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Synchronised Lights Viewing Trial 29th August 2007

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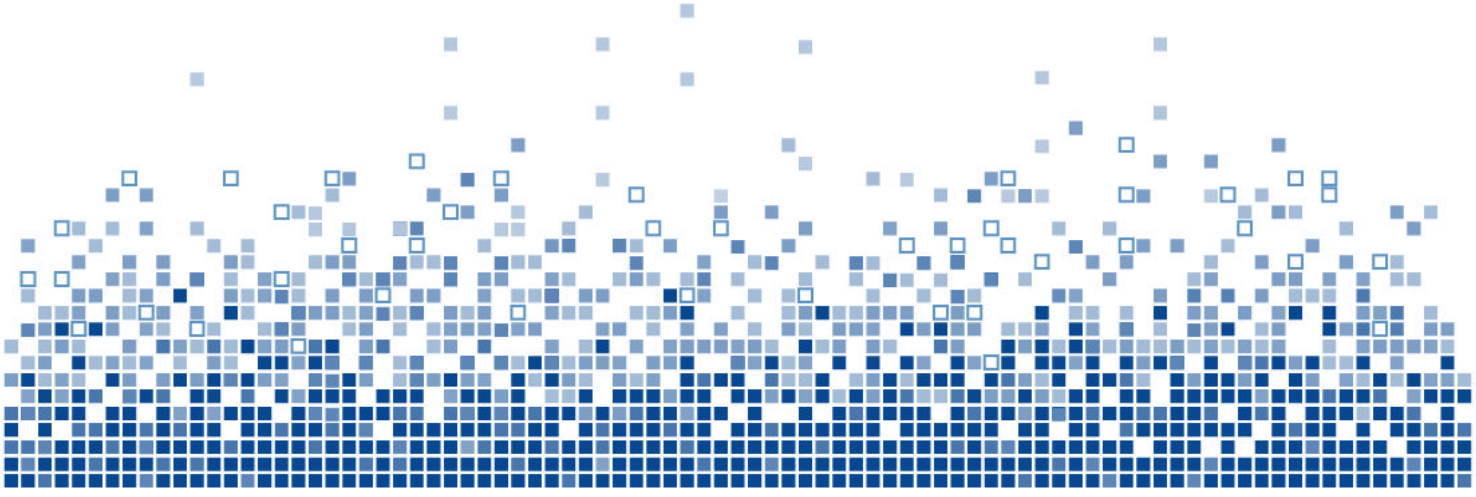

Executive Summary

A viewing trial was held on Wednesday 29th August 2007 to evaluate the effects of angular and temporal separation between synchronised lights. The objective of the trial was twofold:

- To establish the minimum angular separation between synchronised lights that avoids misleading signal information to the mariner;
- To establish the maximum temporal separation, synchronised delay time, at which synchronised lights still appear to be synchronised.

Viewing conditions were favourable and observations started at dusk. The results showed that the minimum angular spatial separation of synchronised lights is 4.5' of arc for reciprocal colours and 3' of arc for like colours. The results also indicated that the maximum slippage time for synchronised lights was 50ms. From these results the following recommendations have been made: -

- That the GLAs, when considering deploying synchronised lights of reciprocal colours i.e. red and green ensure that there is a minimum angular separation of 5' of arc, subtended at the eye of the observer, within the arc of utilisation of the synchronised lights.
- That the GLAs when considering deploying synchronised lights ensure that synchronisation within the system does not 'slip' by more than 50ms.

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1 Introduction

A viewing trial was held on Wednesday 29th August 2007 to evaluate the effects of angular and temporal separation between synchronised lights. A suitable site for conducting such a trial was identified between Dovercourt (Harwich) and Walton-on-the-Naze, as shown in figure 1, with a distance between the exhibition and observation sites being approximately three nautical miles (5.48km). The exhibition site was at Walton-on-Naze with a predominantly sea path between it and the observation site at Dovercourt (Harwich). When observing the exhibited lights, the background was dark with the occasional ship's navigation light in the periphery of the field of view. A new type of light was received just before the trial was due to take place and was exhibited at the end of the trial for interest and comment. This new light had a flash that was modulated with a 10Hz flicker.

