Submission of Feedback by the Night Sky Brightness Research and Monitoring Group of the Institute of Space Sciences and Astronomy (ISSA), University of Malta

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1 Introduction

On the 23rd of June, 2020, the Environment and Resources Authority (ERA) and the Planning Authority (PA) published draft guidelines for the reduction of light pollution in the Maltese Islands. The Night Sky Brightness Monitoring group (within the Institute of Space Sciences and Astronomy of the University of Malta) reviewed these much needed and welcome guidelines, which we find to be aligned with the call we made in a study published in early 2020 underlining 'the requirement for a nationwide strategy on light pollution' [2].

This document presents a number of recommendations for these guidelines as part of the call for public consultation.

2 Recommendations

2.1 Street lighting

2.1.1 Interpretation of EN13201-1:2014

Sec. 6.10 makes reference to EN13201-1:2014 in regard to street lighting. The current document does not capture the fact that the EN13201-1:2014 guidelines are not legally binding in themselves, which failure may result in misinterpretation of this standard, leading to over-lighting of roads (as has indeed been the case in certain locations in Malta, resulting in a detrimental 11× increase in NSB [2]). It is important that the guidelines reflect the fact that the same CEN/TR 13201-1:2014 ('Road lighting - Part 1: Guidelines on selection of lighting classes'; abstract) states that:

> The decision on whether a road should be lit is defined in the national road lighting policy. This varies by country or municipality. Specific guidelines are usually available at national level for each country. This Technical Report does not give the criteria on which a decision to light an area can be made, nor on how a lighting installation should be used.

2.1.2 Reference to EUR 29631 EN

In the present document, there is no reference at all to EUR 29631 EN ('Revision of the EU Green Public Procurement Criteria for Road Lighting and traffic signals') [3] of the Joint Research Centre (JRC), the European Commission's science and knowledge service. Consequently, there is no indication whatsoever that its recommendations will be followed. **It is important that this failing is addressed accordingly.** Here, it is pertinent to highlight some salient points from this document. EUR 29631 EN states (with the emphasis being their own):

> ***The standard [13201-1:2014] only provides recommendations on road class definition and associated lighting levels - it is not legally binding per se.*** [3, p. 6]

Consideration of this proviso is especially relevant to a situation like Malta's, where high levels of light pollution are found across the entire archipelago. The country's small size effectively means that light pollution in one zone can easily impact the rest of the Islands. In fact, it ought to be mentioned that zoning has repeatedly been flagged as having limited effectiveness due to the widespread reach of skyglow (e.g. [3, p. 60]), in particular in situations that follow regulations on the ratio of upward light output (R_{ULO}) as in Malta's

Policy GZ-UTIL-5. This mandates practical solutions which are appropriate to the local scenario, following strict adherence to the ALARA (As Low As Reasonably Achievable) principle, which is discussed further below. A case in point that illustrates the importance of this aspect is provided by the Dark Sky Heritage Areas (DSHAs) in Gozo. The lower night sky brightness in these areas is primarily due to two factors: (1) remoteness from urban zones, and (2) being coastal areas, in the direction facing the sea there is a void of artificial lighting. Despite this, light pollution is encroaching even upon these sites, with a brightness gradient having been established (see Sec. 3.2 and Fig. 3 of [2]).

EUR 29631 EN also makes note of the overly bright standards:

> In fact, the EN 13201 lighting levels in general are considered as very high by many stakeholders, especially for the higher class roads. [3, p. 7]

Criticism of alignment with the same EN 13201 by stakeholders also led the JRC to state:

> However, JRC emphasised that the alignment of the scope with EN 13201-2 does not in any way imply that the EN 13201-1 guidance for setting lighting levels for each road class are to be followed or complied with by procurers who wish to apply the EU GPP criteria. [3, p. 17]

2.1.3 The ALARA principle and the LIL Standard

As has already been mentioned, the document should refer and emphasise adherence to the ALARA (As Low As Reasonably Achievable) principle. The same principle is also encouraged by the JRC:

> In order to reduce light pollution, the selection of the class should always be made using the principle "As Low As Reasonably Achievable" (ALARA) at any moment of time. [3, p. 6]

Furthermore,

> The JRC encourage that procurers wishing to follow the EU GPP criteria follow the ALARA (As Low As Reasonably Achievable) principle when deciding on required lighting levels. [3, p. 17]

