

WORKING GROUP ON CONTROLLING LIGHT POLLUTION *(GROUPE DE TRAVAIL POUR CONTROLE DE LA CONTAMINATION LUMINEUSE)*

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1. Priorities for Protection of Existing and Potential Astronomical Sites from Light Pollution

A small working group of a dozen individuals, most working part time, obviously cannot take on the whole, planetary-wide responsibility for controlling light pollution alone. Key elements of our approach therefore include:

- (1) form alliances to cover as much of the ground as possible,
- (2) choose areas where our own expertise and experience can be most valuable and
- (3) set clear priorities for pragmatic action at sites chosen for their existing and potential value to world-wide, ground-based astronomy.

This report is adapted from an article to appear in a book on the conference on controlling light pollution, held in La Serena, Chile in March, 2002. Extensive web references are given here to powerpoint presentations from that conference.

2. Alliances Covering Prime Observing Sites

To cover as much ground as possible, members of the International Dark Sky Association (IDA) who are also members of our IAU working group (iauwg) have been encouraging heavy use of the world-wide web. The IDA web page (<http://www.darksky.org>) is now the world's leading source of information on controlling light pollution. Most of the IDA web-based material is in English. This helps get the message out world-wide. In particular it helps provide access for educators and authorities having control over areas around prime observatory sites in Hawai'i, the Southwest United States and elsewhere.

The iauwg gives highest priority to protection of Mauna Kea:

<http://www.cfht.Hawaii.edu/ObsInfo/IslandLights/>

and of the northern part of Chile, particularly an East-West strip stretching across the country between Cerro Paranal and the ALMA site in the Chajnantor plateau area at ~ 5000m altitude above sea level near San Pedro de Atacama (<http://www.eso.org/alma/site/>).

There is thus also a special need for web-based material in Spanish. Following the lead of Spain's OPTC and helped by its most active member, iauwg member Javier Diaz del Castro (e.g. <http://www.iac.es/proyect/optc/law.htm>) we were able to help set up a somewhat similar organization in Chile, the Oficina de Proteccion de la Calidad del Cielo del Norte de Chile, OPCC (<http://www.opcc.cl>).

Our group has also been working with the U.S. New Initiatives Office (NIO) "Sites" program which is seeking suitable locations for new Extremely Large Telescopes (ELTs) in the 30-100m diameter range. This site work includes comparison of parameters of existing

and potential sites primarily in Hawaii, Mexico, South-Western United States and Northern Chile. We are also beginning to work more closely with ESO's search for a "Nest for the OWL" (ESO's 100-m Overwhelmingly Large telescope). For a collection of relevant Power-Point presentations related to the properties of these sites, see:

<http://www.ctio.noao.edu/sitetests/WorkShopOct2001/meeting.html>

3. Working Group Members: Activities, Expertise and Experience

The most important contribution so far is "The First World Atlas of the Artificial Night Sky Brightness" by Cinzano, Falchi and Elvidge

<http://arxiv.org/abs/astro-ph/0108052>

(Pierantonio Cinzano is a member of the iauwg). This quantitative map of the status of light pollution in the late 1990's is a fundamental point of reference for the global mission of the Working Group. The Group's highest priority for the medium term is to help find ways to fund a second such Atlas to provide a ten-year baseline (1997-2007) and thus aid identification of rates of change of light pollution. This will help bypass the considerable uncertainties involved in purely population-based models. Studies of large cities in Italy have shown that although their populations are stable, light pollution continues to grow at rates of up to 8% or so each year. Skies over the Atacama desert are more likely to be lit by mines than by cities. A second "World Atlas of the Artificial Night-Sky Brightness" would assist the iauwg and the world's astronomers in estimating lifetimes for existing and potential observatory sites.

The International Dark-Sky Association (IDA), including two of its Board members and its Executive and Associate Directors, is particularly strongly represented on the IAU working group. The IDA embraces work that goes well beyond even the direct mission of IAU Commission 50, and is our best current route to reaching out to influential allied groups outside the world of astronomy. A fine example is Elizabeth Alvarez del Castillo, who, in addition to being a (new) member of the iauwg, is also Associate Director of the IDA with a strong educational background and is one of two elected representatives of the International Lighting Commission (CIE) for liaison with the IAU. Another iauwg member, Margarita Metaxa, is very active in international educational networks as well as being the current chairperson of the IDA's Educational Working Group:

<http://www.darksky.org/wrkgrups/eduwg.html>.

That group's mission is to: "Develop an interdisciplinary program to include Light Pollution awareness at all levels of education involving both science and social aspects. Develop programs that would integrate into the teacher's curriculum and programs at all levels in schools, universities, general public/teachers, including lighting projects, biology, and science/social issues". A summary of her recent work is at:

<http://www.ctio.noao.edu/~emond/lpc/m-metaxa.ppt>.

