SAFETY OF NAVIGATION CONFERENCE

Cape Town, South Africa, 29 August 2016

Session 2-4: IALA Risk Management Tools

28/08/2016

Coastal State Obligations

SOLAS V/12-13

to Provide Aids to Navigation

in accordance with

Traffic Volume

and Degree of Risk

How to measure Traffic Volume? How to Quantify Risk?

What are the major risk contributions?

Where in our waterway are these risks located?

What can we do to mitigate the risk?

How much does waterway geometry matter?

What Aids to Navigation are most effective?

Do Visual Aids really make any difference?

What if traffic volume doubles?

What if we get a 20% increase in tankers?

What is Risk?

Any activity that might lead to an unwanted outcome involves "risk"….examples?

Driving to work
Smoking
Navigation at sea

Risks are unwanted events in the future that can be avoided or reduced or *mitigated* (lessen the severity)

driving within speed limits
not smoking
VTS and/or improved aids to navigation

Definition of Risk

"Risk" is the chance of injury or loss defined as a measure of "probability or likelihood" and "severity or impact" on health, property or the environment

RISK?


PLAY AT
YOUR
OWN
RISK


DO NOT FEED
PIGEONS AND GULLS
It is an offence to deliberately
place food on the ground to
feed Pigeons and Gulls
LET NATURE TAKE CARE OF ITSELF
Maximum Fine
£2500

Basic Risk Equation

$$R = P \cdot C$$

R = Risk

P = Probability that undesired incident occurs

C = Consequences of undesired incident

IALA Risk Management Toolbox:

Qualitative Tool - PAWSA

Simulation Tools

Quantitative Tool – IWRAP

(Project) - SQUART

Different approaches to model waterways in terms of incident probability and risk

The IALA Risk Management Tools

PAWSA

"Port and Waterway Safety Assessment tool"

Port and Waterway Safety Assessment (PAWSA) Tool

Developed by US Coast Guard to:

Identify major waterway hazards

- Estimate risk levels and consequences
- Evaluate possible risk reduction (mitigation) measures
- Prepare for implementation of selected measures

Expert opinion of groups of stakeholders (2 day workshop) follow the PAWSA Workshop Guide

Based on 7 Excel™ Workbooks to determine whether existing risks are:

- **Acceptable** until circumstances change
- Not acceptable **but risk control options identified**
- Not acceptable and **more data required**

PAWSA : Objective

The purpose of PAWSA is to provide Authorities and waterway communities with an effective tool to evaluate risk and work toward long term solutions tailored to local circumstances. The assessment should identify solutions that are cost effective and meet the needs of waterway users and stakeholders.

PAWSA: the risk model

Since risk is defined as the product of the *probability* of a casualty by its *consequences*

$$R = P \times C$$

the Waterway Risk Model includes variables dealing with both the causes of waterway casualties and their effects.

PAWSA in brief

Basically, it is a two day meeting (16 hours) of experts representative of all stakeholders/users of a waterway to discuss its safety aspect and the associated risks, and the way to improve.

Exchanges of opinions between experts. Need to be organised: the facilitator.

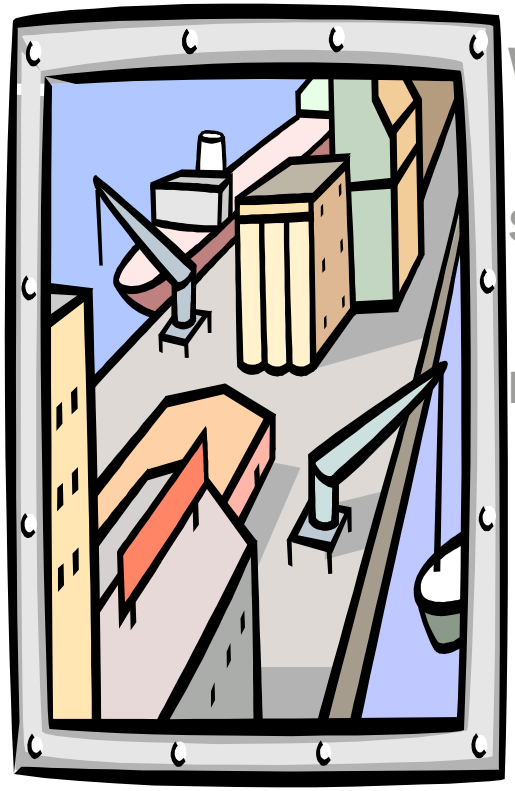
6 categories and 4 factors, i.e. 24 risk factors. Use of matrix and rating assessment from 1 to 9 analyzed with "the Excel™ workbook" (PAWSA software).

.../...

Waterway Risk Model

Vessel Conditions	Traffic Conditions	Navigational Conditions	Waterway Conditions	Immediate Consequences	Subsequent Consequences
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
Commercial Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Material Release	Aquatic Resources
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic

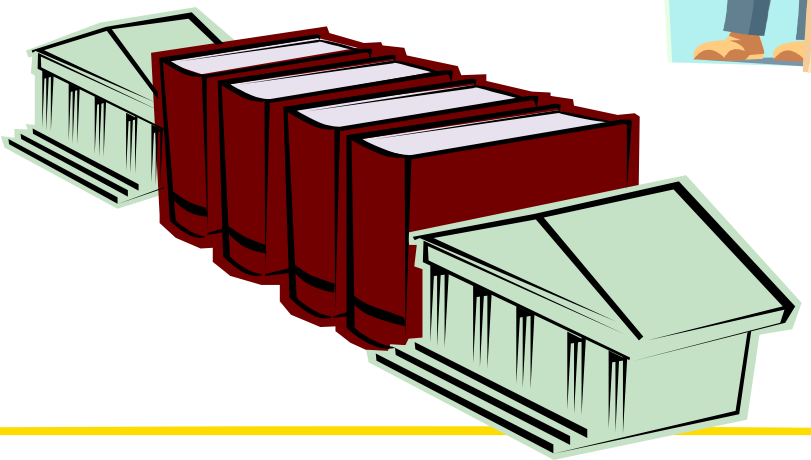
TEAM EXPERTISE



Waterway User

Stakeholder

Regulator



PAWSA in brief

…/…

There are five steps (« books »)

1 – evaluation of the experts

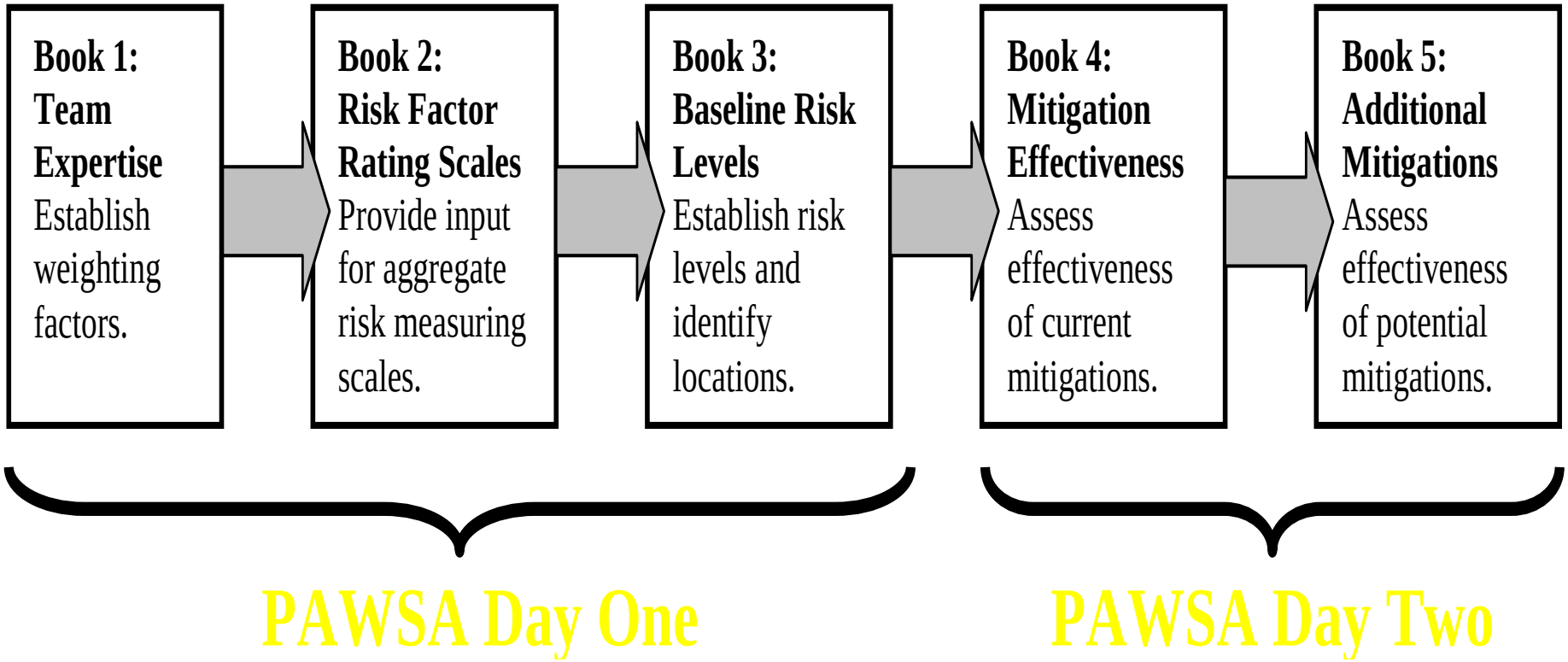
2 – evaluation of the estimation of risks

3 – evaluation of the waterway

4 – evaluation of the waterway with the measures already adopted

5 – proposal and evaluation of new measures.

PAWSA PROCESS



PAWSA in brief

The main difficulties of the exercise are the organization (A CD, available to IALA Members, is extremely well done and useful), the choice and availability of the participants, and the facilitator's role.