Figure 1 - Location of viewing site (Harwich) and exhibition site (Walton – on – Naze).

2 Objective

The objective of the trial was twofold:

- To establish the minimum angular separation between synchronised lights that avoids misleading signal information to the mariner;
- To establish the maximum temporal separation, synchronised delay time, at which synchronised lights still appear to be synchronised.

3 Viewing Conditions

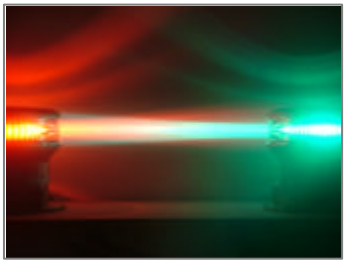
- Visibility: - Good (˜ 16M) with scintillation
- Sea Conditions: - Smooth
- Observations started at dusk.

- Approximate illuminance from each light at eye of the observer: - 3 µLux

4 Methods

The trial was designed in six parts in order to meet the objectives. The following details the purpose and method of each part.

Part A – The effect of red and green synchronised lights



The purpose of this observation was to establish the minimum subtense angular separation between lights of reciprocal colours. In this case, when red and green lights are mixed they appear white. Based on the distance between the exhibition site and the observation site the separation of the lights was increased in steps of 0.5' (minutes) of arc until all observers concluded that there was clear separation between the colours.

Part B – The effect of red and red synchronised lights

The purpose of this observation was to establish the minimum subtense angular separation between lights of the same colour, in this case red. Based on the distance between the exhibition site and the observation site the separation of the lights was increased in steps of 0.5' of arc until all observers concluded that there was clear separation between the two red lights.

Part C – The effect of green and green synchronised lights

The purpose of this observation was to establish the minimum subtense angular separation between lights of the same colour, in this case green. Based on the distance between the exhibition site and the observation site the separation of the lights was increased in steps of 0.5' of arc until all observers concluded that there was clear separation between the two green lights.

Part D - The effect of green and green synchronised delay lights

The purpose of this observation was to identify the maximum time delay between the start of the flashes of two lights, at which the lights still appeared synchronised. The lights were exhibited at their minimum separation distance as in part c and then the 'sync delay' was increased in 10ms steps until observers noticed a delay.

Part E – The effect of green flickering lights

The purpose of this observation was to evaluate the effectiveness of a new light that flickers at 10Hz during the flash period.

Part F – The effect of green flickering lights with synchronised green and green lights

The purpose of this observation was to evaluate the effectiveness of a flickering light as part of a synchronised chain. The green synchronised lights were placed at their minimum separation distance as in part C and observations were made.

5 Observations

Eleven experienced observers were used in this trial and all were asked not to confer until observations had been made. The exhibited lights were identified by alphanumeric indicators when presented to the observers. This was so as not to influence the outcome with expectation [1]. An observation sheet, developed by R&RNAV, see appendix 1, in conjunction with international best practice was used to obtain the optimum results from observations. A list of equipment used for the trial can be found in appendix 2

6 Results & Analysis

The following graphics show the averaged observations for each part of the trial: -