The other CIE representative on the iauwg, Nigel Pollard, is a lighting engineer with special expertise in countryside lighting (<http://www.detr.gov.uk/planning/litc/03.htm>) in the United Kingdom (which complements Pierantonio's studies of large cities in Italy). His expertise has helped in iauwg efforts to reach out to biologists and help influence the UK Government (most recently its Environment Agency) to take an increasing role in controlling light pollution.

The iauwg has astronomers working in three top-priority areas for site protection, Mauna Kea (Richard Wainscoat, <http://www.ctio.noao.edu/~emond/lpc/r-wainscoat.ppt>), Northern Chile (Malcolm Smith, <http://www.ctio.noao.edu/~emond/lpc/m-smith.ppt>) and the South-West United States (David Crawford, <http://www.darksky.org>). As mentioned earlier, efforts to control light pollution in Chile are being led by the OPCC.

The primary technical/engineering advisor to the OPCC (and to the Chilean Government) on controlling light pollution is iauwg member and IDA Lighting Award winner, Prof. Enrique Piraino. Enrique heads the illumination laboratory in the School of Engineering

at the Catholic University of Valparaiso. His engineering work formed the basis for the national-level "Norma Luminica" which has the force of law in controlling light pollution in the astronomically-sensitive 2nd, 3rd and 4th regions of Chile.

4. Priorities for Future Work by the iauwg

The iauwg has to be quite selective in what its individual members take on. Most of us can only work in this field as part-timers at best. Nevertheless, by careful selection of areas of work, our group members have been able to produce enormous leverage on the use of our time. We decided last March, during the conference on light pollution in La Serena <http://www.opcc.cl/> led by the iauwg, that our priorities for new work in addition to the ongoing work described above will be as follows:

1. Seek ways to support the production of a "Second World Atlas of the Artificial Night Sky Brightness".
2. Investigate the consequences of the International Telecommunication Union (ITU) becoming involved in the regulation of frequencies between 20 and 375 THz (15 microns and 0.8 microns, the infrared and (red) optical spectrum. Seek how best to combine these initiatives with work being done by the IAU in conjunction with the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS).
3. Seek ways to monitor the artificial night sky brightness from key existing and potential observatory sites, as a complement to the modelling of satellite-based measurements.
4. Develop more quantitative experience on financial savings from the use of quality lighting in regions around key existing and potential observatory sites.
5. Extend international educational outreach programs based around light pollution - including teacher exchanges and the use of videoconferencing.

Working-group members are already active in each of these areas.

4.1. The Second World Atlas

Work on this is stalled for lack of money to support access to the DMSP archive (Elvidge) and to support the work of Cinzano and Falchi in Italy in turning these more recent data into a second atlas. Much of the initial effort here is directed towards seeking new sources of funding.

4.2. The International Telecommunication Union

Annex 1 to ITU.R.S.[Doc. 4/65] "Technical and operational characteristics of satellites operating in the 20-375 THz band (15-0.8 μm)", a draft document from ITU Working Party 4A notes that: "The term 'radio waves' is defined in the ITU Radio Regulations as "Electromagnetic waves of frequencies arbitrarily lower than 3,000 GHz propagated in space without artificial guide". With the increased pressure for use of the radio spectrum and the advancement of technology, more attention is being given to the use of frequencies above 3,000 GHz for free space telecommunications. Telecommunication links have become a reality in the frequency bands above 3,000 GHz as a result of many recent technological developments in optical communication devices such as optical fibre, solid state lasers (GaAs, InP), modulators (electro-optic modulators) and detectors (photodiodes). Free space telecommunication at frequencies above 3,000 GHz has the ability to support data rates in the tens of Gb/s as well as meet gain and directivity requirements of beams used for deep space applications. For telecommunications, attention is being focused on frequencies in the band 20-375 THz (15-0.8 μm). Though some links have been demonstrated, much of the technology for these links is still in development but evolving rapidly. Such links can provide telecommunication

signals on Earth-to-space, space-to-Earth, and space-to-space paths as well as on terrestrial links. They are being considered for satellites in geostationary orbit (GSO) as well as those in non-geostationary orbit (non-GSO) such as low Earth orbits (LEO). Technical and operational characteristics are required for the free space telecommunication links operating in these spectral regions for use in future sharing studies. The specifications and operations of some systems in this region are described in the following sections.”

The IAU has so far been seeking to work mainly with the United Nations Committee on the Peaceful Uses of Outer Space (UN-COPUOS) in controlling the increasing number of potentially serious sources of light pollution from space. André Heck’s talk at the La Serena conference set down a list of such sources. Our iauwg has begun to consult with Commission 50 and the central IAU authorities concerning an appropriate response to the ITU initiatives. As viewed from the perspective of at least some members of the US WP 7D:

- The emissions from space will occur.
- They will either be regulated by the ITU (which has looked after radio astronomy fairly well) or by some unknown third party with a weaker or non-existent track record in achieving at least some degree of rational control and sharing of the electromagnetic spectrum. Or -
- They will not be regulated at all.

