THE IMPLEMENTATION AND COMMISSIONING OF DUKC® IN-TRANSIT AT THE PORT OF MELBOURNE

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1 SUMMARY

Dynamic Under Keel Clearance (DUKC®) is a proprietary under keel clearance (UKC) management system (installed at 19 ports world wide) that predicts the UKC of vessels, accounting for the latest environmental, vessel and transit information.

Historically, DUKC® Systems have been recognised for the enormous economic benefits which are usually provided to waterway owners and users. However, increasing international recognition is being given to the significant benefits which dynamic determination of under keel clearance provides as a risk mitigation tool. While OMC has pioneered this tool for 17 years, leading international bodies such as PIANC and IALA are now developing guidelines and standards around dynamic UKC determination.

Risk mitigation has been the primary motivation for the recent DUKC® implementation into the Port of Melbourne, Australasia's largest and one of the world's top 50 container ports. The entrance to the Port is considered one of the most difficult pilotage and technical modelling challenges anywhere on earth.

To manage these conditions, DUKC® technology has been integrated onto Portable Pilot Units (PPU)s and into the VTS Centre to enable vessel speed and predicted under keel clearance to be monitored onboard and ashore. While primarily a risk mitigation tool in the Port's challenging waters, the full DUKC® suite has been installed to also deliver efficiency benefits to port users.

This implementation process of DUKC® at the Port of Melbourne involved PoMC installing the latest state of the art instruments to provide near real-time environmental data of the highest quality. Intensive modelling studies were undertaken of wave/current interaction effects on vessel motions, including full-scale vessel motion measurements, in order to validate DUKC® predictions for use in this challenging stretch of water. In addition, PoMC commissioned two independent risk assessment studies.

This presentation summarises 3 key pre-implementation studies undertaken by the Port of Melbourne which concluded that the DUKC® system was capable of delivering improved safety and efficiency benefits to port users in comparison to existing static rules.

It also details OMC's experience in installing real time In-Transit DUKC® for the Port of Melbourne, with the main challenge being the reliable delivery of data from ship to shore.

The presentation concludes with a brief introduction to DUKC Series V, the most recent adaptation, which is web-based.

2 INTRODUCTION

The history of shipwrecks since settlement began at Melbourne in 1835 attests to the reality that Port Phillip Heads (The Heads) poses one of the most challenging waters for ship navigation to be found anywhere on earth.

At The Heads, the bay is constricted to a width of approximately 3km, resulting in strong tidal currents up to 7 knots flowing to and from the bay from Bass Strait (see Figure 1). The Heads is also exposed to large, long swells up to 5m significant wave height propagating from the Southern Ocean which interact with the strong tidal currents and complex hard bathymetry to create wave conditions that vary considerably, both spatially and temporally.

Picture long swells up to 5 metres significant wave height, combined with currents up to 7 knots on the ebb that cause even ships in excess of 250 metres in length to plunge several metres downward in extreme conditions.

Now add unforeseen circumstances such as delays, vessel breakdowns, excess loading or deteriorating environmental conditions.

It's a challenging picture. Even more so, with the increasing size of vessels which are expected to arrive at the Port of Melbourne in the coming years.

SO HOW DO YOU REDUCE THESE RISKS?

The Port of Melbourne Corporation (PoMC), faced with this responsibility, recently commissioned the DUKC® technology as an effective tool for managing under keel clearance risks in its various approach channels

However, this was not before more accurate data was obtained, and independent experts were commissioned to undertake risk assessments of the system specifically for the Port of Melbourne. This restricted entrance to the Bay is not only one of the world's most difficult pilotage challenges but is also a technical challenge for under keel clearance prediction.

The following sections will cover three key studies, detailed below, undertaken as part of this pre-implementation and validation process prior to the installation of DUKC® at the Port of Melbourne.

3 KEY RISK MITIGATION STUDIES UNDERTAKEN AT THE PORT OF MELBOURNE

THE FIRST NECESSARILY INVOLVED COLLECTING MORE ACCURATE DATA AND REFINING ALGORITHMS.

Initial attempts to configure a DUKC® system for the Port of Melbourne in early 2000 were thwarted by the technical difficulty of measuring and predicting wave conditions in The Heads. Subsequently, from 2005 the PoMC invested heavily in wave measurement. A large quantity of high-quality wave data has been collected in The Heads using new state-of-the-art instruments located at critical locations of the shipping channel and these data, together with sophisticated modelling techniques, have allowed this obstacle to be overcome. This section will detail the process undertaken towards gaining this key predictability of waves through The Heads.

A group of Triaxys buoys was located some 8km offshore from The Heads (see Figure 1).

