Underkeel Clearance

Refresher and changes since EMPA 2015 Lisboa
CATZOC’s
Under-keel clearance methodology

11 May 2017

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Have I got your attention?
The “For Why”?

- Coastal Tanker (205 m)
- Aframax (245 m)
- Suez-Max (285 m)
- VLCC (330 m)
- ULCC (415 m)
The present “norm” for UKC

• Most ports (and vessels) use Static Rules
  – Created in an era when:
    • Vessels were smaller
    • Speeds were lower
    • Squat was a relatively unknown phenomena (Tuck 1966 - ship dynamic movements)
    • Actual squat unknown (with new forms still being evolved!)
    • Computers not available
  – It is a simple method to ensure safety
    • Minimum distance (i.e. 1 metre) or %age of vessels draught (i.e. 10%)
    • Well known Rule of Thumb – 10%, But this is for calm waters only!
    • Does the allowance include squat or is the allowance after squat?
    • Is Roll/Heel calculated and applied?
    • More appropriate to call it Static Allowance than Static UKC

• The Static Rule Paradox
  – The paradox of the static rules is that without an incident a port’s static rules may appear validated and considered safe.
  – In reality, where underkeel limits are critical and conditions variable, there may be times when the clearance is marginal and the vessel has experienced an unknown “near miss”.

And still we use them
Manage Risk with Net regime

STATIC RULES - GROSS
Traditional rules based on static data and no allowance for change

DYNAMIC - NET
Uses fixed safety limit with variable allowances for environmental and vessel conditions

VARIABLE RISK

FIXED (CONSTANT) RISK
Using PIANC Guidelines as an operational tool

An improved methodology for assessing underkeel clearances
PIANC WG 49

Harbour Approach Channels
Design Guidelines
Channel Depth factors

2.1

- DESIGN WATER LEVEL
- TIDAL OFFSET DURING TRANSIT AND MANOEUVRING *)
- ALLOWANCE FOR UNFAVOURABLE CONDITIONS *)
- STATIC DRAUGHT INCLUDING Trim AND LIST
  - ALLOWANCE FOR STATIC DRAUGHT UNCERTAINTIES
  - CHANGE IN WATER DENSITY
  - SQUAT, INCL. DYNAMIC Trim
  - DYNAMIC HEEL DUE TO WIND AND TURNING
  - WAVE RESPONSE ALLOWANCE
- NET UKC
  - ALLOWANCE FOR BED LEVEL UNCERTAINTIES (SOUNDING AND SEDIMENT CONDITIONS)
  - ALLOWANCE FOR BOTTOM CHANGES BETWEEN DREDGINGS
  - DREDGING EXECUTION TOLERANCE

*) values can be positive or negative
<table>
<thead>
<tr>
<th>Component</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Draught Uncertainties</td>
<td>The ship’s draught is not always known with absolute certainty.</td>
</tr>
<tr>
<td>Water Density</td>
<td></td>
</tr>
<tr>
<td>Ship Squat including dynamic trim</td>
<td>Prediction of ship squat depends on ship characteristics and channel configurations. ... the most important ship parameter is its speed $V_S$.</td>
</tr>
<tr>
<td>Dynamic heel</td>
<td>During turning of a vessel, heeling will occur depending on the ship’s speed, rate of turn, metacentric height and tugboat line forces.</td>
</tr>
<tr>
<td>Wave response allowance</td>
<td>Potentially the largest ship factor, especially if the ship is in an exposed channel where large waves are present. Ships in water have a natural period of oscillation in heave, roll and pitch. Resonance, with amplification of ship motions, can be expected if their natural period is close to the period of the dominant wave forcing.</td>
</tr>
<tr>
<td>Net underkeel clearance $\text{UKC}_{\text{Net}}$</td>
<td>Largest Component and is what is left as a ‘safety’ margin for the ship after subtracting the other ship factors (wave-induced vertical ship motions, ship squat and dynamic heel) from the nominal channel bed level or depth. UKCNet should be based on kind and size of ship, commodities transported, environmental consequences, density of traffic, etc…</td>
</tr>
</tbody>
</table>
The limiting value of MM depends on ship type, channel dimensions and alignment, and ship traffic (including whether one-way or two-way).

