Safety Regulation Group

CAA PAPER 2005/01

Enhancing Offshore Helideck Lighting - Onshore Trials at Longside Airfield

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Civil Aviation Authority

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Reliance on Automation

April 2005

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Foreword

The research reported in this paper was funded by the Safety Regulation Group (SRG) of the UK Civil Aviation Authority, and was performed by QinetiQ Ltd. The work follows on from the earlier trials at the NAM K14 platform reported in CAA Paper 2004/01, and comprises two dedicated flight trials conducted at Longside Airfield near Aberdeen. The aim of the trials was to refine the new offshore helideck lighting scheme established during the NAM K14 trials, investigate the effects of a helideck net on the lighting, and to evaluate some new ideas and technologies.

This paper is based on the contractor's final report ref. QinetiQ/FST/CR024482, which has been edited by SRG's Research Management Department to make the presentation more suitable for the intended audience. All significant changes to the original report have been reviewed by and agreed with the contractor.

The CAA accepts the results of the study which have significantly improved the understanding and knowledge of the factors affecting the performance of the new offshore helideck lighting scheme. Further trials have been performed at Norwich Airport during 2003 and 2004 to establish the detailed characteristics of the scheme from which a specification is to be produced. These additional trials and the specification are to be reported in a separate CAA paper.

The overall programme of research on helideck lighting was commissioned in response to concerns that existed within the industry, and which were subsequently confirmed by the results of a questionnaire survey of the offshore helicopter pilot population reported in CAA Paper 97009.

Safety Regulation Group

04 February 2005

Executive Summary

QinetiQ Bedford are conducting a series of flight trials on behalf of the Safety Regulation Group of the Civil Aviation Authority (CAA) to address the need for improved offshore helideck lighting.

Visual aids are currently provided in accordance with the Standards and Recommended Practices described in the International Civil Aviation Organisation (ICAO) Annex 14 Volume II, and CAA Civil Aviation Publication (CAP) 437. However, a survey of offshore pilot opinion on workload and safety hazards reported in CAA Paper 97009 provided strong support for research into enhancing the existing visual aids and assessing new technologies.

Trials carried out at the NAM K14B platform during 1998 and 1999 and reported in CAA Paper 2004/01 had examined a number of options and showed that the visual acquisition of the helideck could be improved if the colour of the deck perimeter lights was changed from yellow to green and/or the low level floodlights were switched off. Benefit was also gained in the final approach and landing stages by outlining the Touchdown Marking circle using two concentric broken circles comprising strips of yellow Light Emitting Diodes (LEDs). Improved positional and orientation cues were gained from a Heliport Identification Marking (the 'H') illuminated using green Electro Luminescent Panels (ELPs).

This document reports on further dedicated trials conducted at Longside Airfield, Aberdeenshire during 2002, with the aim of investigating:

- the suitability of green perimeter lights with a modified vertical intensity distribution;
- the use of a single LED Touchdown Marking circle compared to a double circle;
- the use of an outline ELP 'H' compared to a solid ELP 'H';
- the effectiveness of a fluorescent 'H', lit by Ultra Violet (UV) lighting at the origin of the Limited Obstacle Sector (LOS);
- the effectiveness of a floodlight mounted at the origin of the LOS, to illuminate the existing painted 'H';
- the effects of a landing net on the visual aids.

The trials were conducted at night with approaches completed against various configurations of lighting both with and without a landing net. Pilot ratings for each configuration were given following each approach. Results showed that all configurations provided positional and translational rate cueing information, but of varying benefit.

Specific conclusions derived from the results of the trials are:

- The suitability of the proposed new perimeter light vertical intensity distribution was not assessed in flight due to the apparent lower than expected intensity of the pre-prototype Orga L55 units.
- There was no additional advantage in having two concentric lit Touchdown Marking circles when there was no landing net in place.
- With a net in place, the cueing was enhanced in the hover and landing with two Touchdown Marking circles compared to one.
- A solid 'H' gave no improvement in cueing over an outline 'H' when no landing net was in place, and a preference for an outline 'H' was stated.
- When a landing net was in place, the net impaired the cueing performance of the outline 'H', and a preference for a solid 'H' was indicated.

- The lit ‘H’ provided heading information to the pilot, however the intensity of the ELP was low, and was washed out by the aircraft landing light.
- The luminous intensity of the fluorescent ‘H’ panels when illuminated by the UV lamps was insufficient for any ratings to be given.
- The white LOS floodlight provided heading information and, below an altitude of 100 ft, it provided useful textural cues to the pilot.
- Without the net in place, the preferred configuration was green perimeter lights, single lit Touchdown Marking circle, and lit outline ‘H’, with the LOS floodlight for additional cueing.
- With the net in place, the preferred configuration was green perimeter lights, double lit Touchdown Marking circle, and lit solid ‘H’, with the LOS floodlight for additional cueing.

The following recommendations are made:

- In order to expose the preferred configuration to a wider sample of pilots over a range of meteorological conditions, it should be installed on an offshore helideck for a formal in-service trial. Installing the configuration on an offshore platform would also enable the performance to be assessed when flying a standard offshore approach rather than the slightly modified profile flown during the trial.
- Due to the difficulties in achieving and maintaining the required levels of intensity from an ELP ‘H’ and its initial cost, it is considered desirable to develop and trial a higher intensity (LED) version of a lit 'H'.
- Further investigation and evaluation of the higher intensity perimeter lights should be carried out to establish whether they meet the proposed new vertical intensity specification, and confirm the absence of glare.
- It is considered essential to derive ranges at which all visual cues need to be seen by the pilot in order to define a specification for the lighting intensities under worst visibility conditions.
- In the deployment of all helideck lighting elements it is recommended that their intensity distributions be tailored to minimise the proportion of light directed up at angles greater than 10° to avoid the hazard of glare to the pilot.

Section 1 Introduction

1 Background

1.1 QinetiQ Bedford was tasked with conducting a series of flight trials on behalf of the Safety Regulatory Group of the Civil Aviation Authority to address the need for improved offshore helideck lighting and marking.

1.2 The final approach and landing phases of all offshore helicopter operations are carried out by reference to visual cues that are derived from the destination platform. On occasions when an instrument approach procedure is in use, the latter stages of the operation remain a visual task.

1.3 Visual aids in the form of both marking and lighting are provided. These are generally in accordance with the Standards and Recommended Practices described in the International Civil Aviation Organisation (ICAO) Annex 14 Volume II, [Reference 1] and CAA Civil Aviation Publication (CAP) 437 [Reference 2]. However, current operational experience at night, and considerations related to the possible future reduction of operating minima through the use of Differential Global Positioning System (DGPS) guidance, indicated the need to review the existing provisions. In addition a survey of offshore pilot opinion on workload and safety hazards [Reference 3] provided strong support for research into enhancing the existing visual aids and assessing new technologies.

1.4 In the light of the above, flight trials were set up to assess the benefits of changing the colour of the perimeter lighting and of using lighting to enhance the deck markings at night. The trials were carried out on the NAM K14B platform during 1998 and 1999 [Reference 4] which examined a number of options but, in particular, showed that:

- the visual acquisition of the helideck could be dramatically improved if the colour of the deck perimeter lights were changed from yellow to green;
- in the final approach, hover and landing there was considerable benefit to be gained by outlining the Touchdown Marking circle using two concentric broken circles comprising strips of yellow Light Emitting Diodes (LEDs), the colour being chosen to reflect that of the painted circle;
- replicating the Heliport Identification Marking (the ‘H’) using green Electro Luminescent Panels (ELPs) gave greatly improved positional and orientation cues during the latter stages of the approach.

1.5 Studies subsequent to the K14 trials showed the intensity specification for perimeter lights presently given in ICAO Annex 14 Volume II to be flawed. A new specification was developed, based on operational data taken from normal in-service operations, which called for significantly raised intensity at low elevation angles, but a reduced intensity at higher angles. This paper can be found in Appendix A. It was therefore necessary to test the overall suitability of a green perimeter light meeting the improved specification prior to proposing its adoption.

1.6 Following on from the previous trial it was decided that a further dedicated trial would be carried out to refine the preferred lighting configuration and, in particular, to investigate:

- the suitability of perimeter lights with a revised vertical intensity distribution;
- use of only one LED circle instead of a double circle;

- use of an outline ELP ‘H’ instead of a solid ELP ‘H’;
- the effectiveness of a fluorescent ‘H’, lit by a Ultra Violet (UV) floodlight mounted at the origin of the Limited Obstacle Sector (LOS), instead of an ELP ‘H’;
- the effectiveness of a floodlight mounted at the origin of the LOS to illuminate the painted ‘H’;
- the effects of a landing net on the visual aids.

1.7 This was to be followed by an in-service flight trial on a suitable, offshore platform with a significant number of night helicopter operations. The purpose was to expose the preferred lighting configuration to a wider sample of pilots in a range of meteorological conditions.

1.8 An offer to use the Forties Bravo production platform, some 100 NM (~185 km) north-east of Aberdeen was made by BP. This was considered an ideal venue because of its high numbers of aircraft movements, and having an aircraft (SA-365N2) actually based on it for ‘in-field’ operations. This offer was accepted and QinetiQ and CAA staff met with BP to establish what might be achieved.

1.9 Unfortunately, for a number of reasons, including the lack of capacity to accommodate trials staff on the platform and the lack of the necessary hazardous area approvals for most of the equipment proposed for the installation, it was only possible to install a set of 24 green perimeter lights.

1.10 In an attempt to achieve some progress during 2002 it was agreed that an on-shore dedicated trial be carried out at an appropriate site. This site was Longside Airfield, Aberdeenshire. This is a small airfield primarily used for training by the two major offshore helicopter operators flying out of Aberdeen; CHC Scotia Helicopters Ltd. (Scotia), who owned the site, and Bristow Helicopters Ltd (BHL). The emphasis of this on-shore trial was to be on the latter stages of the approach and landing, as the initial deck acquisition would be unrepresentative and much better addressed by the in-service trial on the Forties Bravo.

1.11 Due to the time and effort required to install the landing net, it was originally planned that the trial take place over two consecutive evenings. The configurations without the landing net were to be evaluated during the first evening, and the trial then repeated on the second evening with the net in place. However, due to circumstances beyond the control of the trials team, the second evening’s trial could not be performed as intended and, consequently, had to be undertaken later in 2002.

2 Scope of Report

2.1 This report presents the results and analysis of the on-shore flight trials performed at Longside Airfield.

2.2 The structure of the report is as follows. This section provides an introduction to the flight trials conducted. Section 2 provides details of the trial installation and Section 3 describes the flight trial conduct. The data acquired during the trials is presented in Sections 4 and 5. Section 6 contains a discussion of the results with the conclusions in Section 7, and recommendations in Section 8. The acknowledgements and references are contained in Sections 9 and 10 respectively.

Section 2 Trial Installation

1 Trial Site

1.1 The World War 2 airfield at Longside near Peterhead, Aberdeenshire was selected for the trial installation. The airfield was owned by Scotia, one of the two major offshore helicopter operators flying out of Aberdeen.

1.2 This airfield is primarily used for training by both Scotia and BHL crews and is therefore not heavily utilised. This allowed easy access for installation of the trial lighting pattern and the subsequent trials flying. There was also the potential to expose training crews to the chosen lighting pattern and thereby canvas additional opinion from offshore line pilots.

1.3 At the time of the trials, Longside consisted of a single runway (28-10), approximately 800 m long and 45 m wide. A centre section, approximately 20 m wide and extending approximately 600 m from the eastern end, had been resurfaced with tarmac and formed the used runway area.

1.4 The site chosen for the trials installation was on the northern side of the old runway surface towards the western end, within the old compass base area and well clear of the used runway surface (Figure 1). This would minimise the obstruction to training aircraft, being to one side, and would leave a clear area to the south in the event of a rejected take off or overrun on landing.

1.5 The size of the simulated helideck was based on a dimensional value (D) of 22.5 m. This would allow use by the largest of aircraft normally in use on the North Sea, the Sikorski S61, and also be comparable in size with the BP Forties Bravo helideck, on which it was proposed to carry out subsequent in-service trials. The complete installation is shown in Figure 2.

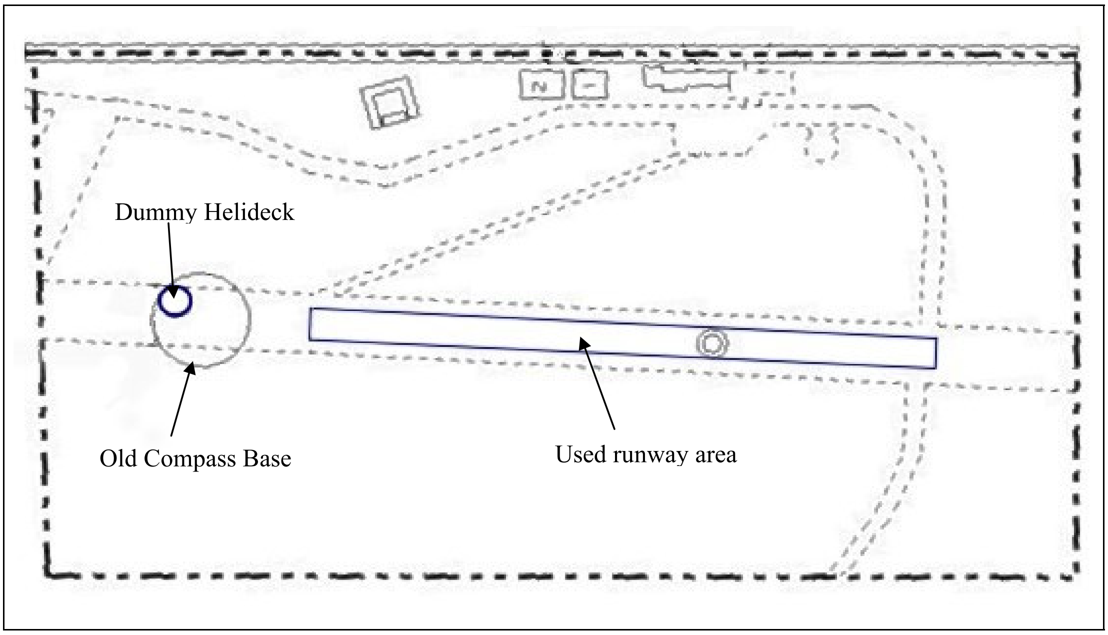

Figure 1 Longside Airfield Layout

Figure 2 Complete Trial Installation

2 Deck Perimeter Lights

2.1 The perimeter lights were Orga EVX2080 units (used for the previous K14B installation), supplemented by a number of new Orga EVX3060 items (which are similar in design and performance). These are shown in Figure 3 below. Both light types were fitted with Orga HPL20-006 lamps which are Osram 230 V, 20 W folded fluorescent tubes with an ES connector, and fitted within an aviation green filter.

Figure 3 Perimeter Lights

2.2 The lights were positioned at 3 m intervals and were attached to the runway surface using M10 galvanised studs, 150 mm long, which were anchored into 12 mm holes drilled in the runway surface using a two-part resin bonding system. Each light fitting was attached by two such studs secured by plain nuts and locking washers.

2.3 Each light fitting was connected to the next around the perimeter (and the first to the supply) by 1.5 mm^2 SWA cable, entering each unit via waterproof cable glands. The cables were additionally anchored at approximately 1 m intervals between the light fittings by cable tying to the eye nuts provided for securing the net (see sub-section 7). All cable ties used for the installation were of the weather resistant type to minimise the likelihood of becoming brittle and subsequent failure due to UV exposure, and the consequent risk of damage to aircraft through ingestion.

3 LED Touchdown Marking Circles

3.1 The inner and outer edges of the Touchdown Marking circle were delineated using aviation yellow LEDline, supplied by HIL-TECH International Ltd., and which were similar to those used for the K14B trial. Both circles comprised 16 strips of LEDline, the inner strips being 1.5 m in length, and the outer 2.0 m in length. The strips were bolted to galvanised steel channel both to give them rigidity and also to provide a route for the cabling connecting the strips together. The channel was anchored to the runway surface using galvanised steel bridge fixings bolted down, as per the perimeter lights, using resin-bonded studs. However, because the strips were likely to be landed on by aircraft operating to the trials 'helideck', dome nuts were used to minimise the risk of tyre damage. Figure 4 shows the LED strips in place with additional sections of channel to protect the cabling between the strips. The lighting intensity profile of the LED strips is given in Appendix B.

3.2 The cabling to the LEDs (supplying only 12 vdc) was a twisted pair of 4 mm^2 conductors, fed from both ends of the circle. This was to reduce the voltage drop due to the resistance of the cables which were carrying a significant current. Four, 4 mm^2 two-core SWA cables fed the power from the supplies out to the circles.

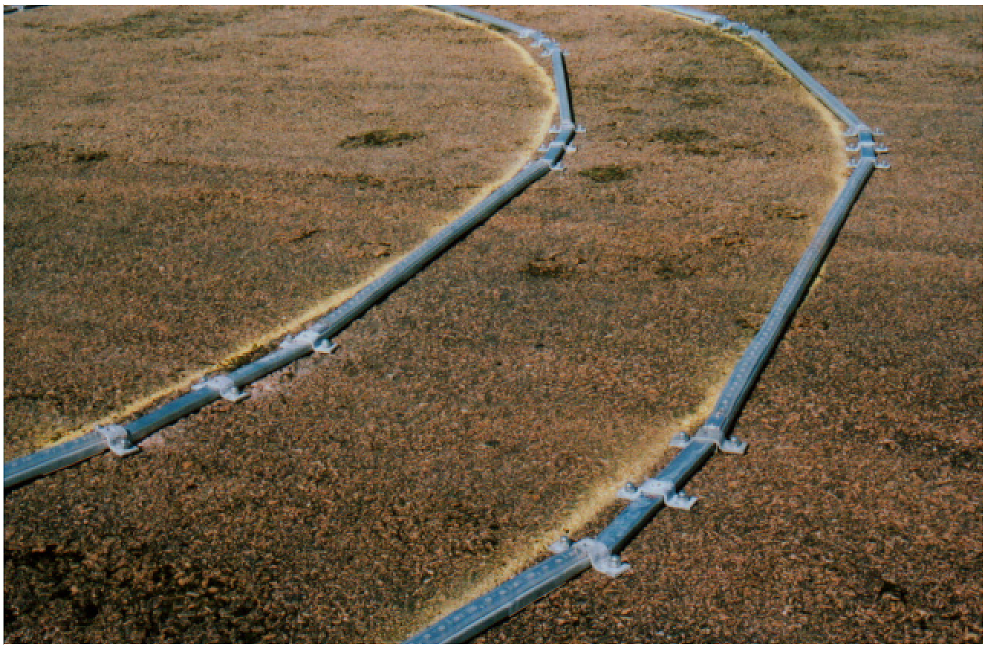

Figure 4 LED Strips

4 ELP 'H'

4.1 An ELP 'H', manufactured by Pacel Ltd and previously used for the K14B trials, was deployed in the centre of the deck. It was discovered, long after the K14B trial and just before installation at Longside, that this 'H' was in fact somewhat smaller than the painted 'H' on a deck, being 3 m x 2 m x 0.3 m rather than the normal (UK) 4 m x 3 m x 0.75 m painted 'H'. Additionally, it had suffered a failure whilst on the K14B platform and was returned to the manufacturer for replacement of the ELP in one leg of the 'H'. The output level from the new panel was approximately double that of the other panels, hence modifications were carried out to the inverter power supply unit to reduce the light output of the new panel to match that of the old. The cables to the two original panels had also been cut off close to the panels when they had been removed from the K14B, hence cable splicing kits were required to graft new cabling to them. Unfortunately, these are quite bulky and lay in the wheel landing area. Once again, the panels were attached to the runway by resin-bonded studs and domed nuts. The cables (1.5 mm^2, 3 core SWA) were grouped together and fed out of the central deck area with those from the two circles. The 'H' is shown in Figure 5 below.

