CIE standard that specifies the calculation methodology for the evaluation of the amount of energy used by lighting systems in

buildings. The standard- shall provide a numeric indicator for lighting energy requirements used for certification purposes;- can be used for existing buildings and of new or renovated buildings;- provides reference values as a basis for the targets for energy allocated for lighting usage, keeping in mind lighting design requirements;- provides a methodology for the calculation of instantaneous lighting energy use for the estimation of the total energy performance of the building.

JTC 7 (D3/D1) Discomfort caused by glare from luminaires with a non-uniform source luminance (Chair: Naoya Hara, JP), started 2015.

1. To review the literature on glare from non-uniform light sources to identify the parameters that influence the discomfort prediction (UGR) and define limits to the applicability of the UGR formula.

2. To propose a correction to the UGR formula that takes into account the non-uniformity of glare sources

8.5 Proposed TCs

TC 3-xx Assessment of Discomfort Glare from Daylight in Buildings (Chair: T. Iwata, JP)

To take up the work of the closed TC 3-39 and complete the report.

JTC xx (D6/D2/D3) JTC on Quantifying ocular radiation input for nonvisual photoreceptor stimulation (co-chairs L. Schlangen, NL; A. Wojtysiak, DE)

9 Reporterships (DRs)

9.1 Closed DRs

DR 3-30 Daylight Systems Metrics - Evaluation of Daylight Systems and Products (M.Fontoynont, DK), closed in 2014.

Report completed. This led to the formation of TC 3-55.

9.2 New DRs

DR 3-29 Variable Transmission Glazing (VTG): Current Trends and Future Prospects for Uptake by the Building Sector (J. Mardaljevic, UK), opened in 2011.

DR 3-31 Available Daylighting Metrics (J. Mardaljevic, UK),opened in 2014.

10 Liaisons

10.1 Official Liaisons

- Hillevi Hemphäla (SE) ISO/TC 159

  This is a new liaison in the process of being formalized with ISO. Dr. Hemphäla will replace Mr. Bedocs, who retired from the role.

- Yoshiaki Uetani (JP) ISO/TC 163/SC 2

  Prof. Uetani has completed his task with the completion of ISO 10916:2014. A new liaison with this group will be required.

- Yannick Sutter (FR) and Bernard Paule (FR) ISO/TC 205/WG 7

  These liaison officers are in the process of being appointed.

- Lou Bedocs (UK) CEN TC 169

  In addition to Mr. Bedocs, several people who are active in CIE D3 are also active in various working groups of this CEN TC.

10.2 Informal Contacts

- Terry McGowan – International Dark-Sky Association

  Although IDA concerns are primarily outdoors, there are questions concerning night-time spill from windows that we might wish to address.

- John Selander – Illuminating Engineering Society of North America

  Mr. Selander resigned from this role in 2014; sadly, he died in July 2015. Whether or not there will be a replacement from IESNA remains to be seen because of organizational change there and at the CIE CB.

11 Future Activities

At its 2015 meeting, D3 members and observers spent considerable time in the initial stages of developing a research strategy to guide future work. This will be followed up with a survey to refine the items, and a document presented to the Division Directors committee in the fall of 2015.

12 Other Achievements, Issues, etc.

As part of its planning effort, D3 has consulted with editors of key lighting journals (under the banner Lighting Research Advisory Task Group), which has been very helpful.

In the past quadrennium, D3 has adopted a pattern of holding its meetings by WebEx in even-numbered years. This reduces the travel burden on members, and furthermore provides more time for online discussions in advance of decision-making. A LinkedIn discussion group was established for the purpose, as being an accessible platform. This process requires more development, to encourage greater participation.

This is a time of great change in the lighting industry, but many aspects of lighting application will not change significantly in the short term. We know that novel light sources and luminaires have revealed problems with existing metrics, particularly with respect to glare. Scientific work is needed in these areas before it will be time to create technical committees to form recommendations or guidance.

Division 4: Lighting and signalling for transport
Quadrennial Report 2011-2015

Ad de Visser, NL (DD till 2014), Ron Gibbons, US (DD from 2014)

2015-07-30

1 Terms of Reference

To study lighting and visual signalling and information requirements of transport and traffic, such as road and vehicle lighting, delineation, signing and signalling for all types of public roads and all kinds of users and vehicles, and visual aids for modes other than road transport.

2 Division Officers

2011-2015:

Director:	Ad de Visser (NL) (2011-2014)
	Ron Gibbons (US) (2014-2015)
Associate Director 1 (TC 4-15/../40)	Ron Gibbons (US) (2011-2014)
	Dionyz Gasparovsky (SK) (2014-2015)
Associate Director 2 (TC 4-45/../51):	Yandan Lin (CN)
Secretary:	Ans van den Broek (NL) (2011-2015)
Acting secretary:	Maurice Donners (NL) (2014-2015)
Editor:	Nigel Parry (GB) (2011-2015)

2015-2017:

Director:	Ron Gibbons (US)
Associate Director 1:	Yandan Lin (CN)
Associate Director 2:	Dionyz Gasparovsky (SK)
Secretary:	Maurice Donners (NL)
Editor:	Nigel Parry (GB)

3 Division Meetings

2011: Sun City (ZA), 2011-07-11, 15
meeting held in conjunction with the 27th CIE Session

2012: Blacksburg (US), 2012-09-11, 13
(meeting held at Virginia Tech)

2013: Paris (FR), 2013-04-17, 19
meeting held in conjunction with the CIE midterm Session and Centennial celebration

2014: Kuala Lumpur (MY), 2014-04-28, 30
(meeting held in conjunction with CIE Conference Lighting Quality and Energy Efficiency

4 Symposia and Workshops

2011 Elderly and visually impaired
Cyril Chain (FR), Yukio Akashi (JP)
Sun City, ZA, 2011-07-13

2012 CIE Introductory Tutorial & Workshop on Mesopic Photometry
Teresa Goodman (GB)
Vienna, AT, 2012-01-24-25

2013 Street light levels
Steve Fotios (GB)
Paris, FR, 2013-04-17

5 Strategy 2011-2015

- Lighting Quality and Energy Efficiency
  - Application of LED's
    - Review of quality parameters
    - Effects of spectral distribution
  - Road reflection properties
  - Passive devices
  - Lighting concepts
  - Control strategy
- Mesopic vision
- Lighting for Elderly
- Basics
  - Rev. of CIE 30.2, measurements
  - CIE 194 glossary/ standard
  - Existing fundamental TC's

6 Administrative Matters and Communication

- Code of procedures
- Lead time TC's
- Use of collaboration tool and WebEx
- When starting TC
  - Evaluate/cluster existing publications
  - Produce work schedule (possibly by reporter)
- Reviewing cycle of existing publications
- TC meeting schedule: intermediate WebEx meetings
- Lack of volunteers
- Document numbering

7 Publications

7.1 Published

7.1.1 CIE Technical Reports

CIE 194:2011 On Site Measurement of the Photometric Properties of Road and Tunnel Lighting

CIE 206:2014 The Effect of Spectral Power Distribution on Lighting for Urban and Pedestrian Areas

8 Technical Committees (TCs)

TC 4-11 High Level Matters High level matters (chair: Division secretary) Permanent TC, organising informal “meetings” of all Division experts by social events and common visits or trips to oil the Divisional “machine”.

TC 4-15 Road Lighting Calculations (Chair: Sermin Onaygil, TR)

To revise CIE 30.2 with the object of incorporating recently developed techniques relating to visibility, glare and other lighting variables. To recommend whether a CIE/ISO standard in this area is appropriate.

TC 4-19 Road Visibility in Fog (Chair: Michele Colomb, FR)

TC 4-21 Interference by Light with Astronomical Observations (Chair: Marc Gillet, BE)

TC 4-32 Surface Colours for Traffic Signs (Chairs: Pieter Walraven, NL –2007; David Burns, US, 2007–2008; Jürgen Ewald, NL, 2008–2015)

TC 4-33 Discomfort Glare in Road Lighting (Chair: Stephan Völker, DE)

To study the known mathematical description of the discomfort glare in road and vehicle lighting, its scaling and comparisons with field studies and to condense the outcome in a report that should result in methods for discomfort glare assessment. To review or replace Publication CIE Publication 31.

TC 4-36 Visibility Design for Roadway Lighting (Chair: Vacancy)

To develop a technical report on design procedures for roadway lighting based on the visibility level concept.

TC 4-40 Requirements for Retroreflective Traffic Signs (Chair: Paul Carlson, US)

TC 4-45 Performance Assessment Method for Vehicle Headlamps (Chair: Gert Langhammer, DE)

Extend the technical report describing the development of requirements for an objective procedure to evaluate forward-lighting system performance in terms of active safety taking into account latest forward lighting technologies.

TC 4-46 300 mm Roundel Signals (Chair: Ron Gibbons, US)

Develop a CIE Standard, for proposal to ISO, providing the colorimetric and photometric properties of 300 mm road traffic control roundel signals. Review CIE Standard S006.

TC 4-47 Application of LEDs in Transport Signalling and Lighting (Chair: Steve Jenkins, AU)

To review the application and methods of measurement of LEDs in transport lighting and signalling as far as they affect the visual performance of the users of the transport system. To prepare a Technical Report which includes the findings of the review and recommendations for the visual characteristics of LED signals and lighting.

TC4-50 Road Surface Characterization for Lighting Applications

To revise Publication CIE/PIARC TR 66 1984 containing the standards. To propose methodologies for the determination of parameters from calculation and from laboratory and on site measurements, considering also the evaluation of uncertainty. To publish Data. Review CIE Publications 47 and 144, excluding the sections on markings.

TC 4-51 Optimizing of Road Lighting (Chair: Haldun Demirdes, FR)

Develop guidance on optimization of road lighting to balance the benefits and costs. Primary issues include accident risk and energy consumption. Tasks include ot set up a Technical Report or update CIE publication 93 and to provide an analysis of lighting quality. Chair: Per Ole Wanvik (NO)

TC 4-52 Lighting for pedestrians: new empirical data (Chair: Steve Fotios, GB)

To establish empirical data that might be used to determine design criteria when lighting to meet the needs of pedestrians. The committee will review evidence of, and the applicability of, three approaches to establishing such criteria: 1. by considering how lighting influences the visual needs of pedestrians. 2. by considering the costs and benefits of lighting. 3. by considering current practise in different regions.

JTC 1 (D1/D2/D4/D5) Implementation of CIE 191:2010 Mesopic Photometry in Outdoor Lighting (Chair: Stuart Mucklejohn, GB)

To investigate adaptation and viewing conditions and define visual adaptation fields in outdoor lighting. To define lighting applications where mesopic photometry could be used. To provide guidelines for implementing mesopic photometry in outdoor lighting.

JTC 8 (D1/D2/D3/D4/D5/D6/D8) Terminology in light and lighting (Chair: Peter Zwick, DE)

To address any issues regarding terms and definitions related to the International Lighting Vocabulary (ILV). This includes coordination within CIE Divisions to maintain and update the ILV, coordination with IEC on questions related to the incorporation of ILV terms and definitions into IEC 60050-845 “International Electrotechnical Vocabulary. Lighting”, coordination with ISO/TC 12 on questions related to the incorporation of ILV terms and definitions into ISO 80000-7 “Quantities and units – Part 7: Light and radiation” and any further terminology issues within CIE.

9 Reporterships (DRs)

DR 4-34	Bob Parks	Retro reflective and other passive devices as Energy Savers
DR 4-35	Otto Letamendi	Crime and Road Lighting
DR 4-36	Axel Stockmar	CEN/TC169, Lighting Applications
DR 4-37	Pentti Hautala	CEN/TC226, Road Equipment
DR 4-38	Elizabeth Alvarez del Castillo	IAU (International Astronomical Union)
DR 4-39	Ad de Visser	GTB (The International Automotive Lighting and Light Signalling Expert Group - Groupe de Travail "Bruxelles 1952")
DR 4-41	Axel Stockmar and Cyril Chain	Lighting for Elderly
DR 4-42	Cyril Chain	LUCI (Lighting Urban Community International)
DR 4-43	Jean-Claude Martin and Eric Dumont	PIARC

DR 4-44	Malcolm Nicholson	IALA (International Association of Marine)
DR 4-45	Pål Larssen	Enabling technologies for energy savings.
DR 4-46	Raoul Lorphèvre	GLA (Global Lighting Association)
DR 4-47	Steve Jenkins	LED Billboards
DR 4-48	TBN	Intrusive Light
DR 4-49	Chao-Hua Wen	Flicker from Lighting on High Speed Road
DR 4-50	Dionyz Gasparovsky	Document Status - Joint with DIV5

10 Liaisons

10.1 Official Liaisons

Organizations that CIE have agreements on technical cooperation and important to Division 4:

ISO, CEN, LUCI and GLA

CIE officer: Ad de Visser (NL) to:

ISO/TC 022/SC 08 "Lighting and light-signalling"

ISO/TC 022/SC 22 "Motorcycles"

ISO/TC 022/SC 23 "Mopeds"

ISO/TC 022/SC 35 "Lighting and visibility"

ISO/TC 022/SC 38 "Motorcycles and mopeds"

10.2 Informal Contacts

Informal “liaisons” are listed under reporterships. (See above).