A minimum value of 5% of draught or 0.6 m, whichever is greater, has been found to provide adequate MM for most ship sizes, types, and channels.

Applying this guideline then vessels less than 12.0 m draft have minimum MM of 0.6 m and vessels with drafts greater than 12.0 m draft an MM of 5%.
(PIANC WG30) defined the **nautical bottom** as “the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship’s keel causes either damage or **unacceptable effects on controllability and manoeuvrability.**”

This guideline is implemented through full analysis and complemented by pilot experience of actual ship handling.
Reasons for change

• Changing from a Gross approach to a Net approach can:
  – Improve safety
  – Enhance Master/Pilot Information Exchange

• Use PIANC Guidelines
  – as a UKC management template a rather than a channel design tool

• The first step to a DYNAMIC approach to UKC
95% existing static rule conservative

Potential for draught increases and/or productivity gains through increased tidal windows

4% existing static rule marginal

Potential for a touch bottom incident. High risk but actual risk never quantified

1% existing static rule unsafe

Very high potential for a touch bottom incident

Marsden Point NZ, Groundings: Eastern Honor & Capella Voyager 2003
Squat

Squat Channel Blockage is different for every port so actual squat is like a fingerprint as it is unique to that port.

\[
Sinkage = 1.5 \frac{Displacement}{LBP^2} \cdot \frac{Speed^2}{g.\text{waterdepth}}
\]
Wave theory – Wave period and height

- Wave period relates to wave length.
- Commonly used wave periods:
  - $T_p$: Peak period
  - $T_z$: Zero-crossing period
  - $T_m$: Mean period (=average)

- Significant Wave Height $H_s$
  - Stands for significant wave height.
  - Corresponds well to visual estimate of wave heights.
  - Average of largest one third of waves over a certain period of time.
  - Also known as $H_{1/3}$

![Graph showing wave period and significant wave height](image)
Wave Summary

Figure 3. Example Rayleigh distribution of wave heights (source: NOAA)

<table>
<thead>
<tr>
<th>Number of Waves</th>
<th>Max/Sig Ratio</th>
<th>Exposure Time (@ 10 sec Tp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>280000</td>
<td>2.50</td>
<td>31 days</td>
</tr>
<tr>
<td>10000</td>
<td>2.14</td>
<td>27 hr</td>
</tr>
<tr>
<td>3000</td>
<td>2.00</td>
<td>8 hr</td>
</tr>
<tr>
<td>1000</td>
<td>1.86</td>
<td>2 hr 40 min</td>
</tr>
<tr>
<td>500</td>
<td>1.76</td>
<td>1 hr 20 min</td>
</tr>
<tr>
<td>300</td>
<td>1.69</td>
<td>48 min</td>
</tr>
<tr>
<td>100</td>
<td>1.52</td>
<td>16 min</td>
</tr>
<tr>
<td>10</td>
<td>1.07</td>
<td>1.5 min</td>
</tr>
</tbody>
</table>

Table 1. Maximum/Significant wave height ratio
Significant wave height is a good representation of the general swell state, but is far from representative of the maximum possible wave height.

Vessels are exposed to swells for approximately 15-20 minutes during transit, depending on the speed of the vessel. (=100 waves encountered per transit)

Useful rule of thumb: Maximum wave height on a typical transit is about 1.5 times the Hm0.

