Approach Channels – A Guide for Design

Progress of MarCom Working Group 49/121

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HR Wallingford Ltd
Brief history

• 1972 - Working Group 2 of the PIANC International Oil Tankers Commission (IOTC)
• 1980 - Working Group 4 of PIANC International Commission for the Reception of Large Ships (ICORELS)
• 1985 - Working Group of PTC II “Underkeel clearance for large ships in maritime fairways with hard bottom”
• 1995 - Working Group 30, a joint PIANC-IAPH group in co-operation with IMPA and IALA, published preliminary guidelines, followed by:
• 1997 - “Approach Channels – A guide for design”
### Table 5.2: Additional Widths for Straight Channel Sections

<table>
<thead>
<tr>
<th>WIDTH</th>
<th>Way Speed</th>
<th>Outer Channel exposed to open water</th>
<th>Inner Channel protected water</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Yawed speed (towt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fast</td>
<td>0.1 B</td>
<td>0.1 B</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.9 B</td>
<td>0.9 B</td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>0.9 B</td>
<td>0.9 B</td>
<td></td>
</tr>
<tr>
<td>(b) Prevailing cross-wind (towt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wind E (E - Beaufort 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.9 B</td>
<td>0.9 B</td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>0.9 B</td>
<td>0.9 B</td>
<td></td>
</tr>
<tr>
<td>(c) Prevailing cross-current (towt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low 0.3 - 0.5</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.1 B</td>
<td>0.1 B</td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>0.1 B</td>
<td>0.1 B</td>
<td></td>
</tr>
<tr>
<td>(d) Prevailing longitudinal current (towt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low 15.0</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>(e) Significant wave height Hₚ and length L (m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hₚ &gt; 13 and L &lt; 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low 0.3 - 0.5</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>(f) Aids to Navigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Bottom surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low 0.0.1</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>(h) Depth of waterway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low 1.5</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>0.0 B</td>
<td>0.0 B</td>
<td></td>
</tr>
</tbody>
</table>
Replace existing guidelines, so title is:

- “Harbour Approach Channels – Design Guidelines”

Brief:

- Review, update and, where appropriate, expand on the design recommendations in the WG30 1997 report
- Consider recent developments in simulation and other design tools
- Consider sizes and handling characteristics of new generation vessels
Membership

Comprises:

- Maritime engineers
- Naval architects
- Scientists
- Port engineers
- Maritime pilots (IMPA)
- IAPH representatives
- IALA cooperation
- 3 members from WG30

20 members from:

- Australia
- Belgium
- Canada
- Finland
- France
- Germany
- Japan
- The Netherlands
- South Africa
- Spain
- UK
- USA
Received support from:

- International Association of Ports and Harbours (IAPH)
- **International Maritime Pilots Association (IMPA)**
- International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)
- Institute for Water Resources, USA
- US Naval Academy
- USACE
- Coastal Development Institute of Technology (Japan)
- Akishima Laboratories (Mitsui Zosen) (Japan)
- HR Wallingford, UK
Other resources:

SAFE WATERWAYS

Part 1(a)

GUIDELINES FOR THE SAFE DESIGN OF COMMERCIAL SHIPPING CHANNELS

Published by the Waterways Development Division, CANADIAN COASTAL ENGINEERING (December 2001)

Finnish Maritime Administration

Designing the maritime configuration of ports, approach channels and flotation areas.

2nd Edition
December 2003

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Pietro Ricotta Goffi

FOOT NOTE:

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PRICE:
40,10 € (VAT included)
Asked to prioritise:

- Vertical motions of ships in channels
- Vertical clearances under bridges, overhead cables, etc. (air draught)
- New and future generation ship characteristics
- Acceptable levels of risk and clearance margins
- Methods for assessing operating limits
- Use of ship navigation simulation in channel design
- Manoeuvring limits in adverse conditions, e.g. consider tug effectiveness at speed and in waves
- Restrictions on pilot boarding, tug attachment/ detachment
Work undertaken:

- Examined requirements, scope and resources
- Reviewed WG30 1997 report
- Have adopted a modified 1997 channel width design method, despite considering several other possible methods (eg. the design standards of Spain and Japan)
- Identified new structure for document, keeping empirical methods for conceptual design and recommended methodologies for detailed design
- Three sub-groups formed to focus on the specific areas (Vertical, Horizontal and “General/Everything else”)
- 14 meetings held
New report structure:

- 1997 guidelines had main sections on “Concept design” and “Detailed design”
- New guidelines separate vertical (Chapter 2) and horizontal (Chapter 3) aspects
- Conceptual and detailed design issues within each main chapter
- Design ship dimensions updated for larger and new generation vessel sizes (Appendix C)
- Recognise that designer needs to think through process, rather than having a “black box” solution
Guidance provides:

- **Conceptual design empirical methods:**
  - Width – Sum of ship beams, modified WG30 method
  - Depth – New initial estimate method and “intermediate” calculation methods included

- **Guidance on detailed design methods**

- **Emphasise results of conceptual design empirical methods are not a final design**

- **Expect conceptual design to be conservative**

- **Optimise using detailed design methods described in the guidelines**
Channel design

Vertical dimensions

• Re-introduce modified 1985 depth components:
Squat – What method to use?

- Barrass2 (1981)
- Barrass3 (2004)
- Eryuzlu and Hausser (1978)
- Eryuzlu et al. (1994)
- Hooft (1974)
- Huuska/Guliev (1976)
- ICORELS (1980)
- Japan/Yoshimura (1986)
- MARSIM (2000)
- Millward (1990)
- Millward (1992)
- Norrbirn (1986)
- Romisch (1989)
- SLS Trial Formula (2002)
- Tothill
- Tuck (1966)
- VLCC
## Appropriateness of methods

<table>
<thead>
<tr>
<th>Code ID</th>
<th>Configuration</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$F_{nh}$</td>
<td>$C_B$</td>
<td>$S$</td>
<td>$B/T$</td>
<td>$h/T$</td>
<td>$h_T/h$</td>
<td>$L/B$</td>
<td>$L/T$</td>
</tr>
<tr>
<td>Tuck (1966)</td>
<td>Y Y Y</td>
<td>$F_{nh}$</td>
<td>Y</td>
<td>$0.6 - 0.8$</td>
<td>$2.19 - 3.5$</td>
<td>$1.1 - 2.0$</td>
<td>$0.22 - 0.81$</td>
<td>$5.5 - 8.5$</td>
<td>$16.1 - 20.2$</td>
</tr>
<tr>
<td>Huuska/Guliev (1976)</td>
<td>Y Y Y</td>
<td>$&lt; 0.7$</td>
<td>$0.6 - 0.8$</td>
<td>$2.19 - 3.5$</td>
<td>$1.1 - 2.0$</td>
<td>$0.22 - 0.81$</td>
<td>$5.5 - 8.5$</td>
<td>$16.1 - 20.2$</td>
<td></td>
</tr>
<tr>
<td>ICORELS (1980)</td>
<td>Y (Y)</td>
<td>$&lt; 0.7$</td>
<td>$0.6 - 0.8$</td>
<td>$2.19 - 3.5$</td>
<td>$1.1 - 2.0$</td>
<td>$0.22 - 0.81$</td>
<td>$5.5 - 8.5$</td>
<td>$16.1 - 20.2$</td>
<td></td>
</tr>
<tr>
<td>Barrass3 (2004)</td>
<td>Y Y Y</td>
<td>$V^2$</td>
<td>$0.5 - 0.85$</td>
<td>$0.1 - 0.25$</td>
<td>$1.1 - 1.4$</td>
<td>$1.1 - 1.4$</td>
<td>$1.1 - 1.4$</td>
<td>$1.1 - 1.4$</td>
<td>$1.1 - 1.4$</td>
</tr>
<tr>
<td>Eryuzlu2 (1994)</td>
<td>Y Y</td>
<td>$F_{nh}$</td>
<td>$&gt; 0.8$</td>
<td>$2.4 - 2.9$</td>
<td>$1.1 - 2.5$</td>
<td>$6.7 - 6.8$</td>
<td>$6.7 - 6.8$</td>
<td>$6.7 - 6.8$</td>
<td>$6.7 - 6.8$</td>
</tr>
<tr>
<td>Römisch (1989)</td>
<td>Y Y Y</td>
<td>$V_{Cr}$</td>
<td>$2.6$</td>
<td>$1.19 - 2.25$</td>
<td>$8.7$</td>
<td>$22.9$</td>
<td>$22.9$</td>
<td>$22.9$</td>
<td>$22.9$</td>
</tr>
<tr>
<td>Yoshimura (1986)</td>
<td>Y Y Y</td>
<td>$V^2$</td>
<td>$0.55 - 0.8$</td>
<td>$2.5 - 5.5$</td>
<td>$1.2$</td>
<td>$3.7 - 6.0$</td>
<td>$3.7 - 6.0$</td>
<td>$3.7 - 6.0$</td>
<td>$3.7 - 6.0$</td>
</tr>
</tbody>
</table>

