Approach Channels – A Guide for Design

Progress of MarCom Working Group 49/121

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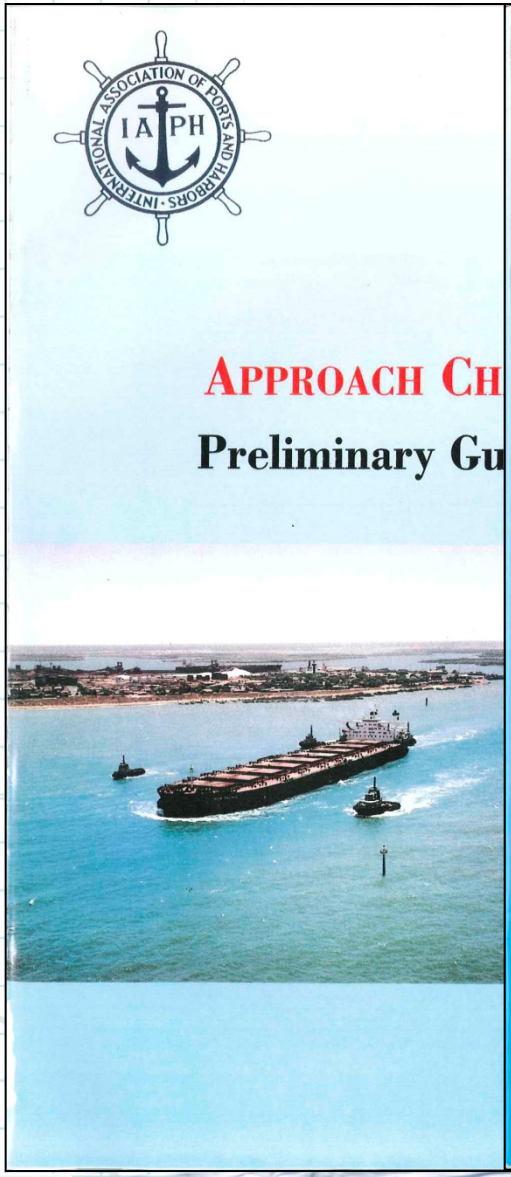
PIANC guidance on channel design

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”

