

## IALA GUIDELINE

# G1123 THE USE OF IALA WATERWAY RISK ASSESSMENT PROGRAM (IWRAP)

**Edition 2.0**

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# DOCUMENT REVISION

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Revisions to this document are to be noted in the table prior to the issue of a revised document.

Date	Details	Approval
16 June 2017	First issue Revision of Recommendation O-134 to only contain recommendatory content and move guidance content to a new Guideline.	Council 64
June 2022	Edition 2.0 Revision of document to simplify Guideline and remove manual aspects of the original Guideline.	Council 75

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## 1. INTRODUCTION

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The IALA Waterway Risk Assessment Program (IWRAP) is a desktop risk assessment program which is aimed at the calculation of probabilities of ship collisions, allisions and groundings. The program is a part of the overall IALA Risk Management Toolbox as referenced in IALA Guideline *G1018 Risk Management*. IWRAP is a quantitative tool intended to work in conjunction with other tools in the Toolbox. The tool involves developing a model of the waterways to be analysed, including the geometry of the relevant routes, the traffic volume and composition, as well as the bathymetry of the waterways in question.

Once the model has been defined, IWRAP calculates the expected average annual number of collisions and groundings likely to occur. This calculation is based on the above-mentioned model and a set of so-called Causation Factors which can be thought of as the probability that the vessel fails to make an evasive action to avoid the grounding or collision.

IWRAP only addresses the probability of collisions and groundings, it does not consider the consequences associated with these incidents. It is left to the analyst and the authority performing the analysis to assess the possible consequences of the incidents. The output of IWRAP tool is well suited for performing such an analysis.

### 1.1. OBJECTIVE OF THE IWRAP TOOL

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The purpose of IWRAP is to provide authorities with a standardized quantitative method to calculate the probability of collisions, allisions and groundings in a given waterway. IWRAP allows different scenarios to be developed, so that changes in traffic volume or composition, changes in route geometry, changes in the mix of Marine Aids to Navigation or the introduction of other mitigating options, may be evaluated in terms of changes in the expected average annual number (probability) of collisions and groundings.

### 1.2. BACKGROUND

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IWRAP has evolved from a probabilistic methodology for estimating the probabilities of groundings and collisions, developed at the Technical University of Denmark, inspired by the work of Fujii and MacDuff in the 1970's and the "Minimum Safe Design" (MSD) tool originally developed in Canada and used by the Canadian Coast Guard.

When the first version of IWRAP was initially tested, the results obtained seemed credible and in accordance with the accident statistics in the considered area and experts were satisfied with the results. However, at a later stage, when the tool was applied to other areas it yielded an unrealistic high number of collisions and groundings.

In 2007 the IALA Risk Management Steering Group decided to initiate the development of the second generation of IWRAP. Thanks to the dedicated efforts of a team of IALA members, research institutes and universities, led by the Danish Maritime Safety Administration (DAMSA), a new tool, named IWRAP Mk II, was developed from scratch and validated.

The first training seminar dedicated to IWRAP was held in Kuala Lumpur, Malaysia in April 2009, using the Malacca Strait as a test case for training purposes. The program is now a part of the World-Wide Academy curriculum and training is conducted on multiple locations all over the world.

The basic IWRAP software (limited functionality) is available free of charge to IALA members. A commercial version is also available which automates the inputting of information on volume and composition of the vessel traffic in a given area, based on AIS data. Information about how to purchase the commercial version can be obtained from IALA.

## 2. IWRAP MK II RISK ASSESSEMENT METHODOLOGY OVERVIEW

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IWRAP is implemented as a standard software application that forms the framework for the process of defining a model of the waterway being analysed. The IWRAP Risk Assessment process involves the following steps:

- Input
  - AIS data. For successful use of the IWRAP quantitative tool it is essential to have good quality AIS data available of a suitable duration for the area under consideration
  - Density of vessels without AIS e.g., fishing and pleasure vessels
  - Charts/Bathymetry. This data could include planned developments together with existing features
- Operation
  - Defining IWRAP “model” area.
  - Defining Bathymetry, Routes, Waypoints and Legs.
  - Entering Traffic Volume Distributions on each Leg.
  - Defining Traffic Lateral Distribution.
  - Defining Grounding due to Drifting parameters.
  - Defining other traffic in the area.
  - Selecting Causation Factors.
- Output
  - Density Analysis
  - Track analysis
  - Emissions
  - Replay of AIS tracks.
  - Model outputs - result calculation and assessment.

