ANALYSIS OF PIANC GUIDELINE AND ROM STANDARD IN DESIGN OF APPROACH CHANNEL AND HARBOR BASIN

by

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ABSTRACT

For the harbor waterway and coastal engineering the approach channel and harbor basin play an important role. It will be dangerous for the sailing vessel to make the channel too shallow and the basin too narrow, in turn it will be to thriftless if the channel is over deep and the basin is over wide, which means the project cost will increase. A moderate size of channel and basin is recommended. In order to find out this moderate size, several primary standards in the world have respective calculation methods. PIANC is short for Permanent International Association of Navigation Congresses, and it has a well-rounded system and criterion for the design work of harbor engineering. ROM is the standard system in Spain, and it becomes more and more prevalent in waterborne transportation industry, especially in South America and Caribbean nations. PIANC's design guidelines and ROM standard have different methods in calculating the depth and width of approach channel and harbor basin in port project, which are caused by diversity of designing factors. In order to analyze the respective results and summarize the characteristics of these two standards, this article analyzes the factors and methods in the designing of approach channel and harbor basin and takes a project as an example. An appropriate suggestion of channel and harbor basin in design phase is proposed after comparing the results in using these two standards and real-time manoeuvring simulation study of the vessel, which can be safer and economical for the project and supply technical support in designing works.

1. INTRODUCTION

This paper analyzes the PIANC guideline and ROM standard of 3 dimensions in harbor engineering, which are width of channel, depth of channel and width of harbor basin. The calculation method of these 2 standards is not same. Combining with a actual project and Real-Time simulator analysis, this paper gives a result of these 3 dimensions in PIANC guideline and ROM standard.

2. Width of approach channel

2.1 PIANC guideline

In the PIANC guideline, the width of straight channel can be calculated in the following modern method, which should provide adequate navigational safety in the concept design phase. In detail design phase, local conditions may require an optimization with respect to cost, operational conditions and environmental aspects.

For the overall width bottom width of an access channel with straight sections, i.e. **Figure 1: Channel and fairway definition** is given by:

$$W=W_{BM}+\Sigma W_i+W_{BR}+W_{BG} \quad \text{(One-way channel)} \tag{1}$$

$$W=2W_{BM}+2\Sigma W_i+W_{BR}+W_{BG}+\Sigma W_P \quad \text{(Two-way channel)} \tag{2}$$

Where:

W_{BM} =width of basic manoeuvring lane as a multiple of the design ship's beam B, given in Table 1.

ΣW_i=additional widths to allow for the effects of wind, current etc, given in Table 2.

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W_{BR}+W_{BG}=bank clearance on the 'red' and 'green' sides of the channel, given in Table 3.
ΣW_P=passing distance, comprising the sum of a separation distance between both manoeuvring lanes W_M (shown in **Figure 2: Elements of channel width**) and an additional distance for traffic density, given in table 4.

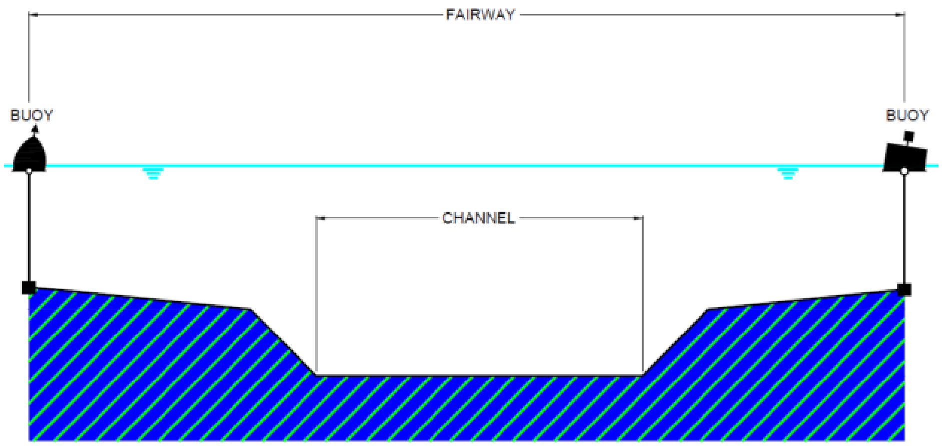

Figure 1: Channel and fairway definition (PIANC)

