Driving Innovation for Safer Maritime Navigation

GRAD111

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Mobile Aid to Navigation Light Character Trial

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Executive Summary

It is now incumbent on competent AtoN authorities to mark Mobile AtoN where there is a requirements to do so under both the Nairobi Wreck Convention and SOLAS.

A viewing trial was held in Harwich, Essex on 11 October 2018 to ascertain a recommendation to IALA for a new mobile AtoN light character. This had previously been discussed at IALA and innovative designs for the character had been demonstrated in the GRAD laboratories, IALA, including at the IALA Conference in 2018.

Observers from all three General Lighthouse Authorities of the UK and Ireland were present at the trial and recorded their observations against a numerical scale. It was decided that a specific character with flickering components would be best; however, it was decided at the trial to demonstrate new designs “on the fly.” The preferred design can be seen graphically within this document at Figure 5.

The preferred character will be presented to IALA for further work as required.

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Reference Documents

[1] IMO, *Nairobi International Convention on the Removal of Wrecks*. London, UK: IMO, 2007.

[2] HMG, *Merchant Shipping Act 1995*. 1995.

[3] IMO, 'SOLAS Chapter V - Safety of Navigation'. IMO, 01-Jul-2002.

[4] IALA, 'R-1016 Mobile Marine Aids to Navigation'. IALA, Dec-2017.

[5] Malcolm Nicholson, Ian Tutt, 'Synchronised Lights Viewing Trial', Research & Radionavigation, Harwich, Technical Report RPT-09-03-MN-IT-07, Aug. 2007.

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[6] IALA, *R-1001 The IALA Maritime Buoyage System*, 1.0. St Germain-en-Laye, France: IALA, 2017.

[7] Ervin S. Ferry, 'Persistence of Vision', *Am. J. Sci.*, vol. 44, no. 261, pp. 192–207, Sep. 1892.

[8] T.C. Porter, 'Contributions to the Study of Flicker', *Proc. R. Soc.*, vol. 63, pp. 313–329, 1902.

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1 Introduction

1.1 Background

The Nairobi International Convention on the Removal of Wrecks, 2007[1] (NICRW), was adopted by an international conference held in Kenya in 2007. The Convention provides the legal basis for States to remove, or have removed, shipwrecks that may have the potential to affect adversely the safety of lives, goods and property at sea, as well as the marine environment.

The Convention provides a sound legal basis for coastal States to remove, or have removed, from their coastlines, wrecks which pose a hazard to the safety of navigation or to the marine and coastal environments, or both. The treaty also covers any prevention, mitigation or elimination of hazards created by any object lost at sea from a ship (e.g. lost containers). Wreck, under the terms of the wreck convention, is defined as:

- a sunken or stranded ship;
- any part of a sunken or stranded ship, including any object that is or has been on board such a ship;
- any object that is lost at sea from a ship that is stranded, sunken or adrift at sea;
- a ship that is about, or may reasonably be expected, to sink or to strand, where effective measures to assist the ship or any property in danger are not already taken.

Thus it is clear, within the UK and Ireland, that under the Merchant Shipping Act 1995[2] (MSA), Chapter 21, Part IX, Chapter 3 section 252(2)(b) "…lighthouse authorities have the power to light or buoy the vessel or part of the vessel and any such other property until it is raised, removed or destroyed…" lighthouse authorities have the responsibility to mark wrecks and other items pertaining to wrecks. Similar legislation is enacted in other countries.

As well as their responsibilities under the NICRW and any local legislation such as the MSA, lighthouse authorities may be responsible for the marking of other items other "mobile" items should they be deemed a hazard to navigation by a competent person under the auspices of the International Convention for the Safety of Life at Sea (SOLAS)[3] based on the volume of traffic and the degree of risk presented to that traffic. So was born the idea of a "Mobile AtoN" or MAtoN.

Other expected uses of MAtoN (from IALA Recommendation R-1016[4]) are:

- Mobile Ocean Data Acquisition System (ODAS) (e.g. currents, weather)
- Drifting wreckage (e.g. abandoned vessels, drifting shipping containers , debris that is not stationary)
- Water quality & pollution monitoring equipment or systems
- Mobile guard zones & convoys
- Underwater operations
- Enhance navigational safety during military operations (e.g. no sail zones during minesweeping, target exercises)
- Identifying end of drifting lines (e.g. seismic survey lines and long fishing lines)
- Towed and deployed applications (e.g. cable laying)
- Pollution containment and clean up
- Search & Rescue applications
- Small unmanned systems and equipment
- Special events (e.g. channel swimming).

