Safety Regulation Group

CAA Paper 2012/03

Specification for an Offshore Helideck Lighting System

www.caa.co.uk

Safety Regulation Group

CAA Paper 2012/03

Specification for an Offshore Helideck Lighting System

July 2012

ISBN 978 0 11792 712 4

Published July 2012
Re-Published July 2012 due to Pagination changes

Enquiries regarding the content of this publication should be addressed to:
Flight Operations 2, Safety Regulation Group, Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR.

The latest version of this document is available in electronic format at www.caa.co.uk/publications, where you may also register for e-mail notification of amendments.

Published by TSO (The Stationery Office) on behalf of the UK Civil Aviation Authority.

Printed copy available from:
TSO, PO Box 29, Norwich NR3 1GN
Telephone orders/General enquiries: 0844 477 7300
Fax orders: 0870 600 5533
www.tsoshop.co.uk
E-mail: caa@tso.co.uk
Textphone: 0870 240 3701

List of Effective Pages

INTENTIONALLY LEFT BLANK

Contents

Foreword

Executive Summary

Report

INTENTIONALLY LEFT BLANK

Foreword

This paper effectively represents the culmination of the CAA's helideck lighting research programme, funded by the CAA's Safety Regulation Group, the Offshore Division of the UK Health and Safety Executive, and Oil and Gas UK. The flight trials campaigns at the NAM K14 platform, Longside airfield and at Norwich Airport, reported in CAA Papers 2004/01, 2005/01 and 2006/03 respectively, provided the data and experience to enable a draft technical specification to be produced. The specification was then used to tender for the production of prototype lighting systems for installation on offshore helidecks for in-service trials to validate the specification.

The revised perimeter lighting has already been adopted by ICAO as a new minimum international standard for a touchdown and lift-off area (TLOF) lighting system in Annex 14 Vol.II, effective from 01 January 2009. In addition, the Touchdown/Positioning Marking circle and Heliport Identification Marking ('H') lighting forms an acceptable alternative to floodlighting in these specifications. The CAA believes that the new lighting scheme represents a significant safety enhancement over traditional floodlighting and is updating its guidance material to replace floodlighting with the new scheme.

At the time of publication of this paper, however, the final version of the circle and 'H' lighting has yet to be evaluated. The existing guidance on floodlighting systems will therefore be retained in CAP 437 in an appendix to facilitate the retention of existing systems as a back-up to the new lighting to support the transition. This paper will be updated to include the results of the evaluation of the final version of the circle and 'H' lighting and re-published. The guidance on floodlighting will be removed from CAP 437 once the specification for the circle and 'H' lighting has been fully validated and at least one viable production system is available for installation.

INTENTIONALLY LEFT BLANK

Executive Summary

Starting in 1995, the UK CAA has conducted a number of dedicated offshore and onshore trials aimed at identifying ways of improving the lighting of offshore helidecks. This initiative was born out of concerns within the industry that were highlighted further in an independent offshore helicopter pilot opinion survey reported in CAA Paper 97009.

Three main problems exist with current helideck lighting systems:

- The location of the helideck on the platform is often difficult to establish due to the lack of conspicuity of the perimeter lights.
- Helideck floodlighting systems frequently present a source of glare and loss of pilots' night vision on deck, and further reduce the conspicuity of helideck perimeter lights during the approach.
- The performance of most helideck floodlighting systems in illuminating the central landing area is inadequate, leading to the so-called 'black hole' effect.

A series of three dedicated trials were conducted at the NAM K14B satellite in the southern North Sea during 1998/9 which established the basis of a new helideck lighting scheme. This scheme was tested and refined during two dedicated flight trials performed at an onshore site (Longside airfield) during 2002. A third series of trials were then conducted at Norwich Airport to establish the detail of the lighting scheme to support the production of a specification.

These trials were completed in 2004, and a specification was drafted. Prototype systems were manufactured to meet the specification and installed on the Perenco Thames A platform in the southern North Sea and the Centrica CPC-1 platform in Morecambe Bay. The lighting systems were subjected to in-service trials to evaluate their performance in a representative offshore environment, over a range of meteorological conditions, and to expose the system to a larger number of pilots.

For various reasons the trials were not as extensive as had been expected, but the results obtained are nevertheless very encouraging. The main issue arising from the trials was that provision for increasing the intensity of the circle and 'H' lighting would be desirable to accommodate platforms with high levels of cultural lighting and/or helidecks with high luminance LED perimeter lights. Some issues regarding the durability of the lighting system were also experienced during the trials. The reasons for the problems encountered are understood and a production version of the system with these weaknesses designed out is being developed. The production version of the system is presently being manufactured and tested and it is hoped to install this equipment on the CPC-1 for further demonstrations and in-service evaluation.

In view of the very positive results obtained to date, the positive feedback received from the Oil and Gas UK Helicopter Task Group, and AAIB safety Recommendation 2011-053, the CAA is adding the new lighting to its best practice guidance material contained in CAP 437, in the 7th edition of the document.

The CAA will encourage all operators of offshore helidecks to implement the new lighting scheme once final validation of the specification has been completed and at least one viable production system is available for installation.

INTENTIONALLY LEFT BLANK

Report

1 Introduction

1.1 Overview

1.1.1 This report provides a recommended technical specification for an offshore helideck lighting system in support of the CAA's best practice guidance material published in CAP 437 "Offshore Helicopter Landing Areas - Guidance on Standards" [7]. The development of the system is described along with the production and validation of the associated technical specification.

2 Background

2.1 General

2.1.1 The UK CAA has, for a number of years, been seeking to improve the performance of lighting schemes on offshore helidecks. The existence of scope for improvement was common knowledge within the industry, but the results of an offshore helicopter pilot questionnaire-based survey [1] added impetus and helped to focus efforts.

2.1.2 The questionnaire survey was actually performed in connection with a study of the pilot workload associated with the completion of flight deck paperwork, i.e. load and balance, and fuel planning. All aspects of offshore helicopter operations were covered, however, partly for camouflage (and, thus, to maximise objectivity) and partly in order that any problems relating to pilot workload could be better set in context.

2.1.3 Six of the 53 questions in the questionnaire related to helideck lighting. For each question, respondents were asked to score statements on a scale of one to ten. Top level analysis of the scores submitted by the pilots indicated that, of the 15 aspects of offshore operations covered by the questionnaire, helideck lighting at night was ranked 6th in terms of contribution to pilot workload and 4th highest in terms of contribution to safety hazards. These results are considered to support the case for improvement to offshore helideck lighting.

2.1.4 Respondents were also invited to submit written comments for a number of the questions. A total of 475 written comments were submitted for the six questions relating to helideck lighting and are reproduced in Appendix E of [2]. Review of these comments identified the following three main areas of concern:

- The location of the helideck on the platform is difficult to establish due to the lack of conspicuity of the perimeter lights - the yellow perimeter lights and white flood lights blend in with the yellow and white lighting widely used for general offshore installation lighting.
- The performance of most helideck floodlighting systems in illuminating the central landing area is inadequate, leading to a lack of visual cues and the so-called 'black hole' effect.
- Helideck floodlighting systems are frequently a source of glare and loss of pilots' night vision on the deck, and further reduce the conspicuity of the helideck perimeter lights during the approach.

2.1.5 In view of the very good response rate (73%) to the survey, the results are considered to be robust and representative. The task of solving the three main deficiencies identified by the questionnaire survey was therefore adopted by the CAA as the primary objective of its research into helideck lighting systems.

2.1.6 Although some aspects of lighting are well understood, the overall effectiveness of lighting schemes depend on the environment in which they are required to operate and also the vagaries of human visual perception, neither of which are well defined. The research programme therefore initially took an empirical approach and comprised a number of offshore and onshore flight trials. The three main sets of trials were:

- the offshore trials conducted at the NAM K14B platform in the southern North Sea;
- the onshore trials performed at Longside Airfield near Aberdeen;
- the onshore trails performed at Norwich Airport.

2.1.7 The trials were used to evaluate different schemes and concepts but had to make use of existing available lighting products and prototype samples. Although good enough for demonstration purposes, this equipment was not necessarily suited to the application. Having established the scheme, it was therefore necessary to then apply the theory to produce a specification that could be used by the industry to produce and install optimised systems. The specification then needed to be validated to 'close the loop' prior to incorporation in any guidance or standards.

2.2 NAM K14B Trials

2.2.1 These trials were performed during 1998/99 using a S-76 helicopter chartered from Bristow Helicopters, and are reported in [2]. During these trials, the following changes to the current standard helideck lighting were evaluated:

- Changing the colour of the standard perimeter lights from yellow to green.
- Using green electro luminescent panel (ELP) lighting in lieu of the standard perimeter lighting.
- Illuminating the inner and outer edges of the Touchdown/Positioning Marking circle with yellow light-emitting diode (LED) strips.
- Illuminating the 'H' in the centre of the landing area with green ELP.
- Adding hoods to the floodlights.
- Turning the floodlights off.

2.2.2 These changes were applied in a number of combinations, and the relative benefits were assessed by means of questionnaires that were completed at the end of each approach by the trials pilots while the next lighting configuration was being set up. Ratings for presentation and workload were awarded by the pilots on a ten-point scale. Each of the three trials commenced with an approach to the standard lighting configuration (yellow perimeter lights and floodlights without hoods), which was pre-allocated mid-scale workload and presentation ratings of five in order to 'calibrate' the pilots.

2.2.3 The main overall conclusions of this work were that:

- changing the colour of the perimeter lights from yellow to green greatly increased the conspicuity of the helideck and extended the acquisition range;
- illuminating the inner and outer edges of the Touchdown/Positioning Marking circle with yellow light-emitting diode (LED) strips significantly enhanced the visual cueing environment from the final approach through to touchdown;

- illuminating the 'H' in the centre of the helideck with green ELPs significantly enhanced the visual cueing environment during the final approach;
- the floodlights, with or without hoods, degraded the conspicuity of the helideck during acquisition and were a source of dazzle or glare to the pilots while the helicopter was on the deck.

2.2.4 The recommended lighting configuration for providing a significantly enhanced visual cueing environment derived from these trials was; green incandescent perimeter lights, yellow LED strips illuminating the inner and outer edges of the Touchdown/ Positioning Marking circle, green ELP illuminated 'H', and no floodlights. A photograph of this configuration taken during the trials is presented in Figure 1. Note that the 'floodlighting' visible in the photograph is stairwell lighting, i.e. part of the platform lighting and not helideck floodlights.

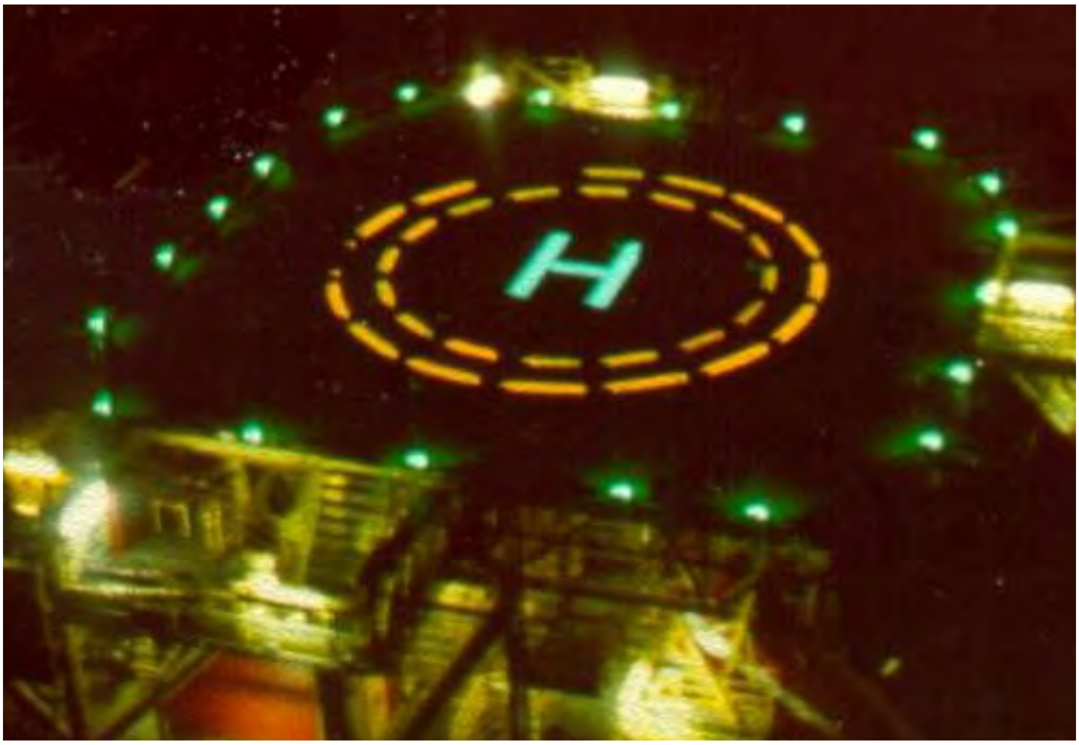

Figure 1 Photograph of preferred lighting configuration as determined by the trials performed at the NAM K14B platform [2]

2.3 Longside Airfield Trials

2.3.1 The preferred configuration from the K14B trials was installed at Longside Airfield near Aberdeen, UK, for further experimentation. This onshore location was chosen to avoid the significant logistical difficulties associated with conducting offshore trials. These trials were performed during 2002 using a S-76 helicopter chartered from CHC Scotia Helicopters and are reported in [3].

2.3.2 The main aims of these trials were to evaluate a single lit Touchdown/Positioning Marking circle (as opposed to a double circle), an outline 'H' (instead of a solid 'H'), and the effect of a helideck net on the various lighting configurations. If adequate, a single lit circle and an outline 'H' would be significantly less expensive to provide which would assist implementation of the final scheme.

2.3.3 Two trials were completed during 2002, one without a helideck net installed and one with. The overall conclusions of these trials were:

- Without a net, a single ring of yellow LED strips around the Touchdown/Positioning Marking circle was found to be adequate, and it was judged that this should be located mid-way between the inner and outer edges of the yellow painted marking.
- Without a net, an outline ELP 'H' was found to be better than the solid version.
- With a net fitted, there was a greater preference for two rings of yellow LED strips than was the case without the net.
- With a net fitted, the solid 'H' was much better than the outline version.

2.3.4 Further experimentation was required but the lack of suitable aircraft near to Longside, due to the relocation of the S-76 fleets, necessitated a move to a new location at Norwich Airport.

2.4 Norwich Airport Trials

2.4.1 A new test bed was then installed at Norwich Airport to continue the trials work started at Longside Airfield. These trails were performed during 2003/4 using a Eurocopter AS355 'Twin Squirrel' helicopter chartered from Sterling Helicopters and are reported in [4].

2.4.2 The overall objective of this series of trials was to further improve and refine the revised helideck lighting system, obtain the information required to characterise the Touchdown/Positioning Marking circle and 'H' lighting, to evaluate the suitability of a number of current products and try out some new ideas. A total of six trials were completed and the 'highlights' included the following:

- Green perimeter lights meeting the revised vertical intensity distribution were evaluated and were favourably received by the trials pilots. No adverse effects of the increased intensity were noted.
- A minimum acceptable baseline for the yellow LED Touchdown/Positioning Marking circle was established in terms of coverage (length of LED segments vs. length of gaps), LED density and LED intensity.
- An outline 'H' formed using laser driven optical fibre was trialled and found to perform much better than the existing ELP 'H'; this technology is more affordable, more robust and the on-deck hardware is completely inert.
- An LED Obstacle Free Sector (OFS) chevron marker was evaluated and found to be useful, but only during the very final stages of the approach and landing. The cueing provided was not considered to match that provided by the ELP 'H'.
- The effect of vertical approach profile on the range of the LED Touchdown/ Positioning Marking circle was investigated and useful results obtained.
- The application of laser driven optical fibre to illuminate the helideck net was trialled, but the result was considered to be too artificial or synthetic by the pilots.
- The effects of a helideck net on the key lighting configurations were evaluated, and no significant problems were encountered.
- The effect of rain on the cockpit windows was evaluated and found to be insignificant if not non-existent.

2.4.3 Together with the findings of the two earlier trials, these results enabled the new helideck lighting scheme to be finalised as described in the next section.

2.5 The New Helideck Lighting Scheme

2.5.1 The helideck lighting scheme established from the three sets of trials comprises:

- Green perimeter lighting located around the edge of the helideck, with the same layout as the current scheme but with changes to the characteristics of the individual lights.
- A lit yellow Touchdown/Positioning Marking circle superimposed on the current yellow painted marking.
- A lit green Heliport Identification marking superimposed on the white painted 'H'.
- No floodlights.