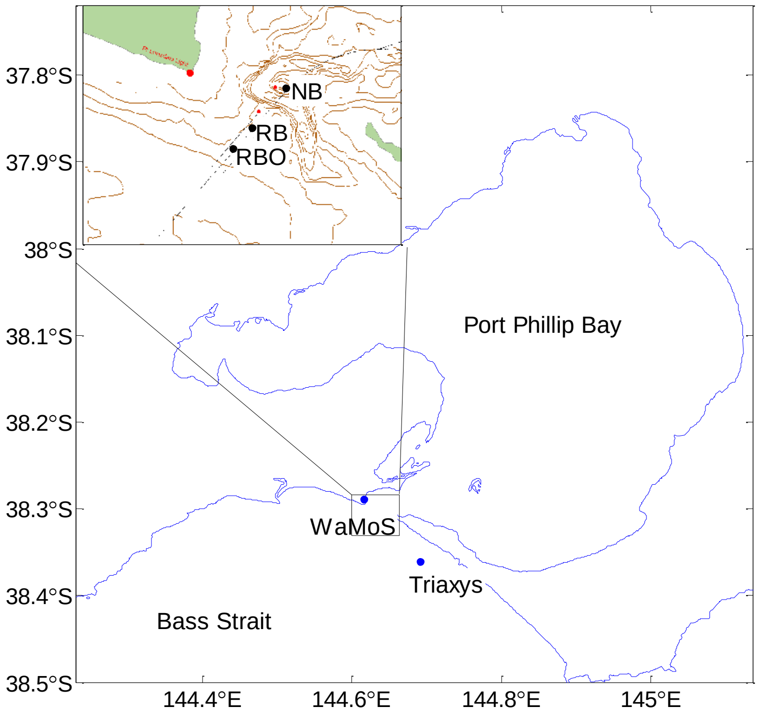

Figure 1: Location of The Heads at the entrance to Port Phillip Bay together with the location of the WaMoS and Triaxys instruments. The insert indicates the complex bathymetry within The Heads.

The buoys provide the offshore real time wave information to the DUKC® System and transmit real time directional data ashore every 30 minutes.

Bottom mounted acoustic profiles (Nortek AWAC's) were deployed at three critical locations on the channel centreline for 2 years in bursts of 6 week deployments.

A WaMoS wave radar was installed at Point Lonsdale in order to measure real-time wave conditions in The Heads. The output of the WaMoS was validated against AWAC wave measurements from the channel centreline. The WaMoS data contributed greatly to understanding the spatial variation of wave conditions in The Heads.

Because the implementation of the algorithm in an operational system requires real time knowledge of the currents in The Heads, and these cannot be measured in real time, an accurate predictor of the currents was also developed and validated.

These algorithms were subsequently integrated within the DUKC® system to provide prediction of wave conditions in The Heads based on measured wave data from the offshore buoys and the WaMoS wave radar and predicted tidal currents. The algorithms have been extensively validated using independent data and have been peer reviewed by an independent oceanographer with extensive experience of conditions in The Heads. The new wave and current algorithms have been independently judged to allow accurate determination of the subsequent dynamic effects on vertical ship motions for any specified ship and loading condition, including the strong wave-current interaction effects at The Heads.

One of the main challenges at The Heads is that environmental conditions are too extreme for deployment of real time instruments. As such, algorithms needed to be developed to transform spatially and temporally a measured offshore wave climate through The Heads (considering both wave height and length as detailed above) up to 36 hours in advance considering the key factors that influence the propagation of wave conditions, namely offshore wave height, period and direction and current speed and direction and tidal height through The Heads and their corresponding interdependencies.

THE NEXT STAGE WAS VALIDATION OF THE PREDICTION OF VESSEL MOTIONS AND UKC FROM THE DUKC® SYSTEM.

In 2007/08 a series of full-scale ship motion and under keel clearance measurements were undertaken by PoMC for 12 vessels transiting the Port of Melbourne channels. The DUKC® System was run "blind" for each ship and the results were provided to PoMC for their independent validation of the accuracy of OMC's ship motion predictions.

Comparisons of the DUKC® predictions against the precise DGPS measurements confirmed that the system accurately predicted squat and turning heel in the Yarra River and South Channel and vessel wave response in The Heads under a wide range of wave/tidal current conditions and vessel types and sizes.

Examples of full-scale vessel measurements undertaken to validate the wave response modelling for wave-current interaction effects are presented in Ref.3. These examples demonstrate the significant effect which strong currents produce on vessel wave response. They also illustrate the excellent agreement which was obtained between measured and predicted motions.

LASTLY, POMC COMMISSIONED OMC TO CALCULATE THE TOUCH BOTTOM PROBABILITY (TBP) OF VESSELS TRANSITING THE PORT OF MELBOURNE UNDER THE GUIDANCE OF THE DUKC® SYSTEM.

TBP's were calculated for a range of typical container vessel classes frequently calling at the Port of Melbourne. Comparisons were made also to International TBP guidelines, in particular:

A grounding rate of 0.03 incidents per 1000 ship movements (PIANC 1997).

The chance that a vessel touches the channel bottom during transit must always be less than 1% for all weather conditions (Savenije, 1996).

The results showed that the Touch Bottom Probabilities of typical vessels operating under the advice of the DUKC® have been found to be at least 2 orders of magnitude safer than the present static rules and are at least 3 times safer then suggested by international guideline. Introduction of the DUKC® System was found to considerably reduce the probability of touch bottom events occurring at the Port of Melbourne.

These risk assessment studies concluded that the DUKC® System would significantly reduce the risk of large vessels grounding in its approach channel.

