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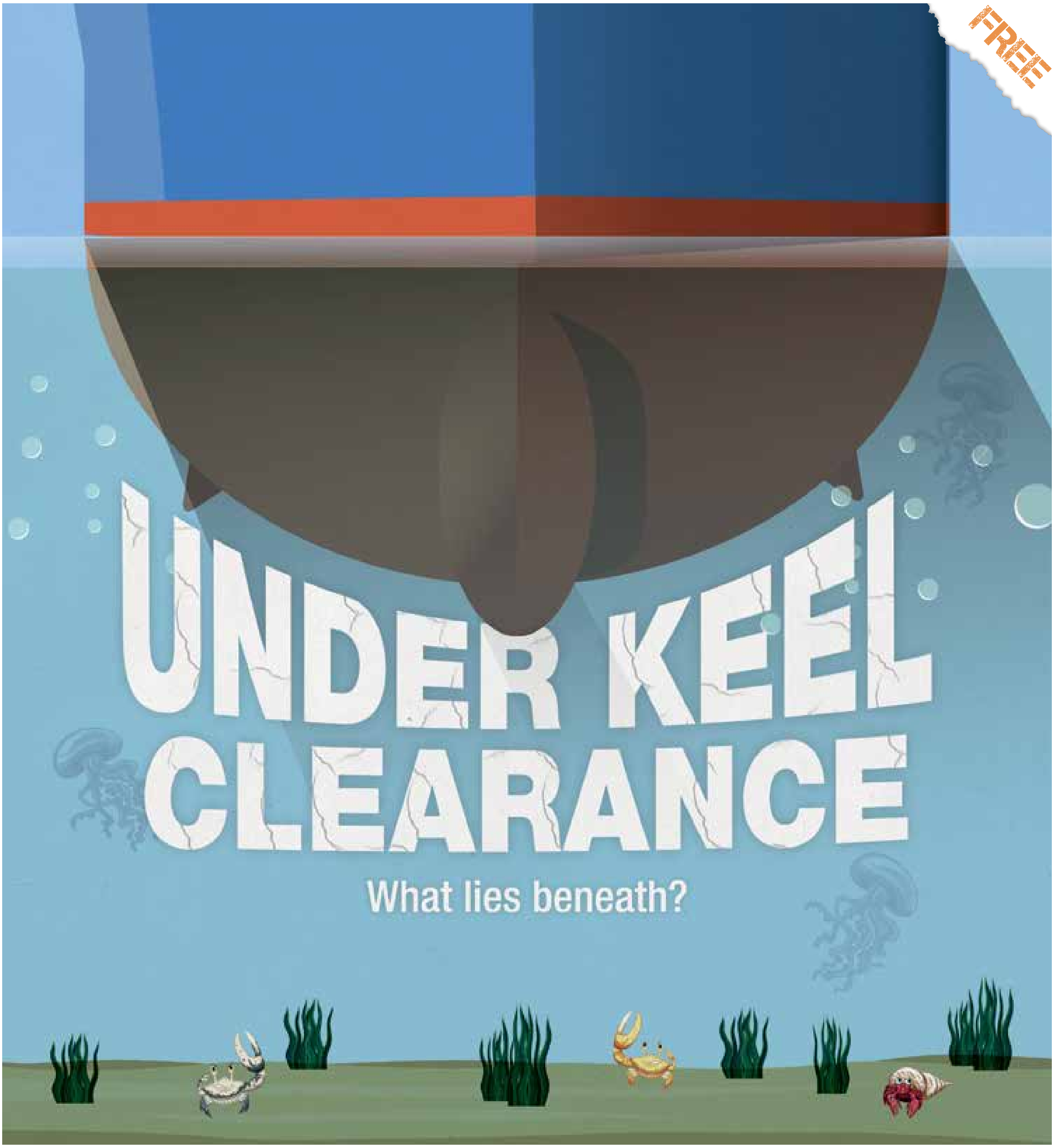
THE NAVIGATOR

Inspiring professionalism in marine navigators



The Nautical Institute

Royal Institute of Navigation

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NAV BRIEF

David Patraiko FNI
Director of Projects, The Nautical Institute

Under Keel Clearance

All navigators will be aware of the importance of Under Keel Clearance (UKC) and the basic calculations involved. In its simplest form, static UKC is the space between the bottom of the ship and the seabed. When UKC=0, you are aground – and that's not usually a good thing.

Calculating the static UKC requires detailed knowledge of chart datum depths through the waterway, tide height at each time and location through the waterway and the ship's draughts.