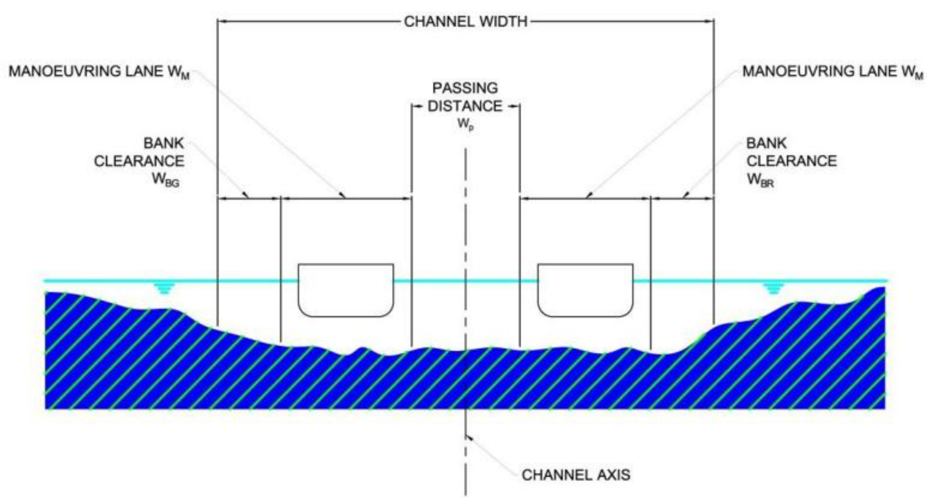

Figure 2: Elements of channel width

Ship Manoeuvrability	Good	Moderate	Poor
Basic manoeuvring Lane, W_{BM}	1.3B	1.5B	1.8B

Table 1: Basic manoeuvring lane W_{BM}

Width W_i	**Vessel speed**	**Outer channel (open water)**	**Inner channel (protected water)**
(a) Vessel speed V_S (kts, with respect) $V_S \geqslant 12$kts 8kts$\leqslant V_S <$12kts 5kts$\leqslant V_S <$8kts	 Fast Mod Slow	 0.1 B 0 0	
(b) Prevailing cross wind V_{CW} (kts) -mild	Fast	0.1 B	

$V_{CW}<15$kts	Mod Slow	0.2 *B* 0.3 *B*	
-moderate 15kts$\leqslant V_S<$33kts	Fast Mod Slow	0.3 *B* 0.4 *B* 0.6 *B*	
-strong 33kts$\leqslant V_S<$48kts	Fast Mod Slow	0.5 *B* 0.7 *B* 1.1 *B*	
(c) Prevailing cross current V_{CC} (kts) -negligible $V_{CC}<0.2$kts	All	0.0	0.0
-low 0.2kts$\leqslant V_{CC}<$0.5kts	Fast Mod Slow	0.2 *B* 0.25 *B* 0.3 *B*	0.1 *B* 0.2 *B* 0.3 *B*
-moderate 0.5kts$\leqslant V_{CC}<$1.5kts	Fast Mod Slow	0.5 *B* 0.7 *B* 1.0 *B*	0.4 *B* 0.6 *B* 0.8 *B*
-strong 1.5kts$\leqslant V_{CC}<$2.0kts	Fast Mod Slow	1.0 *B* 1.2 *B* 1.6 *B*	- - -
(d) Prevailing longitudinal current V_{lC} (kts) -low $V_{CW}<1.5$kts	All	0.0	
-moderate 1.5kts$\leqslant V_{lC}<$3kts	Fast Mod Slow	0.0 0.1 *B* 0.2 *B*	
-strong $V_{lC}\geqslant 3$kts	Fast Mod Slow	0.1 *B* 0.2 *B* 0.4 *B*	
(e) Beam and stern quartering wave height H_S (m) $H_S\leqslant 1$m 1m$<H_S<$3m $H_S\geqslant 3$m	All All All	0.0 0-0.5 *B* 0-1.0 *B*	0.0 - -
(f) Aids to Navigation Excellent Good moderate		0.0 0.2 *B* 0.4 *B*	
(g) Bottom surface Depth $h \geqslant 1.5T$		0.0	

Depth $h < 1.5T$ -Smooth and soft -Rough and hard		0.1 *B* 0.2 *B*			
(h) Depth of waterway		$h \geqslant 1.5T$ $1.5T > h \geqslant 1.25T$ $h < 1.25T$	0.0 *B* 0.1 *B* *0.2 B*	$h \geqslant 1.5T$ $1.5T > h \geqslant 1.25T$ $h < 1.25T$	0.0 *B* 0.1 *B* *0.2 B*

Table 2: Additional widths W_i for straight channel sections

Width for bank clearance	**Vessel speed**	**Outer channel (open water)**	**Inner channel (protected water)**
Gentle underwater channel slope (1:10 ro less steep)	Fast Moderate Slow	0.2 *B* 0.1 *B* 0.0	0.2 *B* 0.1 *B* 0.0
Sloping channel edges and shoals	Fast Moderate Slow	0.7 *B* 0.5 *B* 0.3 *B*	0.7 *B* 0.5 *B* 0.3 *B*
Steep and hard embankments structures	Fast Moderate Slow	1.3 *B* 1.0 *B* 0.5 *B*	1.3 *B* 1.0 *B* 0.5 *B*

Table 3: Additional width for bank clearance W_{BR} and W_{BG}

Width for passing distance W_P	Good	Moderate
Vessel speed V_S (knots) - **Fast: $V_S \geqslant 12$** - **Moderate: $8 \leqslant V_S < 12$** - **Slow: $5 \leqslant V_S < 8$**	 2.0 *B* 1.6 *B* 1.2 *B*	 1.8 *B* 1.4 *B* 1.0 *B*

Table 4: Additional width for passing distance in two-way-traffic W_P

2.2 ROM standard

In ROM standard, the width of straight channel can be calculated in following term (shown in **Figure 3: Channel and fairway definition**).