It is an oral procedure, which implies using the local language.

How to become a facilitator. The case of Douglas Perkins.

AGENDA

Day One AM

Workshop Overview

PAWSA Background

Risk Model Definitions

Expertise Evaluation

Rating Scales Evaluation

Day One PM

Discuss and Evaluate Waterway Risks

Day Two AM

Discuss and Evaluate Existing Mitigations

Day Two PM

Discuss and Evaluate New Risk Mitigations

Re-evaluate Expertise

Workshop Critique

MITIGATION CATEGORIES

Coordination / Planning Improve long-range and/or contingency planning and better coordinate activities / improve dialogue between port stakeholders

Voluntary Training Establish / use voluntary programs to educate mariners / boaters in topics related to waterway safety (Rules of the Road, ship/boat handling, etc.)

Rules & Procedures Establish / refine rules, regulations, policies, or procedures (nav rules, pilot rules, standard operating procedures, licensing, required training and education, etc.)

Enforcement More actively enforce existing rules / policies (navigation rules, vessel inspection regulations, standards of care, etc.)

Nav / Hydro Info Improve navigation and hydrographic information (ports, charts, coast pilots, AIS, tides & current tables, etc.)

…/…

…/…MITIGATION CATEGORIES

Radio Communications Improve the ability to communicate bridge-to-bridge or ship-to-shore (radio reception coverage, signal strength, reduce interference & congestion, etc.)

Active Traffic Mgmt Establish/improve a Vessel Traffic Service (info, advice & control) or Vessel Traffic Information Service (information & advice only)

Waterway Changes Widen / deepen / straighten the channel and/or improve the aids to navigation (buoys, ranges, lights, DGPS, etc.)

Other Actions Risk mitigation measures needed do NOT fall under any of the above strategy categories

PAWSA : end of the session

Conclusions

Critics by participants

PAWSA workshop report

Actions : ressources - implementation

IALA Risk Management Tool **PAWSA**

The CD is free of charge for IALA Members. They have to give indication for what, where, when they intend to use the model and to undertake to provide the detailed results. However, it is strongly recommended to be trained prior to organize a PAWSA session. A new manual guide will be issue end of 2016.

Simulation

IALA Guideline on Use of simulators

International Association of Marine Aids to Navigation and Lighthouse Authorities

IALA

onale de Signalisation Maritime

IALA Guideline No 1058

On the
Use of Simulation as a Tool for Waterway Design and AtoN Planning

Edition 2

(April 2011)

Table of Contents

Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behaviour of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system

(R.E. Shannon,1975)

Different simulation tools are available for design studies and have different capabilities, functionalities and applications :

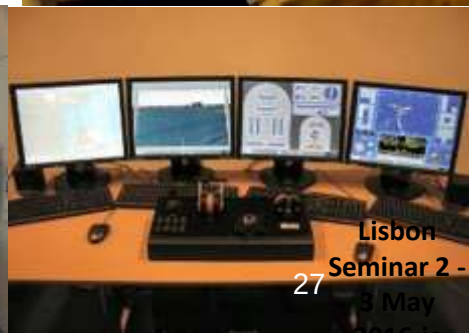
Fast-time simulation

Desktop simulation

Part-task simulation

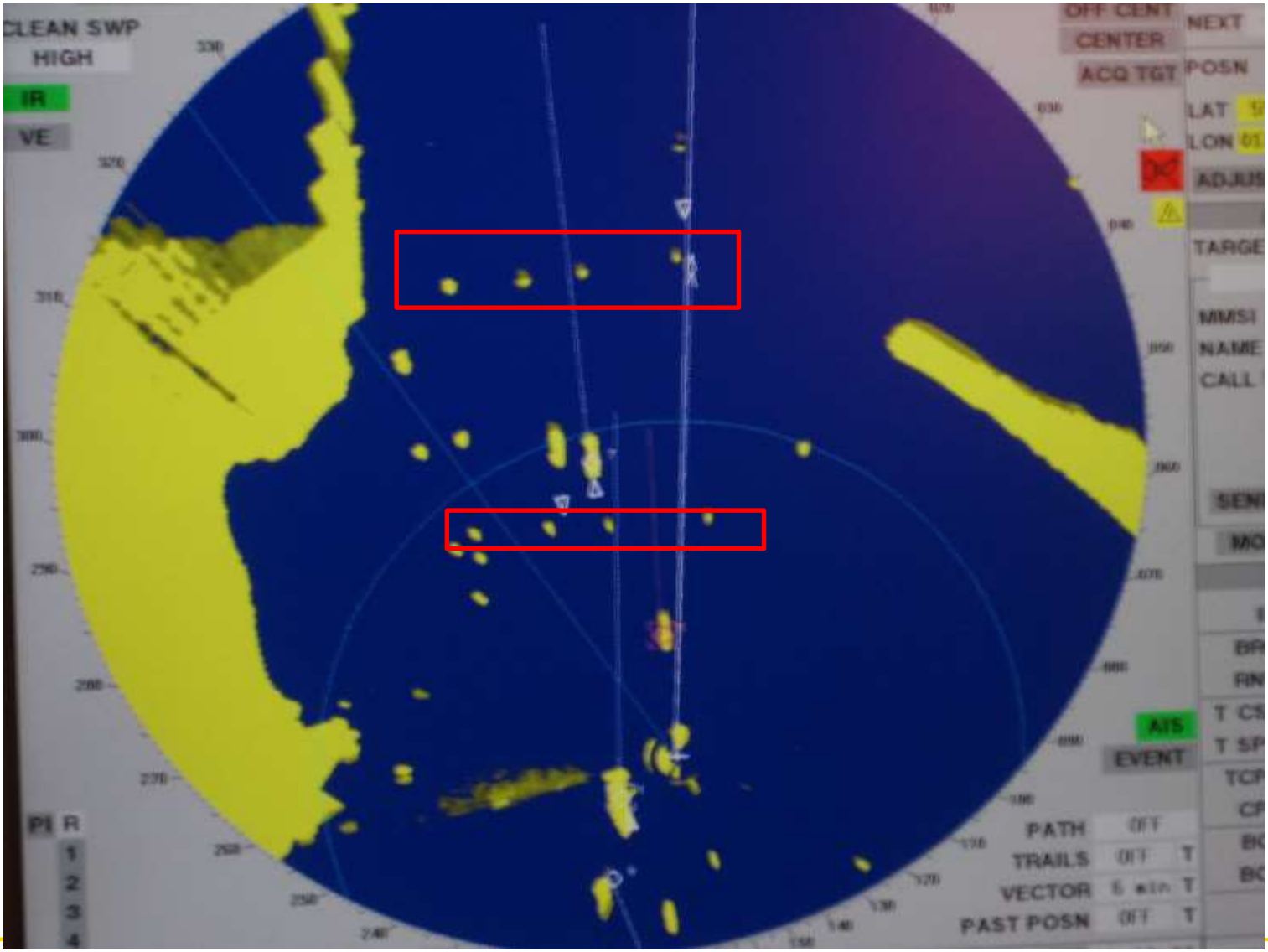
Full-mission simulation

Traffic-flow simulation



Ship Simulators


RL03
102236
L 12236
354
157
82


CLEAN SWP
HIGH
IR
VE
CENTER
ACQ TGT
POSN
NEXT
MMSI
NAME
CALL
AIS
EVENT
PATH
TRAILS
VECTOR
PAST POSN

Use of Ship Simulators for:

1. Waterway design and planning

2. AtoN design and planning

IWRAP Mk2

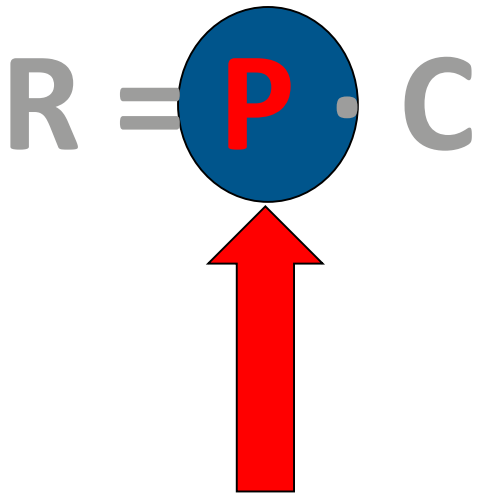
Software tool

Quantitative approach

Probabilistic algorithm

Scenario based

IWRAP ….. Probability ~ Frequency



The aim of the IWRAP project

To provide to IALA members and the maritime world with:

Internationally recognized tool, capable of estimating the annual number of collisions and groundings in a specified navigational area.