All of this is a good start, but how much UKC is actually needed? That is a bit more complicated. Some companies will have a UKC policy, likely included in the Safety Management System (SMS). All navigators on board should be aware of this policy. It may give minimum UKC as an absolute value (e.g. one metre) or as a percentage of the draught (e.g. 15%). It may also vary by situation, such as a minimum 50% of draught in deep water, down to 1.5% alongside. Ports may also mandate a minimum UKC. This should be identified during passage planning.

The story continues. Ships tend to move up and down due to a range of natural forces, all of which need to be taken into account to avoid a grounding. At speed, a ship 'squats' deeper into the water, and the resulting difference in UKC can often be measured in metres. There have been many groundings attributed to squat, and squat calculations need to be tailored to your particular ship and speed.

Roll, heel and pitch might also result in some areas of your hull (not necessarily the keel) getting closer to the bottom. Ships can naturally heel due to swell, windage and turning. Even a slight swell can reduce the UKC by many metres given a pitching motion – something to think about when crossing a bar to get into port. Other issues might include reduced depth due to pipelines or other obstructions. Even the nature and stability of the bottom may change, perhaps due to storms or earthquakes.

It is essential that professional navigators understand UKC and how natural forces can reduce the static UKC. These calculations can be complex, but they must form part of the passage plan and the bridge team / pilot exchange.

Today, sophisticated software programs can reduce UKC margins to the safe minimum for commercial purposes. Lowering the draught by even a few centimetres can result in hundreds of tons of additional cargo. Mariners might not be aware of the detail of those calculations, but should always seek to understand the quality of data used, and always check the results against good seamanship.

As with all issues raised in *The Navigator*, we hope this introduction is the start of a conversation with your bridge teams, in your classrooms and beyond. As always, it pays to learn and share your knowledge through mentoring and collaborative working.

INSIDE THIS ISSUE

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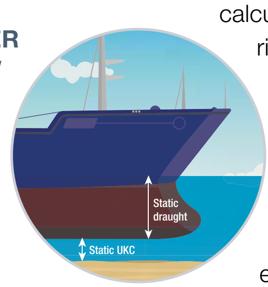

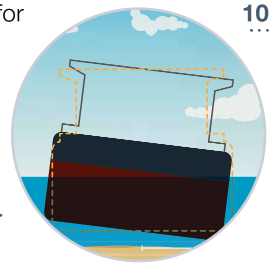

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ALL AT SEA

Emma Ward

We welcome your news, comments and opinions on the topics covered in *The Navigator*

If you would like to get in touch with us, please contact the editor, Emma Ward at navigator@nautinst.org, or look out for the LinkedIn discussion. We look forward to hearing from you.

In November 2020, The Nautical Institute launched a series of videos on our YouTube channel, talking to people who are at sea about mentoring and why it matters (you can read an interview with one of the participants on page 8). We were delighted by the many insightful comments and ideas that those involved offered. See the videos for yourself and learn more about mentoring at **https://www.youtube.com/user/TheNauticalInstitute**.

After the launch, we invited people to share their own experiences with us online across our various social media platforms. Here's some of the discussion. Enjoy!

Emma Ward
Editor

Do not be afraid to ask. Even if you are promoted to a higher rank, or become an officer in the future, still do not be afraid to ask. For sure, there will be things that you don't know. Do not be shy. You'll not be judged for asking. Asking crews, even those whose ranks are lower than yours, is not wrong. Experienced crews are always open to sharing their knowledge. And by asking, it doesn't mean that you are dumb, instead, you are promoting safety… Mentoring and lifting each other is key to promoting safety on board!

Emerson Reyes
Chief Officer

Sailing is always a teamwork matter. Whatever one sails in, you always depend on others' attitudes and expertise. To share knowledge, as well as to be humble enough to ask, enhances commitment and makes us better human beings and professionals. When I first stepped on a ship's deck as a cadet, STCW, ISM MARPOL, MLC, etc. did not exist, but the whole crew of 35 was willing to guide me and answer all my doubts, something I still remember and I am grateful for. I recently met a young Master who told me that in his vessel, conducting of safety sessions is rotated among the whole crew, including apprentice members, to empower every crew member. A genuine exercise of teamwork.

Professor Alberto Zambrana

Thank you for your thoughts! So 'on point'. I remember being a cadet and feeling very isolated and lonely. The word of a shipmate can make such a difference.

