Marine Accident Analysis of Collisions and Groundings:

How to learn from past incidents to avoid them in the future

Webinar: International Union of Marine Insurance

10 April 2018

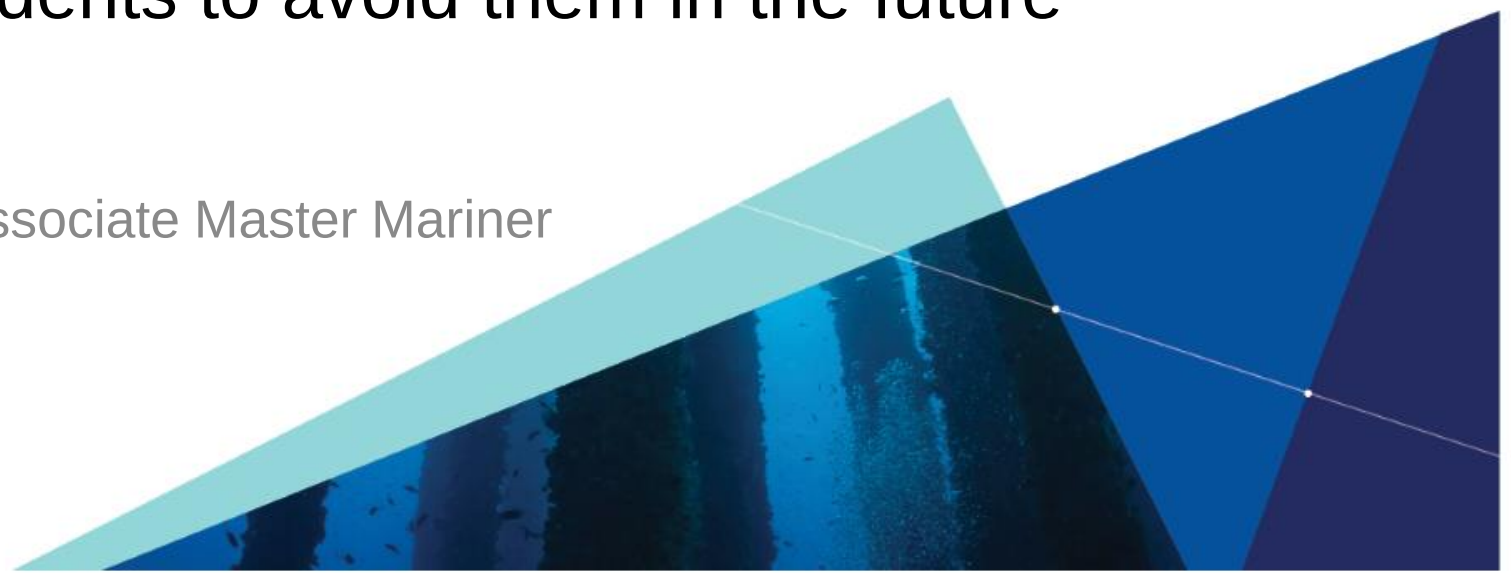
NAUTICAL AFFILIATE
Promoting professionalism in shipping

The Nautical Institute

Marine Accident Analysis of Collisions and Groundings:

How to learn from past incidents to avoid them in the future

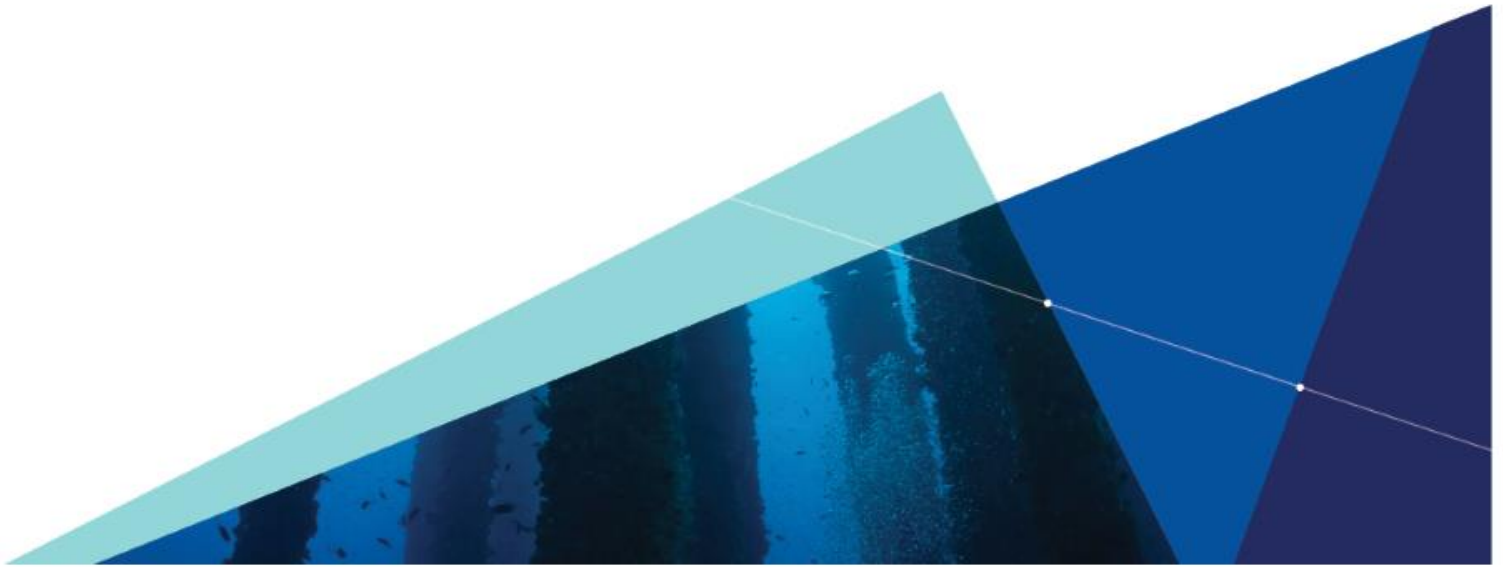
By Captain Paul Whyte MBE AFNI, Associate Master Mariner



Discussion Topics

- Situational Awareness
- Surveying the 3-D waterspace
- International Regulations for Preventing Collisions at Sea, 1972
- How Electronic Evidence Works
- Casualty Investigation and Accident Analysis
- Case Studies
- Conclusions.

Situational Awareness

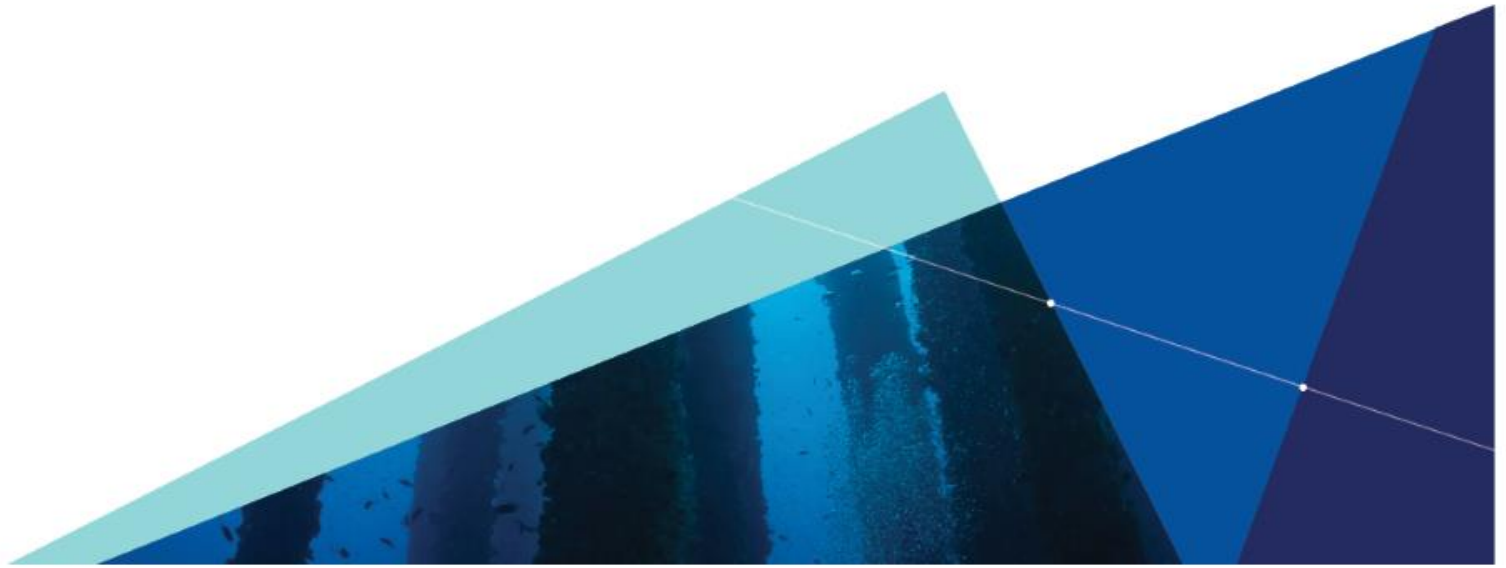


Situational Awareness: The Mystery

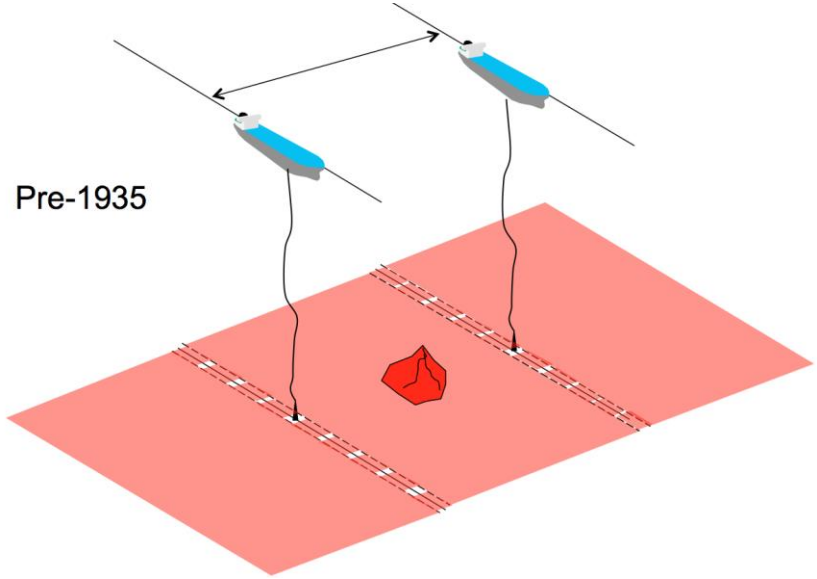
“Navigation is not so much knowing where you are, but knowing where you should not be”

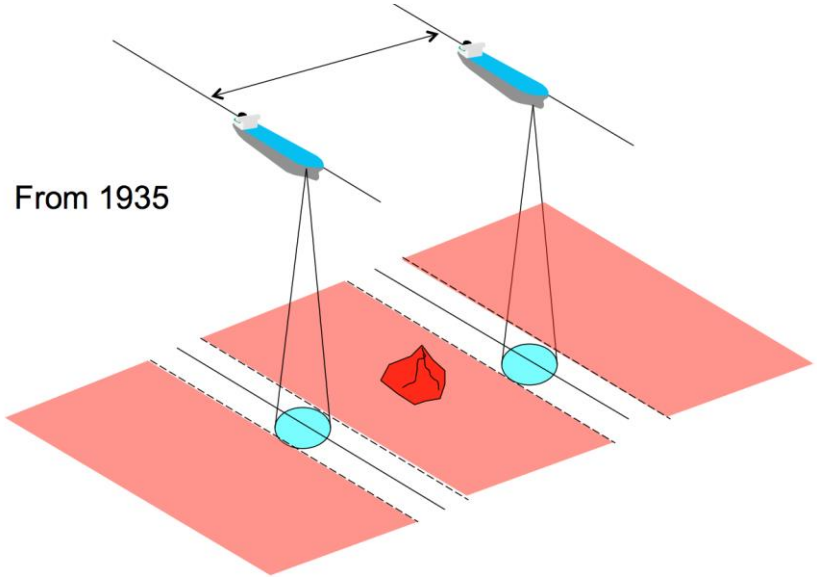
“Collisions are usually avoided by awareness, anticipation, application and action”

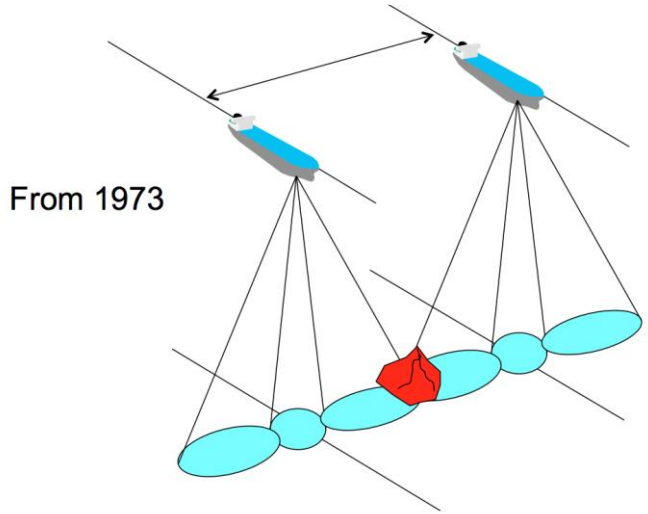
Surveying the 3-D waterspace

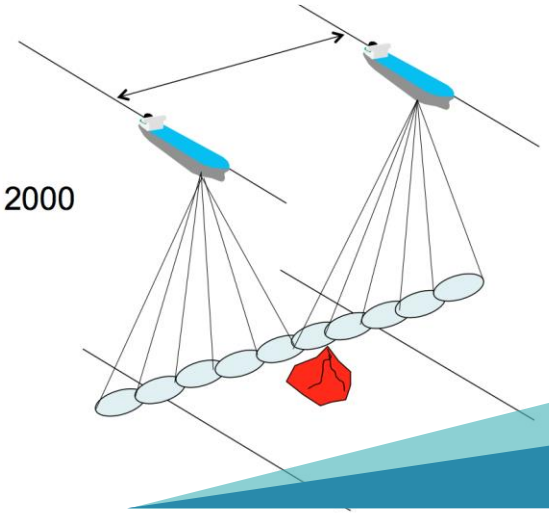


The Basics of Surveying

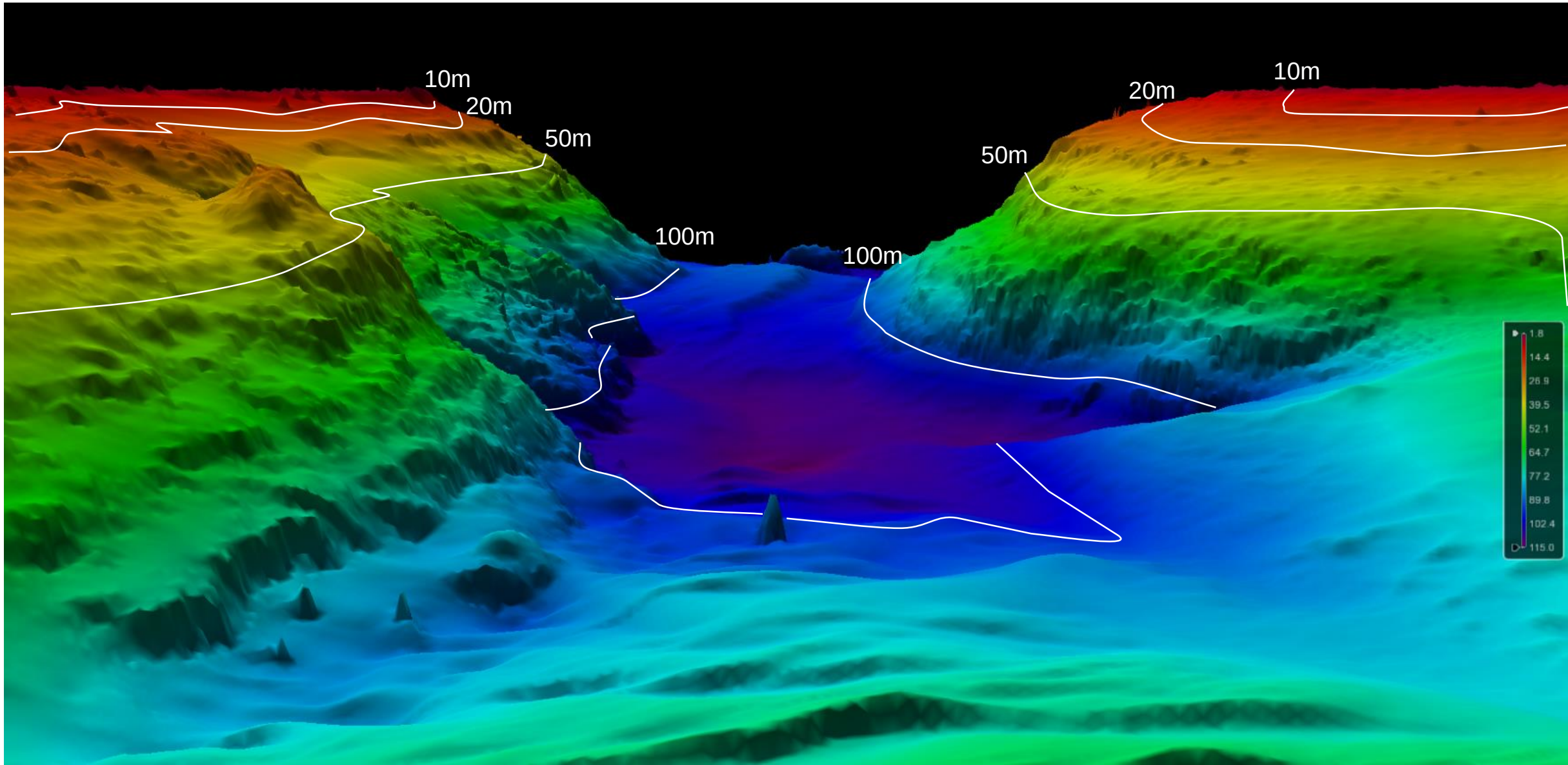




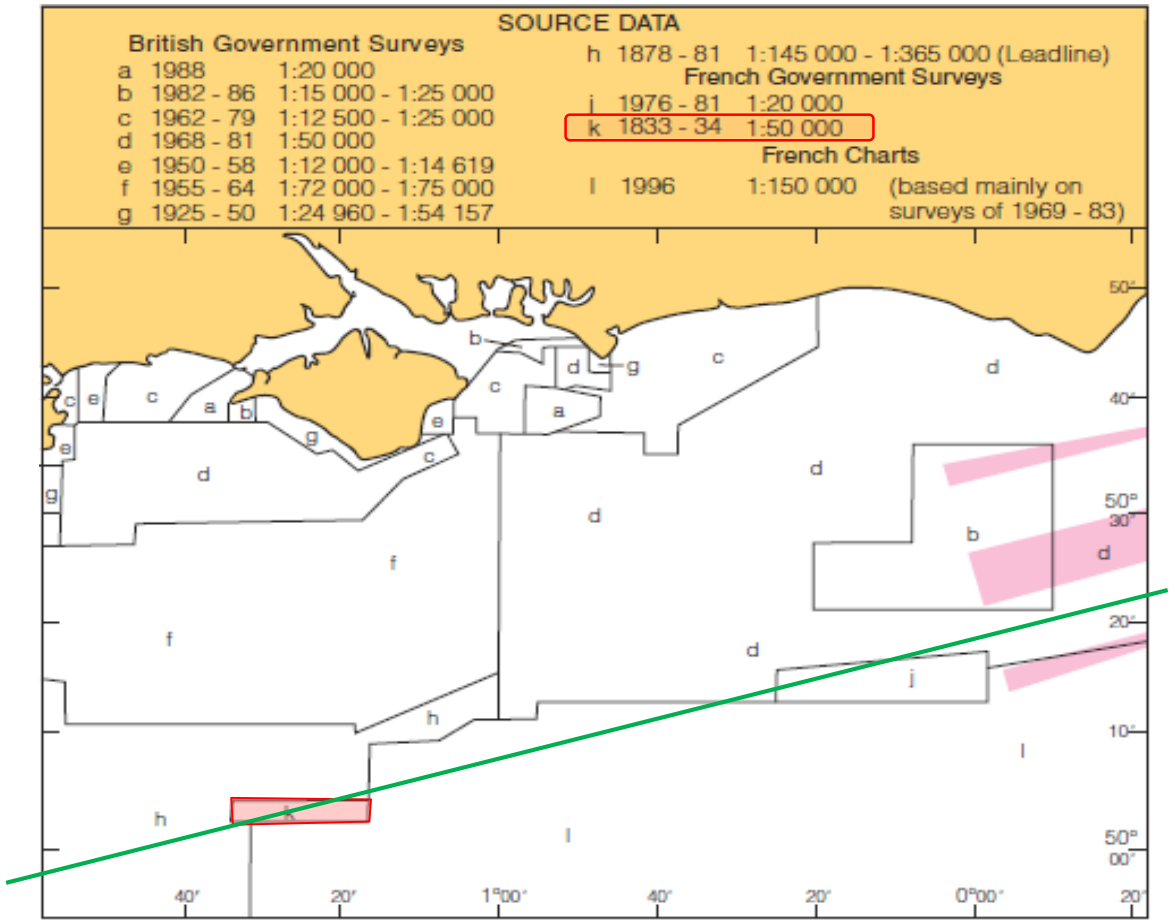




The Basics of Surveying



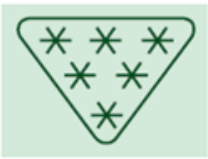
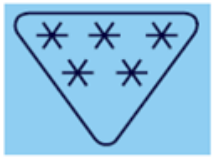
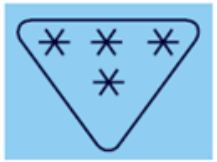
Paper Charts: Source Data Diagram