Undesired Incidents - IWRAP

Powered Groundings

Drifting Groundings

Overtaking Collisions

Head –On Collisions

Crossing Collisions

Merging Collisions

Bend Collisions

Area Collisions

Basic Methodology

$$X_{Gnd} = N_{Gnd} \cdot P_C$$

N_{Gnd} = Number of Grounding Candidates

P_c = Causation Probability

X_{Gnd} = Number of Annual Groundings

BASIC Methodology
Number of Grounding Candidates

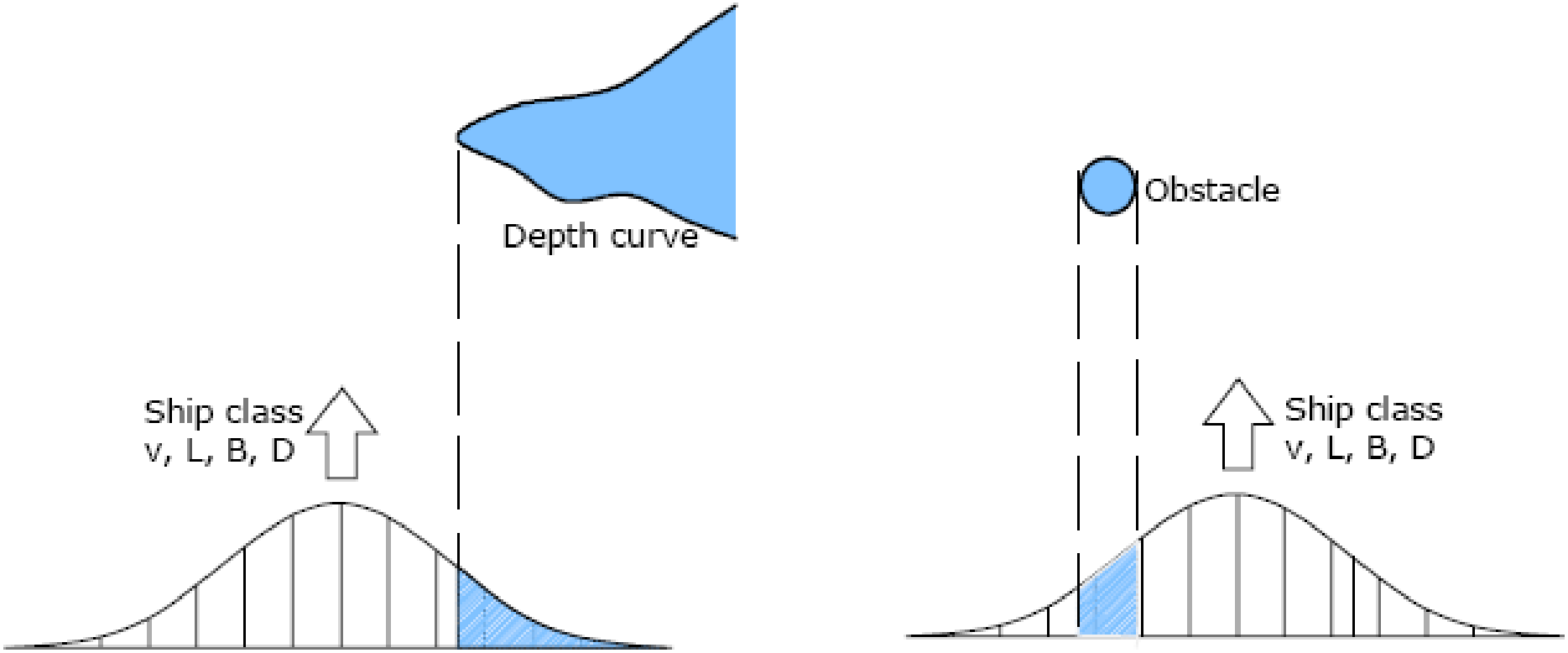
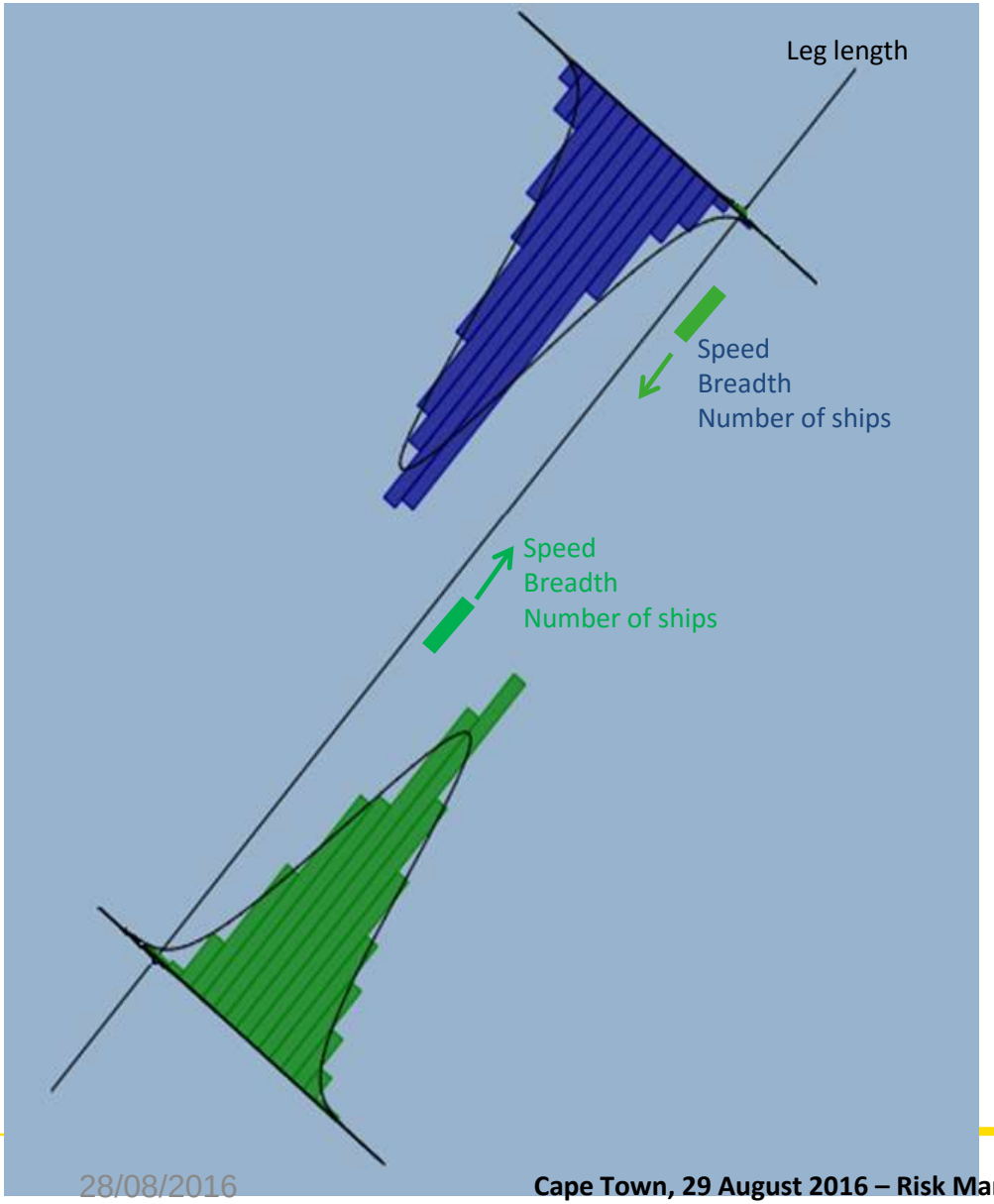


Figure 8-7 Grounding (left)/collision (right) candidates for ships on a straight route (situation I). (Report from COWI Consult AS, 2006)

Head-on and overtaking col.