Jillian Carson-Jackson
President, The Nautical Institute

Mentoring is more than just teaching, it is sharing and caring. It is paying forward to the next generation of seafarers. When I was a cadet, my officer would always tell me that a seafarer is the cumulative outcome of all the officers and mentors he or she has had. Since everything is connected to everything else, a small impact to one can cause ripples of positive change to others. After all, teaching is fulfilling and it is the best way to learn, to review and to master. We owe it to the next generation of seafarers to maintain and uplift the standard of seafaring and safety.

André Chad Acosta

Each seafarer has previous working experiences/backgrounds/working methods to contribute, whatever their rank. Cooperation is one of the most precious resources on board, and being able to aggregate and listen will always be an essential tool for better crew performance.

Isabelle Soares
Second Officer

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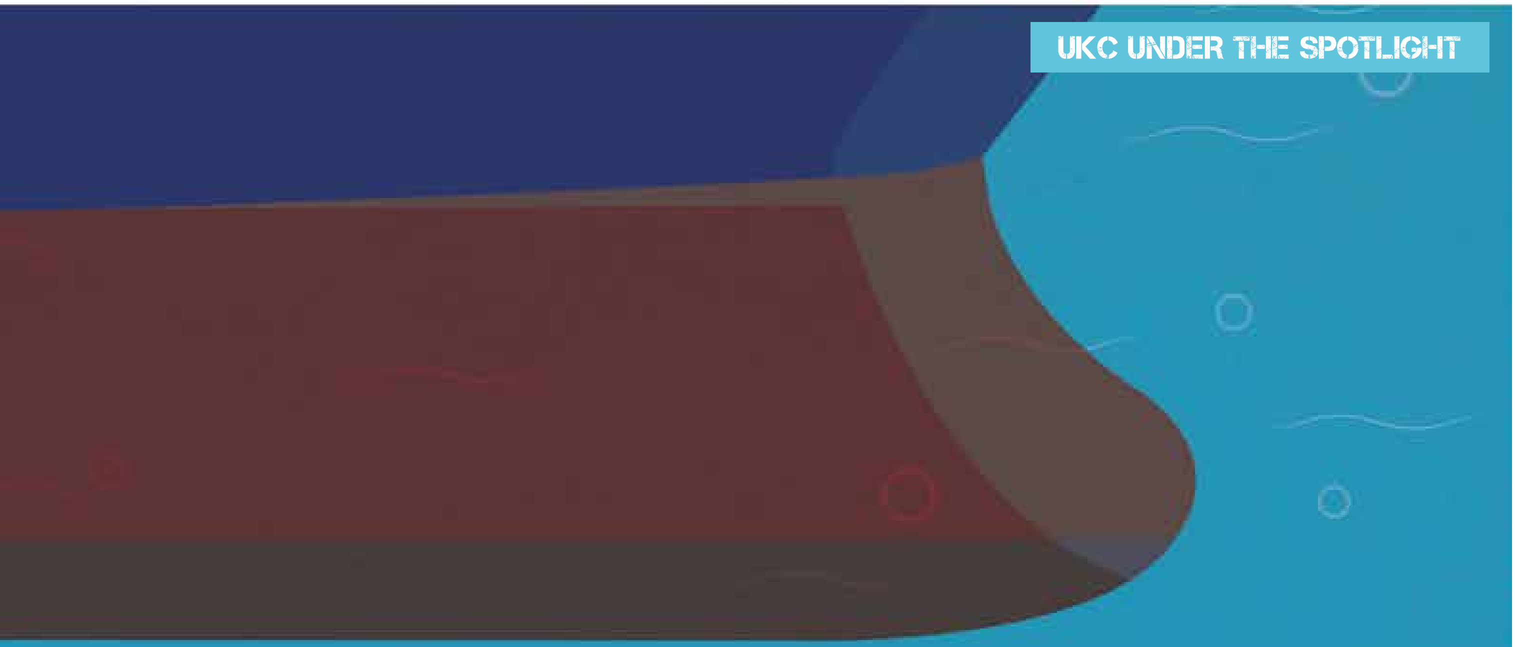
We welcome your news, comments and opinions on the topics covered in *The Navigator*. We reserve the right to edit letters for space reasons if necessary. Views expressed by letter contributors do not necessarily reflect those held by The Nautical Institute

All you ever wanted to know about UKC… but were afraid to ask

Under Keel Clearance (UKC) is a complex topic, and one with many aspects to it – but it is a vital one, as it comes down to what mariners can do to avoid ships grounding in shallow navigation channels. From calculating static UKC to understanding squat and honing UKC management techniques, **Dr Tim Gourlay** explains the basics.