A number of countries, such as Germany, Italy and Slovenia, are already promoting the more ambitious Low Impact Lighting (LIL) standard, which Malta would do well to follow if it is to actively combat the present alarming levels of light pollution. A summary of the standard's requirements[1] is available in [3, p. 60]. Here we quote five especially important criteria:

[1] See: https://www.licht-und-natur.eu/lpec-in-eeb/standards-of-low-impact-lighting/

- CCT < 2200 K with less than 6% of total emission in the <500 nm range (except when average illumination is < 5 lx, where CCT can rise to 2700 K and < 500 nm emission can rise to 10%).
- ULOR [Upward Light Output Ratio] of 0.0% both when new and when dirty.
- Ban on lighting of any roads, exits, and junctions outside of settlements.
- Pole distance must be at least $3.7\times$ the pole height.
- Maximum luminance allowed is 0.5 cd/m^2 (i.e. no brighter than an EN 13201 compliant M5 class road).

The country's small size necessitates that the guidelines should strive to meet such criteria rather than settling for arbitrary minimum requirements.

2.2 Night Sky Brightness Data for the Maltese Islands, and recommendations thereon

The present document refers to 2016 predictive measurements [6] for the Maltese Islands (Sec. 3.4). However, it fails to take into account updated empirical figures published in [2]. This study[2] focusses specifically on the Maltese Islands, and presents local data collected in a uniform, high-resolution grid, resulting in a comprehensive ground-based map of the Night Sky Brightness (NSB); see Fig. 1.

Related to this, we note that the VIIRS panchromatic Day/Night band (DNB) is not sensitive below 500 nm,[3] which should be mentioned and borne in mind when interpreting Fig. 10 (Sec. 3.4) of the guidelines document, as current LED lighting in the Maltese Islands has a spectral energy distribution with a significant contribution in wavelengths < 500 nm (refer also to Fig. 4 of this document). In fact, even Sky Quality Meter (SQM) readings are expected to underestimate the perceived scotopic NSB, such that the measurements effectively represent an optimistic scenario (as pointed out in [2]).

Below, we summarise some of the salient points from the study which point to an urgent need to address the *present* situation (as opposed to only future applications and installations):

- Light pollution is *already* affecting DSHAs, with no zone exhibiting pristine dark skies.
- Light pollution is increasing year on year (refer to, e.g., Supplementary Fig. A.5).
- The Milky Way is visible for only 12.8% of the Maltese Islands.

[2] A preprint version is also available at: https://arxiv.org/abs/2002.04435.
[3] See, e.g., https://modaps.modaps.eosdis.nasa.gov/services/about/products/viirs-c1/VNP02DNB.html.