11 Other Issues

The Board of Administration decided in their meeting in Vienna on 2015-02-11,12 that Divisions 4 and 5 must prepare for merging. The process would be guided by the CIE Past President.

Division 6: Photobiology and Photochemistry
Quadrennial Report 2011-2015

John O'Hagan, GB (DD)

2015-12-30

1 Terms of Reference

To study and evaluate the effects of optical radiation on biological and photochemical systems (exclusive of vision).

2 Division Officers

2011-2015:

Director:	John O'Hagan (GB)
Associate Director 1:	Karl Schulmeister (AT)
Associate Director 2:	Kohtaro Kohmoto (JP) (until April 2014)
Secretary:	Andrew Smedley (GB) (until April 2013)
	Luke Price (GB) (from April 2013)
Editor:	Andy Pearson (GB)

2015-2019:

Director:	John O'Hagan (GB)
Associate Director 1:	Karl Schulmeister (AT)
Associate Director 2:	David Sliney (US)
Associate Director 3:	Shu Takeshita (JP)
Secretary:	Luke Price (GB)
Editor:	Eric Liggins (GB)

3 Division Meetings

2012: Ontario (CA), 2012-06-25
Held in conjunction with the American Society of Photobiology annual meeting.
As an experiment, participation was in person and via WebEx.
There were 12 participants including 3 national representatives

2013: Paris (FR), 2013-04-17
Held in conjunction with the CIE Mid-Term and Centennial meeting in Paris.
There were 19 participants including 6 national representatives

2014: Kuala Lumpur (MY), 2014-04-28
Held in conjunction with the Lighting Quality and Energy Efficiency Conference.
There were 13 participants including 5 national representatives

2015: Manchester (GB), 2015-06-30
Held in conjunction with the 28th CIE Session)
There were 37 participants including 10 national representatives

4 Symposia and Workshops

2014: Workshop: Optical Radiation can be Good for People
Convener: John O'Hagan
Kuala Lumpur (MY), 2014-04-23

Workshop: Optical Radiation can be Bad for People
Convener: John O'Hagan
Kuala Lumpur (MY), 2014-04-26

2015: Workshop: Lighting for Life (Joint Division 3 and Division 6)
Conveners: Jennifer Veitch and John O'Hagan
Manchester (GB), 2015-04-23

5 Strategy 2011-2015 and beyond

The period 2011 to 2015 was used to review long-standing Technical Committees, which had not produced reports.

In terms of new work, there was increasing pressure from industry to produce guidelines or standards for so-called "human-centric lighting". Division 6 supported an expert workshop funded by ZVEI (German Electrical and Electronic Manufacturers' Association) in Manchester in January 2013. This brought together the world experts on the non-vision beneficial effects of light on humans. Division 6 provided the rapporteur and the Division Director attended representing CIE. A peer-reviewed publication was produced, plus a CIE Technical Note.

Looking to the future, the following topics have been identified:

Topics	**Description of research**	**Justification**	**Prioriti-zation**
Risk Group Classification for products emitting optical radiation	None required at the moment	Existing Standard is complex and difficult to use. ICNIRP have also revised their exposure limit guidance. The standard is being revised.	1
Guidance on Illuminators for Treatment of Infant Hyperbilirubinemia	Literature review being carried out by two experts in the field, with input from healthcare facilities	The optical emission from sources needs to be matched to the response function of the relevant chromophores. Equipment has developed over the years that may not be optimised.	2
Non-visual human responses to visible optical radiation	Wide range of research across the world.	Manufacturers are promoting "human centric lighting" without a firm scientific basis. As a minimum this means that consumers could be wasting money on ineffective lighting. However, the lighting could result in adverse effects on health and wellbeing.	3
Measurement standard for non-visual photoreception in the human retina	Review of the performance requirements of detectors and how these can be matched to the non-visual photoreceptor system	Devices are being marketed for assessing the non-visual responses of the human retina without robust scientific characterization. This work will review the requirements, to particularly ensure that studies using different measurement systems are able to be compared.	4

Topics	Description of research	Justification	Prioriti-zation
Plant and animal responses to inappropriate (to be defined) exposures to light at night	D6 will need to engage with researchers active in this area. Two TCs were recently closed due to lack of support.	There is wide concern (at least in the media) that energy efficient lighting and/or lighting throughout the night may adversely impact on plants and animals. It is important that the CIE has a view on the concerns expressed.	5
Review of the vitamin D UV action spectrum (and the quantification of any differences to the erythema action spectrum, and the dose dynamics of both responses)	Many studies use the current CIE action spectrum.	Concerns have been expressed about the validity of the current CIE action spectrum. A review of the literature needs to be carried out and either the action spectrum modified or confirmed.	6
Potential long term chronic detrimental effects on the retina from blue light (e.g. related to macular degeneration)	The evidence is not clear that there is a problem, but studies are being published.	A review is required to consider if the evidence is maturing or whether all studies are using bizarre exposure scenarios. It is important that exposures are compared with natural exposures, such as looking at the blue sky.	7

6 Administrative Matters and Communication

Most Technical Committees are now using Collaboration Tools. In addition, the Division Secretary maintains an email list of about 290 people who are interested in the work of the Division. At the 2015 Division Meeting, it was agreed to set up an area on Collaboration Tools for anyone who wishes to be kept informed of work relevant to the Division – Division 6 Associates. This is based on a scheme already operated by Division 3. Access is given on request. One of the main reasons for this area is that it can be used to maintain information that would otherwise be hidden to former Technical Committee members once the work of the Technical Committee is completed.

7 Publications

7.1 Published

7.1.1 CIE Technical Reports

CIE 201:2011 Recommendations on Minimum Levels of Solar UV Exposure

CIE 203:2012 (including Erratum 1) A Computerized Approach to Transmission and Absorption Characteristics of the Human Eye

CIE 207:2014 Sensitivity of Human Skin to Ultraviolet Radiation, Expressed as Minimal Erythema Dose (MED)

CIE 209:2014 Rationalizing Nomenclature for UV Doses and Effects on Humans

7.1.2 CIE Technical Notes

TN 003:2015 Report on the First International Workshop on Circadian and Neurophysiological Photometry, 2013

7.1.3 Reports by Reporterships

DR 6-41 Mismatch between the in vivo and in vitro Vitamin D Synthesis Action Spectra: Cause-and-effect Relationship

DR 6-37 Short-hand Notations of UV Selected Bands in Photobiology

7.2 Expected

TC 6-49 Infrared Cataract

Technical Report has been reviewed by the Division Editor

TC 6-52 CIE Guide for the Measurement of Upper Air Ultraviolet Germicidal Irradiation Luminaries using Low Pressure Germicidal [short wavelength] UV-C Lamps

Technical Report has been drafted, but a call for additional expertise from Division 2 has delayed the work.

TC 6-64 Optical Safety of Infrared Eye Trackers applied for Extended-Durations

Technical Report has been reviewed by the Division Editor

TC 6-66 Maintaining summer levels of 25(OH)D during winter by minimal exposure to artificial UV sources: requirements and weighing the (dis)advantages

Technical Report almost ready for review by the Division Editor

7.3 Review

7.3.1 Reviewed Publications

ISO 28077: 2006/CIE S 019: 2006 Photocarcinogenesis action spectrum (Non-melanoma skin cancers)

Reviewed by Division Director, Chair of the Technical Committee that drafted the Standard and the CIE Technical Manager. Editorial comments were submitted to ISO. It was felt that there was no additional scientific data to justify amending the action spectrum.

7.3.2 Status of Publications

Current:

CIE TN 003:2015 Report on the First International Workshop on Circadian and Neurophysiological Photometry, 2013

CIE 207:2014 Sensitivity of Human Skin to Ultraviolet Radiation, Expressed as Minimal Erythema Dose (MED)

CIE 203:2012 (including Erratum 1) A Computerized Approach to Transmission and Absorption Characteristics of the Human Eye

CIE 201:2011 Recommendations on Minimum Levels of Solar UV Exposure

CIE 187:2010 UV-C Photocarcinogenesis Risks from Germicidal Lamps

CIE 186:2010 UV-A Protection and Sunscreens

ISO 28077:2006(E)/CIE S 019/E:2006 Photocarcinogenesis Action Spectrum (Non-Melanoma Skin Cancers)

CIE 181:2007 Hand Protection by Disposable Gloves against Occupational UV Exposure

CIE x031:2006 Proceedings of the 2nd CIE Expert Symposium on Lighting and Health

IEC 62471:2006/CIE S 009/E&F:2002 Photobiological Safety of Lamps and Lamp Systems

CIE 174:2006 Action Spectrum for the Production of Previtamin D3 in Human Skin

CIE 172:2006 UV Protection and Clothing

CIE S 019/E:2006 Joint ISO/CIE Standard: Photocarcinogenesis Action Spectrum (Non-Melanoma Skin Cancers)

CIE x026:2005 Proceedings of the CIE Symposium 2004 on LED Light Sources: Physical Measurement and Visual and Photobiological Assessment

CIE x027:2004 Proceedings of the CIE Symposium 2004 on Light and Health: Non-Visual Effects

CIE 158:2004 Ocular Lighting Effects on Human Physiology and Behaviour

CIE S 013/E:2003 International Standard Global Solar UV Index

CIE 155:2003 Ultraviolet Air Disinfection

CIE 151:2003 Spectral Weighting of Solar Ultraviolet Radiation

CIE 148:2002 Action Spectroscopy of Skin with Tunable Lasers

CIE 139-2001 The Influence of Daylight and Artificial Light on Diurnal and Seasonal Variations in Humans - a Bibliography

CIE 138-2000 CIE Collection in Photobiology and Photochemistry

ISO 17166:1999/CIE S 007-1998 Erythema Reference Action Spectrum and Standard Erythema Dose

CIE 134-1999 CIE Collection in Photobiology and Photochemistry, 1999

CIE x016-1998 Measurements of Optical Radiation Hazards

CIE 125-1997 Standard Erythema Dose, a Review

CIE 106-1993 CIE Collection in Photobiology and Photochemistry

CIE 098-1992 Personal dosimetry of UV radiation

CIE 090-1991 Sunscreen Testing (UV.B)

CIE S 009/D:2002 Photobiologische Sicherheit von Lampen und Lampensystemen

Under Review:

CIE 174:2006 Action Spectrum for the Production of Previtamin D3 in Human Skin

IEC 62471:2006/CIE S 009/E&F:2002 Photobiological Safety of Lamps and Lamp Systems

CIE S 009/D:2002 Photobiologische Sicherheit von Lampen und Lampensystemen

8 Technical Committees (TCs)

8.1 Closed TCs

TC 6-08 Guidelines for Obtaining Action Spectra (Chair: David Sliney, US), closed in 2015

Closed for being non-compliant with the Code of Procedure. May be considered for a Reportership.

TC 6-15 Computerized Approach to Reflection, Transmission and Absorption Characteristics of the Human Eye (Chair: David Lund, US), closed in 2012

Report published as 203:2012 (including Erratum 1) A Computerized Approach to Transmission and Absorption Characteristics of the Human Eye

TC 6-20 Phototoxicity in Domestic and Industrial Environments (Chair: Neil Gibbs, GB), closed in 2011.

No response from the chair.

TC 6-21 Low Level UV-A Cataract (Chair: David Sliney, US), closed in 2015

Closed for being non-compliant with the Code of Procedure. May be considered for a Reportership.