The first aspect to consider is the static Under Keel Clearance – that is, how much water is left between the bottom of the ship and the seabed. This is calculated as the available water depth, including tide, minus the draught of the ship (see Figure 1 on the next page). If the ship was drifting along the waterway with no vertical movement, this would be its minimum clearance from the seabed.

Calculating the static UKC requires detailed knowledge of:

> Chart datum depths through the waterway
> Tide height at each time and location through the waterway
> Ship forward and aft draughts on entering the waterway

However, grounding risk is not just about the water depth and the ship draught. The ship also has its own vertical motions, which need to be taken into account. Squat, wave-induced motions and heel each cause parts of the ship to move closer to the seabed. All this means that it is possible for ships to run aground even when the water depth is larger than the draught (positive static UKC). To avoid this, navigators need to allow for vertical motions of the ship and combine them into the overall UKC management plan.

Understanding squat

Squat is the downward vertical movement and change in trim caused by a ship's own wave pattern. The wave pattern changes according to the speed of the ship.

The easiest way to understand squat is to imagine that ship is in a fixed position and that the water is streaming past it at a steady speed. This is how ship models are tested. The Bernoulli equation tells us that when the flow speed is high, the pressure is low, and *vice versa*. In shallow water, the presence of the ship and seabed accelerates the flow, decreasing the pressure on the ship and pulling it downwards.

On the next page, Figure 2 shows the local flow velocities and free surface height around a Panamax bulk carrier travelling at 12 kt in shallow water. At the bow, there is a stagnation zone with low flow speeds and high pressure. This high pressure translates into an elevated free surface. At the forward and aft shoulders, the water is accelerated, causing low pressure and a lowered free surface.

Overall, the presence of the ship causes a generally accelerated flow and lowered free surface. The ship then sinks downwards. It will also change its trim depending on the relative magnitudes of the wave troughs at the forward and aft shoulders. Vessels with large hull curvature at the forward shoulders will have very low pressure there, and a resulting bow-down dynamic trim.

For bulk carriers and tankers, the greatest squat will tend to be at the bow, while for LNG carriers and container ships it may be either at the bow or the stern. Either way, be aware that the propeller may be vulnerable.

Dredged channels, and especially canals, create a blockage effect that increases the flow velocities and pressure changes around the hull. In dredged channels, squat will be 5-10% larger than the standard formula. In canals, it will be approximately double the formula, depending on how confined the canal is.

Roll with it

In long-period swells, grounding can occur even with

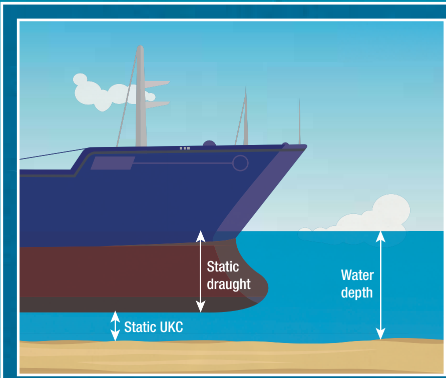


Figure 1 – Static UKC: static draught is taken to be the maximum of fore and aft draughts

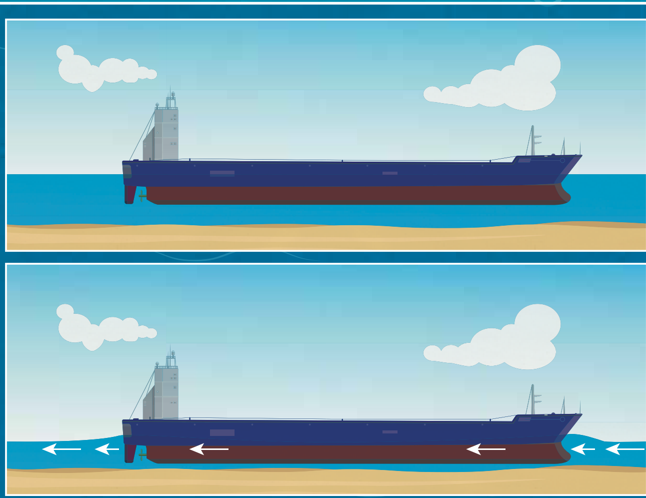


Figure 2 – Panamax bulk carrier with draught 12.2m in 14.0m water depth. Top image: ship at rest; Bottom image: ship travelling at 12 kt.