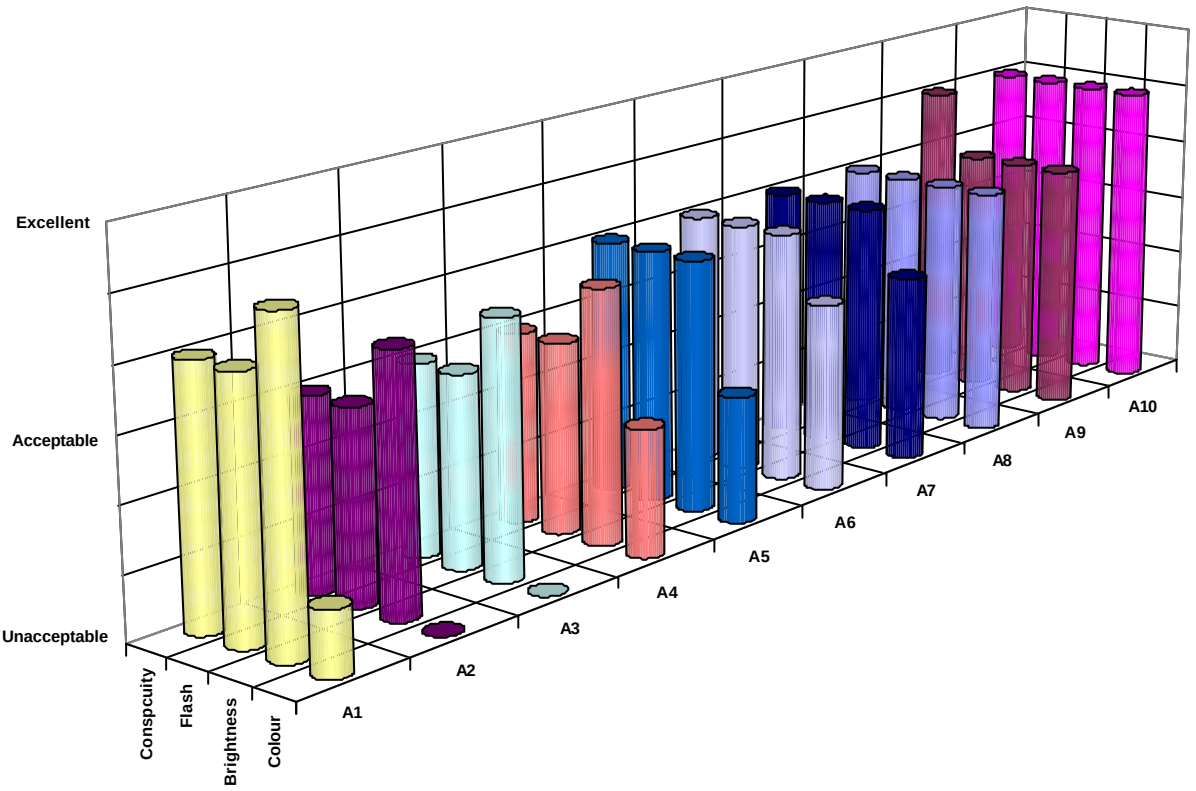


Figure 2 – Average Observations for Part A – The effect of red and green synchronised lights

Part A - The effect of red and green synchronised lights

A1 – 0.1' of arc apart. Comments included "Bright white light with red/green edges". This is reflected in the observations with the combined brightness of two lights being observed as very good, with a good flash and conspicuity (indicative of LEDs [2]). However, the interpretation of the colour was inconclusive and was adjudged as very poor.

A2 – 0.5’ of arc apart. Observations indicate that the colour was unacceptable, the conspicuity and flash were acceptable and the brightness was good.

A3 – 1’ of arc apart. Observations were as A2.

A4 – 1.5’ of arc apart. Starting to see some separation, with the colour being better, but still indeterminate.

A5 – 2’ of arc apart. More separation between lights, still some white.

A6 – 2.5’ of arc apart. Improvement in colour recognition.

A7 – 3’ of arc apart. Same as A6.

A8 – 3.5’ of arc apart. Most observers able to see two separate lights.

A9 – 4’ of arc apart. As lights are separated the synchronised impact of reciprocal colours becomes more apparent.

A10 – 4.5’ of arc apart. All observers agreed that there is clear separation of lights.