Approach Channels – A Guide for Design



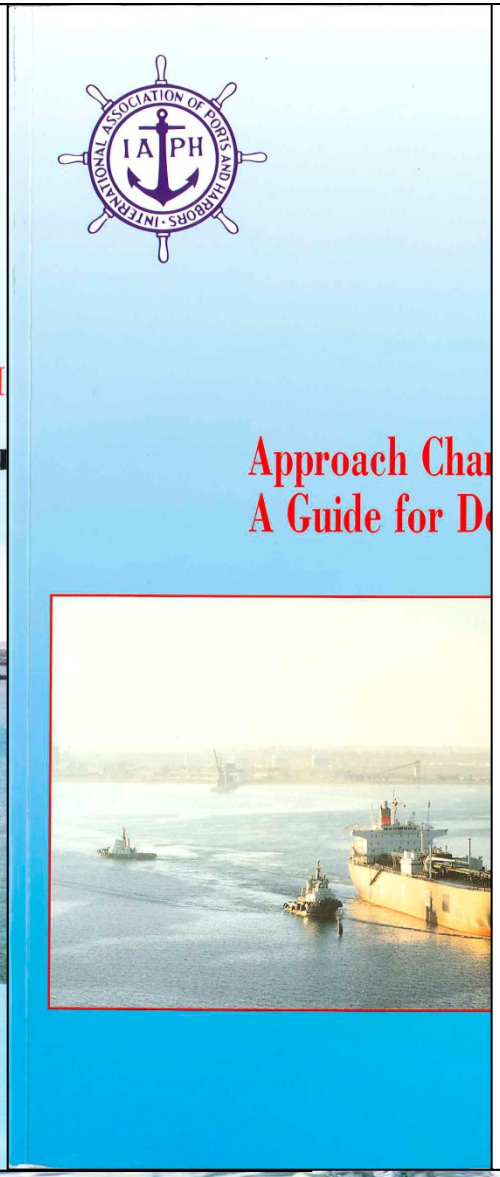


Table 5.2 - Additional Widths for Straight Channel Sections

WIDTH w_i	Vessel Speed	Outer Channel exposed to open water	Inner Channel protected water
(a) Vessel speed (knots)			
- fast > 12		0.1 B	0.1 B
- moderate > 8 - 12		0.0	0.0
- slow 5 - 8		0.0	0.0
(b) Prevailing cross wind (knots)			
- mild ≤ 15 (≤ Beaufort 4)	all	0.0	0.0
- moderate > 15 - 33	fast	0.3 B	-
(> Beaufort 4 - Beaufort 7)	mod	0.4 B	0.4 B
	slow	0.5 B	0.5 B
- severe > 33 - 48	fast	0.6 B	-
(> Beaufort 7 - Beaufort 9)	mod	0.8 B	0.8 B
	slow	1.0 B	1.0 B
(c) Prevailing cross current (knots)			
- negligible < 0.2	all	0.0	0.0
- low 0.2 - 0.5	fast	0.1 B	-
	mod	0.2 B	0.1 B
	slow	0.3 B	0.2 B
- moderate > 0.5 - 1.5	fast	0.5 B	-
	mod	0.7 B	0.5 B
	slow	1.0 B	0.8 B
- strong > 1.5 - 2.0	fast	0.7 B	-
	mod	1.0 B	-
	slow	1.3 B	-
(d) Prevailing longitudinal current (knots)			
- low ≤ 1.5	all	0.0	0.0
- moderate > 1.5 - 3	fast	0.0	-
	mod	0.1 B	0.1 B
	slow	0.2 B	0.2 B
- strong > 3	fast	0.1 B	-
	mod	0.2 B	0.2 B
	slow	0.4 B	0.4 B
(e) Significant wave height H_s and length λ (m)			
- $H_s \leq 1$ and $\lambda \leq L$	all	0.0	0.0
- $3 > H_s > 1$ and $\lambda \approx L$	fast	≈ 2.0 B	
	mod	≈ 1.0 B	
	slow	≈ 0.5 B	
- $H_s > 3$ and $\lambda > L$	fast	≈ 3.0 B	
	mod	≈ 2.2 B	
	slow	≈ 1.5 B	
(f) Aids to Navigation			
- excellent with shore traffic control		0.0	0.0
- good		0.1 B	0.1 B
- moderate with infrequent poor visibility		0.2 B	0.2 B
- moderate with frequent poor visibility		≥ 0.5 B	≈ 0.5 B
(g) Bottom surface			
- if depth ≥ 1.5T		0.0	0.0
- if depth < 1.5T then			
- smooth and soft		0.1 B	0.1 B
- smooth or sloping and hard		0.1 B	0.1 B
- rough and hard		0.2 B	0.2 B
(h) Depth of waterway			
- ≥1.5T		0.0	≥1.5T 0.0
- 1.5T - 1.25T		0.1 B	<1.5T-1.15T 0.2 B
- <1.25T		0.2 B	<1.15T 0.4 B
(i) Cargo hazard level			
- low		0.0	0.0
- medium		~ 0.5 B	~ 0.4 B
- high		~ 1.0 B	~ 0.8 B