TC 6-28 Standardization of Sunscreen Testing (Chair: Uli Osterwalder, CH), closed in 2015

Closed for being non-compliant with the Code of Procedure.

TC 6-33 Photoimmunological Effects Mediated Through the Skin (Chair: Edward de Fabo, US), closed in 2011.

Draft report was considered too technical and no progress was made on making it more accessible.

TC 6-36 UV Protective Materials Used in Shading (Chair: Natasha Nel-Sakharova, ZA), closed 2013.

No report was received.

TC 6-37 Light and Retinal Disease (Chair: David Sliney, US), closed 2015.

Closed for being non-compliant with the Code of Procedure. May be considered for a Reportership.

TC 6-39 UV Radiation in Lighted Environments (Chair: Kohtaro Kohmoto, JP), closed 2011

No progress report was received.

TC 6-42 Lighting Aspects for Plant Growth in Controlled Environments (Chair: Mojtaba Navvab, US), closed 2015.

Closed for being non-compliant with the Code of Procedure. May be considered for a Reportership.

TC 6-43 UV Water Disinfection (Chair: Alexander Cabaj, AT), closed 2011.

Chair had retired and no progress report received.

TC 6-44 Illuminators for Treatment of Infant Hyperbilirubinemia (Vacant), closed in 2013.

Task transferred to a Reportership. Draft report was out of date.

TC 6-45 Optical Radiation Hazard Measurements in the Workplace (Chair: Robert Angelo, US), closed in 2015.

Closed for being non-compliant with the Code of Procedure. Proposed for a Reportership.

TC 6-46 Standardized Action Spectrum for UV Disinfection (Chair: Richard Vincent, US), closed in 2011.

Closed on the advice of the chair and may be re-opened in the future.

TC 6-48 Typical Minimal Erythema Doses (chairs: Janusz Beer and Sharon Miller, US), closed 2014.

Report published with agreed change of title: CIE 207:2014 Sensitivity of Human Skin to Ultraviolet Radiation, Expressed as Minimal Erythema Dose (MED)

TC 6-50 Photodegradation of Pharmaceuticals (Chair: Hanne Tønnesen, NO), closed 2013.

Report would have been a combination of two published papers and there were concerns about copyright issues.

TC 6-51 Standardized Solar Simulator Spectral Irradiance for Sunscreen Testing (Chair: Robert Sayre, US), closed 2011

No information received from chair.

TC 6-53 Personal Dosimetry for UV Radiation (Chair: vacant), closed 2011.

Closed due to inactivity

TC 6-55 Photobiological Safety for LEDs (Chair: Werner Horak, DE), closed in 2013.

Closed due to lack of support from TC members.

TC 6-57 Standardization of Terms and Action Spectra for Blue Light and Retinal Thermal (Chair: Kohtaro Kohmoto, JP), closed 2011.

Closed due to lack of progress.

TC 6-58 A Recommendation on Lower Limits for UV Exposure (Chair: Wim Passchier, NL), closed 2011.

Report published: CIE 201:2011 Recommendations on Minimum Levels of Solar UV Exposure

TC 6-61 Measurement of Radiation Using the Phytometric System for Plant Applications (Chair: Gilberto da Costa, BR), closed 2015.

Closed for being non-compliant with the Code of Procedure. May be considered for a Reportership.

TC 6-62 Action Spectra and Dosimetric Quantities for Circadian and Related Neurobiological (Chair: Howard Cooper, FR), closed 2015.

Closed for being non-compliant with the Code of Procedure.

TC 6-63 Photobiological Strategies for Adjusting Circadian Phase to Minimize the Impact of Shift Work and Jet Lag (Chair: Stephen Lockley, US), closed 2015.

Closed for being non-compliant with the Code of Procedure.

TC 6-65 Photobiological Dosimetry for Low Level Laser/Light Phototherapy (Chair: Terry Lyon, US), closed 2013.

Closed at the request of the chair due to no input from TC members.

JTC 3 Rationalising UV Units (Chair: Richard McKenzie), closed 2014.

Report published: 209:2014: Rationalizing Nomenclature for UV Doses and Effects on Humans (joint publication with the World Meteorological Organization)

8.2 TCs in Progress

TC 6-49 Infrared Cataract (Chair: Tsutomu Okuno, JP), started in 1998.

TC 6-52 Proper Measurement of Passive UV Air Disinfection Sources (Chair: Richard Vincent, US), started in 2000.

TC 6-64 Optical Safety of Infrared Eye Trackers Applied for Extended-Durations (Chair: David Sliney, US), started in 2008.

TC 6-66 Maintaining summer levels of 25OH vitamin D during winter by minimal exposure to artificial UV sources; requirements and weighing the (dis)advantages (Chair: Ann Webb, GB), started in 2013.

JTC 4 (D3/D6) Visual, Health, and Environmental Benefits of Windows in Buildings during Daylight (Chair: Martine Knoop, NL), started in 2012.

JTC 5 (CIE-IEC) Review of IEC 62471/CIE S009 (Chair: John O'Hagan, GB), started in 2012.

8.3 New TCs

JTC 8 (D1/D2/D3/D4/D5/D6/D8) Terminology in light and lighting (Chair: Peter Zwick, DE), started in 2015.

ToR: To address any issues regarding terms and definitions related to the International Lighting Vocabulary (ILV). This includes coordination within CIE Divisions to maintain and update the ILV, coordination with IEC on questions related to the incorporation of ILV terms and definitions into IEC 60050-845 "International Electrotechnical Vocabulary. Lighting", coordination with ISO/TC 12 on questions related to the incorporation of ILV terms and definitions into ISO 80000-7 "Quantities and units – Part 7: Light and radiation" and any further terminology issues within CIE..

8.4 Proposed TCs

JTC (D2/D6) Characterization of the performance of non-visual weighted irradiance and actigraphy logging devices (Chair: Luke Price, GB).

Proposed ToR: to provide performance measurement requirements for wearable instruments designed to be used in the study of non-visual light exposures, activity, sleep and health. The report would follow similar principles to ISO/CIE 19476:2014 (CIE S 023/E:2013) “Characterization of the performance of illuminance meters and luminance meters” but include the five non-visual sensitivity curves from TN003:2015 Report on the First International Workshop on Circadian, and to include a method for characterization of the measurement of motion and timing used in the actigraphy from a collaboration with a suitable specialist non-commercial organization. The scope on light sensors will be restricted to acquisition of spectrally weighting irradiance.

9 Reporterships (DRs)

9.1 Closed DRs

DR 6-37 Definition of UV Wavebands (Masako Sasaki, JP), closed in 2014.

Report available on Collaboration Tools (Division 6 Associates area): DR 6-37 Short-hand Notations of UV Selected Bands in Photobiology

DR 6-40 A Survey of Action Spectra in the Scientific Literature: 19XX – 200X (Alois Schmalwieser), Closed in 2014.

Reporter published in the open literature.

DR 6-41 The Issues of Vitamin D Kinetics (Irina Terenetskaya, UA), closed in 2014.

Report available on Collaboration Tools (Division 6 Associates area): DR 6-41 Mismatch between the in vivo and in vitro Vitamin D Synthesis Action Spectra: Cause-and-effect Relationship

DR 6-42 Report on the 1st International Workshop for Action Spectra of Non-Image Forming Photobiological Effects of Light, IWAS 2013 (Luke Price,GB), closed in 2015.

Report published: TN 003:2015 Report on the First International Workshop on Circadian and Neurophysiological Photometry, 2013.

9.2 DRs in Progress

DR 6-43 Illuminators for Treatment of Infant Hyperbilirubinemia (Michael Lynn & Graham Hart, GB)

9.3 New DRs

DR 6-44 Optical Radiation Hazard Measurements in the Workspace (David Sliney & Robert Angelo, US), started in 2015

9.4 Proposed DRs

R 6-xx A review of the beneficial and detrimental impact of optical radiation on plants

ToR: To review any material from closed TCs 6-42 and 6-61 and propose possible work by CIE.

10 Liaisons

10.1 Official Liaisons

Werner Horak	IEC TC76 WG9
Uli Osterwalder	ISO/TC 217/WG 7
Karl Schulmeister	International Commission on Non-Ionizing Radiation Protection

David H. Sliney IEC/TC 76/WG 1 + American Society of Photobiology

Ann R. Webb World Meteorological Organization

10.2 Informal Contacts

John O'Hagan ISO/TC 274

Contribute to the TC and/or the CIE/ISO liaison group on matters relating to Division 6.

11 Future Activities

The next meeting of Division 6 is planned to be by WebEx towards the middle of 2016.

The 2017 meeting of Division 6 will take place in conjunction with the CIE Mid-Term meeting in Jeju, Korea, October 2017.

A workshop is planned to follow the publication of the revised S009/IEC 62471-1.

Division 8: Image Technology
Quadrennial Report 2011-2015

Po-Chieh Hung, JP (DD)

2015-08-15

1 Terms of Reference

To study procedures and prepare guides and standards for the optical, visual and metrological aspects of the communication, processing and reproduction of images, using all types of analogue and digital imaging devices, storage media and imaging media.

2 Division Officers

2011-2015:

Director:	Jan Morovic (GB) (to 2014)
	Po-Chieh Hung (JP) (from 2014)
Secretary:	Po-Chieh Hung (JP) (to 2014)
	Alessandro Rizzi (IT) (in 2014)
	Christine Fernandez-Maloigne (FR) (from 2015)
Editor:	Ann McCarthy (US) (to 2014)
	Danny Rich (US) (from 2014)

2015-2019:

Director:	Po-Chieh Hung (JP)
Secretary:	Christine Fernandez-Maloigne (FR)
Editor:	Danny Rich (US)

3 Division Meetings

2011: San Jose (US), 2011-11-09
(Informal meeting held in conjunction with the 19th Color and Imaging Conference)
19 attendances

2012: Internet, 2012-12-06
(Formal meeting held through the WebEx remote conference system)
19 attendances including 6 national representatives

2013: Paris (FR), 2013-04-17
(Informal meeting held in conjunction with the CIE interim meeting)
8 attendances

2013: Albuquerque (US), 2013-11-07
(Informal meeting held in conjunction with the 21st Color and Imaging Conference)
18 attendances

2013: Internet, 2013-12-03
(Formal meeting held through the WebEx remote conference system)
26 attendances including 6 national representatives

2014: Boston (US), 2014-11-05
(Informal meeting held in conjunction with the 22nd Color and Imaging Conference)
Approximately 30 attendances

2014: Internet, 2014-12-09
(Formal meeting held through the WebEx remote conference system)
19 attendances including 6 national representatives

2015: Manchester (GB) and Internet, 2015-07-03
(Formal meeting held in conjunction with the 27th CIE Session. The WebEx remote conference system in combination)
35 attendances including 7 national representatives

4 Strategy 2010-2015

Use of social media to increase opportunities for discussion

Easy entrance to the CIE activity using Reportership, rigid review for publication

5 Administrative Matters and Communication

There are some changes in the Division 8 officer positions due to resignation and national committee's issue.

6 Publications

6.1 Published

6.1.1 CIE Technical Reports

CIE 199:2011 Methods for Evaluating Colour Differences in Images

6.1.2 Reports by Reporterships

DR 8-09 Output Linearization Methods for displays and printers.

DR 8-10 Full-Reference Image Quality Metrics: Classification and Evaluation

DR 8-12 3D Multi-view Image/Video Colour Data Format Conversion and Quality Control

6.2 Expected

TC 8-07 Multispectral Imaging

6.3 Review

6.3.1 Reviewed Publications

CIE 163:2004 The Effects of Fluorescence in the Characterization of Imaging Media

6.3.2 Status of Publications

Current:

CIE 162:2010 Chromatic Adaptation under Mixed Illumination Condition when Comparing Softcopy and Hardcopy Images (incl. Erratum 1)

CIE 163:2004 The Effects of Fluorescence in the Characterization of Imaging Media

CIE 199:2011 Methods for Evaluating Colour Differences in Images

Under Review:

CIE 156:2004 Guidelines for the Evaluation of Gamut Mapping Algorithms

CIE 159:2004 A Colour Appearance Model for Colour Management Systems: CIECAM02

CIE 168:2005 Criteria for the Evaluation of Extended-Gamut Colour Encodings

7 Technical Committees (TCs)

7.1 Closed TCs

TC 8-09 Archival Colour Imaging (Chair: Robert Buckley, US), closed in 2015

Without report and transferred to new TC 8-15, Melitte Buchman (US)

TC 8-10 Office Lighting for Imaging (Chair: Yasuki Yamauchi, JP), closed in 2015

Without report and transferred to Reportership R 8-14, Yasuki Yamauchi (JP)

7.2 TCs in Progress

TC 8-07 Multispectral Imaging (Chair: Masahiro Yamaguchi, JP)

TC 8-11 CIECAM02 Mathematics (Chair: Changjun Li, CN)

TC 8-12 Image and Video Compression Assessment (Chair: Pascal Bourdon, FR)

7.3 New TCs

TC 8-13 Colour Gamuts for Output Media (Chair: Kiran Deshpande, GB), started in 2013

ToR: To study and recommend methods for computing and communicating colour gamuts for output colour reproduction media.