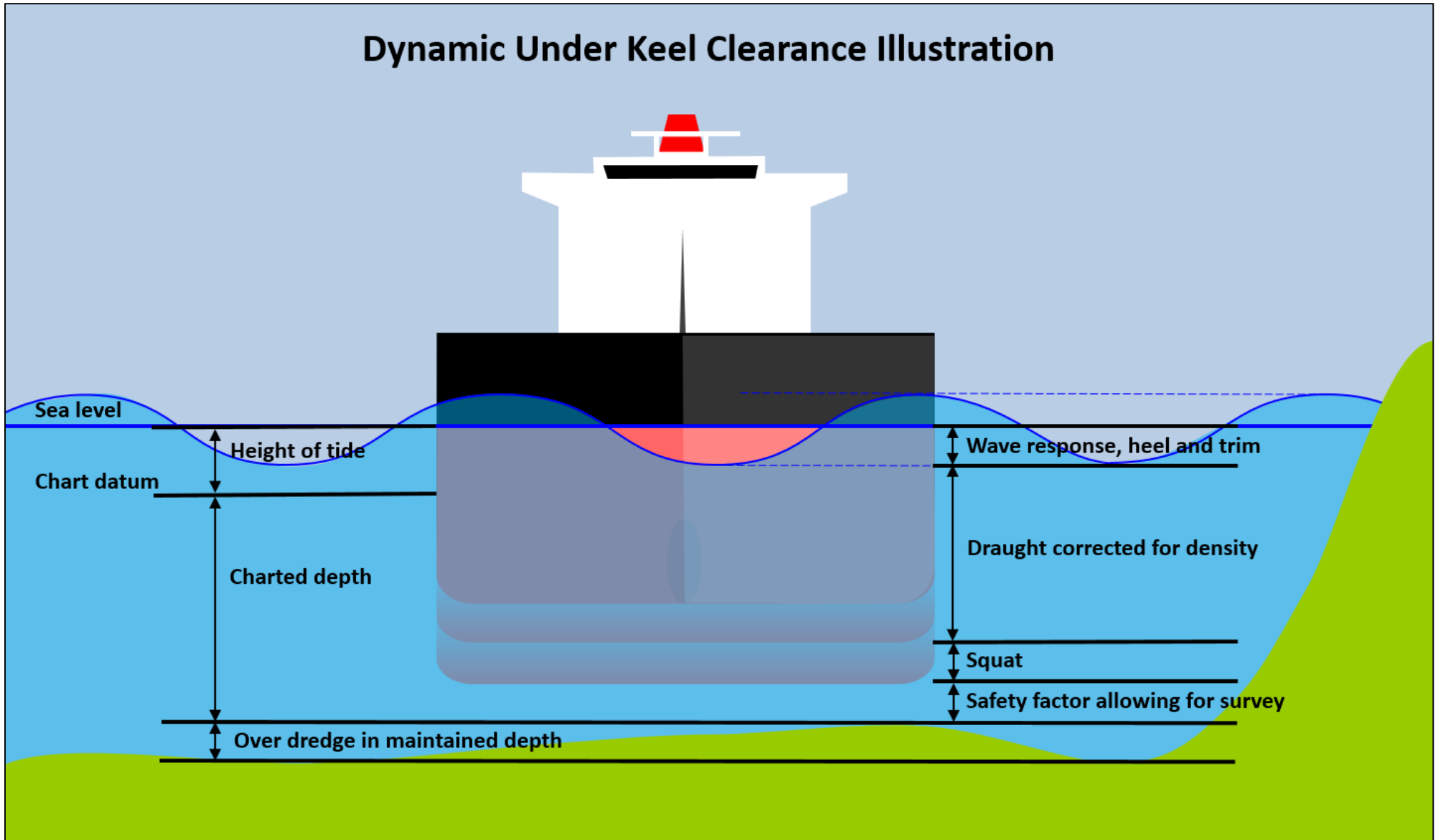
- English Channel Chart
- Area K, NE lane Dover Straits TSS
- Today we consider quality instead of the age of the survey

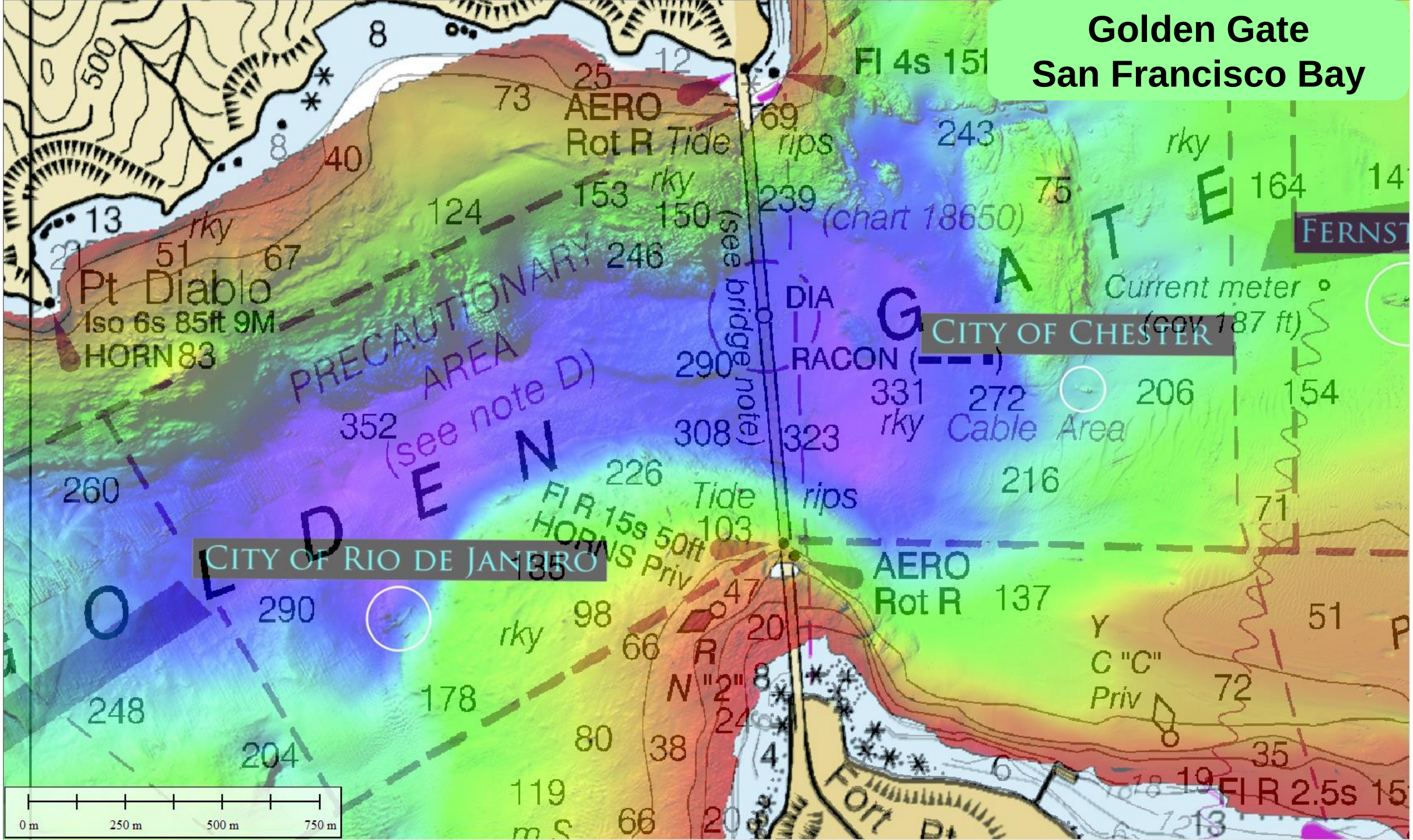
Electronic Charts: Category of Zones of Confidence

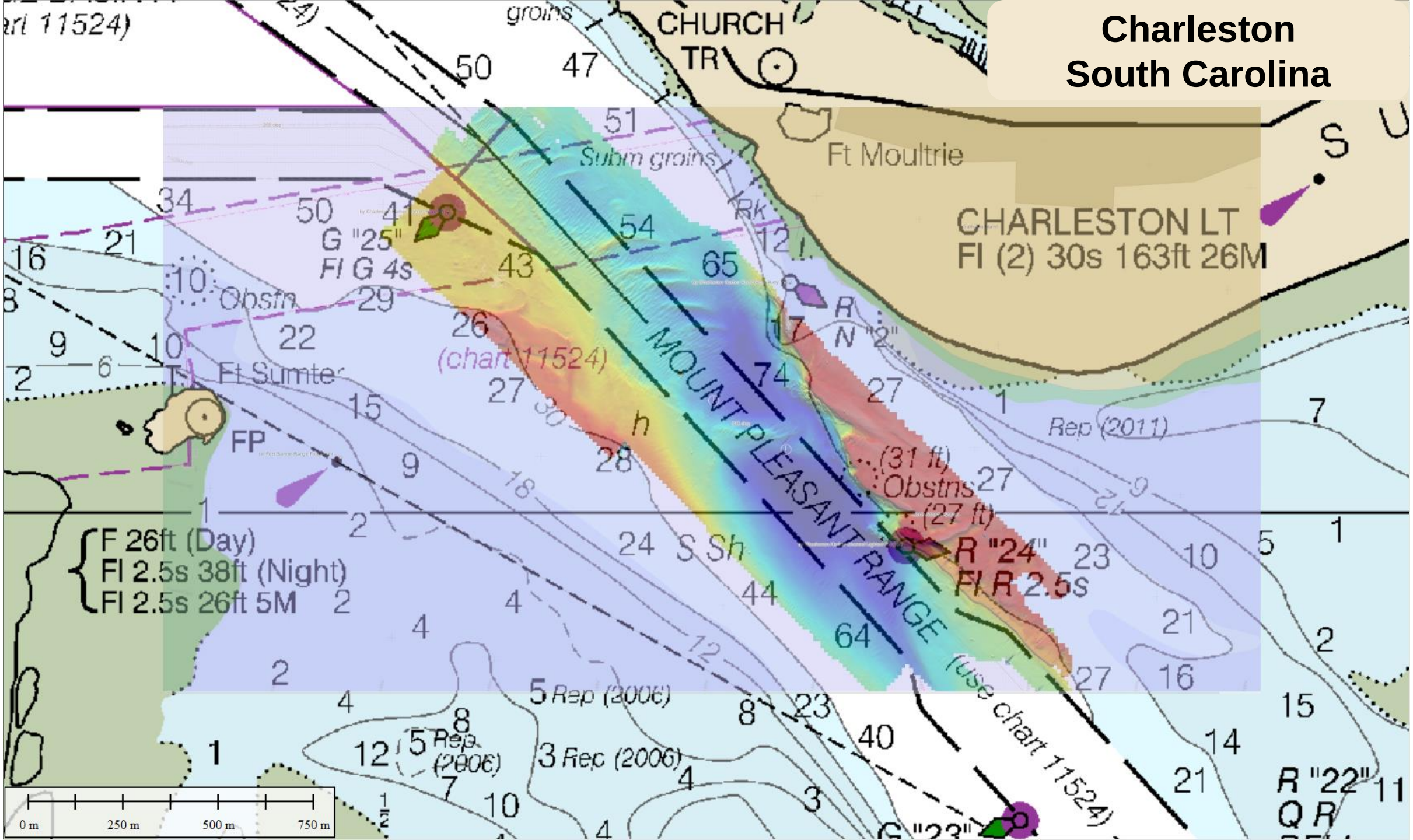
1	2	3	4	5
ZOC[1]	*Position Accuracy*[2]	*Depth Accuracy*[3]	*Seafloor Coverage*	*Typical Survey Characteristics*[5]
A1	**± 5m + 5% depth**	**0·5m + 1% depth** Depth (m) / Accuracy (m) 10 / ± 0·6 30 / ± 0·8 100 / ± 1·5 1000 / ± 10·5	Full area search undertaken. Significant seafloor features detected[4] and depths measured.	Controlled, systematic survey[6]. High position and depth accuracy achieved using DGPS or a minimum of three high quality lines of position (LOP) **and a multibeam, channel or mechanical** sweep system.
A2	**± 20m**	**1·0m + 2% depth** Depth (m) / Accuracy (m) 10 / ± 1·2 30 / ± 1·6 100 / ± 3·0 1000 / ± 21·0	Full area search undertaken. Significant seafloor features detected[4] and depths measured.	Controlled, systematic survey[6] achieving position and depth accuracy less than ZOC A1 and using a modern survey echo sounder[7] and **a sonar or mechanical sweep system.**
B	**± 50m**	**1·0m + 2% depth** Depth (m) / Accuracy (m) 10 / ± 1·2 30 / ± 1·6 100 / ± 3·0 1000 / ± 21·0	Full area search not achieved; **uncharted features, hazardous to** surface navigation are not expected, but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOC A2 using a modern survey echo **sounder but no sonar or mechanical sweep system.**
C	**± 500m**	**= 2·0m + 5% depth** Depth (m) / Accuracy (m) 10 / ± 2·5 30 / ± 3·5 100 / ± 7·0 1000 / ± 52·0	Full area search not achieved; depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
D	Worse than ZOC C	Worse than ZOC C	Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	Unassessed – the quality of the bathymetric data has yet to be assessed.			

ZOC 1	CATZOC Symbol
A1	
A2	
B	
C	
D	
U	

2-D Under Keel Clearance

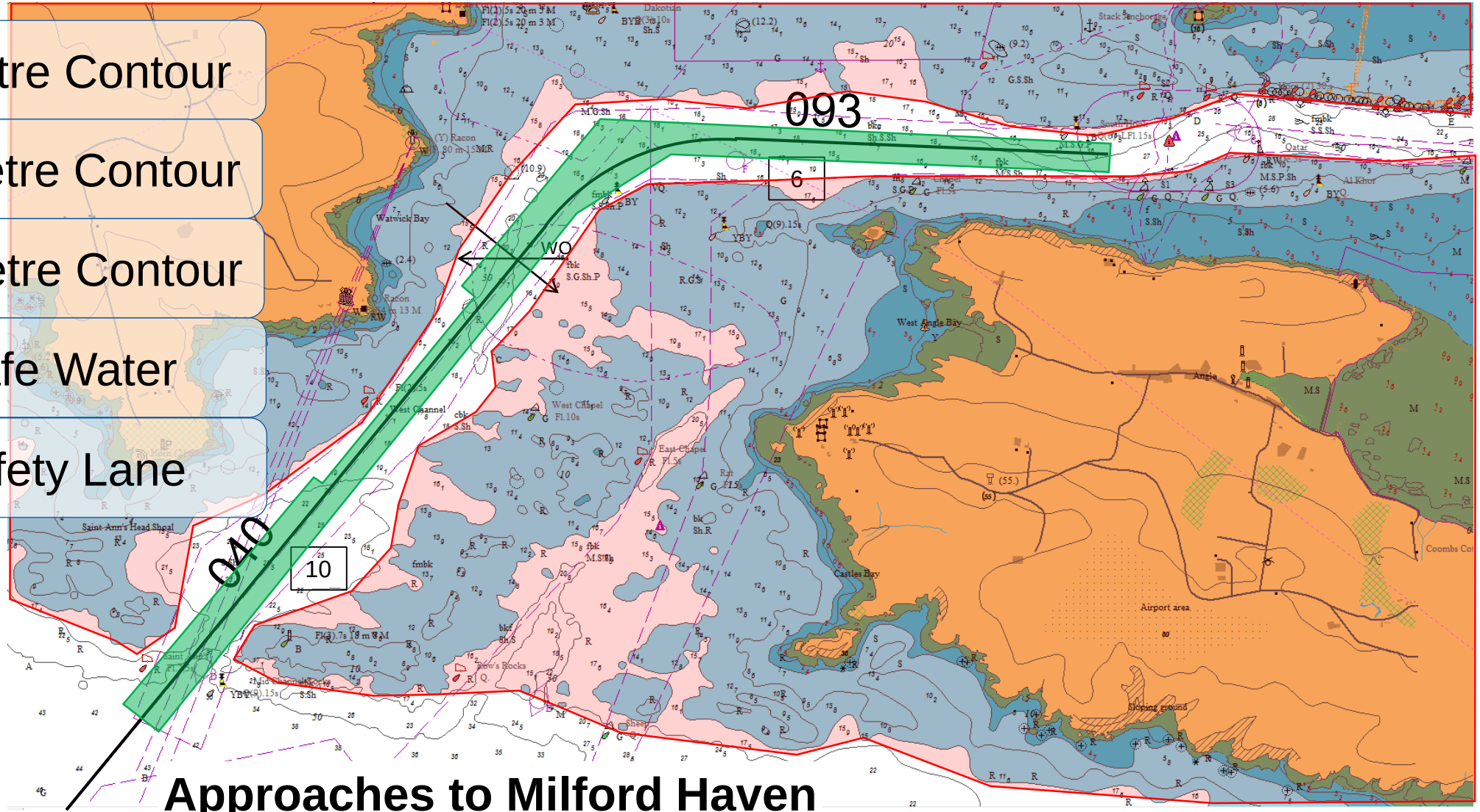



Golden Gate
San Francisco Bay
Pt Diablo
Iso 6s 85ft 9M
HORN 83
PRECAUTIONARY AREA
(see note D)
(see bridge note)
DIA
RACON (---)
CITY OF CHESTER
Current meter
(CGV 187 ft)
Cable Area
AERO
Rot R
Tide
rips
rky
Fl 4s 151
(chart 18650)
Fl R 15s 50ft
HORNS Priv
CITY OF RIO DE JANEIRO
C "C"
Priv
Fl R 2.5s 15
Fort Pt
0 m
250 m
500 m
750 m