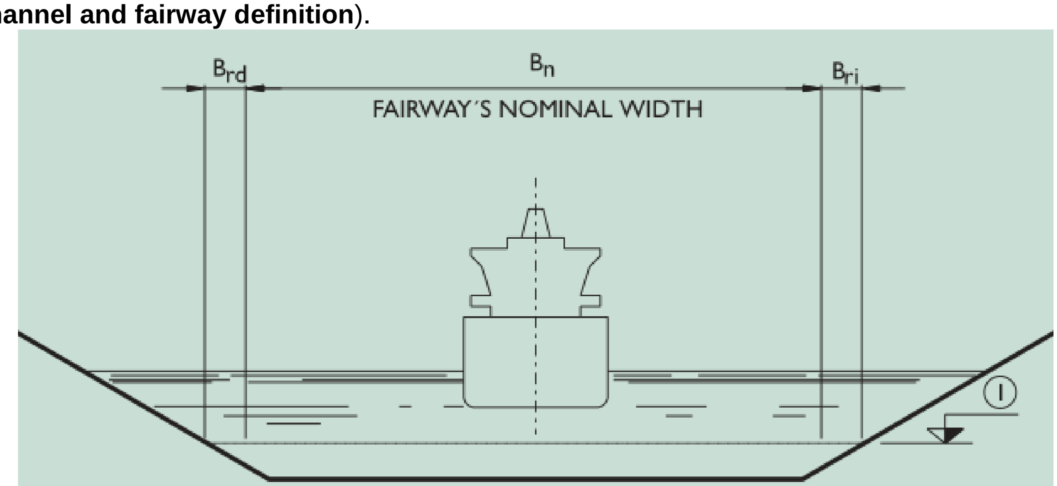

Figure 3: Channel and fairway definition (ROM)

$$B_t = B_n + B_r \tag{3}$$

Where:

B_t= The fairway's overall width.
B_n= The fairway's nominal width or clear space which must remain permanently available for vessel navigation, including safety margins.
B_r= An additional reserve width for taking into account boundary.
The bottom width B_n of straight channel can be calculated in the following method.

$$B_n=B+b_d+2(b_c+b_r+b_b)+(rh_{sm}+rh_{sd})_i+(rh_{sm}+rh_{sd})_d \text{ (One-way channel)} \quad (4)$$

$$B_n=2[B+b_d+2(b_c+b_r+b_b)]+b_s+(rh_{sm}+rh_{sd})_i+(rh_{sm}+rh_{sd})_d \text{ (Two-way channel)} \quad (5)$$

Where:
B=Maximum beam of vessels which will sail over the fairway.
b_d=Additional width of the vessel's swept path produced by navigation with a certain angle–drift angle to the fairway's axis, in order to correct the vessel's drift caused by the wind, wave, current or tugboat effect. The additional width necessary (b_d) will be calculated with the following formula:

$$b_d=L_{pp}*\sin\beta \text{ (for evaluating water spaces)} \quad (6)$$

$$b_d=L*\sin\beta \text{ (for evaluating above water spaces)} \quad (7)$$

where:
L_{pp} = Length between the design vessel's perpendiculars.
L= Design vessel's length overall.
β =Angle of drift, which can be determined with the following formulas.

$$\sin\beta =\sin\beta_1+\sin\beta_2+\sin\beta_3+\sin\beta_4 \quad (8)$$

where:
β_1 is drift caused only by wind action.
β_2 is drift caused only by current action.
β_3 is drift caused only by wave action.
β_4 is drift caused only by tug-boat action.

$$\beta_1=\arcsin[(K_v*C_v*V_{sr}*\sin\alpha_{VT})/V_r] \quad (9)$$

where:
K_v =Coefficient depending on the ratio h/D between the site's water depth (h) and the vessel's draught (D) and the angle α_{vr}, shown in table 5.

h/D	K_v			
	$\alpha_{vr}\leqslant10°$	$\alpha_{vr}\leqslant30°$	$\alpha_{vr}\leqslant60°$	$\alpha_{vr}\leqslant90°$
⩽1.2	0.0243	0.0161	0.0130	0.0121
2.0	0.0255	0.0168	0.0136	0.0127
⩾5.0	0.0259	0.0171	0.0139	0.0129

Table 5: Coefficient K_v

$$C_v =(A_{LV}/A_{LC})^{0.5} \quad (10)$$

A_{LV}=Windage of the vessel's longitudinal projection.
A_{LC}=Vessel's longitudinal submerged area projected onto the centre line plane.
V_{vr}=Wind speed relative to the vessel being analyzed.
V_r=Vessel's speed relative to the water.
α_{vr}=Angle between the relative wind direction (incoming) and the vessel's centre line plane.

$$\beta_2=\text{arctg}[(V_c*\text{sine}\alpha_{CV})/(V+V_c*\cos\alpha_{CV})] \quad (11)$$

where:
V_c =Absolute current speed considered as the fairway's operating limit.
V =Absolute vessel speed relative to the seabed.
α_{CV}=Angle between the absolute current direction and the vessel's absolute speed.

$$\beta_3=\arcsin e[K_w*(g/D)^{0.5}*(H_s/V_r)] \quad (12)$$

where:

K_w =Coefficient depending on the ratio h/D between the site's water depth (h) and the vessel's draught (D) and the angle α_{vr}, shown in table 6.

h/D	K_w						
	$\alpha_w \leqslant 10°$	$\alpha_w \leqslant 30°$	$\alpha_w \leqslant 60°$	$\alpha_w \leqslant 90°$	$\alpha_w \leqslant 120°$	$\alpha_w \leqslant 150°$	$\alpha_w \leqslant 170°$
⩽1.2	0.0296	0.0512	0.1067	0.1323	0.1183	0.0725	0.0418
2.0	0.0310	0.0537	0.1118	0.1387	0.1240	0.0760	0.0439
⩾5.0	0.0315	0.0546	0.1137	0.1410	0.1261	0.0772	0.0446

Table 6: Coefficient K_w

α_w= Angle between the wave propagation direction and the vessel's centre line plane.
g= Acceleration of gravity
D= Draught of the vessel under analysis.
H_s= Significant wave height of the waves considered as the fairway operating limit for the vessel being analyzed.
V_r= Vessel's speed relative to the water.

$$\beta_4 = \arcsin e[K_r*((g*F_{TR})/(A_{LC}*\gamma_w))^{0.5}*(1/V_r)] \quad (13)$$

where:
K_r =Coefficient depending on the ratio h/D between the site's water depth (h), shown in table 7.

h/D	K_r
⩽1.2	0.45
2.0	0.47
⩾5.0	0.48

Table 7: Coefficient K_r

F_{TR} = Component of the force resulting in the vessel's transverse direction from tug-boats acting on it.
γ_w = Specific weight of water.

b_c =Additional width through positioning errors, shown in Table 8.

	Operation without a pilot or captain experienced in site being considered	**Operation with a pilot or captain experienced in site being considered**
Visual positioning in open estuaries,without navigation marking	100m	50m
Visual positioning referred to buoys or beacons in approach ways	50m	25m
Visual positioning between buoy or beacon alignments marking the fairway's limits	20m	10m

Table 8: Additional width b_c

b_r = Additional response width which assesses the additional deviation that may occur from the moment when the vessel's deviation from its theoretical position is detected and the instant when the correction becomes effective.

$$b_r = (1.5 - E_{max}) * b_{ro} \quad (14)$$

Where:
E_{max} = Maximum Risk admissible determined with the criteria.
b_{ro}= Additional response width, given in table 9.

Vessel's manouvrability	b_{ro}	
	$h/D \leqslant 1.2$	$h/D \geqslant 1.5$
Good	0.1 B	0.1 B
Medium	0.2 B	0.15 B

Bad	0.3 *B*	0.2 *B*

Table 9: Additional response width

b_b = Additional width for covering an error which might derive from the navigation marking systems.

$$b_b = D*\sin 0.5^\circ \quad (15)$$

Where:

D= The distance between 2 buoys along the channel direction.

rh_{sm}, rh_{sd}=Additional safety clearance which should be considered on each side of the fairway to enable the vessel to navigate without being affected by bank suction or rejection effects, shown in Table 10..

	rh_{sm}	rh_{sd}	$rh_{sm}+rh_{sd}$
Fairways with sloping channel edge and shoals($V/H\leqslant 1/3$)			
Vessel's absolute speed⩾6m/s	0.6 *B*	0.1 *B*	0.7 *B*
Vessel's absolute speed between 4 and 6 m/s	0.4 *B*	0.1 *B*	0.5 *B*
Vessel's absolute speed⩽4m/s	0.2 *B*	0.1 *B*	0.3 *B*
Fairways with rigid slopes($V/H\geqslant 1/2$) or with rocky or structural banks			
Vessel's absolute speed⩾6m/s	1.2 *B*	0.2 *B*	1.4 *B*
Vessel's absolute speed between 4 and 6 m/s	0.8 *B*	0.2 *B*	1.0 *B*
Vessel's absolute speed⩽4m/s	0.4 *B*	0.2 *B*	0.6 *B*

Table 10: Additional response width

b_s = the passing distance between the two lines, given in Table 10

	b_s	
	Fairway in exposed areas	Fairway in sheltered areas
Vessel's absolute speed⩾6m/s	2.0 *B*	-
Vessel's absolute speed between 4 and 6 m/s	1.6 *B*	1.4 *B*
Vessel's absolute speed⩽4m/s	1.2 *B*	1.0 *B*
Traffic density: 0-1 vessels/hour	0.0 *B*	0.0 *B*
Traffic density : 1-3 vessels/hour	0.2 *B*	0.2 *B*
Traffic density: ＞3 vessels/hour	0.5 *B*	0.4 *B*

Table 11: Passing distance b_s

3. Depth of approach channel

3.1 PIANC guideline

In PIANC guideline, the depth of channel can be calculated in Table 11

Description	Vessel speed	Wave conditions	Channel Bottom	Inner channel	Outer channel
Ship Related Factors					
Depth	⩽10kts	None		1.10*T*	
	10-15kts			1.12*T*	
	＞15kts			1.15*T*	
	All	Low swell ($Hs<1$m)			1.15*T*-1.2*T*
		Moderate swell (1m＜*Hs*＜2m)			1.2*T*-1.3*T*
		Heavy swell ($Hs>2$m)			1.3*T*-1.4*T*