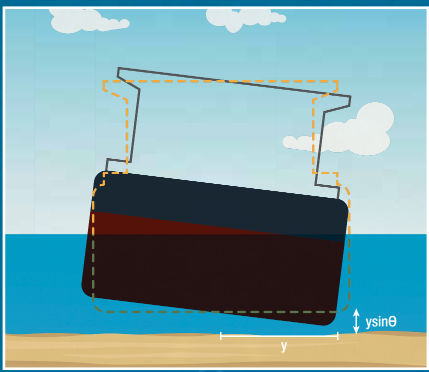


Figure 3 – Effect of roll on UKC

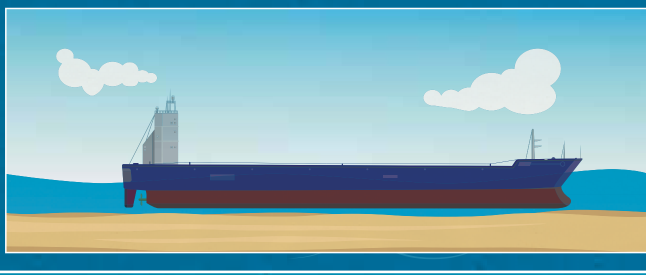


Figure 4 – Panamax bulk carrier in head seas. Wave period is 12 seconds and wave height is 4m. Draught is 12.2m, water depth is 14m and bow is close to grounding

large static UKC values. The important motion components are roll, heave and pitch, each of which produce vertical motions of the ship. Once you know the angle of roll and the distance from the ship's centreline to the turn of the bilge, or the tip of the bilge keel (labelled as 'y' in the diagram in Figure 3 above), a simple trigonometrical calculation allows you to work out the increase in depth, and therefore the decreased UKC.

This method may also be used for wind heel, which is primarily important for car carriers, container ships and LNG carriers. It may also be used for heel due to turning, which is primarily important for container ships. There are standard methods for predicting heel angle due to wind or turning.

In order to predict which wave conditions are likely to produce large rolling, it is helpful to know the ship's natural roll period. This is the period that a ship would roll at, if pulled over to one side and then released. Large roll angles occur when the wave period is close to the ship's natural roll period.

Heave and pitch

Waves in ship navigation channels, particularly head seas or following seas, produce pitching motions which can make the bow or stern vulnerable to grounding. The ship's centre of gravity also moves up and down, which is the heave motion. Depending on the phasing between heave and pitch, the bow or stern may have larger vertical movement.

Heave and pitch motions in shallow water are quite different from those in deep water. Waves of the same period are shorter and travel more slowly in shallow water than in deep water. The ship's motions are also damped more by the presence of the seabed. All of this means that ship motions tend to be smaller in shallow water than in deep water.

Figure 4 shows a Panamax bulk carrier of 180m in length heading into these waves. The ship is long enough that the aft half of the ship may be mostly in a wave crest, while the forward half of the ship is mostly in a wave trough. The result is a bow-down pitch angle, which can lead to grounding.

UKC management in practice

For ships transiting port approach channels:

- Masters must be satisfied that there is sufficient UKC according to their ship-specific calculations.
- Ports must be satisfied that there is sufficient UKC according to

their port-specific calculations.

In practice, the port-specific calculations tend to govern the transits, as these should include detailed modelling of the local conditions. However, Masters' knowledge of the behaviour of their own ships and their UKC judgement are an important part of the decision-making process. The good judgement of the Master is especially important in 'unusual' environmental conditions.

It is also useful for the crew to have a squat table readily available on the bridge. This squat table should be ship-specific, as, for example, wide-beam ships squat more than narrow-beam ships.

UKC management techniques for ports typically fall into three categories:

Fixed minimum static UKC

This method is ideal for port approach channels that are protected from ocean swells, and where simplicity is required. For example, the high-volume port of Kwai Chung in Hong Kong uses a fixed minimum static UKC of 15% of the draught (HKPA 2012).

UKC tables

For ports where metocean conditions (especially swell) are variable, but simplicity is important, paper or spreadsheet UKC tables may be used. These give the required static UKC for each ship class as a function of the most important input variables (typically swell height and period).

UKC software

UKC software allows more inputs and more specific UKC modelling. It includes allowances for squat, heel and wave-induced motions, and facilitates the in-built inclusion of tide and swell predictions and real-time measurements.

The increased usage of UKC software internationally should help to improve safety and efficiency of ships in navigation channels.

The right ship for the right port

Stuart Edmonston, Director, Loss Prevention, UK P&I Club

The previous article underlines how important it is for Master and port to be satisfied that there is sufficient UKC according to their specific calculations. However, that also depends on making sure that the right ship is calling at the right port in the first place.