Charleston
South Carolina
CHURCH
TR
Ft Moultrie
CHARLESTON LT
Fl (2) 30s 163ft 26M
G "25"
Fl G 4s
Obstn
Ft Sumter
FP
MOUNT PLEASANT RANGE
(chart 11524)
Subm groins
Rk
R
N "2"
(31 ft)
Obstns
(27 ft)
R "24"
Fl R 2.5s
Rep (2011)
S Sh
F 26ft (Day)
Fl 2.5s 38ft (Night)
Fl 2.5s 26ft 5M
5 Rep (2006)
3 Rep (2006)
5 Rep (2006)
(use chart 11524)
R "22"
Q R
0 m
250 m
500 m
750 m

Basics of Anti-Grounding

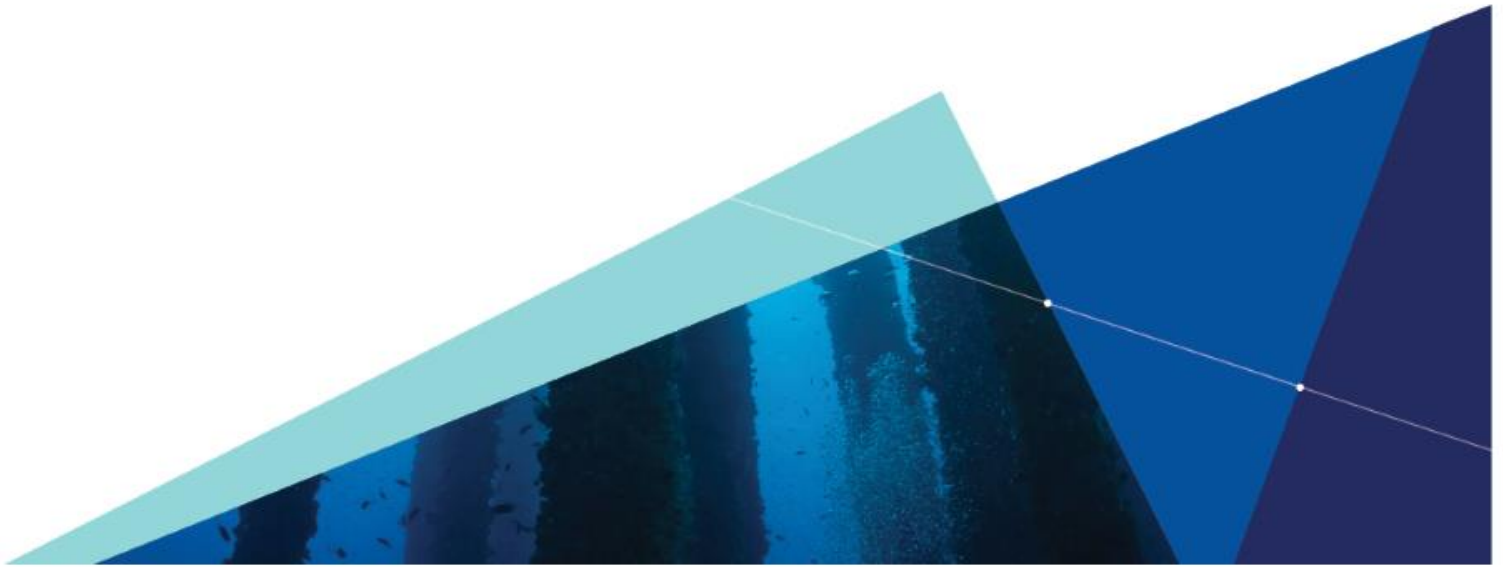
- 5-Metre Contour
- 10-Metre Contour
- 15-Metre Contour
- Safe Water
- Safety Lane



Approaches to Milford Haven

International Regulations to Prevent Collisions at Sea, 1972

(COLREGS)



Basics of the COLREGS

COLREGS:

- Introduced 1846
- 41 Rules plus 4 Annexes
- 8,600 Words
- Theory (no Practical) Test
- Revalidate every 5 years

UK HIGHWAY CODE:

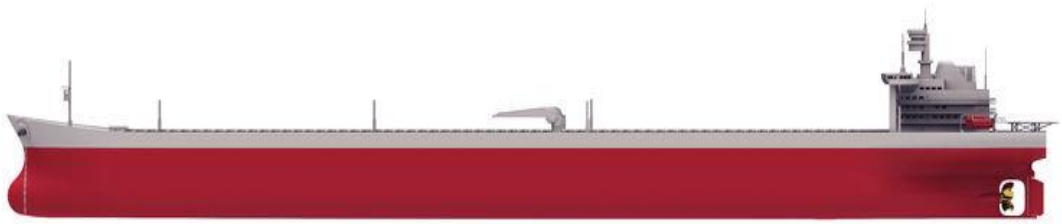
- Introduced 1931
- 307 Rules plus 9 Annexes
- 25,000 words
- Theory and Practical Test
- Valid until 70 and re-test

Basics of the COLREGS

- **Awareness:** maintain a proper lookout (R5)
- **Anticipation:** safe speed (R6) gives space and time to assess
- **Application:** know COLREGS and particularly risk of collision (R7)
- **Action:** take positive and early action to avoid a collision (R8).

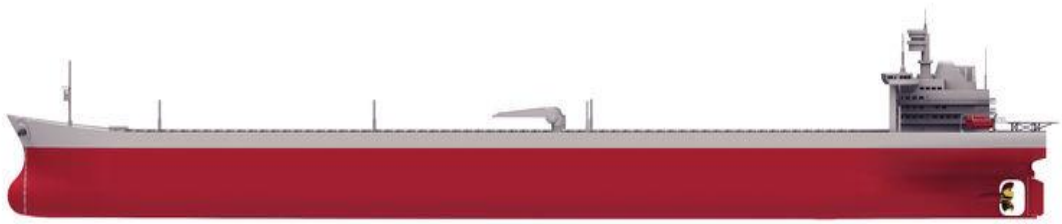
When does a risk of collision exist? Zones of Interest

- Height of eye and radar range
- Vessel size
- Vessel speed and manoeuvrability
- Visibility
- Location
- Under keel clearance.



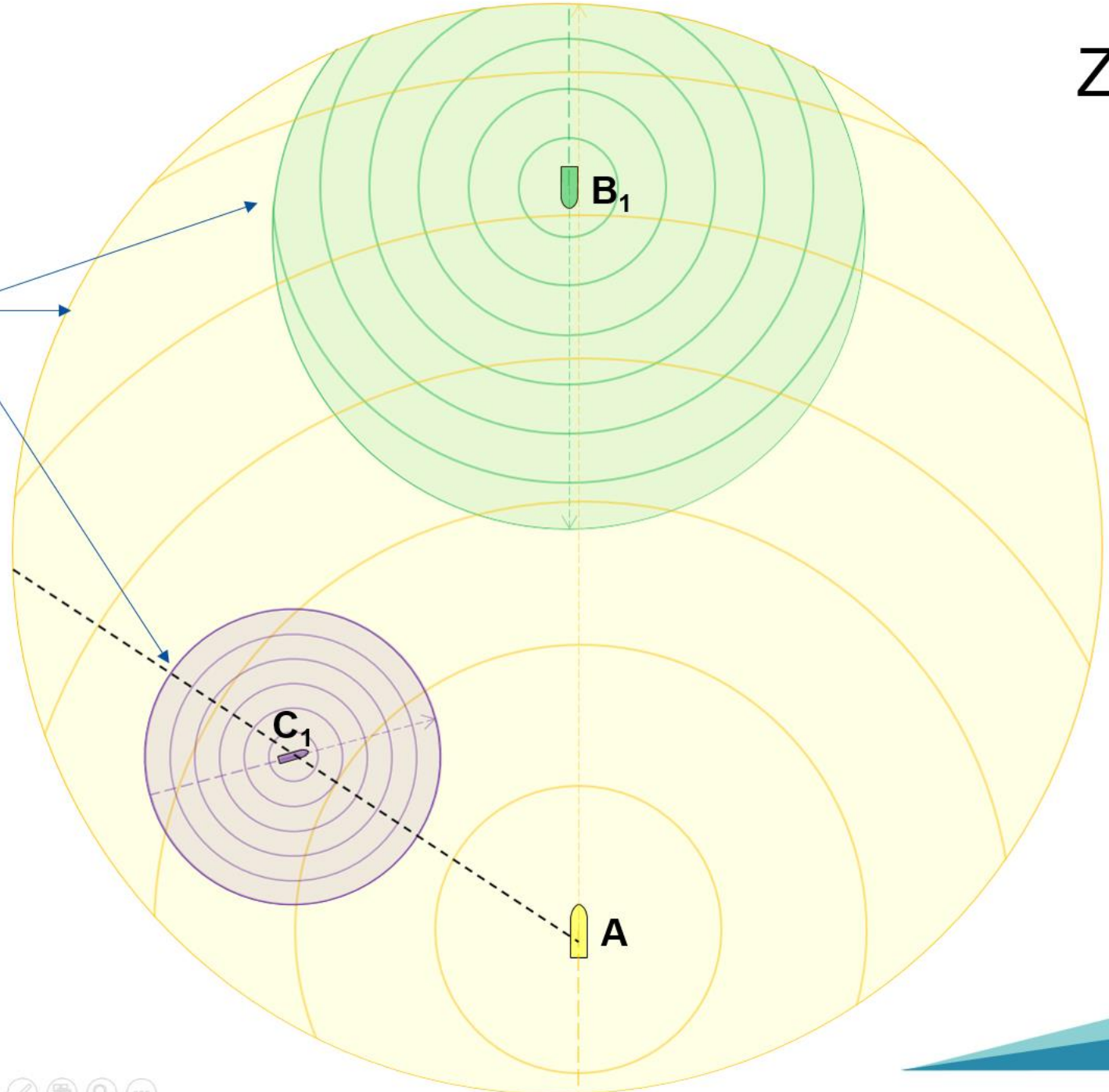
When does a risk of collision exist? Zones of Interest

- Height of eye and radar range
- Vessel size
- Vessel speed and manoeuvrability
- Visibility
- Location
- Under keel clearance.



Zones of Interest

Radar Ranges

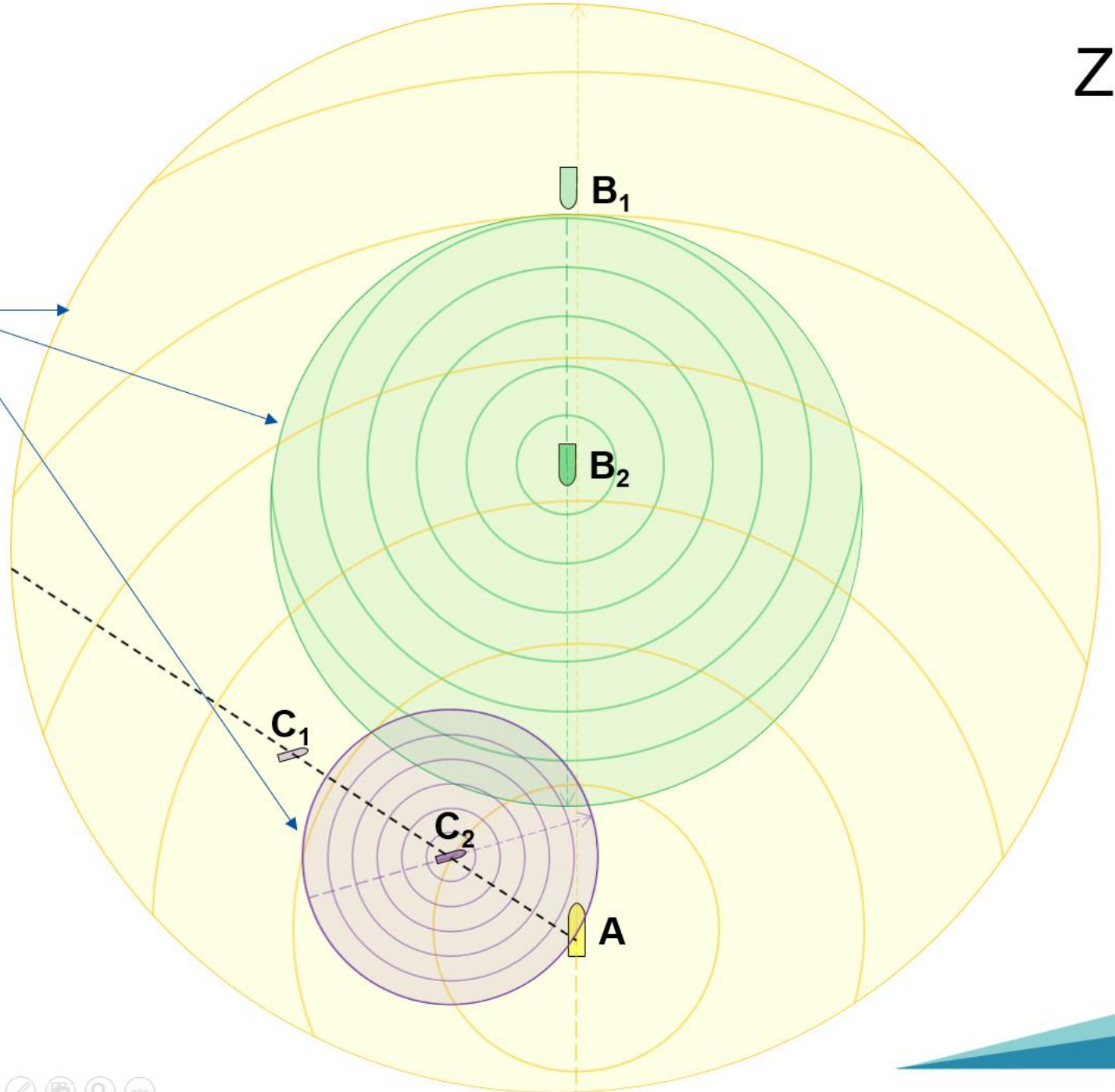


A & B = Head-on situation

A & C = Crossing situation

B & C = No risk of collision

Zones of Interest



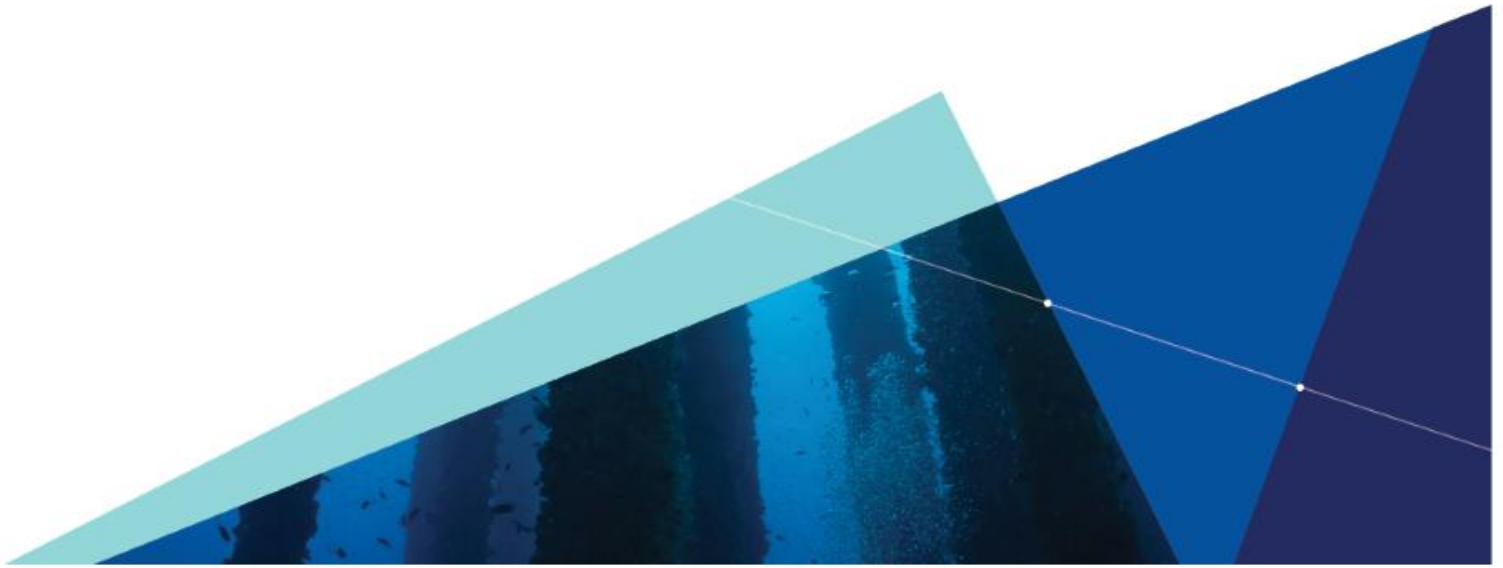
Probability

A = Stood-on for C
= Altered starboard for B & C

B = Did nothing

C = Did nothing

Electronic Evidence

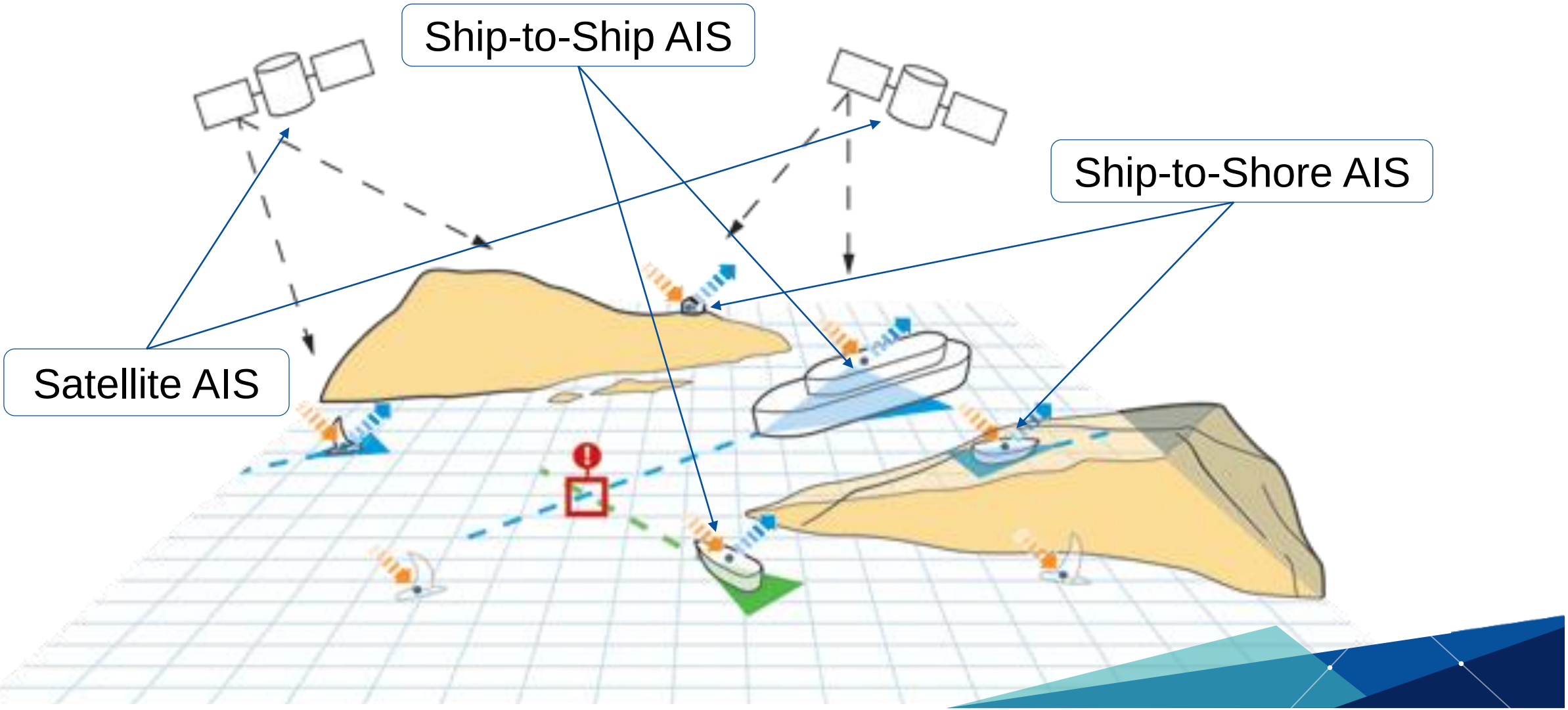


How Electronic Evidence Works: Modern Bridge

How it works: Sources of Electronic Evidence

- Automatic Identification System (AIS)
- Electronic Chart Display and Information System (ECDIS)
- Voyage Data Recorder (VDR)
- Audio, Video and Still Images.