4.2 During discussions between the CAA and QinetiQ on the objectives of the trial, it was suggested that the cost of an ELP 'H' could be reduced if only an outline was required rather than a solid 'H'. It was therefore agreed that both full and outline configurations would be investigated. The full stroke width of the 'H' is approximately 300 mm and is made up of three, equal width strips. For those runs where an outline was required the centre strip was simply covered using 100 mm wide carpet tape.

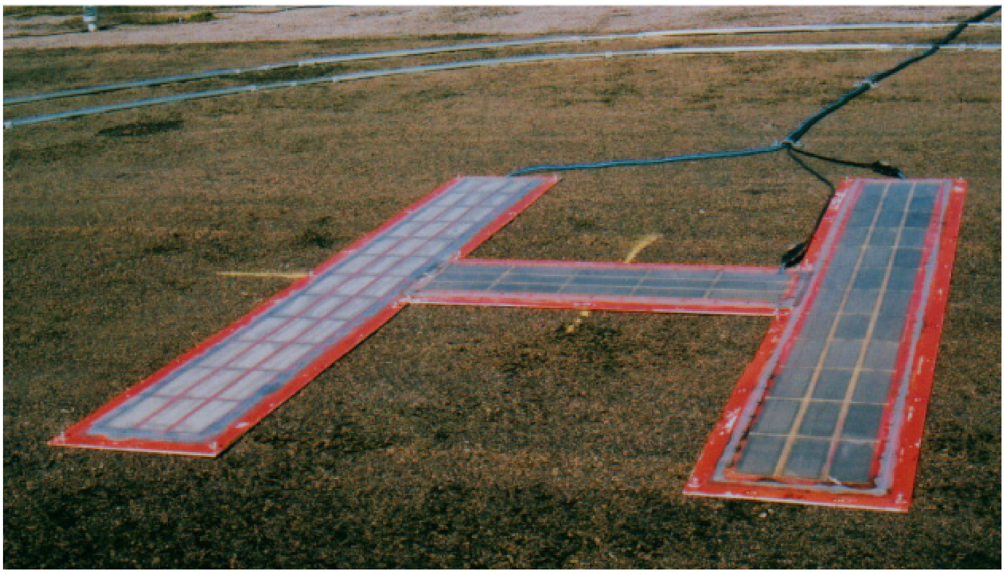

Figure 5 ELP 'H'

5 Floodlighting – Limited Obstacle Sector (LOS)

5.1 Floodlighting was mounted within the LOS significantly higher than the current deck level flood lighting for improved effectiveness. CAP 437 currently allows obstacles of height up to 0.05 D at the edge of the perimeter within the LOS. This would allow lights to be positioned at up to 1.125 m above deck height in this instance. Calculations determined that two Orga SHLF218 helideck floodlights would theoretically give the required level of illumination of 10 lux at the centre of the Touchdown Marking circle, although not over its entire area.

5.2 There remained, however, the issue of glare from these relatively bright sources. Calculations showed that 150 mm deep horizontal louvres, mounted 25 mm apart would significantly reduce the glare seen by the pilot with the helicopter on the ground (this represents the worst case since the elevation of the pilots' eyes relative to the lights is at its lowest value), without noticeably affecting the illumination levels on the deck surface. The calculations for the louvre design can be found in Appendix C .

5.3 The CAA had also been approached by Alstom and BPI (Translight) Ltd. with a suggestion that their UV light and fluorescent paint combination might provide a practical alternative to the ELP 'H'. They offered to provide a UV source and painted 'H' for the trials. It was agreed to add this to the trials installation.

5.4 A framework, manufactured from galvanised steel channel, was erected on the western edge of the perimeter, on which was mounted two Orga floodlights with louvres attached. This is shown in Figure 6. These were positioned to be no greater than the 0.05 D height of 1.125 m specified in CAP 437. Additionally, a pair of UV floodlights, supplied by Alstom was fitted to the frame, again not exceeding the 0.05 D height. All the lights units were depressed at the front by approximately 5.2° to direct the centre of the main beam at the centre of the deck. Both types of light on the frame operated from 230 V, 50 Hz and a waterproof socket mounted on the framework allowed the powering of either but not both systems at any one time.

5.5 Alstom also supplied a lightweight aluminium 'H', painted with white fluorescent paint, the same size as the ELP 'H' which could be attached over the ELP's using the existing fixings.

Figure 6 LOS and UV Floodlights

6 High Intensity Deck Perimeter Lights

6.1 Whilst the EVX2080/3060 perimeter lights were considered to be adequate in most conditions, calculations showed that, in the worst case visibility (0.75 NM (~1400 m)) the output would be insufficient (see Appendix A). These lights provide approximately 12 cd between 0° and 20° from the horizontal, however 31 cd would be required to make them visible in the worst case scenario. Orga, who had been working on a higher intensity perimeter light, offered to make a number of pre-prototype units available to the trial for evaluation.

6.2 Eight units were supplied. These were based on an existing L55 fitting to which a metal baffle was attached, designed to be used for the trial only with the aim of reducing the output at higher angles and prevent glare to the pilot when close to the deck. Figure 7 shows these additional fittings, which were attached to plates that were, in turn, bolted down using the existing perimeter fixings. The new units were positioned adjacent to the eight original fittings starting adjacent to the power distribution box on the northern edge of the deck and going anti-clockwise. A separate, temporary supply cable was installed back to the generator.

Figure 7 High Intensity Perimeter Light

7 Landing Area Net

The helideck net, which had been supplied to QinetiQ some years earlier by the CAA, was estimated to weigh in excess of 0.5 T and was therefore installed using a crane. It transpired that the net was not, in fact, square, being approximately 15 m x 13 m. It was positioned with the long direction east - west and with the northern edge just overlapping the outer circle of LED. A short sector of the southern outer circle was uncovered. The net was tied using nylon rope, at approximately 1.5 m intervals around its perimeter, to the eye nuts positioned between the perimeter lights (Figure 8).

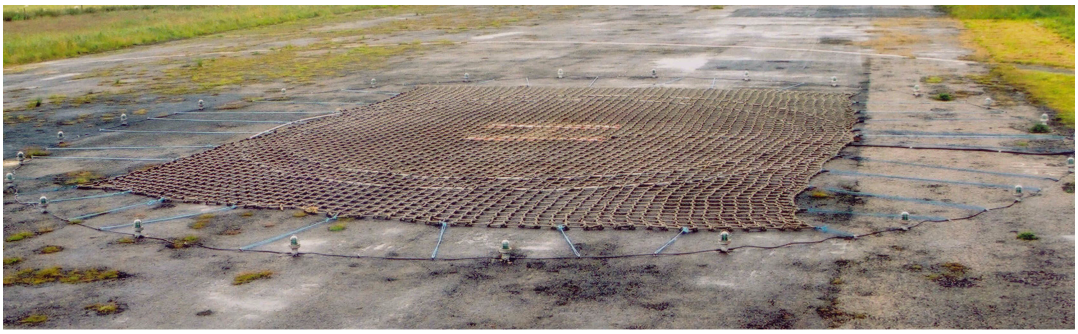

Figure 8 Landing Area Net

8 Power Supplies

8.1 All the cabling from the perimeter lights, circles and 'H' was fed to a junction box mounted on the edge of the runway just outside the perimeter. This contained two 12 vdc power supplies, and fusing and distribution for all three circuits.

8.2 Power for the pattern was provided by a towable diesel generator. This was connected via two flexible, armoured cables which ran from the junction box away from the runway edge onto the grass, and then parallel to the runway to a position some 30 m away from the pattern to the western side.

8.3 A box containing the main circuit breaker and Residual Current Device (RCD) for the system and the 115 V, 400 Hz power supply for the ELP 'H' was mounted on the 'A' frame of the diesel generator. This generator was towed out for each evening of trials.

Section 3 Trial Conduct

1 Introduction

1.1 The purpose of these onshore dedicated trials was to develop and refine the helideck lighting system that was recommended following earlier offshore dedicated trials at the K14B platform [Reference 4], prior to submitting it to extended in-service trials. Various modifications to the helideck lighting system were evaluated, and the cueing performance of each configuration for the final approach, hover and landing phases evaluated.

2 Method

2.1 In order to assess the effect of a landing net on the visual aids, it was necessary to conduct the trial over two days. This was due to the size and weight of the net, which required a crane to install.

2.2 The aircraft used was an S-76 operated by two CAA pilots, the handling pilot being an experienced rotary wing test pilot, and the co-pilot a Senior Flight Operations Inspector. On the first evening the configurations were assessed without the net. Operational data was recorded prior to lift off on the first run and remained valid for the entire sortie. The trial proforma can be found in Appendix D. All test personnel had a headset with a microphone and communications were recorded on a tape recorder.

2.3 Each run was intended to comprise a normal approach, starting at a height of 500 ft and range of 2 NM (~3700 m), and finishing with a hover alongside and landing on the 'deck' as per normal offshore procedures. In practice, however, a number of approaches commenced at much less than the intended 2 NM (~3700 m). Use of the aircraft landing light, as per normal offshore procedures, was permitted. During selected runs, the pilot flying was required to report the range at which a particular aid became a usable cue. Prior to the commencement of each run the QinetiQ Trial Manager confirmed the configuration of the next run and the details of any data that were required during the run.

2.4 Following completion of the approach and landing of each run, the pilot flying was prompted for his responses to the 'post run' rating questionnaire. He was asked to provide a rating from 1- 5 (where 1 is 'poor' and 5 is 'excellent') for different aspects of the visual cueing information, based on his experience of cueing during offshore operations. These were recorded on the trial proforma (in Appendix D). On some occasions a rating response was given as a range, e.g. 3 - 4, or 3½ - 4. In these cases the middle figure of this point has been taken. In the examples quoted here ratings of 3.5 and 3.75 would result. Ratings of 0 were also sometimes given where it was considered that no information was provided.

2.5 The QinetiQ Trial Manager also noted any additional comments. The lighting configuration required for the next run was then set up and confirmed prior to lifting off and commencing the run.

2.6 After the evening's flying, a de-briefing of the pilots was conducted to gain additional pilot comments on each of the aids, and combinations of aids that had been evaluated.

2.7 The net was then installed during the following day in preparation for the second evening's flying. Unfortunately, due to circumstances outside of the trial team's control, it was necessary to cancel the second trial, and a further attempt on the following night was also unsuccessful. The assessment of a selection of the configurations with the net intended for the second night was not, therefore, carried out. An opportunity to examine various configurations from the ground and the roof of the trials van parked adjacent to the pattern was, however, taken (see Appendix G).

2.8 The assessment of configurations with the net in place was conducted some months later. As before, an S-76 aircraft was used and was operated by two CAA pilots. The majority of the trials team, including the handling pilot, was the same as for the first trial.

3 Lighting Configurations

3.1 Table 1 shows the planned run matrix for the assessment without the net. A decision was taken during the trial to delete runs 9 and 10, with the solid 'H', based on the results of run 8 which showed there was no significant difference between the outline and the solid 'H'. A total of 10 runs were therefore completed.

3.2 The first run comprised only the perimeter lights with the standard vertical intensity distribution in order to provide a baseline against which subsequent configurations could be judged. The lighting pattern was then built up by the addition of various lighting components individually and then in various combinations. These included the evaluation of the concepts outlined above (i.e. one circle vs. two circles, solid 'H' vs. outline 'H'). Practical issues also influenced the choice of run order. For example, since tape was used to mask the H to create an outline 'H' for comparison with a solid 'H', it was necessary to complete the runs with the tape (outline 'H') before the runs without the tape (solid 'H'). The fourth run was repeated so that the baseline and outline 'H', and baseline and solid 'H' runs were consecutive, allowing a more reliable comparison to be made.

3.3 The run matrix of the configurations tested with the net in place at a later date is given in Table 2. The combinations of aids were determined by the results of the earlier assessment without the net in place. The main objective was to determine whether the net had an effect on the cueing performance on the various configurations of circles and 'H'. The performance of the LOS floodlight with the net in place was also to be evaluated.

3.4 Based on the results of runs 2 and 3, the decision was taken to employ both Touchdown Marking circles for runs 4, 5 and 7.

3.5 As indicated in paragraph 3.1 not all planned runs were completed on the first trial. Also some lighting configurations were assessed both with and without the net. To aid the analysis, a unique identifier was allocated to each lighting configuration that was completed and for which data were collected and analysed. Table 3 shows this list of lighting configurations and their identifiers.

Table 1 Run Matrix of Configurations for Assessment without the Net Installed

Run No.	Green Perimeter Lights	Yellow LED Circle (Outer)	Yellow LED Circle (Inner)	Green ELP 'H' - Solid	Green ELP 'H' - Outline	LOS Floodlight	LOS UV Floodlight	Comments
1	✓							Baseline (perimeter lights only)
2	✓	✓						Baseline + outer circle only
3	✓	✓	✓					Baseline + both circles
4	✓				✓			Baseline + outline 'H'
5	✓	✓			✓			Baseline + outer circle + outline 'H'
6	✓	✓	✓		✓			Baseline + both circles + outline 'H'
7	✓				✓			Baseline + outline 'H' (repeat of Run 4)
Short break to remove tape to convert ELP 'H' from outline 'H' to solid 'H'.								
8	✓			✓				Baseline + solid 'H'
9	✓	✓		✓				Baseline + solid 'H' + outer circle only
10	✓	✓	✓	✓				Baseline + solid 'H' + both circles
Short break to install cover over ELP 'H' with fluorescent H								
11	✓	✓	✓			✓		Baseline + both circles + LOS floodlight
12	✓	✓	✓				✓	Baseline + both circles + fluorescent 'H'

Table 2 Run Matrix of Configurations for Assessment with the Net Installed

Run No.	Green Perimeter Lights	Yellow Led Circle (Outer)	Yellow Led Circle (Inner)	Green ELP 'H' - Solid	Green ELP 'H' - Outline	LOS Floodlight	Comments
1	✓						Baseline (perimeter lights only)
2	✓		✓				Baseline + inner circle only
3	✓	✓	✓				Baseline + both circles
4	✓	✓	**?** (*)		✓		Baseline + LED circle(s)* + outline ELP 'H'
5	✓	✓	**?** (*)	✓			Baseline + LED circle(s)* + solid ELP 'H'
6	✓					✓	Baseline + LOS floodlight
7	✓	✓	**?** (*)			✓	Baseline + LED circle(s)* + LOS floodlight

NOTE: * Single/double LED circle - dependent on the results of Runs 2 and 3.

Table 3 Table of Lighting Configurations Assessed

Lighting Configuration		Trial	
Identifier	**Configuration**	**No Net (Table 1)**	**Net Fitted (Table 2)**
a)	Baseline (perimeter lights only)	Run 1	Run 1
b)	Baseline + one circle only	Run 2 (outer)	Run 2 (inner)
c)	Baseline + both circles	Run 3	Run 3
d)	Baseline + outline 'H'	Runs 4 & 7	-
e)	Baseline + one circle + outline 'H'	Run 5	-
f)	Baseline + both circles + outline 'H'	Run 6	Run 4
g)	Baseline + solid 'H'	Run 8	-
h)	Baseline +both circles + LOS floodlights	Run 11	Run 7
i)	Baseline + LOS floodlights	-	Run 6
j)	Baseline + both circles + solid 'H'	-	Run 5

Section 4 Trial Results – Without Net Installed

1 Introduction

1.1 The trial was conducted on 17 July 2002 at night with a half moon providing a little ambient light. The visibility was 10 km plus, with a cloud base of 2500 ft. The wind was light and variable and there was no precipitation.

1.2 A total of 10 runs were completed, all without the net installed. Ratings of the provision of visual cueing information in the final approach, hover and landing phases were taken after each run. The only exception to this was run 7, which served purely to re-datum the pilots and therefore no ratings were taken.

1.3 Data from run 12 has also been excluded from the analysis. The last configuration tested included the addition of a fluorescent UV 'H' instead of an ELP 'H'. This did not work as expected in that the UV 'H' did not fluoresce significantly when illuminated with the UV light. Since in this run it would have been the UV 'H' that provided any additional cueing information, it was decided to omit any rating data for this run from the analysis.

1.4 Rating data from 8 runs were therefore available for analysis which is reported in sub-sections 2 to 4 below. Pilots were also asked to give a range at which each of the aids became a usable cue, and comments made throughout the sortie were also recorded. These are reported in sub-section 5.

2 Final Approach Phase Ratings

2.1 A summary table of the ratings awarded for the provision of cues in the final approach phase, and bar charts for each of the items of visual cueing information, are presented in Appendices E and F respectively. These data indicate that there was no difference in the cueing information provided by a double lit Touchdown Marking circle over a single circle (configurations b) and c), and e) and f)), or by a solid lit 'H' compared to an outline lit 'H' (configurations d) and g)).

2.2 The ratings data for the final approach phase are further summarised in the left-hand section of Figure 2. Note that for cases where there was considered to be no difference in the ratings between runs, a single symbol has been used to represent more than one run. The figure shows that all configurations resulted in an improvement in at least one item of visual cueing information available to the pilot during the final approach phase compared to the baseline.

2.3 The provision of flight path angle information was improved in all combinations that included the lit Touchdown Marking circle(s) (configurations b), c), e), f) and h)), and was further improved by the addition of the lit 'H' (configurations e) and f)). Curiously, the addition of the lit 'H' alone (configurations d) and g)) did not result in any improvement. The addition of the LOS floodlight (configuration h)) had no effect either.

2.4 Attitude information was improved in all combinations that included the lit Touchdown Marking circle(s) (configurations b), c), e), f) and h)).

2.5 Azimuth alignment information was found to be lacking with just the green perimeter lights of the baseline (configuration a)). The lit Touchdown Marking circle(s) alone (configurations b) and c)) provided a small amount of information, but it was the lit 'H' that significantly improved the ratings (configurations d) and g)). Still higher ratings were awarded when the lit 'H' and Touchdown Marking circle(s) were combined (configurations e) and f)) and, by inference from configuration h), the LOS floodlight provided a level of azimuth alignment information slightly lower than the 'H'.

2.6 Closure rate information was improved by the addition of the lit Touchdown Marking circle(s) alone (configurations b) and c)). The lit 'H' did not produce any improvement by itself (configurations d) and g)), and actually degraded the positive effect of the lit Touchdown Marking circle(s) when the two aids were combined (configurations e) and f)). The LOS floodlight did not provide any additional closure rate cues.

3 Hover and Landing Phase Ratings

3.1 A summary table of the ratings awarded for the provision of cues in the hover and landing phase, and bar charts for each of the items of visual cueing information, are presented in Appendices E and F respectively. As for the final approach phase, these data indicate that there was no difference in the cueing information provided by two lit Touchdown Marking circles over a single circle (configurations b) and c), and e) and f)), or by a solid lit 'H' compared to an outline lit 'H' (configurations d) and g)).

3.2 The ratings data for the hover and landing phase are further summarised in the right hand section of Figure 2. Note that for cases where there was considered to be no difference in the ratings between runs, a single symbol has been used to represent more than one run. As for the final approach phase, the figure shows that all configurations resulted in an improvement in at least one item of visual cueing information available to the pilot during the final approach phase compared to the baseline.

3.3 All configurations provided greater lateral and longitudinal position and translational rate information compared to the baseline. Equal improvements in all four items of visual cueing information were obtained with the addition of either the lit Touchdown Marking circle(s) or the lit 'H', or both together (configurations b), c), d), e), f) and g)). The addition of the LOS floodlight (configuration h)) had a slightly negative effect on the improvement provided by the lit Touchdown Marking circles.

3.4 Height and descent rate information was also improved in all enhanced configurations. The greatest improvement was provided by configurations containing the lit 'H' (configurations d), e), f) and g)), followed by the lit Touchdown Marking circle(s) (configurations b) and c)). Configurations comprising both aids (configurations e) and f)) scored the same as the lit 'H' alone. The addition of the LOS floodlight to the lit Touchdown Marking circles (configuration h)) produced a slight improvement in the height information over that provided by the lit Touchdown Marking circles alone.