Notes:
1. Y=Yes
2. Only $h/T$ enforced for Römisch formula.
3. Only Barrass3 and Römisch predict stern squat $S_S$ explicitly. Others predict maximum squat, whether at bow or stern.
4. $V^2$: Squat a function of square of velocity
5. $V_{Cr}^2$: Squat a function of more than square of velocity
6. $F_{nh}^{2+}$: Squat a function of more than square of $F_{nh}$. 
7. $V_{Cr}$: Squat a function of critical speed $V_{Cr}$.
8. ICORELS sometimes used in Restricted channel although originally developed for Unrestricted.
Channel design

Horizontal aspects – Take into account:

- Width in straight sections
- Width through bends
- Curvature of bend
- Channel / manoeuvring area layout
- Ship length – Inherent in considering ship beam
- Shallow water
- Space for tugs
- 2-way channels
Channel design

Horizontal aspects

- Assessed other methods, in particular, design standards of Spain and Japan
- Kept conceptual method similar to WG30 1997 method, but modified
- Still need site specific / design ship specific parameters
- Detailed design considers semi-probabilistic and probabilistic methods
- Range of existing channels used for comparison
## Horizontal aspects – Conceptual design

### Comparison - 1997 and 2011 versions (1)

#### Method for estimation of conceptual design channel width:

Required width \( w \) can be calculated as:

\[
w = w_{\text{bt}} + \sum w_i + w_{\text{br}} + w_{\text{bs}}
\]

- \( w_{\text{bt}} \): basic manoeuvring width
- \( w_i \): additional clearances for straight channel sections
- \( w_{\text{br}} \): bank clearance on port (red) side of channel
- \( w_{\text{bs}} \): bank clearance on starboard (green) side of channel

For 2 way channel, \( w = 2w_{\text{bt}} + 2\sum w_i + w_{\text{br}} + w_{\text{bs}} \)

#### Key for comparison between methods

<table>
<thead>
<tr>
<th>Method</th>
<th>No change</th>
<th>Decrease in width allowance</th>
<th>Increase in width allowance</th>
</tr>
</thead>
</table>

#### Table

<table>
<thead>
<tr>
<th>Width factor</th>
<th>Allowance</th>
<th>Basis</th>
<th>Ship speed</th>
<th>PIANC 1997</th>
<th>PIANC 2011</th>
<th>Notes on comparison between methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>( w_{\text{bt}} ) =</td>
<td>Basic manoeuvring lane</td>
<td>Good ship manoeuvrability</td>
<td>Fast</td>
<td>1.3</td>
<td>1.3</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate ship manoeuvrability</td>
<td>Fast</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor ship manoeuvrability</td>
<td>Fast</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>( w_{\text{br}} = w_{\text{bs}} - )</td>
<td>Bank clearance</td>
<td>Gentle underwater channel slope (1:10 or less steep)</td>
<td>Fast</td>
<td>0.7</td>
<td>0.7</td>
<td>Additional category for &quot;gentle&quot; channel slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sloping channel edges and shoals</td>
<td>Fast</td>
<td>0.5</td>
<td>0.5</td>
<td>Values added for fast speed in inner channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steep and hard embankments, structures</td>
<td>Fast</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>( w_i = )</td>
<td>Allowance for vessel speed</td>
<td>Fast (&gt;12 knots)</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate (8-12 knots)</td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slow (5-8 knots)</td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevailing cross wind</td>
<td>Mild (&lt;= 15 knots)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate (15-33 knots)</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Severe (33-48 knots)</td>
<td>0.6</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>
### Horizontal aspects – Conceptual design