Working Group 49

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

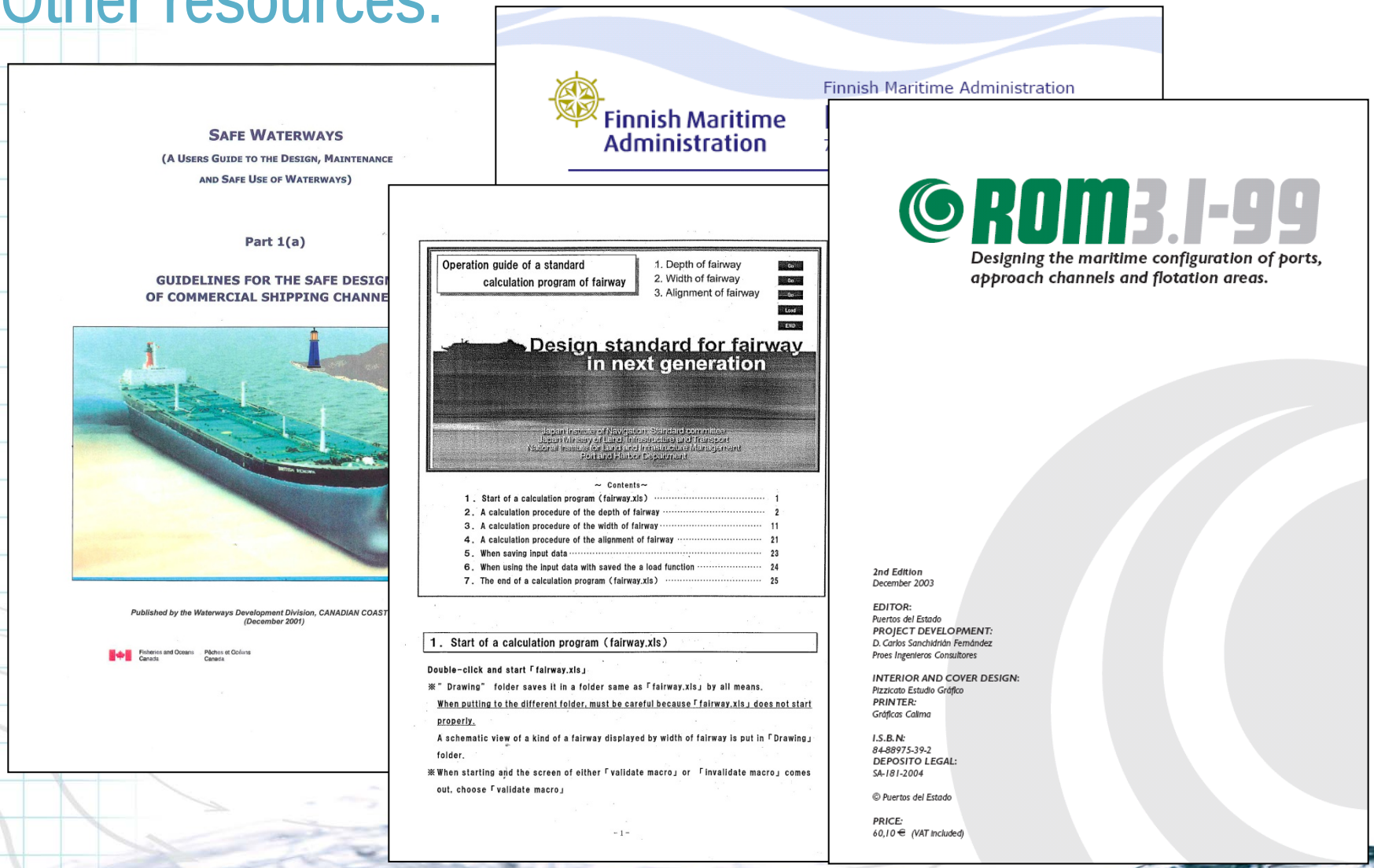
20 members from:

- 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:



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

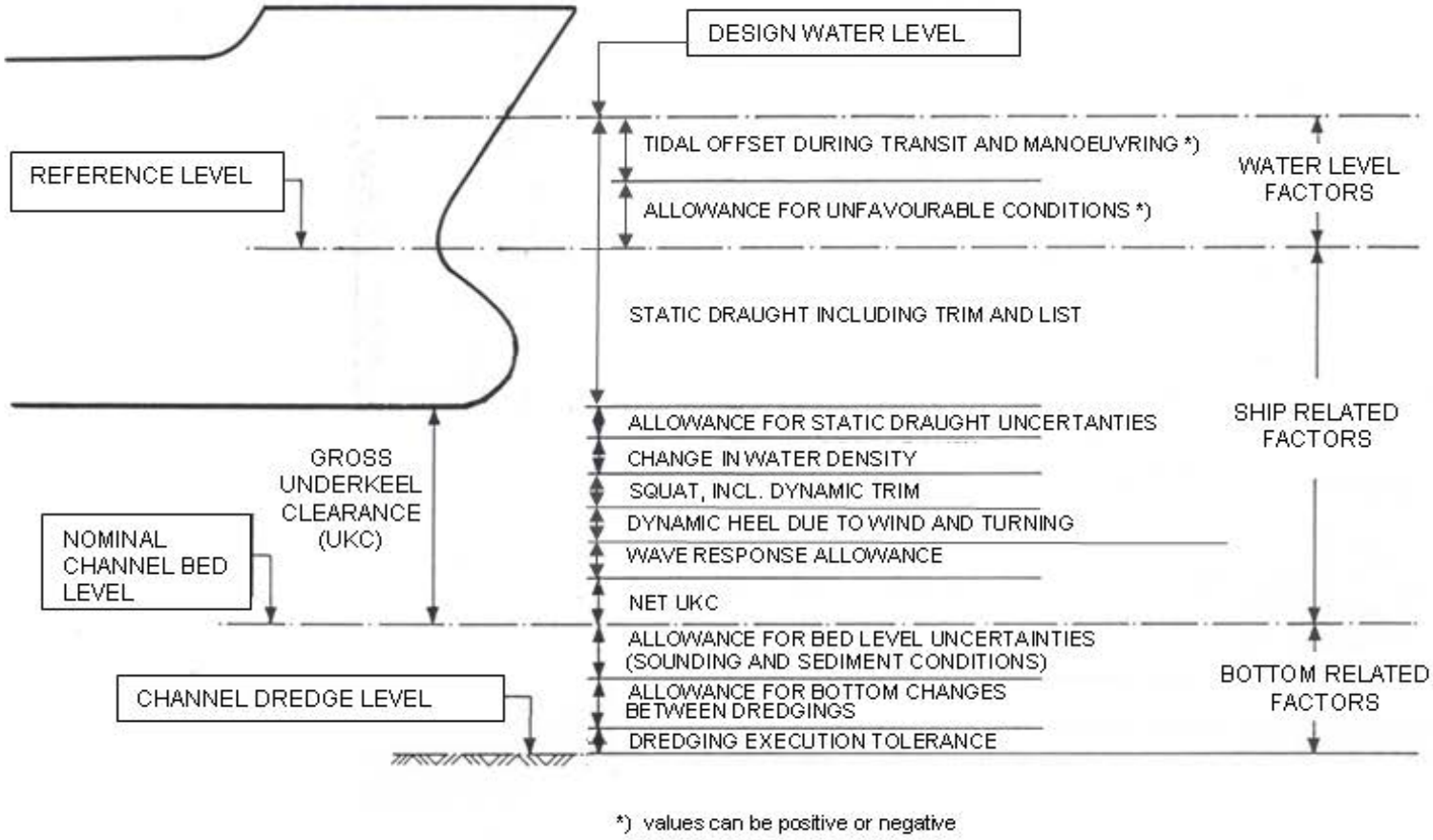
Channel design

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

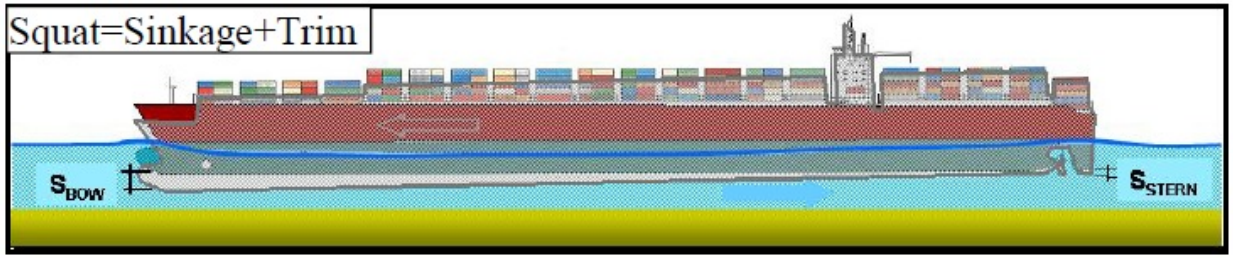
Vertical dimensions

- Re-introduce modified 1985 depth components:



Squat – What method to use?

- Barrass2 (1981)
- Barrass3 (2004)
- Barrass4 (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)
- Norrbin (1986)
- Romisch (1989)
- SLS Trial Formula (2002)
- Tothill
- Tuck (1966)
- VLCC



Appropriateness of methods

Code ID	Configuration			Constraint							
	U	R	C	F_{nh}	C_B	S	B/T	h/T	h_T/h	L/B	L/T
Tuck (1966)	Y	Y	Y	F_{nh}^{2+}							
Huuska/Guliev (1976)	Y	Y	Y	≤ 0.7	0.6 - 0.8		2.19 - 3.5	1.1 - 2.0	0.22 - 0.81	5.5 - 8.5	16.1 - 20.2
ICORELS (1980)	Y	(Y)		≤ 0.7 V_{Cr}	0.6 - 0.8		2.19 - 3.5	1.1 - 2.0	0.22 - 0.81	5.5 - 8.5	16.1 - 20.2
Barrass3 (2004)	Y	Y	Y	V^2	0.5 - 0.85	0.1 - 0.25		1.1 - 1.4			
Eryuzlu2 (1994)	Y	Y		F_{nh}^{2+}	≥ 0.8		2.4 - 2.9	1.1 - 2.5		6.7- 6.8	
Römisch (1989)	Y	Y	Y	V^{2+}, V_{Cr}			2.6	1.19- 2.25		8.7	22.9
Yoshimura (1986)	Y	Y	Y	V^2	0.55 - 0.8		2.5 - 5.5	≥ 1.2		3.7 – 6.0	