International best practice recommends allowing for at least 1 in 10000 wave occurrence, which translates to a maximum wave height of 2.15 times Hm0.
Wave Response

• Affected by:
  – **Sea Conditions!**
    • wave height & period
    • wave to hull angle of incidence
    • wave-current-vessel interaction
  – **Vessel**
    • hull geometry
    • stability characteristics
    • vessel speed (relative to waves)

• Inherent difficulty and danger in generalising wave response of one vessel against another
How do we calculate?
In the field of ship design, a response amplitude operator (RAO) is a set of engineering statistics that are used to determine the likely behaviour of a ship when operating at sea. Known by the acronym of RAO, response amplitude operators are obtained from accurate models from running specialized computer programs. RAOs are calculated for all ship motions and for all wave headings.

\[
\text{RAO}(\omega) = \frac{a}{\zeta_a} = \frac{F_0}{C - (M + A(\omega))\omega^2 + iB(\omega)\omega}
\]
6 degrees of freedom

- 3 translational (**heave**, surge, sway)
- 3 rotational (yaw, **roll**, pitch)

As vessel has 6 degrees of freedom so the RAO data consists of 6 amplitude and phase pairs for each wave period and direction.

- These relate to the amplitude of the vessel motion to the amplitude of the wave, and a phase, which defines the timing of the vessel motion relative to the wave.

- RAO amplitude and phase vary for different types of vessel, and
- for a given vessel type they vary with draught, wave direction, forward speed and wave period.
RAO’s used as a estimation tool

- **Sea:**
  - Short period waves.
  - All waves with periods less than 7 seconds
  - **Does not significantly affect ship motions**

- **Swell:**
  - Medium period waves.
  - All waves with periods over 7 seconds and less than 30 seconds
  - **Significantly affect ship motions**

---

**Table 1**

<table>
<thead>
<tr>
<th>Panamax EXPORT (130°)</th>
<th>Wave Period (s)</th>
<th>9</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell Direction (° TN)</td>
<td>70</td>
<td>1.1</td>
<td>2.6</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.5</td>
<td>1.4</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.4</td>
<td>0.9</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>0.4</td>
<td>0.8</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Capesize EXPORT (130°)</th>
<th>Wave Period (s)</th>
<th>9</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell Direction (° TN)</td>
<td>70</td>
<td>0.6</td>
<td>1.3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.2</td>
<td>0.5</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.2</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>0.2</td>
<td>0.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Container IMPORT (310°)</th>
<th>Wave Period (s)</th>
<th>9</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell Direction (° TN)</td>
<td>70</td>
<td>1.9</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>1.2</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.8</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**Table 4**

<table>
<thead>
<tr>
<th>Container EXPORT (130°)</th>
<th>Wave Period (s)</th>
<th>9</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell Direction (° TN)</td>
<td>70</td>
<td>0.9</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.5</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.4</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>0.4</td>
<td>0.8</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Exports vs Imports

Exports: **Pitching** significant factor :: Imports: **Roll** significant factor
CATZOC’s

An emerging concern for all vessels!
Do we care?
When IHO developed the S-57 standard the quality of survey data used to compile ENCs had to be encoded within a composite data quality indicator known as: ‘Category of Zone of Confidence’ (CATZOC)

UK MAIB Reports that concluded CATZOC’s may have been a causal factor*

– No 18/2015, 14 July 2014:
  • “Report on the investigation of the grounding and flooding of the ro-ro ferry Commodore Clipper in the approaches to St Peter Port, Guernsey”

– No 18/2007, 9 August 2007:
  • “Report of the investigation of the grounding of the jack-up barge Octopus towed by the tug Harald, Stronsay Firth, Orkney Islands, 8 September 2006”.

*Point to consider: “Would these findings be similar if paper charts involved?”
ENC’s do not mean NEW!

• ENCs that are on the market today do not always depict the real world as accurately as would be desired.

• ENCs (and paper charts) are compiled from multiple data sources, some modern and comprehensive, some old (even ancient) and others from all stages in between.