	Add for channel bottom type				
	all	all	Mud	None	None
			Sand/clay	0.4m	0.5m
			Rock/coral	0.6m	1.0m

Table 12: Channel depth components estimates

3.2 ROM standard

In ROM standard the factors taking part in determining water depths in navigation channels and harbor basins are shown in **Figure 4: Factors of water depths in navigation channels and harbor basins.**

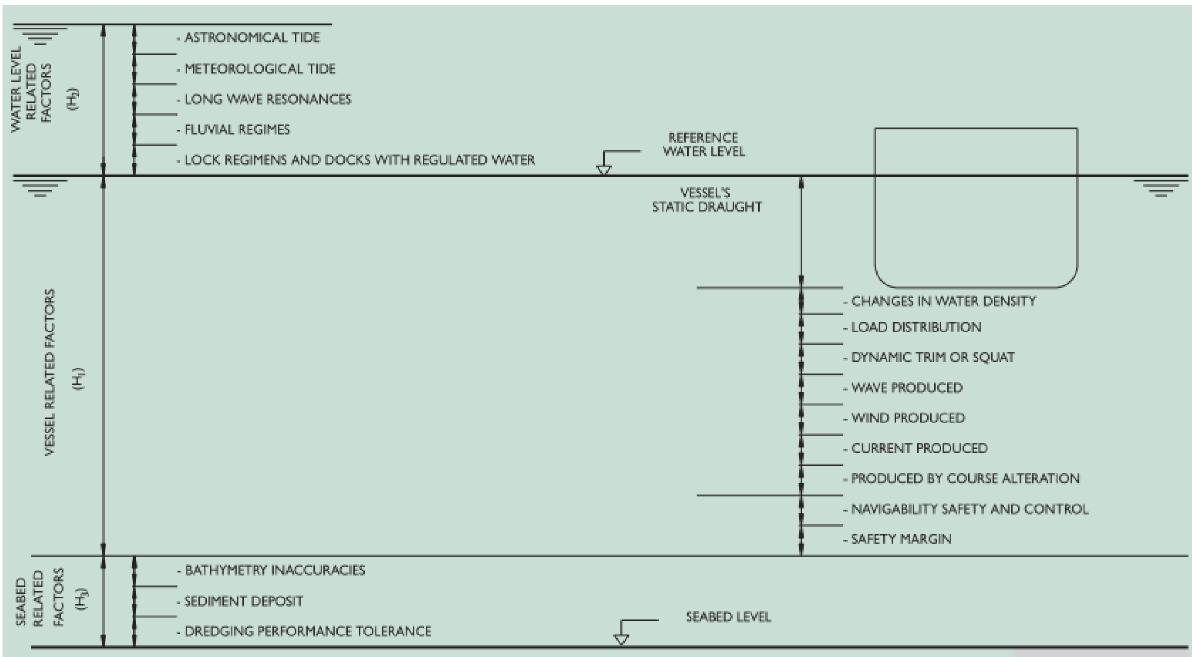

Figure 4: Factors of water depths in navigation channels and harbor basins

Where:
H_1 is the depth caused by the static draught of vessel, dynamic environment and other natural conditions element.
H_2 is the design water level, which is determined by the tide, wave, fluvial, requirement of navigation.
H_3 is the margin depth cause by seabed related factors.

The vessel related factors H_1 is constituted by the following factors:
$H_1=D_e+d_s+d_g+d_t+0.7d_w+rv_{sm}+rv_{sd}$ (vessel's centerline) (16)
$H_1=D_e+d_s+d_g+d_t+d_w+d_v+d_c+d_r+0.7rv_{sm}+rv_{sd}$ (vessel's port and starboard sides) (17)
Choose the max of value of H_1 above.

D_e is the static draught of the maximum design vessel.
d_s is the change in vessel's draught caused by changes in the density of the water. 3% of the vessel's static draught of increase is applied when the vessel moves from salt water to fresh water.
d_g is the additional draught due to cargo distribution.
d_t is the dynamic trim or squat which is taken to be the additional increase in relation to the water's static level.

$$d_t = 2.4*(\nabla/L_{PP}^2)*(F_{nh}^2/(1-F_{nh}^2)^{0.5})*K_s \quad (18)$$

Where:
d_t =Maximum value of dynamic trim (m)
∇=Vessel's volume of displacement (m^3)
L_{PP} =Vessel's length between perpendiculars

F_{nh} =Froude number, $F_{nh} = V_r/(gh)^{0.5}$
V_r =Vessel's speed relative to the water,excluding local effects (m/sec.)
g=Acceleration of gravity
h=Depth of water at rest,excluding local effects
K_s=Non-dimensional correction coefficient

d_w is the increase of vessel's draught caused by waves, shown in Table 12.