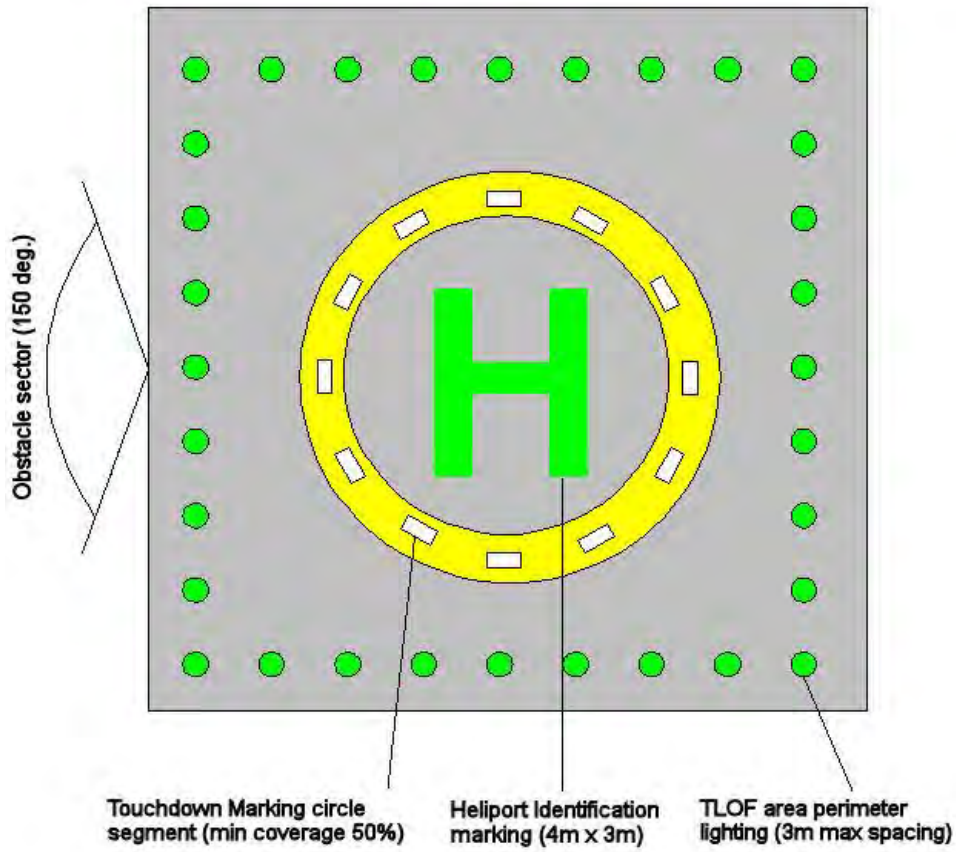

Figure 2 Schematic of the new helideck lighting scheme

2.5.2 Figure 2 presents a schematic of the preferred configuration as agreed by the ICAO Visual Aids Panel.

2.5.3 The green perimeter lighting solves the problem of locating the helideck on the offshore installation by providing a good colour contrast. The pattern formed by the perimeter lighting forms the largest visual cue and is the first that the pilot will see during the approach. The perimeter lights provide visual cues throughout the approach and landing.

2.5.4 Between them, the lit circle and 'H' markings address the lack of visual cues in the centre of the helideck. Being physically larger, the circle provides good visual cues earlier in the approach than the 'H'. The pilot derives range and approach path cues from the size and shape of the ellipse formed by the circle. Additional range cues are obtained from the gaps between the segments and then the gaps between the individual light elements within the segments as they become distinguishable as the approach progresses.

2.5.5 These cues are supplemented by the 'H' at closer ranges which provides the heading cues missing from the axially symmetric circle. The straight lines and vertices of the 'H' also provide good cues during the latter stages of the approach and especially while translating to the hover over the helideck. The 'H' also locates the 210° obstacle free sector, the cross bar of the 'H' being aligned with the bisector of the obstacle free sector.

2.6 Finally, the problems of glare and/or loss of night vision are solved by the removal of the floodlights. The absence of the floodlights also improves the conspicuity of the perimeter lights.

NOTE: It is recognised that on some platforms it may be desirable to retain the floodlights for providing illumination for on-deck operations such as refuelling. In such cases, the floodlights should be turned off for the approach, landing and take-off. In addition, particular care should be taken to maintain correct alignment to ensure that they do not cause dazzle or glare to the pilots while the helicopter is on the helideck.

3 Derivation of the Specification

3.1 Specifying Helideck Lighting Intensity

3.1.1 General

3.1.1.1 The three main factors that determine the intensity of the lighting required are:

- the helicopter approach profiles and procedures;
- the background lighting environment in which it has to work;
- the meteorological conditions in which it has to work.

3.1.1.2 Although some account of the approach profiles and procedures could be taken, it was not possible to reproduce a representative offshore lighting environment at the Longside or Norwich Airport test sites, and it was not possible to control the weather during any of the trials. It was therefore necessary to apply the established theory to the trials results to take due account of all of these factors.

3.1.2 Calculation of Intensity

3.1.2.1 An important parameter is the range at which the pilot needs to be able to see the lighting which has a direct influence on the minimum intensity required. The visual range of a light is given by Allard's Law, which shows that the brightness of a light will reduce as the inverse square of the range of the observer from the light, and will decay exponentially as a function of atmospheric attenuation (visibility). The equation used to define Allard's Law is:

$$I = E_t\, R^2/e^{-\sigma R}$$

where:

I = Intensity of the light unit (Candelas).

E_t = Eye Illumination threshold (lux).

NOTE: The value of E_t depends on the background brightness and the probability of detection. The ICAO Annex 3 Attachment D value for a typical night of $E_t = 10^{-6.1}$ has been assumed in the absence of data relevant to offshore platforms.

R = Visual range of a light in the specified conditions of E_t and σ.

σ = Extinction coefficient (m^{-1}). This represents the atmospheric attenuation.

NOTE: Using ICAO Annex 3 Attachment D, the extinction coefficient σ is given by:

$$\sigma = 2.996/M$$

where:

M = Meteorological Visibility or Met Vis (M).

3.1.2.2 Remembering the issue of dazzle and glare identified from the questionnaire survey [1], it is also necessary to ensure that the lighting is not too bright at any point during the approach and landing.

3.1.3 Coverage in Azimuth

3.1.3.1 Given that approaches to offshore installations must be performed substantially into wind, helicopters can, in principle, approach the helideck from any direction. It follows, therefore, that the specified intensity of the helideck lighting pattern must be maintained for all angles of azimuth.

3.1.4 Coverage in Elevation

3.1.4.1 In the absence of instrument guidance, helicopter approaches to offshore platforms are conducted visually and are therefore subject to variability in terms of their vertical profiles. In order to try to quantify the flight paths which the lighting should accommodate, data from 271 night approaches to 52 different offshore platforms was made available by Bristow Helicopters from their Helicopter Operations Monitoring Programme (HOMP) - see [5] and [6]. Figure 3 shows the mean and the range of the vertical profiles as defined by this data set.

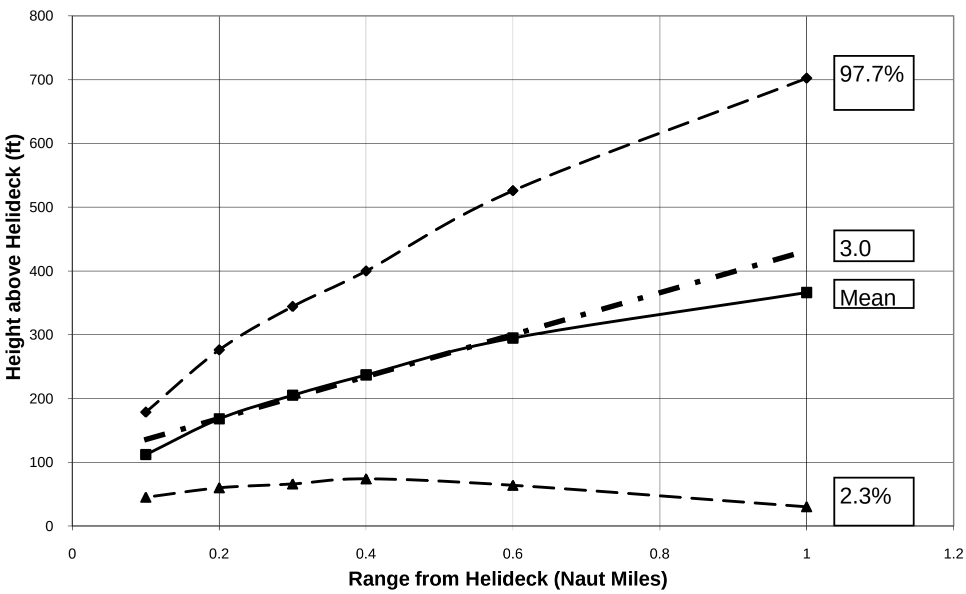

Figure 3 Vertical flight paths of helicopter visual approaches to offshore platforms at night

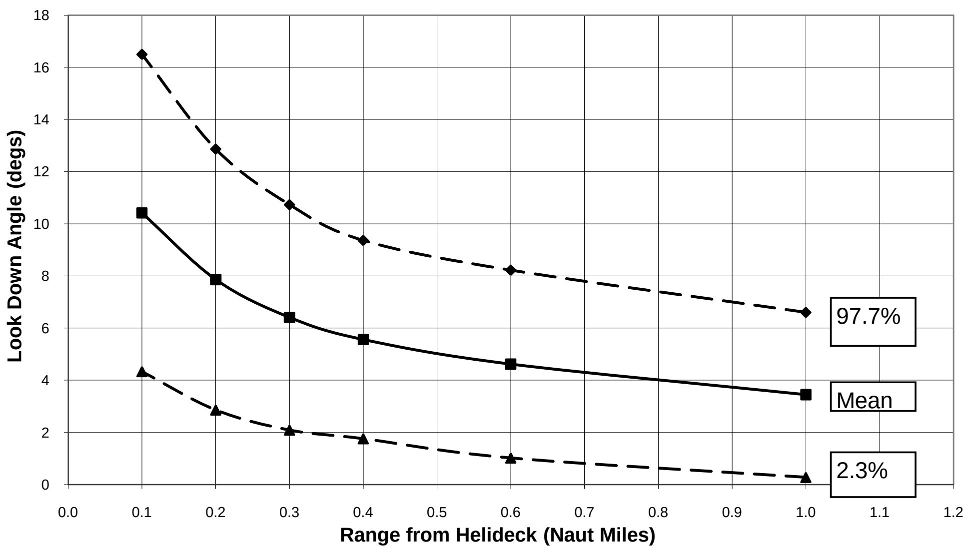

Figure 4 Look down angles (elevation of helicopter from helideck lights) for helicopter visual approaches to offshore platforms at night

3.1.4.2 In Figure 4, these data are translated into the equivalent 'look down' angle, which is identical to the angle of elevation of the helicopter from the helideck and hence the helideck lighting.

3.1.4.3 It is immediately clear that the elevation of the helicopter varies markedly with range from the helideck. Since the intensity required for a light to be visible to the pilot also varies with range, it follows that the minimum required intensity of the lighting will vary with the elevation of the helicopter. By controlling the distribution of intensity of the helideck lighting as a function of elevation, it is possible to ensure that the lighting is bright enough to be seen at longer ranges (lower elevations) without causing dazzle or glare at closer ranges (higher elevations).

3.2 Perimeter Lighting

The specification of the perimeter lighting for the new helideck lighting scheme is described in detail in Appendix A of [3].

3.2.1 Colour

3.2.1.1 A clear conclusion of the experimental work was that a good colour contrast between the helideck perimeter lighting and the installation 'cultural' lighting is necessary for adequate location of the helideck. Green was chosen because:

- it indicates a safe environment;
- it was found to be very conspicuous during the trials - it provides a good colour contrast and there is currently no other green lighting on offshore installations;
- the human eye is particularly sensitive to green light.

3.2.1.2 Inspection of the three definitions of 'green' in the international standards [7] indicates the appropriate colour coordinates to be:

yellow boundary $x = 0.36 - 0.08y$

white boundary $x = 0.65y$

blue boundary $y = 0.39 - 0.171x$

3.2.2 Intensity

3.2.2.1 In terms of intensity, the operational requirement is defined by the need for the pilot to be able to clearly see the lighting under the most onerous viewing conditions likely to be encountered in service. In the case of the helideck perimeter lights, these conditions are defined by the operating minima comprising the minimum decision range of 0.75 NM, and the minimum operating meteorological visibility of 0.75 NM. Applying these values for visual range (R) and meteorological visibility (M), together with a value of $10^{-6.1}$ for the eye Illumination threshold (E_t) to Allard's law yields an intensity of 31 cd.

3.2.3 Coverage in Azimuth and Elevation

3.2.3.1 As explained in Section 1.3, the specified intensity of the helideck lighting pattern must be maintained for all angles of azimuth.

3.2.3.2 Inspection of Figure 4 indicates that intensity established in Section 2.2 should be maintained for elevations from just above the horizontal to around 7.5 degrees as a minimum. Higher elevations are encountered at shorter viewing ranges where less intensity is required. The minimum intensity required for elevations above 7.5 degrees can be calculated using the range and elevation data from the upper curve in Figure 4.

3.2.3.3 At the time the specification was being developed, it had been recognised that the existing helideck perimeter light specification in the ICAO standards [8] was inappropriate, and discussions within the ICAO Visual Aids Panel had already resulted in a proposed new specification. The original and revised ICAO specifications are presented together with the specification detailed in Appendix A of [3] in Figure 5.

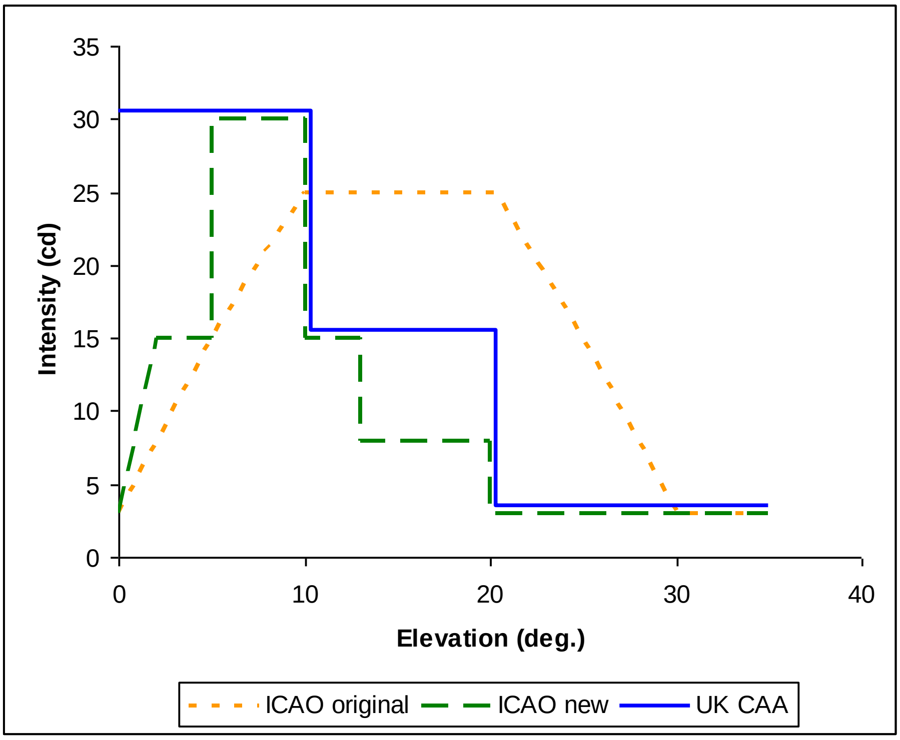

Figure 5 Comparison of perimeter light intensity distributions (original and new ICAO, and the UK CAA)

3.2.3.4 As well as stipulating yellow light, the original ICAO specification (orange dotted line) provides insufficient intensity at elevations below about 8 degrees, and significantly more than is necessary at elevations between 10 and 30 degrees. The new ICAO specification (green dashed line), which was developed for onshore heliport applications as much as for offshore helidecks, specifies the green light found to be very effective during the UK trials and is much improved in terms of intensity distribution. The minimum intensity at the lowest elevations, however, is still arguably insufficient for use offshore, although the specification does note that the main beam may need to be extended down to the horizontal for some applications.

3.2.3.5 The specification being developed in the UK (blue solid line) was adjusted to either meet or exceed the proposed new ICAO specification at all angles of elevation. In addition, in order to avoid glare a maximum intensity of 60 cd was adopted for all angles of elevation and azimuth. This figure was taken from a study performed in The Netherlands by TNO Human Factors [9], and was validated during the trials at Norwich Airport [4].

3.2.3.6 The UK specification is identical to the new ICAO specification in all other respects, and the final specification adopted for CAP 437 [10] is detailed in Table 1 below. Note that no need to change the existing requirements in respect of the number and spacing of helideck perimeter lights was identified by either the UK trials or by ICAO.

Table 1 New CAP 437 helideck perimeter light intensity specification

Elevation	**Intensity**	
	Min	**Max**
0° - 10°	30 cd	60 cd
>10° - 20°	15 cd	60 cd
>20° - 90°	3 cd	60 cd
Azimuth	-180° to +180°	

3.3 Touchdown/Positioning Marking Circle

3.3.1 General

3.3.1.1 The basic concept of the lit Touchdown/Positioning Marking circle was established during the first set of trials at the K14 [2], but the majority of the work on the detail of this aspect of the lighting scheme was undertaken during the Longside Airfield [3] and Norwich Airport [4] trials. The circle design parameters investigated were:

- the number and location of circles;
- the proportion of the circle that was lit (coverage);
- the density of light sources within the segments forming the lit circle;
- the intensity of the lit circle.

