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Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **x** ENG **□** PAP **x** Input

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Agenda item [[2]](#footnote-2) IALA Report ENG 13, Action item 29

Technical Domain / Task Number 2 WG1

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IALA Documents on Leading Lines

# Summary

Leading lines belong to the most important visual Aids to Navigation. They are designed primarily for navigation through small channels, where the competent authority does not rely on electronic equipment only.

IALA has provided three documents on leading lines.

* Recommendation R0112 (E-112) On Leading Lights
* Guideline 1023 The Design of Leading Lines
* Leading Line Design Programme (MS Excel spreadsheet)

The input paper shows the necessity on updating and rearranging these documents and makes proposals for this.

Three new documents are presented as drafts.

* Revised Guideline on The Design of Leading Lines
* Revised Leading Line Design Programme (Spreadsheet)
* Tutorial for the revised Leading Line Design Programme (separated from the Guideline)

## Purpose of the document

The committee is asked to work on the three input papers (guideline, spreadsheet and tutorial). It is proposed to concentrate any work on the transformation of the existing documents into the three new ones as a first step.

The committee is asked to finish this work in 2022.

The committee is asked to put an extensive revision into the working plan for next working period.

## Related documents

* Recommendation R0112 (E-112) On Leading Lights
* Guideline 1023 The Design of Leading Lines
* Leading Line Design Programme (Spreadsheet)

# Background

The IALA recommendation R0112 on leading lights was first published in 1998 and is still unchanged although it was reformatted twice due to new IALA templates.

From 1996 to 2001 the US Coast Guard developed an MS Excel spreadsheet for the design of leading lines. The manual for the spreadsheet became the IALA Guideline 1023 on leading lines, which is still in force. It was reformatted in 2005 and 2021. The spreadsheet and the guideline can now be found at the IALA website under "Technical AtoN software".

# Discussion

Although the content of the existing papers and the spreadsheet are still useful and very important tools for the design of leading lines, there are some severe problems, which reduce the benefit of the document.

* The definitions and dimensions of recommendation, guideline and spreadsheet are not consistent.
* The guideline does not reflect the requirements of the recommendation completely.
* There are only very few explanations, which may lead people to fill out the spreadsheet without understanding the methodology and therefore it becomes likely that wrong results will be achieved.
* For ranges above 5 M (nautical miles) the resulting values for luminous intensity and daymark size become too large to handle.
* The calculations include specific regulations of the U.S. Coast Guard, which are not used in other countries (for example daymark shape and size).
* There are errors in all the three documents.

# Recommendation R0112

The existing recommendation gives very detailed regulations via extensive equations. The key statement is the required sensitivity in chapter 6. c), which is stated as obligatory.

In contrast to this, the guideline uses a weaker sensitivity , which is then used for assessment with the additional Cross-Track Factor.

In summary, the key requirement of the recommendation is weakened twice. This is a strong conflict between the superior recommendation and the inferior guideline.

As the existing Excel tool directly uses the guideline, it can be assumed that the sensitivity was the preferred measure for the leading line design for 20 years.

There are additional problems with the recommendation as it uses different abbreviations and switches between mean high and low water for height datum.

According to the current IALA document hierarchy the existing R0112 does not fit into the schemes of recommendations. As a consequence the existing recommendation should be withdrawn.

Of course the content should be kept in a guideline.

# Guideline 1023

The guideline is a manual for the proprietary Excel spreadsheet. It includes only very few information on the design principles, the geometry and the photometry.

To preserve the knowledge and the information, which are kept in the Excel spreadsheet, it is necessary to extract the hidden equations in the spreadsheet and make them visible as mathematical equations. This will enable the competent IALA committee to develop future versions of the design procedure.

There is a need to include alternatives for intensity and daymark size calculation, which are in use in other countries.

# Spreadsheet

The spreadsheet needs some editorial changes. It should reflect the design methodology of the guideline. However, it needs a small tutorial as well.

# Proposals

In future, the most important IALA document on leading lines should be the guideline. This contains all relevant information about the design of leading lines. It should not be a manual/tutorial for the spreadsheet. In the first step, it is only necessary to move all the content of the recommendation, the spreadsheet and the old guideline into a new guideline.

The spreadsheet should have a slight update and it needs a separate manual for the IALA AtoN Software site.



1. Document Structure

# Conversion of the existing IALA Documents

The proposed new documents reflect the existing ones completely. The content of the old recommendation and guideline is moved to the new guideline and is rearranged. Some part of the old guideline moved into the new and short tutorial for the Excel spreadsheet. Many explanations and some alternative calculations were added to the new guideline.