Right at the start of the 'fixing' process, when the brokers representing the shipowner and charterer are negotiating potential new business, both sides should be very clear about the dimensions of the ship being fixed. This sounds like common sense, but it is amazing how often the relevant dimensions are misunderstood or miscalculated. The relevant length overall, breadth, depth, load draughts and air draughts should be recorded clearly and unambiguously in the fixture note. The shipowner should be explicit about any existing policies or parameters regarding UKC. There is absolutely no room for any misinterpretation.

Where brokers fix the ship on a voyage to a named port or place, they should work openly and constructively with the charterers to ensure the ship can actually reach the port or terminal, use it, and return from it without being exposed to any danger which cannot be avoided by good navigation and seamanship. It would be prudent for the charterers to carry out their own due diligence: properly check and re-check safety parameters of the port or terminal with the local agents and/or the P&I Club Correspondents. Have there been any recent incidents and/or litigation involving UKC problems in the recent past, and, if so, what (if any) lessons have been learnt?

All this should happen before a ship is employed. Even so, sometimes the minimum (UKC) requirements are brought into question. This might be because charterers request to reduce the UKC parameters once the ship is already in operation, or it becomes clear that the owners' requirements cannot be met (for example due to restrictions imposed by port authorities or the Pilot). What happens then?

In this situation, the Master should liaise closely with the company's DPA and P&I Club. The Master should properly record and document their UKC calculations and carry out a thorough risk assessment, taking into account all stages of the voyage to and from the berth. This risk assessment should include relevant controls, such as additional bridge manning, minimum speed, tug assistance, soundings and position monitoring. The latest sounding information, including the nature of the bottom, should be ascertained directly from the local authorities and/or terminal facilities. Consideration should be given to Noting Protest in the normal way.

Taking time to research the safety risk in advance will help to ensure that the right ship is fixed for the proposed voyage, and this helps to reduce the risk of navigation incidents and potential litigation in the future.

WATCHOUT

In this series, we take a look at maritime accident reports and the lessons that can be learned

Insufficient focus on effects of squat caused ferry to ground

What happened?

A roll on-roll off freight ferry grounded in conditions of good visibility, shortly after setting off on its voyage. The bridge team heard a loud noise and felt a shuddering vibration for around seven seconds. Propulsion and steering were not affected, so the vessel was able to set off again quite quickly. However, the ferry soon started showing a seven-degree list to port and was brought back to port. There, it was discovered that a port-side heeling tank and void space had been breached during the grounding. The ferry was taken out of service for three weeks while the damage was repaired.

During investigations, it became clear that the bridge team on the ferry had not considered the effects of squat adequately during their passage planning and had not allowed sufficient UKC given the state of the tide. In addition, the electronic navigation system was not being used effectively to spot potential areas of grounding or to help calculate a safer level of UKC. The ferry's onboard procedures specifically stated that the Master was obliged to be aware of the effects of squat (including channel and vessel widths), sea conditions (including swells) and how these could affect the ship's handling, UKC and speed. These aspects were not covered in enough detail during planning, leading directly to the grounding incident.

Why did it happen?

> The bridge team did not consider the effects of squat properly during passage planning prior to the journey.

> One of the vessel's previous Masters had produced a ready reckoner to assist with passage planning. This advised that, when leaving on a flooding tide with a draught of 5.5m, a minimum height of tide of 1.3m on the harbour gauge was required. The ready reckoner did not allow for the potential decrease in UKC due to squat.

> The ferry's planned course brought it straight into the area where it grounded, due to UKC calculations not being sufficient.

> The electronic navigation system was not being used to its full potential, meaning that the bridge team did not benefit from an early enough warning to avoid the impending grounding.

What changes have been made?

> The ferry company has taken steps to raise awareness amongst its employees around dealing with shallow water, the effects of squat and effective passage planning.

> Onboard procedures documentation has been revised to highlight the potential for squat and interaction in pilotage waters when determining speed and UKC.

> The company has also enhanced its overall bridge resource management training and electronic navigational systems.

DURING INVESTIGATIONS, IT WAS DISCOVERED THAT THE BRIDGE TEAM ON THE FERRY HAD NOT CONSIDERED THE EFFECTS OF SQUAT ADEQUATELY DURING PASSAGE PLANNING

The Nautical Institute's Mariners' Alerting and Reporting Scheme (MARS) - *https://www.nautinst.org/resource-library/mars.html* - comprises a fully searchable database of incident reports and lessons, updated every month. If you have witnessed an accident or seen a problem, email Captain Paul Drouin at mars@ nautinst.org and help others learn from your experience. All reports are confidential – we will never identify you or your ship.