Representatives of their Working Party firmly believe that the best course of action is for the IAU and its working group to join with them to seek to optimise use of this part of the spectrum long before it becomes a more serious issue.

4.3. Monitoring Sky Brightness from Ground-Based Observatories

TASCA and PASCA (all-sky cameras) are being brought on-line:

<http://www.ctio.noao.edu/~david/tasca.htm>

for monitoring light pollution above Cerro Tololo and Cerro Pachon. It is hoped that these cameras will be seen as cost-effective aids to similar monitoring of the skies above other key observing sites. (CTIO expects to continue observatory support of this initiative, as part of AURA’s ongoing commitment to contribute at least 1% of its operating budget in Chile in support of controlling light pollution over Cerro Tololo and Cerro Pachon and other sites it may become interested in).

Educational aspects of this effort include star counts in schools and communities around major observatories, following the lead provided in Austria by N. Zeitlinger

<http://www.ctio.noao.edu/~emond/lpc/n-zeitlinger.ppt>

The Chilean schools network “RedLaSer” plans such an experimental star-counting exercise initially around Cerro Tololo and Cerro Pachon, including local towns and cities. These data can eventually be compared with satellite maps of artificial night-sky brightness in the region (e.g. <http://www.ctio.noao.edu/~emond/lpc/f-falchi.ppt>).

4.4. Pragmatic Engineering Studies in Regions around Key Observatories

Work in Chile and in other astronomically-sensitive regions of the world have been mentioned above (towards the end of Section 2). Current follow-up projects include involving moving local authorities to work more closely with lighting professionals to adopt quantitative approaches towards quality lighting.

The Municipality of La Serena has opened its financial records of expenditures on lighting so that pragmatic studies can be made of energy savings and the results of various approaches to lighting key areas of the city within the strict confines of a very limited municipal budget. Several local suppliers of lighting systems are co-operating with these

insitu tests. The Municipality of La Serena has also announced that it will incorporate the requirements of the Chilean "Norma Luminica" (DS686) into municipal master plans such as its "Plan Regulador". More advanced lighting experiments are being planned for selected blocks in the town of Vicuña, including the use of dual LPS and white light fixtures and evaluation of social response to these installations as part of a professional study being led by Enrique Piraino. The work of the OTPC in the Canary Islands, led by iauwg member Javier Castro, has been the inspiration for the street lighting experiments in Vicuña. Such work is vital if poor Chilean towns and villages are to be given reasonable guidance on how to comply with the requirements of the new lighting legislation. This legislation begins to have major impact on municipal budgets in 2005. Accurate financial studies of that impact are in their infancy, so this is a major project being led for the OPCC by its Director, Pedro Sanhueza and by iauwg member Enrique Piraino.

4.5. International Education Networks

Leadership in setting up the first international schools network based on education in light pollution (between Canada, Greece and the United Kingdom) was provided by iauwg members Margarita Metaxa and John Percy. Margarita Metaxa has recently been participating in the European netd@ays on-line program and the global Hands-on Universe program

<http://hou.lbl.gov/global/>,

as well as serving as chairperson of IDA's Educational Working Group

<http://www.darksky.org/wrkgrups/eduwg.html>

The capabilities offered by videoconferencing over IP have opened up enormous potential for live, broadcast-quality communication between schools. Within the context of a sister-city program set up by the wife of one of our iauwg members, children and teachers have met over a videoconferencing system which exists between the Gemini telescopes in Hawaii and Chile. Three teachers from the island of Hawaii will visit Chile in March, 2003 in the context of the Gemini-sponsored StarTeachers program

http://www.ctio.noao.edu/AURA/redlaser/STT_01.html

<http://www.gemini.edu/project/announcements/press/2002-12.html>.

Three teachers from La Serena will visit Hawaii later in 2003. This kind of program based on Internet2 connectivity will be extended to include teacher exchanges within the framework of some form of Project ASTRO (<http://www.noao.edu/education/astrotucson.html>) in the United States. Much will be learned about the complexities of working between cultures and across language barriers during this initial effort. The US National Optical Astronomy Observatory's Public Affairs and Educational Outreach Program is proposing inclusion of funding for bilingual international schools networking in the specific context of light pollution as part of its budget submission to the United States National Science Foundation in 2004.

Acknowledgments. I would like to thank each and every one of the members of our Working Group for their hard and productive work on behalf of astronomy and on behalf of the environment.

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Chairperson of the Working Group