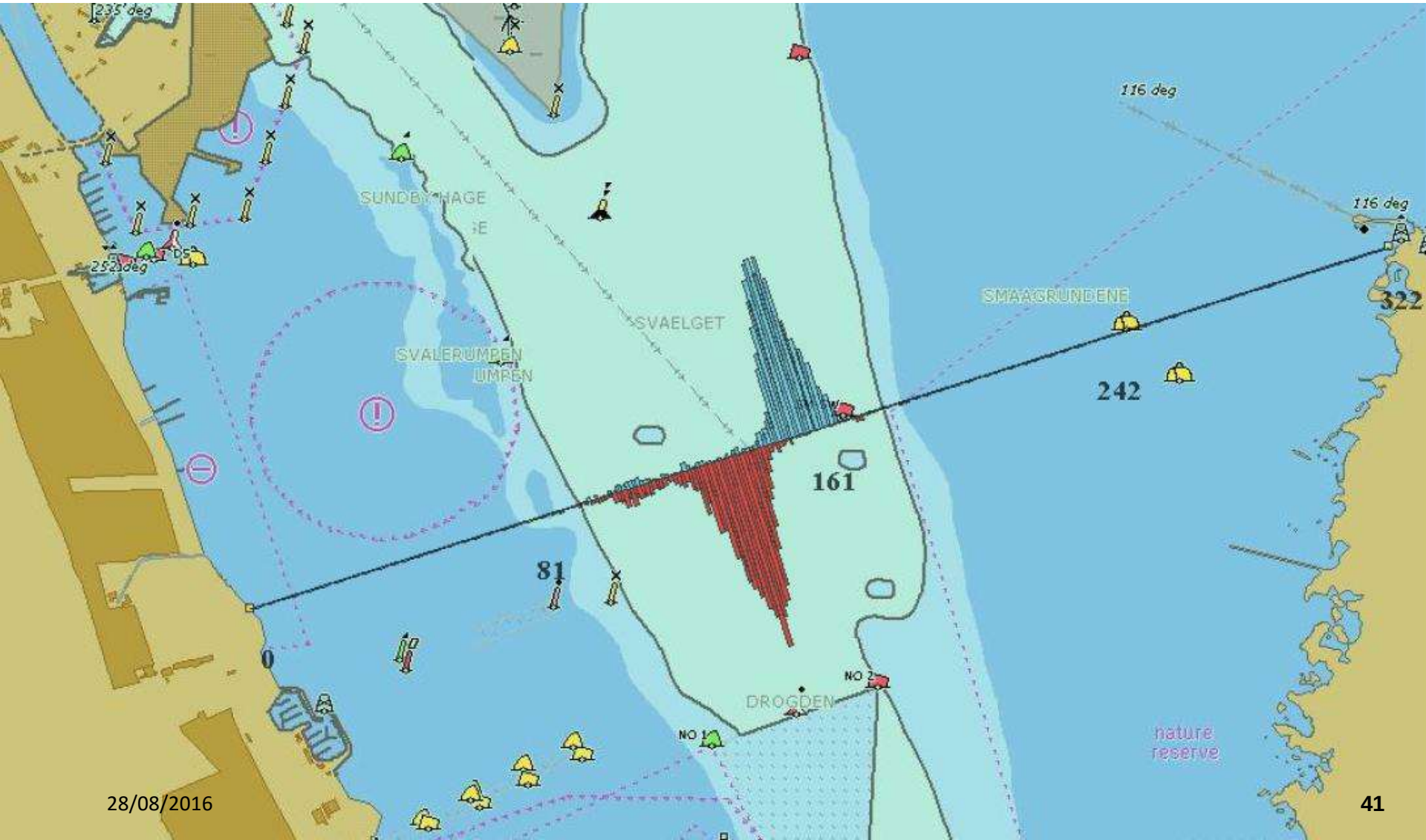


Head-on and overtaking collision

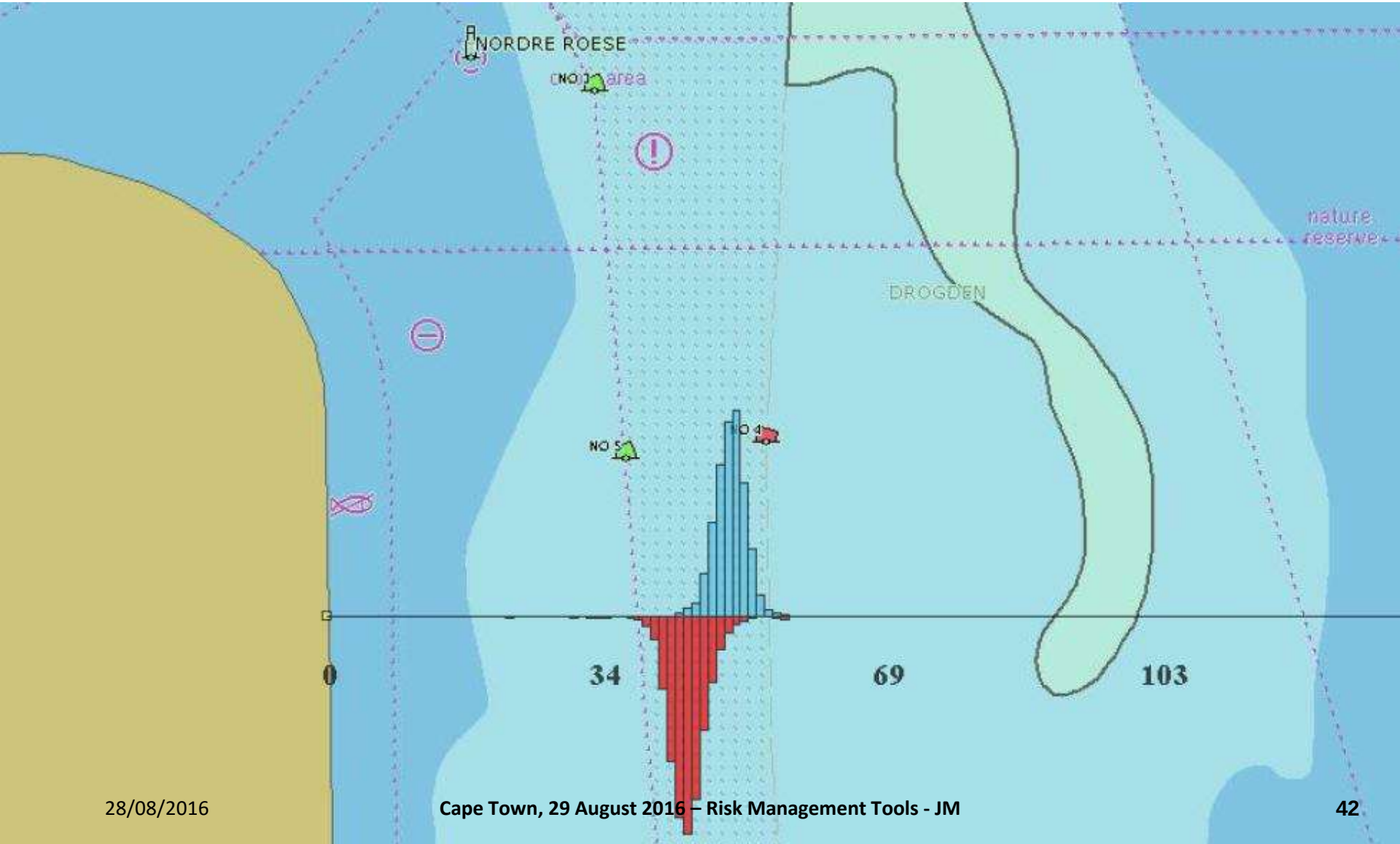
In the figure to the left we have a shipping lane with ships to the right sailing north east and ships to the left sailing south eastward. Using AIS-data we can calculate the number of ships located at different distances from the centre of the lane. This produces two histograms, green and blue in the figure. The histograms show that most of the ships sail some distance from the centre of the lane. However a few ships sail very close to the centre line. The histograms can be fitted to a statistical distribution, for example a normal distribution. It is then possible to calculate the probability that a ship will be at a certain distance from the centre line. Using both distributions we can calculate the number of ships that are on a collision course. This value, called the geometrical number of collisions, is then multiplied by a human factor value in the order of 0.0001. Instead of head-on collision ships can also collide when overtaking each other. This is modelled the same way as head-on collision.

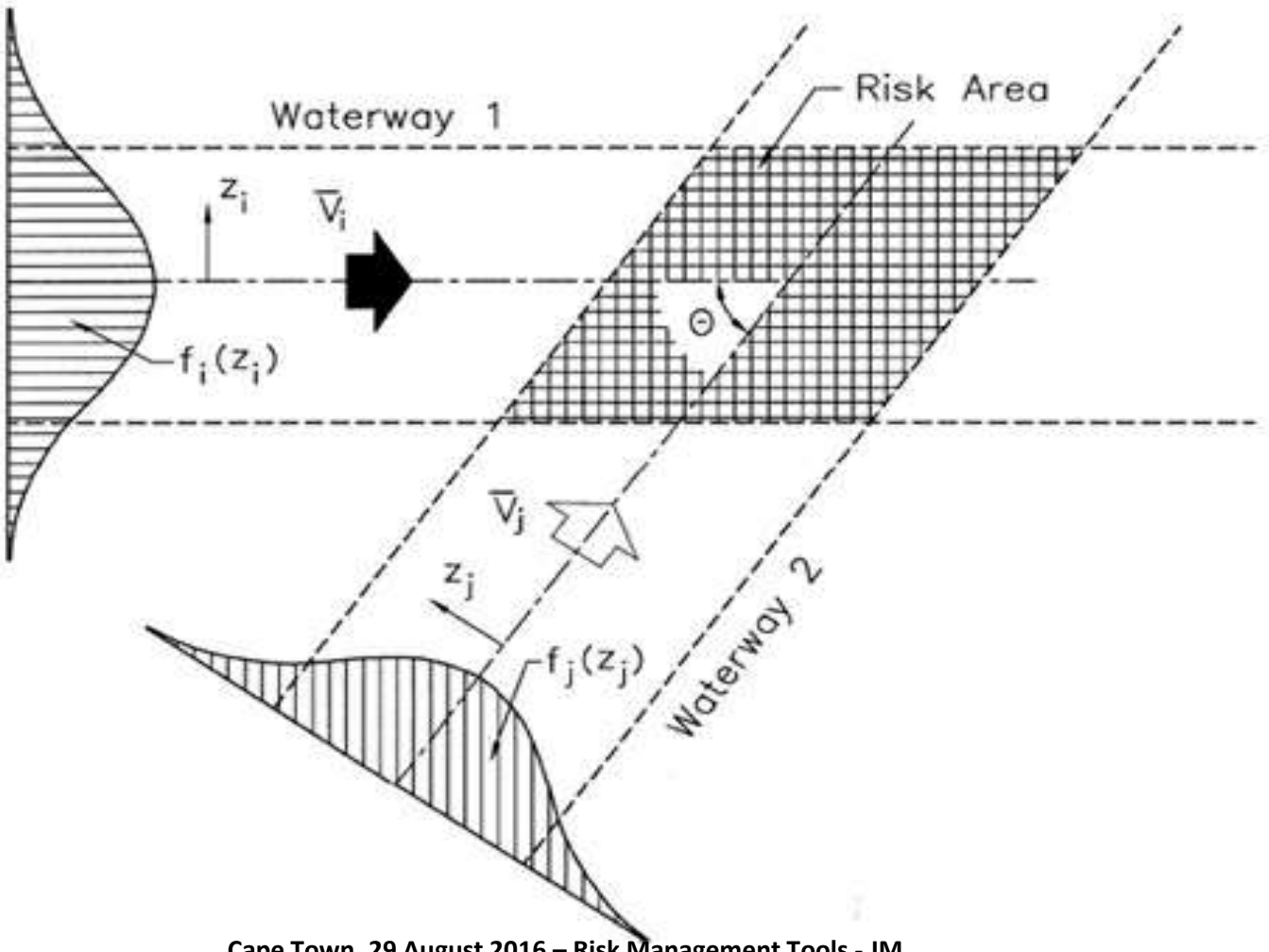
$$N_{col} = N_{geometric} \times P_{causation}$$