1.2 Developments to Date

With the background set out above, it was noted within the International Association of Marine AtoN and Lighthouse Authorities (IALA) AtoN Requirements and Management Committee (ARM) that it was incumbent on it to develop not only guidelines and recommendations on the subject, but also to look at the development of a new and distinctive light flash character that would stand out from fixed AtoN. It was unanimously agreed that this should be some sort of a special mark and hence the light should be a yellow colour. It was also agreed that to be distinctive enough, the flash characters should have some sort of "flickering" element. These flickering characters were first demonstrated to be conspicuous by Japan Coast Guard and this was confirmed by R&RNAV in 2007[5]. Other guidance on MAtoN by IALA is provided in Recommendation R1016[4].

GRAD (formally R&RNAV) volunteered to undertake this development and produced a technology demonstrator. This demonstrator was shown within the GLA and also at IALA ARM and ENG (Engineering and Sustainability) committees, as well as at the 2018 IALA Conference at Incheon (Republic of Korea). All of these demonstrations were at short range and indoors typically over just a few metres.

Feedback was garnered from a host of possible characters, many of which were developed on a bespoke basis, but this was down-selected to just ten which were chosen for a demonstration to be conducted in near to operational conditions over the expected usage range of a MAtoN of up to 5 miles.

2 Objective

A trial was organised such that experienced observers of different sexes and age ranges would observe the ten different flash characters at a distance of around 3 NM. From the results of the trials it was expected that a flash character could be recommended to IALA either for publication in the Maritime Buoyage System (MBS)[6] and subsequent use by competent authorities and other users, or that other research groups could take this recommendation and work on it further, potentially in collaboration with GRAD.

In July 2018, two sites around the River Stour and River Orwell estuaries on the Essex/Suffolk (UK) border were surveyed as potential trial site locations. This was to provide for diversity of locations due to the challenges of rival background lighting from the Port of Felixstowe and the Harwich International Port at Parkeston as well as other local street lighting and local fixed and floating AtoN. These sites and the observers' location are shown in Figure 1.