TC 8-14 Specification of Spatio-Chromatic Complexity (Chair: Noël RICHARD, FR), started in 2015

ToR: To produce a state-of-the-art report on the existing definitions of the complexity notation related to the aspects of non-uniform surfaces, generally defined as textured. To combine these definitions in order to produce a single embedding of the spatial and chromatic variations in a generic and vector form.

TC 8-15 Archival Colour Imaging (Chair: Melitte Buchman, US), started in 2015

ToR: To recommend a set of techniques for the accurate capture, encoding and long-term preservation of colour descriptions of digital images that are either born digital or the result of digitizing 2D static physical objects including documents, maps, photographic materials and paintings.

8 Reporterships (DRs)

8.1 Closed DRs

DR 8-09 Output Linearization Methods for displays and printers (Klaus Richter, DE)

Report published in Division

DR 8-10 Full-Reference Image Quality Metrics: Classification and Evaluation (Marius Pedersen, NO)

Report published in Division

DR 8-12 3D Multi-view Image/Video Colour Data Format Conversion and Quality Control, (Abdul Karim Hezerul, MY)

Report published in Division

8.2 New DRs

DR 8-11 Colour image reproduction for 3D printing (Kaida Xiao, UK), started in 2013

ToR: To report methodology of colour image reproduction for 3D printing system in multi-disciplinary applications including computer graphic, rapid prototyping and medicine.

DR 8-13 Common colour appearance (Craig Revie, UK), started in 2014

ToR: To study the topic of common colour appearance to determine whether people mean the same thing when they use this term. The report will collect examples of what people refer to as common colour appearance including for displays, printing systems and brand management. The report will also identify some counter examples.

DR 8-14 Office Lighting for Imaging (Yasuki Yamauchi, JP), started in 2015

ToR: To publish a Technical Note on the spectral power distribution and illumination levels used to view images in office lighting conditions, collected through the activity of TC8-10.

DR 8-15 A survey on Quality Metrics on Stereoscopic Imaging (Christine Fernandez-Maloigne, FR, Jesus Jaime Moreno, MX, Alessandro Rizzi, IT), started in 2015

ToR: "To publish a Technical Note to describe the state of the art of the Stereoscopic Image Quality Assessments (SIQA), and psychophysical experiments to evaluate the Metrics on Stereoscopic Imaging.

9 Liaisons

9.1 Official Liaisons

CIE Central Bureau	ISO/TC 036: Cinematography
Danny Rich	ISO/TC 130: Graphic Technology
Hideyasu Kuniba	ISO/TC 042: Photography
CIE Central Bureau	ISO/TC 159/SC 04/WG2: Ergonomics, SC 4: Signals and Controls, WG 2: Visual display requirements
CIE Central Bureau	ISO/IEC/JTC1/SC29: Joint Committee on information technology, SC29: Coding of audio, picture, multimedia and hypermedia information
Naoya Katoh	IEC TC100/TA2 Multimedia Systems and Equipment
Dr. Ellen Carter	ASTM
Marc Mahy, Mr. Fumio Nakaya	International Color Consortium
Klaus Richter	ISO/IEC/JTC1/SC28: Joint Committee on information technology, SC28: Office Equipment

9.2 Informal Contacts

Po-Chieh Hung	Society for Imaging Science and Technology

WORKSHOP AND SEMINAR REPORTS

Report on the Seminar
COLOUR QUALITY OF LED LIGHTING

Conveners: Ronnier Luo, GB/CN and Tran Quoc Khanh, DE

The program of the Workshop contained an Introduction (Tran Quoc Khanh, Ronnier Luo) as well as lectures on recent important topics including intercultural colour preference (Yandan Lin, Xiao Xing, Peter Bodrogi, Tran Quoc Khanh, Dragana Stojanovic), LED lighting for museum paintings (Ferenc Szabó, Peter Csuti and Janos Schanda), aspects of future LED lighting considering various quality indices (Peter Bodrogi, Tran Quoc Khanh, Dragana Stojanovic), the development of a colour discrimination index (Ronnier Luo and Lihao Xu), and a new quality index of whiteness (Aurelien David).

In the Introduction, the current and future evaluation methods of colour quality have been compared. It was pointed out that today's lighting engineers need a more comprehensive system of colour quality metrics to develop usable rules for the spectral design of LED spectra for better user acceptance. In order to achieve optimal LED spectra, it is essential to find out the correlations among these colour quality metrics and to apply them in real LED luminaires while the determination of the semantic meanings and acceptance ranges of the values of these metrics in laboratory and in field tests is also necessary. Multi-metrics can be defined with different weightings for different lighting applications.

The lecture on intercultural colour preference concentrated on the object scene dependence of white tone preference comparing the subjects' answers across China and Germany. Results of a cooperation research between the Fudan University (Shanghai) and the Technische Universität Darmstadt were presented. The aim was to provide guidance to design and apply lighting products for a better user acceptance on the global market. Subjects looked into a viewing booth (at 743 cd/m^2 at the white bottom) containing a combination of either red, or blue or colourful objects and marked their preference rating on a scale between 0 (worst) and 100 (best) for different LED light sources with 7 different CCTs between 2700 K and 6500 K. A general CCT preference between 4000 K and 5000 K was found in both Laboratories while Chinese women living in Darmstadt preferred warm white CCTs (2700 K – 3500 K) for reddish objects in contrast to Chinese men and Europeans. These results will be validated by immersive viewing in real rooms at different illuminance levels.

In the lecture on LED lighting for museum paintings, Dr. Szabo gave the talk to introduce the two European projects. The first LED4ART project was on the lighting quality and energy efficiency LED illumination for art applications. The second HI-LED project was on human centric lighting with much wider scope. All the research materials in relation to museum lighting are summarised in his talk. The quality of museum lighting includes visual comfort, conservatory, colour rendering, uniformity and non-visibility part of luminaires. In the first project, they proposed a LED lighting based on a method which applied the colour inconstancy concept using the real painting samples between the daylight of 6500K and a more preferred warm light at 3500K. The lighting system was finally installed in the Sisten Chapel, Ventican, as the highlight of the project. In the second project, they investigated the most comfort viewing conditions for museum paintings, they found that 4500K at 200 lx performed the best. Finally, they introduce their recent work on pigment aging test with an aim to optimise LED prescription based on the CIE damage index.

In the lecture on the aspects of future LED lighting considering various quality indices, after a brief history of colour quality metrics, it was pointed out that the LED's technological parameters can be varied in a flexible manner to optimize (combinations of) different colour quality parameters, colour fidelity, preference (naturalness, vividness), colour harmony, colour discrimination, visual clarity, etc. For demanding lighting applications (e.g. fashion show, museum, shop, motor show), a high CRI (R_a>90) and a good white point shall always be maintained while e.g. vividness can be maximized. Luminous efficiency shall not be a spectral optimization criterion. To help optimize LED spectra, an analysis of the correlations among the indices R_a, $R_{a,2012}$, CQS Q_p and Q_g as well as FCI has been shown for a set of LED

spectra. Good and bad examples of 6-component multi-LED spectra with different R_a and Q_g values were presented and a “spectral cause analysis” was carried out. White points “below the Planckian” have the capability of providing high CQS Q_g values. It was concluded that, in case of the lack of correlation, compromise solutions for the optimal LED spectra exist and the spectral cause analysis is important for conscious LED spectral design.

In the lecture on the development of a colour discrimination index, the concept of colour discrimination index was first introduced, a new lighting quality indicator. It could be based on different parameters such as colour spaces, test samples, different measures including colour difference or colour gamut regions. Colour discrimination indices were developed based on the above parameters. They were used to optimise LED prescriptions for testing materials of stone, wood, organ samples. The results of maximum visibility showed convergence to 3 LEDs, close to 420, 500 and 660 nm for all three set of samples.

In the lecture on the new quality index of whiteness, the concept of whiteness, a lighting quality indicator, was introduced. It concerns the visual perception in viewing white materials, especially for those having optical brightening agent (OBA). A working group at Lighting Illumination Society (LES) chaired by David is aimed to propose such index which will predict the whiteness for white LED sources at different CCTs.

It was concluded that different applications need different optimization target functions from constructed from the combinations of existing colour quality metrics. The resulting optimal LED spectra shall be validated visually and the range of “acceptable” numeric values (e.g. >90?) shall be defined by semantic rating experiments.

Report on the Seminar
ASSESSING LIGHTING METRICS

Conveners: Peter Boyce, GB, and Jennifer Veitch, CA

Summary

A metric is a well-defined measure that a designer can use to evaluate a design, a researcher can use to characterise light exposures, and a regulator can use to set standards. For many years the most common metrics used for indoor lighting have been daylight factor, task illuminance, illuminance uniformity, correlated colour temperature, colour rendering index and unified glare rating. Today, there are other metrics being proposed, some evolutionary such as those related to colour fidelity and gamut area, and some revolutionary, like mean room surface exitance and the universal lumen. The purpose of this seminar was not to add to the list of proposed new metrics but rather to examine what is required for a new metric to be adopted. This question was addressed by representatives of those who assess a metric's validity from the photometry and applied research perspective and those who are concerned with its utility, from the design and industry perspective. Common features of these presentations were an emphasis on clarity of definition, a recognition that new technologies have revealed the limitations of some metrics and an agreement that reliable and stable metrics and their associated criteria protect the public from unsafe or undesirable conditions. Consideration of the presentations and subsequent discussion identified the essential characteristics for a metric to be successful.

1 Introduction

Peter Boyce set the stage, providing background concerning lighting metrics, both current and newly proposed. He opened by saying that a metric is a well-defined measure that is useful to designers in evaluating designs; to researchers in characterizing lit scenes; and to regulators, in setting standards. Useful lighting metrics should:

- be relevant to some outcome that matters,
- be quantitative,
- have established calculation criteria,
- be calculable during design, and
- be measurable after installation.

Six metrics are most frequently used to characterize interior lighting design: daylight factor, task illuminance, illuminance uniformity, correlated colour temperature, colour rendering index, and unified glare rating.

New metrics have been proposed in response to changing conditions: new lighting technologies, better understanding of the physiology of visual and non-visual effects of light, increased recognition of the importance of lighting to human well-being, and increasing pressure to decrease lighting energy use. Climate-based daylight modelling has given us Useful Daylight Illuminance and Daylight Autonomy [Reinhart et al. 2006]. The advent of light-emitting diodes (LEDs) reopened consideration of metrics for light source colour properties, leading to suggestions that at least two metrics are needed to provide a good characterization, likely one that addresses colour fidelity and a second to describe the gamut area [Guo and Houser 2004; Rea and Freyssinier-Nova 2008]. Cuttle [2013] has argued that task illuminance is a poor metric when most tasks are visually easy; He argued that the purpose of lighting is to provide visual experience in illuminated space. The two metrics he proposed as the basis of this design approach are mean room surface exitance and a hierarchy of lighting expressed in target/ambient illumination ratios for various targets within the space. Perhaps most provocatively, Rea [2013, 2015] has argued that photopic

illuminance based on V(λ) is inadequate to predict perception and performance for many purposes, and suggested that different spectral weighting functions ought to be applied to assess the quantity of light depending on the application and the purpose of the lighting in it.

Despite the many proposals for new metrics, lighting standards and recommendations have not changed in recent years. It seems that scientific validity is a necessary but not a sufficient condition for new metrics to be adopted. This seminar was designed to explore why that is the case. The panellists each had a different perspective on the use of lighting metrics and the barriers to change. Following the panel presentations, there was an open discussion with the audience.