3.3.1.2 Although it was only practical to evaluate a limited number of permutations of the circle design during the trials, it is considered that the results are sufficiently conclusive to be used with some confidence. It was concluded from the results of the three trials that the lit circle should meet the following requirements:

- it should comprise one or more concentric circles each of at least 16 discrete lighting segments; a single circle should be positioned at the mean radius of the painted circle; multiple circles should be symmetrically disposed about the mean radius of the painted circle.

- the lighting segments should be of such a length as to provide coverage of between 50% and 75% of the circumference, and be equidistantly placed with the gaps between them not less than 0.5 m.
- the lighting segments should comprise a number of lighting elements, spaced no less than 3 cm and no greater than 10 cm.
- in order to mitigate the effects of a landing net, the width of the segments should not be less than 40 mm.

3.3.1.3 Although the precise design of the circle is not critical to its effectiveness, it was noted that the benefits of the scheme following deployment in-service will be maximised if the cueing is consistent from one helideck to the next. It therefore follows that it is desirable for the above constraints to be placed on the design of the circle to ensure an appropriate degree of consistency.

3.3.2 Colour

3.3.2.1 The obvious choice of colour for the circle would be to match the colour of the yellow painted circle. Discrimination of the yellow circle from any yellow cultural lighting on the platform is not an issue here because:

- the circle is located in a dark area separated from the platform lighting;
- the circle is delineated from the platform lighting by the green helideck perimeter lighting; and
- the distinct pattern of the circle provides contrast against the general platform lighting.

3.3.2.2 Inspection of the international standards [7] indicates the appropriate colour coordinates to be:

red boundary	$x = 0.382$
white boundary	$y = 0.79 - 0.667x$
green boundary	$y = x - 0.12$

3.3.3 Intensity

3.3.3.1 As regards intensity, it was established during the Norwich Airport trials [4] that the minimum range at which the circle should be visible to the pilot should be 0.5 NM. Given this visual range (R), the minimum operating meteorological visibility (M) of 0.75 NM and an eye Illumination threshold (E_t) of $10^{-6.1}$, the intensity required of a point source of light can be calculated using Allard's law as for the perimeter lights.

3.3.3.2 However, the Touchdown/ Positioning Marking circle is too large to qualify as a point source and there is no known methodology for calculating its effective intensity. In the absence of any better information, the results of some empirical research performed by deBoer on narrow rectangular lights were used to calculate the required intensity for a single circle segment. This involved calculating the minimum point source intensity required using Allard's law, and then multiplying the result by a 'Rectangular Shape Factor' to produce the minimum total segment intensity. The 'Rectangular Shape Factor' is a function of the angle subtended by the segment at the eye of the observer as follows:

$$\text{Shape Factor} = [\tan^{-1} (60 \cdot L/R)]^{0.6}$$

where:

L = Length of circle segment (m).

R = Visual range (m).

NOTE: The relationship established experimentally by deBoer was at a background luminance of 300 Nits, which equates approximately to $E_t = 10^{-5.0}$. This is a little inconsistent with the value of E_t used elsewhere for this work ($E_t = 10^{-6.1}$), but produces a conservative result.

This assumes that the segment is being viewed 'broadside' where the light emitted by the segment will appear most spread out to the observer, i.e. the worst case. The minimum total segment intensity therefore varies as a function of segment length as follows:

$$\text{Intensity} = E_t \cdot R^2/e^{-\sigma R} \, [\tan^{-1} (60 \cdot L/R)]^{0.6}$$

3.3.3.3 The relationship for R = 0.5 NM, M = 0.75 NM and $E_t = 10^{-6.1}$ is shown graphically in Figure 4. Note that the minimum segment length compliant with the minimum gap size of 0.5 m and the minimum circle coverage of 50% is 0.5 m. A segment length of 2.5 m would correspond to a helideck 'D' value (see [7]) of at least 30.5 m and therefore represents the likely maximum length in practice.

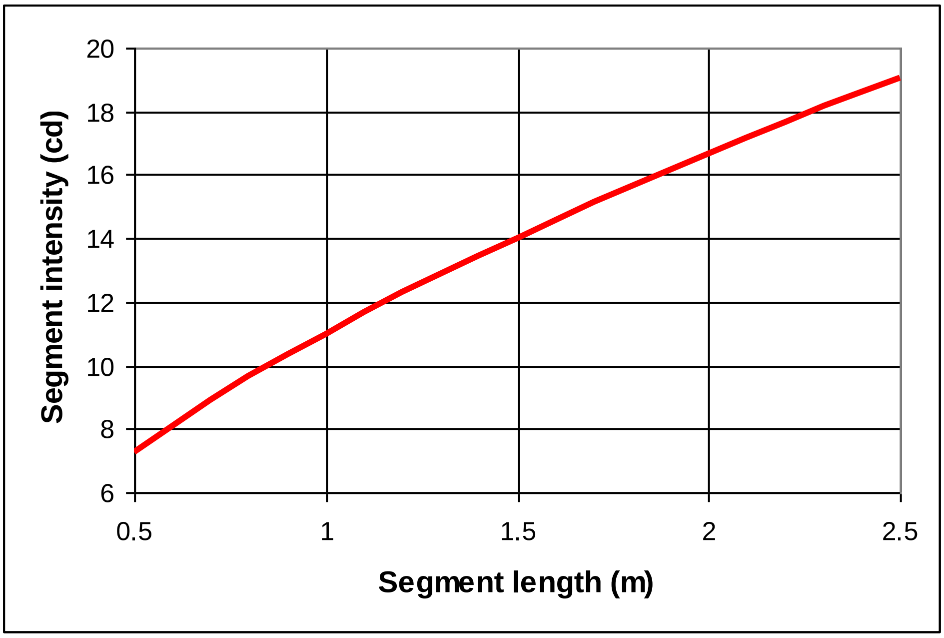

Figure 6 Variation of minimum Touchdown/ Positioning Marking circle segment intensity with segment length

3.3.3.4 Hence, the circle segment length is first established from the circle diameter, the number of segments and the coverage, and the total segment intensity is then calculated. The intensity of each light element (e.g. LED) within the segment is then simply the total required segment intensity divided by the number of light elements. The number of light elements is determined from the segment length and the spacing of the light elements (i.e. between 3 and 10 cm).

3.3.4 Coverage in Azimuth

3.3.4.1 Given the axial symmetry of the circle, it follows that the circle will automatically be visible from all angles of azimuth. However, since the visual cueing provided by the circle depends on the pilot being able to see the whole of the circle, it is necessary for the minimum segment intensity determined by Section 3.5 to be maintained for all angles of azimuth.

3.3.4.2 Since this may be difficult to achieve in practice (e.g. due to the need for cable entry/exit provisions), the light intensity for each of the lighting segments specified in Section 3.5 need only be maintained over the range + 80° to - 80° from the normals (i.e. the normals to the sides of the segment that will form both the inside and outside edges of the circle) to the longitudinal axis of the strip.

3.3.4.3 This range of azimuth has been derived by considering the worst case which is represented by the configuration with the smallest change in orientation of the segment longitudinal axis from one segment to the next (i.e. largest circle with largest number of strips). A 22 m helideck with a mean circle diameter of 12 m and a segment length of 0.5 m, results in 36 segments and a change in orientation from one segment to the next of 10°. Hence no more than two segments (at the 3 o'clock and 9 o'clock positions) will ever be viewed from outside the + 80° to - 80° range. This is considered satisfactory.

For the remaining angles of azimuth of + 10° to -10° either side of the longitudinal axis of the segment, the maximum intensity should be as defined in Table 2 below.

Table 2 Touchdown/Positioning Marking circle segment intensity specification

Elevation	Intensity	
	Min	Max
0° - 10°	As a function of segment length as defined in Figure 6.	60 cd
>10° - 20°	25% of min intensity >0° to 10°	45 cd
>20° - 90°	5% of min intensity >0° to 10°	10 cd
Azimuth	-80° to +80°	-90° to +90°

* Measured from normals to longitudinal axis of circle segment.

3.3.5 Coverage in Elevation

3.3.5.1 The minimum segment intensity at the minimum acquisition range of 0.5 NM should be as specified in Section 3.5. Referring to Figure 4, this value of intensity should be maintained for elevations from around 1 degree up to about 8 degrees as a minimum. Higher elevations are encountered at shorter viewing ranges where less intensity is required or wanted (risk of glare). Consideration of these factors resulted in the specification detailed in Table 2 above.

3.3.5.2 The maximum 'main beam' intensity of 60 cd in Table 2 derives from [9] as for the perimeter lights. The maximum intensities at higher elevations are, to some extent, arbitrary, but are based on practical design considerations and the overall aim for the luminance of the perimeter lights to be equal to or greater than that of the Touchdown/Positioning Marking circle segments.

3.4 Heliport Identification Marking ('H')

3.4.1 General

3.4.1.1 Illuminating the 'H' marking in the centre of the helideck was one of the ideas tried out during the first set of trials at the K14 [2]. The initial configuration comprised a 'filled' 'H' lit using electro-luminescent panels (ELPs). This was assessed further in outline form also using ELPs during the Longside trials [3]. Finally, a laser illuminated 'leaky' optical fibre version of an outline 'H' was evaluated at Norwich [4].

3.4.1.2 In the absence of a helideck net, there was no strong preference for either the 'filled' or the outline 'H', but with a net the filled 'H' was preferred. A firm conclusion, however, was that the lit 'H' should be the same size as the 4 m x 3 m painted 'H' regardless of which version is used. The dimensions of the 'filled' and outline 'H' are shown schematically in Figures 7 and 8 respectively.

Although both forms of 'H' would perform satisfactorily, it was considered desirable that the scheme utilised just one in the interests of standardisation and the benefits that it confers. The outline 'H' was selected partly because it was expected to be significantly cheaper to produce, and partly due to concerns regarding the large lit area of the filled 'H' for which it would be difficult to achieve and maintain the minimum required helideck friction.

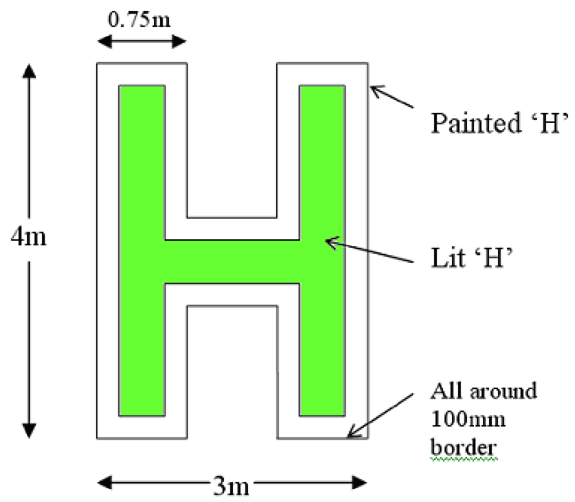

Figure 7 Filled' 'H' marking

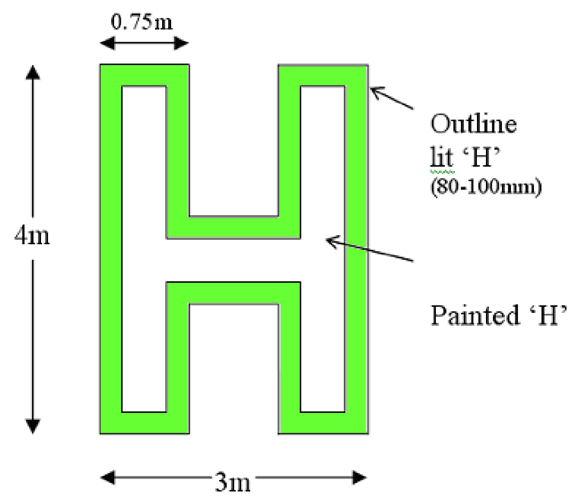

Figure 8 Outline form of 'H' marking

3.4.2 **Colour**

3.4.2.1 The obvious choice of colour for the lit 'H' marking might have been white to match the colour of the painted 'H'. At the time of the trials, however, no suitable lighting technology was available to provide a lit white 'H'. Green ELP was therefore used partly due to its availability, but also for the same reasons that green was chosen for the helideck perimeter lights, i.e. the good colour contrast against the installation cultural lighting.

3.4.2.2 As for the perimeter lights, the appropriate colour coordinates in the international standards [7] are:

yellow boundary $x = 0.36 - 0.08y$

white boundary $x = 0.65y$

blue boundary $y = 0.39 - 0.171x$

3.4.3 **Intensity**

3.4.3.1 In terms of intensity, it was established during the Norwich Airport trials [4] that the minimum range at which the 'H' marking should be visible to the pilot should be 0.25 NM. The required intensity for the 'H' can be calculated in the same manner as the Touchdown/Positioning Marking circle segment, i.e. using a visual range (R) of 0.25 NM, the minimum operating meteorological visibility (M) of 0.75 NM, an eye illumination threshold (E_t) of $10^{-6.1}$, and the deBoer Rectangular Shape Factor. The segment length assumed for the calculation of the shape factor is the 4 m edge of the 'H'. This yields a minimum intensity for the 4 m edge of the 'H' at the minimum acquisition range of 0.25 NM of 3.5 cd.

3.4.4 **Coverage in Azimuth and Elevation**

3.4.4.1 For the reasons stated in Section 1.3, the values of intensity detailed in Table 3 below should be maintained for all angles of azimuth.

Referring to Figure 4, the value of intensity derived in Section 4.3 should be maintained for elevations from around 2 degrees up to about 12 degrees as a minimum. Higher elevations are encountered at shorter viewing ranges where less intensity is required or wanted (risk of glare). Consideration of these factors resulted in the specification detailed in Table 3 below.

Table 3 Heliport Identification marking (4 m edge) intensity specification

Elevation	**Intensity**	
	Min	**Max**
2° - 12°	3.5 cd	60 cd
>12° - 20°	0.5 cd	30 cd
>20° - 90°	0.2 cd	10 cd
Azimuth	-180° to +180°	

3.4.4.2 The maximum 'main beam' intensity of 60 cd in Table 3 derives from [9] as for the perimeter lights. The same maximum intensity has been adopted for the circle and the 'H' at higher elevations as the relatively low intensity of the lighting and the close range of the helicopter renders any discrimination unimportant. The maximum intensities at higher elevations are, to some extent, arbitrary, but are based on practical design considerations and the overall aim for the luminance of the Touchdown/ Positioning Marking circle segments to be equal to or greater than that of the 'H'.

4 Validation of the Specification

4.1 General

4.1.1 The specification described in the foregoing sections has been derived from a mixture of empirical and theoretical studies. In addition, much of the trials work was performed in an unrepresentative lighting environment, in a very limited range of meteorological conditions, and by a small number of pilots. It was therefore considered necessary to perform a final check of the specification prior to incorporating it in the standards and guidance material.

4.1.2 Normal aviation practice is to conduct an in-service trial where a prototype of the new lighting scheme is installed on an offshore installation and feedback on its performance collected via aircrew questionnaires. In view of its location in the centre of the helideck, an additional important aspect of the circle and 'H' lighting that needs to be evaluated is the durability of the equipment in this harsh environment.

4.1.3 The specification for the new scheme was therefore tendered to a number of helideck lighting manufacturing companies and, following a bid evaluation and selection process, contracts were awarded to two competing companies. It was considered desirable for the trial to be conducted using two independent lighting system solutions. Firstly, this would enable two different solutions to be evaluated and hence maximise the probability of a successful outcome. Secondly, it would avoid a single company dominating the market at the end of the trial. This latter point was of particular concern since the CAA cannot directly mandate the improved lighting system, and it was feared that a monopoly situation could act as a deterrent to industry take-up. Unfortunately, one of the companies failed to make satisfactory progress and their contract had to be terminated and the project continued with a single company, AGI Ltd.

4.1.4 The contract awarded to AGI Ltd was to initially produce one prototype system. The equipment was designed, manufactured and tested, and was installed on the Perenco Thames A installation in the southern North Sea. This system had to be replaced with a modified version and a third system was commissioned and installed on the Centrica CPC-1 platform in Morecambe Bay.

4.2 In-Service Trials at the Perenco Thames A Platform

4.2.1 General

4.2.1.1 The installation of the system on the Thames A was completed at the beginning of February 2007. A photograph of the system installed on the Thames A is presented in Figure 9 below, with photographs of a Touchdown/Position Marking circle segment and the Heliport Identification Marking ‘H’ in Figures 10 and 11 respectively.