	Wave height (m)							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Vessel's length overall (L_{pp} in m)	Vertical displacement (m)							
75	0.10	0.17	0.34	0.58	0.76	1.02	1.30	1.58
100	0.05	0.14	0.28	0.46	0.65	0.87	1.12	1.36
150	0.00	0.09	0.20	0.34	0.51	0.69	0.87	1.08
200	0.00	0.05	0.15	0.26	0.40	0.57	0.72	0.92
250	0.00	0.03	0.10	0.21	0.33	0.48	0.63	0.80
300	0.00	0.00	0.07	0.16	0.25	0.39	0.56	0.68
400	0.00	0.00	0.04	0.11	0.18	0.31	0.51	0.58

Table 13: increase of vessel's draught cause by wave

d_v is the increase of vessel's draught caused by wind.

$$d_v=(B\sin\theta_{TV})/2 \quad (19)$$

$$\tan\theta_{TV}=(F_{TV}*d_{vd})/[\gamma_w(I-\nabla d_{bg})] \quad (20)$$

Where:
θ_{TV}=Vessel's rolling angle cause by cross wind action
F_{TV}=Component of the resultant wind action force on the vessel in its transverse direction.
d_{vd}=Vertical distance between the F_{TV} line of action for the case of vessels underway and the centre of drift.
γ_w=Specific weight of water
I=The area moment of inertia of the water plane of constant displacement about its longitudinal axis.

$$I=(\pi*L_{pp}*B^3)/64 \quad (21)$$

∇= Vessel's displacement expressed in units of volume.
d_{bg}=Vertical distance between the mass centre of gravity and the centre of buoyancy (centre of the submerged volume) of the vessel being analyzed.

$$d_{bg}=KG-D[0.84-(0.33*C_b)/(0.18+0.87*C_b)] \quad (22)$$

Where:
KG = Height of the mass centre of gravity above keel
D =Vessel's mean draught under the load conditions considered
C_b =Block coefficient at the foregoing draught D

d_c is the increase of vessel's draught caused by current.

$$d_c=(B\sin\theta_{TC})/2 \quad (23)$$

$$\tan\theta_{TC}=(F_{TC}*d_{cg})/[\gamma_w(I-\nabla d_{bg})] \quad (24)$$

Where:
θ_{TC}=Vessel's rolling angle cause by cross current
F_{TC}=Component of the resultant current action force on the vessel in its transverse direction.
d_{cg}=Vertical distance between the F_{TC} line and the vessel's centre of gravity.

d_r is the increase of vessel's draught caused by alterations of approach channel.

$rv_{sm}+rv_{sd}$ is the clearance for the vessel's manoeuvrability and control (rv_{sm}), and safety margin (rv_{sd}), , shown in Table 13..

	rv_{sm}	rv_{sd}	$rv_{sm}+rv_{sd}$

Large displacement vessels (>30,000 t)			
− Navigation over silty or sandy seabed			
Unlimited vessel speed (> 8 knots)	0.6	0.3	0.9
Limited vessel speed (≤8 knots)	0.3	0.3	0.6
Vessel at rest (quays, berthing, etc.)	0.0	0.3	0.3
− Navigation over rocky seabed			
Unlimited vessel speed (> 8 knots)	0.6	0.6	1.2
Limited vessel speed (≤8 knots)	0.3	0.6	0.9
Vessel at rest (quays, berthing, etc.)	0.0	0.6	0.6
Vessels with a medium and small displacement (≤10,000t, except small, recreational and fishing boats)			
− Navigation over silty or sandy seabed			
Unlimited vessel speed (> 8 knots)	0.3	0.3	0.6
Limited vessel speed (≤8 knots)	0.2	0.3	0.5
Vessel at rest (quays, berthing, etc.)	0.0	0.3	0.3
− Navigation over rocky seabed			
Unlimited vessel speed (>8 knots)	0.3	0.6	0.9
Limited vessel speed (≤8 knots)	0.2	0.6	0.8
Vessel at rest (quays, berthing, etc.)	0.0	0.6	0.6
Vessels with displacements between 10,000 and 30,000 t -Linearly interpolate as a function of the displacement given in sections 1 and 2			
Small, recreational and fishing vessels			
− Navigation over silty or sandy seabed			
Unlimited vessel speed (> 8 knots)	0.2	0.2	0.4
Limited vessel speed (≤8 knots)	0.1	0.2	0.3
Vessel at rest (quays, berthing, etc.)	0.0	0.2	0.2
− Navigation over rocky seabed			
Unlimited vessel speed (>8 knots)	0.2	0.4	0.6
Limited vessel speed (≤8 knots)	0.1	0.4	0.5
Vessel at rest (quays, berthing, etc.)	0.0	0.4	0.4

Table 14: Clearances for the vessel's manoeuvrability safety and control and safety margin

H_3 is the margin depth cause by seabed related factors.
The first factor is margin for bathymetry inaccuracies, which in shown in Table 14

	With wave compensation system	Without wave compensation system
Outer waters	1% of the water depth	0.25m+1% of the water depth
Inner water	1% of the water depth	0.1m+1% of the water depth

Table 15: Margin for bathymetry inaccuracies

The second factor is sediment deposit between two dredging campaigns.
The third factor is dredging performance tolerance, the adoption of tolerances of 0.30 m for soft ground and 0.50 m for rocky ground are recommended.

4. Width of harbor basin

4.1 PIANC guideline

In PIANC guideline, the nominal diameter of the turning basin should be more than 2 times of the vessel's length.