Sharing is caring

Cruise ship Second Officer **Kruskayta Arellano** talks about breaking down cultural barriers at work and why navigators must keep sharing their knowledge for the good of everyone involved

Name: Kruskayta Arellano

Current Position: Second Officer

What interests you about a career at sea?

I like the idea that we can transport multiple goods, sail long distances and make the most incredible experiences for guests while they are on board our ship. It is incredible how a little team can work together to move and operate a huge ship, breaking down language barriers and learning how to coexist in a relatively tiny, multicultural place with people whom you have never met before, but will soon become your second family. This is a profession where you must learn multiple things and develop multiple skills that you employ every day. It's like doing a little bit of everything!

Where do you see yourself in five years' time? Ten?

I see myself being more confident, doing my best to share the knowledge gained through the years with other people and contributing to a better environment on board. In five years, I will be hopefully signing up for my Master's licence and very happy to continue enjoying the life at sea and keeping myself updated with the shipping industry. In ten years' time, I would like to have command of a vessel. I really would like this to happen in a cruise ship so I can carry on learning more languages and experiencing different cultures.

How has mentoring helped you in your career?

Mentoring has helped me to increase my confidence. I enjoy the freedom of having conversations between partners, supervisors and with the whole crew, as well as making connections that increase everybody's knowledge. It is good to be able to forget about the fear of speaking up or being judged. Instead, mentoring helps us to open our minds, giving us different points of view to help improve the safety culture, increase efficiency in different fields and understand why we do some activities in a certain way. As soon as we take at least ten minutes out of our day to share our knowledge, we see a huge improvement in our lives. It is possible that sometimes we do not even notice how much we are helping each other and how many barriers we are breaking down.

How can experienced navigators help those coming up behind them to improve on their knowledge and skills?

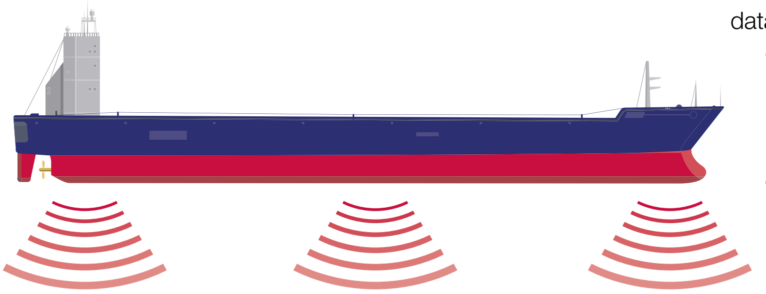
I think that experienced navigators can try different techniques to create and develop a team who feel confident about sharing doubts and ideas with each other. That way, everybody will have a voice that will be heard and analysed; the environment on board will be healthier and everyone can enjoy higher levels of confidence, efficiency and safety. For example, experienced navigators could invite other, less confident navigators to have a chat which, little by little, will move them out of their comfort or shyness zone and encourage them to share their own experiences and opinions.

Once, when I was working on board a vessel, we noticed that scheduled meetings were not working well because people felt bored and tired of how they were being run. We tried to change the way we ran meetings by keeping to the topic at hand but also introducing other activities. We made up some cards and balloons with messages, safety signs and questions inside to help keep people's attention and interest in the issues and topics around them. We got positive results and many of the people involved realised that they had been losing their wider awareness about life in their second home by just focusing strictly on their job schedules and not staying aware of everything else going on around them.

Dr Andy Norris FRIN FNI

Thinking in three dimensions

Dr Andy Norris, an active Fellow of The Nautical Institute and the Royal Institute of Navigation, looks at calculating and negotiating the distance from land – at sea and in the air



Many of the aids that we use for safe navigation give information to help establish our position over the Earth's surface in two-dimensional form. These include charts, radar, GNSS, AIS, navigation lights and the optical and acoustic scenes. However, safe maritime navigation is heavily influenced by the three-dimensional reality of the situation, just as it is for aircraft and submarines. Unfortunately, surface vessels cannot readily use movement in the vertical dimension to avoid obstacles – although they can be carefully handled in a way that minimises their draught.

Ships may well spend a good deal of time manoeuvring close to land – beneath them. In direct contrast, the time that aircraft spend manoeuvring close to the land is extremely short. Aircraft have good control of their vertical movement, but even so, commercial aircraft only have to be flown close to the ground during take-off and landing – which is only permitted in highly regulated areas. Many aircraft are also able to utilise automated landing systems, although these need constant monitoring by the pilot.