Figure 9 AGI prototype lighting system on the Thames A

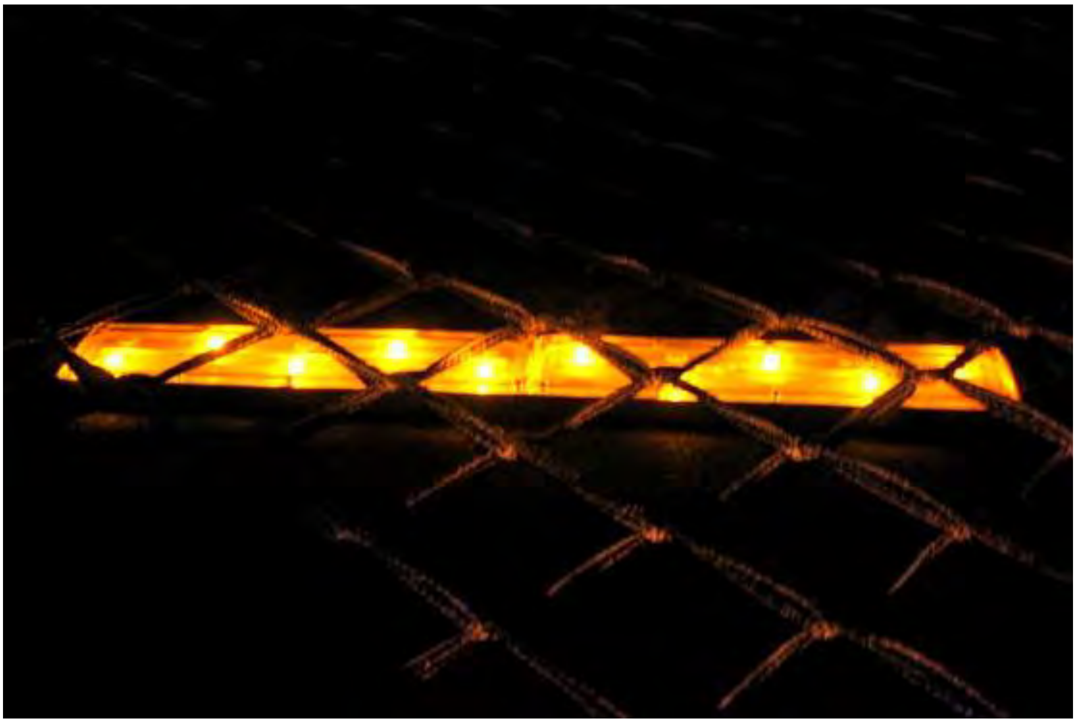

Figure 10 Touchdown/Positioning Marking circle segment on the Thames A

Figure 11 Heliport Identification Marking ('H') on the Thames A

4.2.2 Initial Trials

4.2.2.1 The trials proforma (see Appendix A) was issued to CHC Scotia at North Denes, the helicopter operator, shortly after the installation had been completed but, unfortunately, only three reports had been received by the end of the winter 2006/7 night flying season. The initial feedback provided by the proformas was somewhat mixed. The results are summarised in Table A1 in Appendix A.

4.2.2.2 At 0.25 NM, the range of the Touchdown/Positioning Marking circle was rated lower than the design aim of 0.5 NM for two out of the three approaches (proformas 1 and 3), although only one of these two pilots considered this to be too late in the approach (proforma 3). Interestingly, the approach for which the range of the circle was considered to be satisfactory was performed by a pilot who only occasionally visited the platform; it would be expected that the improved visual cueing would be more useful to pilots who are less familiar with the platform.

4.2.2.3 The Heliport Identification Marking ('H') performed as anticipated having a useable range of 0.25 NM for all three approaches. All pilots considered this to be satisfactory, and this is in accordance with the design aim.

4.2.2.4 As regards the overall ratings, two pilots awarded maximum ratings (proformas 1 and 3) and the other felt that the system did not represent a significant improvement. Curiously, the pilot who considered the performance of the circle inadequate (proforma 3) rated the system more highly than the pilot who found it useable at the design minimum range of 0.5 NM (proforma 2).

4.2.2.5 Turning to the comments, the most positive feedback was received from the pilot who was least familiar with the platform (proforma 1). The pilot who was a regular visitor and gave the lowest overall ratings (proforma 2) noted that it might be of greater benefit in conditions of low visibility. In addition, the comments made by the other pilot who was familiar with the platform (proforma 3) imply that he thought the lighting would be more useful on satellite platforms where the visual cueing environment is poorer.

4.2.3 Dedicated Trial

4.2.3.1 A Sikorsky S-76 helicopter was chartered from CHC Scotia Helicopters and a dedicated trial was performed in July 2007 for the benefit of ICAO Heliport Design Working Group, Visual Aids and Offshore Sub-Group members. During this trial it was noticed that the green 'H' appeared brighter than the Touchdown/Positioning Marking circle which was unexpected. Subsequent tests established that the LEDs used to produce the circle segments and the 'H' did not conform to the LED manufacturer's specification sheet. In particular, the yellow LEDs used for the circle segments were only about half the required intensity at low angles of elevation where the intensity requirement is highest. This had not been detected during the production of the system as no photometric testing of the panels had been performed, this in order to expedite installation in a bid to take advantage of the winter 2006/7 night flying season.

4.2.3.2 A replacement system was subsequently produced and installed on the Thames A in April 2008 which, unfortunately, was after the end of the 2007/8 night flying season. Leading up to the 2008/9 night flying season, the system suffered from water ingress to the electrical connectors despite them being specified to be IP66 rated. An attempt to rectify the problem by replacing the connectors with potted in-line splices was made but the rework resulted in damage to the panels and further water ingress. Despite several attempts to rectify the problem, the system never remained serviceable for long enough to conduct any further evaluations and the trial was discontinued.

4.2.4 Conclusions

4.2.4.1 It was established that the Touchdown/Positioning Marking circle initially installed did not meet the specification and the mixed feedback obtained is thus entirely understandable. The 'H' appeared to perform satisfactorily but this result should be treated with caution as the photometric characteristics of the 'H' were not in accordance with the specification.

4.2.4.2 Despite the unrepresentative performance of the lighting, the comments received from the pilots participating in the in-service trial and the observers who attended the demonstration flight were generally positive.

4.2.4.3 It was concluded that the system showed good promise, but that a further in-service trial was required using a system confirmed to meet the photometric specification and of a design that is more resistant to water ingress.

4.3 In-Service Trials at the Centrica CPC-1 Platform

4.3.1 General

4.3.1.1 The installation of the system on the CPC-1 was completed at the beginning of February 2009. A photograph of the system installed on the CPC-1 is presented in Figure 12 below, with photographs of a Touchdown/Positioning Marking circle segment and the 'H' in Figures 13 and 14 respectively.

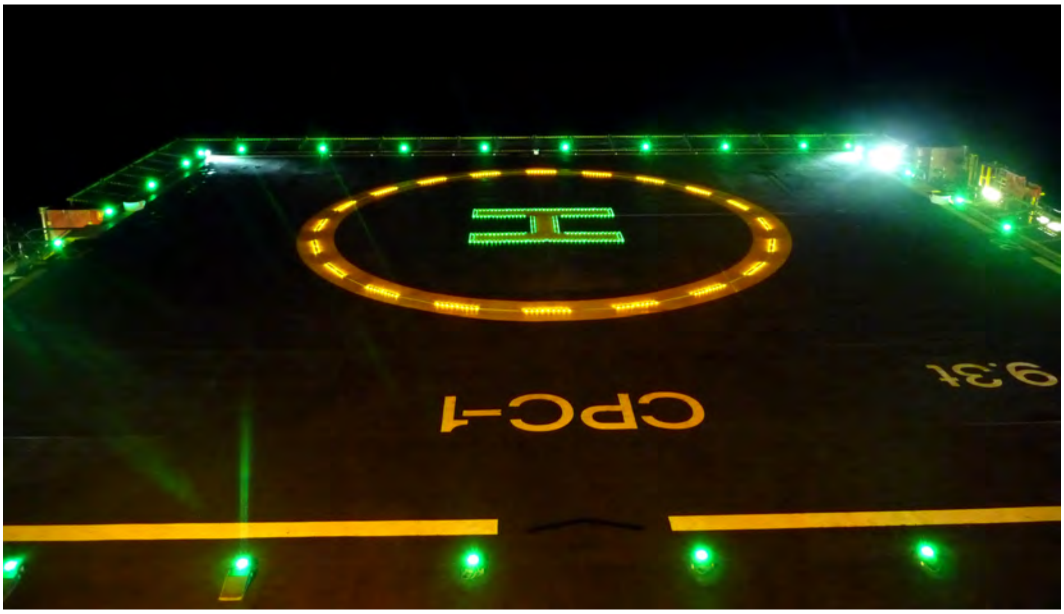

Figure 12 AGI prototype lighting system on the CPC-1

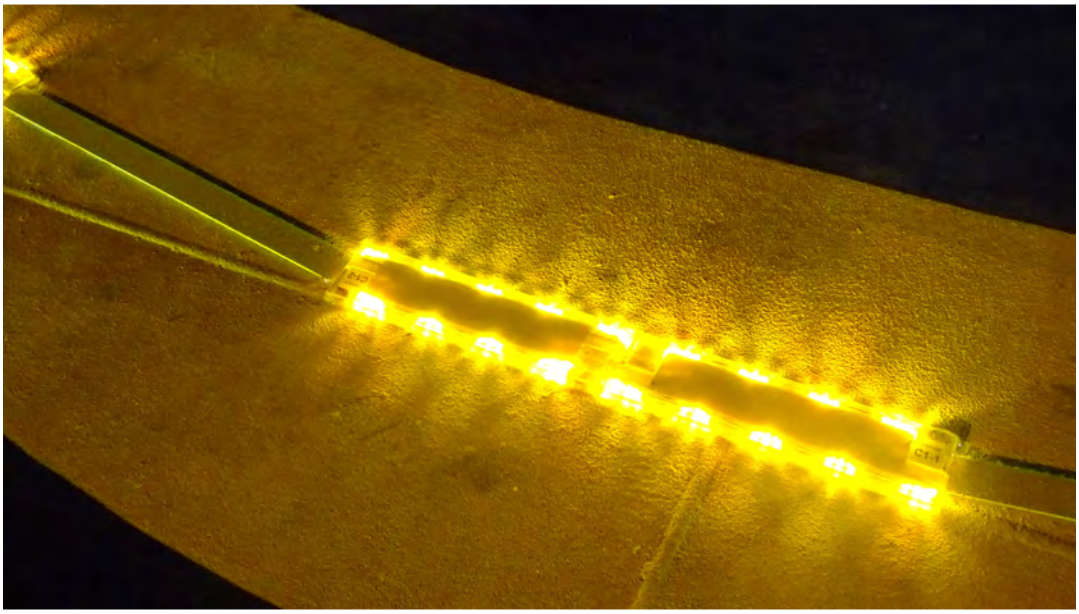

Figure 13 Touchdown/Positioning Marking circle segment on the CPC-1

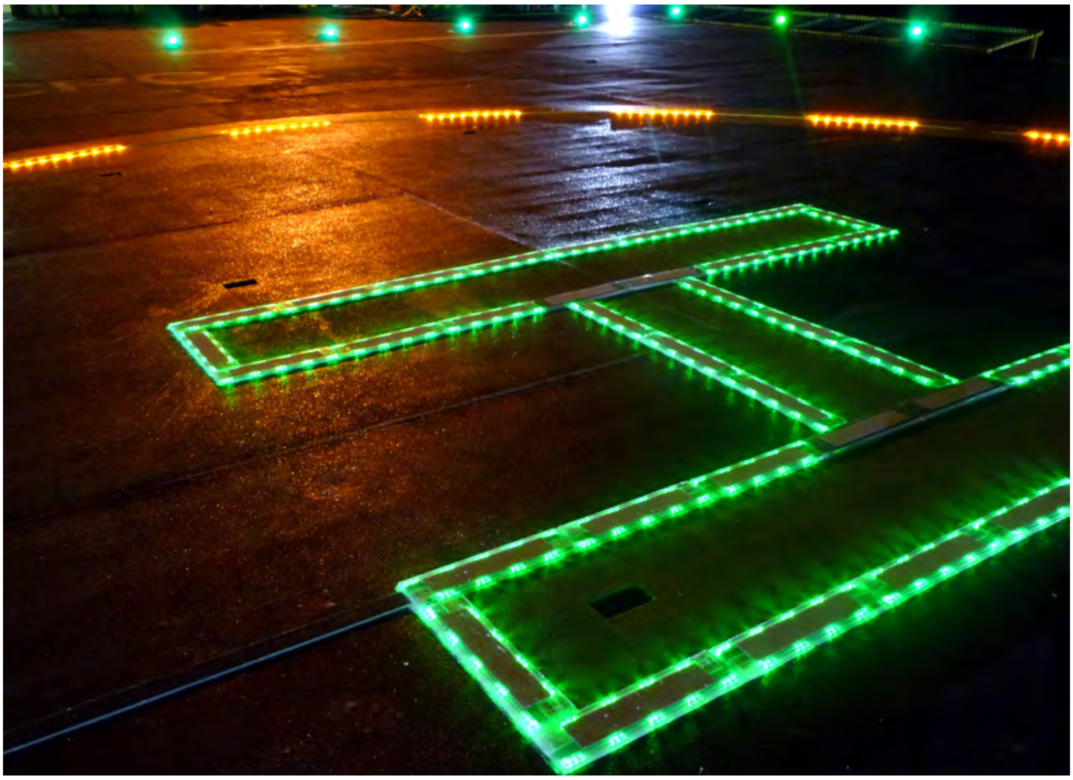

Figure 14 Heliport Identification Marking ('H') on the CPC-1

4.3.2 **Initial Trials**

4.3.2.1 The same trials proforma as used for the trial on the Thames A (see Appendix A) was issued to CHC Scotia at Blackpool. The trial commenced mid-February 2009 and a total of ten proformas (covering 14 approaches) were returned before the trial had to be suspended due to some sections of the 'H' becoming detached from the deck surface. One further proforma was received in June 2009 after the 'H' had been refitted. The results from the proformas are summarised in Table A2 in Appendix A.

4.3.2.2 The majority of the results are very positive, suggesting that the system performed as intended. Due to the short duration of the trial, however, the range of meteorological conditions experienced was quite small. All evaluations were performed in good visibility and precipitation was present in only one case (proforma 2). Whereas these factors would be expected to lead to better results, it should be noted that all pilots were regular visitors to the platform; during the initial trial at the Thames A, regular visitors appeared to be more critical of the system.

4.3.2.3 The results for the Touchdown/Positioning Marking circle are very encouraging. The minimum useable range of 0.5 NM or greater was achieved in all but one evaluation (proforma 5); a useable range of 0.75 NM was reported in four evaluations (proformas 3, 7, 8 and 11). The useable range was considered satisfactory in all cases except for two (proformas 5 and 9), one of which corresponded to the case where a range of only 0.25 NM was experienced (proforma 5). The intensity of the circle at close range was judged to be 'about right' in all cases apart from this case (proforma 5).

4.3.2.4 The results for the Heliport Identification Marking ('H') are also considered encouraging. The design minimum useable range of 0.25 NM was reported in seven out of the ten evaluations (the 'H' was inoperative in one case - proforma 10), and achieved 0.5 NM in four cases (proformas 4, 7, 8 and 11). In three cases the 'H' only achieved a useable range of 0.1 NM (proformas 3, 5 and 6), one of which corresponded to one of the cases where a low useable range was also reported for the circle (proforma 5). The useable range was considered satisfactory in all cases apart from one (proforma 9); curiously, the useable range was reported to be 0.25 NM in this case. The intensity of the 'H' at close range was judged to be 'about right' in all cases.

4.3.3 As regards the overall ratings for the approach, the maximum rating was awarded in eight cases, a high rating in two (proformas 3 and 9) and a neutral rating in one case (proforma 4). It should be borne in mind that the one neutral rating was associated with a daylight approach; the system was not designed for daylight use where higher intensities would be required ($E_t = 10^{-6.1}$ was used for the design of the lighting, $E_t = 10^{-4.0}$ for typical day). For the landing, the maximum rating was awarded in six cases, and a high rating in five (proformas 3, 4, 7, 8 and 9). In terms of comparing the lighting with helideck lighting meeting current standards, eight pilots awarded the highest rating, two a high rating (proformas 3 and 9) and one had no opinion (proforma 4).

4.3.3.1 Relatively few comments were noted, but those received were positive and two very positive indeed (proformas 1 and 11).

4.3.4 **Further Trials**

4.3.4.1 The in-service trials on the CPC-1 recommenced on 27 October 2009 and a total of six proformas (covering 15 approaches) were returned before the trial had to be suspended due to an electrical fault on the lighting system. The results from the proformas are summarised in Table A3 in Appendix A.

4.3.4.2 One of the results was positive and the rest were very positive. This is considered very encouraging as 12 approaches (proformas 4, 5 and 6) were conducted in conditions of low visibility, and six (proformas 4 and 6) in conditions of low visibility and rain.

4.3.4.3 The useable range for the Touchdown/Positioning Marking circle was estimated at 0.75 NM for 12 out of the 15 approaches (proformas 1, 5 and 6), and the minimum useable range of 0.5 NM was achieved for the remaining three (proformas 2, 3 and 4). The useable range was considered satisfactory and the intensity of the circle at close range was judged to be 'about right' in all cases.

4.3.4.4 The design minimum useable range for the Heliport Identification Marking ('H') of 0.25 NM was achieved in all cases but one (proforma 1) where a range of 0.1 NM was achieved. Curiously, this coincided with a reported useable range for the circle of 0.75 NM. Nevertheless, the range for the 'H' was considered satisfactory and the intensity of the 'H' at close range was judged to be 'about right' in all cases.