3.5 Heading information was only available with configurations containing either the lit 'H' or the LOS floodlight (configurations d), e), f), g) and h)), which all produced equal ratings.

3.6 Yaw rate information was improved only in configurations containing the lit Touchdown Marking circle(s) (configurations b), c), e), f) and h)), where equal ratings were awarded in each case.

4 Summary of Ratings

4.1 It can be seen that of all the trial configurations, the combination of the green perimeter lights with one or two circles and the 'H' (outline or solid) provided the most enhanced cueing environment overall, without the net installed. This configuration can be seen in Figure 1 below.

Figure 1 Illustration of all Components of the Preferred Configuration

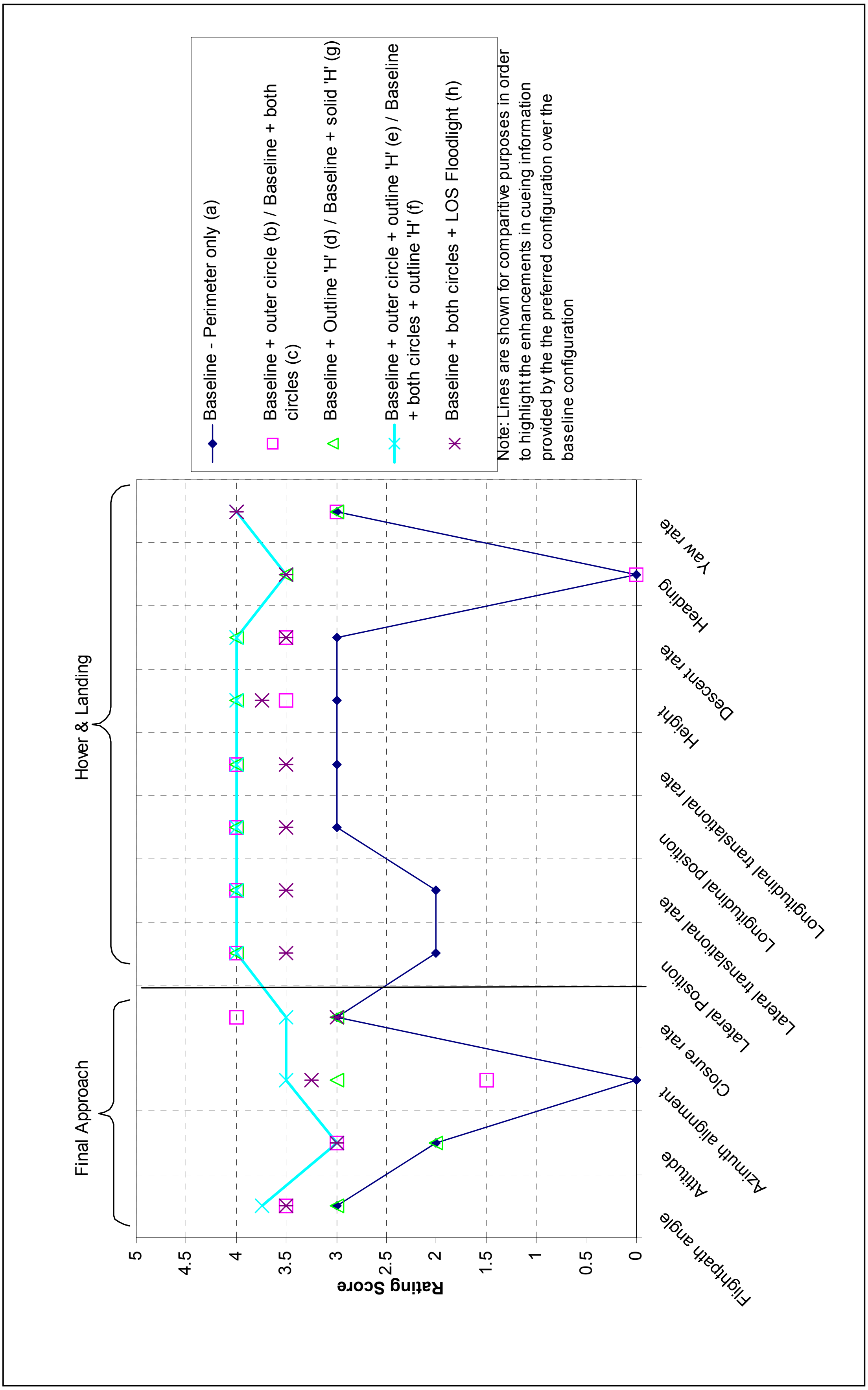

Figure 2 Comparison of all Runs without Net Installed

5 Pilot Comments

5.1 Perimeter Lights

5.1.1 The green perimeter lights were considered to be of most benefit at the longer ranges. They were regarded as a perfectly usable cue from 1 NM (~1850 m), providing excellent cues for the location and the general aspect of the deck, with it being very obvious where the deck was located. The regular, even pattern was thought to be very good and acted as a good angle of approach indicator. The flat oval shape of the lights also gave good perspective information and, when at 200 ft, the lights provided closure rate information. It should be noted, however, that a regular circular pattern of perimeter lights, as was presented to the pilot in the trial installation, is atypical to that on offshore platforms. A less regular, often octagonal, shape is more typical (see Section 6 paragraph 1.4).

5.1.2 When the perimeter lights were used on their own however, in the latter stages of the approach it was stated the quality of information provided seemed to degrade. The centre of the deck looked rather black and it was considered that it was at this point that more information was required in the middle of the deck.

5.1.3 The intensity of the lights was considered to be acceptable, however their effectiveness may be degraded by cultural lighting that would be encountered offshore but not present during the trial.

5.2 Touchdown Marking Circles

5.2.1 With one Touchdown Marking circle lit, the circle could be seen at 1.2 NM (~2200 m) but it was not usable as a cue at this point. The circle started becoming more prominent at 0.8 NM (~1480 m) and from 0.2 NM (~370 m), and probably 0.3 NM (~550 m), it was regarded as looking quite useable. It was commented that the circle was very obvious and enhanced the aspect information available at this point. At around 300 - 400 m from the deck, the detail of the individual LEDs and strips became visible which provided useful cues. It was considered that it was at this latter stage that this aid is most usable. Prior to this however, the presence of the circle in the middle of the pattern had helped to enhance the obviousness of the deck and, in the middle part of the approach at a height of 500 ft, it had also helped with perspective.

5.2.2 It was considered that there was no significant difference in the cueing information available with two circles compared to one circle. At a range of 0.6 NM (~1100 m) the two circles just looked like a thicker yellow line than with one, and it was only at 0.2 NM (~370 m) that they could be clearly distinguished as being two circles. As with one circle, the detail of the strips started to be seen at 300 - 400 m from the deck. Two circles were not considered to be any worse than one, although there was a slight enhancement in terms of general information available from 400 - 100 ft. This was not considered to be a big improvement, however, and the glare was slightly worse (see paragraph 5.2.3 below) which detracted from the general view. It was commented that two circles might provide more information than one with the net installed. If one circle only was used however, it was considered that the preference would be for the inner circle rather than the outer one when there was no lit ‘H’ present, and for the outer circle if the lit ‘H’ was present. This was based on the feeling that a more even spread of light sources across the deck, with minimisation of large dark areas was preferred. No direct comparison of the inner/outer circles was flown, however.

5.2.3 The only adverse comment concerning this aid was that, due to the transparencies on the aircraft being not particularly clean, the light from the LED strips scattered on the transparencies and caused a slight amount of glare. This was seen when coming over the deck edge and looking through the chin window and was slightly worse with two circles. This could possibly be reduced by dimming the LEDs.

5.3 Illuminated 'H'

5.3.1 No differences between the outline and the solid ELP 'H' were apparent in terms of the ratings given for visual cueing information provided. The 'H' was not visible at 0.4 NM (~740 m), something in the middle of the deck could vaguely be made out at 0.3 NM (~550 m), and at 0.2 NM (~370 m) it could just about be seen that it was an 'H'. It became a useable cue at 300 m from the deck, where it could be seen clearly. The 'H' provided good information in the latter stages, and filled in the previously bare middle part of the deck. The main benefit of the 'H' was when translating over the deck when good lateral translational rate information was provided. Good translational information was also provided as it disappeared under the aircraft. It was commented that the 'H' did provide some useful information regarding heading relative to the deck, the short centre stroke of the 'H' being aligned with the bisector of the obstacle-free sector. The segmented composition of the 'H' also provided additional cues.

5.3.2 It was also stated that the 'H' provided something 'real' in the middle of the deck, as compared to the LEDs (circles) which have an abstract appearance. At close range something with a more 'natural feel', without a large contrast to the surrounding area, like the ELP 'H' is preferable. It was commented that if the composition of the 'H' were changed to LED, which is being considered as a possibility, then this aspect and the issue of glare would need to be carefully considered.

5.3.3 Although there was no difference in the ratings given for the outline and the solid 'H', a slight preference was expressed for the outline 'H'. Slightly more perspective information was gained from the outline form. It was reported that the solid 'H' did not add anything, and that there was some glare at very close range with this configuration which was not experienced with the outline form.

5.4 White LOS Floodlight

5.4.1 The white LOS floodlight was helpful from a range of 150 m, and a height of 100 ft. The pilot commented that it illuminated the texture of the deck and gave a lot of detail to orient the aircraft. It also provided quite good infilling when the aircraft's landing light was steered away. There was no significant glare from the LOS floodlight, even when the aircraft was in the optimum position, i.e. when the aircraft is on the deck and the elevation of the pilots' eyes relative to the floodlights is at its lowest value. It was considered that there was a definite gain in raising the floods from the deck surface where they are currently located. It was thought that the floodlights would be more helpful if they were brighter, provided there was no glare as a consequence.

5.5 UV Floodlight

5.5.1 The aluminium panels, painted with white fluorescent paint, placed over the ELP 'H' and illuminated by two UV lights, failed to fluoresce. The painted 'H' was only visible if illuminated with the aircraft landing light and, unlike the white light, the UV light did not generate any textural cues on the surface of the deck.

5.6 Combinations of Individual Aids

5.6.1 With the addition of the lit circle to the baseline of the green perimeter lights, it was commented that the yellow circle made a 'nice contrast' to the green and started to provide more detail even from a range of 1.1 NM (~2000 m).

5.6.2 When the 'H' alone was added to the baseline pattern, from a distance of 0.8 NM (~1500 m) it was considered that the set-up looked just as it did with the green perimeter lights only (since the 'H' could not be seen at this distance). As reported above, it was not until 400 m that it could just about be seen that it was an 'H' and not until 300 m from the deck that it could be seen clearly and it became a useable cue. It was commented that it looked 'bare' and 'not very interesting' as compared to having the yellow LEDs present, and that this provided a definite indication that the circle(s) represented a significant enhancement.

5.6.3 It was felt that the benefit of the addition of the white LOS floodlight to the configuration was the illumination of the deck surface that generated textural cues. The ratings given, however, indicate that the floodlight was also beneficial in the provision of heading cues.

5.6.4 The preferred configuration was the combination of green perimeter lights, one circle (the outer circle was the one presented), and the outline 'H'. It was felt that this gave all the information that was required in all stages of the approach and landing. The green perimeter lights, supplemented by the yellow circle, gave deck location and general information at longer ranges. The yellow circle gave more aspect information and detail in the middle stages and then, in the latter stages, the single circle of yellow LEDs and the 'H' in the middle gave a good solid aiming point with a nicely filled in centre.

Section 5 Trial Results – With Net Installed

1 Introduction

1.1 Although it was not possible to fly approaches to the deck with the net installed on the first trial, the trials team did have an initial look at the effect of the net from the ground, and from the roof of the trials van which gave a look-down angle of approximately 6º. These observations are reported and discussed in Appendix G.

1.2 A dedicated trial was subsequently conducted on 7 November 2002 at night with no moon to provide any ambient lighting. The visibility was 25 km plus, with no significant cloud base and no precipitation.

1.3 A total of 7 runs were completed, all with the helideck net installed on top of the deck lighting. Ratings of the provision of visual cueing information in the final approach, and hover and landing phases were taken after each run. Pilots were also asked to state the range at which each of the aids became a usable cue and comments made throughout the sortie were recorded. These are reported in sub-section 5.

2 Final Approach Phase Ratings

2.1 A summary table of the ratings awarded for the provision of cues in the final approach phase, and bar charts for each of the items of visual cueing information, are presented in Appendices E and F respectively. These data indicate that there was no difference in the cueing information provided by a solid lit 'H' compared to an outline lit 'H' (configurations f) and j)), and only a minor benefit of two lit Touchdown Marking circles compared to a single circle (configurations b) and c)). The ratings data for the final approach phase are further summarised in the left hand section of Figure 1.

2.2 The provision of flight path angle information was improved in all configurations containing the lit Touchdown Marking circle(s) (configurations b), c), f), h) and j)). The single lit Touchdown Marking circle (configuration b)) was awarded a slightly lower rating than the double circle.

2.3 The rating for attitude information was unchanged from the baseline by the addition of either a single lit Touchdown Marking circle (configuration b)) or the LOS floodlight (configuration i)). Configurations containing the double lit Touchdown Marking circle (configurations c), f), h) and j)), however, were rated slightly lower than the baseline.

2.4 Azimuth alignment information was improved only by the addition of the lit 'H' (configurations f) and j)).

2.5 Closure rate information was improved with the addition of the lit Touchdown Marking circle(s) (configurations b), c) and h)), and further improved with the addition of the lit 'H' (configurations f) and j)). The LOS floodlight by itself (configuration i)) had no effect.

3 Hover and Landing Phase Ratings

3.1 A summary table of the ratings awarded for the provision of cues in the hover and landing phase, and bar charts for each of the items of visual cueing information, are presented in Appendices E and F respectively. These data indicate that slightly greater benefit was provided by a solid lit 'H' compared to an outline lit 'H' (configurations f) and j)), and by two lit Touchdown Marking circles over a single circle (configurations b) and c)). The ratings data for the hover and landing phase are further summarised in the right hand section of Figure 1.

3.2 All configurations provided greater lateral and longitudinal positional and translational rate information compared to the baseline. Increments in the ratings awarded for each of the four items of visual cueing information were obtained by adding a single lit Touchdown Marking circle (configuration b)), changing to a double lit circle (configuration c)), and then adding a lit solid 'H' to the double circle (configuration j)). The outline lit 'H' provided no additional benefit when added to the double lit Touchdown Marking circle (configuration f)). The LOS floodlight produced only a small increase in the ratings awarded for lateral and longitudinal translational rate information (configurations h) and i)).

3.3 Height and descent rate information was also improved in all enhanced configurations. Adding a single lit Touchdown Marking circle improved both ratings (configuration b)), and changing to a double lit circle (configuration c)) produced a further improvement but in descent rate information only. Still further improvement was obtained by the addition of either an outline or solid lit 'H' (configurations f) and j)). The LOS floodlight produced a modest improvement in both ratings by itself (configuration i)), and in height information only when used in conjunction with the double lit Touchdown Marking circle (configuration h)).

3.4 The addition of either an outline or solid lit 'H' (configurations f) and j)) provided heading information which was not available from either the perimeter lights or the lit Touchdown Marking circle(s). An improvement in the rating awarded was also obtained with the LOS floodlight by itself (configuration i)), but not when used with the lit Touchdown Marking circles (configuration h)). In the latter case, the double lit Touchdown Marking circle reduced the conspicuity of the LOS floodlight (see paragraph 5.3.2).

3.5 A slight increase in the ratings awarded for yaw rate information was obtained for configurations containing the double lit Touchdown Marking circle only (configurations c), f), h) and j)).

4 Summary of Ratings

A summary of the ratings for all the runs with the net installed is given in Figure 1. It can be seen that of all the trial configurations with the net installed, the combination of green perimeter lights, both circles and the solid 'H', provided the most enhanced cueing environment overall.

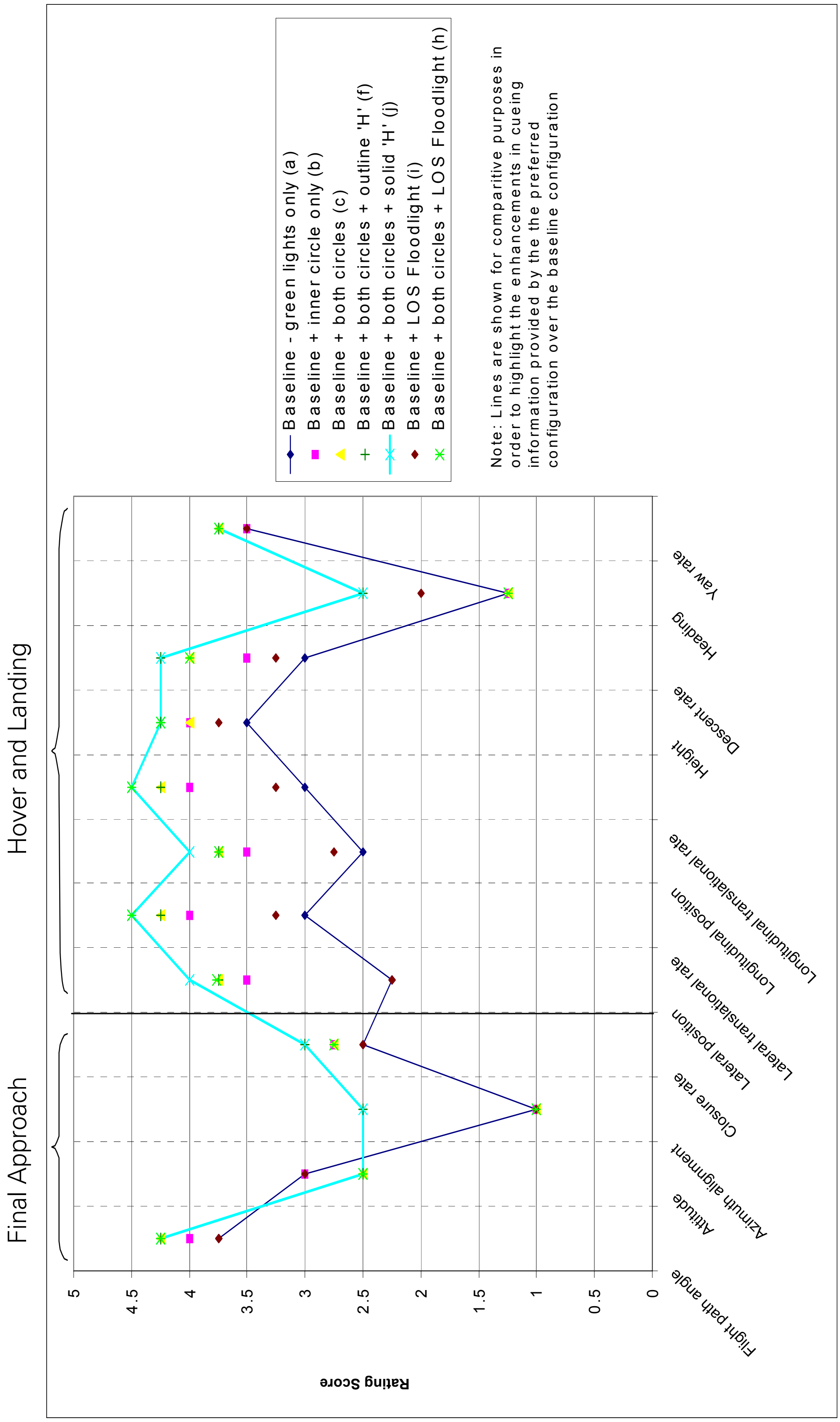

Figure 1 Comparison of all Runs with the Net Installed

5 Pilot Comments

5.1 Touchdown Marking Circles

5.1.1 With one Touchdown Marking circle lit, there was a reasonable view of the yellow circle at about 1 NM (~1850 m), with a good view at about 0.7 NM (~1300 m). It was considered that the circle gave a nice target to aim at and still looked fairly continuous even with the net in place. Although it was a little broken in places it still looked very much like a circle and was providing good cueing information.