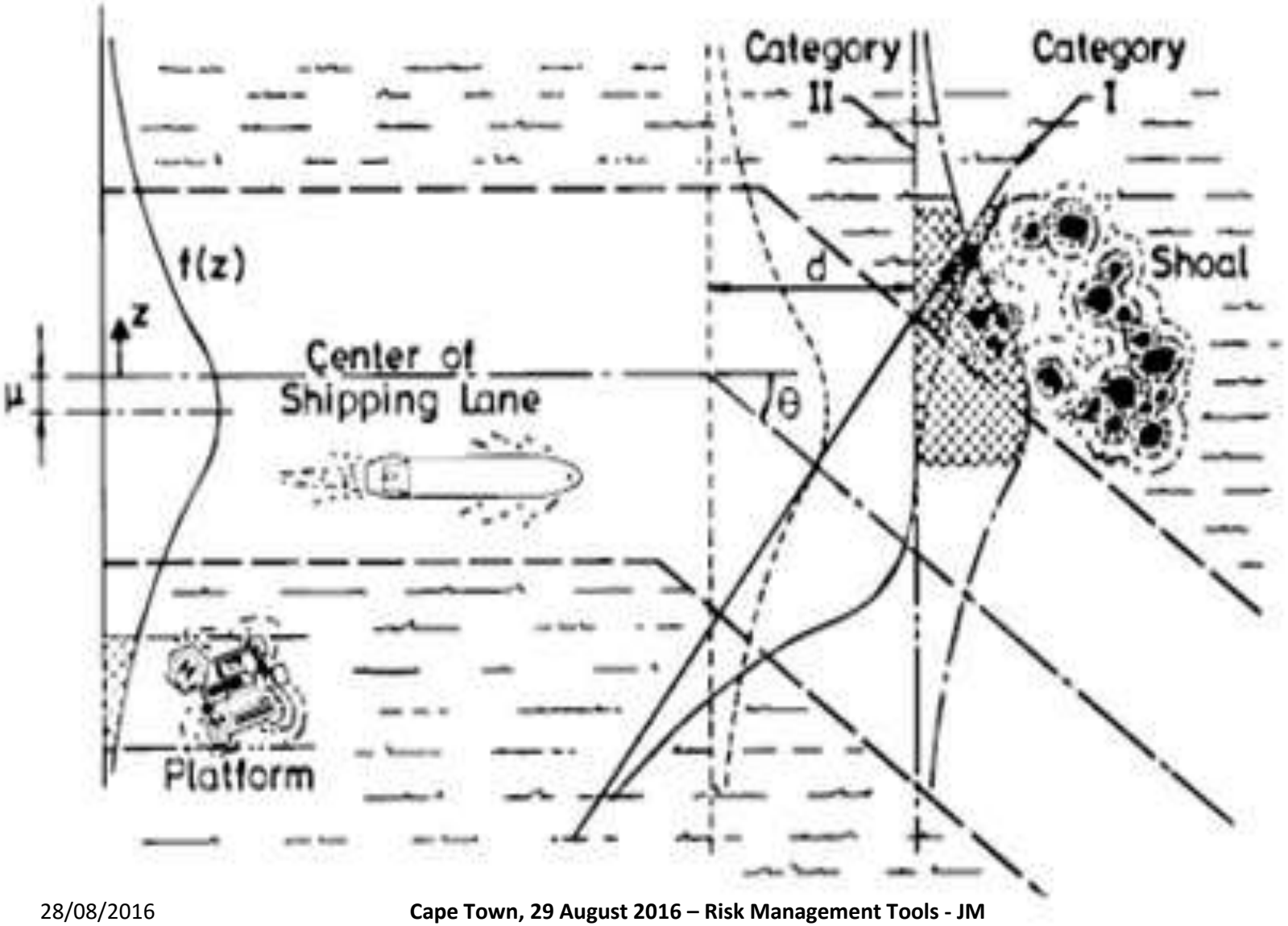
Lateral Distribution of Vessels



Lateral Distribution of Vessels

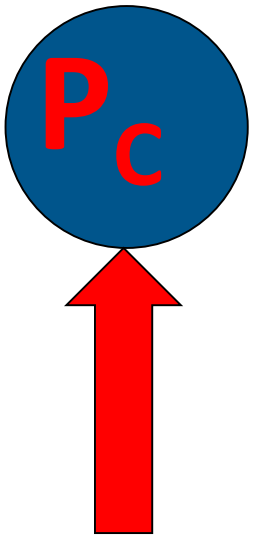



Waterway 1
Risk Area
z_i
$\bar{V}_i$
$f_i(z_i)$
Θ
$\bar{V}_j$
z_j
$f_j(z_j)$
Waterway 2


Category
II
Category
I
f(z)
z
d
Shoal
Center of
Shipping Lane
μ
θ
Platform

Basic Methodology

$$X_{Gnd} = N_{Gnd} \cdot P_C$$



N_{Gnd} = Number of Grounding Candidates

P_c = Causation Probability

Elements of Causation Probability Factors
”Human Factors”

Inadequate training	Carelessness	Ego
Physical limitations	Wishful thinking	Laziness
Inadequate communication	Ignorance	Greed
Bad judgement	Negligence	Alcohol
Fatigue	Folly	Mischief
Boredom	Panic	Violations

Ineffective regulatory requirements	Production orientation	Inequitable promotion / recognition
Poor planning / training	Cost-profit incentives	Ineffective monitoring
Poor communications	Time pressures	Ego
Low quality culture	Rejection of information	Negative incentives
Low worker morale	Complex structure	Violations

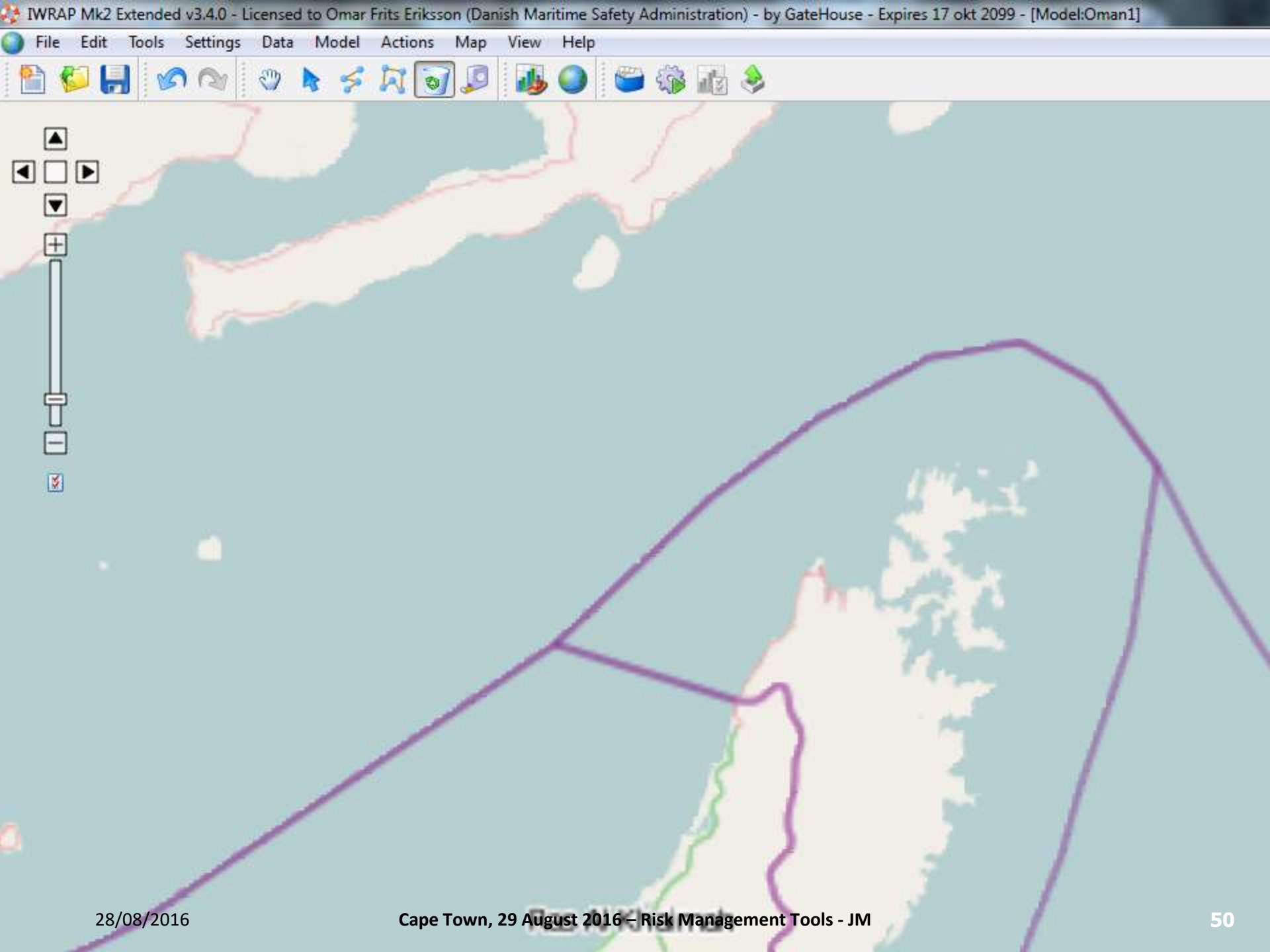
IWRAP Default Causation - Probabilities

Fuiii. Fuiii et Mizuki. Matsui. Mac Duff. Cowi Consult. Karlson et al.. Pedersen et al.. etc.