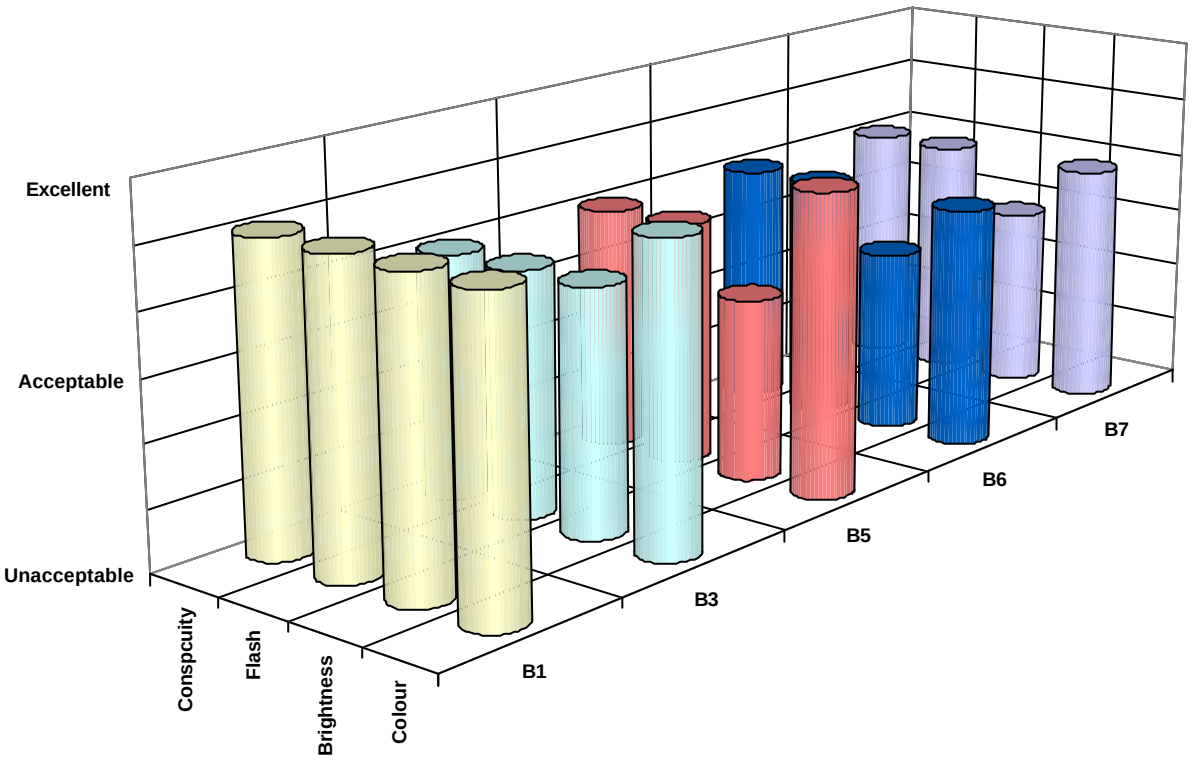


Figure 3 – Average Observations for Part B – The effect of red and red synchronised lights

Part B – The effect of red and red synchronised lights

B1 – 0.1’ of arc apart. Comments included “Very good single red light”. This is reflected in the observations with the combined brightness of two lights being observed as very good, with a very good flash and conspicuity. The colour is also described as very good.

B3 – 1’ of arc apart. Comments included “uneven flash”. This would be due to the scintillation experienced during the trial.

B5 – 2’ of arc apart. Some observers questioning if there were two red lights. This is reflected in the observations. As the lights are beginning to separate the combined brightness is lost and the lights do not appear as bright.

B6 – 2.5’ of arc apart. More observers asking if there are two red lights.

B7 – 3’ of arc apart. All observers agreed that there is clear separation between the two red lights.

N.B. Parts 2 & 4 were missed due to time constraints.