2 Panellist Presentations

2.1 Metrics and Metrology

Peter Blattner, Director of CIE Division 2 - Physical Measurement of Light and Radiation, opened with the observation that “there are no metrics without metrology”. The two words share the Greek root *μετρώ*, or metró, meaning “to measure“.

He added an item to the list of requirements for essential characteristics of a metric: that they should be based on an internationally-agreed system, such as the International System of Units (www.bipm.org). Information about photometry and radiometry in the SI is available here: http://www.bipm.org/metrology/photometry-radiometry/. In the field of light and lighting, responsibility is divided between the International Committee for Weights and Measures (CIPM) and CIE, with CIPM being responsible for defining the fundamental units for radiometry and photometry, and CIE being responsible for establishing the standardized action spectra for photobiological and photometric quantities. The two organizations work in a coordinated way through the Consultative Committee on Photometry and Radiometry (CCPR).

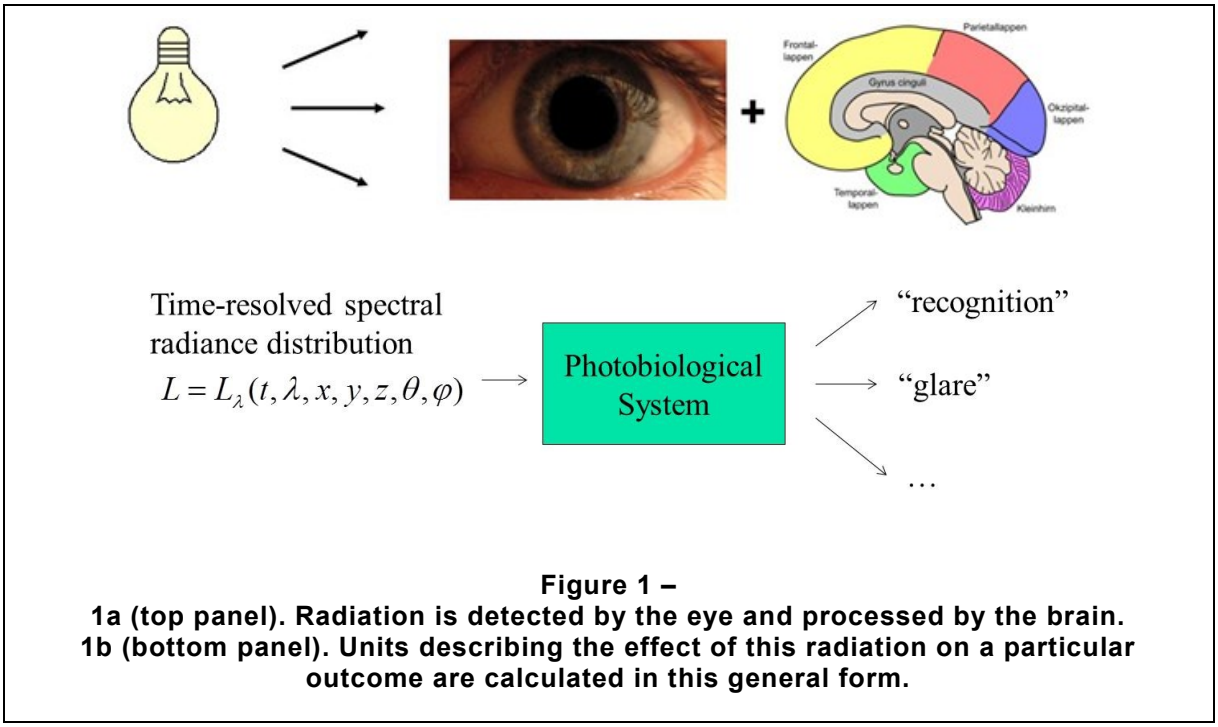

Figure 1 –
1a (top panel). Radiation is detected by the eye and processed by the brain.
1b (bottom panel). Units describing the effect of this radiation on a particular outcome are calculated in this general form.

In the general case, when we are considering the use of radiation for human purposes, we consider the schematic shown in Figure 1. Radiometric quantities are weighted by an established action spectrum to show the total contribution of the exposure to a given effect.

For example, when considering erythema (skin reddening, as in sunburn), erythemal irradiance is calculated by the formula

$$E_{\mathrm{er}} = \int E_{\lambda}(\lambda) \cdot s_{er}(\lambda) \cdot \mathrm{d}\lambda \qquad \text{[Eq 1]}$$

where E_{er} is in units W·m^{-2}, spectral irradiance $E_{\lambda}(\lambda)$ is in W·m-2·nm^{-1} and dλ is in nm. The action spectrum $s_{er}(\lambda)$ is dimensionless, as it is a weighting function. When one calculates new quantities for photochemical or photobiological effects, they take this general form and are radiometric quantities. Thus, it is incorrect to describe such new quantities as “melanopic lumens”.

The exception occurs when we are considering exposures related to vision, when the system becomes photometric rather than radiometric. Photometric units are based on the fundamental unit, the candela (see the SI Brochure at http://www.bipm.org/en/publications/si-brochure/candela.html). The fundamental equation for relating the photometric quantity, luminous flux (lumen, lm) to the radiometric quantity, radiant flux (W), is

$$\Phi_{\mathrm{v,X}} = \frac{K_{\mathrm{cd}}}{V_{\mathrm{X}}(\lambda_{\mathrm{a}})} \int_{\lambda} \Phi_{\mathrm{e},\lambda} V_{\mathrm{X}}(\lambda)\, \mathrm{d}\lambda \qquad \text{[Eq 2]}$$

[CIE 2004]. Note that in Eq 2 above, $V_x(\lambda)$ is the spectral weighting function (spectral luminous efficacy) for photopic vision, and K_{cd} is the constant in lm/W based on the fundamental definition of the candela. K_{cd} = 683 lm/W = 683 cd sr·W^{-1}. If one wanted to describe the luminous flux related to dark-adapted, scotopic vision, one would use a different constant and a difference spectral luminous efficacy function, K'_{cd} = 1700 lm/W and $V'_x(\lambda)$. One would then calculate the quantity *scotopic luminous flux* but the unit would remain the same: the lumen.

Thus, as we learn more about the effects of optical radiation on humans, we need not define new units – rather, we may define new quantities. One specifies the observer in the name of the quantity, but the units are unchanged.

Another important consideration for lighting metrics is that the measurements require metrological traceability, which is property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty. Although this is not usually a legal requirement, it is important to quality assurance. This is a matter of ensuring the calibration status of the equipment used.

Traceability alone is not enough, however: Problems arise when one is measuring a light source different from the one under which the instrument was calibrated. Different instruments have different errors across the spectrum and these differences in the spectral match can result in large errors when measuring a light source other than the calibration source [e.g., Ouellette 1993]. Because this can be particularly problematic with LED light sources, there is consideration within Division 2 that reference spectra should be changed from incandescent sources to an LED spectrum, and this will be discussed elsewhere during the Manchester meetings.

In any case, CIE has established indices for assessing the quality of the spectral match for key properties [CIE 2013]. Similar problems can occur with imaging luminance measurement devices, for which quality indices are in the process of being established by TC 2-59 (publication expected later in 2015), and spectroradiometers (TC 2-51, expected publication in 2016).

Dr. Blattner’s final point concerned the importance of quantifying measurement uncertainties, and of understanding how they arise. If the measurement uncertainties are large, decisions

made on the basis of the measurement are at risk. For example, one might conclude wrongly that a given product delivers a total luminous flux of 800 lm at a T_{cp} of 6200 K. If the true values were 1000 lm at 5900 K, the product would be wrongly labelled, with possible results being that consumers accept the item but are disappointed when it does not perform as expected; or that producers find that the item is rejected because it does not meet requirements. If one understands the sources of measurement uncertainty one can take action to reduce them, with the result being more accurate measurements and better results for all.

2.2 Metrics for Communication

Jennifer Veitch spoke in her capacity as the Chair of CIE TC 3-34, which published report CIE 213:2014 [CIE 2014], “Guide to Protocols for Describing Lighting”. The purpose of the report is to define metrics that can lead to a complete specification of a luminous environment. Her focus in the seminar was to address how we use metrics to communicate about the lit environment.

Although have been calls for a single, unified metric for lighting quality, this is unrealistic. Consider the many metrics used to assess physical health: weight and height (and as a composite of these, body mass index), blood pressure, lung capacity, blood composition (cholesterol, cell counts, metabolites). Medical personnel assess these against criteria that have been set for each one; these criteria take into account contextual factors such as the individual’s age, sex, and goals. The criteria have been set by consensus, generally based on evidence that relates the metrics to health status. Thus, for example, most adults are given target blood pressure readings of 120/80, whereas for a person with diabetes the targets are slightly lower (Heart and Stroke Foundation of Canada 2015). Target resting heart rates for well-trained athletes are lower than for people with moderate fitness (American Heart Association 2015).

Similarly, there are many metrics against which to judge lighting quality. A general model of lighting quality was suggested by Veitch at the First CIE Symposium on Lighting Quality [Veitch 1998] and subsequently adopted in publications of the Illuminating Engineering Society of North America [Quality of the Visual Environment Committee 2009; Rea 2000]; Figure 2 shows this model. According to this model, lighting quality – like physical health – is context-specific. We have different purposes for the lighting in different applications, and sometimes for different actors within the same application (for example, patients and medical staff in a hospital room). In some circumstances, keeping the installation simple is of critical importance; in others, achieving an artistic composition in keeping with the setting is more important. Achieving good lighting quality means balancing the different requirements in a manner that is appropriate for the context.

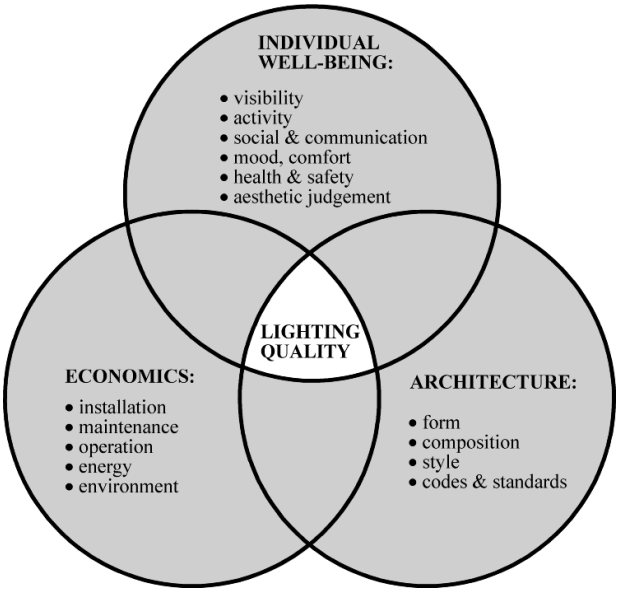

Figure 2 – Lighting quality definition developed at the First CIE Symposium on Lighting Quality (Veitch 1998).

Dr. Veitch expanded on the requirement that useful metrics should be relevant to some outcome that matters, saying that metrics should be predictors of what we want to achieve, or what we want to prevent. These predictions can lead to criteria. Criteria are target values that might vary depending on the context. Thus, for example, DiLaura et al. [2011] developed a method for establishing target task illuminance levels for various settings, and these are modified based on the viewer age and task difficulty levels.

CIE 213:2014 set out a catalogue of metrics and described the means to measure each, providing relevant, specific, and objective definitions of the supporting concepts within each metric. The goal of this committee was to clarify each one so that subsequent researchers and designers alike would communicate clearly about the lit environment. Table 2 sets out the categories and the metrics within each – see the report for the full details.

Table 1 – The protocols for describing lighting in CIE 213:2014 are organized by categories	
Category	**Metrics**
1. People:	Age Visual capabilities
2. Context:	Setting
3. Lighting Systems and Components	Luminaires Controls Daylighting Shading
4. Room Surface Light Levels and Distribution	Luminance Illuminance Ratios
5. Task Details	Contrast Size Display screen characteristics
6. Task Area Light Distribution	Luminance Illuminance
7. High-Luminance Areas	UGR
8. Modelling	Hemispheric illuminance
9. Colour Appearance	R_a, CCT, chromaticity
10. Dynamic Effects	Flicker Modulation %, frequency

Armed with these clear definitions, it would then be possible to establish suitable criteria for each metric, within various contexts. Just as we accept many metrics in the evaluation of our health, we should expect there to be several metrics used to assess the quality of a lit environment. We await further research and discussion to enable the establishment of criteria for the various metrics.

