

## An Investigation Regarding Seafarers' Resistance to Using ECDIS Black-background Chart Display Modes

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Colours are used on charts to aid in distinguishing between features. Optimum colour contrast is required under all viewing conditions; from bright sunlit conditions during the day to a darkened bridge at night. The colours specified by the International Hydrographic Organization (IHO) for use in Electronic Chart Display and Information Systems (ECDIS) were developed by Perception Institutes specifically to give a clear display under such conditions. This has resulted in the five colour tables that are required to be available in ECDIS.: *bright sun, day-white background, day-black background, dusk and night.*[IHO] Each table contains a palette of optimised colours to best depict the various charted features under varying ambient light conditions.

There have been anecdotal reports of seafarers' resistance to using the black background 'night' display modes, preferring to use the white background 'daylight' display at night by turning down the brilliance and contrast controls in ECDIS. Because

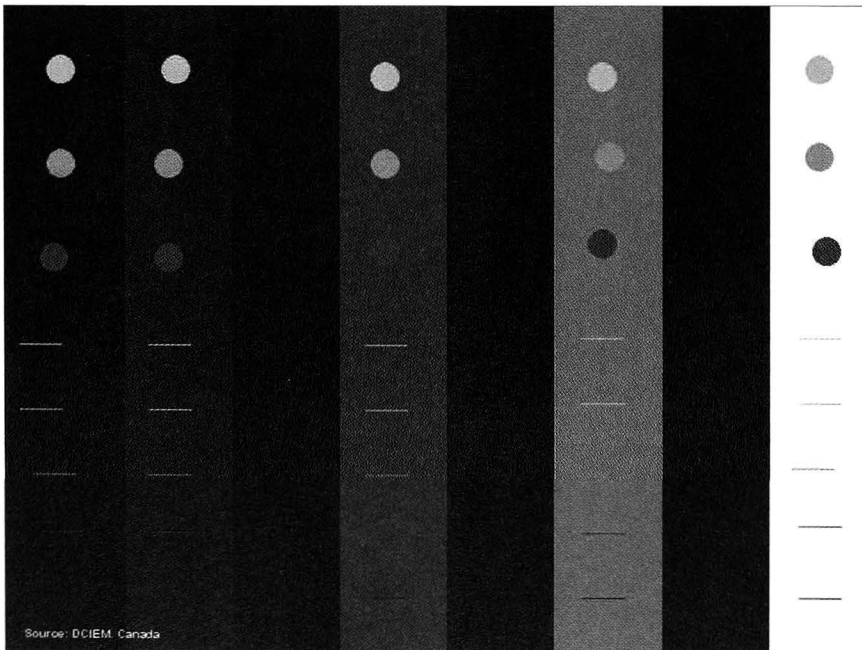


Figure 1: Brightness Induction: Typical effects of discrimination of identical foreground colours against varying background brightness levels

this practice has the potential to render some charted features unnoticeable or indistinguishable, thereby placing a ship in potential danger, staff at the Australian Maritime College (AMC) at Launceston, Tasmania, undertook a snapshot survey of students undertaking ECDIS familiarisation training. 65 Seafarers were polled after completing ECDIS training to identify their past viewing practices and their likely future preferences when using ECDIS or ECDIS-like ECS at night. This paper reports on the outcome of the survey.

### **Colour Discrimination and ECDIS**

There are two principal issues concerning the use of electronic chart displays on bridges of ships: minimum colour discrimination and the preservation of night vision.[Kaufmann, 1990]

Minimum colour discrimination is the smallest colour difference that the human eye can discriminate under different conditions. The brightness of a small area will change as a function of the colour and brightness of its background. This is known as brightness induction. This is of particular significance in ECDIS because much of the information is presented as small symbols in a range of colours against varying backgrounds. It has been found that using saturated foreground colours against de-saturated (pale or washed out) background colours, and by making sure that the luminance of the foreground colours (brightness) are consistently higher or lower than the luminance of the background colours is an effective *method of enhancing colour discrimination*. [McFadden, 2001]

The mariner must be able to use an ECDIS display under all levels of ambient illumination. This obviously ranges from bright daylight to very low light levels at night at sea.