Additionally, landing areas are well lit, smooth and readily inspectable by ground-based staff. Approaches and take-offs are regulated by ground controllers, who also ensure that the airport-based electronic systems that assist the landing are working well. All this means that, for commercial aircraft, it is very much easier to avoid any 'grounding' problems compared to the maritime world – except in some very exceptional circumstances, which generally result in tragedy.

> THE SEABED IS A COMPLEX SURFACE THAT IS LIKELY TO DIFFER IN DEPTH AT ALL POINTS UNDER THE ENTIRE HULL

Ships spend a lot of time in situations where the keel is extremely close to the seabed, sometimes with less than a metre or two of estimated Under Keel Clearance (UKC). In comparison, if a vessel approaches this close to any above-water obstacle, it becomes an emergency situation, unless the vessel is manoeuvring very cautiously in known conditions, e.g. when berthing.

Hidden depths

The obvious problem with the underwater scene is the general lack of high-precision information available to the navigator. We have to rely on integrating information from a host of sources, including charted data, onboard depth sensors, tidal data, maritime notices, radioed information, physical markers and the current sea conditions, in order to get the best concept of the actual situation.

Also, we need to be constantly aware that no single figure can possibly describe the actual detailed situation under the hull. The reality is that the seabed is a complex surface that is likely to differ in depth at all points across the entire hull. These differences can be quite major when the ground is sloping, such as near the edges of a dredged channel, or if debris has fallen into the channel. The actual manoeuvring of the vessel can also cause major changes in depth along the vessel even if the seabed is completely flat.

Laser-based range equipment, known as LiDAR, could be used as the basis to give navigators a much improved real-time depiction of the situation directly under the keel – and of the surrounding area, below and even above the water surface. LiDAR has been used for some years for underwater surveying. LiDAR-based systems directed towards the navigation of commercial vessels are now beginning to emerge, not least because of current thinking towards the use of autonomous vessels.

The existing international requirements for the performance and fitting of depth sensors to ships have not changed since 2001. It will be interesting to see how they evolve as LiDAR technology becomes increasingly available for appreciably assisting the safe navigation of vessels.

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TAKE 10

Unclear about Under Keel Clearance? These top ten tips will help answer many of the most pressing questions

1
Nearest hazard
Charts and radar can be seen as depicting shipping in a two-dimensional format. However, the nearest navigational hazard for ships is often under the keel.

2
Safe navigation
Understanding how to predict and manage Under Keel Clearance (UKC) is critical to safe navigation. All navigators must be aware of their UKC, how UKC can change and any company or port limitations.

3
Static UKC
Quite simply, how much water is left between the bottom of the ship and the seabed in calm static waters. This is easily calculated using known draughts, salinity, height of tide and chart datum.

4
Dynamic draughts
Ships don't always stand still. A ship's draught can change due to features like squat, roll, pitch and heave.

5
Squat analysis
A known physical property where the draught of a ship can become deeper (by metres) with an increase in speed and the proximity of shallow water and narrow channels. Squat can be estimated by tables and/or calculations. It should always be specific to your ship (hull design) and should be assessed at the passage planning stage.

6
Roll, pitch and heave
Even slight movement by sea swell can deepen the draught by many metres. This can be particularly important when entering a port across a shallow bar, where an ocean swell is present.

7
At fixture
Even navigators can't control everything! The issue of UKC for individual ports should be addressed at the stage where a vessel is contracted or 'fixed' for charter. This will save a great deal of trouble and possible litigation – but it is still important to check, for every port, every time.

8
Management plan
UKC can and should be managed. When making a plan, gather the most up-to-date information on depths and bottom contour, ship and company UKC policy, and know when a reduction in speed is necessary to ensure safety.

9
Be wary
Not all underwater hazards are charted. Be wary of the possibility of changing depth due to environmental conditions or obstructions such as anchors and debris. The date of the latest hydrographic survey may also be an indication of risk.

10
Complexity
Understanding UKC and how to manage it can be complex. It is well worth discussing these issues with your bridge team and taking the time to mentor those who are starting out.

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Over the years, our fantastic team of distributors have got paper copies of *The Navigator* on tens of thousands of ships and into training institutions worldwide. We know this has made a real difference to seafarer's lives and how they operate – and we love hearing back from each and every one who has taken the time to send us a Navsnap or tell us how their day is going.

The Covid-19 pandemic has had a severe and profound effect on seafarers. One of the (minor!) effects for us has been that we are unable to print and distribute *The Navigator* on paper in anything like the same scale due to worldwide travel restrictions. We know that means it is harder for navigators to get their hands on a copy. But we want to continue to share the message that now, more than ever, navigators matter. The world as we know it would not exist without the efforts of those at sea.

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