2.3 Metrics and Lighting Design

Naomi Miller spoke from her expertise as a lighting designer and scientist at Pacific Northwest National Laboratory. Her presentation began with the metrics currently in use, and then moved on to what lighting professionals would like to use and how they might be led to use new metrics.

Table 2 shows the metrics that professionals currently use, with some notations indicating metrics that are little-used. These metrics are low-level functions that establish that a lighting design might reasonably achieve its goals as regards relative light levels and distribution patterns. On the basis of these, a lighting designer might rethink choices of luminaires, spacing, and location to avoid glare problems or to deliver more or less light in particular locations; would narrow the selection of light sources to achieve desired colour performance; or would establish that the plan would meet requirements for lighting energy use.

Table 2 – Lighting professionals use different metrics for interior and exterior applications, and some metrics more than others	
Interior Lighting	Exterior Lighting
Illuminance (horizontal and vertical)	Illuminance (horizontal and vertical)
CCT, CRI, Duv, R9	Uniformity ratios
Lumens per Watt, Watts per square unit area	CCT, CRI, Duv, R9
Candela values from luminaire for reflected glare potential	Lumens per Watt, Watts per square unit area
Luminance of surfaces (rarely)	Luminance of roadway from driver angle
Average luminance of luminaire (rarely)	S/P ratios (seldom)
VCP and UGR (rarely)	Veiling luminance ratio of luminaire (rarely)
S/P ratios (rarely)	Luminance of signage (rarely)

She observed that lighting professionals wish that lighting metrics were more effective at dissuading clients and contractors from making bad choices. That is, that lighting metrics were more useful at excluding lighting designs and products that result in glare, headaches, poor visibility, excessive energy use, and/or distracting, overlit, underlit, bland, unhealthy, unsafe or incoherent visual environments. As Ms Miller said, “None of the current metrics encourage clients to implement functionally effective lighting that renders spaces visually uplifting or emotionally supportive.”

From the designer’s perspective, what is needed are metrics that:

- Quantify design lessons learned through experience
- Accurately relate to human experience and needs
- Don’t apply only to a narrow family of products
- Don’t limit creativity and options by being too rigid

Because of limited project time and fees, these metrics should be:

- Easy to understand and explain
- Easy to calculate in advance with software and photometric information
- Easy to confirm in the field with inexpensive but accurate meter/device ($500-$1000 USD) – not only a simple illuminance meter, but high-dynamic-range imaging photometers and spectroradiometers that calculate several quantities.

The adoption of new metrics will be a challenge, even if the above points are met. Credible, influential advocates in the lighting community would need to advocate for new metrics, preferably through professional associations such as the International Association of Lighting Designers (IALD), Professional Lighting Designers Association (PLDA), Illuminating Engineering Society of North America (IES), CIE, and of course many others. Testing the metrics with focus groups would be wise, to obtain their support and to make sure that the new metrics work under various conditions, finishes, and applications. Further research to identify criteria for the new metrics and their implementation in recommendations and standards will also speed their adoption.

2.4 Metrics, Standards, and Industry

Peter Dehoff spoke from his perspective in industry, where he is Director of Standards and Professional Associations at Zumtobel Lighting, and also is active in the Austrian and European standards communities. He opened with the observation that the industry has its own metrics for success, chief among these being profit, but also supported by revenue,

growth, sales, and costs. Industry exists to produce or to trade competitive products and services and only in that context does it concern itself with the quality of its own workplaces, its relationship to its customers, or its mission or vision statements.

That said, success in business means delivering to customers so that they are satisfied and maintaining a reputation for good projects or products that are reliable. Lighting metrics help with this success by providing a basis for good communication between the parties. Metrics are used to select products for an installation, for initial price calculations, and for energy and life-cycle cost analysis. Product metrics establish the safety of the product and ensure compliance with the relevant standards and directives. In addition to metrics previously mentioned, colour consistency and rated lifetime have become important metrics when considering LED performance.

For lighting design, the favoured metrics remain horizontal illuminance, either in the whole space or on a task, and installed power. These are easy to calculate and to compare between alternatives, but neither is sufficient to evaluate the quality of an installation. Various standards documents describe other possible metrics [e.g., CIE 2001; IESNA 2012], but these are still viewed as optional.

Whether or not more metrics are needed is an open question, and different companies have different opinions on the matter. The one point of agreement is that only metrics that can be reliably measured or calculated will achieve the level of trust that will lead to their adoption. Calculations of alternative illuminance values (e.g., cylindrical or vertical illuminance) have this characteristic, as does contrast rendering factor. Maintenance calculations also are well understood. There are open questions concerning glare predictions from LED luminaires and many questions concerning metrics for colour rendering and characterizing dynamic lighting systems.

Mr Dehoff concluded by saying that industry uses lighting metrics as a basis for comparison, each company doing so both within its own products and designs and against its competitors. Useful metrics are those that are used by everyone in the system; they are the trusted means to establish fair comparisons. The metrics that are used are those that everyone can agree on.

3 Discussion

Following the presentations, audience members had comments and questions. These revolved around three themes.

Criteria establish the minimum acceptable performance. From various perspectives, lighting designers observed that the many criteria we have do not ensure quality, reinforcing Naomi Miller's observations. Marc Fontoynont (DK) observed that one can use calculations at the design stage to provide confidence that criteria will be met, and still find when the installation is in use that it is not more than acceptable. Moreover, there are no parallel metrics for architectural quality, to which lighting design seeks to contribute. Tom Lemons (US) observed that North American stadium lighting recommendations failed to deliver good stadium lighting, but the situation is worse with the new technologies that many professionals are unable to use effectively even to achieve these minimal criteria.

New technologies point to limits of existing metrics. Naomi Miller expanded on this point to say that, as is well known, the advent of LEDs has revealed limitations of colour metrics and glare metrics. Both of these are actively under discussion in CIE and other associations.

Adopting new metrics. Peter Boyce observed that one can't get consensus about a new metric without someone taking the chance on it: We need demonstrations that the new metric can work before it can be moved into standards. Jennifer Veitch added that extensive work is needed to establish meaningful criteria for any new metric, to which Naomi Miller added that

moving slowly is not a bad thing. The fundamentals upon which existing criteria were established have not changed. Had we changed all of our standards 6 years ago with the LED products available then (many of which were not good by any indicator), we would have different documents than ones we might write today. Too-rapid change might have led to poorer quality by leading industry in a different direction.

John Mardaljevic (UK) suggested that one way to achieve adoption of new metrics can be benign dictatorship, offering the example of the recent adoption of climate-based daylight metrics in the UK. This was written in by a regulator and caught some experts by surprise. However, there are risks to that approach, as Mark Duffy (US) pointed out. Some regulators lack specific technical knowledge, and can in the process write text that leads to bad lighting – e.g., colour rendering specifications that leave out a requirement about which reference spectrum one ought to use. Unless the regulators have a deep understanding of the field, criteria can be established that result in bad lighting, the opposite of the official intention.

Another argument for a slow approach to adoption is the potential for manipulation and misuse of complex new metrics. As an example, Peter Thorns (UK) noted that products with long lifetimes, such as many LEDs, cannot be tested in real time. Product lifetime is a statistical prediction, which he fears could be open to manipulation, particularly when there is pressure for a quick result. Peter Blattner responded to this comment by saying that the uncertainty in product lifetime is not unmeasurable, but he concurred that the determination of it requires patience.

4 Conclusions

When Boyce and Smet [2014] summarized the 2014 symposium “Better Metrics for Better Lighting” held in London, UK and sponsored by the Society for Light and Lighting (SLL), they asked (a) whether the particular new metrics proposed at that symposium are likely to be adopted and (b) what would be required for their adoption. This CIE seminar was designed to build on that foundation by providing input from different perspectives: metrology, research, design, and industry. Interestingly, these four perspectives have much in common:

- An emphasis on clarity of definition as the foundation for meaningful metrics.
- Agreement that new technologies have revealed the limitation of past approaches.
- Agreement that reliable and stable metrics, with associated criteria expressed in standards, provide a basis for comparison that protects the public from unsafe or undesirable conditions.

Integrating the comments from all speakers, we find that useful lighting metrics would have the following characteristics, with underlined text indicating changes from the introduction to the seminar:

- be relevant to some outcome that matters, with contextually-appropriate criteria derived from evidence;
- be quantitative within an internationally established measurement system,
- have established calculation criteria expressed in clear definitions,
- be calculable during design,
- be measurable after installation, using traceable measurements, preferably from affordable and easy-to-use instruments;
- be accepted by all as providing a basis for a fair and unbiased evaluation.

One consideration that emerges from reviewing the speakers’ presentations is the need for agreement about the level of precision required for different purposes. In general, high precision (as typified by the metrologists’ approach) will be required of metrics for commercial or regulatory significance, but considerably lower precision (as is generally delivered by inexpensive instruments) is required for design decisions. Clear communication between all

parties will be needed to establish these requirements, without which the metrics will not be widely accepted.

Possible new lighting metrics have been cited here, discussed at the SLL event, and are under development within CIE and other committees. Whether or not any of these new metrics will result in improved lighting, or merely the exclusion of bad lighting, remains to be seen. We can, however, hope that by integrating these different perspectives the final result will be a set of lighting metrics that are both fundamentally sound and applicable in practice.

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Report on the Seminar
ADAPTIVE LIGHTING AND VISIBILITY

Convener: Ron Gibbons, US

The seminar was conducted to discuss the progress made in the implementation of adaptive lighting systems and standards from various countries. Four presenters and countries were represented: Great Britain (Nigel Parry), the Netherlands (Ans Van Den Broek), Norway (Per Ole Wanvik) and the United States.

Adaptive Lighting is an approach to roadway lighting where the lighting levels are adjusted based on the needs of the roadway users. Here considerations of time, traffic volume, pedestrian volume and ambient conditions are all used as inputs to the lighting level selection. A luminaire control system and controllable luminaires are required for implementation.

The US system for implanting adaptive lighting is like most adaptive lighting approaches, based on the CIE work. It was the result of a research project that considered the link between traffic safety and roadway lighting the selection criteria include the traffic volume, pedestrians, roadway type and usage to select the lighting class. The lighting system could then be adapted based on the current roadway conditions or by a time based criteria. The UK system is similar where traffic volume allows for a lighting level to be reduce one class at low volume times. The study of traffic volumes indicated that 95% of British roads could be reduced one lighting class from 22:00 hrs to 06:00 hours. The Dutch system was also presented and showed similar impacts on lighting performance.

The final presentation was highlighted the need for an extensive selection process for the LED luminaires to be used in the Norwegian Adaptive Lighting System. Here several manufacturers systems were evaluated on several different criteria to provide the most desirable outcome for the luminaire performance. Performance of the luminaire and a control system in an adaptive lighting system are critical to implementation success.

The seminar highlighted that most countries are considering implementation of an adaptive lighting system. Most approaches are tie to the CIE approach in Document 115. Finally, the luminaire and control system performance is critical to the successful implementation of an adaptive lighting system.

Report on the Seminar
LIGHTING FOR LIFE

Conveners: Jennifer Veitch, CA, and John O'Hagan, GB

Summary

Apart from vision, it is interesting to note that even after decades of research we know more about the quantities and qualities of light that can do harm than we do about benefit. This seminar brought together some of the key people involved with the research and application of knowledge on the non-vision aspects of our exposure to light. Why can't we specify lighting parameters for optimum health and well-being? Is natural sunlight exposure the best option? How do we take account of age, or of the tasks we want to carry out? Does it matter when we get the light exposure? Is light exposure history important? How can we integrate this knowledge into comprehensive application guidance for high-quality lighting?

Rob Lucas, from the University of Manchester, was one of the co-chairs of the First International Workshop on Circadian and Neurophysiological Photometry, held in the UK in 2013. He spoke about the scientific evidence for single action spectrum for the beneficial effects of light. Luke Price, from Public Health England, addressed the challenges of monitoring light exposures in the field. Jens Christoffersen, from the VELUX Group, is actively involved in the progress with a new European standard for "Daylighting of Buildings", and discussed the challenges related to applying light for life. The last speaker, Jennifer Veitch, National Research Council Canada, described the progress of CIE Technical Committee 3-46 "Research Roadmap for Healthful Interior Lighting Applications". The seminar concluded with time for discussion and questions.