Condition	Causation factor
Head on collisions	$0.5 \cdot 10^{-4}$
Overtaking collisions	$1.1 \cdot 10^{-4}$
Crossing collisions	$1.3 \cdot 10^{-4}$
Collisions in bend	$1.3 \cdot 10^{-4}$
Collisions in merging	$1.3 \cdot 10^{-4}$
Grounding – forget to turn	$1.6 \cdot 10^{-4}$
Mean time between checks after missed turn	180 seconds

The IALA Risk Management Tools

Running IWRAP Mk2”


IWRAP Mk2 Extended v3.4.0 - Licensed to Omar Frits Eriksson (Danish Maritime Safety Administration) - by GateHouse - Expires 17 okt 2099 - [Model:Oman1]
File
Edit
Tools
Settings
Data
Model
Actions
Map
View
Help

First step is AIS data import

Data can be imported as raw NMEA sentences or as decoded comma separated files

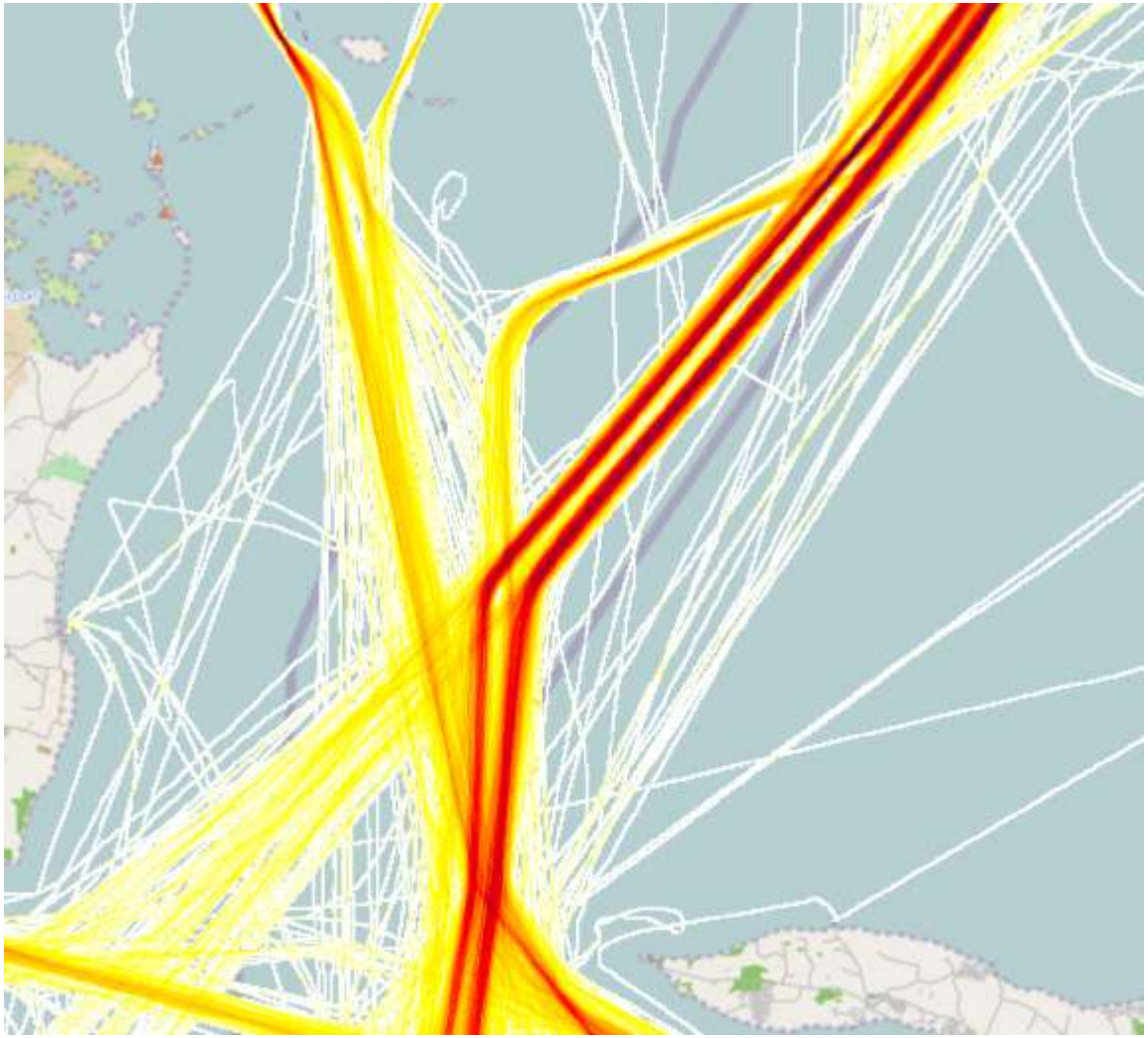
```
01-01-2013 00:09:39,!AIVDM,1,1,,A,16:lIE1PQ>QApFTkEJ61EgiSQP06,0*7B
01-01-2013 00:23:09,!AIVDM,1,1,,B,13LFFj700D2Fu=<fbh>`>mblOLOO,0*61
01-01-2013 00:26:13,!AIVDM,1,1,,A,13nV>P000I2QvRTfi9uIkVs608D=,0*1B
01-01-2013 00:27:55,!AIVDM,2,1,7,B,53nV>P02<c1Hhi4F2218DltEV2222222222220T30`7779POBm4SkDkiH888,0*1E
01-01-2013 00:27:55,!AIVDM,2,2,7,B,8888888880,2*18
01-01-2013 00:29:19,!AIVDM,1,1,,A,13LFFj700H2FphlfbbL`6Eo:041l,0*48
01-01-2013 00:29:44,!AIVDM,2,1,1,B,53LFFj021ukluO;?WV058=@T>1HTdTpN2222220N38Q766w1NB1RDj2CQp888,0*3C
01-01-2013 00:29:44,!AIVDM,2,2,1,B,8888888880,2*1E
01-01-2013 00:34:00,!AIVDM,2,1,6,B,53nV>P02<c1Hhi4F2218DltEV2222222222220T30`7779POBm4SkDkiH888,0*1F
01-01-2013 00:34:00,!AIVDM,2,2,6,B,8888888880,2*19
01-01-2013 01:38:53,!AIVDM,1,1,,B,13aGs5@P00PD;Q@fdJNuVOwPR@L2,0*48
```

DateTime	mmsi	lon	lat	cog	heading	sog	imo	typeOfShipAndcargo	sizeA	sizeB	sizeC	sizeD	draught
30-09-2012 02:28:07	331394000	-51.7236	64.17075	338	176	0.1	9606065	70	198	62	9	23	4
30-09-2012 02:32:30	331394000	-51.7236	64.17078	351	176	0	9606065	70	198	62	9	23	4
30-09-2012 02:36:21	331394000	-51.7236	64.17074	351	175	0	9606065	70	198	62	9	23	4

Static data can be imported seperatly

If you have AIS data in several formats they can be imported one after the other.

Second step is usually a Density plot

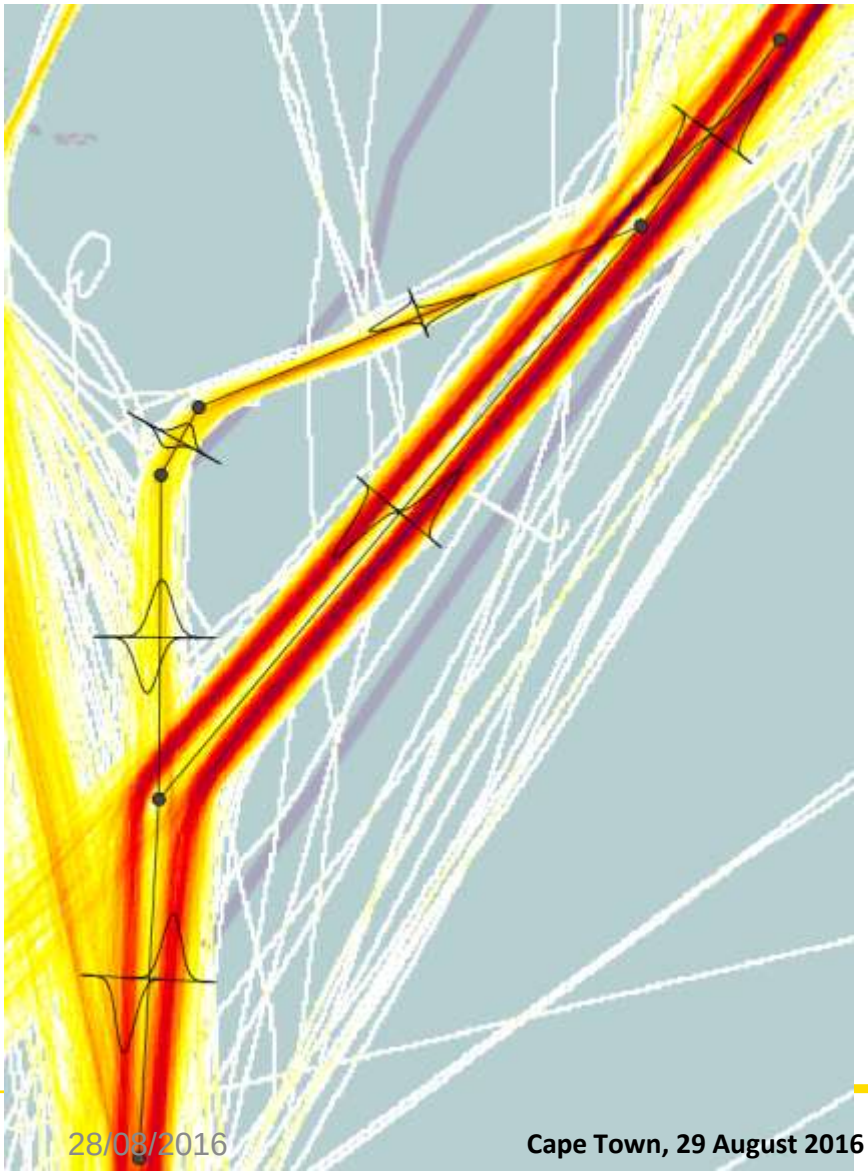


Adding legs

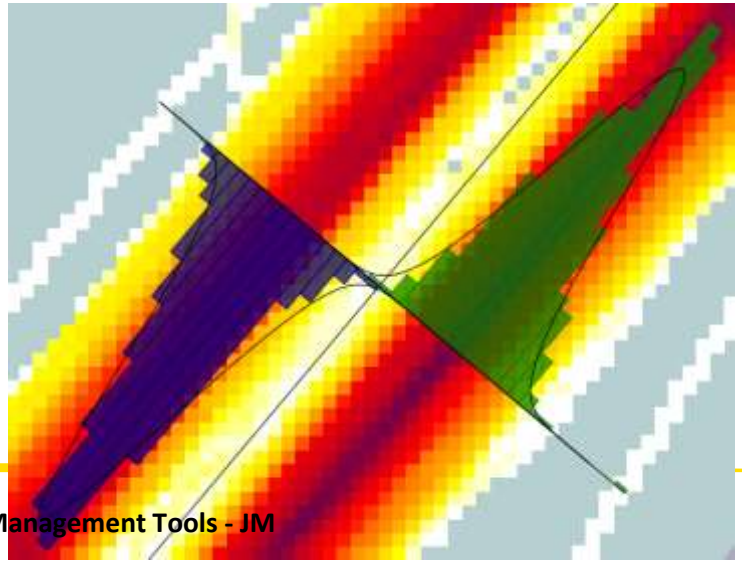
Decide what AIS data belongs to each leg