4.3.4.5 As regards the overall ratings for the approach, the maximum rating was awarded in five cases (proformas 2 through 6), and a high rating in one (proforma 1). The same result was obtained for the landing. In terms of comparing the lighting with helideck lighting meeting current standards, the highest rating was awarded in all cases except one (proforma 1). A high rating was nevertheless awarded in this case which coincided with a low minimum useable range for the 'H' of 0.1 NM.

4.3.4.6 Only one comment was posted (proforma 4), and this was very positive.

4.3.5 **Demonstration Trial**

4.3.5.1 Two dedicated flights were conducted to the CPC-1 on 02 November 2009 using two CHC Scotia Helicopters AS365N Dauphin helicopters. The purpose of the flights was to demonstrate the new lighting scheme to industry representatives. Representatives from the UK CAA, AAIB, Oil and Gas UK, Shell Aircraft, ICAO, HSE, CAA Norway and the system manufacturers (AGI and Orga) attended the demonstrations. A photograph of the system taken during the trial is presented in Figure 15 below.

Figure 15 Aerial photograph of the AGI prototype lighting system on the CPC-1

4.3.5.2 Fortunately, heavy rain and low cloud enabled the lighting to be observed in quite challenging visual cueing conditions. A proforma was completed by the crew of one of the helicopters and this is included in Table 10 in Appendix A (see proforma 4). The helicopter crews were very impressed with the lighting and the feedback from the observers during the subsequent debrief was generally positive.

4.3.5.3 The only issue of any real consequence was that some thought that the intensity of the Touchdown/Positioning Marking circle and the Heliport Identification Marking ('H') could usefully be increased. It was considered that this observation could have been due to the high level of cultural lighting on the CPC-1 (see Figure 15), and/or due to the high luminance of the LED perimeter lights. In any event, it was accepted that there was a need to allow for some degree of adjustment of the intensity of the circle and 'H' lighting.

4.3.6 **Conclusions**

4.3.6.1 The system was evaluated over a wide range of meteorological conditions (see Section 4.4.2), including some of the most challenging ever likely to be encountered offshore, and the results obtained show great promise. Nevertheless, more evaluations in limiting meteorological conditions would be desirable. Although evaluated by a reasonable number of pilots, a broader representation of the pilot community in the trials would also be desirable.

4.3.6.2 Overall the performance of the lighting was very good in almost all cases. There is some variability in the useable ranges reported, however, which is difficult to explain. It may be due to the subjective nature of the evaluation, the coarseness of the rating scale or differences in individual pilots' perceptions. In addition, the approach profile flown in each case may have affected the results; no attempt was made to capture approach profile data, and this will be considered for any future trials.

4.3.6.3 The results from all of the CPC-1 trials are summarised in Section 4.4.

4.4 Summary of Results from In-Service Trials

4.4.1 General

4.4.1.1 The results from the trial at the Thames A have been excluded from the summary presented here as the system was found to be non-compliant with the specification. With reference to Appendix A, some of the proformas submitted by the flight crews were stated to represent more than one approach. In the results presented in this section therefore, the histograms include the results for both the number of proformas and the number of approaches.

4.4.2 Range of Operational Parameters Encountered

4.4.2.1 The operational data from the completed proformas is summarised in Figure 16. A reasonable range of met visibility was experienced, of which the lowest was 5 k. There was mostly no precipitation but five out of 30 approaches which occurred in rain were combined with low visibility. Most approaches conducted at night with similar numbers with/without moon. Overall the range of operational parameters encountered is considered reasonably representative.

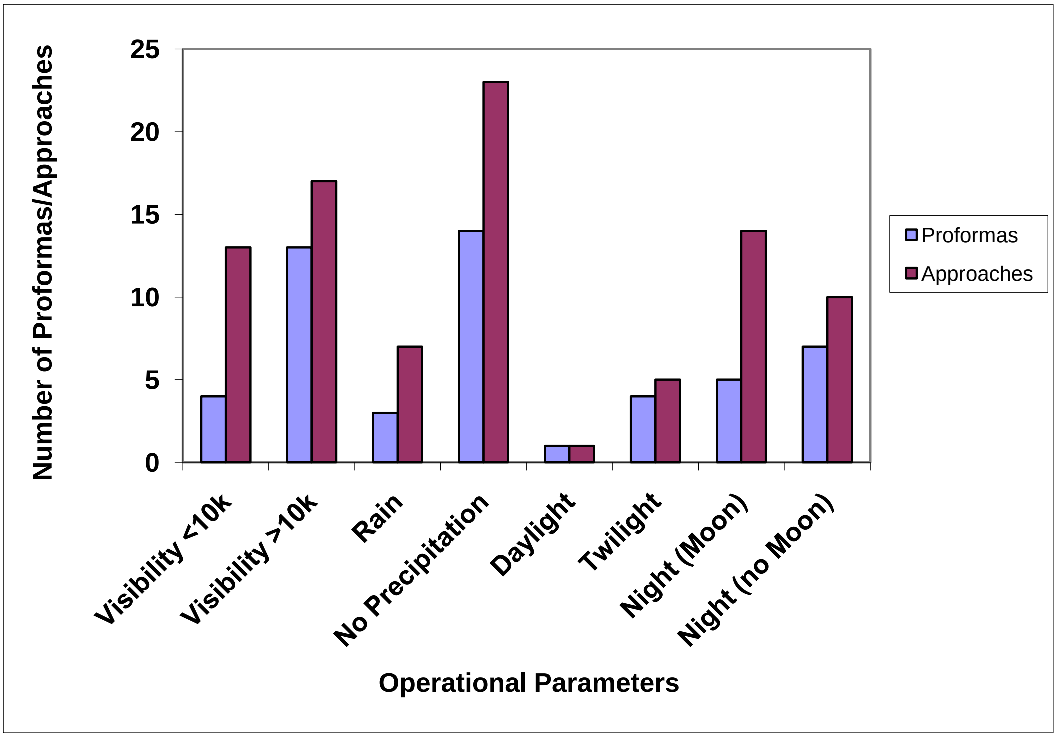

Figure 16 Summary of Operational Parameters Encountered

4.4.3 Evaluation of the Touchdown/Positioning Marking Circle

4.4.3.1 The data for the evaluation of the Touchdown/Positioning Marking circle is summarised in Figures 17 to 19. The useable range of the circle generally met or exceeded the design goal of 0.5 NM, and was considered adequate in all but one case. The intensity of the circle at short range was considered satisfactory in all but one case, and this corresponded to the one case where the range of the circle was judged to be too low (0.25 NM).

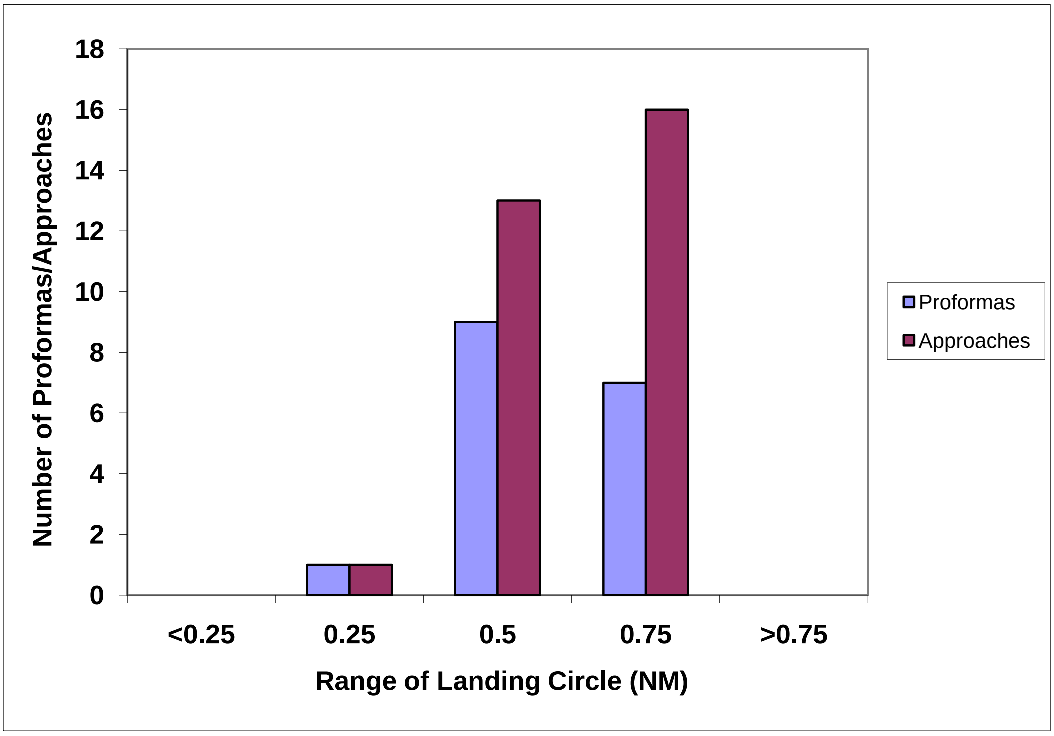

Figure 17 Range of Touchdown/Positioning Marking Circle

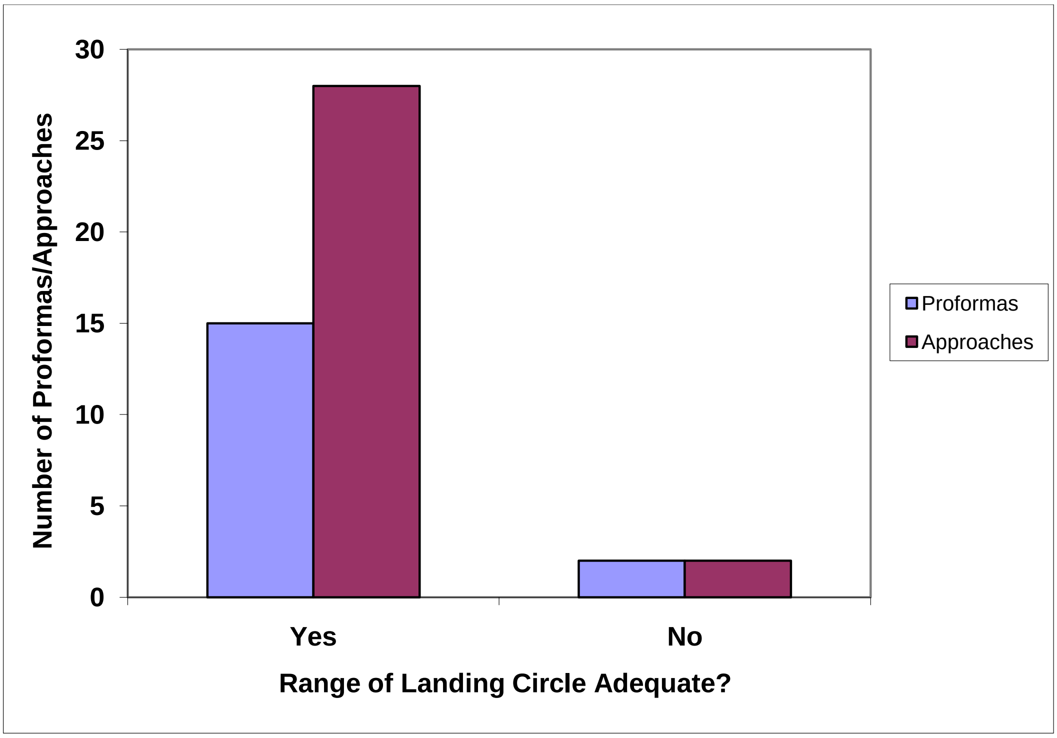

Figure 18 Adequacy of Range of Touchdown/Positioning Marking Circle

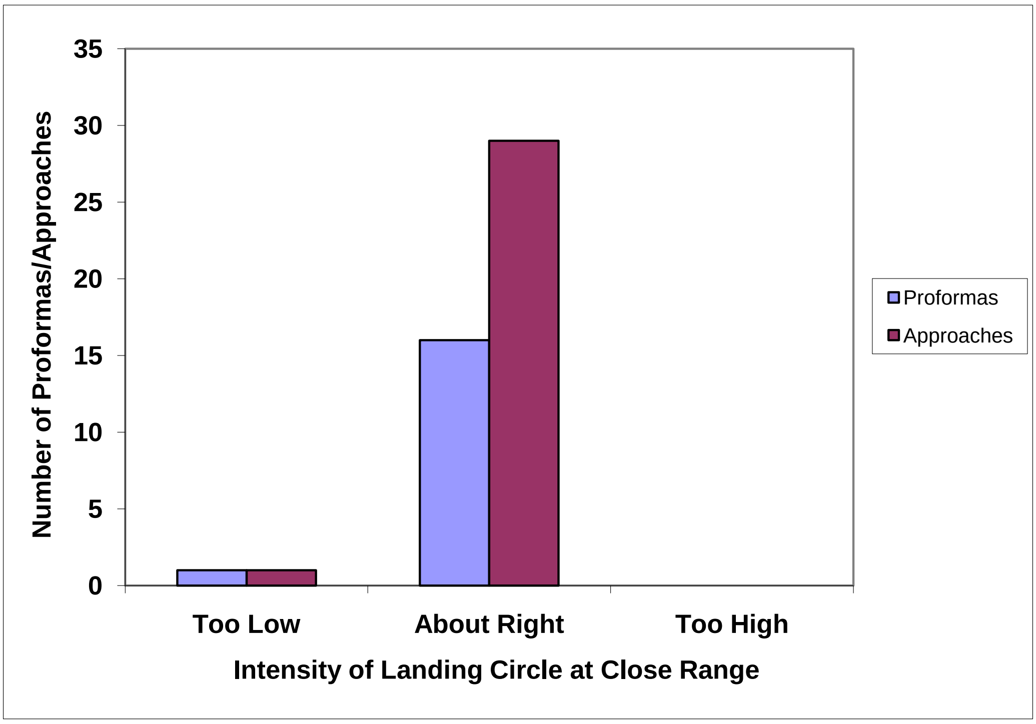

Figure 19 Intensity of Touchdown/Positioning Marking Circle at Close Range

4.4.4 Evaluation of the Heliport Identification Marking ('H')

4.4.4.1 The data for the evaluation of the Heliport Identification Marking ('H') is summarised in Figures 20 to 22.

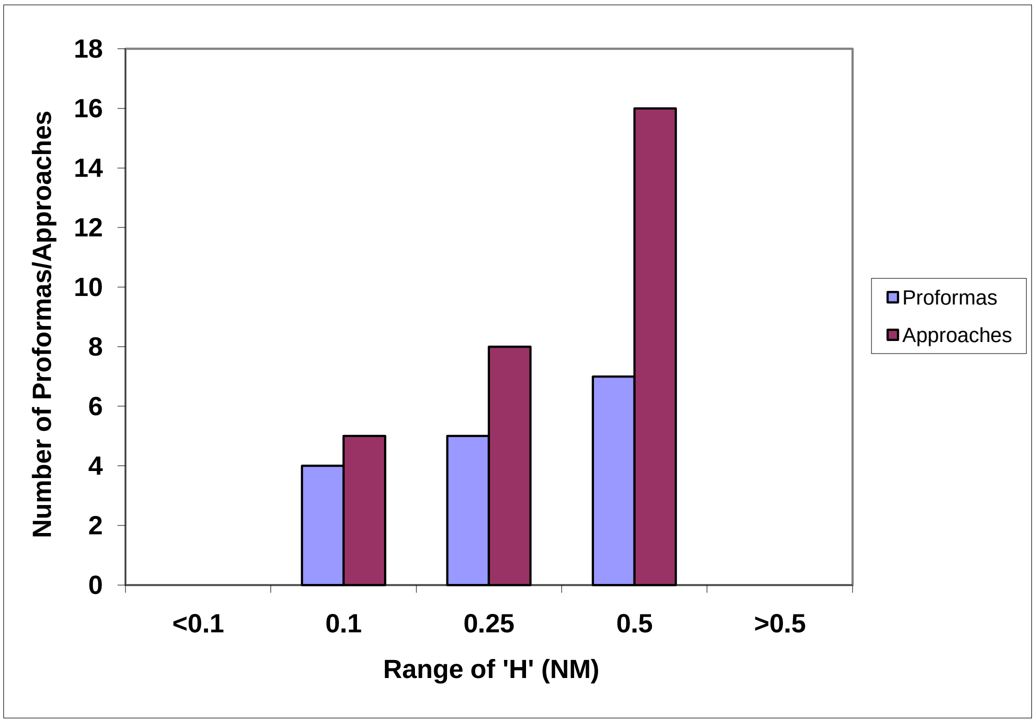

Figure 20 Range of Heliport Identification Marking ('H')