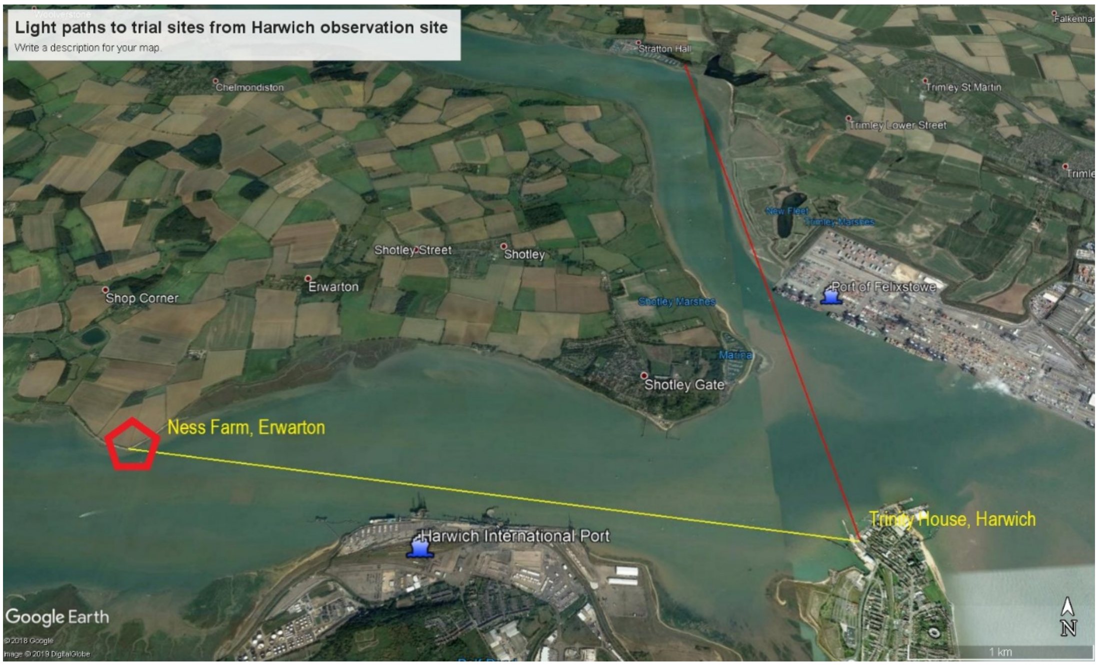

Figure 1 – Light paths from surveyed sites to observation site (site used is indicated)

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3 Viewing Conditions

The trial took place on the 11th October 2018. Observations were made from the 2nd floor viewing room at Trinity House, Harwich. The observers were briefed and the viewing proper started at 20:00Hrs.

Visibility on the night was good at 10 NM+ at 20:00 decreasing to about 5 NM by the end of the trial due to precipitation, hence there was some scintillation effects even at 2.5-3.0 NM observation range of the lights. The sea-state was calm at approximately sea-state 2 (Smooth).

There was some background lighting and rival lighting from other local AtoN, but it became clear when the trial started where the light was and observers found it generally easy to acquire the light. Observation were conducted behind the standard double glazing of the 2nd floor viewing room.

4 Methods

A modified GRAD RLS was used for the trial, populated with a single strip of three Cree XPEBAM-L1-0000-00903, measured to be within the IALA yellow region. A GRAD developed LED driver based on an Arduino processor was used to control the power for the light source. This in turn was driven by a GRAD-developed Arduino LED Light Flasher Configuration Tool v1.9 and a 12 V battery.

The light source set up was taken to the first site at Ness Farm, Erwarton, Suffolk and set up. It was envisaged that the second trial site (Suffolk Yacht Harbour, Levington, Suffolk) would be used, but this was not necessary after the first set of observations.

The characters were demonstrated and the results written down by the observers. Each character was marked on a scale of 1 (terrible) to 9 (excellent). The observers were instructed to score each character on distinctiveness from other AtoN characters. The characters are shown below. A legend is shown in Annex B – Flash character Legend.