5.1.2 With two Touchdown Marking circles lit they were seen further out at 1.4 NM (~2600 m), and it was commented that it was more obvious than with only one circle. The circles looked very obvious at 0.5 NM (~930 m) and provided a lot of information at a height of 200 ft, again providing an aiming point. It was considered that the net was having no significant effect in terms of degrading the cues provided by the circles.

5.2 Illuminated 'H'

5.2.1 The outline 'H' started to be detected in the middle of the deck at 0.3 NM (~550 m), however it was not adding anything to the visual scene at this point. It was starting to become more obvious when closer in, at a height of 240 ft and a range of 0.2 NM (~370 m). However, it was when down at a height of 100 ft that the 'H' was firmly in view, fully usable and useful. It was commented that the 'H' was not as useful with the net on as it was without the net since it was less prominent. The landing light was also seen to degrade the cueing provided by the 'H', which was due to the reflection from the light coloured net.

5.2.2 The solid 'H' began to come into view at a height of 250 ft and a range of 0.25 NM (~460 m) although it was not useful at this stage. It was seen more clearly when at a height of 160 - 170 ft and at a range of 0.2 NM (~370 m). It was considered that the solid 'H' was better than the outline version. It stood out quite well and, although the landing light did wash it out, the effect was not as significant as with the outline version.

5.3 White LOS Floodlight

5.3.1 With the LOS floodlight and the green perimeter lights only, a small floodlit area in the middle of the deck could be seen at 0.6 NM (~1100 m), and it was giving a little information at a range of 0.15 NM (~280 m). The benefits of the floodlighting, however, did not start to be seen until at a height of 150 ft. The lights were illuminating only a small section of the deck close to the light itself. They did not illuminate the centre of the deck. It was considered that there was little difference to the original baseline run of green perimeter lights only, there being only a very slight enhancement in the final stages only.

5.3.2 When the floodlights were combined with the Touchdown Marking circles it was commented that they were being drowned out by the yellow circles. At a height of 150 ft the floodlights were not having any obvious effect, it was only in the latter stages when committing to the deck at a height of 60 ft, that they were providing some benefit in terms of cueing. Again it was felt that there was not much difference to the corresponding run without the floodlights.

Section 6 Discussion

1 General

1.1 It should be noted at the outset that the trial installation at Longside was not, nor was it intended to be, truly representative of an offshore helideck. Obviously the deck was at ground level, not elevated, and it was situated in the middle of an unlit airfield. With the exception of the generator, which had an obstruction light because of its close proximity to the deck, there was no other adjacent lighting.

1.2 The lack of surrounding lighting resulted in a deck that was more representative of a small, dark Normally Unattended Installation (NUI) rather than a large production platform (such as the Forties Bravo) which typically have significant cultural lighting and flares. Nevertheless, the area of particular interest was the effects of the pattern in the latter stages of the approach and landing which is considered to be a more demanding task on the smaller, less well lit decks typical of NUIs.

1.3 Unlike on an offshore helideck, at Longside spillage of light onto the ground and paved areas outside of the marked deck area would have given additional, if unintentional cues.

1.4 At Longside the perimeter lights were evenly spaced in a circular pattern. This is atypical and non compliant with ICAO Annex 14 Vol. II [Reference 1]. A less regular, often octagonally-based shape is more typical due to the number of obstructions that are found on the average helideck offshore. Some of the benefit gained from the green perimeter lights used during the trial could be attributable to the circular layout used. With a more typical perimeter light layout, the incremental benefit of adding additional visual aids might be expected to be greater than evident in these results.

2 Final Approach Phase

2.1 The green perimeter lights provided information regarding location and general aspect of the deck at longer ranges during the approach. The perimeter lights also provided reasonable levels of information for flight path angle, attitude and closure rate, but little or no azimuth alignment information. This was fully expected given the axial symmetry of the circular perimeter light pattern used. The cues provided by the perimeter lights were, by definition, unaltered by the installation of the net, the lights being located outside the area covered by the net.

2.2 The addition of the lit Touchdown Marking circle(s) had a positive effect on the ratings awarded for all final approach information apart from azimuth alignment information. In the case of the latter, as for the perimeter lights, the axial symmetry of the pattern precluded the provision of an azimuth reference. Overall, the double lit Touchdown Marking circle provided no significant advantage over the single circle, and the addition of the helideck net had no significant adverse effect.

2.3 The lit ‘H’ had no effect on the ratings awarded for any final approach information except azimuth alignment information. The usefulness of this aid is clearly limited to the latter stages of the approach where the viewing range is more compatible with its relatively low intensity. There was no difference between the ratings awarded for the outline and solid versions of the lit ‘H’ either with or without the net in place.

2.4 The LOS floodlight provided little benefit except in terms of azimuth alignment information, and then only without the net in place. The absence of a similar result with the net installed was unexpected; if anything, better results were anticipated from the LOS floodlight with the net in place.

3 Hover and Landing Phase

3.1 The addition of the lit Touchdown Marking circle(s) had a positive effect on the ratings awarded for all hover and landing information apart from heading information as for the final approach phase. Without the net in place there was no additional benefit from the double lit Touchdown Marking circle compared to the single circle. With the net in place, however, there was a slight additional improvement in six of the eight visual cueing information items. Otherwise the addition of the helideck net had no significant effect on the performance of this aid.

3.2 When used in combination with the double lit Touchdown Marking circle, the lit 'H' provided improved height, descent rate and heading information both with and without the helideck net in place. Without the net there was no difference in performance between the outline and solid versions. With the net, the solid version was preferred for which slightly better ratings were obtained for positional and translational rate information.

3.3 Overall the only benefit provided by the LOS floodlight was in terms of heading information. Without the net in place, the addition of the LOS floodlight to the double lit Touchdown Marking circle had a small negative effect on the positional and translational rate information. With the net installed, this effect was removed in the case of the positional information, and reversed in the case of the translational rate information. Thus the LOS floodlight was more effective with the net in place as had been expected and contradicting the results for the final approach phase (see paragraph 2.4). Also, with the net installed and when used by itself, the LOS floodlight produced a small positive effect on six of the eight items of visual cueing information.

4 Overall Pattern

4.1 On the basis of the ratings and the pilot reports, the preferred configuration of the visual aids tested, without a landing net in place, was that of:

- Green perimeter lights;
- One lit Touchdown Marking circle;
- Outline ELP 'H'.

4.2 On the basis of the ratings and the pilot reports, the preferred configuration of the visual aids tested, with a landing net in place, was that of:

- Green perimeter lights;
- Two lit Touchdown Marking circles;
- Solid ELP 'H'.

4.3 Calculation had predicted that with the net, the conspicuity of the Touchdown Marking circle and 'H' was likely to be impaired when viewed from typical approach angles, although not as badly as passive paint markings where both the illumination and the pilot's view would be impaired. Based on an initial visual inspection from the ground it was discovered that both the circles and the 'H' were actually more conspicuous when viewed from typical approach angles than might have been expected because the net tended to ride over them. The results of the subsequent flight trial supported this observation. Although, the LED circles looked slightly broken, for example, they still looked very much like circles and provided good cueing information.

4.4 The results of the 17 July 2002 trial without the net in place indicated that one circle was adequate, and the subsequent ground observations with the net installed suggested that one circle might be preferable for that case. It was found, however, that two Touchdown Marking circles provided slightly improved cueing information in the hover and landing with the net fitted. Also, during the runs without the net, the outline version of the 'H' was preferred. This was probably due to the fact it provided additional edges and vertices. It was considered likely, however, that this might be a disadvantage with a net fitted due to excessive 'fragmentation' of the 'H'. The results of the flight trial with the net in place demonstrated this to be the case, with the solid 'H' providing more enhanced cues in terms of positional and translational rate information.

4.5 When there was no net in place, there was a slight preference for one lit landing circle rather than two, with no benefit seen in having two circles. It is possible, however, that a single circle may not be as effective in conjunction with a more representative perimeter lighting pattern (see paragraph 1.4). It is also possible that, with one circle, the pilot's view of a single narrow line of lights may be unduly distorted by precipitation, or grease on the aircraft transparencies. These factors should be borne in mind.

4.6 It was not possible to evaluate the overall suitability and, specifically, the absence of glare from the green perimeter lights designed to meet the new intensity specification. It would not have been possible to demonstrate any improved performance in terms of intensity over the standard units unless low visibility conditions had been encountered. However, when examined from the ground, (at relatively short ranges) the modified L55 light did not appear to be any brighter than the EVX 2080's or 3060's. A quick check using a street lighting meter at a range of approximately 1 m indicated approximately 20 lux (20 lux at 1 m = 20 cd). Further tests in the laboratory at Bedford, again using the street lighting meter, also indicated a peak of approximately 20 cd. This is well short of the anticipated 31 cd which is required to satisfy the worst case, limiting visibility conditions. It should be noted, however, that the colour (co-ordinates x = 0.268, y = 0.724) of the L55 units was significantly different to the EVX 3060s (co-ordinates x = 0.266, y = 0.586) and this may be a factor in the perceived intensity.

5 Hardware

5.1 Some problems and shortcomings were observed with the hardware used for the trial installation which are recorded here for future reference.

5.2 The Orga EVX perimeter units were adequate for the task, however one unit base was cracked when being tightened down onto the uneven runway surface. It should be noted that these units were not, in fact, designed as a perimeter light but as pendant fittings for lighting thoroughfares in a hazardous environment. Also these units do not achieve the output required for worst case limiting visibility.

5.3 The basic Orga L55 units are suitably robust and capable of surviving the rigorous offshore environment. The 'Sombrero' style baffle arrangement was only intended to be used for trial purposes, however, it was felt that these would be inappropriate for the offshore environment given the fragile structure and potential for corrosion and mechanical damage.

5.4 Both this and the previous K14 trials demonstrated weaknesses in the LED strips used for the two Touchdown Marking circles. The base material, a clear thermoplastic, is susceptible to significant expansion and contraction under thermal cycling caused by sunlight. The continuous flexing of the strip caused both cracking at the fixings and a number of failures in the solder connections to the copper tracks within the strip. Additionally, neither the strip nor its cabling (a simple unsheathed twisted pair) are hazardous-area approved and are not considered robust enough for long term use in an offshore environment in their current form.

5.5 The ELP ‘H’ used both in these trials and the previous offshore trial on K14 is not of the correct size for a helideck being 3 x 2 m rather than 4 x 3 m. One upright section had been replaced and was brighter than the other two, although an attempt was made to balance the outputs by varying the voltages from the power supply. The older sections were at approximately half their original output. Their output will continue to decline in use and there is evidence to suggest that this decline will continue even when not switched on. The joints in the cables on two of the panels would create significant trip hazards in the offshore environment and the panels are not hazardous-area approved.

5.6 Problems with the ELP power supply (240 V, 50 Hz to 115 V, 400 Hz) were encountered from vibration and heat build-up within the box mounted on the A-frame of the generator. The box was removed from the generator and was operated with the lid open inside the trials van.

Section 7 Conclusions

From the results of the trials, the following conclusions against the trial objectives as defined in Section 1, paragraph 1.6, are drawn:

- The suitability of the proposed new perimeter light vertical intensity distribution was not assessed in flight due to the apparent lower than expected intensity of the Orga L55 units.
- There was no additional advantage in having two lit Touchdown Marking circles when there was no landing net in place.
- With a net in place, the cueing was enhanced slightly in the hover and landing with two Touchdown Marking circles.
- A solid 'H' gave no improvement in cueing over an outline 'H' when no landing net was in place. Under these conditions a preference for an outline 'H' was stated.
- When a landing net was in place, the net impaired the cueing performance of the outline 'H', and a preference for a solid 'H' was indicated.
- The lit 'H' provided heading information to the pilot, however the intensity of the ELP was low, being washed out by the aircraft landing light.
- The luminous intensity of the fluorescent 'H' panels when illuminated by the UV lamps was insufficient for any ratings to be given.
- The white LOS floodlight provided heading information and below an altitude of 100 ft it provided textural cues of benefit to the pilot.
- Without the net in place, the preferred configuration was green perimeter lights, single lit Touchdown Marking circle, and lit outline 'H', with the LOS floodlight for additional cueing.
- With the net in place, the preferred configuration was green perimeter lights, double lit Touchdown Marking circle, and lit solid 'H', with the LOS floodlight for additional cueing.

Section 8 Recommendations

1 In order to expose the lighting configuration to a wider sample of pilots in a range of meteorological conditions, the preferred configuration with a landing net in place should be installed on an offshore helideck for a formal in-service trial. The assessment should be conducted with a landing net as the worse case in terms of possible degradation of cues from the lighting pattern. Installing the configuration on an offshore platform would also enable the performance to be assessed when flying a standard offshore approach rather than the slightly modified profile flown during the trial.

2 Due to the difficulties in achieving and maintaining the required levels of intensity from an ELP ‘H’ as well as its high initial cost, it is considered desirable to develop and trial a higher intensity e.g. (LED) version of a lit ‘H’.

3 Further investigation and evaluation of the higher intensity perimeter lights should be carried out to establish whether they meet the proposed new vertical intensity specification, and confirm the absence of glare.

4 It is considered essential to conduct further work to derive ranges at which all visual cues need to be seen in order to define a specification for the lighting intensities under worst visibility conditions.

5 It is likely that increasing the intensity of the lighting (circle and ‘H’) in order to meet the worst case visibility range requirement would lead to glare at shorter ranges. In the case of LEDs this is exacerbated due to their very small physical dimensions and hence high luminance. It is therefore recommended that in the deployment of all helideck lighting elements their intensity distribution be tailored to minimise the proportion of light directed up at angles greater than 10° to avoid the hazard of glare to the pilot.

Section 9 Acknowledgements

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Marco Degeling	Orga BV
Mark Healey	Alstom T&D Ltd
Mark Pollard	Alstom T&D Ltd
Frank Guinn	Pacel Ltd

Section 10 References

[1] ICAO Annex 14, Volume II – Heliports.

[2] CAA Civil Aviation Publication 437 – Offshore Helicopter Landing Areas – Guidance on Standards.

[3] CAA Paper 97009 – Questionnaire Survey of Workload and Safety Hazards Associated with North Sea and Irish Sea Helicopters Operations.

[4] CAA Paper 2004/01 – Enhancing Offshore Helideck Lighting - NAM K14 Trials.

Section 11 List of Abbreviations

CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
cd	Candela
DGPS	Differential Global Positioning System
ELP	Electro Luminescent Panel
ES	Edison Screw
ICAO	International Civil Aviation Organisation
LED	Light Emitting Diode
LOS	Limited Obstacle Sector
NAM	Nederlandse Aardolie Madtschappij
NUI	Normally Unattended Installation
RCD	Residual Current Device
SWA	Steel Wire Armoured
UV	Ultra Violet

Appendix A The Specification of Helideck Perimeter Lighting

QinetiQ has been involved in assisting the UK CAA to develop a suite of improved visual aids for helicopter operations to offshore platforms at night [Reference A1]. An essential part of this work is to establish the intensity and coverage of the individual lighting elements needed to achieve the operational requirement.

It is self evident that the required intensity coverage of the lighting (in the vertical) is dictated by the approach paths flown by the aircraft. There has been much discussion within QinetiQ, and between QinetiQ and the CAA as to the vertical approach paths used by helicopters making non-precision approaches to offshore platforms at night. As ever in these circumstances there has been a paucity of reliable data. More recently however, the CAA have been able to access aircraft GPS position and radio altimeter data. This data has been recorded during night approaches through another research programme (Helicopter Operations Monitoring Programme (HOMP) trial - see CAA Papers 2002/02 and 2004/12).

The approach profiles of height against range to 52 offshore platforms, comprising a total of 271 night approaches have been made available. The vertical flight paths are shown in Figure 1 and the associated look down angles in Figure 2. A 'typical' flight path has been superimposed on Figure 1 between 0.6 and 0.2 NM (~1100 and ~370 m), where the flight path might have been expected to have stabilised, and this is found to give a 'typical' descent angle of 3.0 degrees.

The present minimum decision range for operations to offshore platforms is 0.75 of a nautical mile (~1400 m). Thus, one might expect to be able to see the helideck perimeter lights from a range of at least one nautical mile. Irrespective of whether one refers to Figure 1 or 2 of the HOMP data, the perimeter lights might be expected to have coverage down to the horizontal and up to some 8 degrees above. Indeed, it is seen that it is only at ranges of less than 0.33 nautical miles (~610 m) that coverage above 10 degrees would be required. Furthermore, at this reduced range a significantly lower intensity would be required to achieve the same level of conspicuity as that directed at a point 1.0 nautical mile distant.

This implied intensity distribution is however, at direct variance with that published in the appropriate ICAO Annex [Reference A2]. Recommendation 5.3.8.20 states:

'The light distribution of the perimeter lights should be as shown in Figure 5-9, Illustration 6.'

Illustration 6 however, shows a rapid reduction in required intensity below 10 degrees (see Figure 3), rather than an increasing one, as implied by the above argument. There is a concern that manufacturers may implement Illustration 6 literally and build in a roll-off in intensity at low angles thus denying pilots visual cues at range. Indeed, one manufacturer is now marketing a perimeter light which has this roll-off characteristic, whereas their previous model maintained intensity down to the horizontal. Further, it is noted that Illustration 6 does not specify a value for intensity above 30 degrees. It is hoped that no manufacturer would take this literally and cut off all light above this angle.

This matter is considered sufficiently important to be brought to the attention of the ICAO Visual Aids Panel. In an attempt to redress this perceived deficiency a calculation has been made to estimate what minimum light intensity should be directed up the approach path (i.e. the main beam). In carrying out this calculation a number of assumptions have been made, namely that:

- In a worst case the platform has little, if any cultural lighting and the helideck lighting is the predominant visual feature.

- The value of illuminance threshold experienced is typical of that applied to a pilot of a commercial transport aircraft when making visual contact with a precision approach runway in fog at night [Reference A3].
- The eye threshold illuminance is unaffected by colour, irrespective of whether it is white, yellow or green.
- The luminaire may be considered to be a point source.
- The slant range does not differ significantly from the horizontal range.
- The visibility is uniform vertically, as well as horizontally.
- The atmosphere is not significantly spectrally selective over the distances involved.

Through the application of Allard's law, a value of 31 candela has been found to be required for the worst case, having an acquisition range of 0.75 nautical miles (1390 m) in a visibility of 0.75 nautical miles (1390 m) and an assumed eye threshold illuminance of 10^-6.1 log lux [Reference A3]. The use of an illuminance threshold of 10^-6.0 log lux would reduce the acquisition range to 1329 m.

If the HOMP data previously cited can be regarded as representative, then main beam intensity coverage at 0.75 nautical miles would be required from 0 to +7.5 degrees above the horizontal.

The supra-threshold value of intensity to be employed for the coverage outside the main beam at greater angles above the horizontal is more difficult to assess. Calculations based on an illuminance of 24 candela/m^2 (10 times that used for threshold) gave required intensities of 1.4 cd at 300 m, 0.5 cd at 200 m and 0.1 cd at 100 m. This suggests that a value of the order of 3 candela would be adequate for visual cueing at high angles and short ranges. The main beam intensity should roll off smoothly down to this value without marked discontinuity.

Taking account of the above calculations and the revised perimeter light specifications agreed at ICAO, CAA proposes to recommend the following specification in CAP 437.

Elevation	**Intensity**
0° - 90°	60 cd max[1]
>20° - 90°	3 cd min
>10° - 20°	15 cd min
0° - 10°	30 cd min

1. A study of helideck lighting performed for the Dutch CAA by TNO Human Factors (reference [A5]) has indicated that lighting intensities greater than 60 cd can represent a source of glare.