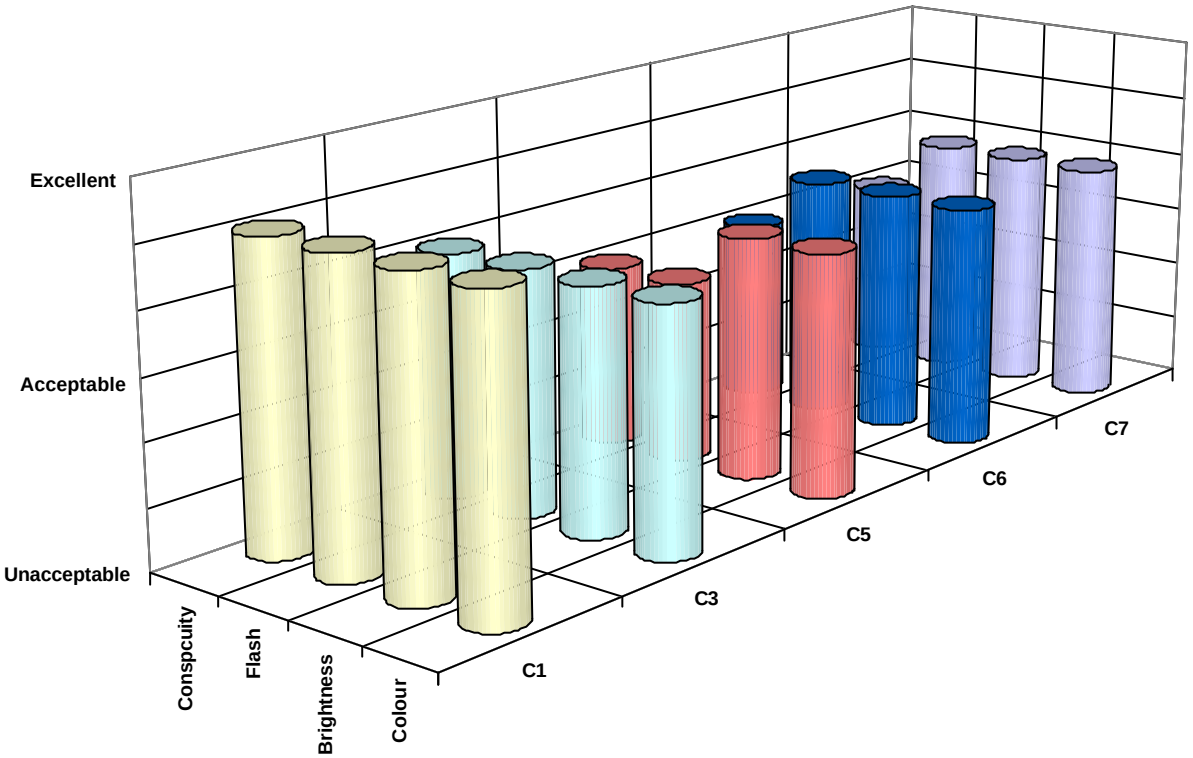


Figure 4 – Average Observations for Part C – The effect of green and green synchronised lights

Part C – The effect of green and green synchronised lights

C1 – 0.1’ of arc apart. Comments included “Very good single green light”. This is reflected in the observations with the combined brightness of two lights being observed as very good, with a very good flash and conspicuity. The colour is also described as very good.

C3 – 1’ of arc apart.

C5 – 2’ of arc apart. Some observers questioning if there were two green lights. This is reflected in the observations.

C6 – 2.5’ of arc apart. More observers asking if there are two green lights.

C7 – 3’ of arc apart. All observers agreed that there is clear separation between the two green lights.

N.B. Parts 2 & 4 were missed due to time constraints.