**Daylight viewing.** In daylight conditions adding white light (from the light falling on a screen) results in image colours tending to de-saturate and hence become more similar in appearance resulting in a reduction in colour discrimination. For this reason, it is always preferable to avoid direct sunlight or even artificial light from falling on computer or video displays.[Cowan, 1993] As shown in Figure 1, a light background makes foreground colours appear more saturated and darker - increasing the separation between background and foreground colours and partially counteracting the effect of high ambient illumination. A commonplace and practical result of this is the almost universal adoption of light backgrounds for most desktop computer applications. The IHO paper chart colour scheme generally follows the same principles (saturated symbology and typescript set against predominantly lighter backgrounds). It is therefore not surprising that an ECDIS daylight colour scheme was based on the traditional paper chart colours. However, this colour scheme is not appropriate for night viewing using electronic displays.

**Night Viewing.** At night, the average luminance of the display becomes a critical factor since the mariner must be able to look at the ECDIS display yet still retain 'night vision'. Using paper chart colour schemes and their reliance on a white background means that the largest areas of the display will be the brightest. Moreover, if the overall image brightness is reduced, then the foreground colours will appear darker because of brightness induction and the visibility of the foreground symbols and lines will be reduced disproportionately. However, if a dark background is used, then any small foreground colours will appear lighter - increasing their visibility. In addition, it is possible to use somewhat brighter symbols because they make up a relatively small proportion of the ECDIS chart display. This is the reasoning behind adopting a black-background display for ECDIS, particularly at night.

### **Impact of Using Brightness/Contrast Controls**

An apparently simple way of adapting an electronic chart display for night conditions is to turn down the brightness and contrast level. However, changing the brightness and contrast of an electronic chart display as a means of reducing the overall light levels leads to changes in chromaticity (the hue and the saturation). Large changes in either the contrast or brightness controls will lead to significant changes in the hue and or saturation or the colours. Research also suggests that observers often miss quite large changes in the appearance of a scene or image on an electronic display even when they are instructed

to monitor the image closely.[DCIEM] Such changes will be critical for safe navigation if they result in a significant reduction in the ability of a mariner to discriminate between colours on an ECDIS display or if they result in a significant shift in colour appearance.

The perception laboratories recommended from the outset that the brightness and luminance adjustments in ECDIS should be controlled or limited in some way. However, it was realised that the mariner would require some control to compensate for the degradation in the monitor over time. As a result, a 'black adjust' symbol (BLKADJ) was introduced in 1999 as a check that the mariner does not 'over adjust' the controls.[IHO<sup>2</sup>] A similar arrangement was not proposed for the light background displays because it was not expected that mariners would opt to use the light background displays at night.

BLKADJ consists of two nested black squares: a 20mm. outer square is coloured black (colour token BKAJ1, ex RES04); and a 12 mm. inner square is coloured just above black (colour token BKAJ2, ex RES05). It is designed to be used by adjusting the contrast and brightness so that the inner square just appears.

Unfortunately, implementation of BLKADJ is not mandatory and few if any ECDIS manufacturers have incorporated the feature. Furthermore, BLKADJ is not configured to work on flat panel displays, which tend to have the black level fixed during the manufacturing process.

## Aims of the Survey

The aims of the AMC 'snapshot' survey were to:

- Test the hypothesis that a majority of seagoing mariners are using a white-background ECDIS display under various ambient light conditions regardless of the shortcomings
- Identify if formal ECDIS training has an impact on mariners' viewing preferences
- Obtain feedback about why a white-background is preferred