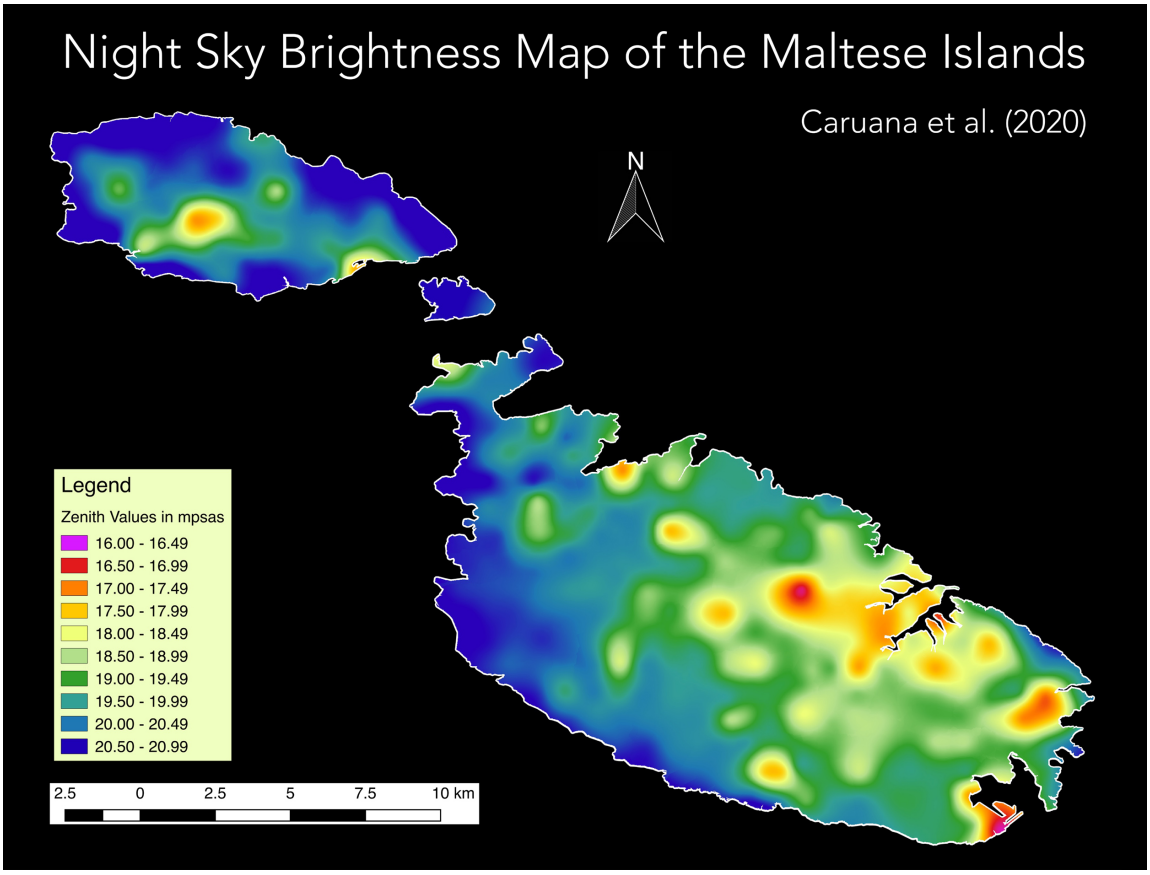

Figure 1: Map of the Night Sky Brightness of the Maltese Islands based on data collected in a 1 km^2 grid [2].

- Main sources of light pollution include public squares and monuments, churches, playgrounds, football grounds, harbours, showrooms, and excessive street lighting.
- Virtually all identified main sources of light pollution can be effectively mitigated.

We note that lighting in harbours is not mentioned at all in the present guidelines document, despite it being a major contributor to light pollution (as described in [2]). To provide but one example, Fig. 2 shows the prevailing situation in Mġarr Harbour (Gozo). While recognising the importance of adequate lighting in such sites, the requirement to follow good lighting practice holds. The situation in Mġarr Harbour is a prime example of ill-conceived, harmful lighting.

The study also made a number of recommendations, specifically:

Figure 2: Excessive, badly-designed, cluttered lighting at Mġarr Harbour, resulting in all three main forms of light pollution: skyglow, glare, and trespass. (Image: J. Caruana)

- In order to help protect DSHAs, a perimeter and ≈ 0.5 km buffer zone needs to be set up, wherein lighting would consist exclusively of Phosphor-Converted Amber LEDs with a CCT of 1700-2500 K (or equivalent); refer to the study's Supplementary Fig. A.11. (This is to be considered in tandem with an overall reduction in light pollution across the archipelago.)
- In Gozo, light pollution is worst in Victoria and Għajnsielem, and targeted efforts should be made to limit the spread of light pollution from these two areas.
- The site of Rdum Majjiesa, and the area between Rdum tal-Vigarju and Miġra l-Ferħa should be protected and added to the list of DSHAs.

Furthermore, preliminary analysis of data collected since the publication of this study indicates an alarming increase in light pollution in urban zones in Gozo within the space of just two years, which is quickly spreading to adjacent zones. This delineates the need for **urgent entrenchment of these guidelines into enforceable policy** that addresses *present* lighting. A good starting point would be the immediate commencement of a lighting curfew for public monuments, historical buildings, churches, showrooms, shop windows, and billboards. There are also a number of unnecessary lighting fixtures (e.g. badly-designed 'ornamental' up-lighters such as shown in Fig. 3) which should be banned immediately.

Figure 3: Badly-designed, unnecessary up-lighters illuminating trees along a promenade in Mġarr (Gozo), resulting in glare and skyglow. (Image: J. Caruana)

2.3 The Spectral G-index

The guidelines should include appropriate discussion of the spectral G-index, stressing the importance of aiming for G $\geq$ 2.0, especially in those areas that are deemed to be ecologically sensitive or important for astronomical observation. (Refer also to [7] and [3, p. 78].) While lowering the CCT is an important consideration, on its own it does not adequately address the problem since significant blue-green emission remains a serious issue (see Fig. 4). This ties to the aforementioned requirement to employ PCA LEDs, or Narrowband Amber LEDs (NBA LEDs), the latter peaking near 595 nm with a relatively narrow spectral width.