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^{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

Width W_i	Vessel Speed	Outer Channel exposed to open water	Inner Channel protected water
(a) Vessel speed (knots, with respect to the water)			
- fast> 12		0.1 B	
- moderate > 8 - 12		0.0	
- slow 5 - 8		0.0	
(b) Prevailing cross wind (knots)			
- mild ≤ 15 (≤ Beaufort 4)	fast	0.1 B	
	mod	0.2 B	
	slow	0.3 B	
- moderate > 15-33 (Beaufort 4 - Beaufort 7)	fast	0.3 B	
	mod	0.4 B	
	slow	0.6 B	
- severe > 33 - 48 (> Beaufort 7 - Beaufort 9)	fast	0.5 B	
	mod	0.7 B	
	slow	1.1 B	
(c) Prevailing cross current (knots)			
- negligible < 0.2	all	0.0	0.0
- low 0.2 - 0.5	fast	0.2 B	0.1 B
	mod	0.25 B	0.2 B
	slow	0.3 B	0.3 B
- moderate > 0.5 - 1.5	fast	0.5 B	0.4 B
	mod	0.7 B	0.6 B
	slow	1.0 B	0.8 B
- strong > 1.5-2.0	fast	1.0 B	-
	mod	1.2 B	-
	slow	1.6 B	-
(d) Prevailing longitudinal current (knots)			
- low ≤ 1.5	all	0.0	
- moderate > 1.5 - 3	fast	0.0	
	mod	0.1 B	
	slow	0.2 B	
- strong > 3	fast	0.1 B	
	mod	0.2 B	
	slow	0.4 B	
(e) Beam and stern quartering wave height Hs (m)			
- $H_s \leq 1$ m	all	0.0	0.0
- 1 m<H_s< 3 m	all	~0.5 B	-
- $H_s \geq 3$ m	all	~1.0 B	-
(f) Aids to navigation			
- excellent with shore traffic control		0.0	
- good		0.2B	
-moderate		0.4 B	
(g) Bottom surface			
- if depth ≥ 1.5 T		0.0	
- if depth < 1.5 T then			
- smooth and soft		0.1 B	
- smooth or sloping and hard		0.1 B	
- rough and hard		0.2 B	
(h) Depth of waterway			
- ≥1.5 T		0.0	≥1.5T 0.0B
- 1.5 T - 1.25T		0.1 B	1.5T-1.15T 0.2B
- <1.25 T		0.2 B	<1.15T 0.4B
(i) High cargo hazards		See explanation in box(i)	

Horizontal aspects – Conceptual design

Comparison - 1997 and 2011 versions (1)

Method for estimation of conceptual design channel width:

Required width 1 way channel, $w = w_{BM} + \sum w_i + w_{Br} + w_{Bg}$

where:
- w_{BM} = basic manoeuvring width
- w_i = additional clearances for straight channel sections
- w_{Br} = bank clearance on port (red) side of channel
- w_{Bg} = bank clearance on starboard (green) side of channel

2 way channel, $w = 2w_{BM} + 2\sum w_i + w_{Br} + w_{Bg} + w_p$

Key for comparison between methods

	No change
	Decrease in width allowance
	Increase in width allowance

				PIANC 1997		PIANC 2011		
Width factor	**Allowance**	**Basis**	**Ship speed**	**Outer channel exposed to open water**	**Inner channel protected water**	**Outer channel exposed to open water**	**Inner channel protected water**	**Notes on comparison between methods**
w_{BM} =	Basic manoeuvring lane	Good ship manoeuvrability		1.3	1.3	1.3	1.3	No change
		Moderate ship manoeuvrability		1.5	1.5	1.5	1.5	
		Poor ship manoeuvrability		1.8	1.8	1.8	1.8	
$w_{Br} = w_{Bg}$ =	Bank clearance	Gentle underwater channel slope (1:10 or less steep)	Fast			0.2	0.2	Additional category for "gentle" channel slope
			Moderate			0.1	0.1	
			Slow			0	0	
		Sloping channel edges and shoals	Fast	0.7	-	0.7	0.7	Values added for fast speed in inner channel
			Moderate	0.5	0.5	0.5	0.5	
			Slow	0.3	0.3	0.3	0.3	
		Steep and hard embankments, structures	Fast	1.3	-	1.3	1.3	
			Moderate	1	1	1	1	
			Slow	0.5	0.5	0.5	0.5	
w_i =	Allowance for vessel speed	Fast (> 12 knots)		0.1	0.1	0.1	0.1	No change
		Moderate (8-12 knots)		0	0	0	0	
		Slow (5-8 knots)		0	0	0	0	
	Prevailing cross wind	Mild (</= 15 knots)	Fast	0	0	0.1	0.1	Values now given for mild wind conditions, with mainly increases elsewhere but with reductions at severe wind conditions for fast and moderate vessel speeds
			Moderate	0	0	0.2	0.2	
			Slow	0	0	0.3	0.3	
		Moderate (15-33 knots)	Fast	0.3	-	0.3	0.3	
			Moderate	0.4	0.4	0.4	0.4	
			Slow	0.5	0.5	0.6	0.6	
		Severe (33-48 knots)	Fast	0.6	-	0.5	0.5	
			Moderate	0.8	0.8	0.7	0.7	
			Slow	1	1	1.1	1.1	