Usually, the analyst would assess the results in terms of expected annual number of collisions and groundings by setting up a baseline waterway scenario and comparing other scenarios to the baseline. If a cost-benefit analysis of different mitigating options is required, the analyst would use the output of IWRAP to further assess the consequences of the resulting collisions and groundings.

Detailed information about the steps involved in the IWRAP Risk Assessment process can be found in the manual included in the IWRAP software and in the IALA IWRAP Wiki.

### 2.1. DEFINE MODEL “AREA”

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The first step in creating a model is to zoom in on the area you want to model and use the **Model Area** tool to draw a polygon defining your area of interest. This polygon is used to filter your AIS data when you either import or download AIS data, i.e., only AIS inside the area will be used.

## 2.2. DEFINING BATHYMETRY, ROUTES, WAYPOINTS AND LEGS

The next step of developing an IWRAP waterway model is to obtain as much information as possible on the geometry of the waterway, its bathymetry and its route layout. The bathymetry information can be obtained from nautical charts.

Information about the routes can best be obtained from AIS data, statistically processed to generate a Density Plot and Heat Map. If such a plot is not available, route layout information may be obtained from other sources.

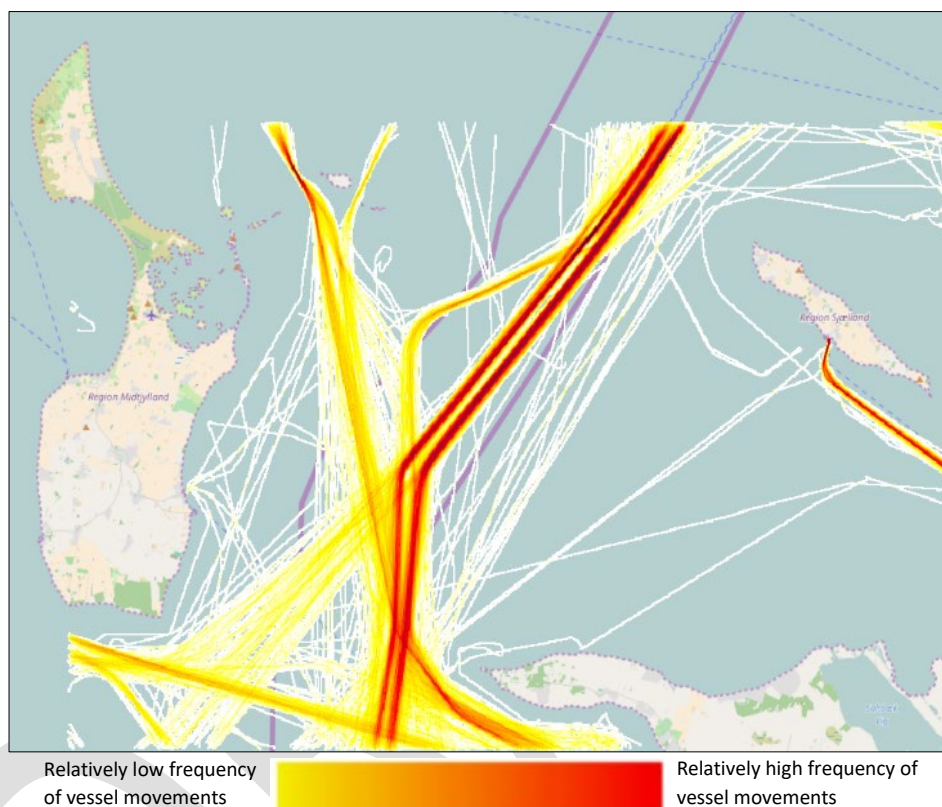


Figure 1 Waterway Density Plot Diagram showing vessel tracks derived from AIS data