-Width of box
-Angle to leg

IWRAP extracts traffic volumes and lateral distributions



	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk
0-25	0	0	0	0	0	0	0
25-50	0	0	0	0	0	0	0
50-75	0	46	15	0	0	327	15
75-100	0	249	124	31	0	748	15
100-125	0	389	62	46	15	264	46
125-150	31	670	0	15	264	311	15
150-175	46	249	0	62	374	264	327
175-200	31	1044	31	0	171	62	779
200-225	0	0	0	0	187	0	93
225-250	15	62	0	0	0	0	140
250-275	15	46	0	0	0	0	15
275-300	0	0	0	0	0	0	15
300-325	0	0	0	0	0	0	0
325-350	0	0	0	0	0	0	0
350-375	0	0	0	0	15	0	0
375-400	0	0	0	0	0	0	0
400>	0	0	0	0	0	0	0
Sum	**138**	**2755**	**232**	**154**	**1026**	**1976**	**1460**



Ship types and ship lengths

Each leg has traffic in two directions

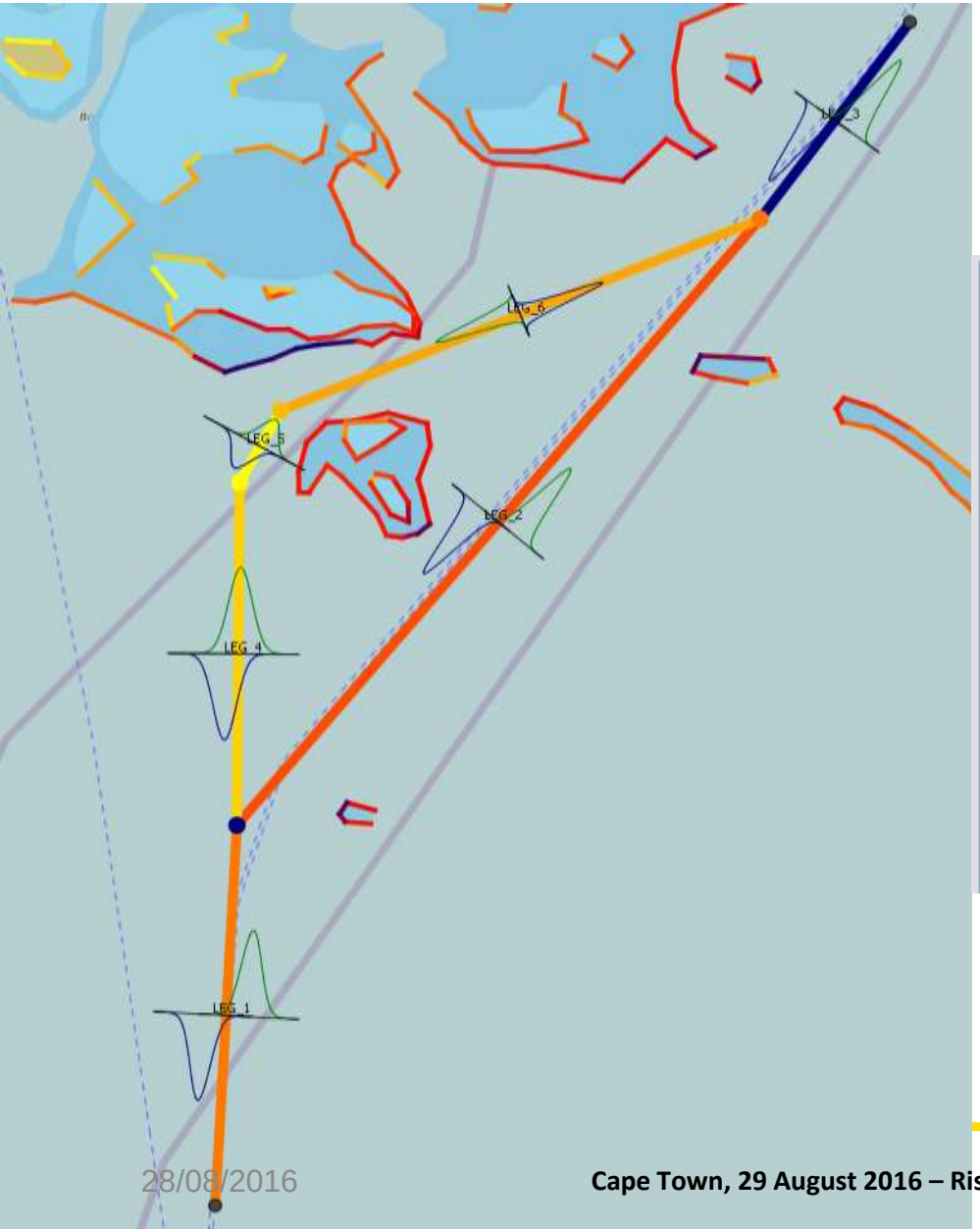
	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Pleasure boat	Other ship	Sum
0-25	0	0	0	0	0	0	0	0	0	0	15	0	0	15	**30**
25-50	0	0	0	0	0	0	0	0	0	0	233	0	0	77	**310**
50-75	0	46	15	0	0	327	15	0	0	0	15	0	0	171	**589**
75-100	0	249	124	31	0	748	15	0	15	0	15	15	0	0	**1212**
100-125	0	389	62	46	15	264	46	31	0	0	0	0	15	46	**914**
125-150	31	670	0	15	264	311	15	0	15	0	0	0	0	15	**1336**
150-175	46	249	0	62	374	264	327	15	0	0	15	0	0	0	**1352**
175-200	31	1044	31	0	171	62	779	514	358	0	0	0	0	0	**2990**
200-225	0	0	0	0	187	0	93	15	296	0	0	0	0	0	**591**
225-250	15	62	0	0	0	0	140	0	0	0	0	0	0	15	**232**
250-275	15	46	0	0	0	0	15	0	31	0	0	0	0	0	**107**
275-300	0	0	0	0	0	0	15	0	0	0	0	0	0	0	**15**
300-325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
325-350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
350-375	0	0	0	0	15	0	0	0	0	0	0	0	0	0	**15**
375-400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
400-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Sum	**138**	**2755**	**232**	**154**	**1026**	**1976**	**1460**	**575**	**715**	**0**	**293**	**15**	**15**	**339**	**9693**

If a detailed static ship table does not exist IWRAP categorises:
All tankers as Oil products tankers
Container ships , Bulk carriers, Ro-Ro cargo ships as General cargo ships

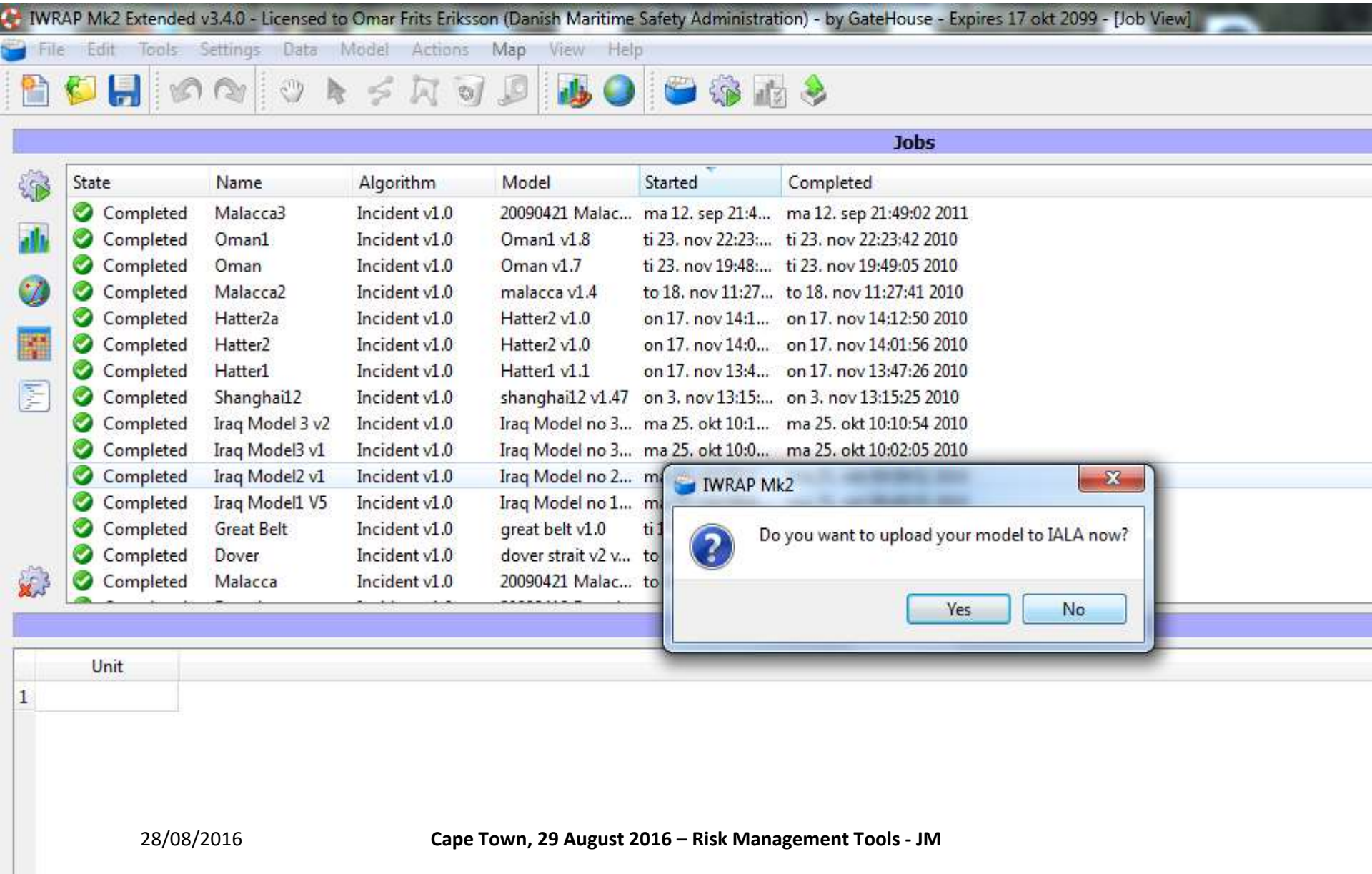
The ship types are not that important as IWRAP does not estimate consequences