Horizontal aspects – Conceptual design

Comparison - 1997 and 2011 versions (2)

Prevailing cross current	Negligible (<0.2 knots)	All	0	0	0	0	Increased values for most conditions
	Low (0.2-0.5 knots)	Fast	0.1	-	0.2	0.1	
		Moderate	0.2	0.1	0.25	0.2	
		Slow	0.3	0.2	0.3	0.3	
	Moderate (0.5- 1.5 knots)	Fast	0.5	-	0.5	0.4	
		Moderate	0.7	0.5	0.7	0.6	
		Slow	1	0.8	1	0.8	
	Strong (1.5-2 knots)	Fast	0.7	-	1	-	
		Moderate	1	-	1.2	-	
		Slow	1.3	-	1.6	-	
Prevailing longitudinal current	Low (</= 1.5 knots)	All	0	0	0	0	Values included for inner channel where not provided previously
	Moderate (1.5-3 knots)	Fast	0	-	0	0	
		Moderate	0.1	0.1	0.1	0.1	
		Slow	0.2	0.2	0.2	0.2	
	Strong (> 3 knots)	Fast	0.1	-	0.1	0.1	
		Moderate	0.2	0.2	0.2	0.2	
		Slow	0.4	0.4	0.4	0.4	
Allowance for wave action	Hs </= 1m and WL </= L	All	0	0	0	0	Revised values with indication given regarding wave direction, as beam waves may affect the drift of the vessel
	Hs = 1-3m and WL = L	Fast	2	-	~0.5	-	
		Moderate	1	-	~0.5	-	
		Slow	0.5	-	~0.5	-	
	Hs > 3m and WL > L	Fast	3	-	~1.0	-	
		Moderate	2.2	-	~1.0	-	
		Slow	1.5	-	~1.0	-	
Provision of navigation aids	Excellent with shore traffic control		0	0	0	0	Doubled width requirements, as defined in explanitory notes
	Good		0.1	0.1	0.2	0.2	
	Moderate with infrequent poor visibility		0.2	0.2	0.4	0.4	
	Moderate with frequent poor visibility		>/= 0.5	>/= 0.5			
Allowance for bottom surface type	If depth >/= 1.5T		0	0	0	0	No change
	If depth < 1.5T - smooth and soft bottom		0.1	0.1	0.1	0.1	
	- smooth or sloping and hard		0.1	0.1	0.1	0.1	
	- rough and hard		0.2	0.2	0.2	0.2	
Allowance for channel depth	Depth >/= 1.5T		0	0	0	0	No change but criteria altered to:
	Depth 1.5T - 1.25T		0.1	0.2	0.1	0.2	1.5T - 1.15T
	Depth < 1.25T		0.2	0.4	0.2	0.4	< 1.15T
Allowance for hazardous cargo	Low		0	0.0			In general no additional width now required for dangerous cargoes, as does not affect navigation, but risk assessment required
	Medium		0.5	0.4			
	High		1	0.8			

Horizontal aspects – Conceptual design

Comparison - 1997 and 2011 versions (3)

w_p = **Additional for two way traffic**

	Allowance for vessel speed	Fast (> 12 knots)		2	-	2	1.8	Value added for fast speed in inner channel
		Moderate (8-12 knots)		1.6	1.4	1.6	1.4	
		Slow (5-8 knots)		1.2	1	1.2	1	
	Encounter traffic density	Light		0	0			Heavy traffic classified as 3 design vessels per day
		Moderate		0.2	0.2			
		Heavy		0.5	0.4	0.5	0.5	

Channel design

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)

PIANC Working Group 49

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

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