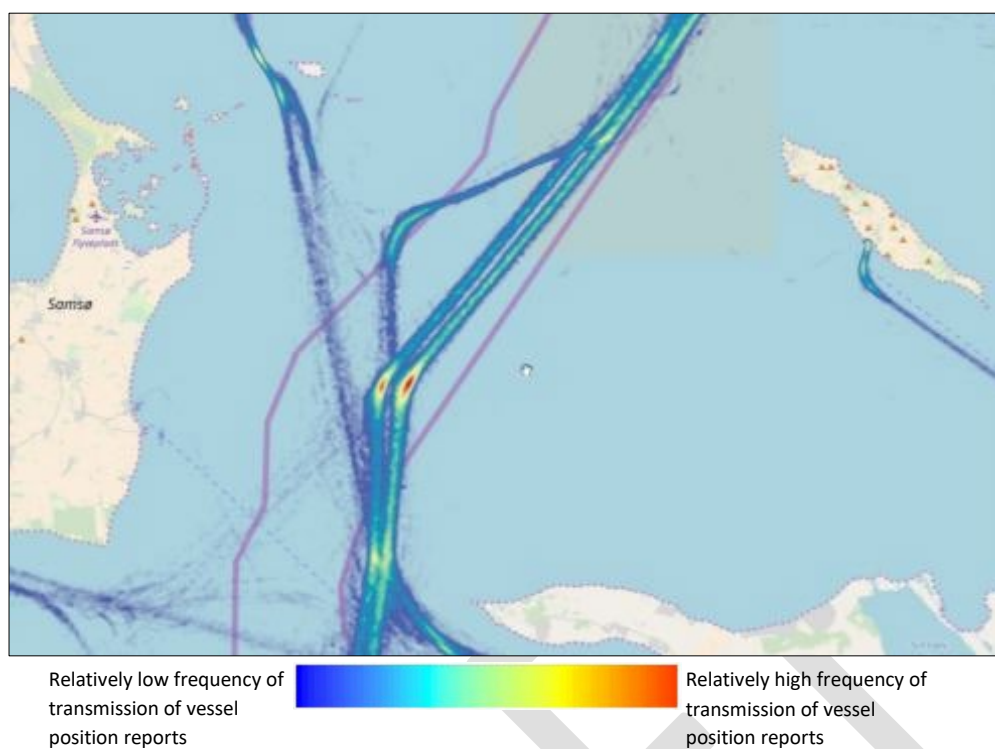


Figure 2 Waterway Heat Map Diagram derived from AIS data showing the density of vessel positions reports

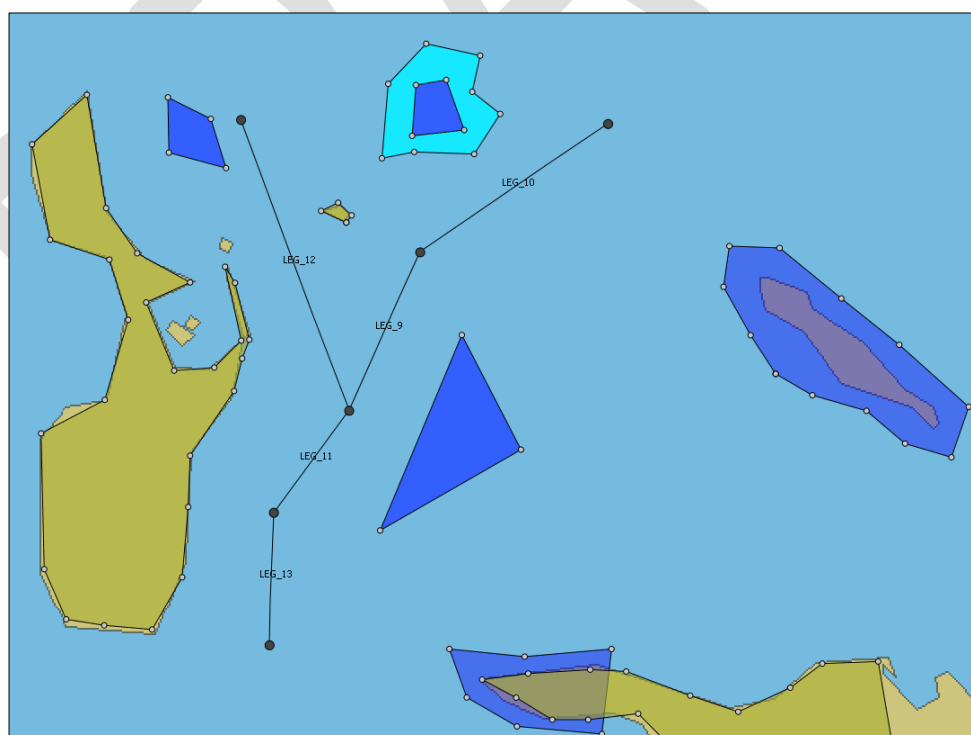


Figure 3 IWRAP Waterway model showing bathymetry and legs.