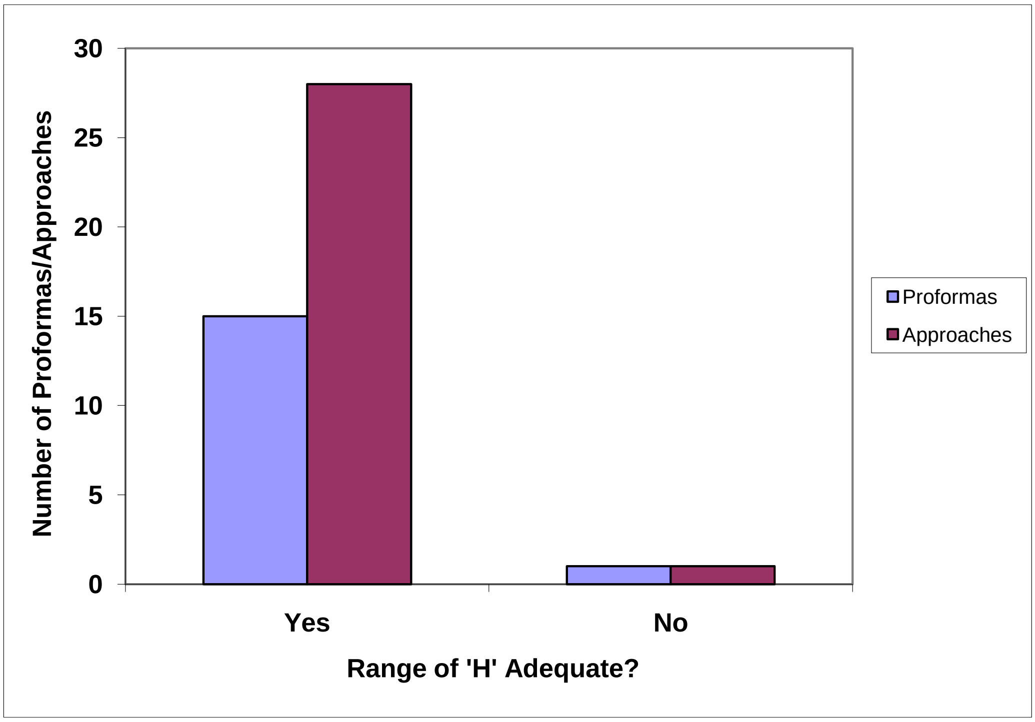

Figure 21 Adequacy of Range of Heliport Identification Marking ('H')

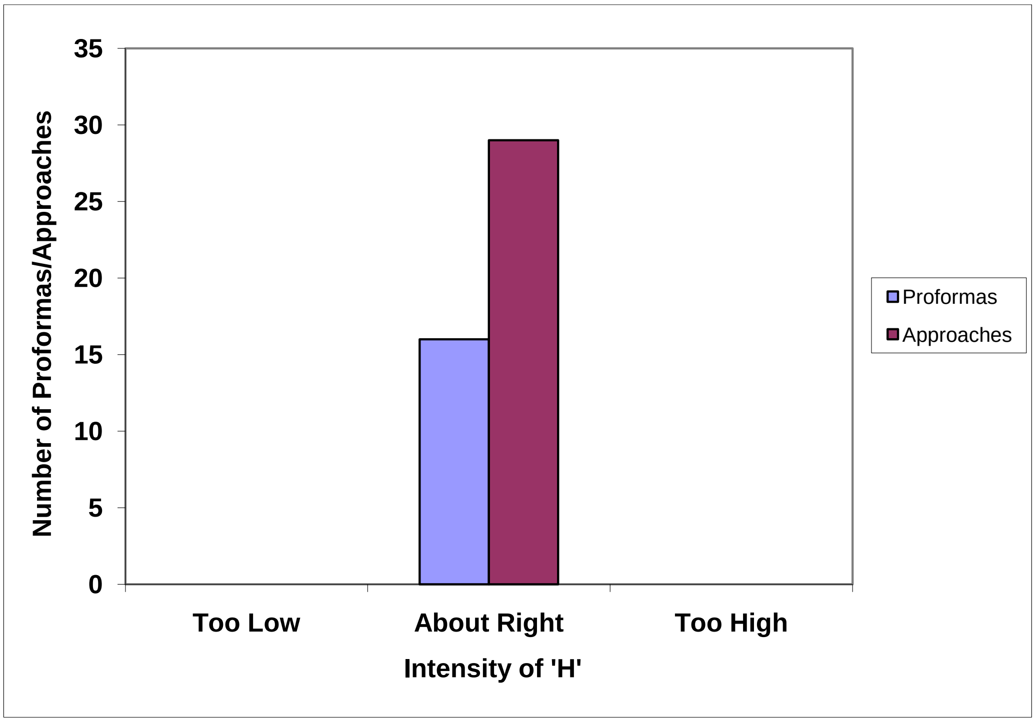

Figure 22 Intensity of Heliport Identification Marking ('H') at Close Range

4.4.4.2 The useable range of the 'H' mostly met or exceeded the design goal of 0.25 NM. Three out of five cases where the range was estimated to be less than 0.25 NM occurred during twilight. Although the range was less than 0.25 NM in five cases, it was only judged to be inadequate in one case. The intensity of the 'H' at short range was judged to be satisfactory.

4.4.5 Overall Evaluation of the New Helideck Lighting Scheme

4.4.5.1 The data for the overall evaluation of the new helideck lighting scheme is summarised in Figures 23 to 25. The visual cueing provided during the approach was mostly considered to be much better. For the landing, the visual cueing was judged to be either better or much better than floodlighting. There were no negative ratings for the system overall; most strongly agreed that the new helideck lighting system represents a significant improvement.

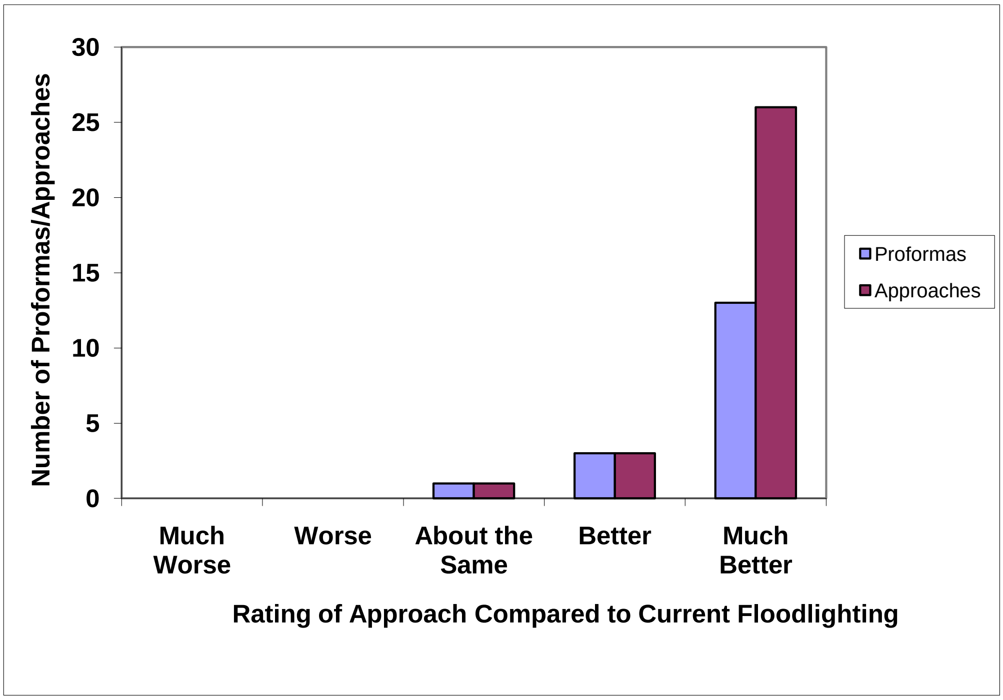

Figure 23 Rating of New Lighting Scheme During Approach

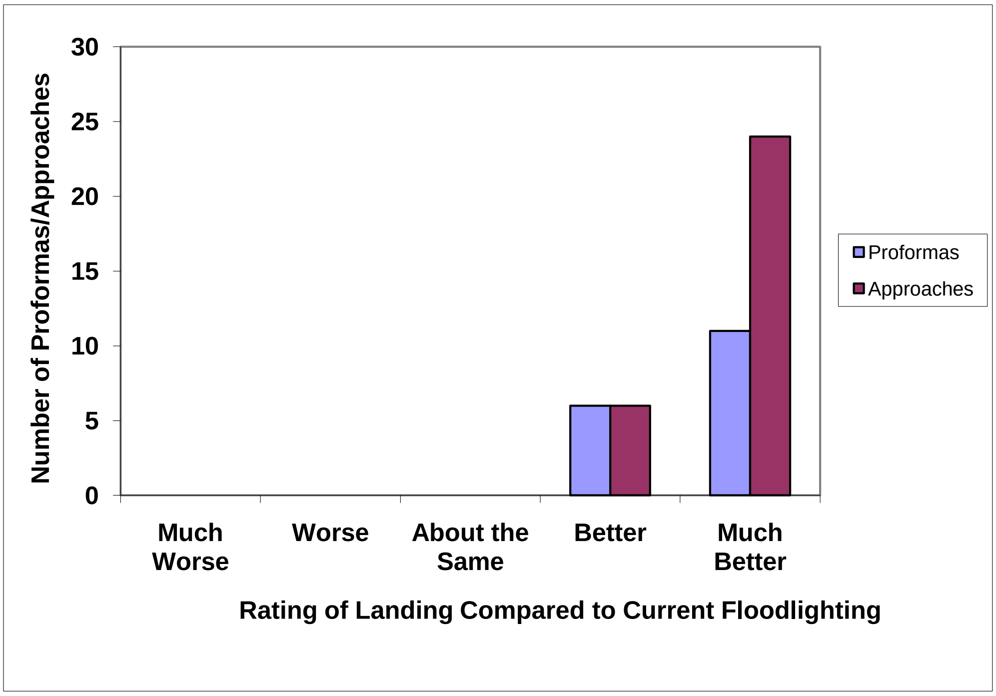

Figure 24 Rating of New Lighting Scheme During Landing

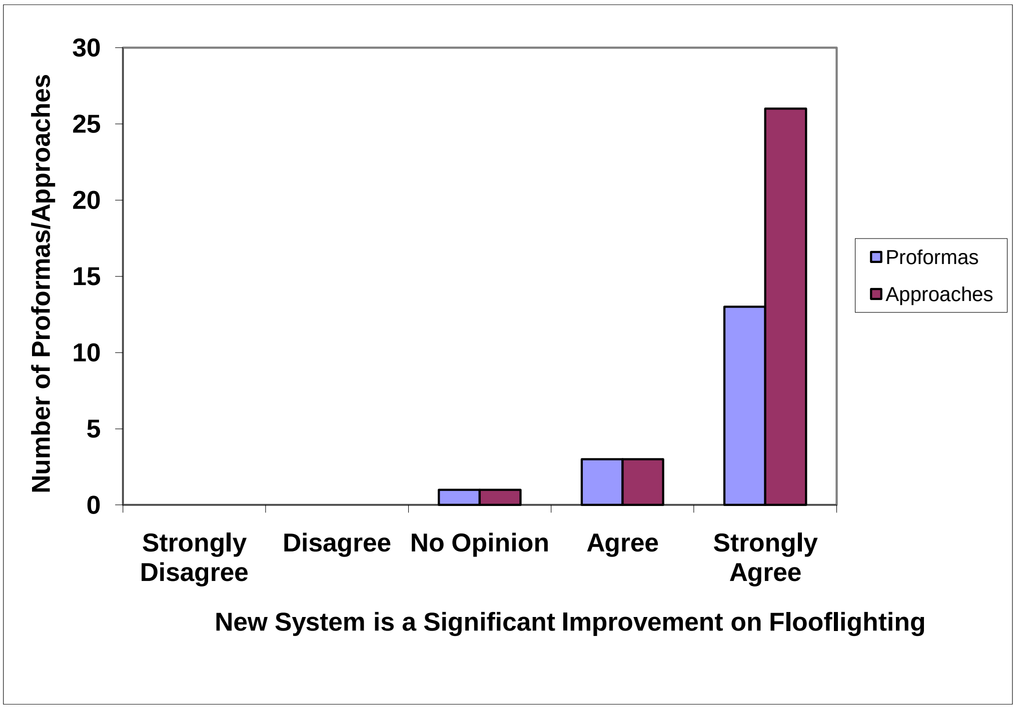

Figure 25 Overall Rating of New Lighting Scheme Compared to Floodlighting

5 Discussion

5.1 Further Trials

5.1.1 General

5.1.1.1 Clearly the duration of the in-service trials were much shorter than had been planned and than would ideally be desired. Nevertheless, the system was evaluated in two representative offshore environments by a reasonable number of pilots operating two different helicopter types, and the vast majority of the feedback was very positive.

5.1.1.2 The main questions outstanding from the trials are considered to be:-

- Is the performance of the system adequate when used in combination with high luminance perimeter lights and/or on offshore installations with high levels of cultural lighting?
- Can the system be made sufficiently robust to survive the environment for an acceptable period of time?

5.1.2 Performance in High Levels of Background Lighting

5.1.2.1 The level of background lighting affects the value of eye illumination threshold and therefore the intensity of the lighting system required to obtain the desired performance. In the absence of any quantitative data, it is entirely possible that the value of eye illumination threshold selected for producing the specification ($E_t = 10^{-6.1}$) is too low for more well lit platforms. In addition, the LED-based perimeter lights introduced on a number of platforms have a much smaller aperture than other forms of perimeter lighting. This increases their luminance making them appear brighter and, consequently, the circle and 'H' lighting appear dimmer.

5.1.2.2 Simply changing the specification to increase the intensity is not considered to be desirable as this could result in the system being too bright on installations with low levels of cultural lighting, e.g. NUIs. Instead, the present specification has been retained as the normal or baseline system performance, and a requirement to provide independent adjustment of the circle and 'H' intensities up to double the present minimum values has been added. (Note that doubling the minimum intensities will not exceed the overall 60 cd glare limit adopted.) It is proposed that the intensity of the circle and 'H' would be adjusted during post installation commissioning trials on each individual platform and then 'fixed' to prevent further 'non-authorised' adjustment.

5.1.2.3 The provision for adjustment of the intensity of the circle and 'H' lighting is being incorporated into the production version of the system being manufactured and tested. It is presently intended that a production system be installed on the CPC-1 for a further demonstration flight and further in-service trials. This will hopefully confirm the effectiveness of the increase in intensity in what is regarded as a 'worst case' lighting environment.

5.1.3 System Durability

5.1.3.1 The problems encountered with the trials systems were partly responsible for the reduced duration of the trials but, in fact, producing equipment that would survive the harsh environment of an offshore helideck was always recognised to be a significant challenge. Indeed, addressing this aspect of the scheme was as much a part of the trials as the evaluation of the performance of the system by helicopter flight crews.

5.1.3.2 While the problems encountered were not reasonably foreseeable, design solutions have already been identified and are being built into a production version of the system. These solutions should ideally be tested prior to wider implementation of the system, and it is possible that further problems may emerge in a longer trial. The further trial suggested in Section 5.1.2 above involving a production version of the system will provide an opportunity to address these issues.

5.2 Implementation

5.2.1 Related Accidents

5.2.1.1 There have been three notable accidents in which visual cueing at offshore platforms is believed to have been a significant factor. These accidents are:

- Sikorsky S-76A, G-BHYB near Fulmar A Oil Platform in the North Sea, 9 December 1987 [11].
- Aerospatiale SA365N, registration G-BLUN, near the North Morecambe gas platform, Morecambe Bay on 27 December 2006 [12].
- Eurocopter EC225 LP Super Puma, G-REDU near the ETAP platform on 18 February 2009 [13].

5.2.1.2 In all three cases:

- helicopters were conducting manually flown, visual approaches to offshore platforms at night;
- the prevailing meteorological conditions resulted in a degraded visual cueing environment;
- the pilot became disoriented and/or suffered a loss of situational awareness.

5.2.1.3 From other CAA-funded research into helicopter flight in degraded visual conditions [14] and various accident reviews (e.g. [15]), the ease with which pilots can become disoriented in such conditions is well established. In view of the significant improvement in visual cueing provided by the new helideck lighting scheme, it is considered reasonable to assume that it's introduction would go a long way to preventing this type of accident.

5.2.2 Other Applications

5.2.2.1 There are a number of onshore elevated heliports in the UK where similar visual cueing conditions to offshore helidecks exist at night. In principle, therefore, it is to be expected that the benefits of the new lighting system would also be realized at these sites.

5.2.2.2 One difference, however, is that the Heliport Identification Marking ('H') at hospital heliports is coloured red rather than white (see Section 5.2.2.4 of [8]). Since the specification for the 'H' in terms of intensity is not particularly onerous and that red LEDs are readily available, it is not believed that there should be any insurmountable problems in producing a version of the system suitable for this application.

5.2.2.3 Another difference is the size of the 'H' marking. At 3.0 m x 1.8 m x 0.4 m, the red hospital heliport marking is somewhat smaller than the 4.0 m x 3.0 m x 0.75 m offshore helideck version. This could adversely affect the acquisition range which may need to be compensated for by an increase in intensity. This aspect should be evaluated by flight trials prior to in-service implementation.

5.2.2.4 Although it is believed that approach profiles to onshore elevated sites are similar to those to offshore helidecks, this aspect should be checked prior to extending the use of the system for such applications.

5.2.3 CAA Position

5.2.3.1 Although the new lighting specification should ideally be fully validated prior to implementation, in view of the accidents near the North Morecambe Platform in December 2006 [12] and at the ETAP platform in February 2009 [13] and the positive trials results obtained to date, it is considered appropriate to progress implementation in advance of full validation. Regardless of whether the specification completely fulfils the intended operational requirement, based on the extensive experimental trials reported in [2], [3] and [4], it is considered that the new system can be relied upon to always provide significantly better visual cueing than current floodlighting systems.