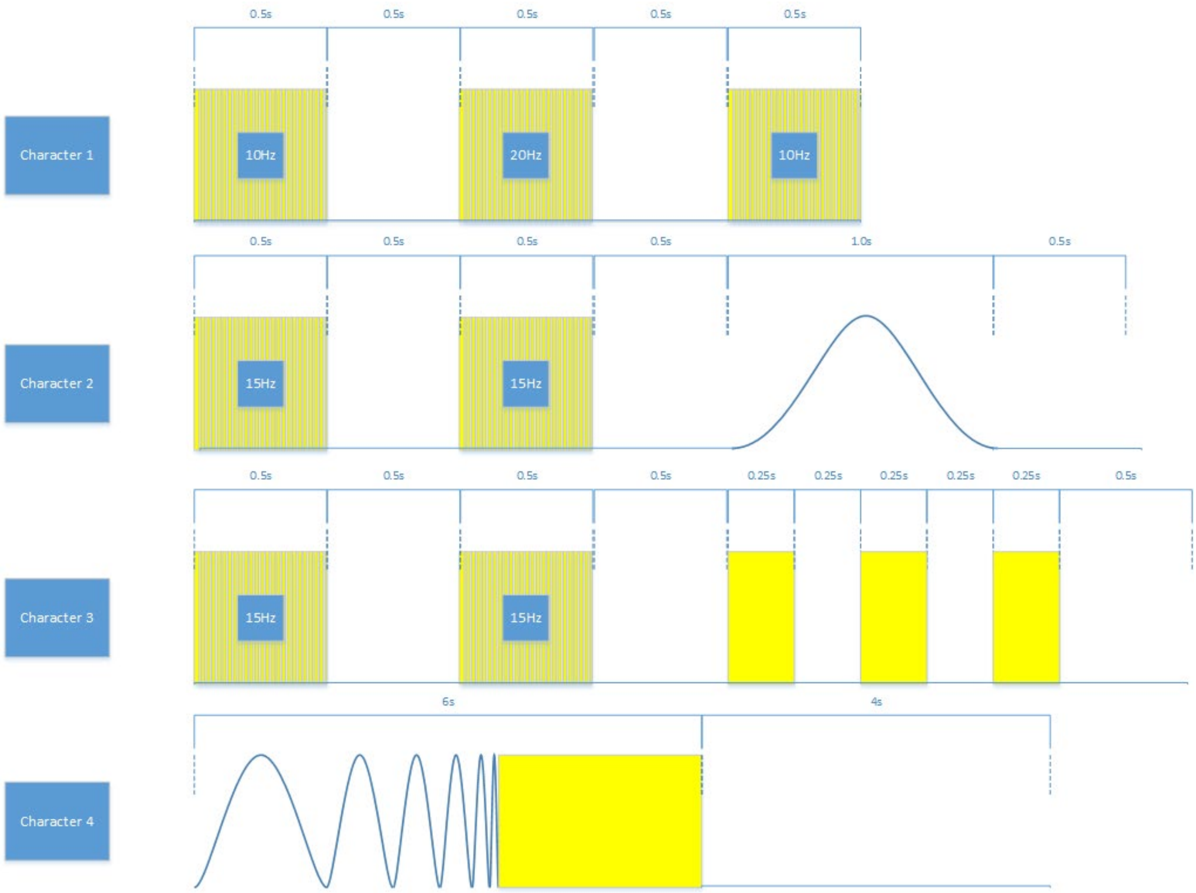

Figure 2 – Flash characters 1 to 4

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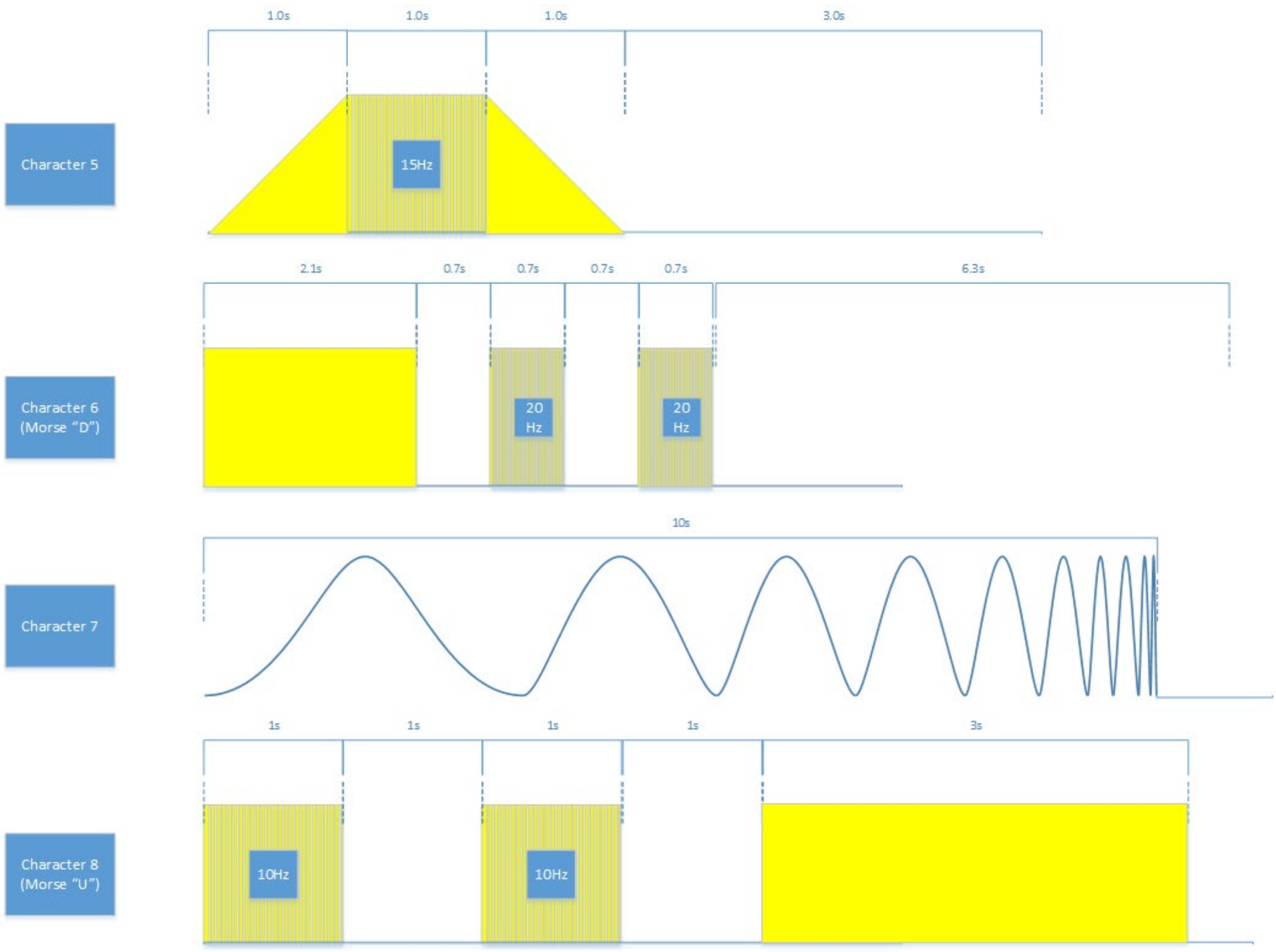