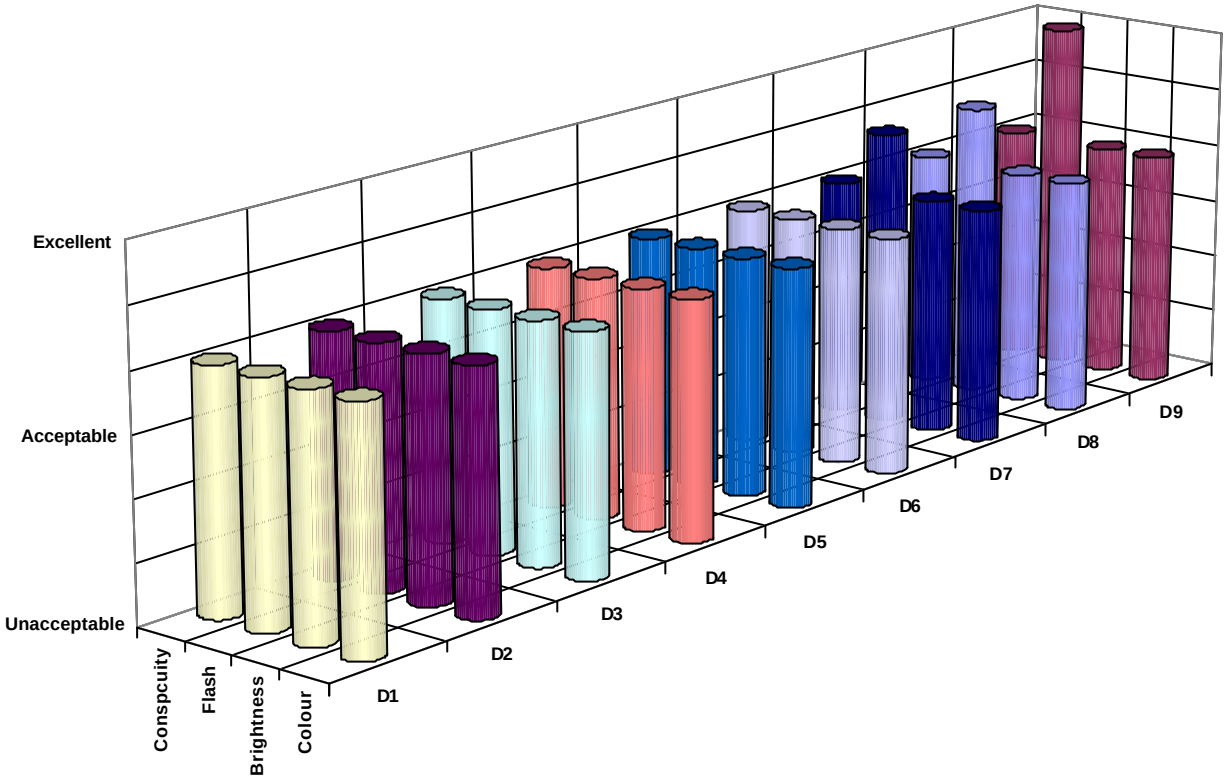


Figure 5 – Average Observations for Part D – The effect of green and green synchronised delay lights

Part D - The effect of green and green synchronised delay lights

D1 – **D6** The lights were exhibited as in C7 with one light being synch. delayed in temporal increments (see Table 1).

D7 – One observer noted that the lights appeared to be out of sync.

D8 – Five observers noted that the lights appeared to be out of sync.

D9 – All observers noted that the lights appeared to be out of sync.

Reference	Separation	Sync. Delay
D1	3' of arc	0ms
D2	-	10ms
D3	-	20ms
D4	-	30ms
D5	-	40ms
D6	-	50ms
D7	-	100ms
D8	-	500ms
D9	-	1000ms