## 2.3. ENTERING TRAFFIC VOLUME DISTRIBUTIONS ON EACH LEG

Once the route layout has been defined, the analyst needs to enter information about the traffic volume and the traffic composition in each direction on each route leg, using the **Traffic Editor**.

**Traffic Distribution Editor : North**

Data Item: **Frequency** Traffic Distribution: **d8-1**

	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship
0-25	0	0	0	0	0	1
25-50	0	25	1	0	0	34
50-75	0	49	55	4	3	787
75-100	0	233	23	23	106	685
100-125	0	196	6	0	238	403
125-150	51	480	17	22	245	232
150-175	60	914	38			176
175-200	25	182	0			24
200-225	35	87	1			1
225-250	736	60	0			0
250-275	71	0	0			0

**Chemical tanker (100-125)**  
 Frequency: 6 passages pr year  
 Average Speed: 13.63 knots  
 Mean Time Between Checks: 180 sec  
 Resulting Causation Factors:  
 -Headon: 0.5000 E-4  
 -Overtaking: 1.1000 E-4  
 -Grounding: 1.6000 E-4

Show Graph... OK Cancel

Figure 4 Traffic Volume Editor used for entering information about vessel traffic volume and composition

IWRAP uses several different types of vessel categories each of which is divided into several length categories. The information about the number of vessels in each category can be obtained automatically from AIS data, however, volumes can be adjusted manually if required.

The traffic table data is also useful record of traffic on respective legs and enabling a cross check of accuracy of data on individual legs.



## 2.4. DEFINING TRAFFIC LATERAL DISTRIBUTION

Having defined the bathymetry, the route layout, waypoints and route legs, as well as the volume and composition/types of the vessels on each leg, the analyst needs to define how the vessels are distributed laterally on each leg in each direction. This is done using the IWRAP Mk II **Leg editor**.

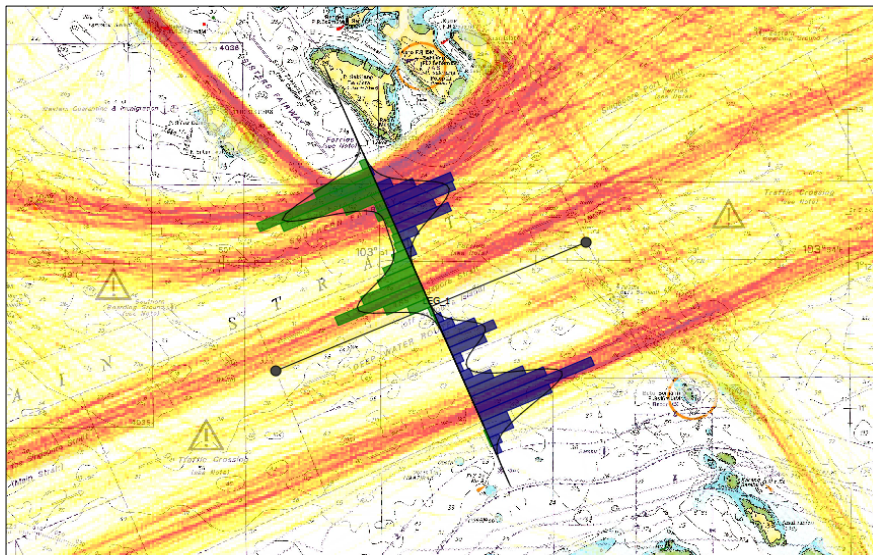


Figure 5 Lateral distribution of vessels on route legs

Figure 6 Route Leg editor used for entering information about lateral distribution of vessels on a route leg

Information about the lateral distribution of vessels can be obtained from AIS data. This is accomplished by defining a passage line perpendicular to the route leg and the program counting all vessels crossing the passage line while noting their lateral position on the passage line. The resulting lateral distribution can then be entered manually into IWRAP using one or more of the predefined standard distributions supported by IWRAP.

## 2.5. DEFINING GROUNDING DUE TO DRIFTING PARAMETERS

IWRAP is capable of modelling ships that run aground while drifting due to a power outage/blackout. The Blackout Frequency can be defined, and the time taken to recover from the blackout (Repair Time) can be expressed in probabilistic terms (Figure 7). Also, the probability of drifting direction can be defined (Figure 8).