References:

[A1] CAA Paper 2004/01 - Enhancing Offshore Helideck Lighting - NAM K14 Trials

[A2] ICAO Annex 14, Vol II Heliports, second edition - July 1995

[A3] ICAO Annex 3, Meteorological Service for International Air Navigation, thirteenth edition - July 1998

[A4] CAA Civil Aviation Publication 437 - Offshore Helicopters Landing Areas - Guidance on Standards

[A5] TNO Human Factors Report ref. TM-02-C003

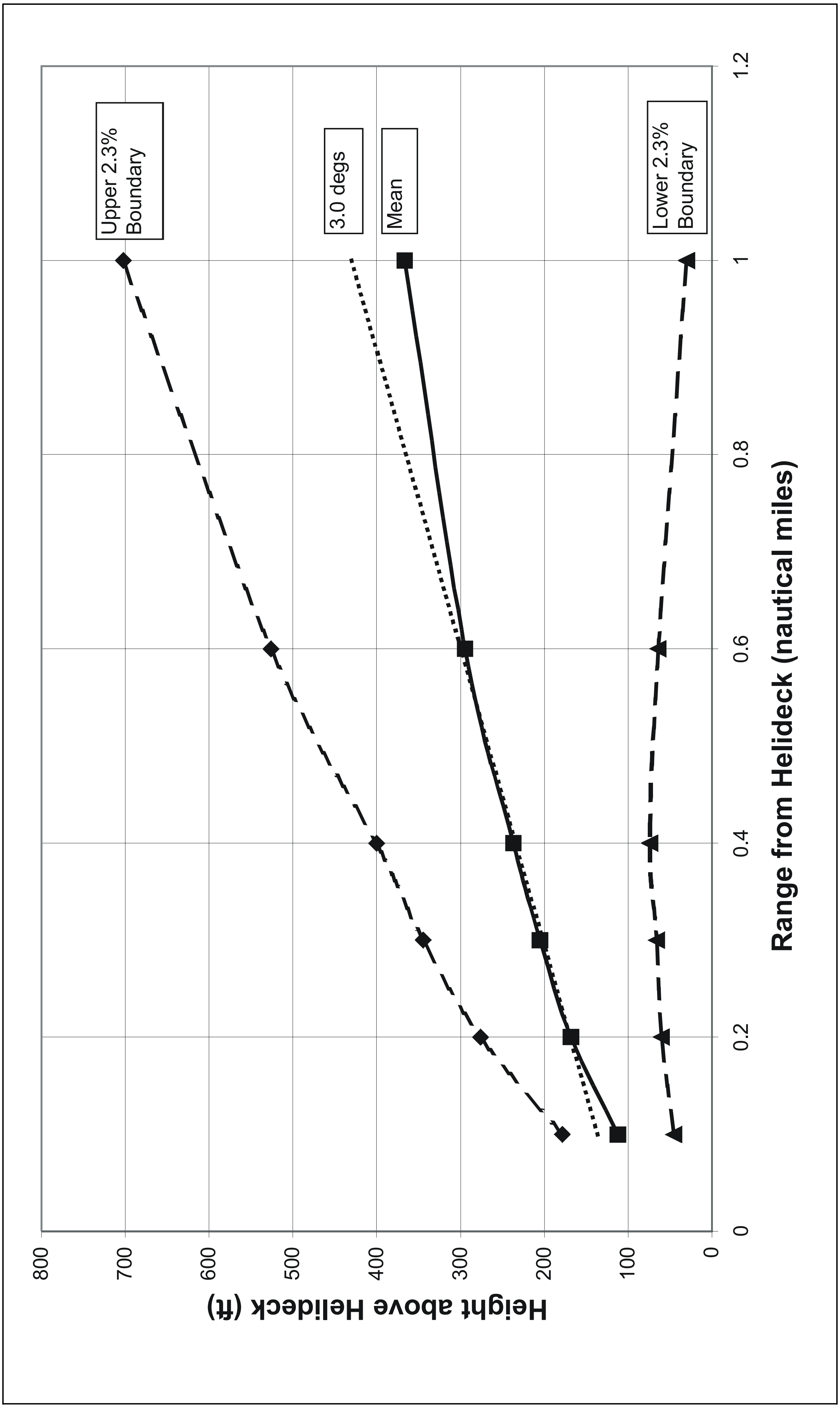

Figure 1 Helideck Night Approach Data from HOMP Project

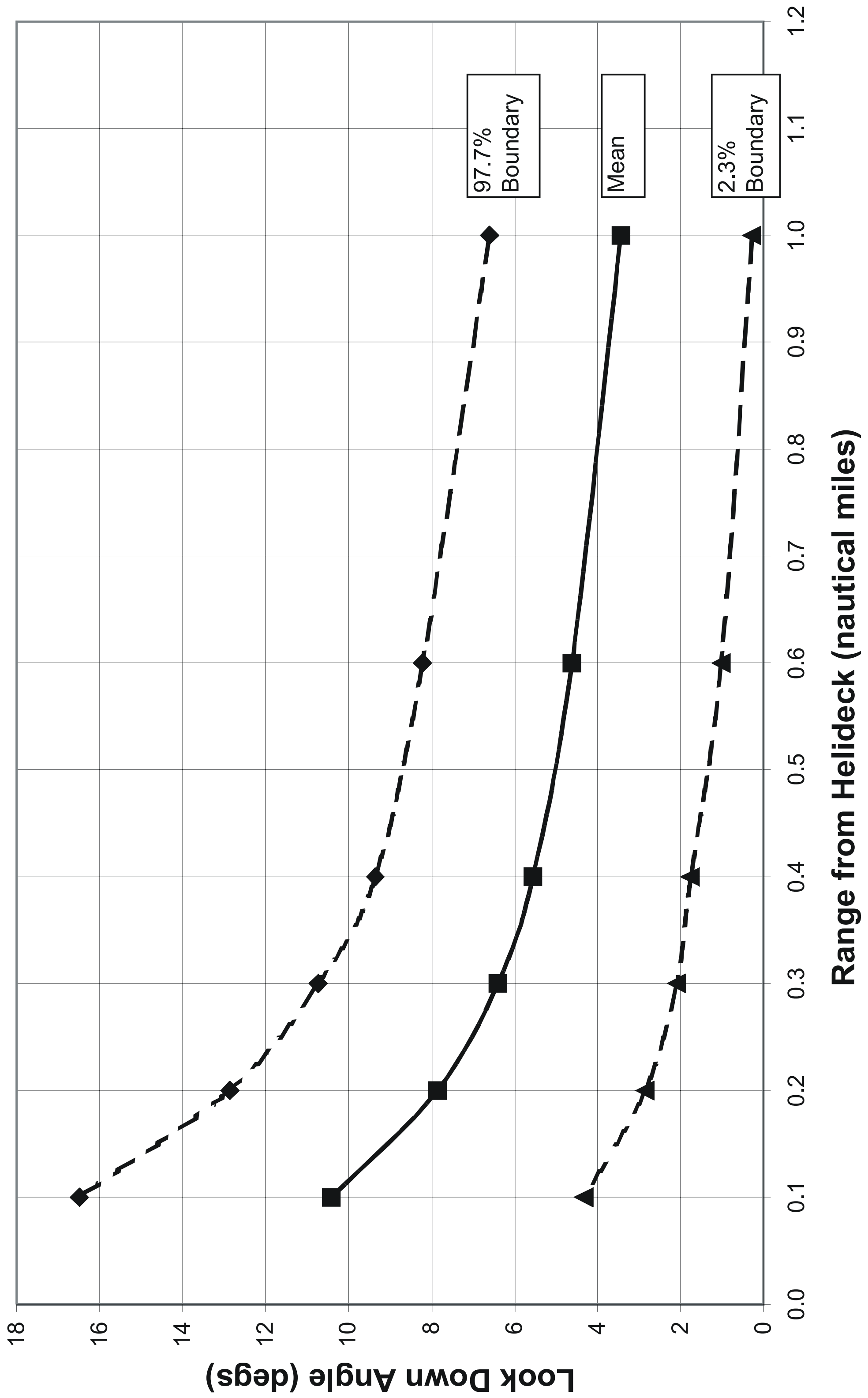

Figure 2 Helideck Night Approach Data from HOMP Project

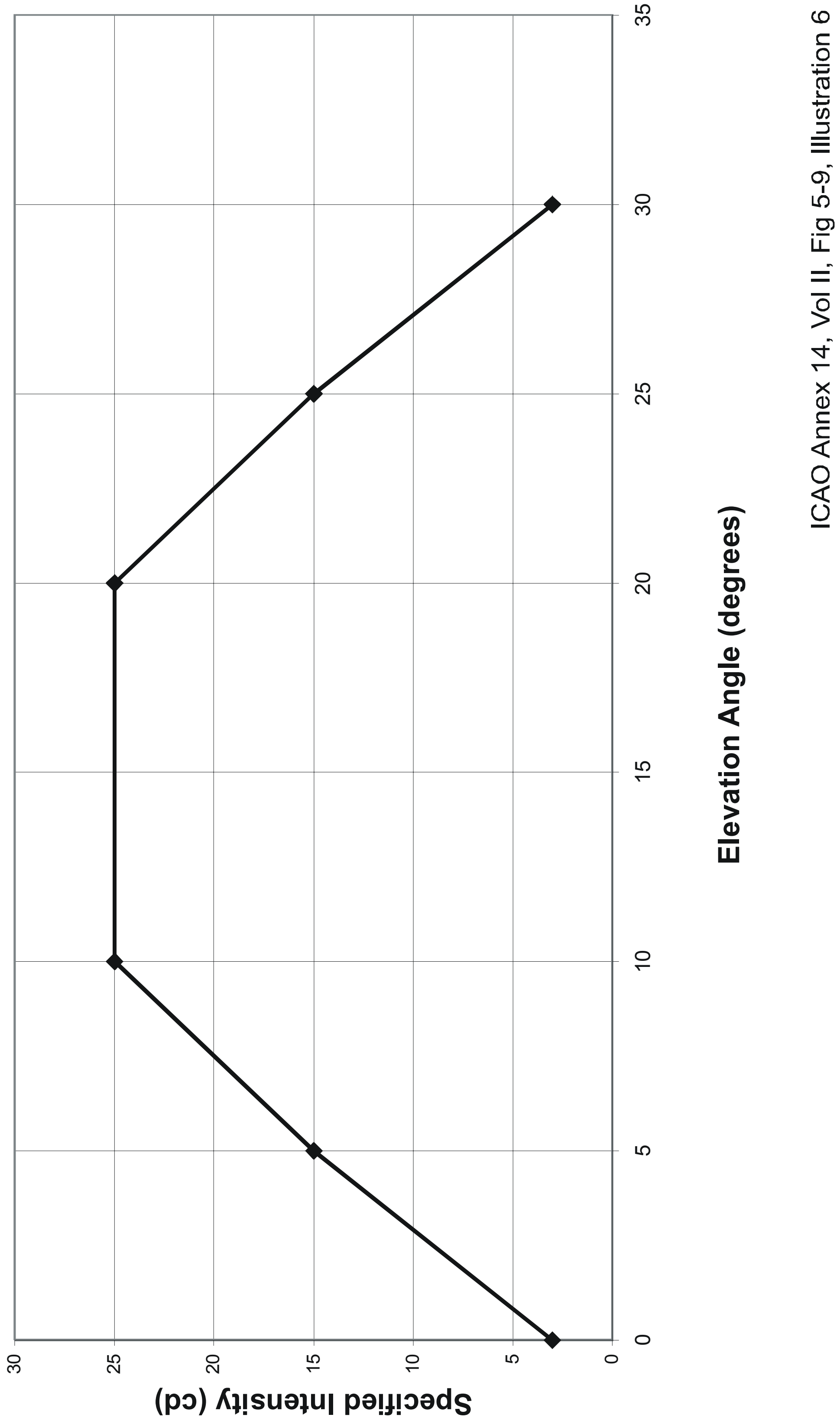

Figure 3 Current Heliport Perimeter Light Specification

Appendix B LED Photometric Tests

In order to have some measure of the performance of the yellow landing circle used at Longside, measurements were made by the British Standards Institute of the spatial (angular) intensity distribution of a sample 'Lamp' of 4 LEDs.

The configuration used for the tests is shown in Figure 1. The sample was powered from a 12 volt dc source and illuminance measurements made from a distance of 3.16 m. The individual LEDs being separated by 0.03 m, thus presented at most a semi-angle of 0.82 degrees at the photometer.

A series of measurements were made at 5 degree intervals over a range of elevation angles 0 to 180 degrees, with respect to the mounting plane of the strip. Four such elevation sections were taken at 0 (normal to the long axis of the strip), 30, 60 and 90 degrees in azimuth.

The results of the measurements are presented as intensities in Figure 2. For this plot each of the calculated intensities have been multiplied by 0.25, in order that they should represent a single 'average' LED. The peak intensity obtained is seen to be some 0.37 candela with an angular distribution somewhat better than that which would be expected from an emitter that obeys a sine law distribution relative to the normal. Even so, the intensity of this 'average' LED is only some 0.07 candela at an angle of 5 degrees above the horizontal (a typical look down angle for 0.5 NM (~930 m) from the helideck).

From the curves it is seen that the intensity is not unduly sensitive to the azimuth angle. This reinforces the view that the intensity distribution is mainly due to the refractive index of the embedding plastic, rather than the shape of the extrusion itself. The visual appearance of the strip is dominated by the refractive image of the individual LEDs. Although there will be a small proportion of internally reflected light this will not compete.

It should be pointed out that a considerable variability in light output is likely to be encountered, partly due to the LEDs themselves and partly to the fact that the four LEDs in a 'Lamp' are arranged in series with an 82 ohm 5% resistor. As a result of this arrangement the total diode potential drop is some 73% of the 12 volt supply and the current is consequently not particularly well defined. A previous attempt to quantify the output variability [Reference 4] showed the standard deviation for a similar sample of four 'Lamps' (16 LEDs) to be 28% of the mean. As a consequence, the range of intensities between the brightest and dimmest LEDs at the two Standard Deviations level would be 3.5:1.

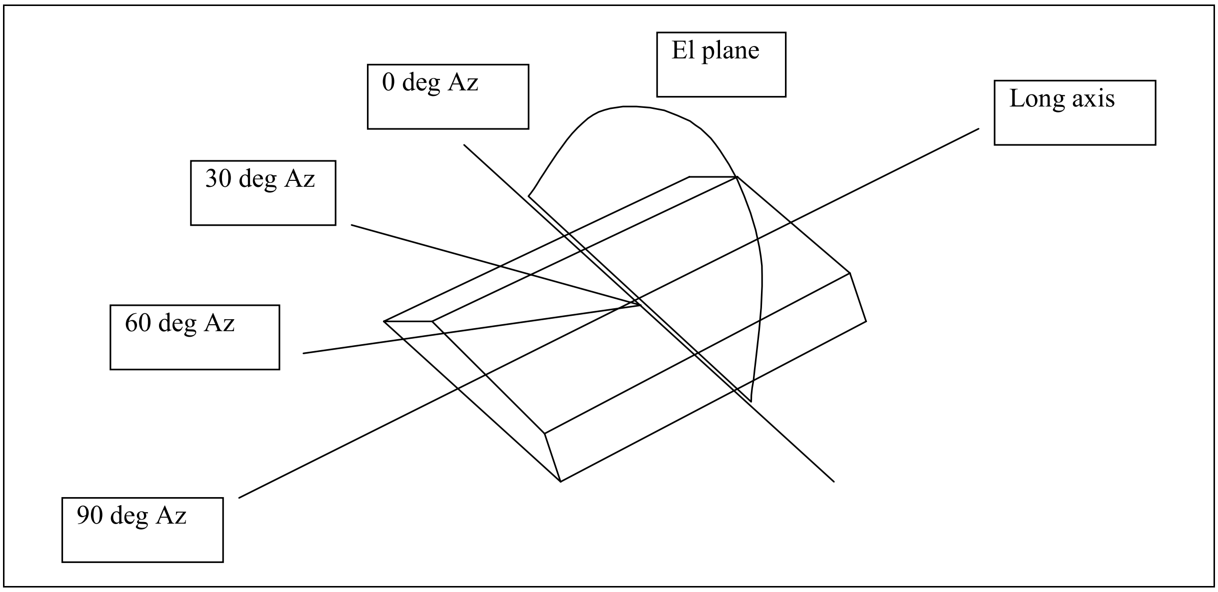

Figure 1

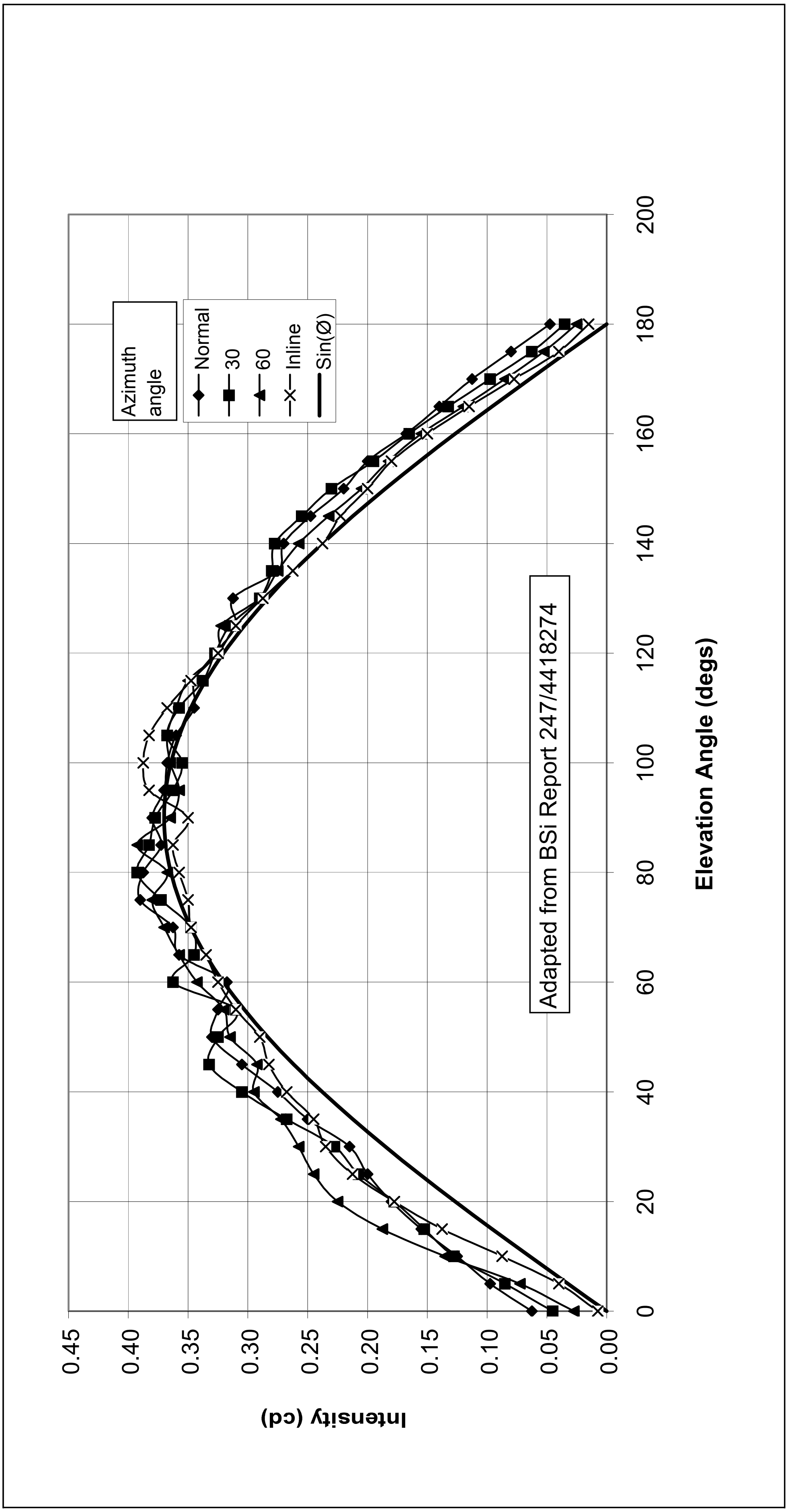

Figure 2 0.25 of the Intensity of a Lamp of four LEDs

Appendix C Louvre Design for Orga Floodlight SHLF218

1 Objective

The intention was to produce a proof of principle design for a set of louvres to reduce the likelihood of glare from a raised floodlight mounted in the Limited Obstacle Sector of an offshore helideck.