5.2.3.2 In view of the foregoing and the positive feedback received from the Oil and Gas UK Helicopter Task Group[1], the CAA proposes to incorporate the specification for the new circle and 'H' lighting presented in Appendix B into CAP 437 for all offshore helidecks whether on existing or new build installations operating on the UKCS.

5.2.3.3 The CAA recognises that a version of the circle and 'H' lighting has not yet been produced which has demonstrated adequate durability. Hence the CAA proposes to retain the existing guidance on floodlighting systems in CAP 437 in an appendix to facilitate the retention of existing systems as a back-up to the new lighting to support the transition.

1. The Helicopter Task Group (HTG) was established by Oil and Gas UK following the accident to G-REDL on 01 April 2009. The objective of the HTG was to try and provide better coordination and communication around helicopter safety issues for the UK oil and gas industry.

5.2.4 CAA Actions

5.2.4.1 The new green perimeter lighting has already been adopted by ICAO in Annex 14, Vol. II and a slightly modified (improved) version of the specification has been incorporated in the CAA's guidance material [10]. Since this element of the lighting scheme became mandatory from 01 January 2009, no further CAA action is required.

5.2.4.2 The Touchdown/Positioning Marking circle and Heliport Identification Marking ('H') lighting scheme has been included in ICAO Annex 14 Vol. II as an acceptable alternative to the existing floodlighting, i.e. it is allowed but is not mandatory under international minimum standards. The CAA published the initial draft specification for the lighting in Appendix E of CAP 437 [10] by way of advance information, and, by reference to this paper, is incorporating the current version of the specification in the 7th Edition of CAP 437. The CAA is also consolidating all guidance on floodlighting into a single appendix in the 7th Edition in preparation for it's eventual removal.

5.2.4.3 The CAA will encourage all operators of offshore helidecks to implement the new lighting scheme once final validation of the specification has been completed and at least one viable production system is available for installation.

6 Conclusions and Recommendations

6.1 Conclusions

6.1.1 The duration of the trials performed were less than ideal. A greater pilot sample size and more evaluations of the system in limiting meteorological conditions would be desirable but, in view of the very good results to date, not essential.

6.1.2 Overall the system performed well and was enthusiastically received by almost all pilots. There was some variability in the results which cannot be explained, but which might be resolved by capturing additional data in any future trials.

6.1.3 The offshore helideck environment is very harsh which was illustrated by the problems that occurred with the reliability of the system, this despite it being designed and manufactured by a company with experience in producing lighting equipment for naval vessels. NB: AGI Ltd has since teamed with Orga, a Dutch offshore platform lighting manufacturer, to produce a production version of the system.

6.1.4 The specification presented in Appendix B is considered sufficiently mature for inclusion in CAP 437 pending final validation through in-service trials of a production version of the system.

6.2 Recommendations

6.2.1 Further in-service trials utilising a production version of the system should be conducted to:

- expand the pilot sample size (NB: Further in-service trials on the CPC-1 would increase the pilot sample size as the helicopter operator servicing the CPC-1 changed to Bond Offshore Helicopters in January 2010.);
- confirm the effectiveness of increasing the system intensity on installations with high levels of background lighting and/or LED perimeter lights;
- collect more feedback on system performance in limiting meteorological conditions;
- confirm that the reliability issues experienced during the trials to date have been satisfactorily addressed and identify any further potential problems.

6.2.2 For any future trials, consideration should be given to capturing approach profile data, e.g. using HOMP.

6.2.3 The specification should be incorporated in CAP 437, retaining the existing guidance on floodlighting in an appendix to facilitate retention of existing systems as a back-up to support the transition to the new lighting.

6.2.4 When final validation of the specification has been completed and at least one viable production system is available for installation, all operators of offshore helidecks should consider the safety benefits of upgrading their existing facilities to meet the new guidance presented in Appendix B of this report and being incorporated in CAP 437.

6.2.5 Consideration should be given to extending the specification to include onshore elevated heliports.

7 References

[1] A questionnaire survey of workload and safety hazards associated with North Sea and Irish Sea helicopter operations, CAA Paper 97009, CAA, London, June 1997.

[2] Enhancing Offshore Helideck Lighting - NAM K14 Trials, CAA Paper 2004/01, CAA, London, January 2004.

[3] Enhancing Offshore Helideck Lighting - Onshore Trials at Longside Airfield, CAA Paper 2005/01, CAA, London, April 2005.

[4] Enhancing Offshore Helideck Lighting - Onshore Trials at Norwich Airport, CAA Paper 2006/03, CAA, London, November 2006.

[5] Final Report on the Helicopter Operations Monitoring Programme (HOMP) Trial, CAA Paper 2002/02, CAA, London, September 2002.

[6] Final Report on the Follow-On Activities to the HOMP Trial, CAA Paper 2004/12, CAA, London, October 2004.

[7] ICAO Annex 14 Vol.1 Aerodromes, Appendix 1.

[8] ICAO Annex 14 Vol. II Heliports.

[9] TNO Human Factors Report Ref. TM-02-C003.

[10] Offshore Helicopter Landing Areas - Guidance on Standards, CAP 437, Sixth Edition, CAA, London, December 2008.

[11] AAIB Report No: 5/1988. Report on the incident to Sikorsky S-76A, G-BHYB near Fulmar A Oil Platform in the North Sea, 9 December 1987.

[12] AAIB Report No: 7/2008. Report on the accident to Aerospatiale SA365N, registration G-BLUN, near the North Morecambe gas platform, Morecambe Bay on 27 December 2006.

[13] AAIB Report No: 1/2011. Report on the accident to Eurocopter EC225 LP Super Pumer, G-REDU, near the Eastern Trough Area Project (ETAP) Central Production Facility platform in the North Sea on 18 February 2009.

[14] Helicopter Flight in Degraded Visual Cueing Conditions - CAA Paper 2007/03, CAA, London, September 2007.

[15] Helicopter General Aviation Safety Information Leaflet, a CAA Accident Prevention Leaflet - HELI-GASIL 2002, CAA London, December 2002.

8 List of Abbreviations

AAIB	Air Accidents Investigation Branch (UK)
CAA	Civil Aviation Authority (UK)
CAP	Civil Aviation Publication
cd	candela
cm	centimetre
ELP	Electro-Luminescent Panel
H	Heliport Identification Marking
HOMP	Helicopter Operations Monitoring Programme
ICAO	International Civil Aviation Organisation
IP66	Ingress Protection level (66 = solid ingress 6 = dust tight with vacuum applied to product; liquid ingress 6 = protected against powerful water jets)
LED	Light Emitting Diode
LOS	Limited Obstacle Sector
m	metre
NAM	Nederlandse Aadolie Madtschappij (Dutch arm of Shell)
NM	nautical mile
NUI	Normally Unattended Installation
OFS	Obstacle Free Sector
TD/PM	Touchdown/Positioning Marking Circle

INTENTIONALLY LEFT BLANK

Appendix A Trials Proformas

The proforma issued for the Thames A trial is shown. The proforma used for the CPC-1 trials was identical except for the platform name.

CAA Thames A Helideck Lighting Report

Introduction:

Analysis of the responses and comments received under the offshore helicopter pilot questionnaire-based survey, conducted on behalf of CAA and reported in CAA Paper 97009, indicates that the visual cueing provided by current helideck lighting systems on offshore platforms is less than ideal. Floodlighting typically fails to illuminate the landing area in the middle of the deck and can present a source of glare. Even when correctly designed and set up, floodlighting does not provide any significant visual cueing until very late in the approach and landing.

Following flight trials at the NAM K14 platform, at Longside Airfield and at Norwich Airport, a specification for a new deck lighting system comprising a yellow lit landing circle and a green lit 'H' marking in lieu of floodlighting has been developed. A prototype system based on this specification has been produced and installed on the Thames A for in-service evaluation. Pilots are requested to provide feedback on the system via this questionnaire to allow the specification to be confirmed or modified as appropriate prior to incorporation as best practice in CAA's guidance material (CAP 437).

As soon as it is safe to do so after completing the approach and landing on the platform, please answer the following questions by ticking the box which most accurately represents your opinion:-

Evaluation of Yellow Landing Circle:

1. At approximately what range from the platform did the yellow landing circle become useful as a visual cue?

☐ **>0.75NM** ☐ **0.75NM** ☐ **0.5NM** ☐ **0.25NM** ☐ **<0.25NM**

2. Was this early enough in the approach?

☐ **YES** ☐ **NO**

3. At close range, the intensity of the yellow landing circle was:-

☐ **too low** ☐ **about right** ☐ **too high**

Evaluation of Green 'H' Marking:

4. At approximately what range from the platform did the green 'H' marking become useful as a visual cue?

☐ **>0.5NM** ☐ **0.5NM** ☐ **0.25NM** ☐ **0.1NM** ☐ **<0.1NM**

5. Was this early enough in the approach?

☐ **YES** ☐ **NO**

6. At close range, the intensity of the green 'H' marking was:-

☐ **too low** ☐ **about right** ☐ **too high**

NB: Please use the area on last page for any written comments you may wish to add.

Please turn over.

Overall Assessment

7. Compared to the normal floodlighting system, in terms of providing visual cues during the approach, the new lighting system was:

□	□	□	□	□
much better	**better**	**about the same**	**worse**	**much worse**

8. Compared to the normal floodlighting system, in terms of providing visual cues during the landing, the new lighting system was:

□	□	□	□	□
much better	**better**	**about the same**	**worse**	**much worse**

9. The new lighting system represents a significant improvement over the existing floodlighting systems.

□	□	□	□	□
strongly agree	**agree**	**no opinion**	**disagree**	**strongly disagree**

NB: Please use area at foot of page for any written comments you may wish to add.

Operational Data:

After flight, please record the following information relating to the approach and landing on the Thames A platform (please record information and tick boxes as appropriate):-

Date: ………… Time (GMT): ………… Aircraft type: …………

Visibility (km): ………… Precipitation: None □ Rain □ Snow □

Ambient light: Twilight □ Night (moon) □ Night (no moon) □

Pilot familiarity with the Platform:

Regular visitor □ Occasional visitor □ First time visitor □

Comments:

Please use this area to record any comments that you wish to make with regard to helideck lighting.

When completed, please post (or fax 01293 573981, or scan and e-mail to dave.Howson@caa.co.uk) this questionnaire to:-

CAA Safety Regulation Group, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR, FAO David Howson, RASA, Wing 2W.

THANK YOU FOR YOUR ASSISTANCE

Table A1 Proforma Results from Winter 2006/7 In-Service Trial on the Thames A Platform

	Date	Time	Visibility	Precipitation	Ambient Light	Pilot Familiarity
1	19.02.07	17.25	10 km+	None	Night (no moon)	Occasional visitor
2	08.03.07	19.45	>10 k	None	Night (no moon)	Regular visitor
3	18.07.07	22.00	10 k	None	Twilight	Regular visitor

	1	2	3	4	5	6	7	8	9	Comments
1	0.25 NM	YES	About right	0.25 NM	YES	About right	Much better	Much better	Strongly agree	The yellow circle and 'H' light in combination with the green deck edge lighting are a very effective cueing combination.
2	0.5 NM	YES	About right	0.25 NM	YES	About right	About the same	About the same	Disagree	The green 'H' seems only to benefit anyone who has problems assessing the 'approach angle'. So in this respect it is an aid to 'angle of approach'. The yellow landing circle … of little benefit to myself for landing, however, in poor conditions my opinion may change.
3	0.25 NM	NO	Too low	0.25 NM	YES	Too low	Much better	Much better	Strongly agree	The Thames usually presents little difficulty at night due to its size. I would like to see these lights on a remote satellite platform where crews face the most challenging approach and landing.

Table A2 Proforma Results from Winter 2008/9 In-Service Trial on the CPC-1 Platform

	Date	Time	Visibility	Precipitation	Ambient Light	Pilot Familiarity
1	13.02.09	17.56	40 k	None	Night (no moon)	Regular visitor
2	14.02.09	07.10	10 k+	Rain	Twilight	Regular visitor
3	15.02.09	17.55	9999	None	Twilight	Regular visitor
4	16.02.09	07.28	>10 k	None	Daylight	Regular visitor
5	16.02.09	18.00	30	None	Twilight	Regular visitor
6	17.02.09	18.05	9999	None	Twilight	Regular visitor
7	18.02.09	18.10	10	None	Night (no moon)	Regular visitor
8	20.02.09	18.34	20	None	Night (no moon)	Regular visitor
9	21.02.09	18.50	9999	None	Night (moon)	Regular visitor
10	25.02.09	18.53	9999	None	Night (no moon)	Regular visitor
11	05.06.09	02.14	40	None	? Night (moon?)	Regular visitor

Table A2 Proforma Results from Winter 2008/9 In-Service Trial on the CPC-1 Platform (continued)

	1	2	3	4	5	6	7	8	9	Comments
1	0.5 NM	YES	About right	0.25 NM	YES	About right	Much better	Much better	Strongly agree	4 approaches [results based on first approach]. Awesome!
2	0.5 NM	YES	About right	0.25 NM	YES	About right	Much better	Much better	Strongly agree	-
3	0.75 NM	YES	About right	0.1 NM	YES	About right	Better	Better	Agree	-
4	0.5 NM	YES	About right	0.5 NM	YES	About right	About the same	Better	No opinion	Although it was coming daylight the deck lighting was highly visible.
5	0.25 NM	NO	Too low	0.1 NM	YES	About right	Much better	Much better	Strongly agree	Although 3 is ticked "too low" it would only need to be slightly brighter.
6	0.5 NM	YES	About right	0.1 NM	YES	About right	Much better	Much better	Strongly agree	[2 approaches]
7	0.75 NM	YES	About right	0.5 NM	YES	About right	Much better	Better	Strongly agree	-
8	0.75 NM	YES	About right	0.5 NM	YES	About right	Much better	Better	Strongly agree	-
9	0.5 NM	NO	About right	0.25 NM	NO	About right	Better	Better	Agree	-
10	0.5 NM	YES	About right	-	-	-	Much better	Much better	Strongly agree	[NB: 'H' not working]
11	0.75 NM	YES	About right	0.5 NM	YES	About right	Much better	Much better	Strongly agree	This lighting is so good that I hope, in the interests of flight safety, the CAA … will mandate its use immediately this trial is over.

Table A3 Proforma Results from Winter 2009/10 In-Service Trial on the CPC-1 Platform

	Date	Time	Visibility	Precipitation	Ambient Light	Pilot Familiarity	Captain	F/O
1	27.10.09	-	>10	None	Night (no moon)	Regular visitor	P1	P2
2	28.10.09	18.30	10+	None	Night (moon)	Regular visitor	P3	P2
3	29.10.09	18.30	10+	None	Night (no moon)	Regular visitor	P3	P2
4	02.11.09	20.30	5	Rain	Night (no moon)	Regular visitor	P4	P2
5	04.11.09	17.25	7	None	Night (moon)	Regular visitor	P5	P2
6	05.11.09	17.30	7	Rain	Night (moon)	Regular visitor	P5	P2

	1	2	3	4	5	6	7	8	9	Comments
1	0.75 NM	YES	About right	0.1 NM	YES	About right	Better	Better	Agree	-
2	0.5 NM	YES	About right	0.5 NM	YES	About right	Much better	Much better	Strongly agree	-
3	0.5 NM	YES	About right	0.25 NM	YES	About right	Much better	Much better	Strongly agree	-
4	0.5 NM	YES	About right	0.25 NM	YES	About right	Much better	Much better	Strongly agree	Demo flight for CAA. In conditions of heavy rain and low cloud the circle/H were of great benefit. This system should be mandated for all decks.
5	0.75 NM	YES	About right	0.5 NM	YES	About right	Much better	Much better	Strongly agree	[6 approaches]
6	0.75 NM	YES	About right	0.5 NM	YES	About right	Much better	Much better	Strongly agree	[5 approaches]

Appendix B Validated Helideck Lighting Scheme Specification

Specification for Helideck Lighting Scheme Comprising: Perimeter Lights, Lit Touchdown/ Positioning Marking and Lit Heliport Identification Marking.

1 Overall Operational Requirement

1.1 The whole lighting configuration should be visible over a range of 360° in azimuth. Although on some offshore installations the helideck may be obscured by topsides structure in some approach directions, the lighting configuration on the helideck need not take this into account.

1.2 The visibility of the lighting configuration should be compatible with the normal range of helicopter vertical approach paths from a range of 2 nautical miles (NM).

1.3 The purpose of the lighting configuration is to aid the helicopter pilot perform the necessary visual tasks during approach and landing as stated in Table B1.