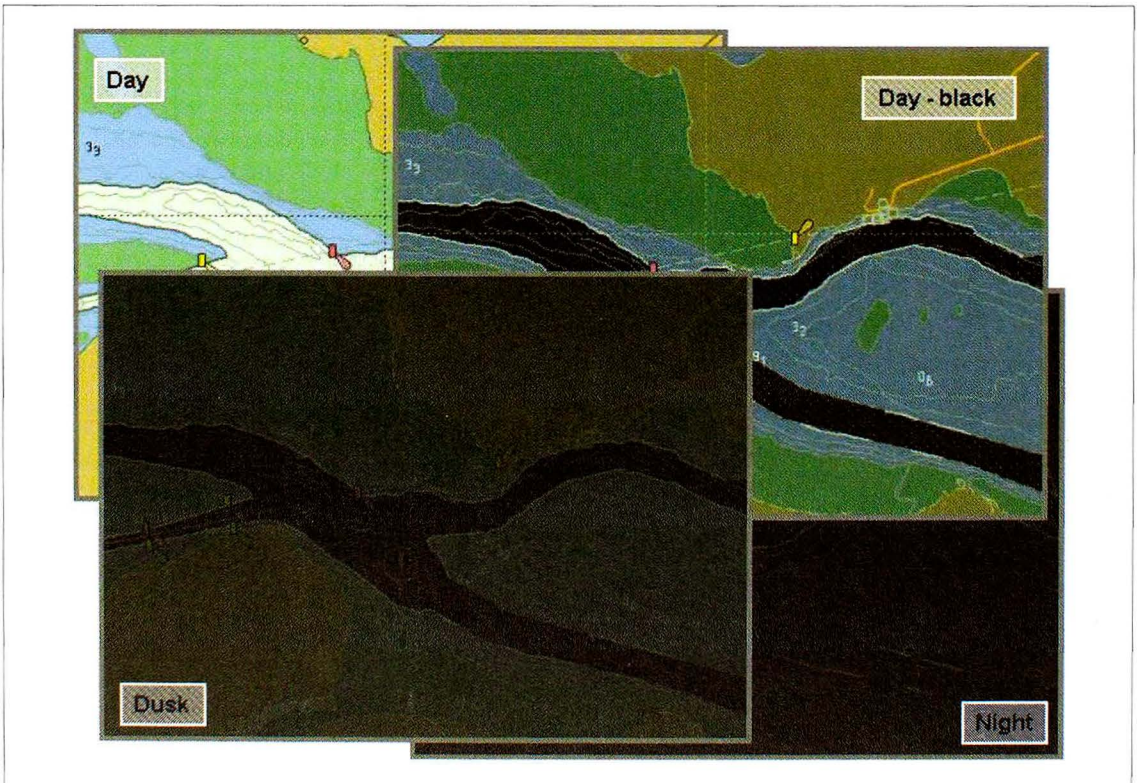


Figure 2: Examples of ECDIS chart display colours

## Methodology

A questionnaire survey was distributed to seafarers at the Australian Maritime College. The respondents came from a varied background; some were 2<sup>nd</sup> Mates, others were experienced Masters and Mates upgrading to STCW 95. Prior to completing the survey, respondents were instructed in the basic use of ECDIS. Instruction was provided primarily using *HSA Endeavour® Navigator*, a high-end ECS offering many of the features of ECDIS. In particular, *Endeavour® Navigator* is configured to display both Electronic Navigational Charts (ENC) and Raster Navigational Charts (RNC) in accordance with the IMO chart presentation requirements.[IHO<sup>3</sup>] A version of *Endeavour®* is currently undergoing ECDIS type-testing (January 2002). It should be noted that as the equipment was not type-approved ECDIS the screen displays were not calibrated to meet the full ECDIS test requirements.

Training involved the use of six training units in the AMC Integrated Marine Simulator (IMS). Practical training involved navigation exercises in simulated daylight and darkness in the Port Phillip and Torres Strait areas. These exercises involved keeping a visual lookout in addition to electronic navigation practice.

Time allocation for ECDIS instruction comprised at least: one hour theory of ECDIS, one hour general familiarisation using *Endeavour Navigator* in 'demonstration' mode, and two hours (including set-up) in the IMS using *Endeavour Navigator* with GPS input. During the theory and general familiarisation training sessions all students received instruction on appropriate display modes for various ambient light conditions. This included advice on the possible dangers associated with using a white background display with low brilliance/contrast adjustment. The survey questionnaire was administered after course participants had completed the simulation exercises.

## Results

There were 65 participants in the survey. Of these, 25 (38 per cent) reported previous ECS/ECDIS experience at sea and indicated that the night display modes were available on their seagoing systems.

The average ECS/ECDIS experience was 26.8 months. (ECS/ECDIS experience varied from 1 week to 144 months).

### Previous Practices at Night at Sea

Of those seafarers with prior ECS/ECDIS experience 40 per cent (10/25) reported using the day display mode regularly at night at sea. 52 per cent (13/25) used the night display mode and 8 per cent (2/25) used the dusk display mode, presumably in bridge conditions with higher than average ambient light levels.

### Measures Taken to Deal with Excessive Light from Day Display When Used at Night at Sea

All the respondents who indicated that they used the day mode at night reported that they turned down the monitor brightness and/or contrast.