2 Assumptions

- For a 22 m helideck the centre of the Touchdown Marking circle is 13.3 m distant from the floodlight (0.5 D+0.1 D+ enough to put the floodlight inside the LOS).
- The effective height of the floodlight is 0.975 m above the surface of the helideck (0.05 D less the height from the centre of the aperture to the top of the fitting).
- The floodlight aperture is assumed to be uniformly lit.
- The far field intensity distribution can be applied to the design of the louvre.
- The louvre obscures, but does not reflect the light.
- The louvre plates have a specified thickness.

3 Aiming Angle for Floodlight

The depression angle of the floodlight required to point the peak of the beam directly at the centre of the Touchdown Marking circle is:

Tan^-1 (0.975/13.3) = 4.2 degrees

It should be noted that due to the inverse cube law for shallow illumination, the illumination will fall off rapidly beyond the aiming point. For example for a 10% increase in range, the illumination due to a specified intensity will fall to 75%.

4 Limitation of Light in the Vertical Plane

The effect of a number of louvre plates of a given thickness, having differing length to spacing ratios (mounted parallel to the nominal principal axis of the floodlight), on the effective intensity at various elevation angles has been calculated using the relationship:

$$E_\theta = 1 - k - \frac{L}{D} Tan\ (\theta)$$

Where E is the luminous efficiency (0 to 1)

L is the length of the louvre plates

D is the spacing of the louvre plates

θ is the angle in elevation offset from the principal axis of the light

k is the proportion of D obscured by a louvre plate viewed end-on.

The effect of louvre plate length to spacing ratio is shown in Figure 1.

For the light to be totally cut off above the horizontal when aimed at the centre of the circle 13.3 m distant would require a louvre plate length to spacing ratio of 14:1. That is to have, for example, louvres 28 cm long spaced 2.0 cm apart. This seems far from practicable and reduces the off axis light intensity directed at the deck unreasonably.

It is considered that the balance between light intensity of the floodlight at deck level and intensity above the horizontal is best served by a **louvre ratio of 6:1.**

For a 6:1 louvre ratio, total light cutoff from the floodlight is achieved at +9.5 degrees above its axis, which equates to 5.3 degrees above the horizontal. This would give a cut off at a height of approximately 2.2 m at the centre of the Touchdown Marking circle. This is considered acceptable for the helicopters in use, whose pilot eye heights vary from 1.6 m to 2.0 m from the deck.

5 Louvre Details

The proposed design to meet the above requirement was:

- The louvre plates to be 15 cms long.
- The uppermost plate to be placed co-incident with the top edge of the lamp window.
- Three further plates to be spaced at 2.5 cms, 5.0 cms and 7.5 cms below the top edge.
- The plate material to be 2 mm aluminium sheet, with a matt black heat resistant finish.
- The plates to be attached using the floodlight front panel fixings.

6 Evaluation of the Effect of Louvres

A simple evaluation of the effect of introducing a louvre to one of the floodlights was carried out at QinetiQ Bedford.

In order to achieve this, the SHLF218 fitting was rotated clockwise (as viewed from the front) and placed on a horizontally mounted on a rotation table.

It should be noted that in normal operation there is no provision for accurate vertical alignment of the beam of the floodlight. The alignment being subject to the position of:

- The filament within the bulb.
- The bulb within the prefocus unit.
- The prefocus unit within the cast housing.

This lack of precision is surprising since the required accuracy of aim in the low level role for which the floodlight is intended is probably of the order of 0.1 degree. In service, the only means for aiming the unit, is by the fall of the light on the helideck.

Since the object of the exercise was to make a comparison of the floodlight performance with and without a louvre, calibration of the measurement device was not seen as essential. For this purpose, Illuminance measurements were made at distance of 6.00 m using an uncalibrated UDT Model 211 Sensor Head, without either photopic or cosine correction elements. For interest an approximate calibration was obtained by comparison against a RS Luxmeter.

7 Discussion of Results

The results of the measurements are shown in Figures 2, 3 and 4 below.

From the measurements it is observed that the on-axis loss is 16.8% (see Figure 2). In addition to a theoretical end-on obscuration loss of 8%, the additional shadowing of the front face of the fitting by the louvre plates when viewed on axis from 6 m is calculated to be approximately 5%. These two elements give a total theoretical loss of 13%. This assumes the plates are flat and normal to the aperture, which in turn is uniformly illuminated. Within these limitations the on-axis loss experienced during the measurements appears reasonable.

For the fitting under examination the measured peak intensity with the 6:1 plates was some 3400 candela. The calculated illumination due to this intensity is 1.4 lux, when the beam is aimed at the centre of the deck 13.3 m distant.

It is noted that, as expected, the louvres affect the intensity of the light off-axis directed both upwards at the pilot and downwards at the helideck. In the latter case however, the effect is negligible for negative off-axis angles exceeding -2 degrees. This represents all distances from the light of less than 9 m for the configuration under consideration.

Figure 3 shows the effect of the louvres on the component of intensity directed above 1 degree below the horizonal. Somewhat more usefully, the same result is shown in Figure 4 expressed as a ratio and overlaid with the theoretically predicted values. The agreement between the two curves is encouraging. It is to be expected that the measured intensity will never fall to zero, due to specular and diffuse reflections of the light from the faces of the plates.

8 Conclusions

- The preliminary design given above is shown to be adequate to test the concept of using louvres to control floodlight intensity in the vertical. For the SHLF218 when depressed by 4.2 degrees, the intensity with the louvres fitted is 50% at the horizontal and 25% at +2 degrees.
- Assuming a uniformly lit aperture and far field conditions, calculation of the obscuration caused by flat normally mounted 2 mm plates with a 25 mm spacing suggests an inescapable on axis-loss of 8%.
- The effectiveness of the design at off axis elevation angles will be dictated by the coating used for the louvre plates and it's condition after prolonged exposure to the elements.
- The use of louvres will in no way mitigate the effects of specular reflection from the deck itself, particularly when wet.

The contribution to the lighting of the helideck by one, or two, LOS floodlights based on the ORGA SHLF218 may be marginal when deployed on a well-lit, offshore production platform, regardless of whether or not louvres are fitted.

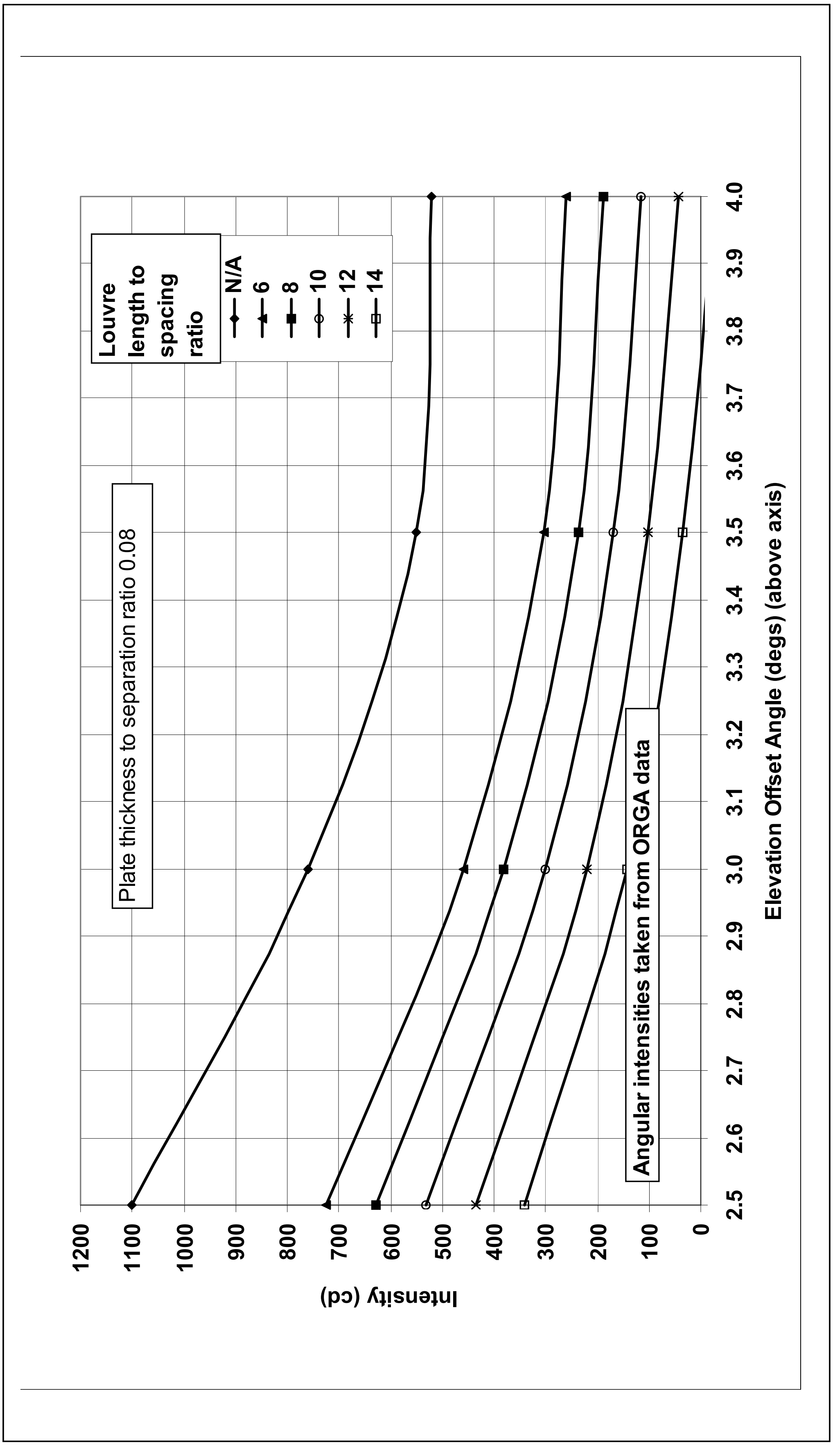

Figure 1 Modelled Effect of Plate Length to Spacing Ratio for Louvres Fitted to an ORGA SHLF218 (grossly simplified)

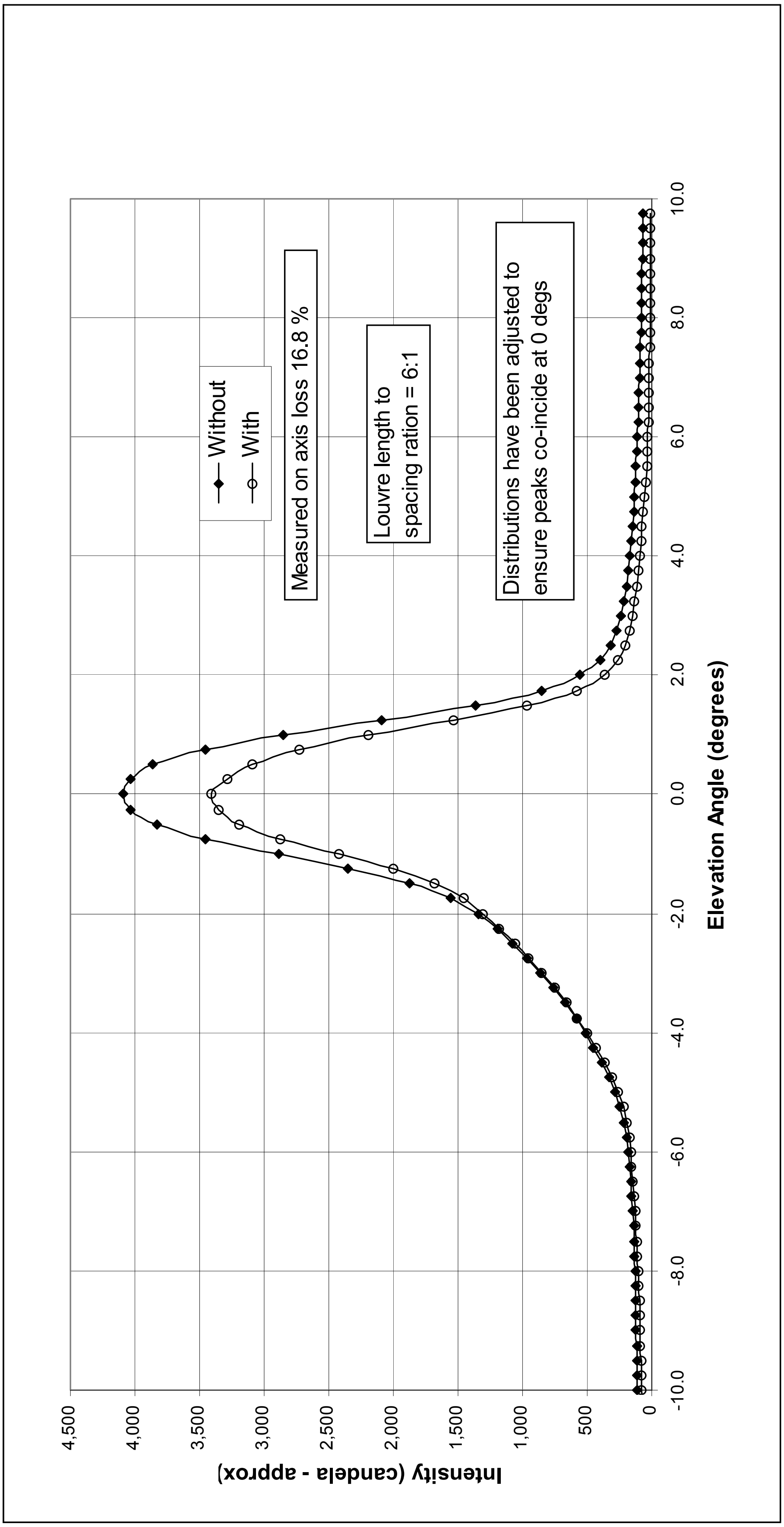

Figure 2 Comparison of ORGA SHLF218 With and Without Louvres

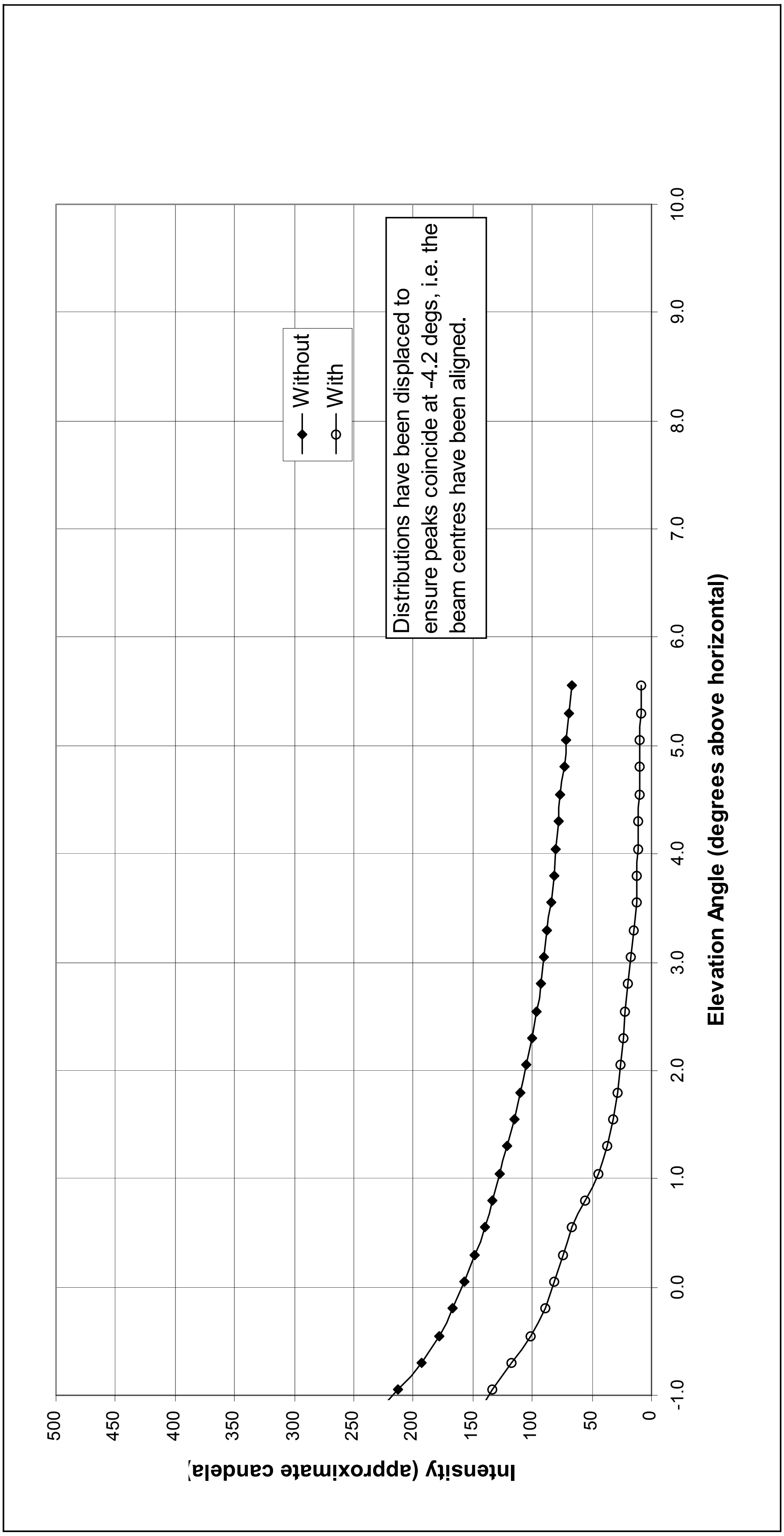

Figure 3 Comparison of ORGA SHLF218 With and Without Louvres - Component of Intensity above 1 degree below the Horizontal

