Marine Accident Analysis of Collisions and Groundings:
How to learn from past incidents to avoid them in the future

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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
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

<table>
<thead>
<tr>
<th>ZOC</th>
<th>Position Accuracy</th>
<th>Depth Accuracy</th>
<th>Seafloor Coverage</th>
<th>Typical Survey Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>± 5m + 5% depth</td>
<td>0.5m + 1% depth</td>
<td>Full area search undertaken. Significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey. High position and depth accuracy achieved using DGPS or a minimum of three high quality lines of position (LOF) and a multibeam, channel or mechanical sweep system.</td>
</tr>
<tr>
<td>A2</td>
<td>± 20m</td>
<td>1.0m + 2% depth</td>
<td>Full area search undertaken. Significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echo sounder and a sonar or mechanical sweep system.</td>
</tr>
<tr>
<td>B</td>
<td>± 50m</td>
<td>1.0m + 2% depth</td>
<td>Full area search not achieved; uncharted features, hazardous to surface navigation are not expected, but may exist.</td>
<td>Controlled, systematic survey achieving similar depth but lesser position accuracy than ZOC A2 using a modern survey echo sounder but no sonar or mechanical sweep system.</td>
</tr>
<tr>
<td>C</td>
<td>± 500m</td>
<td>± 20m + 5% depth</td>
<td>Full area search not achieved; depth anomalies may be expected.</td>
<td>Low accuracy survey or data collected on an opportunistic basis such as soundings on passage.</td>
</tr>
<tr>
<td>D</td>
<td>Worse than ZOC C</td>
<td>Worse than ZOC C</td>
<td>Full area search not achieved. Large depth anomalies may be expected.</td>
<td>Poor quality data or data that cannot be quality assessed due to lack of information.</td>
</tr>
<tr>
<td>U</td>
<td>Unassessed – the quality of the bathymetric data has yet to be assessed.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CATZOC Symbol

- **A1**
- **A2**
- **B**
- **C**
- **D**
- **U**
2-D Under Keel Clearance

Dynamic Under Keel Clearance Illustration

- Sea level
- Chart datum
- Charted depth
- Height of tide
- Wave response, heel and trim
- Draught corrected for density
- Squat
- Safety factor allowing for survey
- Over dredge in maintained depth
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
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• Visibility
• Location
• Under keel clearance.
Zones of Interest

- A & B = Head-on situation
- A & C = Crossing situation
- B & C = No risk of collision
Zones of Interest

Radar Ranges

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)

- **Ship-to-Ship AIS**
- **Ship-to-Shore AIS**
- **Satellite 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**

<table>
<thead>
<tr>
<th>Manoeuvring Status</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ships at anchor or moored and not faster than 3 knots</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Ships at anchor or moored and faster than 3 knots</td>
<td>10 seconds</td>
</tr>
<tr>
<td><strong>Ship 0-14 knots</strong></td>
<td>10 seconds</td>
</tr>
<tr>
<td><strong>Ship 0-14 knots and changing course</strong></td>
<td>3 1/3 seconds</td>
</tr>
<tr>
<td>Ship 14-23 knots</td>
<td>6 seconds</td>
</tr>
<tr>
<td>Ship 14-23 knots and changing course</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Ship &gt;23 knots</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Ship &gt;23 knots changing course</td>
<td>2 seconds</td>
</tr>
</tbody>
</table>
How it works: ECDIS Roll-out and Principle Features

New Passenger Ships >500gt
New Tankers >1000gt
New Cargo Ships >10,000gt
New Cargo Ships >3,000gt
Existing Passenger Ships >100gt
Existing Tankers >3,000gt
Existing Cargo Ships >50,000gt
Existing Cargo Ships >20,000gt
Existing Cargo Ships >10,000gt

Based on IMO Circular letter issued December 2008. Please check www.edmiralty.co.uk for the latest updates and news.
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
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.
Sample MADAS Replay Software
MADAS Replay Software

Menu Bar

Track with history

Replay Time Settings

20/08/2017 21:04:31

Radar overlay

Radar targets with AIS overlay

Compass Graticule

Navigation Data

Distance Scale

Timeline and Events
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

Actual photograph

Visual scene with photo texturing
[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

- 5\textsuperscript{th} 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)
Case 2: PRIMULA SEAWAYS c/w CITY OF ROTTERDAM

- Date 3\textsuperscript{rd} 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.
City of Rotterdam uncontrolled swing to starboard toward mid-channel operating engines astern

Primula Seaways uncontrolled swing to port operating engines astern

City of Rotterdam continues starboard turn

Both vessels rapid speed reduction

Time cursor

Date: 03/12/2015 20:00-21:55

03/12/2015 20:40:00
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.
CM collides with PP causing PP sheer to the port bank

CM classic bank cushion effect

CM accelerates toward PP

PP decelerates

CM collision after bank cushion effect
Case 4: BEEF WELLINGTON Fixed Object Damage

• 5\textsuperscript{th} February 2017, South America

• Full VDR and shore-side CCTV

• Full darkness in calm conditions

• Berthing against strong river current

• No tugs in attendance.
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’.
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