Figure 3 – Flash characters 5 to 8

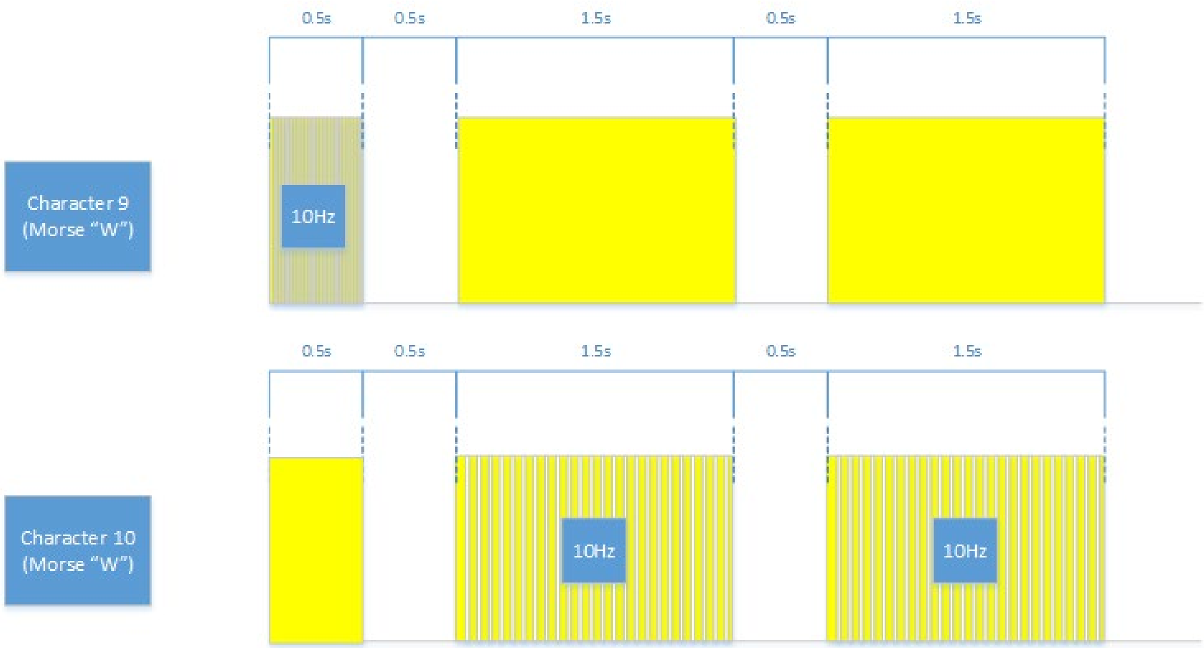

Figure 4 – Flash characters 9 and 10

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5 Observations

Eight observers from all 3 of the General Lighthouse Authorities of the UK and Ireland plus GRAD personnel were used in this trial and all were asked not to confer until observations had been made. The exhibited lights were identified by numerical indicators when presented to the observers. This was so as not to influence the outcome with expectation.