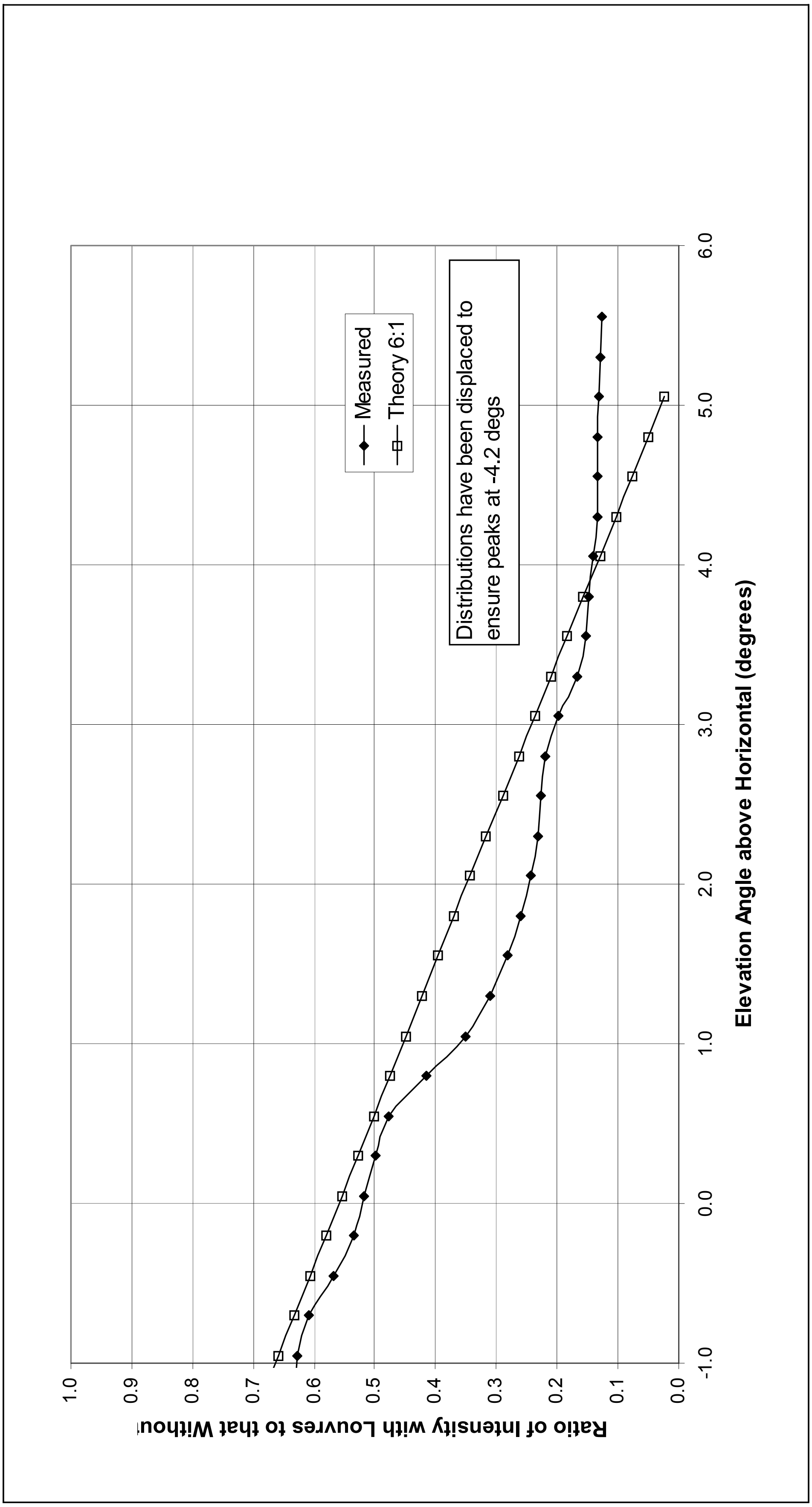

Figure 4 Comparison of ORGA SHLF218 With and Without Louvres - Ratio of Intensity with Louvre to that without

Appendix D Trial Proforma

PRE RUN DATA

TIME (GMT) ____________________

CLOUD BASE ____________________ VISIBILITY (km) ____________________

WIND SPEED (KT) ____________________ WIND DIRECTION ____________________

AMBIENT LIGHT	TWILIGHT	NIGHT/MOON	NIGHT/NO MOON
PRECIPITATION	NONE	RAIN	SNOW

DURING RUN DATA

Run 1 - green perimeter lights only

Range at which **green perimeter lights** became a usable cue: ☐

Run 2 - perimeter lights + outer aiming circle

Range at which the **aiming circle** became a usable cue: ☐

Run 3 - perimeter lights + both aiming circles

Range at which the **aiming circles** became a usable cue: ☐

Run 4 (1st evening only) - perimeter lights + outline 'H'

Range at which the **outline ELP 'H'** became a usable cue: ☐

Run 8 - perimeter lights + solid ELP 'H'

Range at which the **solid ELP 'H'** became a usable cue: ☐

Run 11 - perimeter lights + both aiming circles + LOS floodlight

Range at which the **LOS floodlight** became a usable cue: ☐

Run 12 - perimeter lights + both aiming circles + fluorescent 'H'

Range at which the **fluorescent 'H'** became a usable cue: ☐

POST RUN DATA

Final Approach

Ratings from 1 - 5 (1 = Poor, 5 = excellent)
Ratings should be based on experience of cueing during offshore operations currently.

- Rating of aircraft **flight path angle** provided by the configuration: ☐
- Rating of aircraft **attitude information** provided by the configuration: ☐
- Rating of **azimuth alignment information** provided by the configuration: ☐
- Rating of **closure rate information** provided by the configuration: ☐

Hover and Landing

Ratings from 1 - 5 (1 = Poor, 5 = excellent)
Ratings should be based on experience of cueing during offshore operations currently.

- Rating of information on **lateral position** relative to the deck provided by the configuration:
- Rating of information on **lateral translational rate** relative to the deck provided by the configuration:
- Rating of information on **longitudinal position** relative to the deck provided by the configuration:
- Rating of information on **longitudinal translational rate** relative to the deck provided by the configuration:
- Rating of information on **height** relative to the deck provided by the configuration:
- Rating of information on **descent rate** information by the configuration:
- Rating of information on **heading** relative to the deck provided by the configuration:
- Rating of information on **yaw rate** relative to the deck provided by the configuration:

Appendix E Tables

Table 1 Final Approach Rating Data – Without Net

			Visual Cueing Information				Notes on Ratings
Run	**Configuration**		**Flight path angle**	**Attitude**	**Azimuth alignment**	**Closure rate**	**Run**
1	a)	Baseline - green lights only	3	2	0	3	
2	b)	Baseline + outer circle only	3.5	3	1.5	4	
3	c)	Baseline + both circles	3.5	3	1.5	4	Ratings same as run 2 with note that it was enhanced in very latter stages
4	d)	Baseline + outline 'H'	3	2	3	3	
5	e)	Baseline + outer circle + outline 'H'	3.75	3	3.5	3.5	
6	f)	Baseline + both circles + outline 'H'	3.75	3	3.5	3.5	Ratings as run 5. Slight enhancement at height of 250 - 100 ft.
7		Baseline + outline ‘H’					Refresher run
8	g)	Baseline + solid 'H'	3	2	3	3	No difference from outline ‘H’, no further cueing info - if anything detracts slightly - more glare
9		Baseline + solid 'H' + outer circle					Run deleted
10		Baseline + solid 'H'+ both circles					Run deleted
11	h)	Baseline + both circles + LOS floodlight	3.5	3	3.25	3	
12		Baseline + both circles + fluorescent ‘H’					Omitted from analysis

Table 2 Hover and Landing Rating Data – Without Net

Run		Configuration	Visual Cueing Information								Notes on Ratings
			Lateral position	**Lateral translational rate**	**Longitudinal position**	**Longitudinal translational rate**	**Height**	**Descent rate**	**Heading**	**Yaw rate**	
1	a)	Baseline - green lights only	2	2	3	3	3	3	0	3	
2	b)	Baseline + outer circle only	4	4	4	4	3.5	3.5	0	4	
3	c)	Baseline + both circles	4	4	4	4	3.5	3.5	0	4	Ratings same as run 2 with note that it was enhanced in very latter stages
4	d)	Baseline + outline 'H'	4	4	4	4	4	4	3.5	3	
5	e)	Baseline + outer circle + outline 'H'	4	4	4	4	4	4	3.5	4	
6	f)	Baseline + both circles + outline 'H'	4	4	4	4	4	4	3.5	4	Ratings as run 5. Slight enhancement at height of 250 - 100 ft.
7		Baseline + outline 'H'									Refresher run
8	g)	Baseline + solid 'H'	4	4	4	4	4	4	3.5	3	No difference from outline 'H', no further cueing info - if anything detracts slightly - more glare
9		Baseline + solid 'H' + outer circle									Run deleted
10		Baseline + solid 'H' + both circles									Run deleted
11	h)	Baseline + both circles + LOS floodlight	3.5	3.5	3.5	3.5	3.75	3.5	3.5	4	
12		Baseline + both circles + fluorescent 'H'									Omitted from analysis

Table 3 Final Approach Rating Data – With Net

			Visual Cueing Information				Notes on Ratings
Run	**Configuration**		**Flight path angle**	**Attitude**	**Azimuth alignment**	**Closure rate**	
1	a)	Baseline - green lights only	3.75	3	1	2.5	
2	b)	Baseline + inner circle only	4	3	1	2.75	
3	c)	Baseline + both circles	4.25	2.5	1	2.75	
4	f)	Baseline + both circles + outline 'H'	4.25	2.5	2.5	3	
5	j)	Baseline + both circles + solid 'H'	4.25	2.5	2.5	3	As run 4, slight improvement in some aspects (0.25 added)
6	i)	Baseline + LOS Floodlight	3.75	3	1	2.5	
7	h)	Baseline + both circles + LOS Floodlight	4.25	2.5	1	2.75	As run 3, slight improvement in some aspects (0.25 added)

Table 4 Hover and Landing Rating Data – With Net

Run		Configuration	Visual Cueing Information								Notes on Ratings
			Lateral position	**Lateral translational rate**	**Longitudinal position**	**Longitudinal translational rate**	**Height**	**Descent rate**	**Heading**	**Yaw rate**	
1	a)	Baseline - green lights only	2.25	3	2.5	3	3.5	3	1.25	3.5	
2	b)	Baseline + inner circle only	3.5	4	3.5	4	4	3.5	1.25	3.5	
3	c)	Baseline + both circles	3.75	4.25	3.75	4.25	4	4	1.25	3.75	
4	f)	Baseline + both circles + outline 'H'	3.75	4.25	3.75	4.25	4.25	4.25	2.5	3.75	
5	j)	Baseline + both circles + solid 'H'	4	4.5	4	4.5	4.25	4.25	2.5	3.75	As run 4, slight improvement in some aspects (0.25 added)
6	i)	Baseline + LOS Floodlight	2.25	3.25	2.75	3.25	3.75	3.25	2	3.5	
7	h)	Baseline + both circles + LOS Floodlight	3.75	4.5	3.75	4.5	4.25	4	1.25	3.75	As run 3, slight improvement in some aspects (0.25 added)