Table B1 Visual Tasks During Approach and Landing

Phase of Approach	**Visual Task**	**Visual Cues/ Aids**	**Desired Range (NM)**	
			5000 m met. vis.	**1400 m met. vis.**
Helideck Location and Identification	Search within platform structure	Shape of helideck; colour of helideck; luminance of helideck perimeter lighting	1.5 (2.8 km)	0.75 (1.4 km)
Final Approach	Detect helicopter position in three axes. Detect rate of change of position.	Apparent size / shape and change of size / shape of helideck. Orientation and change of orientation of known features/ markings/ lights.	1.0 (1.8 km)	0.5 (900 m)
Hover and Landing	Detect helicopter attitude position and rate of change of position in three axes (six degrees of freedom).	Known features/ markings/ lights. Helideck texture.	0.03 (50 m)	0.03 (50 m)

1.4 The minimum intensities of the lighting configuration should be adequate to ensure that, for a minimum Meteorological Visibility (Met. Vis.) of 1400 m and an illuminance threshold of $10^{-6.1}$ lux, each feature of the system is visible and useable at night from ranges in accordance with 1.5, 1.6 and 1.7 (below).

1.5 The Perimeter Lights are to be visible at night from a minimum range of 0.75 NM.

1.6 The Touchdown/Positioning Marking (TD/PM) circle on the helideck is to be visible at night from a range of 0.5 NM.

1.7 The Heliport Identification Marking ('H') is to be visible at night from a range of 0.25 NM.

1.8 The minimum ranges at which the TD/PM circle and 'H' are visible and useable (see paragraphs 1.6 and 1.7 above), should still be achieved even where a correctly fitted 200 mm mesh rope netting covers the lighting.

1.9 The design of the Perimeter Lights, TD/PM circle and 'H' should be such that the luminance of the Perimeter Lights is equal to or greater than that of the TD/PM circle segments, and the luminance of the TD/PM circle segments equal to or greater than that of the 'H'.

1.10 The design of the TD/PM circle and 'H' should include a facility to increase their intensity by up to two times the figures given in this specification to permit a once-off (tamper proof) adjustment at installation. The purpose of this facility is to ensure adequate performance at installations with high levels of background lighting.

2 Definitions

The following definitions should apply.

2.1 Lighting Element

2.1.1 A lighting element is a light source within a segment or sub-section and may be individual (e.g. a Light Emitting Diode (LED)) or continuous (e.g. fibre optic cable, electro luminescent panel). An individual lighting element may consist of a single light source or multiple light sources arranged in a group or cluster.

2.2 Segment

2.2.1 A segment is a section of the TD/PM circle lighting. For the purposes of this specification, the dimensions of a segment are the length and width of the smallest possible rectangular area that is defined by the outer edges of the lighting elements.

2.3 Sub-Section

2.3.1 A sub-section is an individual section of the 'H' lighting. For the purposes of this specification, the dimensions of a sub-section are the length and width of the smallest possible rectangular area that is defined by the outer edges of the lighting elements.

3 The Perimeter Light Requirement

3.1 Configuration

3.1.1 Perimeter lights, spaced at intervals of not more than 3 m, should be fitted around the perimeter of the landing area of the helideck.

3.2 Mechanical Constraints

3.2.1 For any helideck where the D-value is greater than 16.00 m the perimeter lights should not exceed a height of 25 cm above the surface of the helideck. Where a helideck has a D-value of 16.00 m or less the perimeter lights should not exceed a height of 5 cm above the surface of the helideck.

3.3 **Light Intensity**

3.3.1 The minimum light intensity profile is given in Table B2 below:

Table B2 Minimum Light Intensity Profile for Perimeter Lights

Elevation	Azimuth	Intensity (min)
0° to 10°	-180° to +180°	30 cd
>10° to 20°	-180° to +180°	15 cd
> 20° to 90°	-180° to +180°	3 cd

3.3.2 No perimeter light should have an intensity of greater than 60 cd at any angle of elevation.

3.3.3 Note that the design of the perimeter lights should be such that the luminance of the perimeter lights is equal to or greater than that of the TD/PM circle segments.

3.4 **Colour**

3.4.1 The colour of the light emitted by the perimeter lights should be green, as defined in ICAO Annex 14 Volume 1 Appendix 1, paragraph 2.1.1(c), whose chromaticity lies within the following boundaries:

Yellow boundary $x = 0.360 - 0.080y$

White boundary $x = 0.650y$

Blue boundary $y = 0.390 - 0.171x$

3.5 **Serviceability**

3.5.1 The perimeter lighting is considered serviceable provided that at least 90% of the lights are serviceable, and providing that any unserviceable lights are not adjacent to each other.

4 The Touchdown / Positioning Marking Circle Requirement

4.1 **Configuration**

4.1.1 The lit TD/PM circle should be superimposed on the yellow painted marking. It should comprise one or more concentric circles of at least 16 discrete lighting segments, of 40 mm minimum width. A single circle should be positioned at the mean radius of the painted circle. Multiple circles should be symmetrically disposed about the mean radius of the painted circle. The lighting segments should be of such a length as to provide coverage of between 50% and 75% of the circumference and be equidistantly placed with the gaps between them not less than 0.5 m. The mechanical housing should be coloured yellow - see CAP 437 Chapter 4 para. 2.11.

4.2 **Mechanical Constraints**

4.2.1 The height of the lit TD/PM circle and any associated cabling should be as low as possible and should not exceed 25 mm above the surface of the helideck when fitted. So as not to present a trip hazard, the segments should not present any vertical outside edge greater than 6 mm without chamfering at an angle not exceeding 30° from the horizontal.

4.2.2 The overall effect of the lighting segments and cabling on deck friction should be minimised. Wherever practical, the surfaces of the lighting segments should meet the minimum deck friction limit coefficient (μ) of 0.65, e.g. on non-illuminated surfaces.

4.2.3 The TD/PM circle lighting components, fitments and cabling should be able to withstand a pressure of 240 lbs/in^2 (1,654,800 pascals), equivalent to one wheel of a 15-ton helicopter touching down heavily on top of them, without damage.

4.3 Intensity

The light intensity for each of the lighting segments, when viewed at angles of azimuth over the range + 80° to -80° from the normal to the longitudinal axis of the strip (see Figure B1), should be as defined in Table B3.

Table B3 Light Intensity for TD/PM Circle Lighting Segments

Elevation	Intensity	
	Min	**Max**
0° - 10°	As a function of segment length as defined in Figure B2.	60 cd
>10° - 20°	25% of min intensity >0° to 10°	45 cd
>20° - 90°	5% of min intensity >0° to 10°	15 cd

4.3.1 For the remaining angles of azimuth on either side of the longitudinal axis of the segment, the maximum intensity should be as defined in Table B3.

4.3.2 Note that the intensity of each lighting segment should be nominally symmetrical about its longitudinal axis.

Note also that the design of the TD/PM circle should be such that the luminance of the TD/PM circle segments is equal to or greater than those of the 'H'.

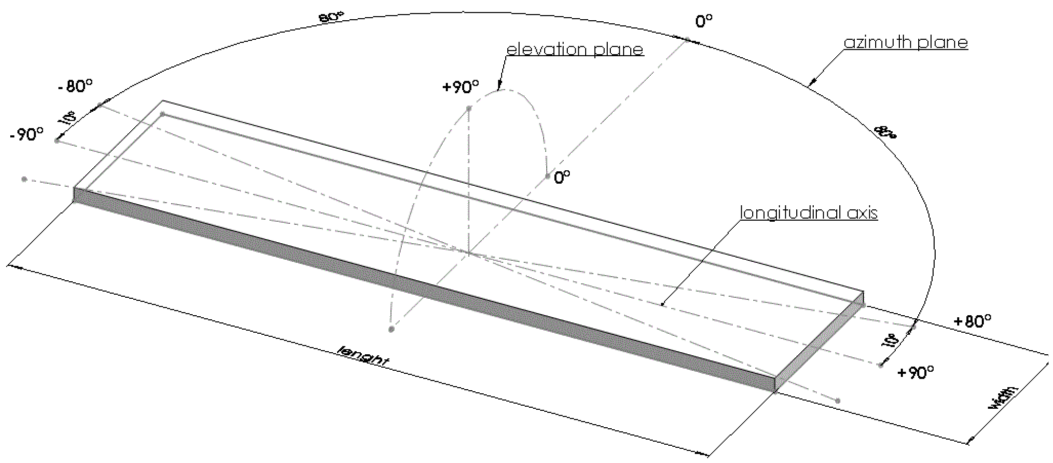

Figure B1 TD/PM Segment Measurement Axis System

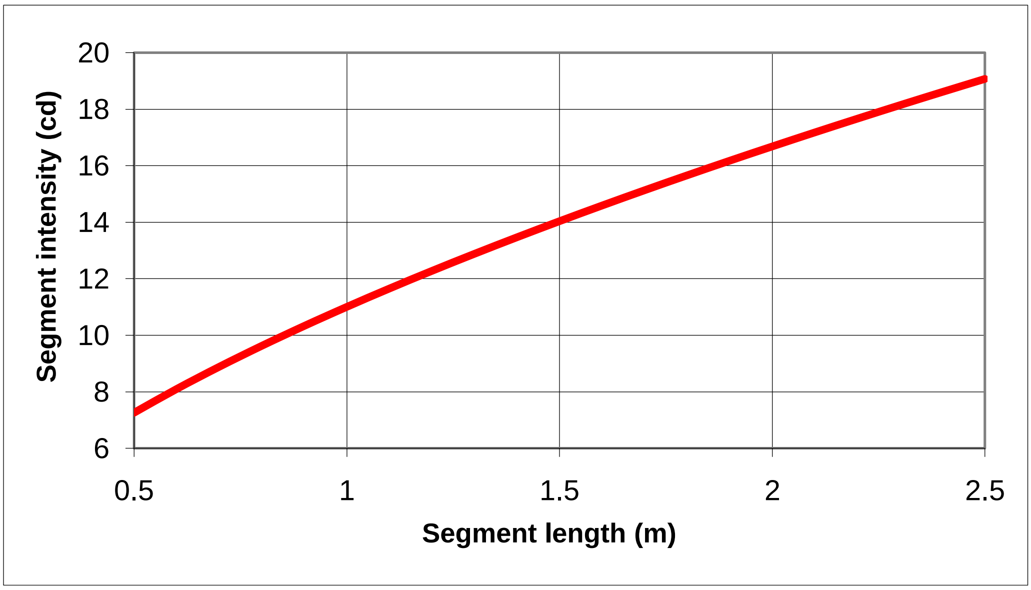

Figure B2 TD/PM Segment Intensity versus Segment Length

NOTE: Given the minimum gap size of 0.5 m and the minimum coverage of 50%, the minimum segment length is 0.5 m. The maximum segment length depends on deck size, but is given by selecting the minimum number of segments (16) and the maximum coverage (75%).

4.3.3 If a segment is made up of a number of individual lighting elements (e.g. LED's) then they should be of the same nominal performance (i.e. within manufacturing tolerances) and be equidistantly spaced throughout the segment to aid textural cueing. Minimum spacing should be 3 cm and maximum spacing 10 cm. The minimum intensity of each lighting element (i) should be given by the formula:

i = I / n

where: I = required minimum intensity of segment at the 'look down'

(elevation) angle (see Table B3).

n = the number of lighting elements within the segment.

4.3.4 If the segment comprises a continuous lighting element (e.g. fibre optic cable, electro luminescent panel), then to achieve textural cueing at short range, the element should be masked at 3.0 cm intervals on a 1:1 mark-space ratio.

4.4 Colour

4.4.1 The colour of the light emitted by the TD/PM circle should be yellow, as defined in ICAO Annex 14 Volume 1 Appendix 1, paragraph 2.1.1(b), whose chromaticity is within the following boundaries:

Red boundary	y = 0.382
White boundary	y = 0.790 - 0.667x
Green boundary	y = x - 0.120

4.5 Serviceability

4.5.1 The TD/PM circle is considered serviceable provided that at least 90% of the segments are serviceable. A TD/PM circle segment is considered serviceable provided that at least 90% of the lighting elements are serviceable.

5 The Heliport Identification Marking Requirement

5.1 Configuration

The lit Heliport Identification Marking ('H') should be superimposed on the 4 m x 3 m white painted 'H' (limb width 0.75 m). The limbs should be lit in outline form as shown in Figure B3.

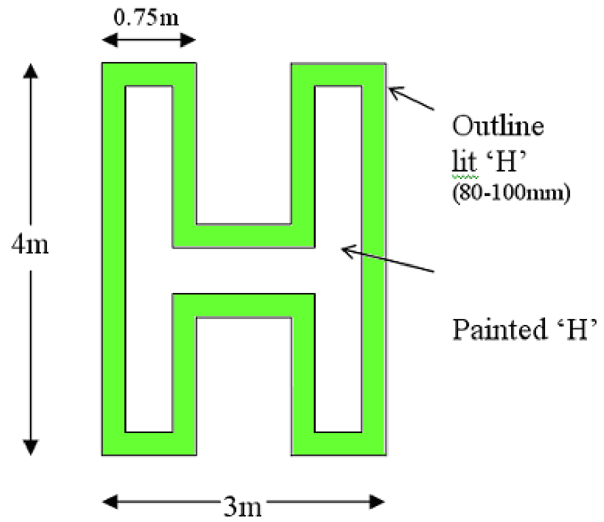

Figure B3 Configuration and Dimensions of Heliport Identification Marking 'H'

5.1.1 An outline lit 'H' should comprise sub-sections of between 80 mm and 100 mm wide around the outer edge of the painted 'H' (see Figure B3). There are no restrictions on the length of the sub-sections, but the gaps between them should not be greater than 10 cm. The mechanical housing should be coloured white - see CAP 437 Chapter 4, Paragraph 2.11.

5.2 Mechanical Constraints

5.2.1 The height of the lit 'H' and any associated cabling should be as low as possible and should not exceed 25 mm above the surface of the helideck when fitted. So as not to present a trip hazard, the lighting strips should not present any vertical outside edge greater than 6 mm without chamfering at an angle not exceeding 30° from the horizontal.

5.2.2 The overall effect of the lighting sub-sections and cabling on deck friction should be minimised. Wherever practical, the surfaces of the lighting sub-sections should meet the minimum deck friction limit coefficient (μ) of 0.65, e.g. on non-illuminated surfaces.

5.2.3 The 'H' lighting components, fitments and cabling should be able to withstand a pressure of 240 lbs/in^2 (1,654,800 pascals), equivalent to one wheel of a 15-ton helicopter touching down heavily on top of them, without damage.

5.3 Intensity

5.3.1 The intensity of the lighting along the 4 m edge of an outline 'H' over all angles of azimuth is given in Table B4 below.

Table B4 Light Intensity for TD/PM Circle Lighting Segments

Elevation	Intensity	
	Min	Max
2° - 12°	3.5 cd	60 cd
>12° - 20°	0.5 cd	30 cd
>20° - 90°	0.2 cd	10 cd

NOTE: For the purposes of demonstrating compliance with this specification, a sub-section of the lighting forming the 4 m edge of the 'H' may be used. The minimum length of the sub-section should be 0.5 m.

5.3.2 The 'H' should consist of the same lighting element material throughout.

5.3.3 If the 'H' is made up of individual lighting elements (e.g. LED's) then they should be of nominally identical performance (i.e. within manufacturing tolerances) and be equidistantly spaced within the limb to aid textural cueing. Minimum spacing should be 3 cm and maximum spacing 10 cm. The intensity of each lighting element (i) should be given by the formula:

$i = I / n$

where: I = intensity of the segment between 2° and 12°.

n = the number of lighting elements within the segment.

5.3.4 If the 'H' is constructed from a continuous light element (e.g. ELP panels or fibre optic cables or panels), the luminance (B) of the 4 m edge of the outline 'H' should be given by the formula:

$B = I / A$

where: I = intensity of the limb (see Table B4).

A = the projected lit area at the 'look down' (elevation) angle.

5.4 **Colour**

5.4.1 The colour of the 'H' should be green, as defined in ICAO Annex 14 Volume 1 Appendix 1, paragraph 2.1.1(c), whose chromaticity is within the following boundaries:

Yellow boundary $x = 0.360 - 0.080y$

White boundary $x = 0.650y$

Blue boundary $y = 0.390 - 0.171x$

5.5 **Serviceability**

5.5.1 The 'H' is considered serviceable provided that at least 90% of the subsections are serviceable. An 'H' subsection is considered serviceable provided that at least 90% of the lighting elements are serviceable.

6 Other Considerations

6.1 All lighting components and fitments should meet safety regulations relevant to a helideck environment such as explosion proofing (Zone 1 or 2 as appropriate) and flammability (by a notified body in accordance with the ATEX directive).

6.2 All lighting components and fitments installed on the surface of the helideck should be resistant to attack by fluids such as fuel, hydraulic fluid, and those used for de-icing, cleaning and fire-fighting. In addition they should be resistant to UV light, rain, sea spray, guano, snow and ice.

6.3 All lighting components and fitments that are mounted on the surface of the helideck should be able to operate within a temperature range appropriate for the local ambient conditions.

6.4 All lighting components and fitments should, as a minimum, meet IEC International Protection (IP) standard IP66, i.e. dust tight and resistant to powerful water jetting.

6.5 All cabling should utilise low smoke/toxicity, flame retardant cable. Any through-the-deck cable routing and connections should use sealed glands, type approved for helideck use.

6.6 All lighting components should be tested by an independent test house. The optical department of this test house should be accredited according to ISO/IEC 17025.

6.7 Provision should be included in the design of the system to allow for the drainage of the helideck, in particular, the area inside the Touchdown / Positioning Marking Circle.