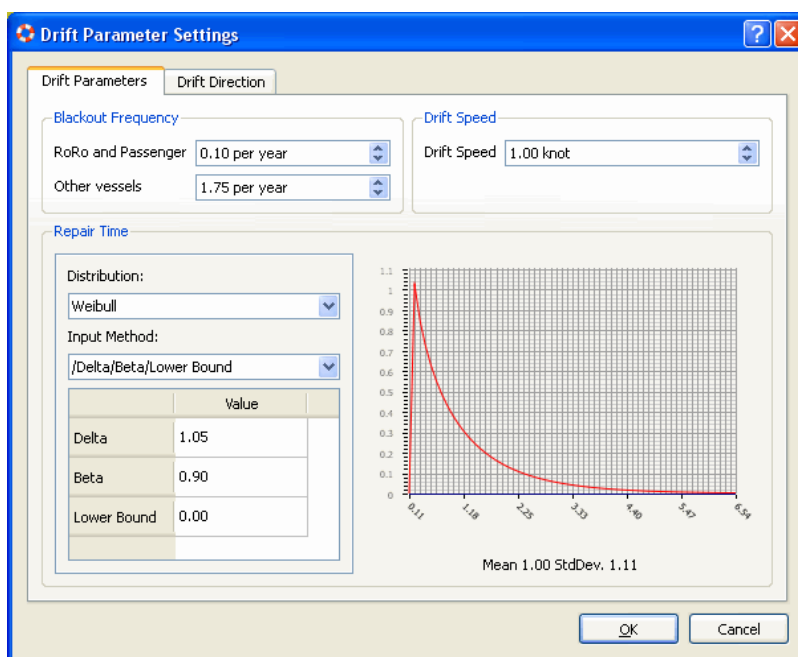


Figure 7 Example of a defined blackout frequency and the time it takes to recover from a blackout

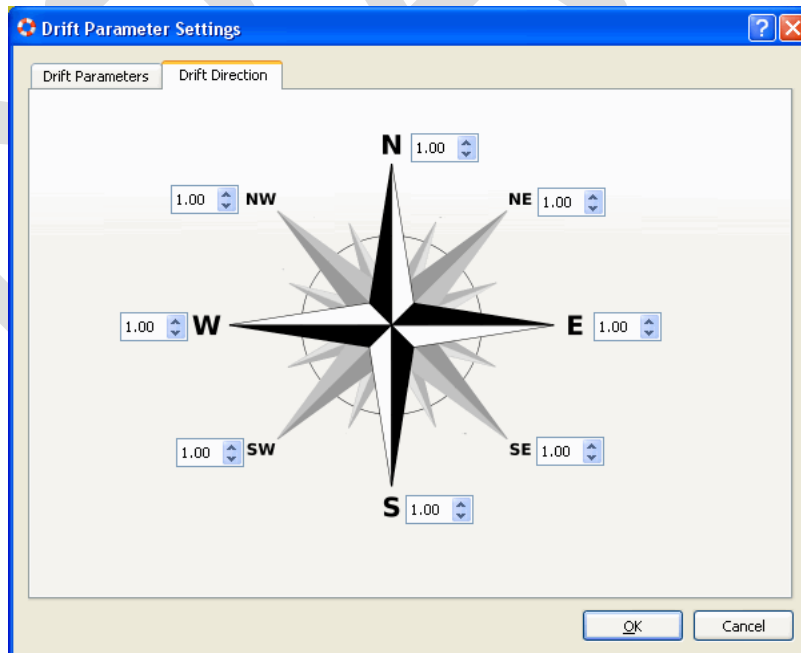


Figure 8 Example of the compass rose used to define probability of drifting direction

## 2.6. DEFINING OTHER TRAFFIC IN THE AREA

Most of the information about traffic volume and composition entered in IWRAP is usually obtained from AIS data. However, there may be several non-AIS vessels, such as fishing vessels and pleasure boats in the area of interest. There is a certain probability of collision with such objects. This can be modelled with IWRAP by assuming a certain density of fishing vessels and pleasure boats per unit area averaged over a year.