How it works: Automatic Identification System (AIS)



How it works: Automatic Identification System (AIS)

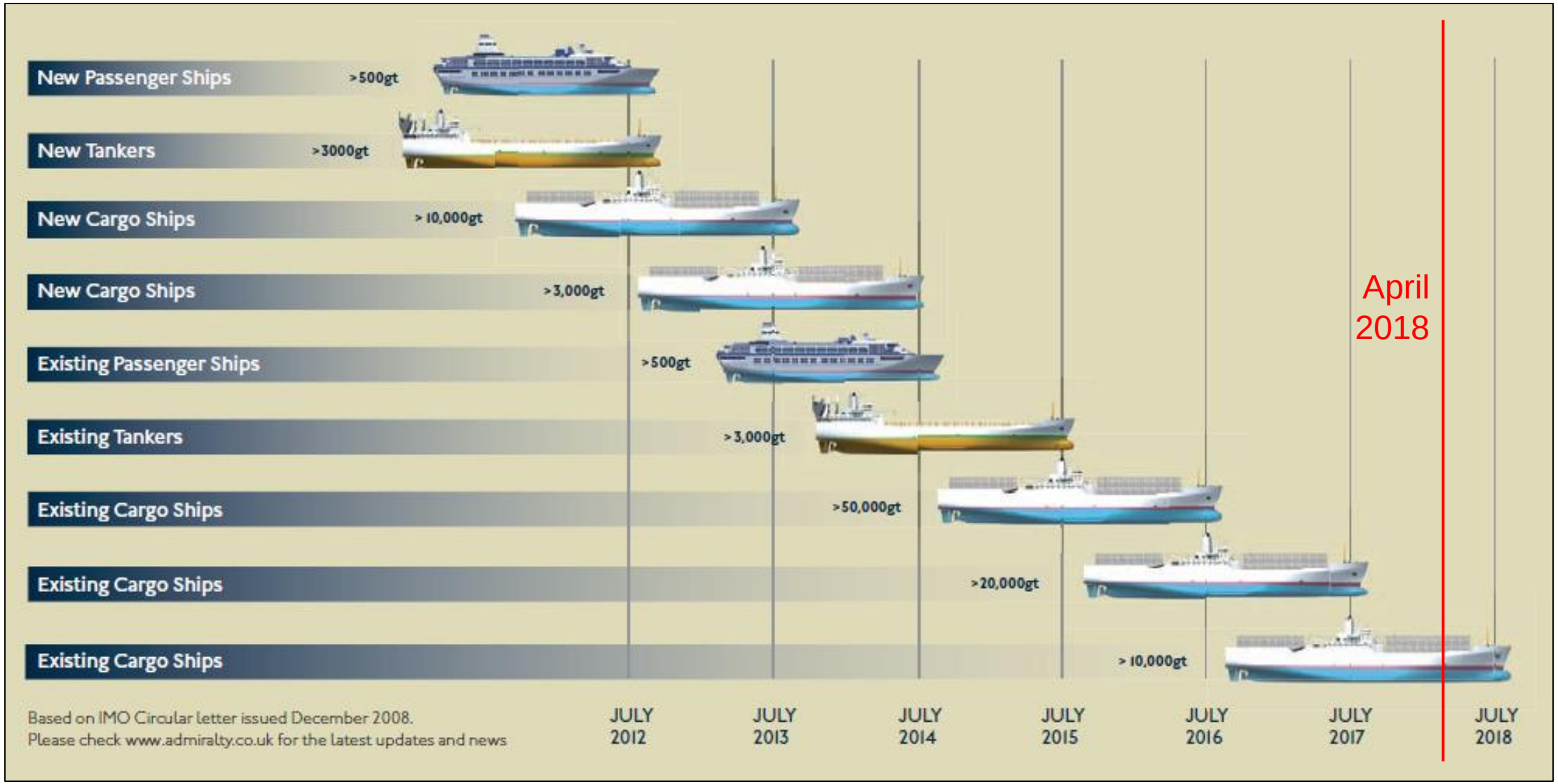
- Vessels over 300 GT (Type A)
- Ship-to-ship situational awareness and manage controlled water space
- Public broadcast VHF transponder device and available open source
- Transmission frequency:
  - **Static:** Every 6 minutes - Vessel details
  - **Dynamic:** Dependant on speed and course - Time, position, course and speed
  - **Voyage Related:** Every 6 minutes - Vessel draft, POB, haz cargo and where bound.

How it works: Automatic Identification System (AIS)

AIS Type A Reporting intervals of Dynamic Information

Manoeuvring Status	Interval
Ships at anchor or moored and not faster than 3 knots	3 minutes
Ships at anchor or moored and faster than 3 knots	10 seconds
Ship 0-14 knots	10 seconds
Ship 0-14 knots and changing course	3⅓ seconds
Ship 14-23 knots	6 seconds
Ship 14-23 knots and changing course	2 seconds
Ship >23 knots	2 seconds
Ship >23 knots changing course	2 seconds

How it works: ECDIS Roll-out and Principle Features



How it works: ECDIS Roll-out and Principle Features

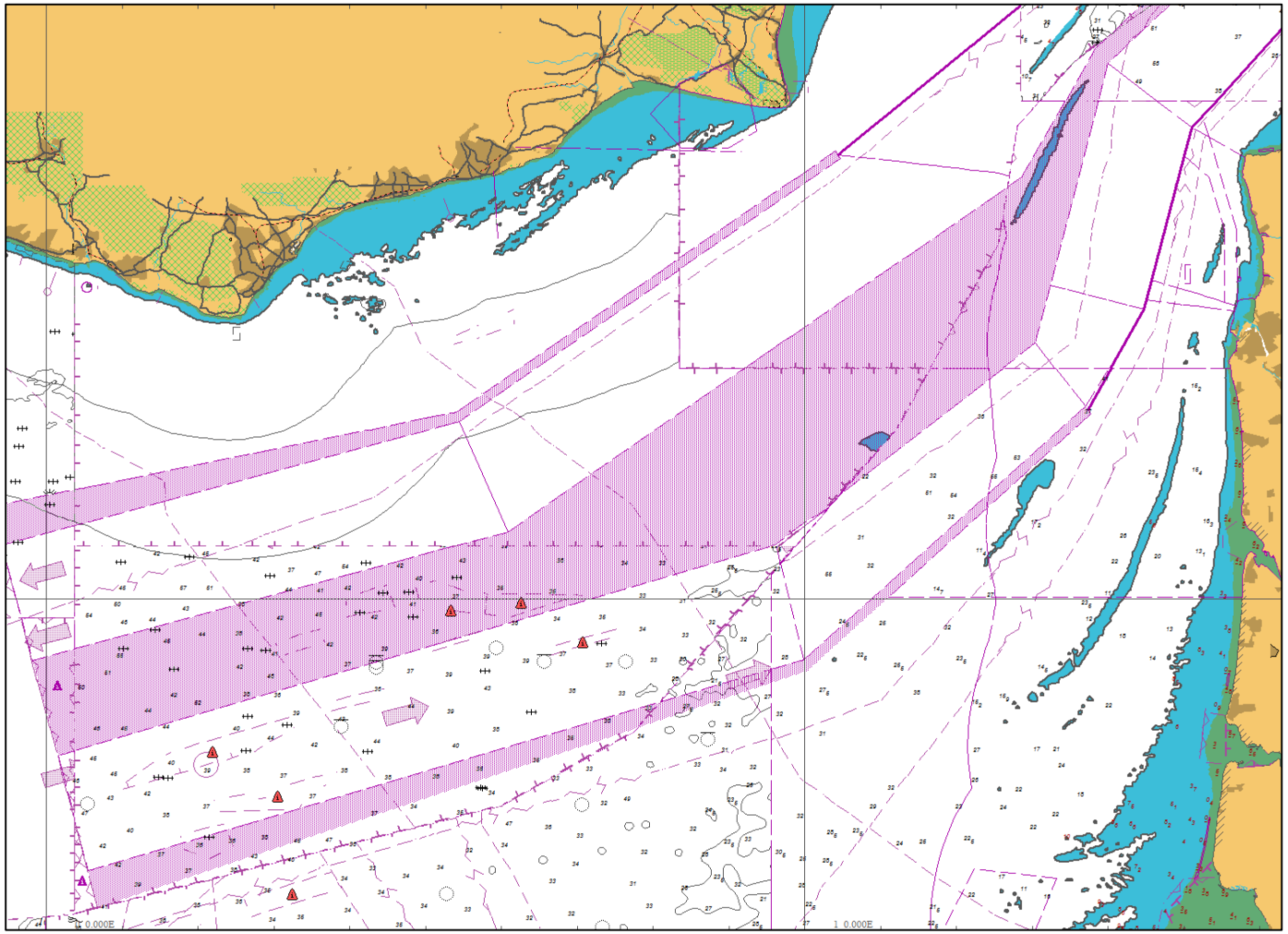
- Electronic chart displaying ‘real-time’ position, course and speed
- Undertakes complex functions to improve ‘situational awareness’:
  - Appraisal, planning, execution and monitoring
  - Monitoring the safe conduct of the vessel.
- Time-saving route planning within pre-defined ‘safety corridor’
- Can ‘replay’ navigation over previous 12 hours
- Records entire voyage 4-hourly time marks.

How it works: ECDIS [PlayStation Generation Y]

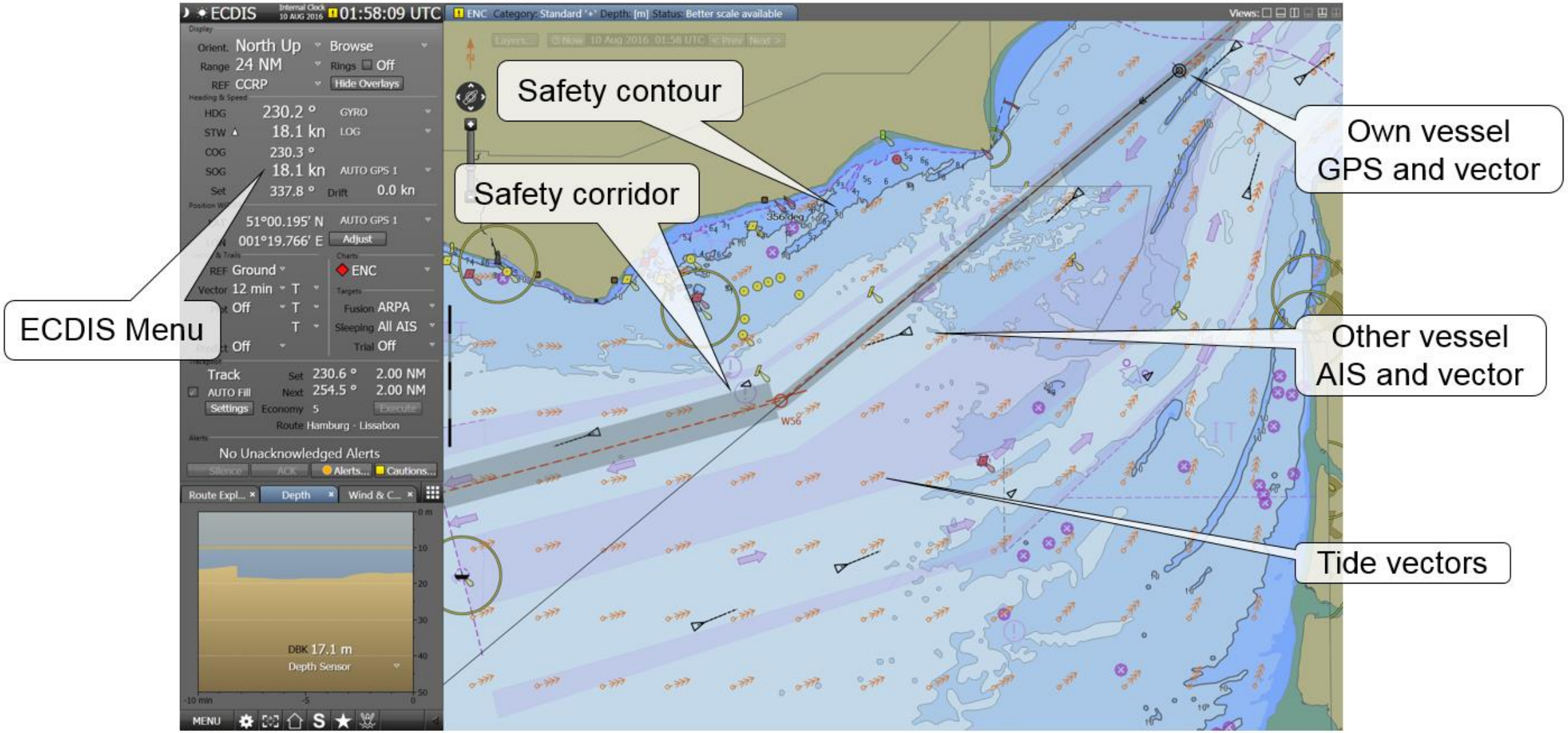
Dover Strait – West

Actually, a raster image that looks like a paper chart

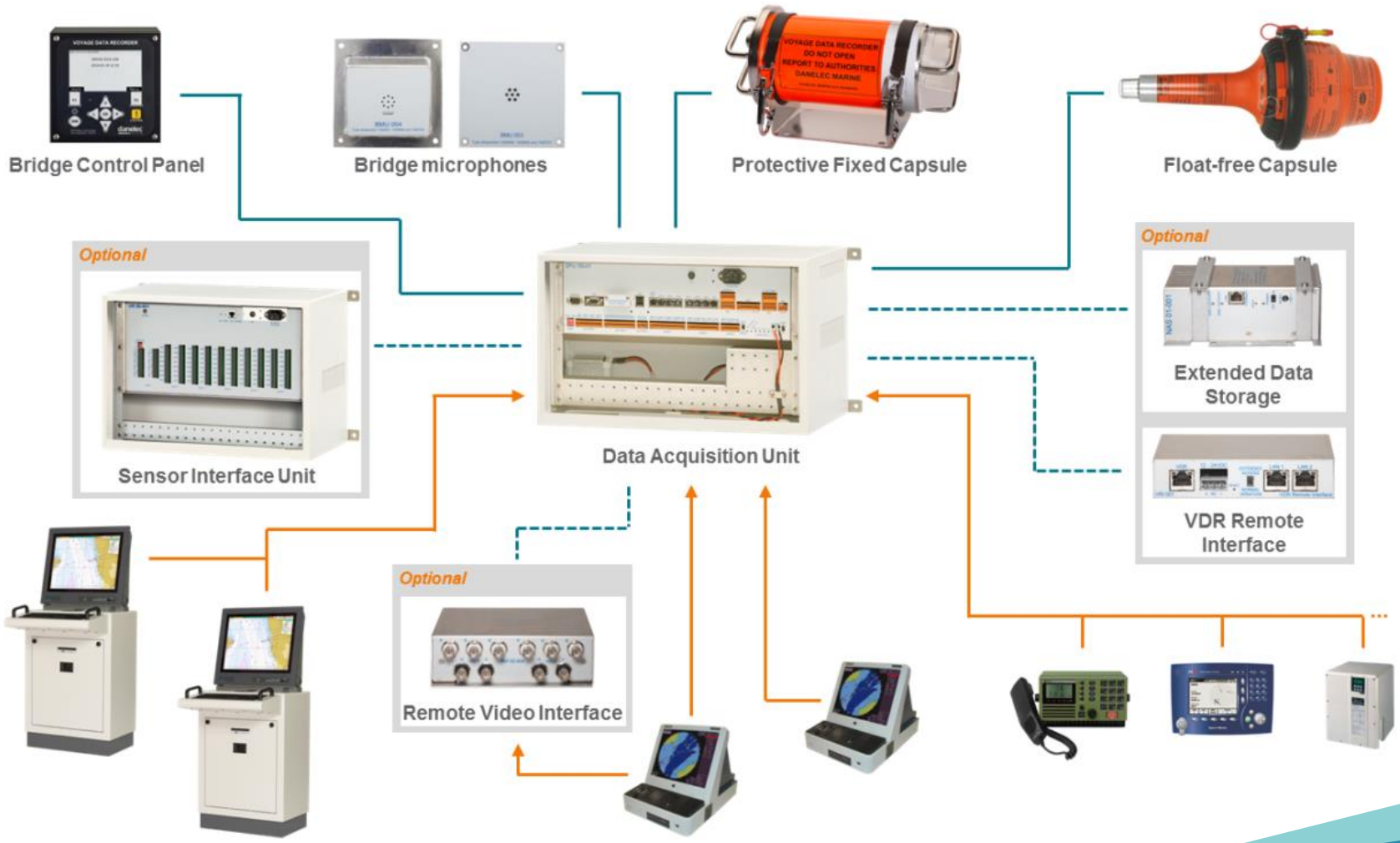
Life before ECDIS… the Paper Chart



How it works: ECDIS [PlayStation Generation Y]