• IHO Data Quality Working Group (DQWG) found:
  – CATZOC’s was not well understood, not liked, nor allowed mariners to adequately make decisions based on data quality.
  – Countries believe that legacy data can only be a maximum of CATZOC B as it does not take into temporal degredation
  – The DQWG has, therefore, rejected CATZOC for S-101 and is developing a new and improved method to depict data quality.
# CATZOC’s – Newer Charts

<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>± 5 m</td>
<td>a = 0.5</td>
<td>Full seafloor erosion or sweep. All significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic high accuracy survey on WGS 84 datum, using DGPS or a minimum three lines of position (LOP) with multibeam, channel or mechanical sweep system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b = 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>± 0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>± 0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>± 1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>± 10.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>± 20 m</td>
<td>a = 1.0</td>
<td>Full seafloor erosion or sweep. All significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey to standard accuracy, using modern survey echosounder with sonar or mechanical sweep.</td>
</tr>
<tr>
<td></td>
<td>b = 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>± 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>± 1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>± 3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>± 21.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>± 50 m</td>
<td>a = 1.0</td>
<td>Full seafloor coverage not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.</td>
<td>Controlled, systematic survey to standard accuracy.</td>
</tr>
<tr>
<td></td>
<td>b = 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>± 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>± 1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>± 3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>± 21.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>± 500 m</td>
<td>a = 2.0</td>
<td>Full seafloor coverage not achieved; low accuracy survey or data collected on an opportunity basis such as soundings on passage.</td>
<td>Low accuracy survey or data collected on an opportunity basis such as soundings on passage.</td>
</tr>
<tr>
<td></td>
<td>b = 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>± 2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>± 3.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>± 7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>± 52.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>worse than ZOC C</td>
<td></td>
<td>Full seafloor coverage 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</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**ZOC CATEGORIES**

(For details see Australian Seafarers Handbook, AHP 20)

<table>
<thead>
<tr>
<th>ZOC</th>
<th>POSITION ACCURACY</th>
<th>DEPTH ACCURACY</th>
<th>SEAFLOOR COVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>± 5 m</td>
<td>≈ 0.5 m ± 1%</td>
<td>All significant seafloor features detected.</td>
</tr>
<tr>
<td>A2</td>
<td>± 20 m</td>
<td>≈ 1.0 m ± 2%</td>
<td>All significant seafloor features detected.</td>
</tr>
<tr>
<td>B</td>
<td>± 50 m</td>
<td>≈ 2.0 m ± 2%</td>
<td>Uncharted features hazardous to surface navigation are not expected but may exist.</td>
</tr>
<tr>
<td>C</td>
<td>± 500 m</td>
<td>≈ 7.0 m ± 5%</td>
<td>Depth anomalies may be expected.</td>
</tr>
<tr>
<td>D</td>
<td>Worse than ZOC C</td>
<td></td>
<td>Large depth anomalies may be expected.</td>
</tr>
<tr>
<td>U</td>
<td>Unassessed</td>
<td></td>
<td>The quality of the bathymetric data has yet to be assessed.</td>
</tr>
</tbody>
</table>
## ECDIS CATZOC/Safety Contours

<table>
<thead>
<tr>
<th>ENC Symbol</th>
<th>Explanation</th>
<th>Additional Information</th>
<th>5011 Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>×</td>
<td>Generic isolated danger symbol – with less depth than user-selected safety contour or where the depth is unknown</td>
<td>Wreck, rock or obstruction</td>
<td>K</td>
</tr>
<tr>
<td>3₂</td>
<td>Sounding of low accuracy</td>
<td>Equates to sounding of doubtful depth</td>
<td>I2  I14</td>
</tr>
<tr>
<td>4 stars</td>
<td>6 stars</td>
<td>A1  A2  B  C  D  U</td>
<td></td>
</tr>
<tr>
<td>5 stars</td>
<td>All significant seafloor features detected; very high accuracy survey</td>
<td>All significant seafloor features detected; high accuracy survey</td>
<td></td>
</tr>
<tr>
<td>4 stars</td>
<td>Uncharted features dangerous to navigation are not expected but may exist; medium accuracy survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 stars</td>
<td>Depth anomalies may be expected; low accuracy survey or passage soundings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 stars</td>
<td>Large depth anomalies may be expected; poor quality data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>Quality of bathymetry yet to be assessed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CATZOC’s accounts for errors