### Views on the Night Display Modes

Respondents were asked to state their specific dislikes with respect to the night display mode. Responses are summarised below:

- ... if night display mode accidentally used in daytime cannot see screen to revert to day display mode – dangerous
- ... tool bars too bright
- ... dark colours not liked
- ... dark colours – too much clutter

- ... too little colour differentiation
- ... too dark
- ... too dim – wrong colour
- ... restrictive
- ... too little colour differentiation- hard to extract information
- ... lack of clarity – no effective contrast of colours
- ... too dark – hard to see features
- ... still too bright – must reduce the actual screen brightness
- ... too dim in night mode – brightness adjustments not user friendly
- ... colour contrast – difficult to assimilate- I am used to white display
- ... view uncharacteristic of conventional paper charts

### Likely Practices at Night at Sea Post-ECS/ECDIS Training

After exposure to ECDIS theory instruction and simulator training involving night-time exercises respondents were asked to indicate whether they would use the night display modes at sea at night in future. Of those seafarers with prior ECS/ECDIS experience 50 per cent (10/20) intended using the night display mode at night at sea. 35 per cent (7/20) intended using the day mode and 15 per cent (3/20) were unsure. Of those seafarers with no prior ECS/ECDIS experience 71 per cent (27/38) intended using the night display mode at night at sea. 24 per cent (9/38) intended using the day mode and 5 per cent (2/38) were unsure.

The following tables summarise the results.

<i>Have you used ECS/ECDIS at sea?</i>	
Yes	No
25 (38 per cent)	40 (62 per cent)

<i>Which mode of display did you consistently use at night?</i>	<i>Which mode of display did you consistently use at night?</i>		
	Night	Dusk	Day
Previous Experience with ECS/ECDIS	13 (52 per cent)	2 (8 per cent)	10 (40 per cent)

<i>Would you use night display mode at sea at night in future?</i>	<i>Would you use night display mode at sea at night in future?</i>		
	Night	Day	Not sure
Previous Experience with ECS/ECDIS	10 (50 per cent)	7 (35 per cent)	3 (15 per cent)
No Previous Experience with ECS/ECDIS	27 (71 per cent)	9 (24 per cent)	2 (5 per cent)
Total - all respondents	37 (50 per cent)	16 (35 per cent)	5 (15 per cent)

## Opinions on Display Modes

All respondents were asked for their opinions on the display modes. These are summarised below:

<i>Reported reasons for preferring night display mode at night</i>	<i>Reported reasons for preferring day display mode at night</i>
... night vision	... better brightness control-tool buttons too bright in night mode
... appropriate (still had to adjust monitor brightness)	... I prefer day screen on low illumination
... reduced light from screen	... easier to extract information. With black background depths/contours are enhanced-crowding other information
... less glare	... more discrimination between land, shallows and deep water
... less light	... greater clarity
... safe lookout	... too much ambient light on bridge for night mode
... no monitor brilliance adjustments on set used	... easier colour discrimination
... less glare- minimised lighting	... better clarity of information
... reduced glare and background light	... night too dim – clarity of display is better
... softens light	... can be dulled – has a softer contrast
... less intense	... night too dim
... better contrasting shades	... softer focus
... reduced glare and background light	... clarity of information
... I hate lights/brightness on the bridge	... more definition
	... colour scheme-recognition of navigational dangers
	... easier to display – comprehend
	... easier to see info in day/dusk
	... easier to see points of interest/dangers
	... greater definition
	... more discrimination
	... easier to discern between chart features
	... depths/bottom colours are more subtle
	... more easy to discern information
	... night tool bars too bright

## Conclusions

From the results of this survey, it appears that:

- The AMC course had little effect on dissuading practising ENC/ECDIS operators from using the day display mode at night. Previous habits or perceptions seem hard to overcome
- ENC/ECDIS training appears to be more influential on seafarers with no previous ENC/ECDIS experience
- A majority of users are critical of the black background associated with the night display mode – principally based on unfamiliarity and a preference for traditional chart colours
- Overall, more than one third (35 per cent) of respondents indicated that in future they would use the day display mode at sea at night. A further 15 per cent were unsure what they would do. These figures are a cause for concern

## Discussion

### Sample Size

It must be acknowledged that the sample size is relatively small; nevertheless, the outcomes appear to provide some noteworthy results that merit further investigation. It would also be beneficial to follow-up the respondents over time to see if their habits at sea differ markedly from those expressed during the survey.