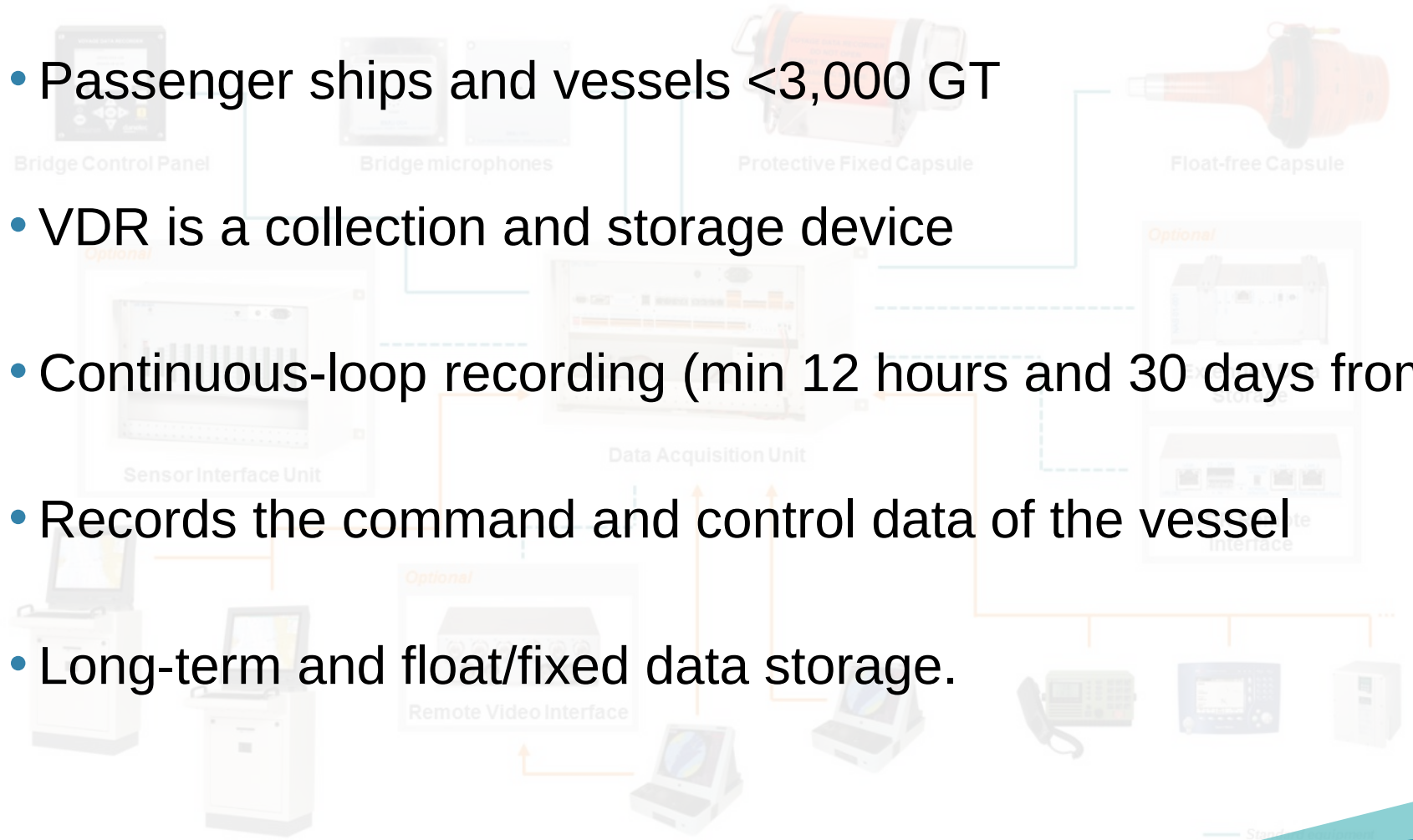


How it works: Voyage Data Recorder (VDR)

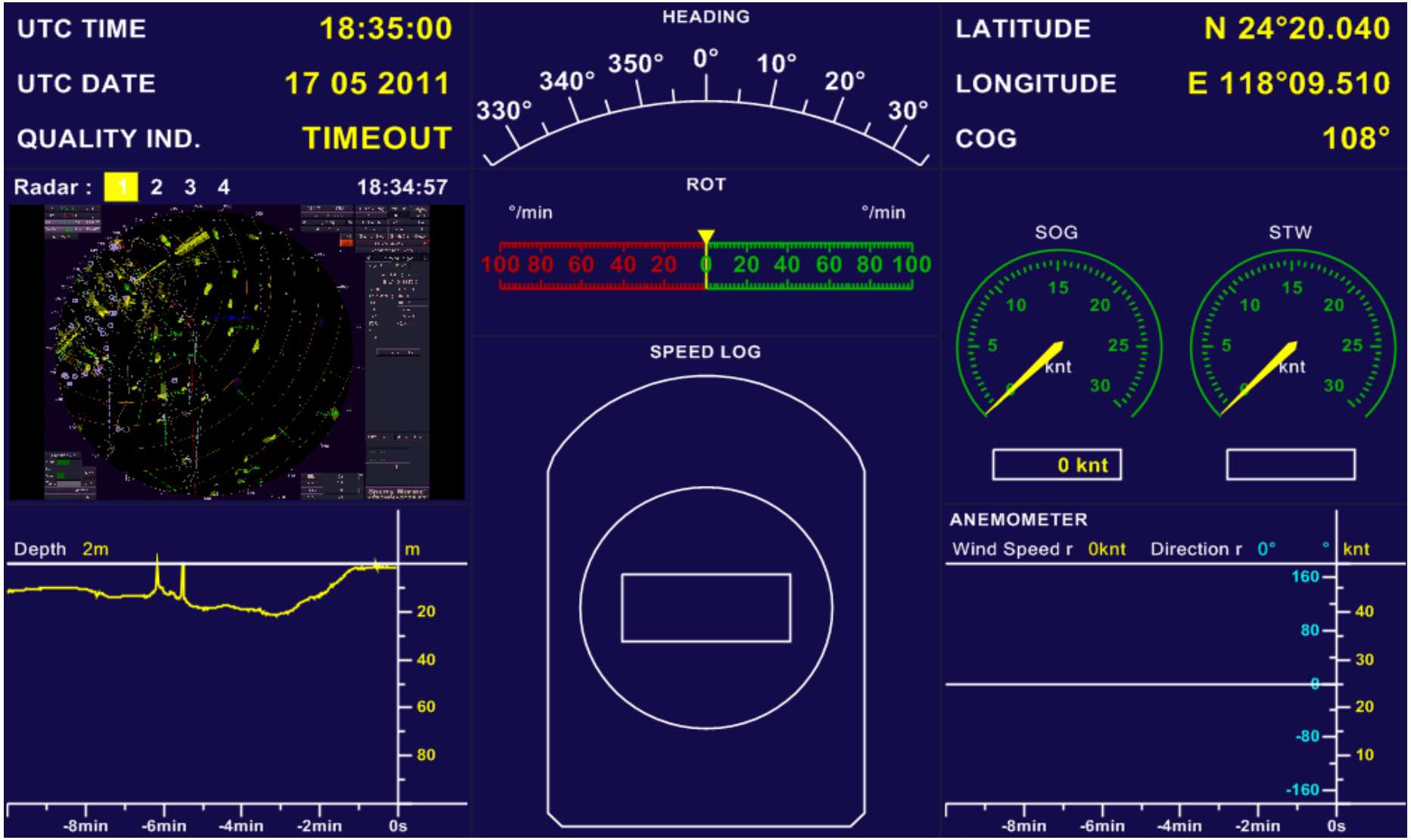


How it works: Voyage Data Recorder (VDR)

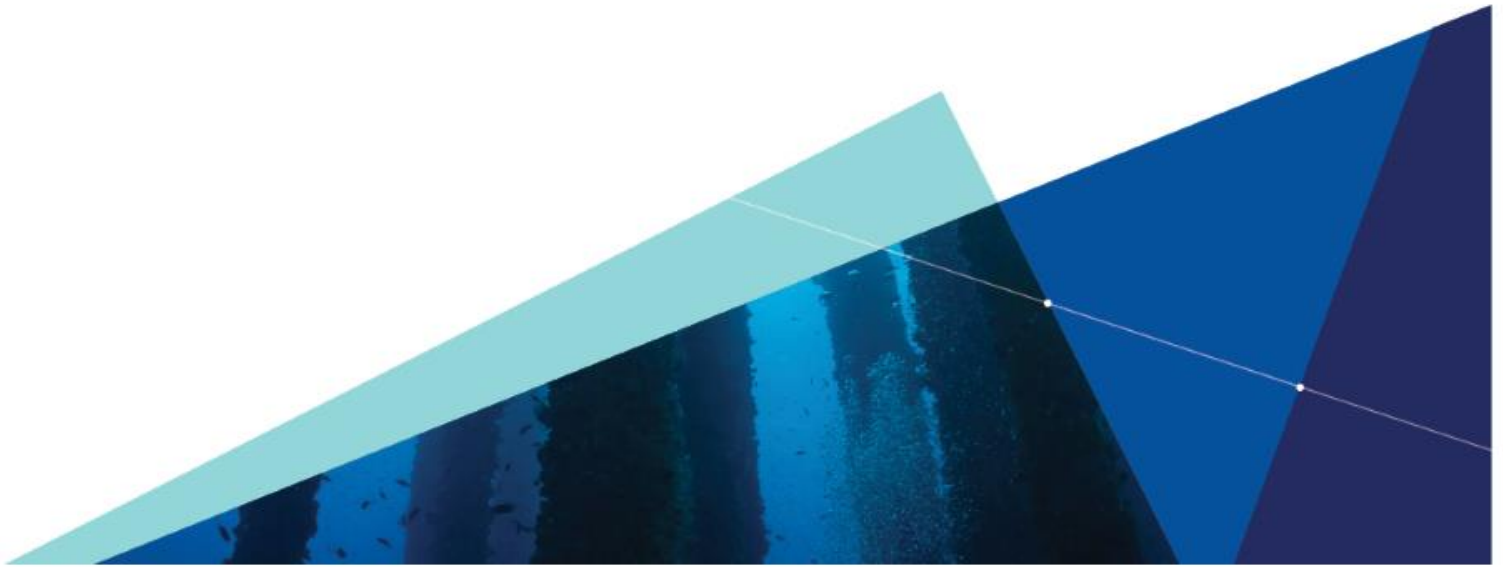
- Passenger ships and vessels <3,000 GT
- VDR is a collection and storage device
- Continuous-loop recording (min 12 hours and 30 days from 01 Jul 2014)
- Records the command and control data of the vessel
- Long-term and float/fixed data storage.



How it works: VDR Replay Software



Casualty Investigation and Accident Analysis



Investigating Failures in Situational Awareness

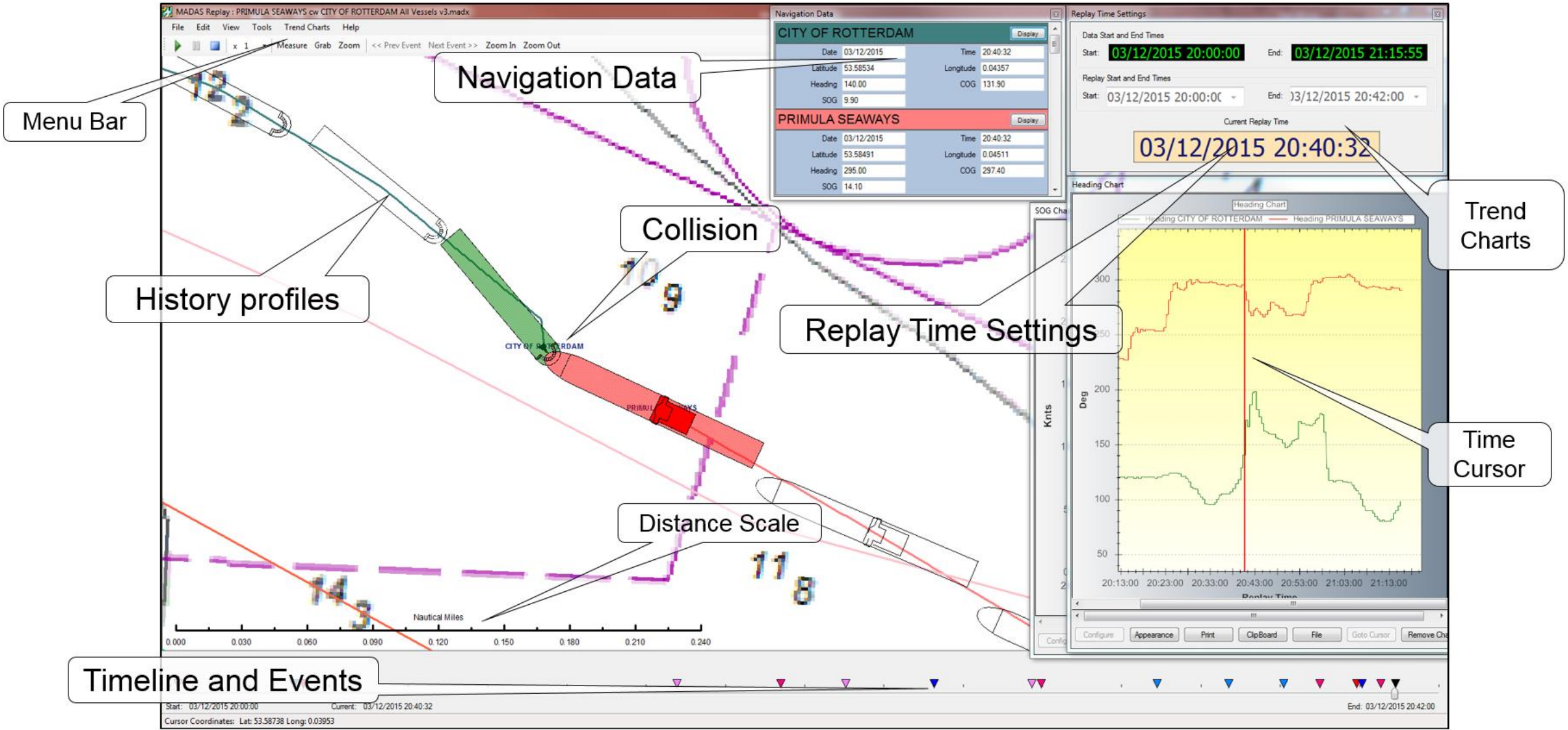
- Groundings and collisions: failure of ‘situational awareness’
- Causation: forensic analysis of electronic evidence
- Validate: compare ‘contemporaneous’ evidence

2-D MADAS (Marine Accident Data Analysis Suite)

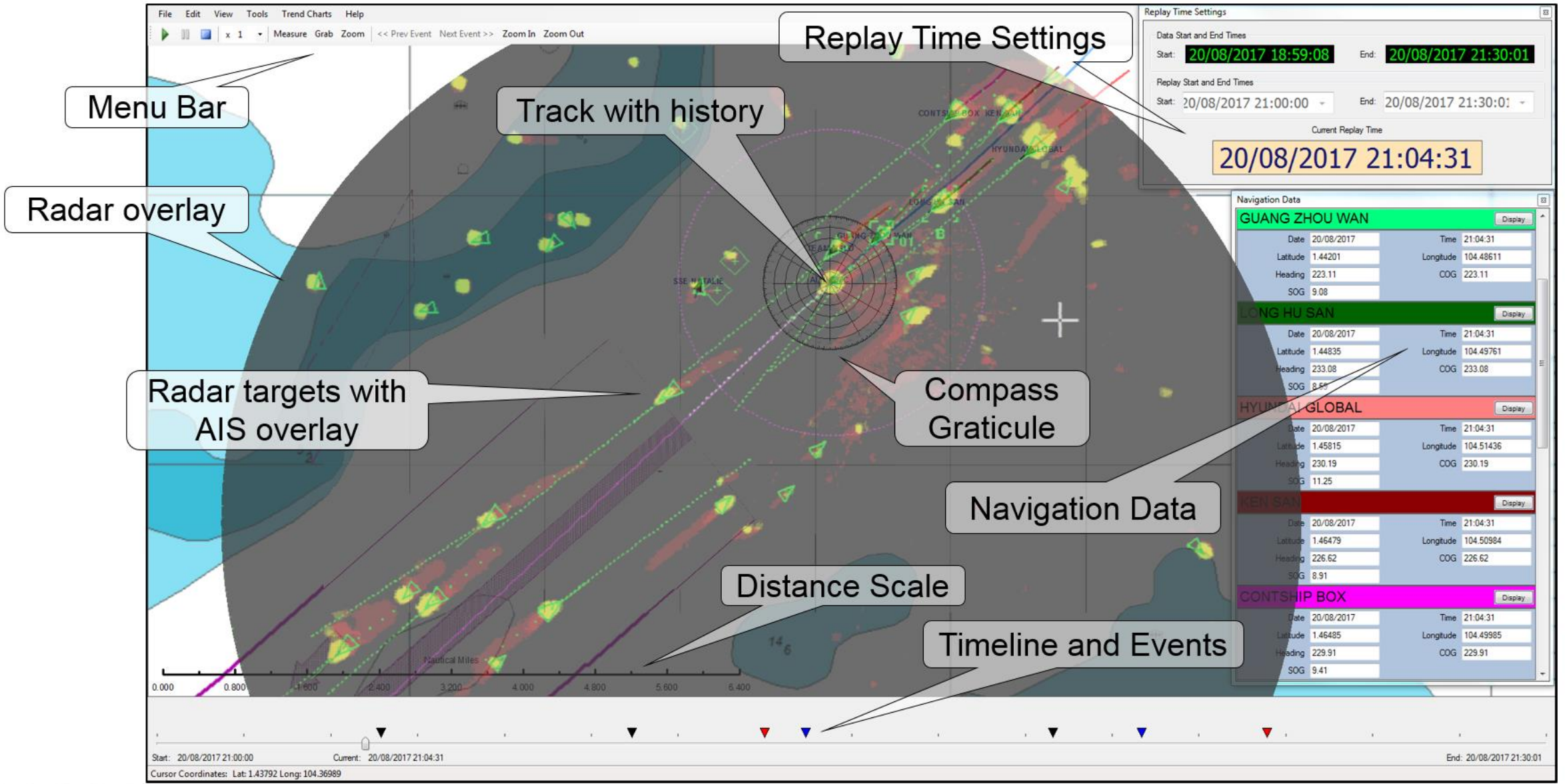
- Developed by Avenca Ltd for UK MAIB and US NTSB.
- The software can:
  - Display multiple tracks
  - Extract and use AIS and/or VDR data
  - Use audio tracks
  - Display charts and overlays
  - Display various media including radar overlay
  - Display ship shapes.