Forecast tide
Booby Island

Forecast tide between
Booby and Goods Island

Forecast tide
Goods Island

X = Distance to
Booby Island ‘meridian’

Y = Distance to
Goods Island ‘meridian’

Recorded water level across Prince of Wales Channel 15/16 May 2007

INH1
Benchmark
5.03 m CD

2m
offset

椭圆面

HAT
Increased error from ellipsoid to seabed at
greater distance from benchmark location

Mean Level
Sea Surface

Geoid
surface

LAT (varying along channel)

Chart Datum (CD) constant along channel

Depth available
for navigation

Seabed

Buoy 3 (Taiwei buoy)

Water level relative to AHD [m]
MAIB Findings

• MAIB’s experience from previous accidents:

Training of watchkeepers in the use of ECDIS and ECS systems is, at best, patchy and that many are able to use only the systems’ most basic functions.

• Specific concerns include:
  – CATZOCs do not provide the navigator with the detail currently shown in the source data diagrams on paper chart.
  – On ECDIS displays, CATZOC data is available, but has to be operator selected.
  – ECS displays that use official electronic charts, are not always able to display CATZOC information.
  – Basic ECS systems that use unapproved charts may not display CATZOC at all. Numerous vessels now carry ECS as a supplementary aid to their approved paper charts, but by default it has become the primary method of navigation for some navigators.
Conclusions

• CATZOC’s interim method to relay confidence in ENC’s
• The significance of CATZOC needs to be understood
• CATZOC’s need to be considered
• Legacy Charts should use at least ZOC B grade
• Understanding of what CATZOC’s are and how to find and interpret them (ECDIS training).
  – CATZOC’s are a menu option so not immediately available
• Using ECS systems with unapproved charts should be discouraged
• Situation unlikely to change even with S100
Commercial developments
Strategic Partnership
OMC International
Metocean Solutions Limited

Systems integrator
Oceanwise
Background to OMC

Operates DUKC systems at 25 waterways
- Operationalised DUKC methodology in 1993.
- More than 150,000 deep draught transits.
- More than 500 ship motion measurements
- Gold Standard in UKC management.
- Involvement in PIANC committees.

Conducted more than 40 channel designs and assessments
- Using DUKC calculations.
- Similar to MetOceans’ Optimal Channel Design.

Aim to assist a wider range of ports with new products
- Growing acceptance of “eNav”
- Web delivery widely accepted.
- Alliance with MetOcean Solutions.
- Allow efficient delivery of OMC expertise to all ports.
MOV – MetOcean View

- High resolution wave forecasting
- Longwave predictions
- Real time monitoring
Systems Integration

- High resolution wave forecasting
- Longwave predictions
- Real-time monitoring

OceanWise
Products
New Products

**BERTH ALERT**
Safety monitoring for moored ships.

**PORT WEATHER**
Wind, waves & tide. Live, forecasts & statistics.

**KEEL CHECK**
Convenient, reliable, auditable. Support for traditional-UKC ports.
Comprehensive Answers to Everyday Problems

Full Dynamic
- Vessel Optimisation Cargo Optimisation
- Chart Overlays Contingency Planning
- In-transit Monitoring / Real Time Updating
- Real Time Safe / Accurate Tidal Windows and/or Draft Calculations (Continually Updated)
- Calibration and Validated Squat and Vessel Motion Models
- Safe Transit Windows Go / No Go Calculations
- Weather Forecasting and Swell Models
- Transit Planning / Speed Profiles
- Predicted Tide and Current Modeling
- Accurate Bathymetry (up-to-date, high resolution, port)
- Real Tides Input
- Fixed Vessel Motion Allowances (roll, pitch, heel)
- Squat Calculation
- Cross Checks to Ensure Clearance Safe
- Clearance as a % of Draft or Fixed Amount (le 10% or 1.00M)