6 Results and Analysis

The results of the trial are shown in Table 1. It can be seen that the results per observer do vary quite widely, with some observers marking more harshly than others (and some not scoring at all in one instance (observer 8)). The scores were normalised for the non-zero scores (Table 2). With or without normalisation, it can be seen that the character which was most distinctive in terms of difference was character 3.

It became clear whilst the observations were taking place, that the flickering flash characters which had been the preferred option in laboratory and other demonstrations, were not suitable "in the wild" over distances of several NM. It appeared that at the higher flicker frequencies, that the flicker was being integrated into a "dull twinkle." This is likely due to the Ferry-Porter Law, which states that the critical fusion frequency of the human visual system reduces with light illuminance, thus causing the flicker to merge[7], [8].

However, during ensuing discussions it was agreed to try other flash characters. As it was thought the best through observation, flash character 3 was used as the basis for the derivation of other characters "on the fly".

Many characters were tried with different flash lengths, different flicker frequencies and different number of flashes. Whilst conducting these iterations it was noticed that flickering characters below a flicker frequency of 7 Hz were better over the required operating range of MAtoN; however, as a very quick flash (VQF as defined in the MBS[6]) is around 4 Hz, the character for a MAtoN should be above this to remain distinctive (noting that the top end of the range of an Ultra Quick Flash is 5 Hz). It was agreed by all observers that the best flash character observed during the trial was a derivative of flash character 3. This is shown in Figure 5 and is named flash character 11 which has a duty cycle of 48.1%.

	Observer number & Scores												
Flash character #	1	2	3	4	5	6	7	8	9	Average (non-zero)	Total score	Rank	Non-zero average rank
1	0	6	5	8	5	1	0	0	7	5.3	32	9	5
2	6	3	4	9	6	1	0	0	4	4.7	33	8	6
3	8	8	6	9	7	3	2	0	7	6.3	50	1	1
4	5	3	7	7	4	1	1	0	4	4.0	32	9	10
5	5	3	5	8	8	1	1	0	5	4.5	36	6	8
6	6	2	6	8	5	2	2	0	5	4.5	36	6	8
7	4	2	8	9	6	6	3	0	7	5.6	45	2	2
8	7	5	4	8	7	1	5	0	6	5.4	43	4	4
9	5	3	5	8	6	1	3	0	6	4.6	37	5	7
10	7	5	7	8	7	1	4	0	6	5.6	45	2	2

Table 1 – Trial observation results

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Flash character #	Observer number & Scores 1	2	3	4	5	6	7	8	9	Average (non-zero)	Total score	Rank	Non-zero average rank
1	5	6	5	8	5	1	5	5	7	5.3	47.9	5	5
2	6	3	4	9	6	1	5	5	4	4.7	42.4	6	6
3	8	8	6	9	7	3	2	6	7	6.3	56.3	1	1
4	5	3	7	7	4	1	1	4	4	4.0	36	10	10
5	5	3	5	8	8	1	1	5	5	4.5	40.5	8	8
6	6	2	6	8	5	2	2	5	5	4.5	40.5	8	8
7	4	2	8	9	6	6	3	6	7	5.6	50.6	2	2
8	7	5	4	8	7	1	5	5	6	5.4	48.4	4	4
9	5	3	5	8	6	1	3	5	6	4.6	41.6	7	7
10	7	5	7	8	7	1	4	6	6	5.6	50.6	2	2