avenca

Sample MADAS Replay Software



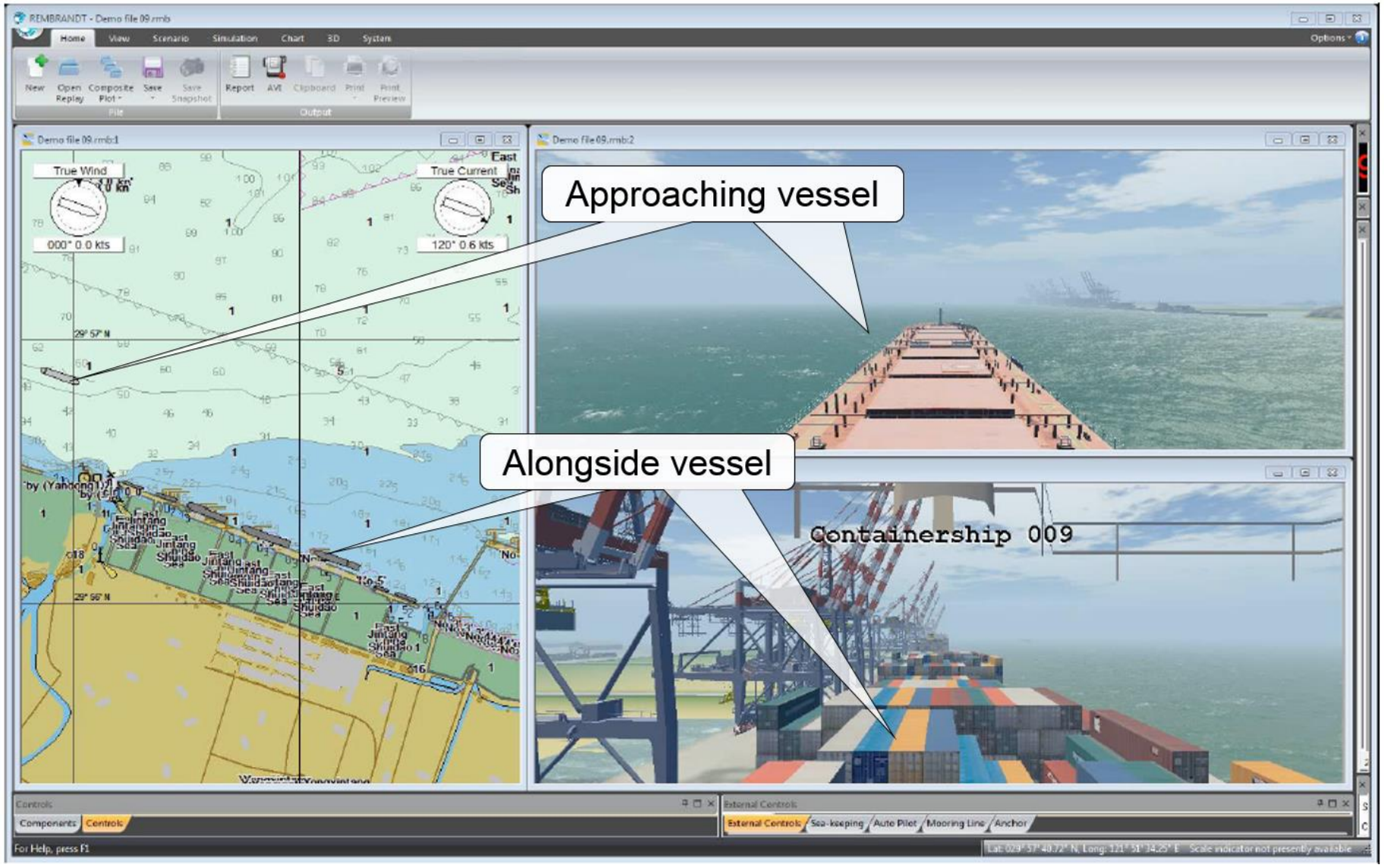
MADAS Replay Software



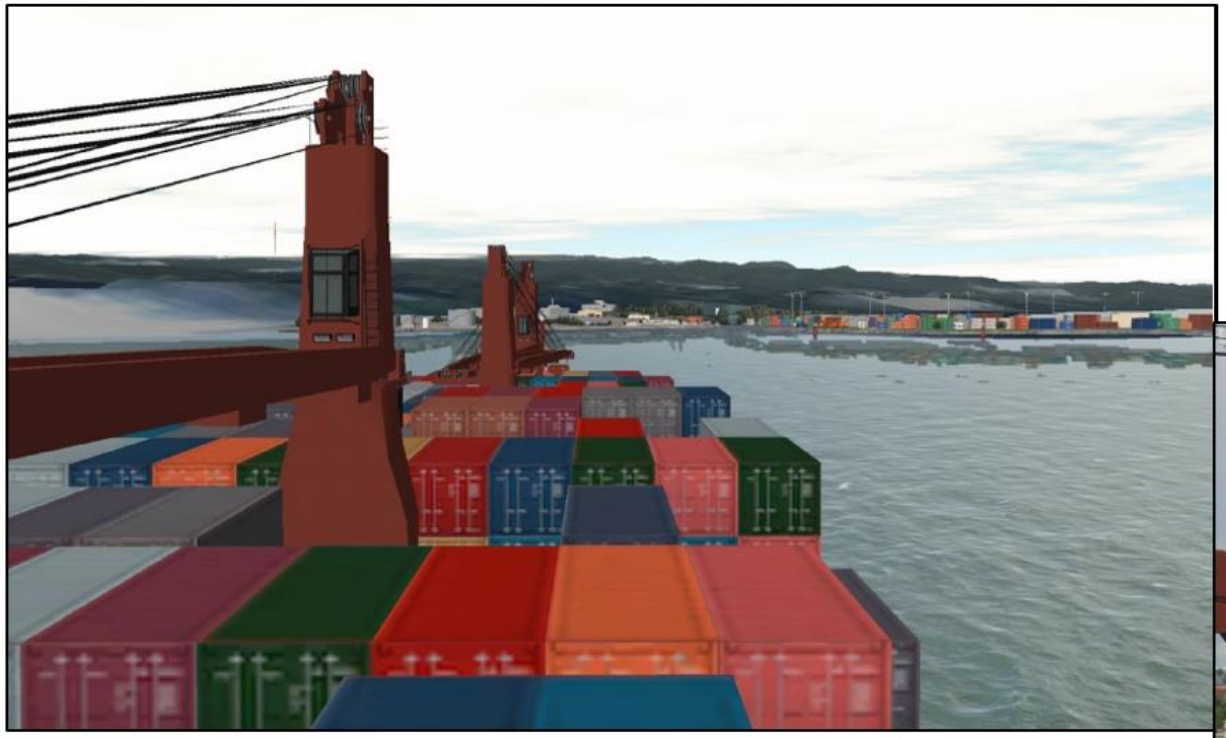
3-D REMBRANDT (Real-time Manoeuvring, Berthing and Training)

- Developed by BMT and used by many shipowners, pilots and port authorities
- The software can model:
  - Recreate environmental conditions
  - Use raster and vector ENC charts to give bathymetric representation
  - Visual topography with additional library or customer specified objects
  - Large vessel database or tailored hull designs and propulsion configurations
  - Imports same electronic data as MADAS.

REMBRANDT – Collision analysis



REMBRANDT – Visual scene with photo texturing



Visual scene with photo texturing

Actual photograph

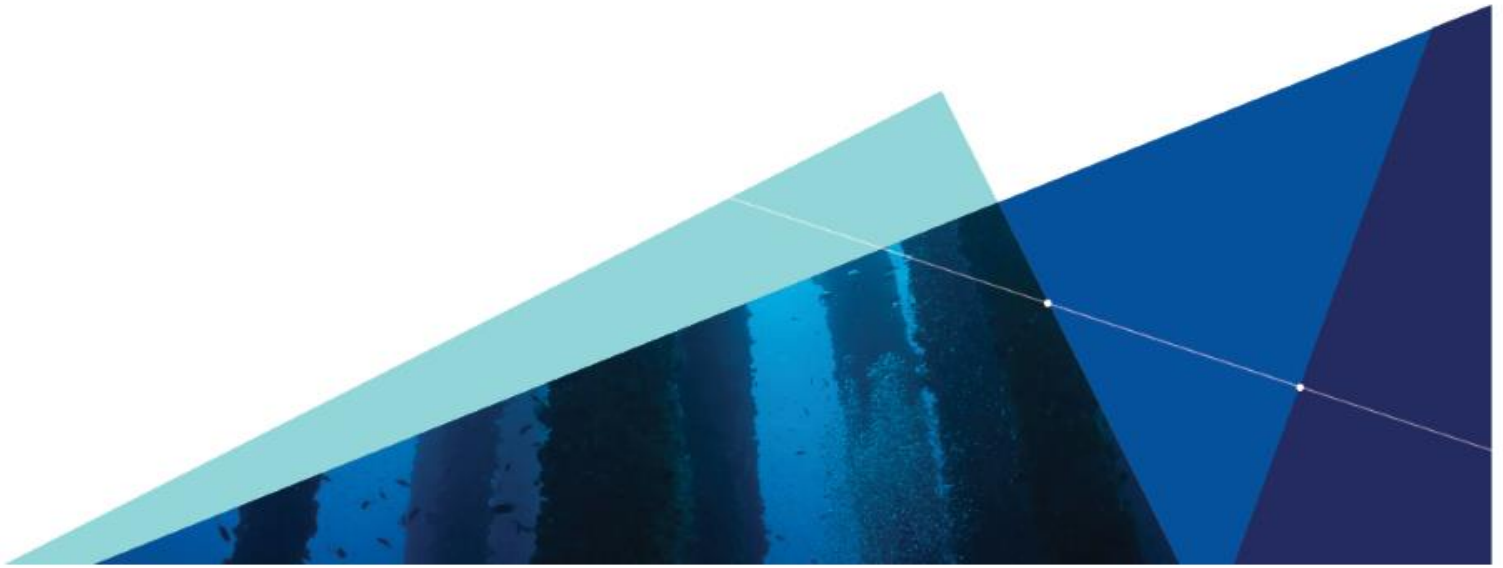
[Traditional] Casualty Investigation and Litigation

- Attend casualty, interview crew and take statements
- Collect contemporaneous [and digital] evidence
- Determine ‘angle of blow’ in collisions
- Determine ‘type and location of damage’ in groundings
- Disclose documentation [including digital evidence]
- Engage experts if no agreement
- Proceed to trial.

[Modern] Accident Analysis

- Undertake accident analysis using electronic evidence
- Validate contemporaneous evidence
- Incontrovertible evidence leads to:
  - Agreed set of facts, and
  - Causation
- Parties agree ‘liability’ and ‘costs’, often without litigation and trial.

Case Studies



Case 1: MV MAKE BELIEVE Allision with the Quayside

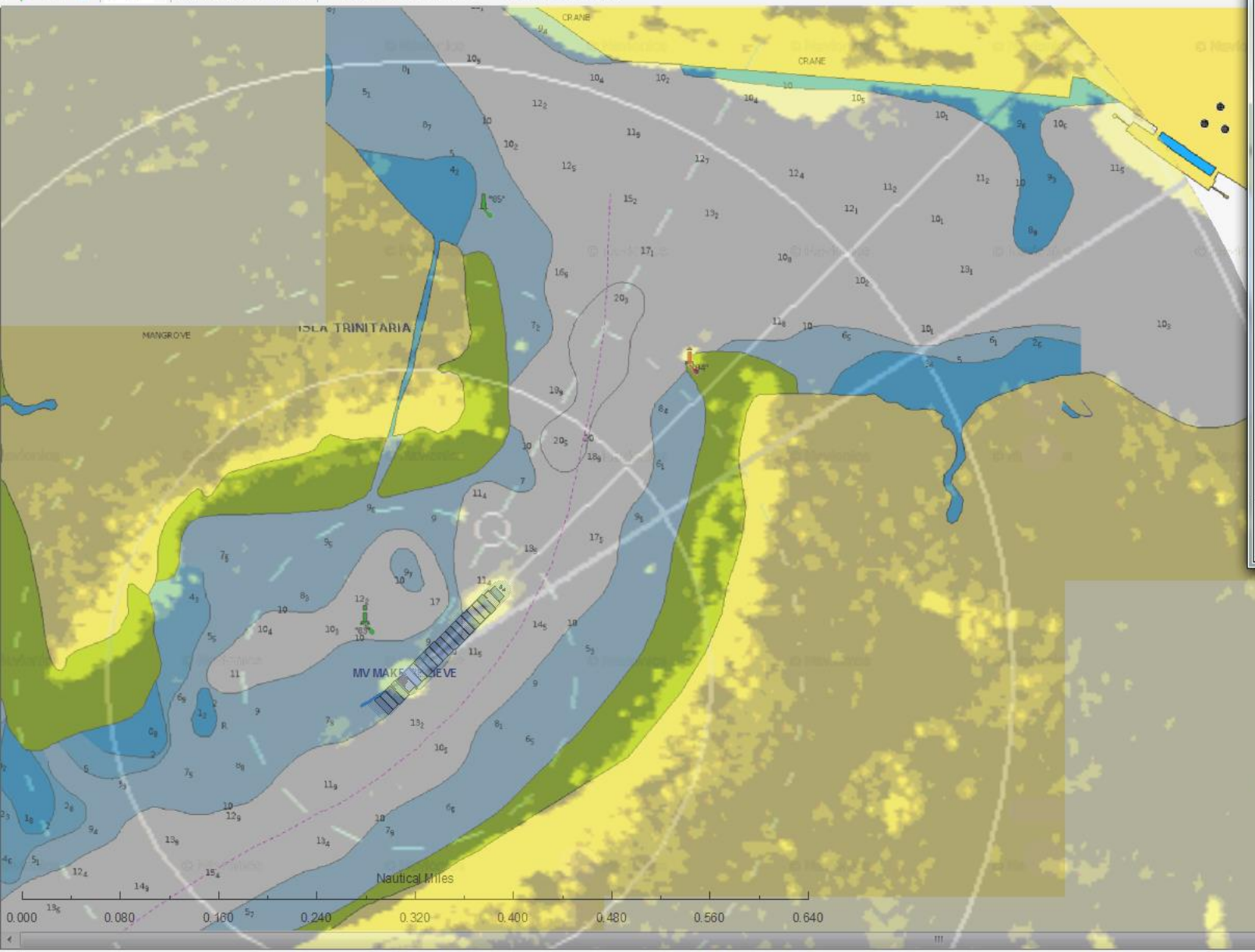
- 5th April 2010, Never Never Land
- Full VDR with radar overlay and audio
- Daylight in favourable conditions
- MV MAKE BELIEVE passes through narrow channel to approach berth
- No tugs in attendance.

(Screenshots i.e. not video)

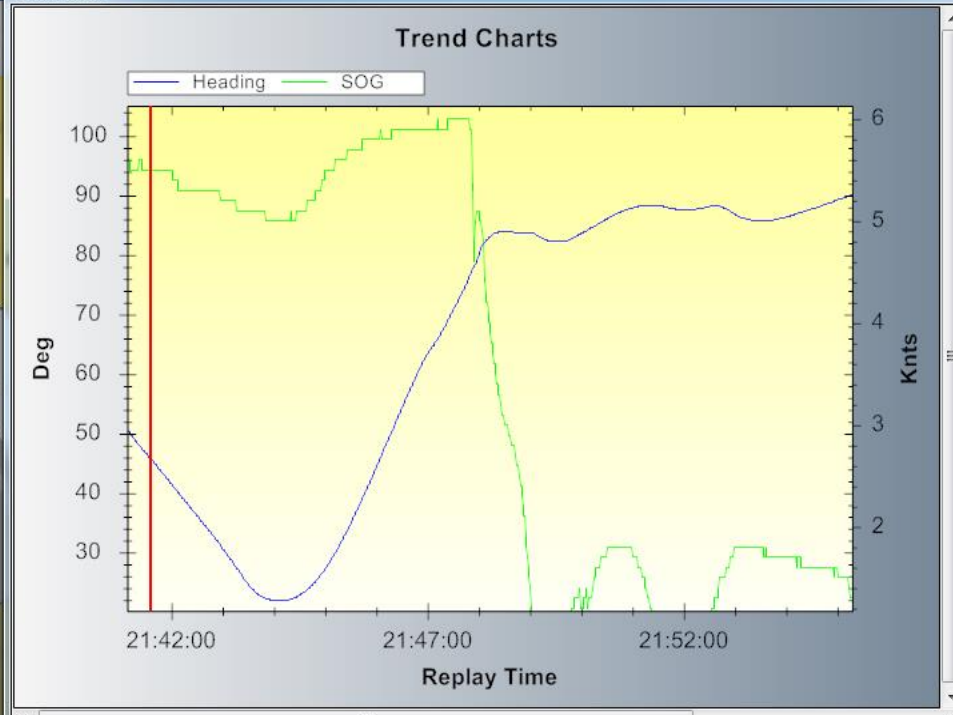
MADAS Replay: MV MAKE BELIEVE Side.madx

File Edit View Tools Trend Charts Help

x 1 Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out



Trend Charts



Configure Appearance Print ClipBoard File Goto Cursor Remove Chart Annotation

Replay Time Settings

Data Start and End Times

Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35

Replay Start and End Times

Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35

Current Replay Time

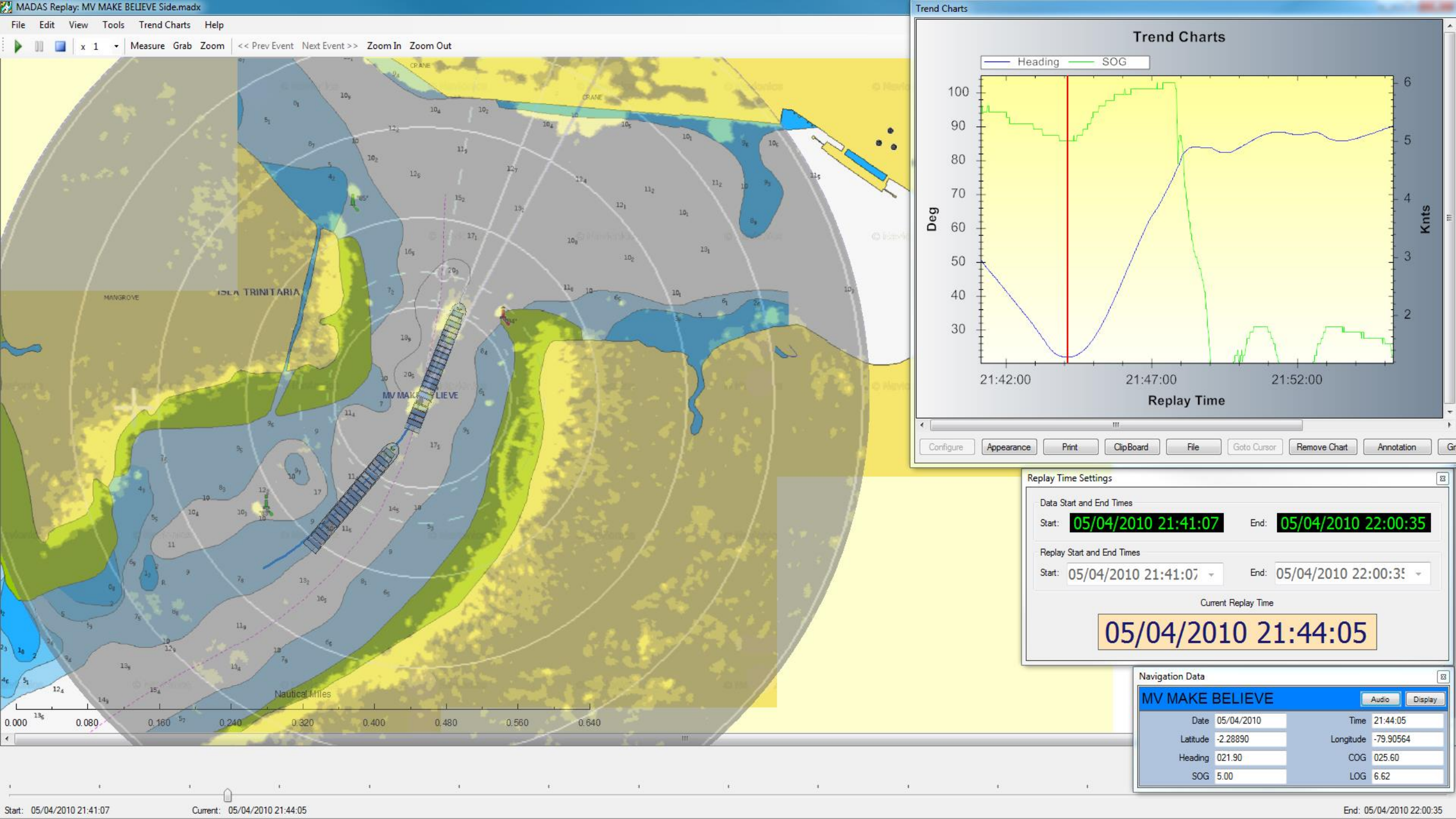
05/04/2010 21:41:34

Navigation Data

MV MAKE BELIEVE Audio Display

Date	05/04/2010	Time	21:41:34
Latitude	-2.29163	Longitude	-79.90797
Heading	046.00	COG	055.30
SOG	5.50	LOG	6.88