### Limitations of Equipment Used in the Survey

Type-approved ECDIS equipment was not used in most cases during the survey. In particular, this means that the performance and display resolution of the screen displays that were used would most likely be inferior to ECDIS. However, it seems unlikely that this would have a major effect on the general preferences expressed by the survey respondents. Obviously, a more rigorous survey using type-approved equipment is required to confirm this.

### Training Improvements

Based on the responses to this study and from observation, it appears that a majority of students instinctively dislike the black background associated with the night display modes. The responses indicate a preference for traditional paper charts colours. Using a chart that shows black areas that would normally be shown as white on a paper chart was described variously as a *'view uncharacteristic of conventional paper charts'* which is *'alien'*, *'disorienting'*, *'cluttered'* and not what operators were *'used to'* requiring *'more time to get used to the dark display'* mode. This contrasts with the day display mode which was generally said to be *'easier to interpret'* due to *'personal preference'*, *'habit and orientation'* and being what operators were *'used to seeing on traditional charts'*.

To overcome this pre-disposition for preferring the paper chart colours, it may be necessary to provide students with a longer period using the black-background colour schemes, allowing them time to become accustomed to a novel display mode. Consideration might be given to insisting that trainees work with a black background display mode during training. Further studies and observations from students on AMC's longer courses may help confirm this.

### Equipment Modifications

Initial recommendations for ECDIS were to limit operator adjustment of contrast and brilliance. This did not eventuate, nor has the 'black adjust' function been taken up by manufacturers. Perhaps this needs to be re-assessed and at the same time extended to include an arrangement for the light background display, similar in concept to the 'black adjust' function. Comparable arrangements would need to be developed for flat panel displays, noting that the black level cannot be adjusted in the same way as in CRT displays.

Perhaps some reconsideration of the amount of brilliance and contrast control that is made available to ECDIS/ECS users is warranted. If ECS/ECDIS equipment is limited in the amount by which the display could be dimmed, then this might also persuade mariners to use more appropriate display modes. However, this may not be feasible due to the advanced state of development of ECDIS and other constraints associated with the display hardware.

## Recommendations

1. In view of the survey findings AMC will continue to survey and report on ECDIS students' preferences for night display options
2. In addition maritime educational institutions should consider:
  - Maximising opportunities for student familiarisation with black background displays
  - Providing greater emphasis on the shortcomings of using a day display mode at night
3. ECDIS/ECS manufacturers should be encouraged to promote the use of the appropriate night display modes
4. IHO should:
  - Encourage the implementation of the 'black adjust' symbol
  - Ensure suitable display adjustment arrangements are defined for flat panel displays
  - Consider introducing adjustment arrangements for the light background display modes

**References**

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- IHO<sup>2</sup> IHO Special Publication 52 (S-52), (1999). Deferred amendment CS04.0.d02.co.033 to IHO Special Publication 52 (S-52), Appendix 2 - Specifications for chart content and display aspects of ECDIS – ‘Night display problems: Contrast and Brightness controls.’
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**Biographies**

Anthony Boyle commenced working at the Australian Maritime College in 1989 after 10 years as a deck officer with the Australian National Line (ANL). He is currently a senior lecturer in Maritime Operations at the Faculty of Maritime Transport and Engineering with particular emphasis on coastal navigation, celestial and offshore navigation, bridge watchkeeping and electronic navigation.

Ian Rodrigues began his sea-going career in 1980. He has held a Master Class I (unrestricted) qualification since 1990 and has sailed as Master in a number of commercial vessels. Ian has been a lecturer at the Australian Maritime College since 1996, specialising in electronic navigation systems, ECDIS, ship control, ship handling, and passage planning. He is a simulations instructor trainer and assistant to the Manager, Simulations.

Robert Ward is a hydrographic surveyor. In his 32 year naval career, over 20 of which have been spent in ships, he has conducted hydrographic and oceanographic surveys across the world. His last sea posting was in command of the Royal Australian Navy surveying ship HMAS Moresby. Ashore, he has served at the RN Hydrographic School as an instructor and at the Australian Navy Hydrographic School as Officer in Charge. Robert is currently Head of External Relations at the Australian Hydrographic Office. Amongst other things, he is responsible for Australia's national and international hydrographic policy and relations, with particular emphasis on electronic chart navigation and digital hydrographic data.

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