Table 1 - Synchronised Delay temporal increments

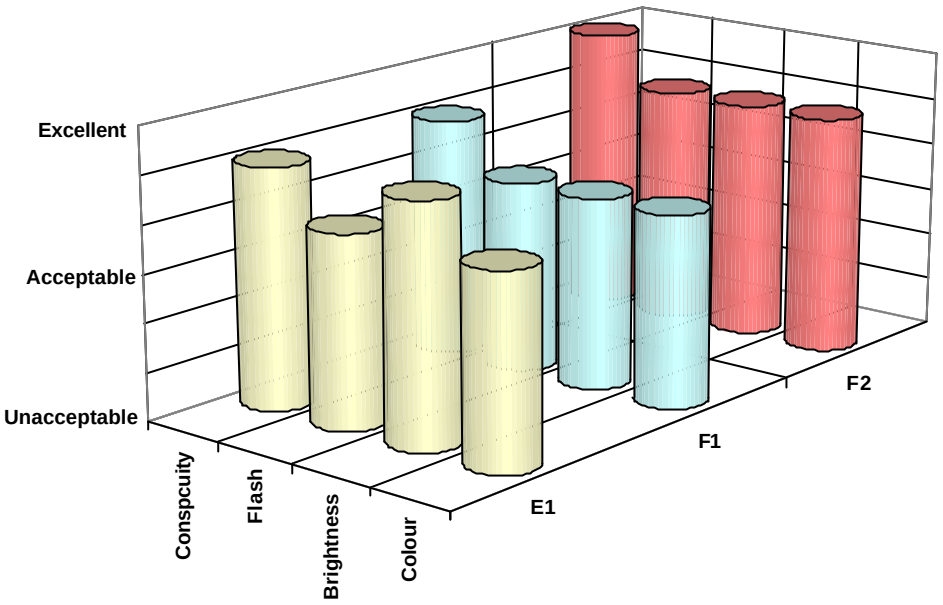


Figure 6 – Average Observations for Part E & F – The effect of green flickering lights and the effect of green flickering lights with synchronised green and green lights.

Part E – The effect of green flickering lights

Part F – The effect of green flickering lights with synchronised green and green lights

E1 – Comments included “Flash on flash”.

F1 – Comments included “Difficult to distinguish spacing”. Lights separated by3’ of arc.

F2 – Lights separated by6’ of arc. Comments included “Clearer spacing”.

7 Conclusions

- It can be seen from the results that, to avoid confusion, the minimum angular spatial separation for all the observers of synchronised lights of reciprocal colours is 4.5’ of arc.
- Likewise, the minimum angular spatial separation for like colours is 3’ of arc.
- The maximum slippage time for synchronised lights to still appear to be synchronised during this trial was 50ms.
- The angular separation of synchronised lights has an impact on their effectiveness.

8 Recommendations

- That the GLAs (when considering deploying synchronised lights of reciprocal colours i.e. red and green) ensure that there is a minimum angular separation of 5’ of arc, subtended at the eye of the observer, within the arc of utilisation of the synchronised lights.
- That the GLAs when considering deploying synchronised lights ensure that synchronisation within the system does not ‘slip’ by more than 50ms.

9 Further Work

During the course of the viewing trial it was recognised that further work was needed regarding the optimum separation of synchronised lights and the effect of sequenced lights. To that end it is proposed that a viewing trial take place during 2008 using the same exhibition site, but with the observers being aboard a vessel.

10 References

Vision and Visual Perception, C. GRAHAM

RPT-28-MN-IT-04 Conspicuity - Colour Comparison of a White LED versus a White Halogen

Appendix 1 – R&RNAV Observer Sheet

Observer

Light 1	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 2	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 3	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 4	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 5	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 6	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Light 7	Excellent	Very Good	Good	Acceptable	Poor	Very Poor	Unacceptable
Colour							
Brightness							
Flash							
Conspcuity							
Comments							

Appendix 2 - Viewing Trial Equipment List

1. Sabik LED - 155 Red GPS Sync lantern S/N: G∅484
2. Sabik LED - 155 Green GPS Sync lantern S/N: G∅481
3. Sabik LED - 155 Red GPS Sync lantern S/N: G∅483
4. Sabik LED - 155 Green GPS Sync lantern S/N: G∅482
5. Sabik LED - Flickering lantern S/N: G1∅72

N.B. *Lights* 1-4 were set to Fl 5s character (fl 1.0s) with peak intensity Io set to 180 cd ±2% (averaged by Talbot's law)