4.2 ROM standard

In ROM standard, the shape of turning basin is a irregular round area, which is shown in **Figure 5: Turning basin in ROM standard.**

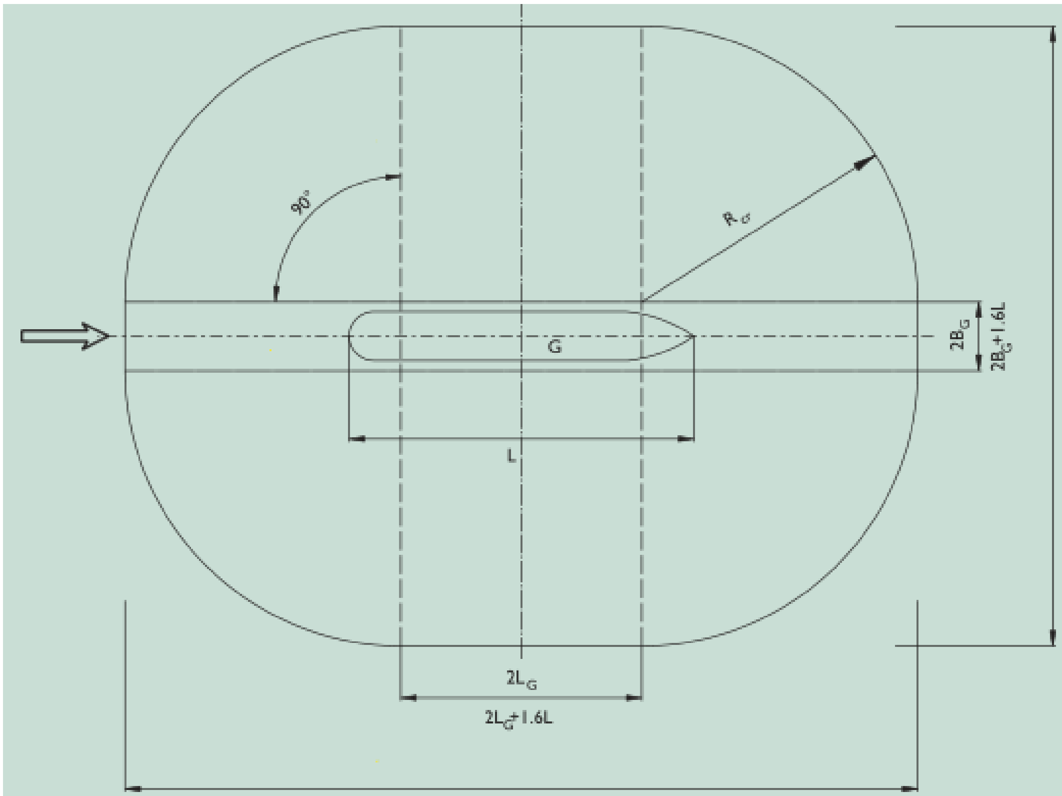

Figure 5: Turning basin in ROM standard

Where:

$B_G \geqslant 0.10L$
$L_G \geqslant 0.35L$
$R_{cr} \geqslant 0.80L$
L is the overall vessel's length.

5. Project example

A cruise terminal project in Panama is located in Panama Bay, face to the Pacific Ocean, nearby Panama Canal. The parameters of design vessels are shown in Table 15.

Design vessel	LOA	Beam	Draught	Passenger
Oasis of the Seas	360m	47m	9.3m	5400
Brilliance of the Seas	293m	32.2m	9.5m	2501

Table 16: Design vessel

The calculation results by using PIANC guideline and ROM standard are shown in Table 16.

	PIANC guideline	ROM standard
Width of channel	170m	200m
Depth of channel	12.1m	12.3m
Width of harbor basin	720m X 720m	760m X 580m

Table 17: Calculation result

The proposed water area layout of the project in shown in **Figure 6: General layout of project**.