## 2.7. SELECTING CAUSATION FACTORS

A very important part of every IWRAP model, are the so-called Causation Factors used within the model. The Causation Factors can be thought of as the probability that the vessel fails to make an evasive action to avoid the grounding or collision. Several default factors have been selected as the IALA default Causation Factors and are presented in Table 1:

*Table 1 IALA Default Causation Factors*

Condition	Causation Factor
Head on collisions	$0.5 \times 10^{-4}$
Overtaking collisions	$1.1 \times 10^{-4}$
Crossing collisions	$1.3 \times 10^{-4}$
Collisions in a bend situation	$1.3 \times 10^{-4}$
Collisions in a merging situation	$1.3 \times 10^{-4}$
Grounding – forgot to turn	$1.6 \times 10^{-4}$

These factors have been carefully selected based on a careful literature study and are believed to be suitable as default factors and applicable in most parts of the world.

However, IWRAP allows the analyst to modify these factors should that be desirable. If the default IALA Causation Factors are modified in a waterway model, the analyst should state this fact and the motivation to do so, in the model report.

The analyst must be aware that confidence in the final results of the model will be related to the confidence in the causation factors used. Change from the default figures is not recommended without careful consideration.

## 2.8. RESULT CALCULATION AND ASSESSMENT

Once the waterway model has been defined, IWRAP can calculate the resulting annual average collisions, allisions and groundings. The results can be displayed in tabular form as shown in Figure 9, or graphically, using colour coding as shown in Figure 10.

Subsequent to the initial calculation of results a comparison between different model results can be portrayed showing the changes in incidents per year.

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File Edit Tools Settings Actions View Windows Help

Jobs					
State	Name	Algorithm	Model	Started	Completed
Completed	An example	Incident v1.0	An_example v1.9	fr 7. nov 11:30:1...	fr 7. nov 11:30:10 2008
Completed	GreatBelt DMA	Incident v1.0	great belt v1.0	on 5. nov 12:19:...	on 5. nov 12:21:16 2008
Completed	Great Belt DMA	Incident v1.0	great belt v1.0	on 5. nov 10:12:...	on 5. nov 10:13:11 2008
Completed	GreatBelt DMA	Incident v1.0	great belt v1.0	on 5. nov 09:12:...	on 5. nov 09:12:54 2008
Completed	GreatBelt	Incident v1.0	great belt v1.0	on 5. nov 09:00:...	on 5. nov 09:01:02 2008

Results		
	An example	Unit
Grounding	0.00212622	Incidents/Year
Drifting Grounding	0.0154795	Incidents/Year
Total Groundings	0.0176057	Incidents/Year
Overtaking	0.000159685	Incidents/Year
HeadOn	0.000512395	Incidents/Year
Crossing	0	Incidents/Year
Merging	9.22789e-05	Incidents/Year
Bend	0.00278524	Incidents/Year
Area	6.19165e-08	Incidents/Year
Total Collisions	0.00354967	Incidents/Year

Figure 9 Tabular result view

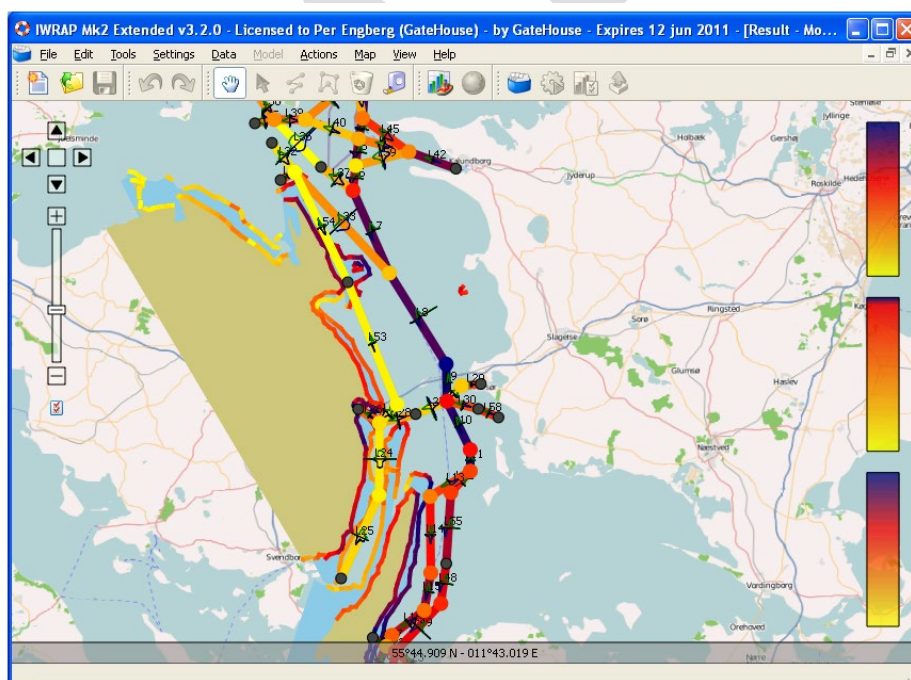


Figure 10 Geographical result view using Colour Coding,

From the tabular result display (Figure 9) the analyst can assess what types of collisions and groundings are most likely to occur. From the geographical result display (Figure 10), the analyst can assess where the collisions and groundings are most likely to occur.