2.4 Miscellaneous points

- Sec. 3.4 should carry updated numbers from [2].
- Sec. 4.1 should include references to the findings of more recent studies, e.g. [1, 4, 5, 8] and others.
- Sec. 4.3 should emphasise the fact that the night sky is part of our collective cultural heritage. Its conservation is important not only for scientific and educational reasons, but also for the preservation of a long heritage of observation, permeating multiple aspects of our culture.

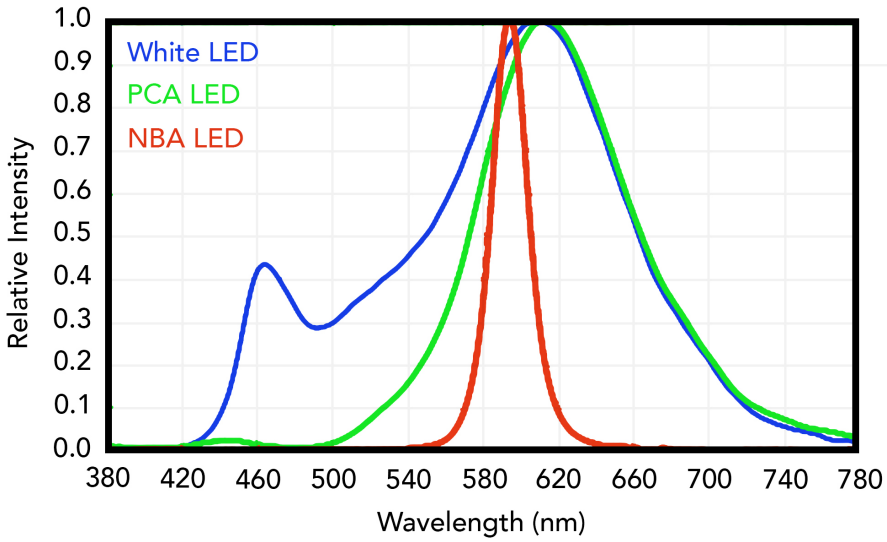

Figure 4: Spectra of a white LED with a CCT of 2700 K (blue), a PCA LED (green), and an NBA LED (red). Notice how despite having a CCT < 3000 K, the white LED spectrum still exhibits significant blue/green emission. (Image adapted from: http://www.flagstaffdarkskies.org/dark-sky-commercial-lighting-products/)

- Sec. 5.8 quotes the 'Good Practice Guidance G27', which excepts 'architectural lighting on historic structures' from the requirement of having 'downward-pointing, full cut-off' lighting. This represents a serious problem, in that such sites are often observed to contribute significantly to the NSB. The present guidelines should address this failing.
- Sec. 6 should include two other sources of light pollution: quarries and concrete batching plants (and other similar industrial sites); see Fig. 5. A recent trend has seen extremely bright lights being installed in such sites, which are left switched on all night long. The problem is exacerbated by the fact that these sites are often located in rural areas close to Dark Sky Heritage Areas. Resulting skyglow has been observed to affect sites such as Dwejra in Gozo. Such lighting should be banned.
- Sec. 6.8 proposes that a lighting report would be required for outdoor lighting in ODZ areas and in large developments. Malta is too small to target only ODZ areas and large developments. This requirement should be extended to all exterior lighting applications and include (as an example, but not limited to) lighting installations by local councils and any outdoor shop-lighting. The spread of light pollution can reach zones situated very far from the original source, and there needs to be a concerted effort to curb it across **the entire archipelago**; it is the only way that the rural

zones and coastal areas can be saved from light pollution's effects.

- Sec. 7 should make mention of monitoring. The regulations applying to Dark Sky Heritage Areas are oftentimes disregarded, especially during summer (see Fig. 6; this very problem is also showcased in Fig. 5 of the guidelines document itself). This period coincides with: (1) the time that young Yelkouan Shearwaters take flight, departing their nests at night, and (2) the best time for Milky Way observation. Ideally, such sites would be overseen by rangers (and this would benefit the site in general, not only in terms of guarding their DSHA status). At a minimum, frequent, unannounced spot-checks by the relevant authorities should be in place. At present, the ability to actually experience a dark sky in a DSHA is oftentimes a matter of luck (depending on the day-to-day activity at the site), such that DSHAs run the very real risk of being so only in name. The document should also mention that there should be clear signage indicating that a specified site is a DSHA, along with instructions of appropriate conduct (e.g. no use of bright torches and camping lanterns); this would help make casual visitors aware of the site's status.
- The present guidelines make no mention of offshore sources of light pollution.
- In general, the document should place more emphasis on the fact that myriad examples of bad lighting practice are **already existent** and that **present examples should be tackled**. Issues pertaining to ecological disruption, disturbance to astronomical observation, and human health are already present. Given that light pollution levels are already severe, present problems (as opposed to only future applications and installations) have to be addressed (in line with what is only hinted at on Page 3 of the guidelines document, i.e. 'reduce the light pollution currently being experienced on the Islands'). Otherwise, the prevailing situation will not improve, and present damage will persist.
- The permitted lighting levels in different situations (e.g. car parks, public squares, fuel service stations, etc.) should be quantified, in accordance with the ALARA principle and LIL standard.