#### Comparison - 1997 and 2011 versions (2)

<table>
<thead>
<tr>
<th>Prevailing cross current</th>
<th>Negligible (&lt;0.2 knots)</th>
<th>Fast</th>
<th>Moderate</th>
<th>Slow</th>
<th>Fast</th>
<th>Moderate</th>
<th>Slow</th>
<th>Increased values for most conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0.2-0.5 knots)</td>
<td></td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Moderate (0.5-1.5 knots)</td>
<td></td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong (1.5-2 knots)</td>
<td></td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prevailing longitudinal current</th>
<th>Low (&lt;3.15 knots)</th>
<th>Moderate (1.5-3 knots)</th>
<th>Strong (&gt;3 knots)</th>
<th>Fast</th>
<th>Moderate</th>
<th>Slow</th>
<th>Values included for inner channel where not provided previously</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allowance for wave action</th>
<th>Hs &lt;= 1m and WL &lt;= L</th>
<th>Fast</th>
<th>Moderate</th>
<th>Slow</th>
<th>Fast</th>
<th>Moderate</th>
<th>Slow</th>
<th>Revised values with indication given regarding wave direction, as beam waves may affect the drift of the vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Provision of navigation aids</th>
<th>Excellent with shore traffic control</th>
<th>Good</th>
<th>Moderate with infrequent poor visibility</th>
<th>Moderate with frequent poor visibility</th>
<th>(&gt;=0.5)</th>
<th>(&gt;=0.5)</th>
<th>Doubled width requirements, as defined in explanatory notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allowance for bottom surface type</th>
<th>If depth (\geq) 1.5T</th>
<th>If depth &lt; 1.5T - smooth and soft bottom</th>
<th>If depth &lt; 1.5T - smooth or sloping and hard</th>
<th>In general no additional width now required for dangerous cargoes, as does not affect navigation, but risk assessment required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allowance for channel depth</th>
<th>Depth (\geq) 1.5T</th>
<th>Depth 1.5T - 1.25T</th>
<th>Depth &lt; 1.25T</th>
<th>No change but criteria altered to: 1.5T - 1.15T &lt; 1.15T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allowance for hazardous cargo</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>In general no additional width now required for dangerous cargoes, as does not affect navigation, but risk assessment required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.4</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>
### Horizontal aspects – Conceptual design

**Comparison - 1997 and 2011 versions (3)**

<table>
<thead>
<tr>
<th></th>
<th>Additional for two way traffic</th>
<th></th>
<th></th>
<th>Value added for fast speed in inner channel</th>
<th>Heavy traffic classified as 3 design vessels per day</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allowance for vessel speed</strong></td>
<td>Fast (&gt; 12 knots)</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Moderate (8-12 knots)</td>
<td>1.6</td>
<td>1.4</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Slow (5-8 knots)</td>
<td>1.2</td>
<td>1</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Encounter traffic density</strong></td>
<td>Light</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Other aspects covering

- Aids to navigation (Chapter 4) – Defer to IALA
- Risk management and analysis (Chapter 5)
- Training issues (Chapter 5)
- Operational rules and limits (Chapter 5)
- Winter navigation and channel design (Chapter 5)
- Environmental issues (Chapter 5)
Production

- 80% draft presented to and reviewed by MarCom - 2013
- Some final drafting undertaken
- Took account of MarCom comments
- Final review by IAPH, IMPA, IALA and MarCom
- Now published – January 2014
Approach Channels – A Guide for Design