Appendix F Charts

1 Charts of Final Approach Ratings (With and Without Net)

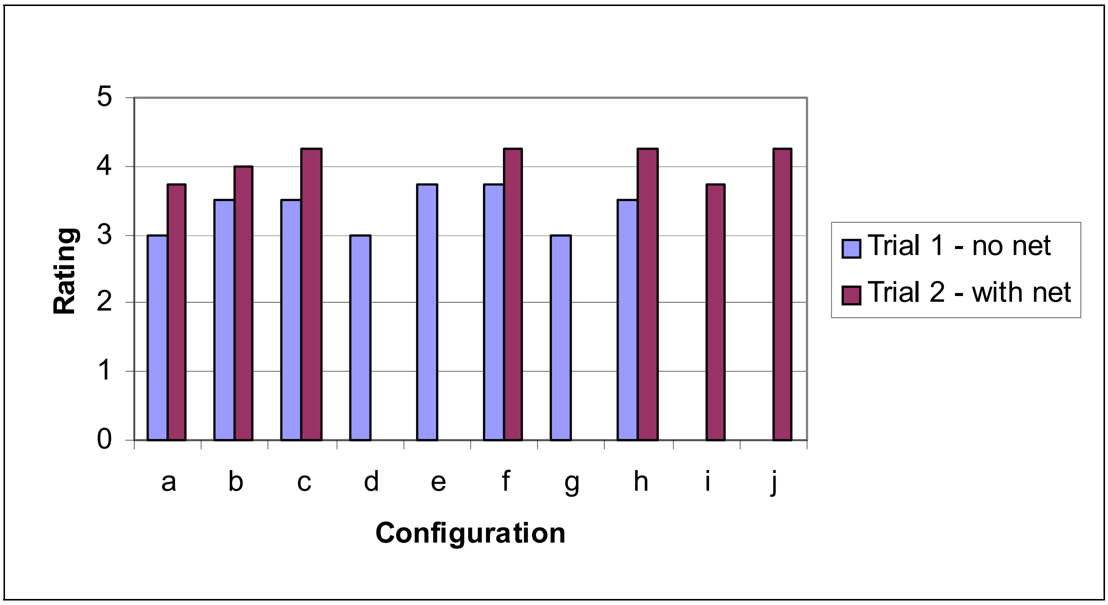

Figure 1 Flight Path Angle Information

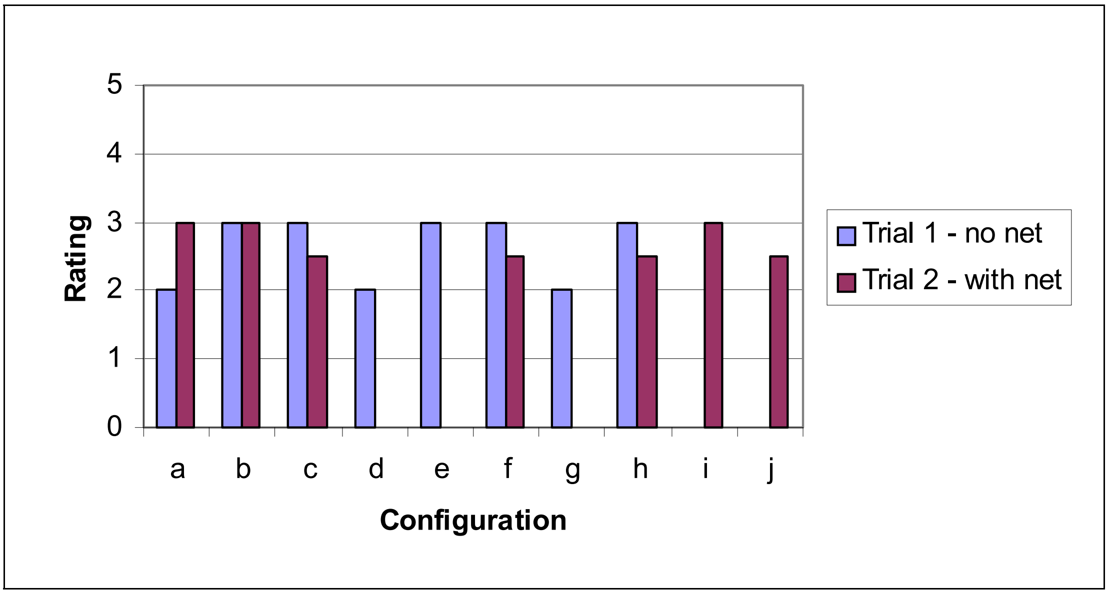

Figure 2 Attitude Information

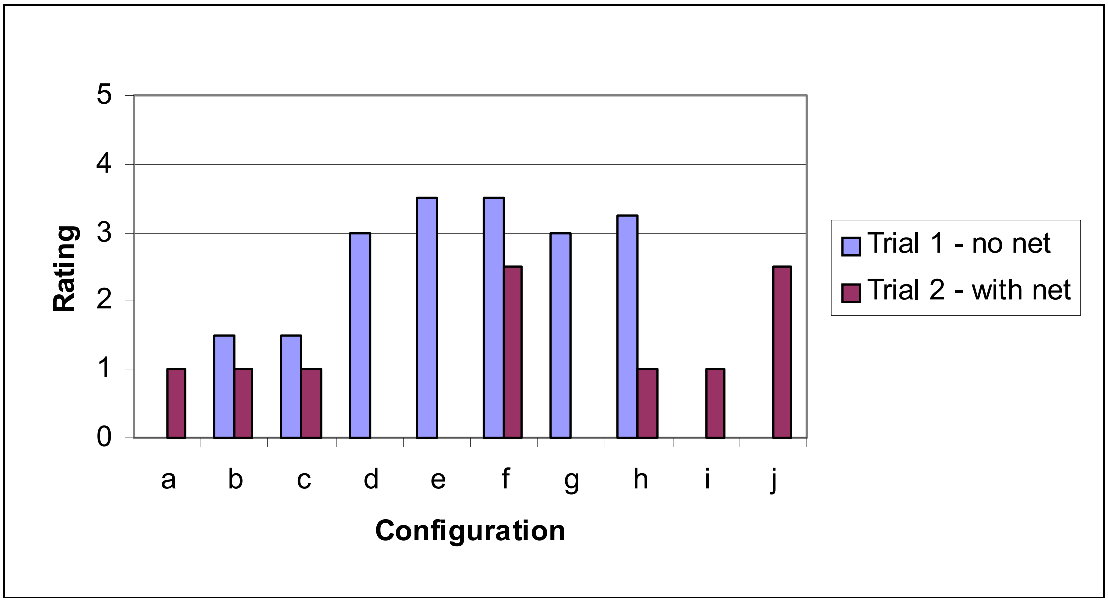

Figure 3 Azimuth Alignment Information

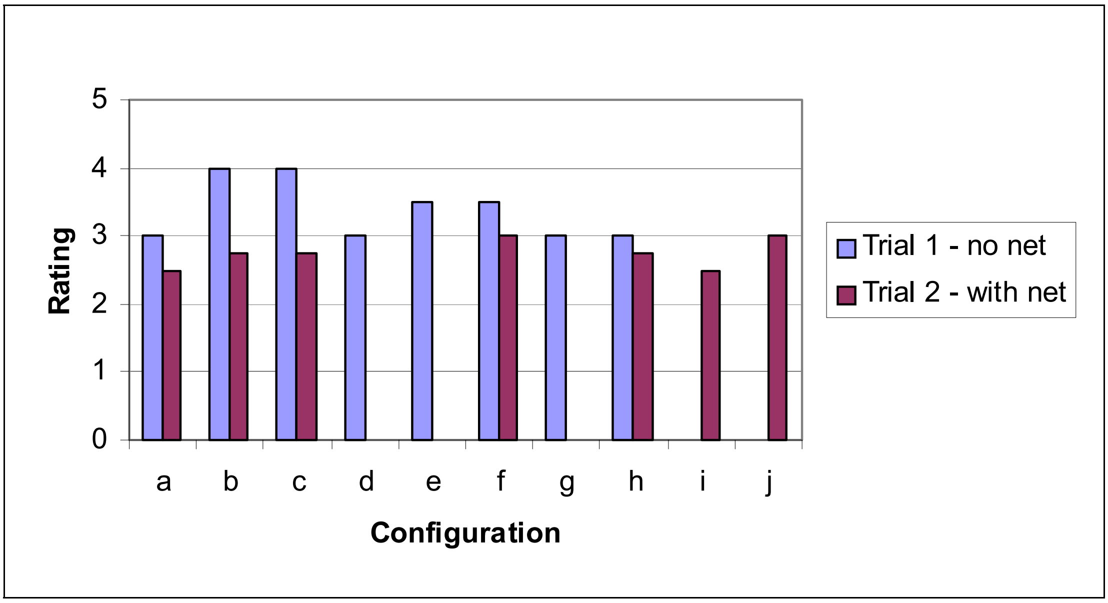

Figure 4 Closure Rate Information

2 Charts of Hover and Landing Ratings (With and Without Net)

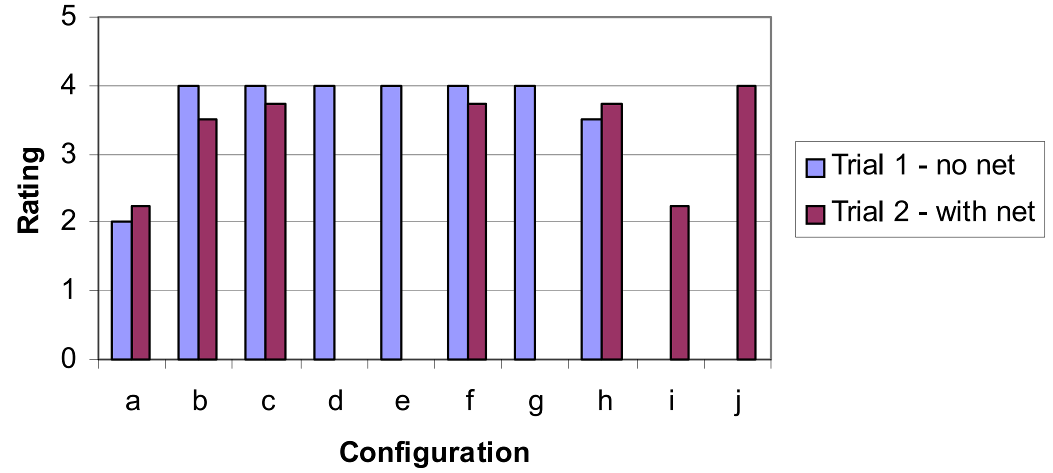

Figure 5 Lateral Position Information

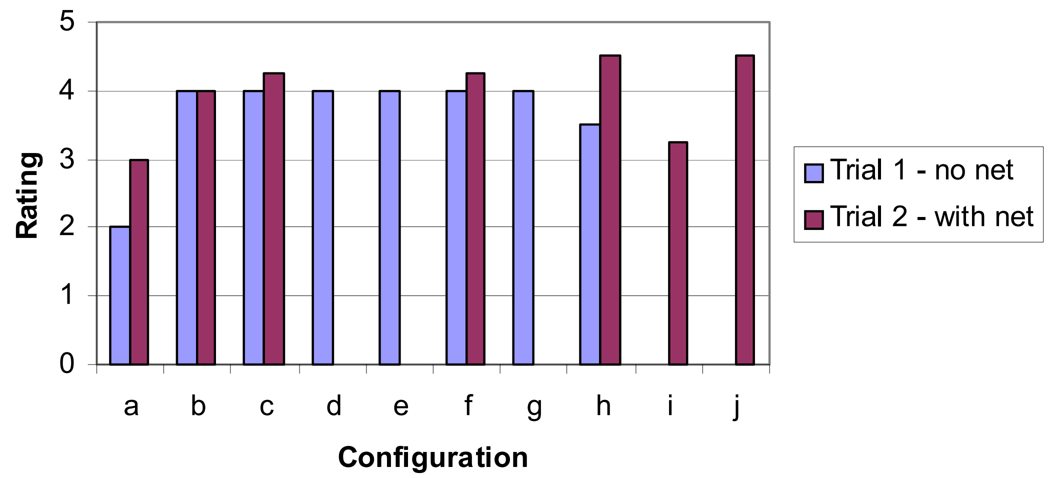

Figure 6 Lateral Translational Rate Information

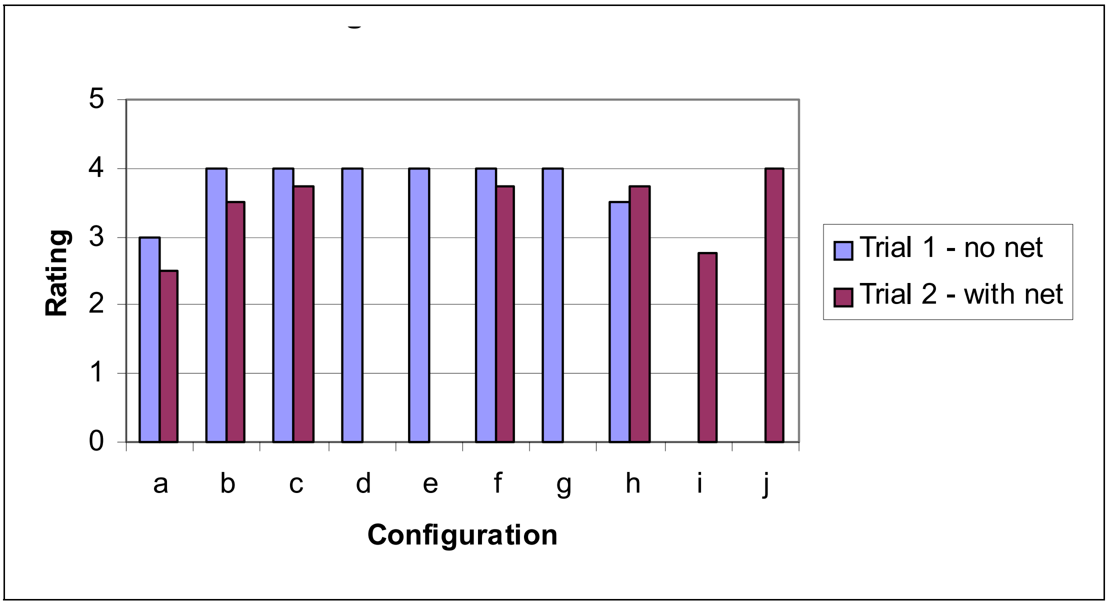

Figure 7 Longitudinal Position Information

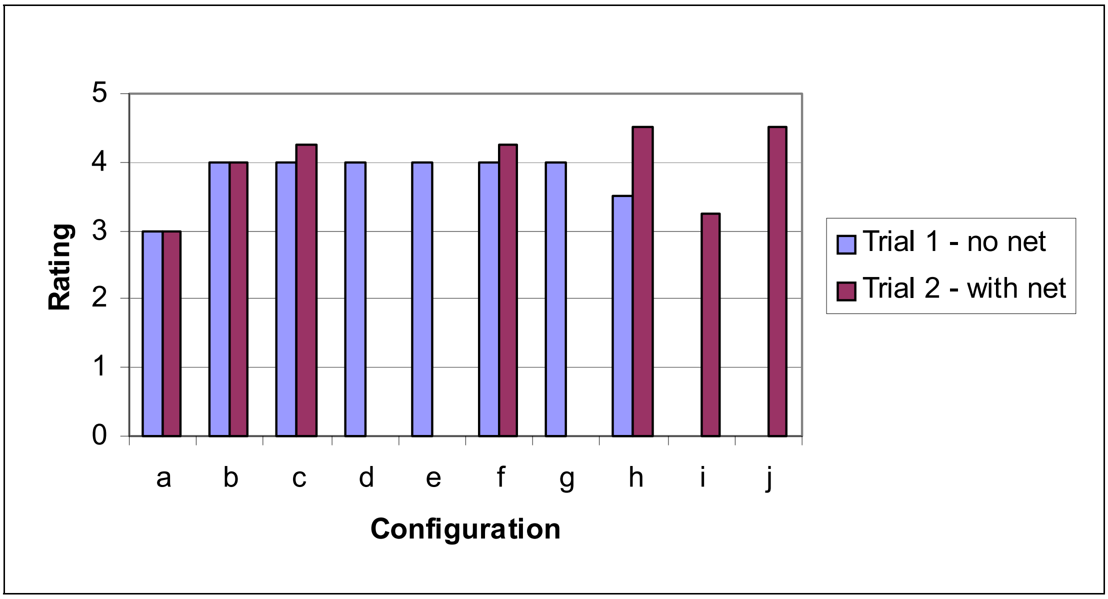

Figure 8 Longitudinal Transational Rate Information

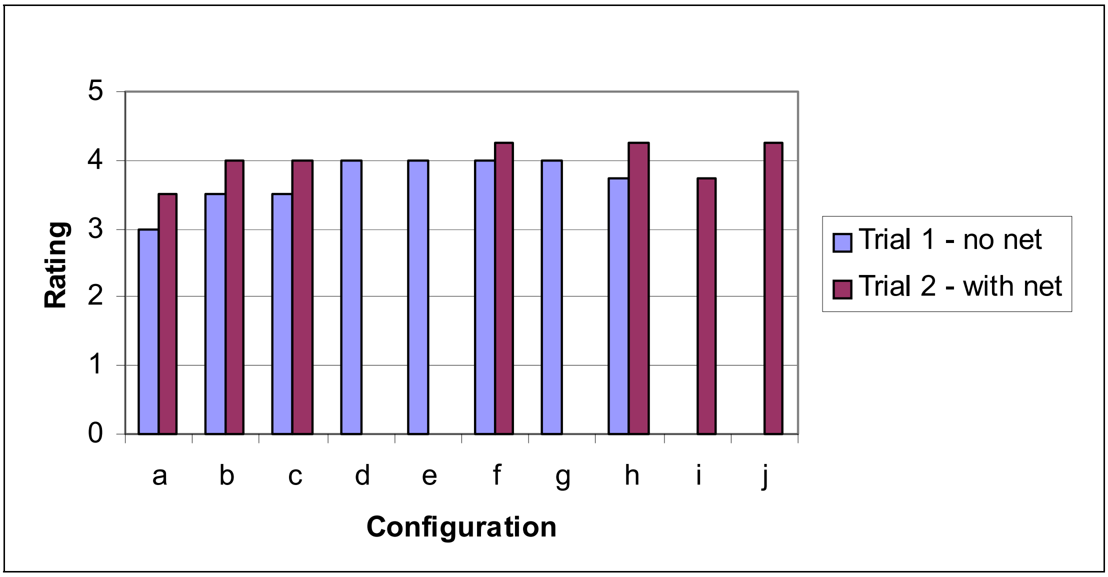

Figure 9 Height Information

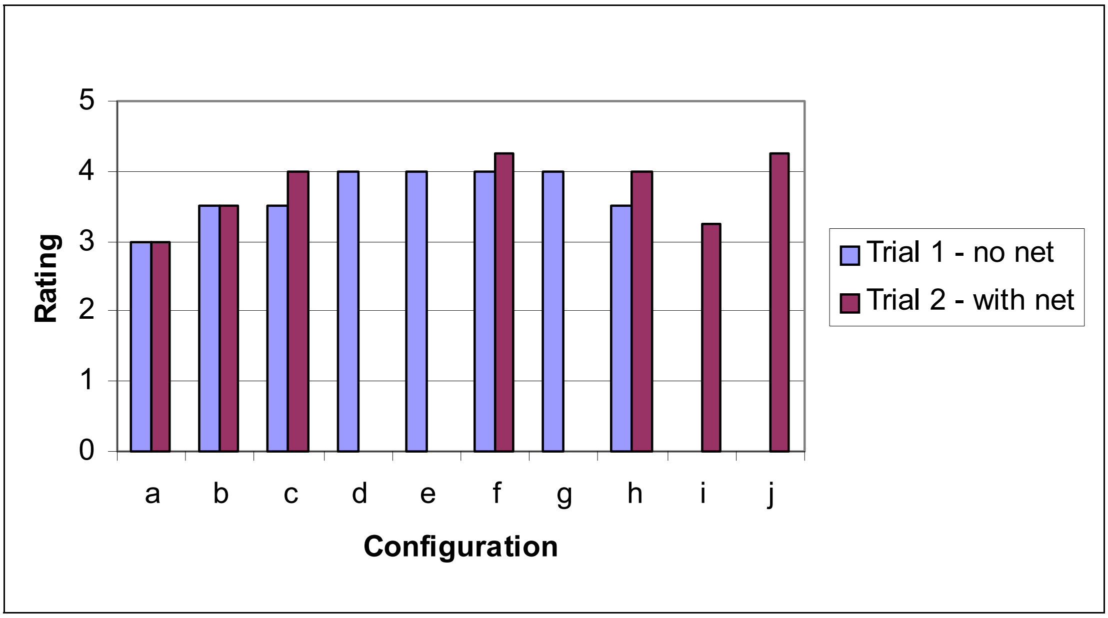

Figure 10 Descent Rate Information

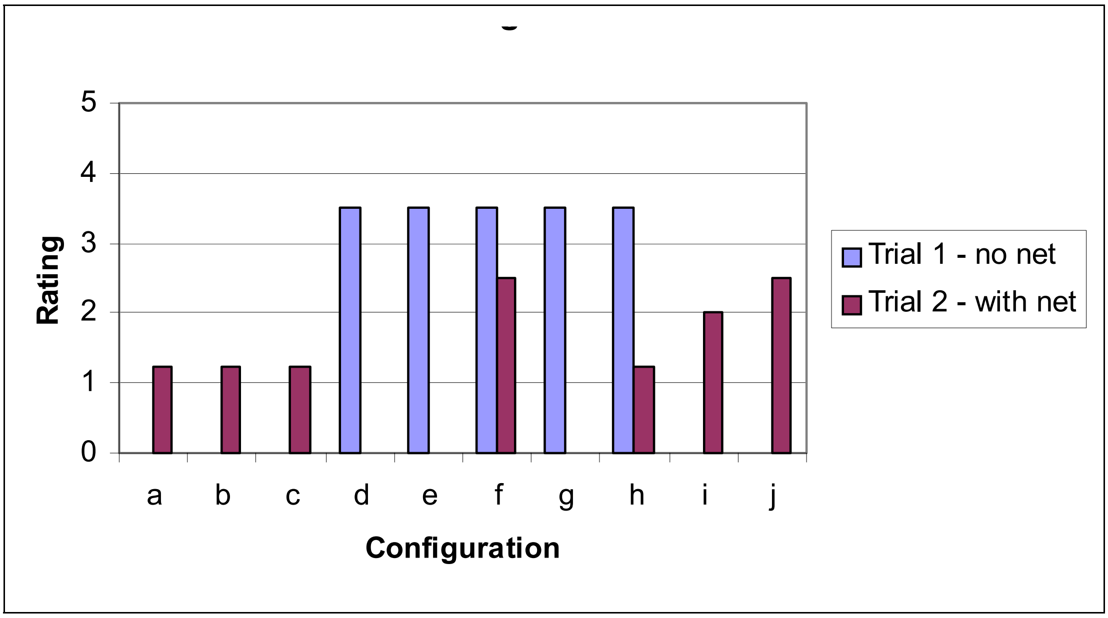

Figure 11 Heading Information

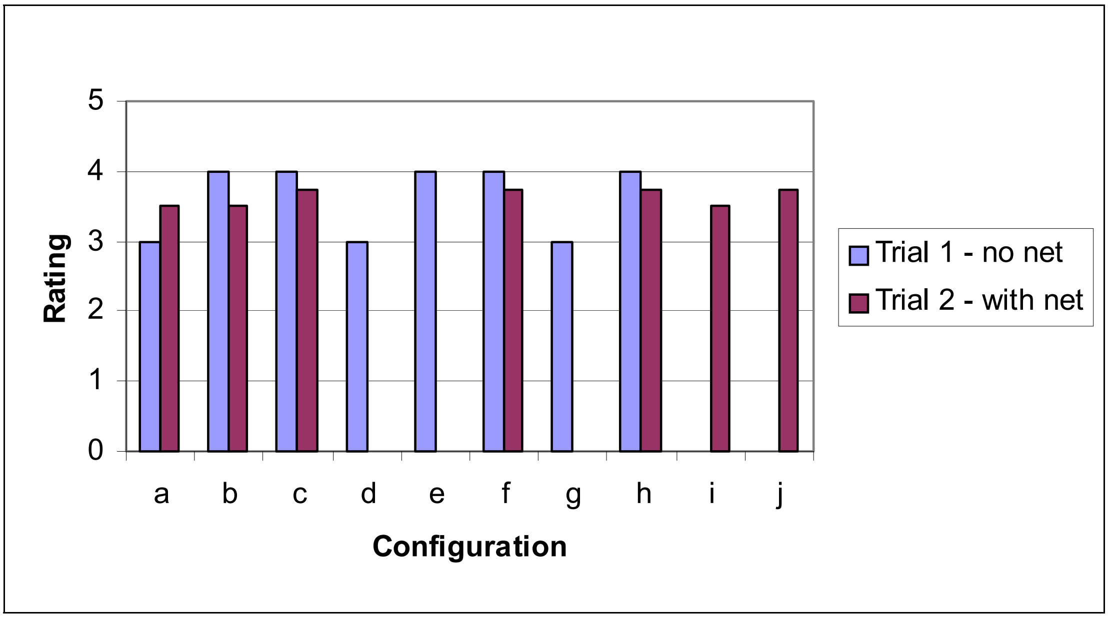

Figure 12 Yaw Rate Information

Appendix G Ground Observations During the First Trial

It was expected that the installation of the net would have some effect on those aids which are installed on the deck surface under the net, i.e. the LED circles and the ELP 'H'. The consensus was that, although there was some disruption of both the circles and the 'H', this would have a minimal impact on the cueing available. At shallow angles the two circles did appear to be somewhat disrupted leading to loss of discrimination between the inner and outer circles which is illustrated in Figure 1. This proved not to be the case, however, at the higher viewing angles encountered in the final approach, hover and landing during the flight trials. One circle was still considered to be adequate, as can be seen in Figure 2. The effect on the outline 'H' was more significant and it was considered that the disruption was excessive. This is shown in Figure 3. With the solid 'H' the random masking of the panel was tolerable and, in fact, added to the texture.

Figure 1 The Effect of a Landing Net on Two Lit Touchdown Marking Circles

Figure 2 The Effect of a Landing Net on One Lit Touchdown Marking Circle

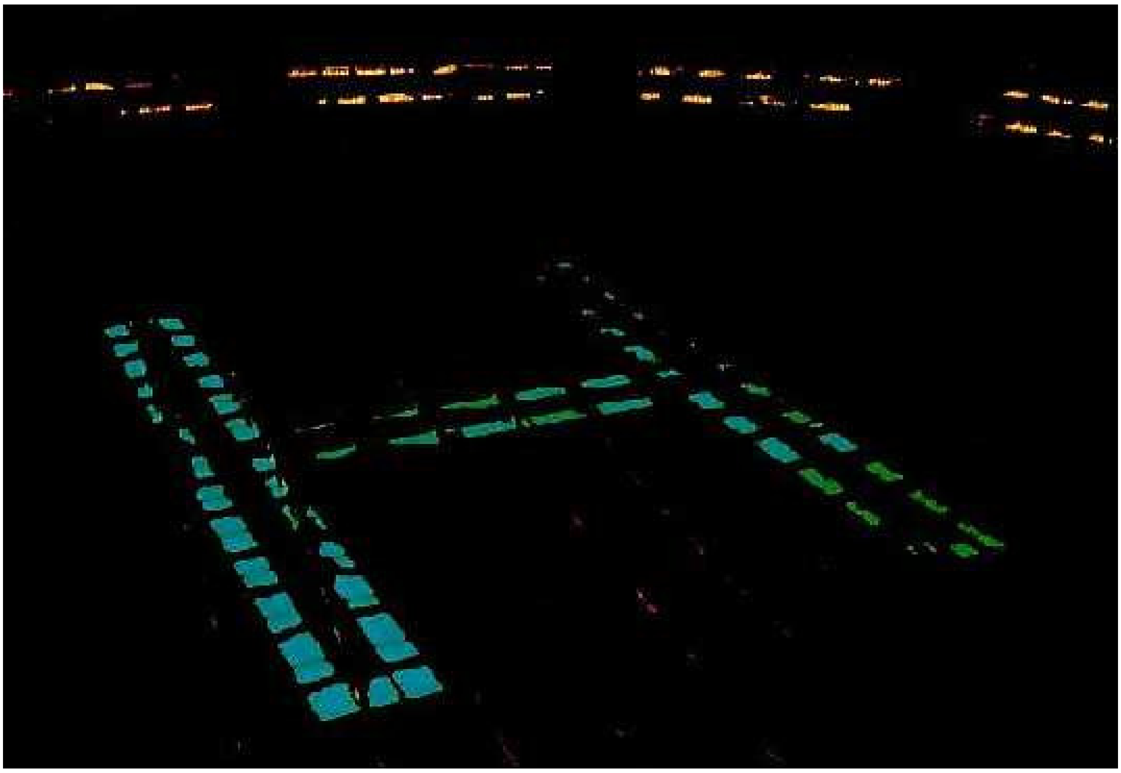

Figure 3 The Effect of a Landing Net on an Outline ELP ‘H’

Interestingly, although the net was tensioned correctly (as required by CAP 437) it still sagged over the raised elements of the pattern (particularly the circles). This allowed them to be seen even below the viewing angle calculated to be the limit for the geometry of the net (20 mm rope at 200 mm spacing = 5.7º).

The effects of the LOS floodlight on the installation were more variable. Whilst there was a splash of light on the deck surface outside the net near to the lights, there was little sign of illumination beneath the net. The net itself, when viewed from the eastern side, was visible only at close ranges with that fraction of the top of the rope that was both visible and illuminated by the floodlights (a very small arc) being noticeable. Viewed from above, the illumination of the net was greater and from the western side (from which it was illuminated), the area within the circle was well lit and provided strong, textural cues.