	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container sl
0-25	0	0	0	0	0
25-50	0	0	0	0	0
50-75	0	46	15	0	0
75-100	0	249	124	31	0
100-125	0	389	62	46	15
125-150	31	670	0	15	264
150-175	46	249	0	62	374
175-200	31	1044	31	0	171

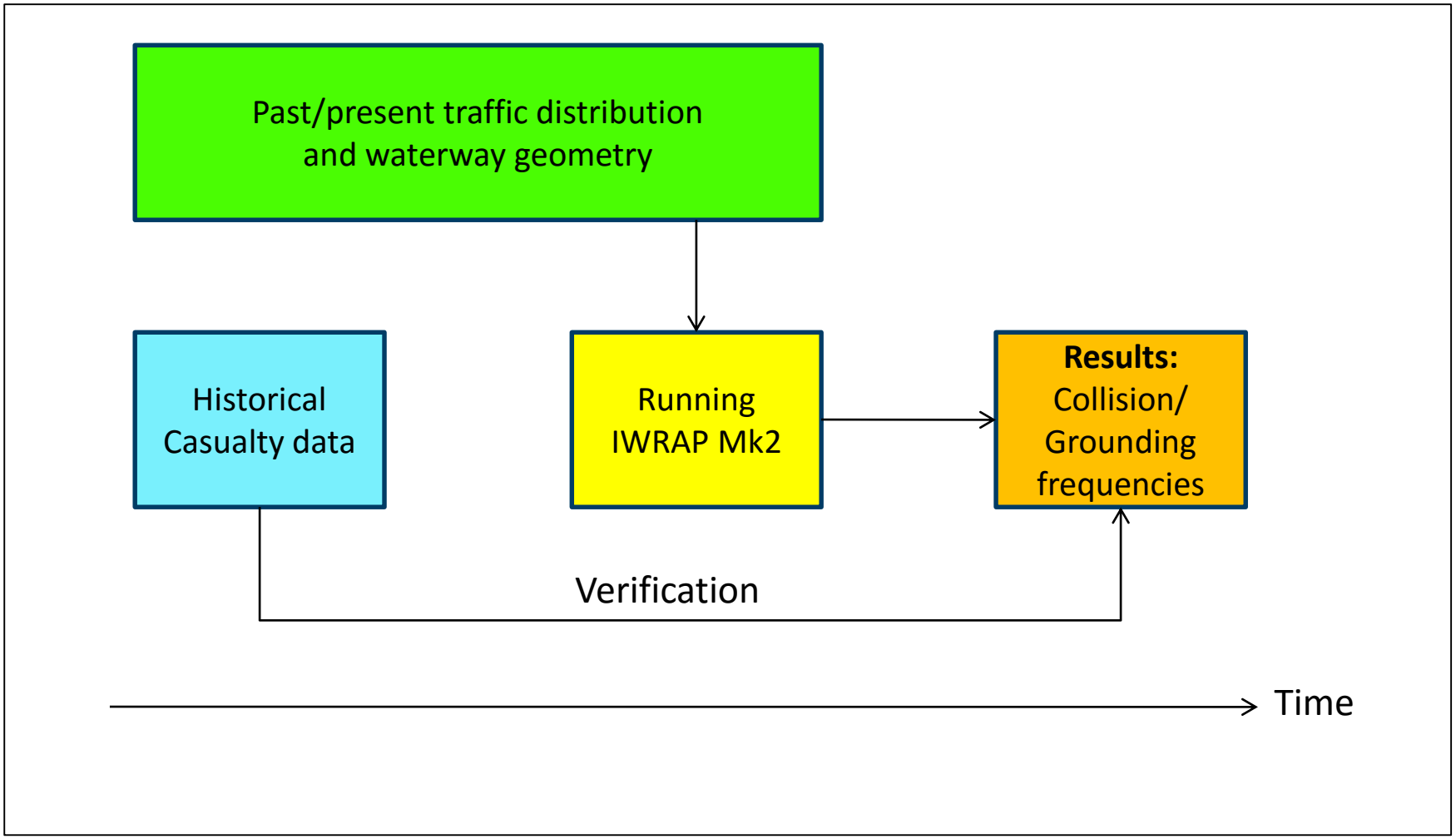
IWRAP results



	Test case	Unit
Powered Grounding	9.762	Years between incidents
Drifting Grounding	10.02	Years between incidents
Total Groundings	4.944	Years between incidents
Overtaking	47.44	Years between incidents
HeadOn	1,840	Years between incidents
Crossing	398.4	Years between incidents
Merging	1,346	Years between incidents
Bend	55.73	Years between incidents
Area	---	Years between incidents
Total Collisions	23.35	Years between incidents


IWRAP Mk2 Extended v3.4.0 - Licensed to Omar Frits Eriksson (Danish Maritime Safety Administration) - by GateHouse - Expires 17 okt 2099 - [Job View]
File Edit Tools Settings Data Model Actions Map View Help
Jobs
State Name Algorithm Model Started Completed
Completed Malacca3 Incident v1.0 20090421 Malac... ma 12. sep 21:4... ma 12. sep 21:49:02 2011
Completed Oman1 Incident v1.0 Oman1 v1.8 ti 23. nov 22:23:... ti 23. nov 22:23:42 2010
Completed Oman Incident v1.0 Oman v1.7 ti 23. nov 19:48:... ti 23. nov 19:49:05 2010
Completed Malacca2 Incident v1.0 malacca v1.4 to 18. nov 11:27... to 18. nov 11:27:41 2010
Completed Hatter2a Incident v1.0 Hatter2 v1.0 on 17. nov 14:1... on 17. nov 14:12:50 2010
Completed Hatter2 Incident v1.0 Hatter2 v1.0 on 17. nov 14:0... on 17. nov 14:01:56 2010
Completed Hatter1 Incident v1.0 Hatter1 v1.1 on 17. nov 13:4... on 17. nov 13:47:26 2010
Completed Shanghai12 Incident v1.0 shanghai12 v1.47 on 3. nov 13:15:... on 3. nov 13:15:25 2010
Completed Iraq Model 3 v2 Incident v1.0 Iraq Model no 3... ma 25. okt 10:1... ma 25. okt 10:10:54 2010
Completed Iraq Model3 v1 Incident v1.0 Iraq Model no 3... ma 25. okt 10:0... ma 25. okt 10:02:05 2010
Completed Iraq Model2 v1 Incident v1.0 Iraq Model no 2...
Completed Iraq Model1 V5 Incident v1.0 Iraq Model no 1...
Completed Great Belt Incident v1.0 great belt v1.0
Completed Dover Incident v1.0 dover strait v2 v...
Completed Malacca Incident v1.0 20090421 Malac...
IWRAP Mk2
Do you want to upload your model to IALA now?
Yes
No
Unit
1

IWRAP Mk2


Past/present traffic distribution and waterway geometry
Historical Casualty data
Running IWRAP Mk2
Results: Collision/ Grounding frequencies
Verification
Time

IWRAP Mk2

The programme is available free of charge for IALA Members

A commercial version can be purchased with a one year license (GateHouse)

SQUART

Simple Qualitative Assessment of Risk

(project)

SQUART Principles

- Risk should be assessed on the worst possible scenario in a defined zone (region), port or waterway on any one day
- An analysis of each Zone is conducted by the Competent Authority in consultation with available stakeholders
- Existing AtoN; hydrographic and meteorological data; traffic route, density and mix statistics and other factors are obtained from all available sources
- Hazards are identified and prioritised
- The frequency (probability) and impact of each risk is agreed
- Control options are proposed for each risk

Level of Risk Matrix

		PROBABILITY		
		LOW (1)	MEDIUM (2)	HIGH (3)
IMPACT	SEVERE (3)		6	9
	MODERATE (2)	2		6
	MINOR (1)	1	2	

ALARP

Risk = Probability * impact or consequence

1; 2 = acceptable: 3; 4 = caution: 6; 9 = unacceptable

Aim to reduce risks to As Low As is Reasonably Practicable **(ALARP)**

The next IALA WWA training seminar on the use of the IALA Risk Management Tools will take place in Panama, 14 – 18 November 2016

Thank you.

Chief Engineer (er) Jacques Manchard
IALA Senior Adviser, IALA World-Wide Academy