Once a baseline result has been calculated, the analyst can adjust the waterway model to account for any desired changes within the waterway. Several scenarios can then be compared to perform sensitivity analysis and evaluate different risk mitigating options.

IWRAP only addresses the *probability* of collisions and groundings it does not consider the consequences associated with these incidents. It is left to the analyst performing the analysis to assess the possible consequences of the incidents, however, the output of IWRAP tool is well suited for such analysis to be performed subsequently.

In addition, the commercial version provides features like replay, passage line analysis, animation, movies, heatmaps etc.

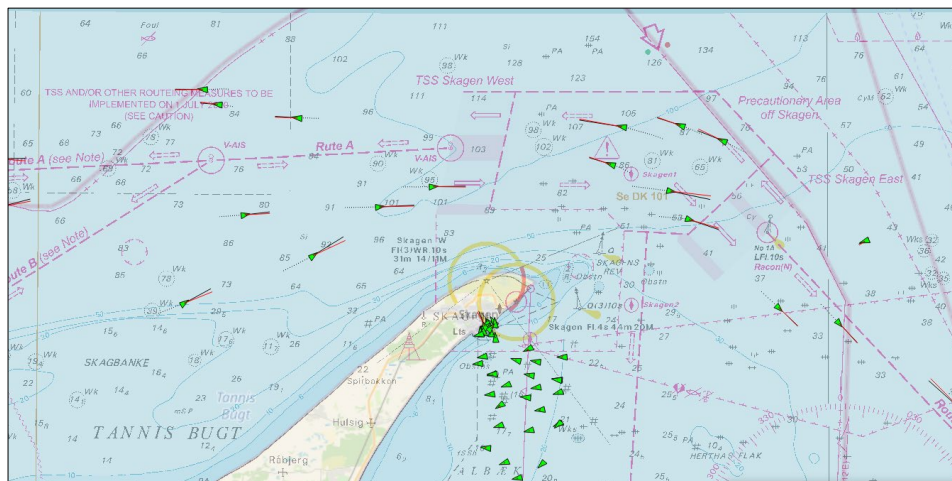


Figure 11 Example of the Replay feature in IWRAP

## 2.9. STRENGTHS AND LIMITATIONS

IWRAP is a quantitative tool intended to work in conjunction with other tools in the IALA Risk Management Toolbox. Each tool has its strengths and limitations, and for IWRAP some of them are listed below:

Some strengths of IWRAP include:

- Stable and proven basic software.
- Well-documented way to compare risks in different scenarios.
- Geographical presentation of areas with higher risk.
- Integrated tools to model traffic from AIS data.
- Training sessions are organized regularly.

Some limitations of IWRAP include:

- Only calculates the frequencies of collision and grounding accidents, not the consequences.
- Commercial software is needed for ease of use in case automatic import of AIS data is desired for calculating the traffic information.
- Adequate resources like regular exercising and learning of the software must be available to use the tool and also, because of manual creation of route legs, it can be very labour-intensive.
- Analysis based on AIS data always refers to the existing situation; for alternative scenarios data has to be modified based on expertise.
- Risk control options that would affect causation factors cannot be demonstrated (unless the causation factors are altered manually, assuming their effectiveness).

### 3. IMPLEMENTATION (THE NEED FOR TRAINING)

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IWRAP is an advanced, very flexible tool useful for creating models of waterways and to analyse the level of risk expressed as the probability of collisions, allisions and groundings in a given waterway. The quality of the analysis is entirely in the hands of the analyst, who must make a number of choices, such as selecting the route layout, estimate traffic density and distribution, and consider Causation Factors. Therefore, it is essential that the analysts using IWRAP are adequately trained and fully capable of understanding the implications of their choices.

### 4. DEFINITIONS

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The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA Dictionary), and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

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