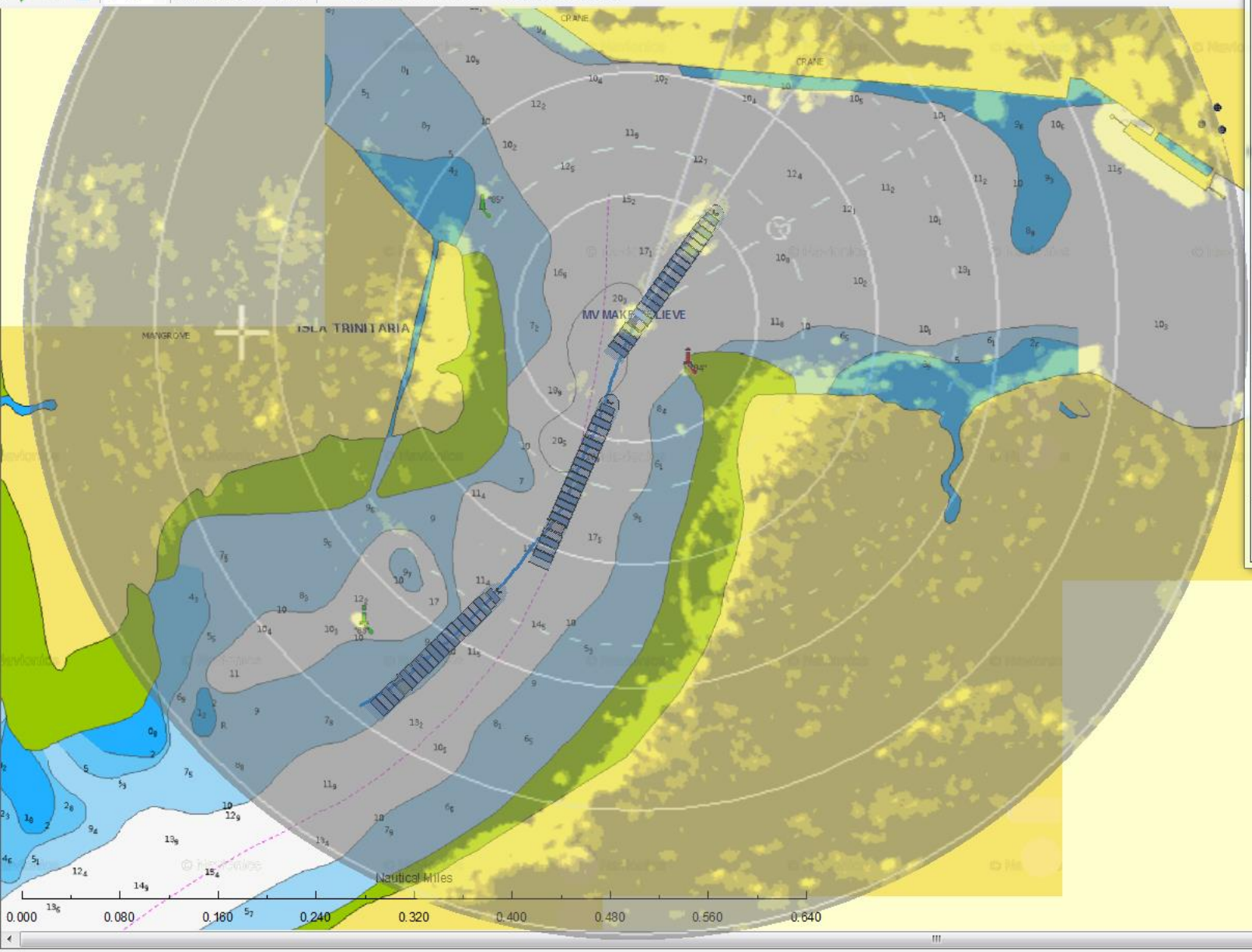
Start: 05/04/2010 21:41:07 Current: 05/04/2010 21:41:34 End: 05/04/2010 22:00:35


MADAS Replay: MV MAKE BELIEVE Side.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
ISLA TRINITARIA
MANGROVE
CRANE
MV MAKE BELIEVE
Nautical Miles
0.000 0.080 0.160 0.240 0.320 0.400 0.480 0.560 0.640
Trend Charts
Heading SOG
Deg
Knts
21:42:00 21:47:00 21:52:00
Replay Time
Configure Appearance Print ClipBoard File Goto Cursor Remove Chart Annotation
Replay Time Settings
Data Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Replay Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Current Replay Time
05/04/2010 21:44:05
Navigation Data
MV MAKE BELIEVE
Audio Display
Date 05/04/2010 Time 21:44:05
Latitude -2.28890 Longitude -79.90564
Heading 021.90 COG 025.60
SOG 5.00 LOG 6.62
Start: 05/04/2010 21:41:07 Current: 05/04/2010 21:44:05 End: 05/04/2010 22:00:35

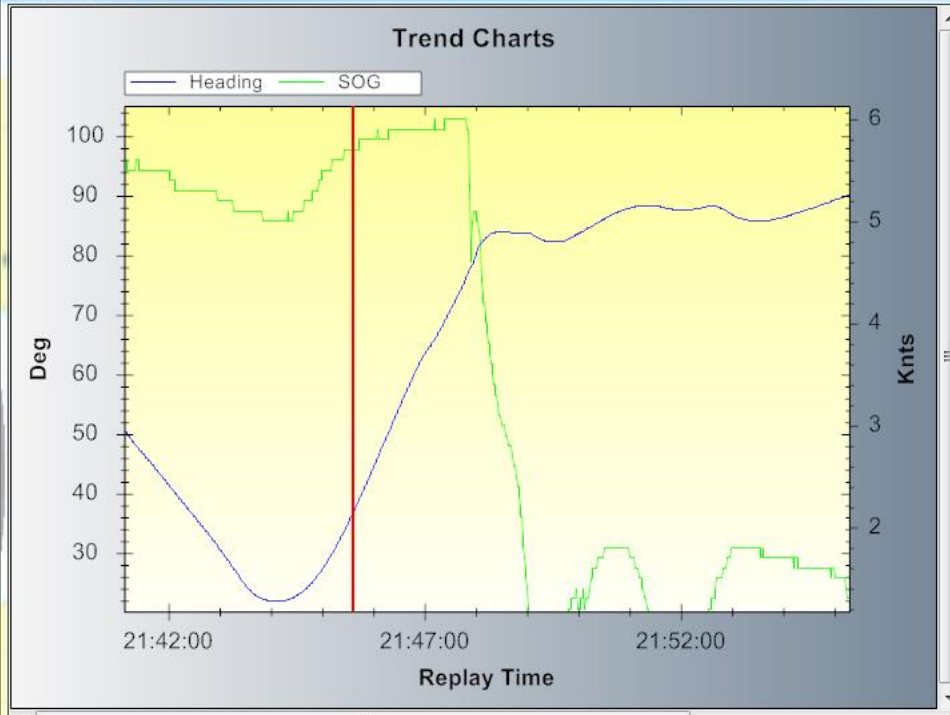
MADAS Replay: MV MAKE BELIEVE Side.madx

File Edit View Tools Trend Charts Help

x 1 Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out



Trend Charts



Configure | Appearance | Print | ClipBoard | File | Goto Cursor | Remove Chart | Annotation

Replay Time Settings

Data Start and End Times

Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35

Replay Start and End Times

Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35

Current Replay Time

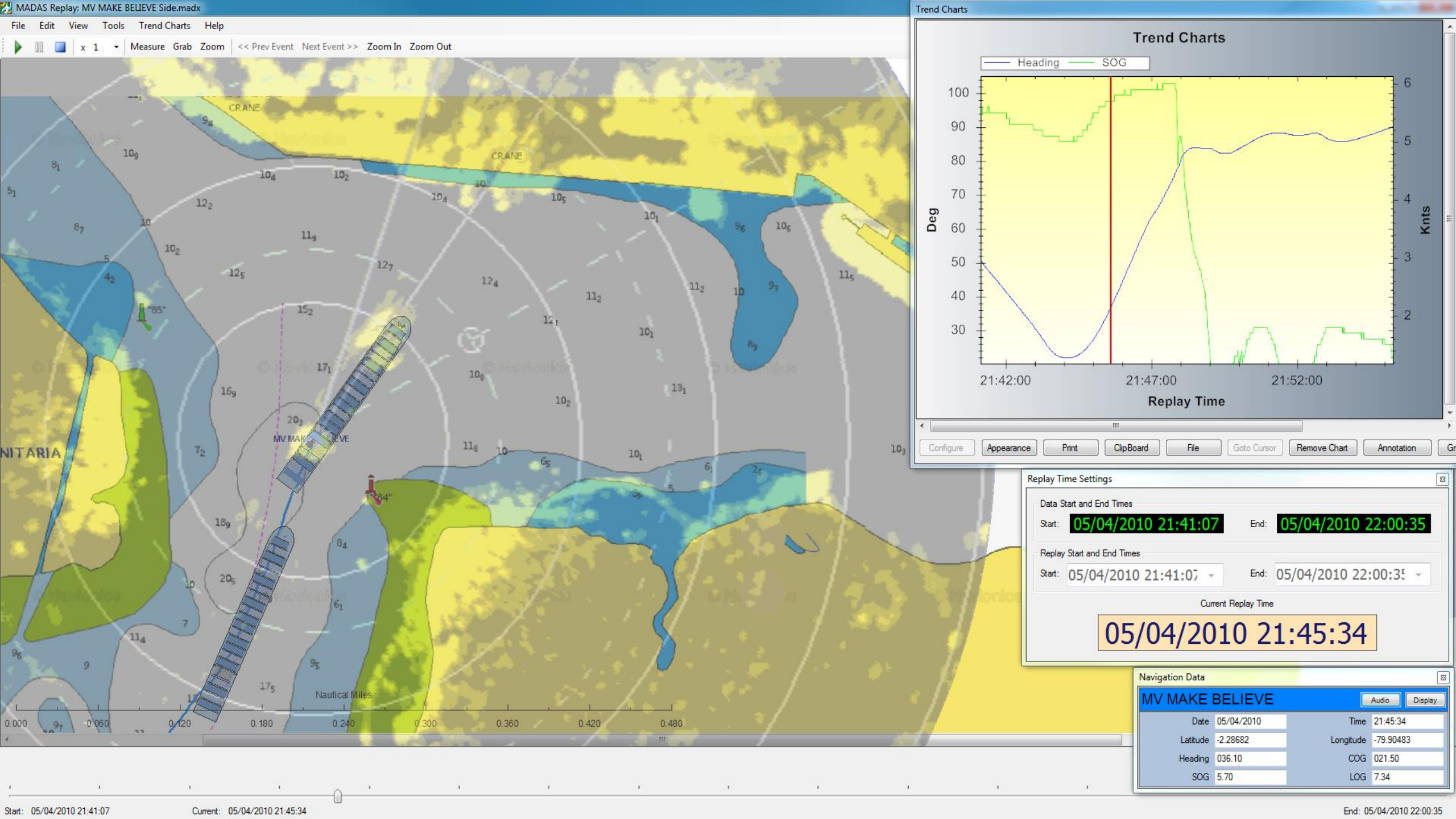
05/04/2010 21:45:34

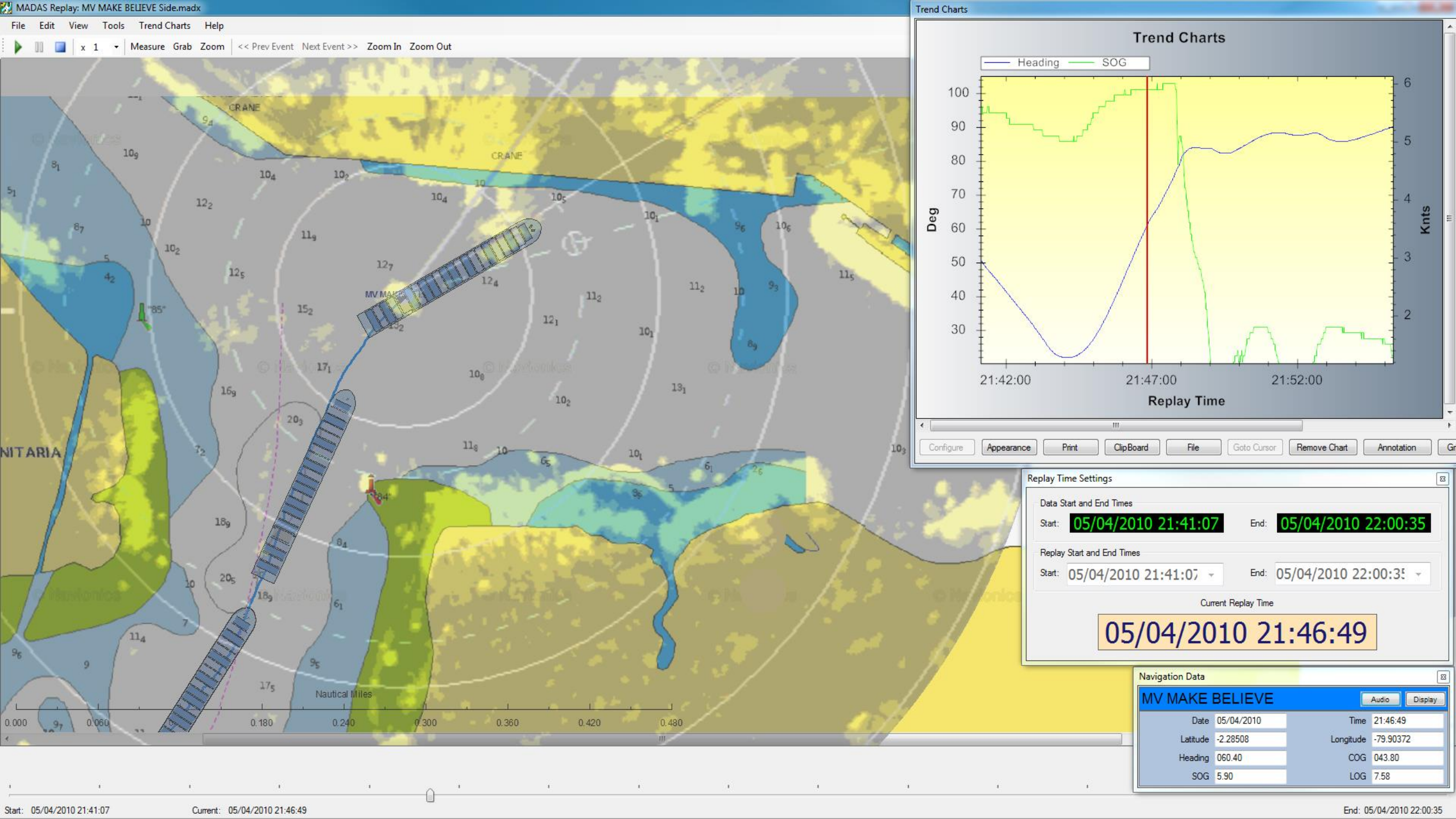
Navigation Data

MV MAKE BELIEVE Audio Display

Date	05/04/2010	Time	21:45:34
Latitude	-2.28682	Longitude	-79.90483
Heading	036.10	COG	021.50
SOG	5.70	LOG	7.34

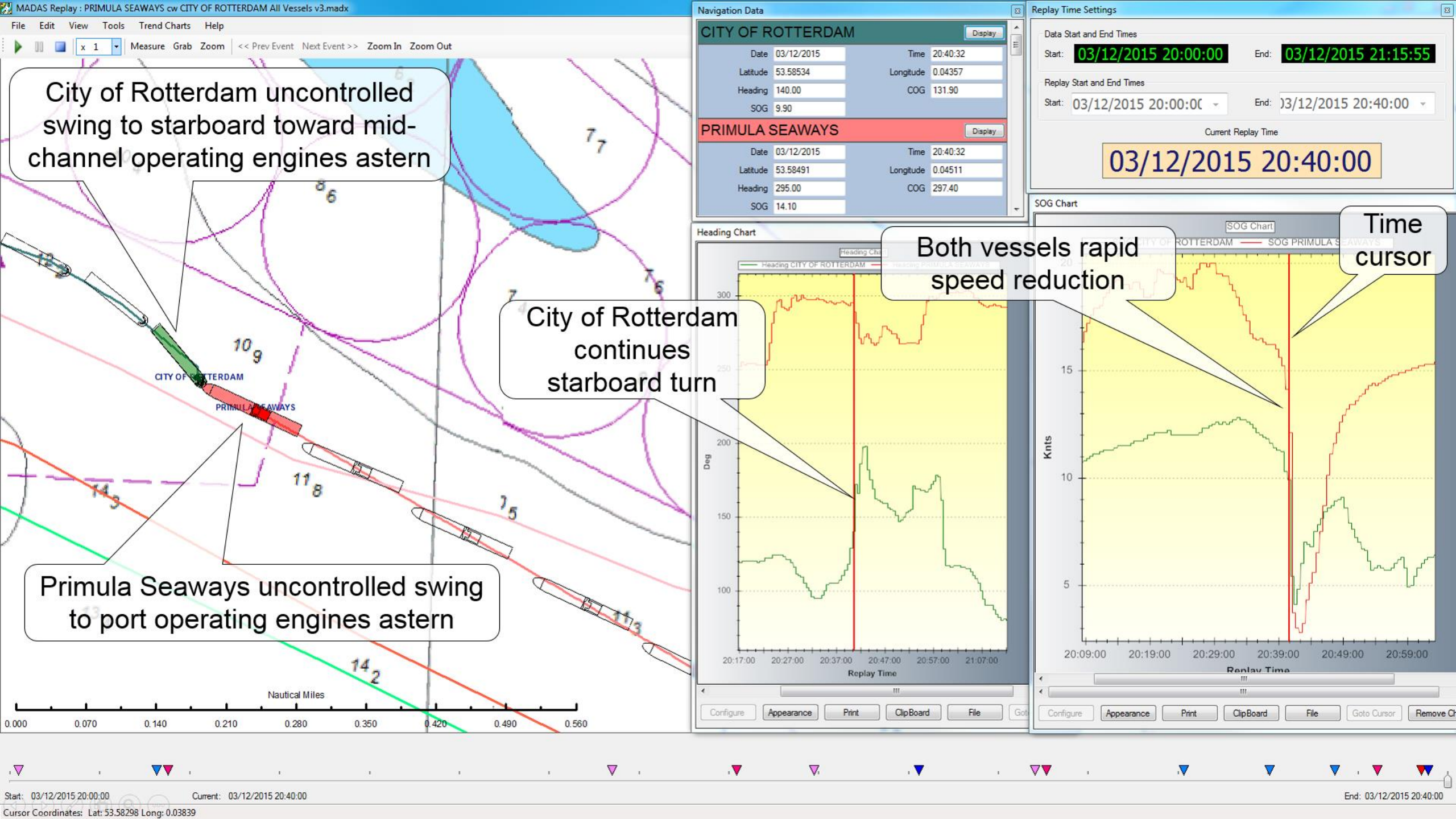
Start: 05/04/2010 21:41:07 Current: 05/04/2010 21:45:34 End: 05/04/2010 22:00:35