Figure 5: An example of severe light pollution arising from bright lighting fixtures. (Image: J. Caruana)

3 Conclusions

The intention, scope, and spirit of the draft guidelines constitute an encouraging step, in that the existence of the problem of light pollution is acknowledged, and this is accompanied by an intention to address it. Besides the need for these guidelines be updated in order to reflect the points discussed in this document, there remains a major concern in regard to their effective implementation.

- As long as one speaks only of guidelines, it is highly doubtful that any significant improvement over the present situation will be registered, in effect only serving the purpose of awareness raising (which, while certainly welcome, has already been sustained by a number of organisations for many years). Authorities can do more than this. The present legal and policy framework (summarised in Sec. 5 of the guidelines) is too vague in respect to light pollution to provide concrete support for effective enforcement. In this respect, given the present situation, having only guidelines is wholly inadequate. These guidelines need to be entrenched in a dedicated policy on light pollution that is both binding and **enforceable**. In the absence of this, future adherence to such recommendations as indicated in the guidelines document will remain optional.

  Perhaps no clearer argument for the requirement of effective enforcement exists than simple consideration of the present situation in current DSHAs. Despite *already* be-

(a) Artificial lighting underneath Dwejra tower washing out the night sky.

(b) Artificial lighting at the Inland Sea and its environs; notice light reflecting off walls and facades.

Figure 6: Unchecked activity (July 2020) at the DSHA of Dwejra, with artificial lighting increasing the NSB and posing issues for nesting Shearwater. Both examples run contrary to the requirements of Policy GZ-DARK1. (Images: J. Caruana)

ing covered by policy, namely GZ-DARK-1 (which prohibits artificial lighting unless related to aerial or maritime navigation), regular use of lighting is made at these sites (see Fig. 6). That such overt contravention is present even in the presence of existing policy makes it amply clear that proper enforcement is direly needed.

Furthermore, these guidelines being a matter of discretionary choice would render action on **already existing** problems more difficult to undertake.

- We encourage the prioritisation of communication and coordinated action between all relevant government authorities, local councils, and the church environment commission to address **present lighting fixtures**. In order, the most practical way forward would be to:

    1. Commence a curfew practice without delay. Public monuments, squares, churches, billboards, school buildings, car parks, and showrooms can be amongst the first examples (amongst many others).

    2. Target severely offending sources for immediate action.

    3. Retrofit existing luminaires with better solutions; where not possible in the short term: (1) ensure that the mounting of current fixtures is properly adjusted to be aligned horizontally, and (2) implement appropriate filters as a temporary measure. The latter is a particularly pertinent point when it comes to road-lighting fixtures which, very unfortunately, have recently been converted to LEDs with no consideration to their colour temperature. This was a wasted opportunity (with longterm effects), for while clear awareness of the importance of this aspect is not a recent development, the spectral distribution was squarely ignored. **This underlines the necessity for other relevant authorities - specifically Infrastructure Malta and Transport Malta in this instance - to pay heed to the best available scientific evidence and observe environment-friendly lighting practices.** There needs to be mutual coordination between all authorities. Indeed, it is very regrettable that in this specific case, these guidelines come too late, because the authorities responsible for roadworks have already proceeded to install luminaires emitting blue-rich light across the entire archipelago.

- The small size of the Maltese Islands means that no site is immune from the effects of light pollution originating in other zones. This necessitates:

    1. The adoption and promotion of the ALARA principle, and

    2. A steady move towards the LIL standard.

We trust that these recommendations will be taken on board, and look forward to registering improvement in the prevailing situation as we continue to monitor the night sky

brightness of the Maltese Archipelago. There is an opportunity to implement effective regulation to curb this widespread problem, with everything to gain and nothing to lose. Mitigating light pollution is not a zero-sum game, and effective action is not difficult to implement, for the solutions are simple in nature. To this end, it is hoped that there is serious commitment by all entities and authorities involved. In the meantime, we remain available to offer assistance and guidance.

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