1 Introduction

As CIE attendees know well, lighting technology has undergone a revolution in recent years with the introduction of solid-state light sources and advanced control technologies. Our understanding of the the complexity of ocular light detection and the physiological and behavioural responses that follow it has also undergone a transformation. We know that light enables vision, but also affects quality of life in myriad other ways. CIE has been actively working towards integrating knowledge in this field with the aim of supporting lighting recommendations that take account of this new knowledge. One of the first documents to integrate the literature in this field was CIE 158:2004/2009 [CIE 2004/2009], which articulated five principles of healthy lighting. CIE also convened expert symposia on Light and Health in Vienna in 2004 [CIE 2004] and on Lighting and Health in Ottawa in 2006 [CIE 2006]. Workshops on the topic were held at the CIE Sessions in Beijing [Brainard and Veitch 2007] and Sun City, South Africa (2011). The seminar held at the Manchester session of the CIE was the latest in this series.

The starting point for this seminar was the observation that despite the tremendous advances in understanding, it remains easier to provide guidance on how to avoid harm from light exposure (for example, from the blue light hazard or UV radiation) than to specify how best to provide beneficial light exposure. The four seminar presentations each addressed a different aspect of the challenges that face us as we work towards a widespread understanding of using lighting for life.

5 Presentations

5.1 Lighting for Life: Biology – Rob Lucas

Rob Lucas is a Professor of Neurobiology at the University of Manchester. He delivered an invited address in the seminar, providing the background concerning the neurobiology underlying circadian regulation through ocular light detection. Having served as one of the co-chairs of the First International Workshop on Circadian and Neurophysiological Photometry, his presentation concluded with a summary of the results of that consultation [Lucas et al. 2014].

His presentation opened with a description of functions that we now know are influenced by patterns of light exposure:

- Phase-setting of endogenous circadian clocks
- Pupil constriction
- Changes in hormone levels
- Gross physiology (heart rate, body temperature, blood pressure)
- Neurophysiological stimulation
- Mood

Intrinsically photoreceptive retinal ganglion cells (ipRGCs) are a class of retinal cells that detect irradiance independent of the rods and cones [Berson et al. 2002] through action of melanopsin [Bailes and Lucas 2010; Güler et al. 2008]. These cells, which number only a small percentage of the total retinal ganglion cell population, are excited by light and continue to respond to light even when isolated from the rest of the retina. Although they detect light independently of the rods and cones, there are cross-connections; the ipRGCs receive input from across the retina [Lucas et al. 2001]. Thus, there is no a priori reason to think that non-image-forming responses are uniquely the result of ipRGC activity.

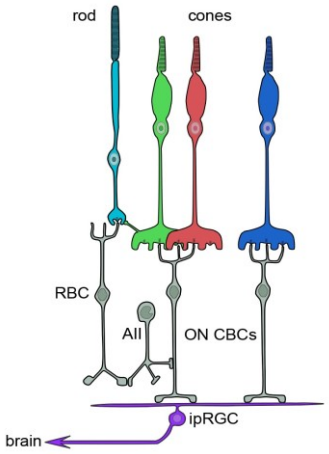

Figure 1 – Summary of the afferent pathways.
The coloured cells in this drawing indicate photoreceptive cells. Rod cell signals are summed by rod bipolar cells (RBC); code signals by cone bipolar cells (CBCs). These contribute to the signals sent by the ipRGCs to the brain.

A key question for photobiologists has been to identify the spectral response function of melanopsin and the action spectrum for circadian regulation in humans. There is an important distinction here: photobiologists have established the spectral response functions of specific photopigments, but for application purposes many wish to understand the action spectrum underlying biological and behavioural responses. These lie downstream of the photoreceptors

themselves, which means that it is insufficient to know only the photopigment spectral response function. This is because we do not know the extent to which each biological response relies on the various photoreceptor types, nor do we know how these cells interact with one another.

This awareness is key to understanding the report of the First International Workshop on Circadian and Neurophysiological Photometry. This group of 14 experts, co-chaired by Prof. Lucas and Prof. George Brainard, was invited to meet in order to address the question of how developments in understanding of 'non-visual' responses could impact methods of measuring light. Many had hoped that a result of this meeting would be a single action spectrum for predicting non-visual responses to light – that one could provide a complement to Vλ to characterize how light exposures (to various sources and various intensities) would influence human physiology and behaviour.

Although the workshop did result in consensus on an action spectrum for ipRGCs themselves, peaking an 490 nm, the workshop outcome was more complex [CIE 2015a; Lucas et al. 2014]. Given the evidence for the involvement of more than one photoreceptor in the input pathway for 'non-visual' responses, it is evident that spectral sensitivity is a complex question. Moreover, there is evidence that this spectral sensitivity of 'non-visual' responses is fundamentally plastic, changing in relation to:

- duration of light exposure
- different responses
- time of day
- irradiance

A goal of current research is to be able to predict which photoreceptors dominate under any given lighting condition and for a particular response type. This is currently not possible. The current state of knowledge is summarized in Figure 2 below. Five photoreceptive cells respond independently to light exposure following spectral response functions shown on the right panel of Figure 2; their signals are combined in as-yet unknown ways to produce an integrated signal leaving the retina and projecting to various brain structures.

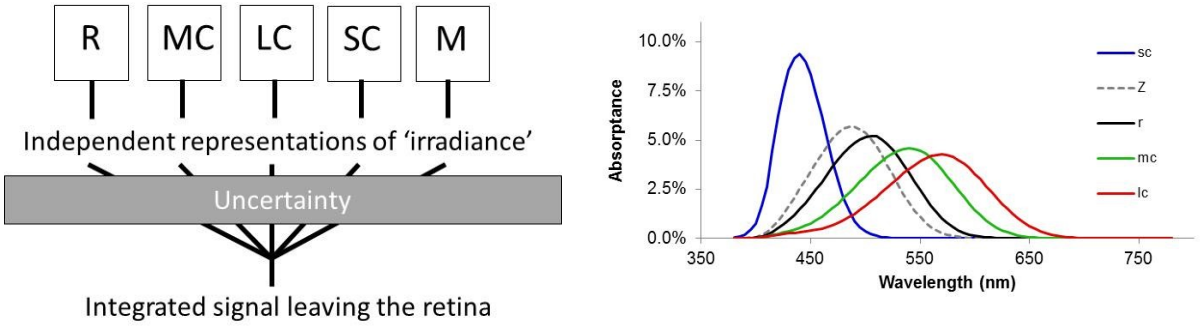

Figure 2 – The workshop conclusions summarized. The left panel shows the schematic of the five photoreceptor types, each independently responding to light exposure. From left, rods, medium-wavelength cones, long-wavelength cones, short-wavelength cones, and melanopsin-containing cells (ipRGCs). The grey box represents the unknown ways in which the signals are combined to produce one integrated signal leaving the retina. The right panel shows the five spectral response functions associated with the photoreceptor types. 'Z' and the dotted line show the consensus for the ipRGCs, the melanopsin-containing cells.

A key outcome of the workshop was its recommendations to researchers. In order to compare and to combine results, researchers ought to record light exposures spectrally and to calculate the input signal to each of the five photoreceptors. An Excel toolbox was developed

for this purpose and published with the workshop review paper [Lucas et al. 2014]; an updated version is available from the CIE website together with CIE Technical Note 003, which is an report from an observer at the workshop [CIE 2015a].

Prof. Lucas concluded with comments on the potential for applications of this knowledge. He emphasized that our understanding of these systems is very incomplete. Empirical observations are that one can maximally engage non-visual physiological responses by exposure to higher intensity light with a greater contribution from short wavelengths ("bluer light"). One can minimize these responses with lower intensity light with a greater contribution from longer wavelengths. However, our grasp of when we want to maximize and minimize these responses is imperfect. Predictions with any degree of accuracy depend on far greater knowledge than currently exists.

5.2 Performance of actigraphy devices – Luke Price

Luke Price is a Senior Radiation Protection Scientist at Public Health England in Oxford, UK. He serves CIE as Secretary of Division 6, Photobiology and Photochemistry, and as CIE Reporter 6-42, he authored CIE Technical Note 003 [Commission Internationale de l'Eclairage (CIE) 2015].

His presentation in the seminar concerned the intersection of metrology and lighting for life. It is widely recognized that coming to an understanding of how light affects physiology and behaviour will require ecological monitoring of light exposures. CIE has well-established calibration standards for general-purpose photometric equipment [ISO/CIE 2014], but the specialized equipment used to monitor light exposures in the field is very different in design from these devices, and there are no established calibration procedures for them. The absence of calibration standards could mean that the results of various investigations are not directly comparable because of inaccurate measurements for which the sources of measurement errors and their magnitude of errors are unknown. It is an advance to have consensus on the five spectral response functions of the five photoreceptor types (Figure 2), but research quality will not improve if there are no calibration procedures to protect the quality of measurements to which these functions are applied.

The presentation, which built upon his previous publications [Price et al. 2012] included preliminary data not for reproduction here to illustrate certain key points:

- The concept of "dynamic resolution" (the smallest detectable change in the quantity being measured) requires an agreed-upon method for its quantification.
- Spectral response error calculation could be simplified from the current calculation of f_1'.
- Existing protocols for angular response may be used, but manufacturing differences from one device to another will affect measurement error.
- Response linearity may require new procedures suitable to these devices.

As a final note, Mr. Price suggested that CIE ought to consider forming a Joint Technical Committee to develop calibration methods suitable for real-world light exposure monitoring.

5.3 Daylight – Jens Christoffersen

Jens Christoffersen is with the Stakeholder Communications and Sustainability department at VELUX A/S in Denmark. In that capacity he works to improve our understanding of the role of daylight as a contributor to well-being, principally (but not only) in residential buildings, and he serves on various industry and standards committees related to daylighting.

His presentation in the seminar concerned industry's response to the advancing knowledge concerning lighting for life. He opened with a précis of the evidence concerning the importance of good daylighting in residences, workplaces, and hospitals. Both the quantity of daylight and the provision of a view confer benefits [Veitch and Galasiu 2012]. For example, Brown and Jacobs [2011], analyzing a large European data set, found that the risk of falls and

of depression were both reduced in homes with better self-reported natural daylight availability. Several investigations have found that a view of nature can be restorative following stressful experiences [Berg et al. 2003; Ulrich 1984].

His firm has integrated these findings into guidance for what they call a Circadian House, the key principles of which are:

- Live in balance with nature - A house in balance with nature allows the occupants to live with and follow the daily and seasonal cycles of the outdoor environment.
- Adaptability - A house whose space and occupants can adapt to changing conditions (daily, seasonal) and needs.
- Sensibility - A house that provides protection against harmful substances which humans cannot sense and allow freedom to control parameters that can be sensed

Applying principles such as these across building types and jurisdictions is best accomplished when standards are developed with these principles in mind. One example is the draft European standard for daylight in buildings, now in development. Many European countries have some sort of mandatory requirements for daylighting. Unfortunately those requirements are usually limited to declaratory phrases like: “adequate daylighting should be provided”, or “rooms should be well-lit”. Thorough instructions, informing how adequate daylighting is achieved or how a room is well-lit, are limited and usually only provided by window-to-floor area. Few European countries specify the required daylight factor for interior spaces, which is calculated during the design phase. Moreover, this quantity is independent of both building orientation and location, meaning that it is a poor predictor of the true daylight exposure of people in the building. The new proposal creates a *target daylight factor* (DT) across a fraction of the relevant floor area (i.e. 50% vertical; 100% roof) for half of the daylight hours in the year. The target daylight factor (DT) is based on internal illuminance of 300 lux and the external diffuse horizontal illuminance at the location of interest (e.g. each European capital city).

With appropriate architectural standards in place to predict light exposures in buildings, it can be possible to increase total light exposure and to reap the benefits suggested by the science. Doing so, however, requires extensive co-operation between the many groups active in this space. Figure 3 shows some of these, with a focus on the European groups with which Dr. Christoffersen is familiar (committee names and structures as of the seminar date). There are gaps between the parties, and tension between those who advocate for more daylight penetration in buildings versus those whose concern is reducing energy consumption. Even if it were the case that we knew well how to specify the proper light exposure for any setting, establishing the proper balances in consensus documents – whether for regions or internationally – will take time.