MADAS Replay: MV MAKE BELIEVE Side.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
CRANE
MV MAKE BELIEVE
Nautical Miles
0.000 0.060 0.120 0.180 0.240 0.300 0.360 0.420 0.480
Trend Charts
Heading SOG
Deg
Knts
21:42:00 21:47:00 21:52:00
Replay Time
Configure Appearance Print ClipBoard File Goto Cursor Remove Chart Annotation
Replay Time Settings
Data Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Replay Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Current Replay Time
05/04/2010 21:45:34
Navigation Data
MV MAKE BELIEVE
Audio Display
Date 05/04/2010 Time 21:45:34
Latitude -2.28682 Longitude -79.90483
Heading 036.10 COG 021.50
SOG 5.70 LOG 7.34
Start: 05/04/2010 21:41:07 Current: 05/04/2010 21:45:34 End: 05/04/2010 22:00:35


MADAS Replay: MV MAKE BELIEVE Side.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
CRANE
MV MAKE BELIEVE
NITARIA
Nautical Miles
0.000 0.060 0.180 0.240 0.300 0.360 0.420 0.480
Trend Charts
Heading SOG
Deg
Knts
21:42:00 21:47:00 21:52:00
Replay Time
Configure Appearance Print ClipBoard File Goto Cursor Remove Chart Annotation
Replay Time Settings
Data Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Replay Start and End Times
Start: 05/04/2010 21:41:07 End: 05/04/2010 22:00:35
Current Replay Time
05/04/2010 21:46:49
Navigation Data
MV MAKE BELIEVE
Audio Display
Date 05/04/2010 Time 21:46:49
Latitude -2.28508 Longitude -79.90372
Heading 060.40 COG 043.80
SOG 5.90 LOG 7.58
Start: 05/04/2010 21:41:07 Current: 05/04/2010 21:46:49 End: 05/04/2010 22:00:35

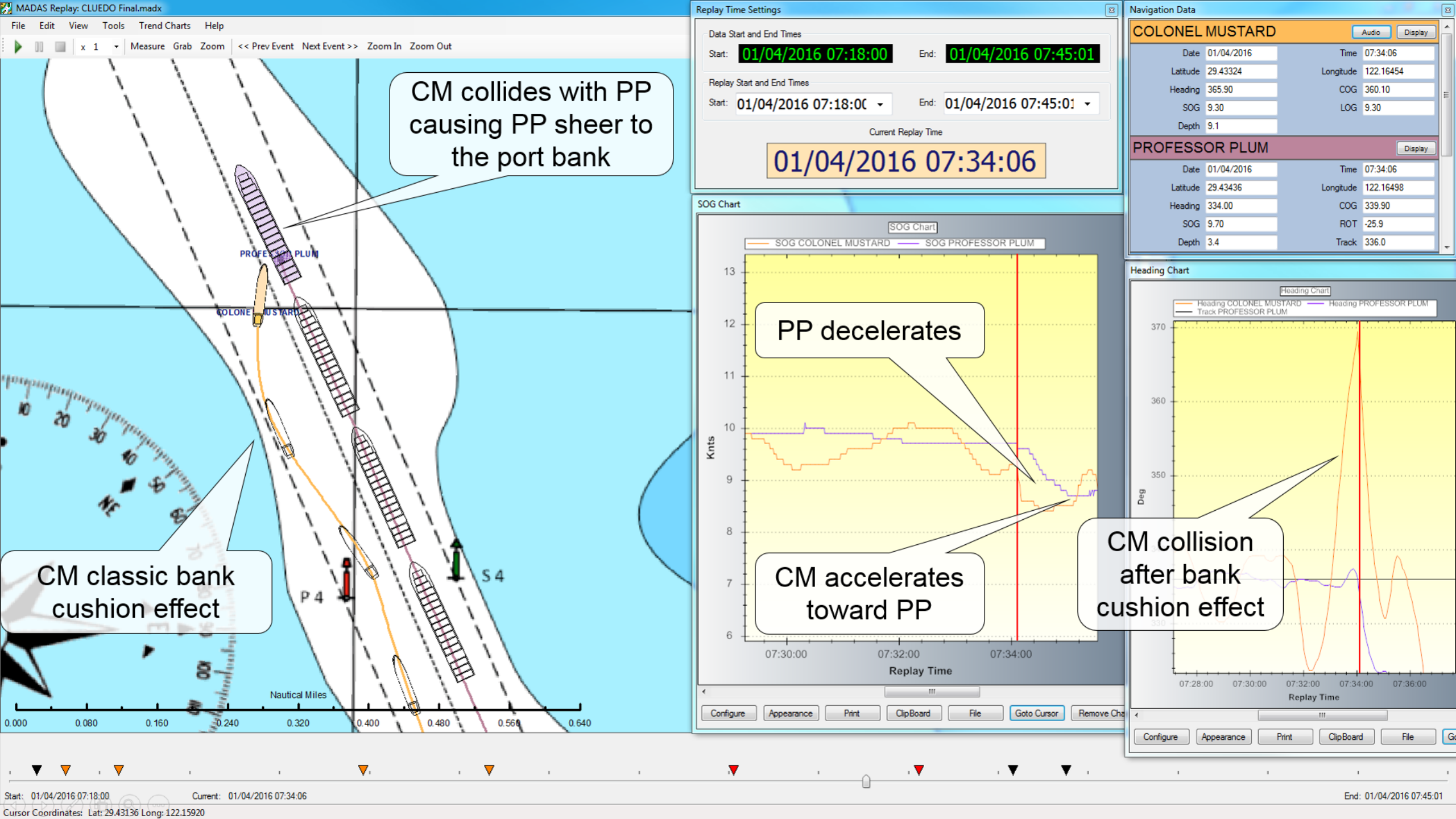
Case 2: PRIMULA SEAWAYS c/w CITY OF ROTTERDAM

- Date 3rd December 2015, Humber Estuary, Hull, England
- Open-Source Terrestrial AIS, no VDR
- Dawn, poor visibility, and very high wind and sea
- CITY OF ROTTERDAM pilot embarked outbound
- PRIMULA SEAWAYS pilot exemption inbound.


MADAS Replay : PRIMULA SEAWAYS cw CITY OF ROTTERDAM All Vessels v3.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
City of Rotterdam uncontrolled swing to starboard toward mid-channel operating engines astern
City of Rotterdam continues starboard turn
Both vessels rapid speed reduction
Time cursor
Primula Seaways uncontrolled swing to port operating engines astern
CITY OF ROTTERDAM
PRIMULA SEAWAYS
Nautical Miles
0.000 0.070 0.140 0.210 0.280 0.350 0.420 0.490 0.560
Navigation Data
CITY OF ROTTERDAM
Display
Date 03/12/2015
Time 20:40:32
Latitude 53.58534
Longitude 0.04357
Heading 140.00
COG 131.90
SOG 9.90
PRIMULA SEAWAYS
Display
Date 03/12/2015
Time 20:40:32
Latitude 53.58491
Longitude 0.04511
Heading 295.00
COG 297.40
SOG 14.10
Replay Time Settings
Data Start and End Times
Start: 03/12/2015 20:00:00
End: 03/12/2015 21:15:55
Replay Start and End Times
Start: 03/12/2015 20:00:00
End: 03/12/2015 20:40:00
Current Replay Time
03/12/2015 20:40:00
Heading Chart
Heading CITY OF ROTTERDAM
Deg
300
250
200
150
100
20:17:00 20:27:00 20:37:00 20:47:00 20:57:00 21:07:00
Replay Time
Configure Appearance Print ClipBoard File
SOG Chart
SOG CITY OF ROTTERDAM
SOG PRIMULA SEAWAYS
Knts
15
10
5
20:09:00 20:19:00 20:29:00 20:39:00 20:49:00 20:59:00
Replay Time
Configure Appearance Print ClipBoard File Goto Cursor
Start: 03/12/2015 20:00:00
Current: 03/12/2015 20:40:00
End: 03/12/2015 20:40:00
Cursor Coordinates: Lat: 53.58298 Long: 0.03839

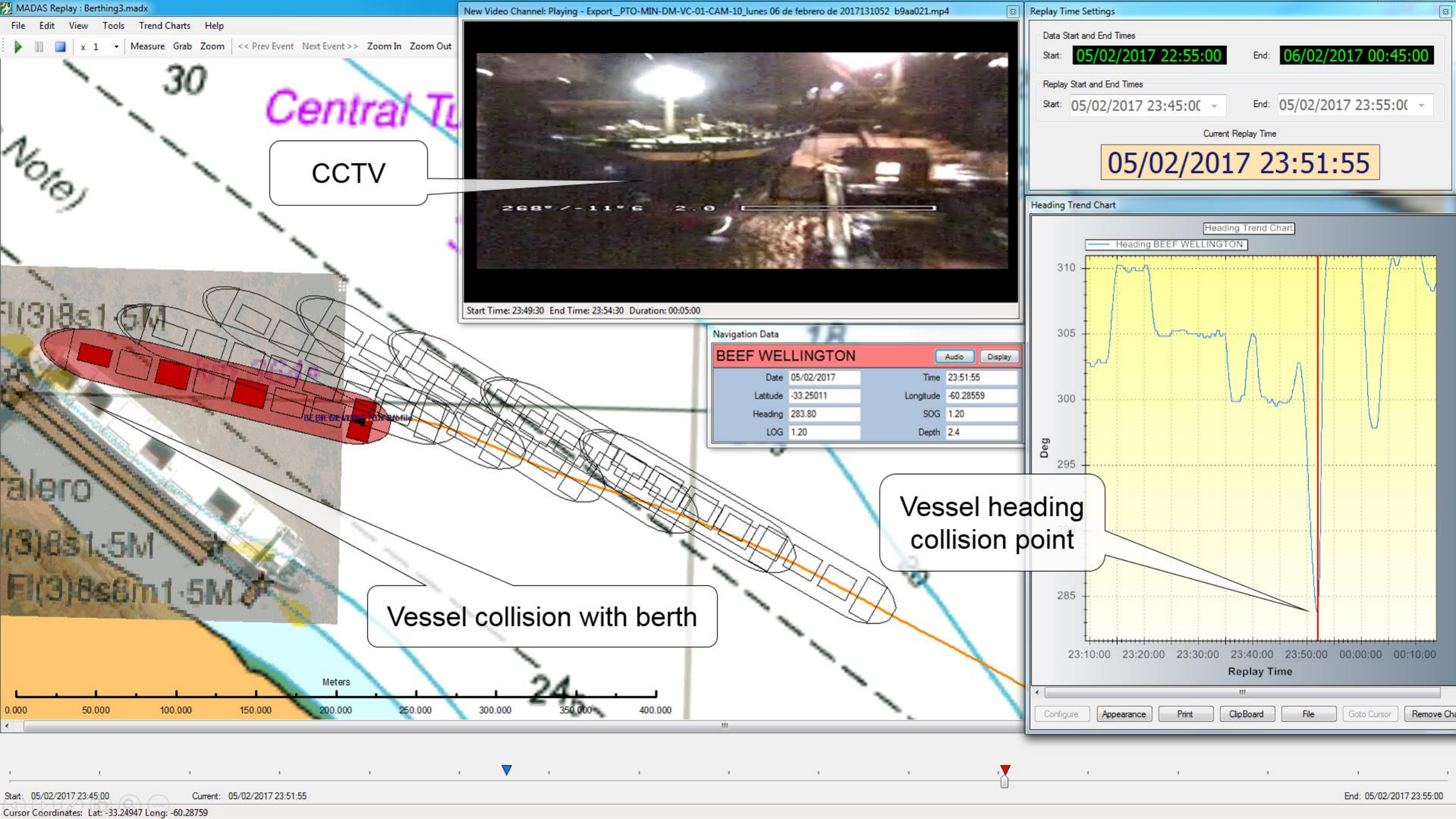
Case 3: COLONEL MUSTARD c/w PROFESSOR PLUM

- April Fool's Day 2016, Canal Interaction
- Full VDR both vessels
- Daylight good visibility and benign conditions
- PROFESSOR PLUM 5x the displacement of COLONEL MUSTARD
- PROFESSOR PLUM allowed overtake of COLONEL MUSTARD.

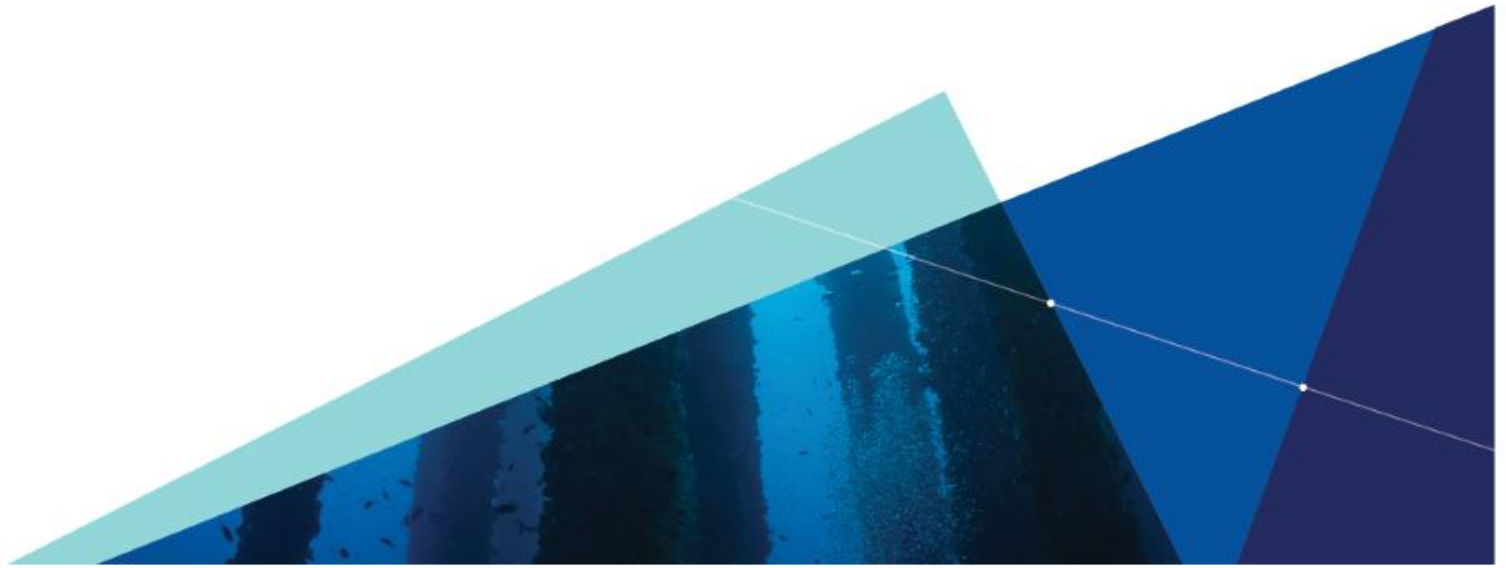

MADAS Replay: CLUEDO Final.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
CM collides with PP causing PP sheer to the port bank
PROFESSOR PLUM
COLONEL MUSTARD
P 4
S 4
CM classic bank cushion effect
Nautical Miles
0.000 0.080 0.160 0.240 0.320 0.400 0.480 0.560 0.640
Replay Time Settings
Data Start and End Times
Start: 01/04/2016 07:18:00
End: 01/04/2016 07:45:01
Replay Start and End Times
Start: 01/04/2016 07:18:0(
End: 01/04/2016 07:45:0:
Current Replay Time
01/04/2016 07:34:06
Navigation Data
COLONEL MUSTARD
Audio Display
Date 01/04/2016 Time 07:34:06
Latitude 29.43324 Longitude 122.16454
Heading 365.90 COG 360.10
SOG 9.30 LOG 9.30
Depth 9.1
PROFESSOR PLUM
Display
Date 01/04/2016 Time 07:34:06
Latitude 29.43436 Longitude 122.16498
Heading 334.00 COG 339.90
SOG 9.70 ROT -25.9
Depth 3.4 Track 336.0
SOG Chart
SOG COLONEL MUSTARD
SOG PROFESSOR PLUM
Knts
PP decelerates
CM accelerates toward PP
07:30:00 07:32:00 07:34:00
Replay Time
Configure Appearance Print ClipBoard File Goto Cursor
Heading Chart
Heading COLONEL MUSTARD
Track PROFESSOR PLUM
Heading PROFESSOR PLUM
Deg
CM collision after bank cushion effect
07:28:00 07:30:00 07:32:00 07:34:00 07:36:00
Replay Time
Configure Appearance Print ClipBoard File
Start: 01/04/2016 07:18:00
Current: 01/04/2016 07:34:06
End: 01/04/2016 07:45:01
Cursor Coordinates: Lat: 29.43136 Long: 122.15920

Case 4: BEEF WELLINGTON Fixed Object Damage

- 5th February 2017, South America
- Full VDR and shore-side CCTV
- Full darkness in calm conditions
- Berthing against strong river current
- No tugs in attendance.


MADAS Replay : Berthing3.madx
File Edit View Tools Trend Charts Help
Measure Grab Zoom << Prev Event Next Event >> Zoom In Zoom Out
New Video Channel: Playing - Export_PTO-MIN-DM-VC-01-CAM-10_lunes 06 de febrero de 2017131052 b9aa021.mp4
Start Time: 23:49:30 End Time: 23:54:30 Duration: 00:05:00
Replay Time Settings
Data Start and End Times
Start: 05/02/2017 22:55:00 End: 06/02/2017 00:45:00
Replay Start and End Times
Start: 05/02/2017 23:45:00 End: 05/02/2017 23:55:00
Current Replay Time
05/02/2017 23:51:55
CCTV
Navigation Data
BEEF WELLINGTON
Audio Display
Date 05/02/2017 Time 23:51:55
Latitude -33.25011 Longitude -60.28559
Heading 283.80 SOG 1.20
LOG 1.20 Depth 2.4
Heading Trend Chart
Heading BEEF WELLINGTON
Deg
Replay Time
Vessel heading collision point
Vessel collision with berth
Meters
Configure Appearance Print ClipBoard File Goto Cursor
Start: 05/02/2017 23:45:00 Current: 05/02/2017 23:51:55 End: 05/02/2017 23:55:00
Cursor Coordinates: Lat: -33.24947 Long: -60.28759

Conclusions



Conclusions

- Specialist tools are needed to decipher electronic evidence
- Forensic analysis provides incontrovertible evidence
- Tools of the trade are 2-D analysis and 3-D visualisation
- The facts and causation can be quickly agreed
- Parties can quickly agree ‘liability’ and settle ‘costs’.

Marine Accident Analysis of Collisions and Groundings:

How to learn from past incidents to avoid them in the future

Webinar: International Union of Marine Insurance

10 April 2018

NAUTICAL AFFILIATE
Promoting professionalism in shipping

The Nautical Institute

LOC

ONE PARTNER.
WORLDWIDE SUPPORT.

NAUTICAL AFFILIATE
Promoting professionalism in shipping

The Nautical Institute