The spreadsheet was redesigned and the alternative calculations from chapter 9 introduced.



1. Moving Content

# MAJOR Changes

The content of all three document was checked and the suitable content is collected in a draft guideline. The draft guideline tries to explain each equation and the design principles without explicitly mentioning the spreadsheet.

## Height Reference

The height datum is not specified in the IALA guideline, although there are specifications done by IHO in the chart specifications.

There are some problems with the height of the lights. According to IHO chart specification and IHO standardization of list of lights, the heights are referenced to mean high water (MHW) or mean sea level (MSL, when mean tidal range MTR <= 0.3 m). This is stated explicitly in the old guideline (3.3.17 and 3.1.18). However, the equations shown in the guideline (6.6) and the recommendation (11.3) are only valid, when the heights are referenced to mean low water (MLW). As the spreadsheet is actually working with a reference to mean high water (see sheet 'Leading Line' cells C62, C63, C65, C66), the new draft guideline use high water throughout. In consequence, the equations and the figures are changed.

## Simplified Calculation

In the current spreadsheet the height of lights and daymarks are transformed from metres to feet and vice versa. The draft guideline removes this transformations, so all calculation are in SI units.

In the current spreadsheet Allard's law is used with visibility and transmissivity and switches between both cases. To give a more consistent presentation, all calculations are now based on meteorological visibility. However, the transmissivity is still shown.

Some illuminance values in the current spreadsheet are presented in to avoid an exponent, and therefore the factor 1 000 000 appears in some cells. This worsens the readability of the spreadsheet. The draft now uses throughout in scientific format with mantissa and exponent.

## Numbers

The value for nautical mile was found to be 1852 m and 1837 m (very old value) in the spreadsheet and is now corrected to 1852 m.

## Intensity Calculation

In the old guideline and spreadsheet, the recommended luminous intensity is ten times the minimum value. This may be practical for ranges up to 5 M, but for larger ranges the recommended intensities become too large. In these cases the designer may incorrectly find, that a leading line is not the right tool to mark a channel and gives up the idea of using it.

To solve this problem in the draft guideline, two more practical alternatives are included for determining the recommended luminous intensity.

## Daymark Size

The daymark size in the current guideline depends on the meteorological visibility. This may cause very large daymark heights, which cannot be realised. IALA Guideline 1094 on Daymarks has alternative methods, which are included in the revised guideline on leading lines and the spreadsheet.

## Geographical Range Factor

The geographical range factor is typically between 2.03 and 2.12. The old spreadsheet uses 2.08. When the Navguide 2018 was developed, IALA decided to use 2.03 as the preferred value. This value is now introduced in the draft guideline and the revised spreadsheet.

The calculated ranges are a little bit smaller or, when a required height is calculated with a fixed range, the height is increased by a small amount.

The value 2.03 is not fixed but can be changed in a single spreadsheet cell.

# Chapter Description (Guideline)

Chapter 1 and 2 are new content.

Chapter 3 'Background' is from E-112, Annex 1 and is unchanged.

Chapter 4 'History' is new.

Chapter 5 is written newly, but all the numbers are drawn from the existing IALA excel chart and were given new names according to mathematical standards.

Chapter 6 is written newly, but all the equations are drawn from the existing IALA excel chart and were written according to mathematical standards.

In Chapter 6.2.2. two alternative calculations for the recommended intensity are added.

In Chapter 6.10.2 two alternative calculations for the daymark length, which are consistent with IALA 1094, are added.

Chapter 7 is written newly, but describes the procedure and assessment from the existing IALA excel chart.

Chapter 7.5.1. is from old guideline chapter 2.5. with a revised intro in 7.5.1.1

Chapter 7.5.2 to 7.5.4 is from old guideline 4.4 to 4.6.

Chapter 8.1.1. is from old guideline 3.7 but changed.

Chapter 8.1.2. is from old guideline 2.6.

Chapter 8.1.3. is from old guideline 5.4.

Chapter 8.2. is from old guideline 2.7.

Chapter 8.3. is from old guideline 2.9 but additions are made.

Chapter 8.4. to 8.9. is from old guideline 5.2., 5.3 and 5.5. to 5.8.

Chapter 8.10. is from recommendation chapter 5.

Abbreviations (10) and Appendix 1 are new.

# Action requested of the Committee

See 1.1.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)