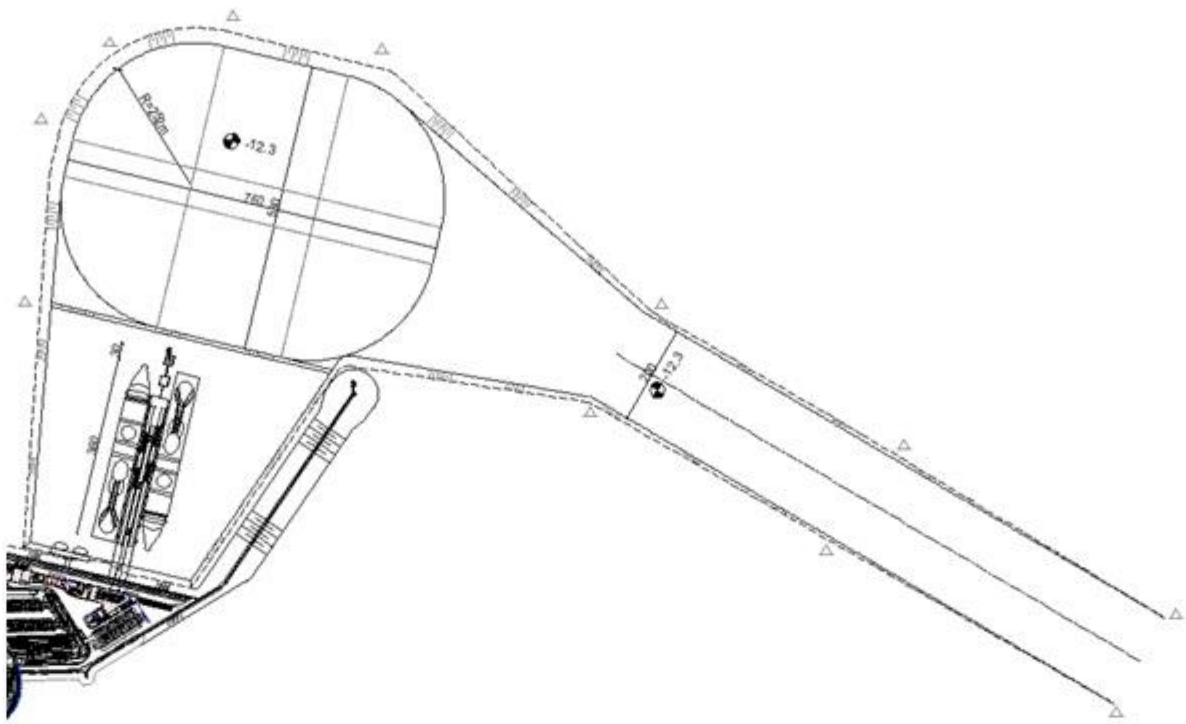

Figure 6: General layout of project

In order to make compare of the design (in ROM standard) and actual manoeuvre operation, a Real-Time simulator analysis was made, the result is shown in **Figure 7: Safe manoeuvre space.**

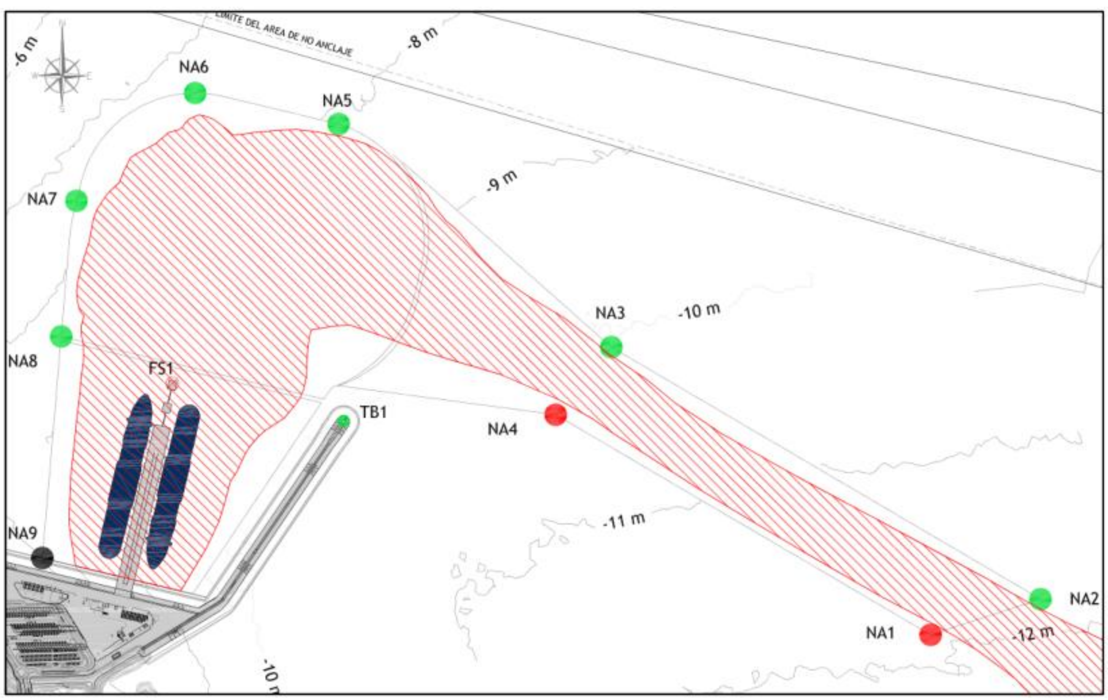

Figure 7: Safe manoeuvre space

This result shows that the shadow area of the vessel track is completely contained inside the water area. The shadow area of harbor basin is nearly an oval, so the design method of ROM standard is more closely aligned with actual manoeuvre operation. And at the corner of the harbor basin, the boundary of water area can be reduced. As for the width of channel, the design result of ROM standard is more conservative, and the design result of PIANC guideline is on the risky side, the Real-Time simulator analysis shows that the ROM standard is more suitable in this project.

6. CONCLUTIONS AND RECOMMENDATIONS

1. The PIANC guideline and ROM standard has respective characteristics and scope of application. For the width of channel, the design method of PIANC guideline is more dangerous and the ROM standard is more conservative.
2. For the depth of channel, the design result of PIANC guideline and ROM standard are almost same.
3. For the shape and width of the harbor basin, the design method of ROM standard is a irregular oval and PIANC guideline is a regular round, the ROM standard is more closely aligned with actual manoeuvre operation.

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