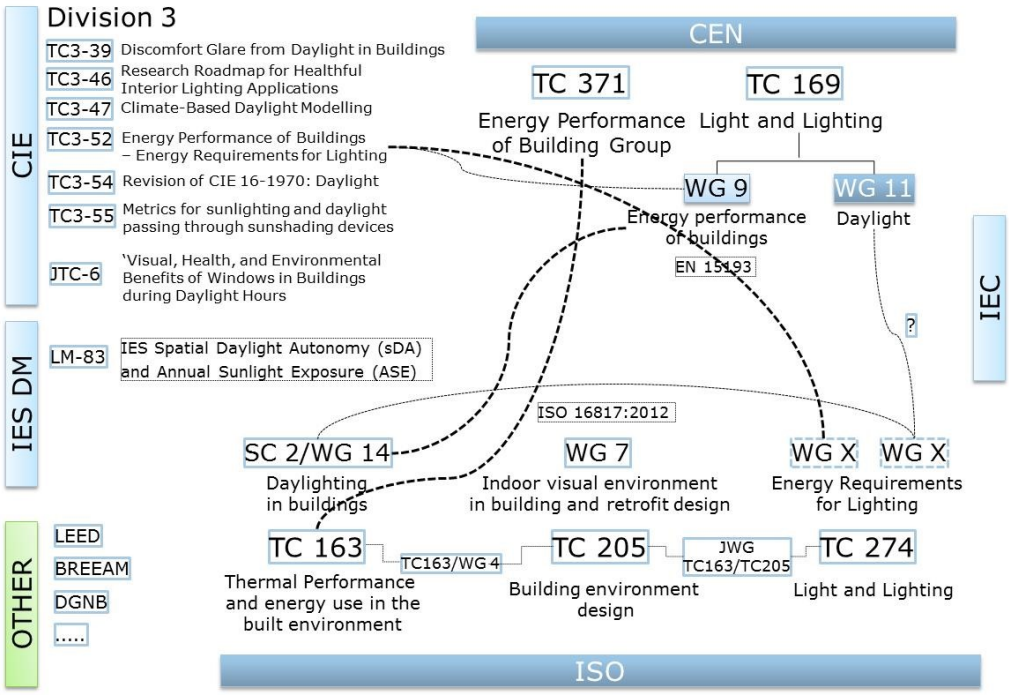

Figure 3 – A partial listing of committees and working groups that develop documents aimed at influencing the use of daylight in buildings. CIE – Commission Internationale de l'Eclairage. ISO – International Organization for Standardization. IEC – International Electrotechnical Commission. CEN – European Committee for Standardization. IES – Illuminating Engineering Society of North America. LEED – Leadership in Energy and Environmental Design. DGNB -- German Sustainable Building Council.

5.4 The road to healthful lighting applications – Jennifer Veitch

Jennifer Veitch is a Principal Research Officer at the National Research Council of Canada, and Director of CIE Division 3. She spoke in this seminar in the role of Technical Committee Chairman of TC 3-46 – Research Roadmap for Healthful Lighting Applications.

TC 3-46 was established in 2007 with the following Terms of Reference:

> "This TC will review relevant CIE publications (CIE 158:2004 and the two CIE expert symposia on light and lighting and health in 2004 and 2006) and the more recent scientific literature to identify the information that is needed before such lighting application may take place. The output will be a technical report which will describe a research roadmap intended to stimulate fundamental research into questions relevant to lighting applications."

The seminar presentation outlined the structure of the draft report following a committee meeting held earlier in the week, and which was expected to proceed to the Enquiry Draft stage of more general review during the autumn of 2015. The general conclusion of the committee is that despite the scientific advances that have occurred in parallel with the committee's work, there remains an absence of detail that would permit sound recommendations for healthful lighting to complement existing lighting recommendations and standards.

The draft report includes 28 major research questions (some with sub-questions), in the following broad categories:

- Fundamentals: Acute effects; Retinal sensitivity; Neurophysiology; Other processes
- Pattern: Daily; Amplitude; Exposure; Application; Light sources; Illuminances; Reflectances; Design; Duration; Daylighting
- Individual Differences: Age; Disorders; Visual impairment; Stressors; Other
- Application – specific: Shift work

Importantly, the report further identifies the importance and the ease of answering each question, with the intent being to focus the attention of both researchers and application specialists on making the best contributions with the funding and time available. Noting the challenges for application that are created by poorly designed and inadequately reported investigations, the report also includes an extensive discussion of research methods.

Among the most important, but also most difficult, questions to answer is this integration based on the report:

> "Taken overall, what is the general pattern of daily light and dark exposure, in terms of intensity, spectrum, timing, and duration that supports healthy functioning?"

Considered in this way, the committee also recognized that healthful lighting recommendations may be different from the usual design guidance. Few people spend all of their time in one setting with lighting specified by a single authority (although there are exceptions to this rule). Maintaining a proper balance of light and dark exposure will not only be a matter of providing lighting products or installations, but of public health. The report includes a discussion of considerations related to healthful lighting recommendations beyond the required research.

6 Conclusions

The four presentations in this seminar represent very different areas of interest and expertise, from fundamental photobiology and metrology through applied research and architectural applications. Strikingly, the presenters were agreed in the conclusion that there is much still to accomplish before the level of understanding of how light exposure influences human physiology and behaviours will be sufficient to support strong recommendations. Moreover, as seen in Figure 3, the pathway to those recommendations is itself complex.

The audience questions following the four presentations sought clarifications of points raised in each talk. As in prior workshop sessions in 2007 and 2011, there remained a tension between those who seek more rapid application – even if knowledge is preliminary – and those who advocate a cautious approach. There being no immediate resolution to this difference of opinion, the session closed with an invitation to the audience to read the CIE Position Statement "Recommending Proper Light at the Proper Time" [CIE 2015b], to watch for the publication of CIE Technical Note TN 003 [CIE 2015a], and to watch for opportunities to volunteer on upcoming CIE technical committees that will be formed to address Lighting for Life-related topics. With so many open questions and application challenges, it will require the collective action of many within CIE to ensure that during the 29th CIE Session in Washington, D.C. the discussion moves from generalities to specific applications of lighting integrated into lighting quality recommendations – so that indeed we are "Lighting for Life".

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Report on the Workshop
COLOUR IMAGING REPRODUCTION FOR 3D PRINTING

Convener: Kaida Xiao, GB

Background

Recently the technology of additive manufacturing, including three dimensional (3D) printing, has developed dramatically. One of the biggest advantages of 3D printing systems is their ability to directly interconnect with advanced manufacturing techniques and allow custom made production, with excellent accuracy and savings in both time and cost. Colour 3D printing using inkjet technology has evolved to produce full spectrum colour, solid objects in many different materials. This technique has been utilised extensively for rapid prototyping and is gaining popularity in multidisciplinary applications. With the evolution of various 3D imaging capturing techniques, another milestone has been achieved, allowing accurate acquisition and transformation of target object geometric data into 3D digital models. By combining 3D image capture and 3D printing, there is huge potential to achieve “What You See Is What You Get” processing for any objects.

However, the accurate reproduction of coloured 3D objects is still a huge challenge for colour and imaging science. Conventional colour image reproduction techniques based on CIE Colorimetry have been developed for more than 20 years and perform very well in transforming colour images from one digital media to another under various viewing conditions. However, CIE standard observer and psychophysical data for colour appearance modelling and colour difference evaluation were all obtained for flat colour samples. Therefore, to apply conventional colour image reproduction technique for 3D objects might not be straightforward or accurate. Moreover, more complex viewing conditions are always encountered when a 3D object is viewed and compared to the original. To preserve a colour reproduction for any illumination, a spectral based colour reproduction is even more important for 3D objects than for flat images. Furthermore, a full-colour 3D model contains a significant amount of data. A trade-off between the complexity of a model and accuracy of the model prediction has to be taken into consideration as well.

The objectives of this workshop is to bring researchers, engineers and users who work in the field of 3D colour imaging reproduction together, to understand more deeply what the most pressing challenges are in this area, and to stimulate cross-disciplinary collaborations that might help address these issues.

Welcome and Presentations

Dr Kaida Xiao, opened the workshop with a welcome and outlined the objectives of this workshop.

The workshop consisted of presentations by three speakers; Dr Kaida Xiao from University of Liverpool, United Kingdom, Dr Tzunghan Lin from National Taiwan University of Science and Technology, Taiwan and Dr Ching Seong Tan from Multimedia University, Malaysia.

The first presentation was from Dr Kaida Xiao introducing the technologies currently in use for full colour 3D printing and their multi-disciplinary applications. Recent studies of full colour 3D printing, including colour evaluation for different colour binders, printer and infiltration materials, printer repeatability, stability, uniformity and printer colour gamut, were summarised respectively.

As an example of a successful case study, Dr Xiao introduced his work on colour image reproduction for 3D printing facial prostheses. A workflow for 3D colour image reproduction was developed to efficiently connect 3D image capturing with 3D colour printing. Conventional colour management technique was applied for developing colour profile for 3D camera and 3D

printing respectively. By printing starch power and infiltrating with silicone, facial prostheses were produced with accurate shape and fine texture, whilst offering significant savings in time and cost. Colour reproduction for facial prostheses was evaluated against human skin colours, with performance significantly enhanced compared to standard models. However, limitations of colour image reproduction for this particular application were also addressed, including illumination dependency, effect of skin colour and texture to 3D reproduction.

Dr Tzunghan Lin gave a talk to introduce his research in 3D colour image acquisition and 3D colour printing. He briefly summarised recent developments of 3D image acquisition systems and pointed out that although the overall image resolution of captured 3D object is increasing, there remains a misalignment problem between colour and 3D geometry data. This is because an additional camera is typically used to capture colour information alongside the camera used to achieve 3D geometry. Dr Lin introduced recent work on the development of a new colour 3D scanner system which allows usage of the same camera to capture both 3D shape and colour. On the topic of colour reproduction of 3D printing, he believes that it is the poor colour uniformity of 3D printing systems, which affects overall printing quality. A research team at the National Taiwan University of Science and Technology are working on this issue, including print multi-directional colour charts, creating a look-up table for 3D objects and gamut mapping.

The final presentation was given by Dr Ching Seong Tan to introduce his work on 3D image acquisition modalities to multi-view image/video colour data format conversion and the quality control. He summarised the technological requirements for 3D-Imaging modalities that affect the 3D imaging quality from various imaging process, such as: acquisition, transmission, storage, processing and display. He iterated that 3D imaging modalities are not just for visual effect, but also fall into the needs of quantitative evaluation. In order to maintain and minimize the quality degradation during the imaging processes, he suggested a colour data format conversion of 3D multi-view image/video for 2D/3D displays, and to take into account their effect on 2D/3D image and colour quality.

Discussions

After each presentation, questions and comments were raised and discussed. Finally, general discussions were drawn on the challenge of 3D WYSIWYG reproduction. As Dr Lin addressed, due to large uniformity problem, it is desirable to take into consideration of 3D geometry in both 3D image capturing and 3D colour printing. Both speakers and participants discussed the importance of 3D texture information to quality of 3D reproduction. For 3D colour printing, material information is very important and needs to be taken into account in the reproduction system. Clearly, there is limitation of applying CIE colour difference formula to predict colour difference between 3D object. Professor Ronnier Luo proposed that a large psychophysical experiment needs to be looking at and described some preliminary work currently ongoing in his research team.

At end of the workshop, Dr Po-Chieh Hung, director of CIE Division 8, described that this topic is of great interest to CIE Division 8 and encouraged researchers to work closely with this topic. Professor Youngshin Kwak, director of CIE Division 1, suggested establishing a new joint focus group between CIE division 1 and CIE division 8 and scheduling regular meetings for this topic.

Summary

The CIE Division 8 workshop provided the opportunity for a diverse group of researchers to come together and discuss a hot research topic: colour image reproduction for 3D printing. In order to take full advantage of the wide range of perspectives, the presentations were brief, and the focus of the workshop was on discussion and networking, as means to develop greater understanding between the different parties to create opportunities for collaboration.