Static
- Advanced Static Rules
- Static Rules

DUKC®
- (Portweather)
- Keelcheck
- Static

OMC International | METOCEAN SOLUTIONS

Engineers | Oceanographers
DUKC® - Dynamic Under-keel Clearance

Consistent scientific approach utilising near real time and forecast environmental data (tides, waves, currents) and using sophisticated ship modelling to calculate ship motions and Dynamic UKC.
### Vessel Specifications

<table>
<thead>
<tr>
<th>Vessel Length</th>
<th>Vessel Beam</th>
<th>Vessel Draft</th>
<th>Minimum Depth</th>
<th>Tide</th>
<th>Squat</th>
<th>Pitch</th>
<th>Roll</th>
<th>UKC</th>
</tr>
</thead>
<tbody>
<tr>
<td>300m</td>
<td>50m</td>
<td>14.8</td>
<td>15.1m</td>
<td>2.3m</td>
<td>0.7m</td>
<td>0.1deg</td>
<td>0.8deg</td>
<td>1.3m</td>
</tr>
</tbody>
</table>

[https://vimeo.com/165530252](https://vimeo.com/165530252)
Ensures Safety and

Maximises Productivity and Efficiency and

Increased Economic Benefits

(By exploiting the inefficiencies of the static rule)

• Enhanced decision making with transit plan accuracy
• Detailed reports Improved Master/Pilot Information Exchange
• Enhanced vessel scheduling/reduced channel conflicts
• Enhanced contingency planning
• Removes commercial pressures
• Implements a shared picture between ship and shore
Example DUKC Planning Advice

Draft vs Time

**UKC Chart Overlay**

<table>
<thead>
<tr>
<th>Passage Commencement Time (AWST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00</td>
</tr>
<tr>
<td>14</td>
</tr>
</tbody>
</table>

**Draft (m):**
- 14 to 15
- 16 to 17
- 18 to 19
- 20 to 21

**Sailing Window:**
- 20Mar2013 1330 to 20Mar2013 1430, 1 hours 0 mins

**Maximum Draft for High Waters:**
- 20Mar2013 1400 18.25m (High Water 20Mar2013 1606 5.37m)
- 21Mar2013 0300 17.45m (High Water 21Mar2013 0333 4.63m)

**Maximum Draft for Selected Start Time:**
- 20Mar2013 1345 18.20m
Example DUKC On-shore Monitoring
Example DUKC On-board Advice
Simple Account-based Approach

Free
For individual exploration

Pro
For professional ports

Plus
For custom solutions
Portal Home Screen

OMC International

Portal Home Screen

Safer Shipping | Smarter Ports

Portland Harbour portal home

TIDE
Portland Leads 1 Tide
21Mar2017 1235
0.24 m
Tide
-0.00 m
Predicted

TIDE
Portland Harbour Tide
21Mar2017 1235
0.24 m
Tide

WIND
Portland Harbour Wind
25Mar2017 1200
17.9 km
Speed
6.0 m/s
Gust
197°
Direction

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AUS Eastern Daylight Time (UTC+11:00)
Example KeelCheck Result
Example KeelCheck Result
Ship Motion Calculators

PIANC 2014 – Indicative vessel squat

PIANC 2014 – Estimated sinkage due to wave induced ship motions

PIANC 2014 – Indicative wind heel

Estimated stability parameters

<table>
<thead>
<tr>
<th>KG</th>
<th>GM</th>
<th>KM</th>
<th>Roll period</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.62 m</td>
<td>3.17 m</td>
<td>13.79 m</td>
<td>13.79 s</td>
</tr>
</tbody>
</table>
Congress theme: Lighthouses
Safer | Smarter

An alliance providing trusted solutions for ports and harbours