Table 2 – Normalised trial observation results

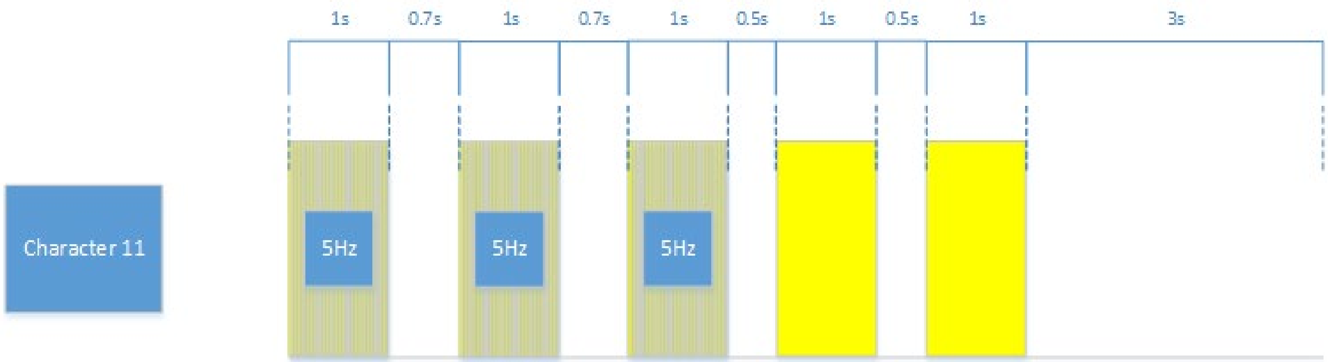

Figure 5 – Flash character 11 (preferred character)

7 Conclusions

- It is incumbent on competent authorities to provide a means of marking mobile floating and semi-submerged items through international and local legislation[1], [2]
- Mobile AtoN flash characters need to be distinctive from other characters in the IALA Maritime Buoyage System yet still retain a near special mark characteristic
- Distinctiveness can be achieved through the use of flickering/partially flickering characters
- Flickering flash characters need to be above 4 Hz (VQF), but below 7 Hz to be effective over the operational range required for MAtoN
- The recommended character for further work is character 11 as shown in Figure 5 and this will be recommended for use by IALA as standardisation of this flash character will be required internationally

8 Recommendations

- Flash character 11 is recommended by GLA for further work within the GLA and IALA with regard to MAtoN flash characters
- GRAD Head of Research and Development reports findings to the IALA ARM committee
- GLA to invite other competent AtoN authorities to replicate and verify/challenge these results, or conduct their own trials to suggest distinctive flash characters for MAtoN

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Annex A – List of participants

Name	Role	Affiliation
Barry Phelan	Observer	Irish Lights
Damien O'Connor	Observer	Irish Lights
Neil Askew	Observer	Irish Lights
Adam Lewis	Observer	Northern Lighthouse Board
Peter Douglas	Observer	Northern Lighthouse Board
Rob Dory	Observer	Trinity House
Roger Barker	Observer	Trinity House
Alwyn Williams	In-field operative	GRAD
Link Powell	Observer	GRAD
Lorraine Mahoney	Observer	GRAD
Martin Bransby	Trial Director	GRAD

Table 3 – List of participants

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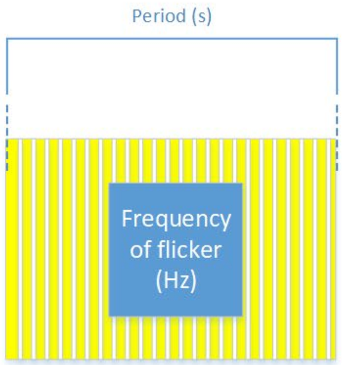
Annex B – Flash character Legend

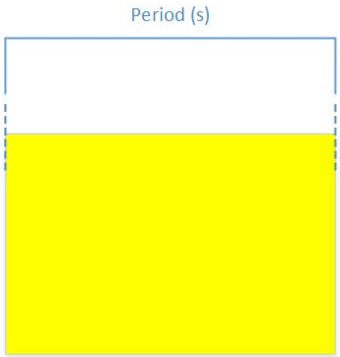
Legend

Flickering character part

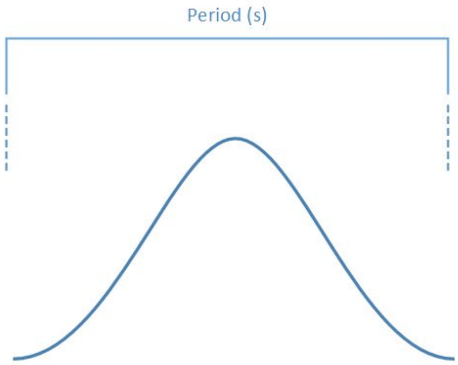


Note: The flicker frequency is not to scale

"Normal" square flash profile character part



Sinusoidal or Gaussian flash profile character part



Note: The colour of the sinusoidal character was IALA yellow as for the other character parts

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