Following these favourable results, PoMC, in consultation with Port Phillip Sea Pilots, decided to install OMC's latest upgraded technology DUKC® In-Transit to reduce the risk of grounding in the treacherous entrance to Port Phillip Bay.

4 WHAT IS DUKC® IN-TRANSIT?

DUKC® software has undergone a number of releases and versions (Series) since the first installation in 1993 (DUKC® Desktop). However, the accuracy of the complex numerical calculations (the "engine") at the heart of the DUKC® system has remained essentially unchanged and has been validated by undertaking more than 250 ship transits to obtain full-scale measurements of vessel speed, track and vertical displacements.

DUKC® In-Transit is Series 4 of the DUKC® suite. It is the integration of DUKC® technology onto laptops carried by pilots (DUKC® PPU) and into VTS centres (DUKC® VTS), which enables vessel speed and predicted UKC ahead to be monitored onboard and ashore. This technology is the only proven system worldwide which can monitor in real time a vessel's UKC during the entire journey, from berth to deep water, or vice versa. Only DUKC® can provide this in-transit capability of UKC management.

DUKC® PPU has now been rolled out to all 35 Port Phillip Sea Pilots, enabling them to reliably and accurately determine how deep and efficiently their large vessels can safely go without the risk of running aground in the Port of Melbourne.

The pilot units receive and process live up-to-the-second DUKC® data while in transit through the Heads, across Port Phillip Bay and along the Yarra River. This information enables a pilot to monitor that the vessel's speed is consistent with the predicted safe DUKC® passage plan and adjust speed as required. By using DUKC® PPU the risk of grounding can be continuously monitored, properly managed, and effectively mitigated, especially when conditions or circumstances change, such as vessel breakdown or overloading.

This system has also been successfully integrated into Melbourne's VTS Centre to allow VTS operators, already trained by OMC, to monitor safe under keel clearance during transit of all deep-draught ships.

The VTS operators receive the same under keel clearance predictions and grounding warnings as the ship's pilot receives on the PPU. The operator can transmit this information to the pilot by radio in the case of a communications failure or pilot laptop damage/loss while boarding.

This in-transit technology assimilates on-the-fly all information required to assess the risk associated with a ship's intended passage and to provide warnings and suggest evasive action when the risk of delays or grounding will exceed predetermined limits.

5 INSTALLATION OF DUKC® IN-TRANSIT AT THE PORT OF MELBOURNE

As part of the commissioning of the DUKC® system at the Port of Melbourne, there was a requirement to implement OMC's real time DUKC® In-Transit at VTS and on the Port Phillip Sea Pilots (PPSP) pilots' laptops.

PoMC reasoned that while it could ensure there was an appropriate and safe transit window for a vessel, the pilots must also take responsibility for the safe transit of their vessels.

5.1 TWO MAIN CONCERNS

The first - a transit could take as long as six hours (the average is three to four hours) and during that period the environmental conditions at the Heads could change significantly. This could undermine the quality of the original transit plan.

A second concern was if the pilot changed his transit speed profile from the plan, this could significantly change the squat component in the calculated under keel clearance, thereby leading to increased high touch bottom risk.

The real time DUKC® In-Transit system could address these issues as environmental data was regularly updated, and the pilot could adjust his speed profile and his plan, or even abort if necessary. The pilot could also manage the squat component, as he could verify what the appropriate speed for the transit should be to ensure a safe under keel clearance was maintained at all times.

5.2 WHERE TO INSTALL THE SYSTEM?

OMC considered two options on where best to install the real time system, the primary purpose being the delivery of data between ship and shore. The options were to:

Install the system locally on each laptop and feed the environmental data to the laptop from ashore.

Major benefits:

- System can still be run when communications go down briefly or for extended periods of time when there is no significant change in environmental conditions.
- Relatively fast once initial calculations completed.
- Environmental data could be sent via AIS or other means.

Major disadvantages:

- Significant pilot support issues.
- No integration with shore VTS; or monitoring of proposed passage plan.
- Initial calculations are CPU intensive which could be difficult for existing laptops.
- Unknown whether data being received or if being used correctly.

Install a system on a shore server which the pilots could access.

Major benefits:

- Dedicated computer/server system.
- Improved and simpler support (both from OMC and PoMC).
- Shore VTS to pilot integration and improved monitoring.
- VTS assistance when pilot laptop or communications unavailable.
- Continuous environmental feed to server that is applicable to all vessels

Major disadvantages:

- Requires robust ship/shore data communication link.
- Cannot be run remotely where there is no communications.
- Slower to obtain results due to data links.
- Reliant on good telecommunication coverage and reliability.

Overall, PoMC and OMC decided that the benefits in having a server based shore system outweighed the disadvantages. Both options required a communication link between pilot and shore, and in this respect a laptop installation was more robust with respect to disruptions with communications. However, with this option 35 laptops and pilots who were living around the Bay area would require reliable 24/7 support.

5.3 COMMUNICATION ISSUES

The primary issue was therefore one of ensuring a robust telecommunication connection between the pilot and server, and due to the type of data exchange needed it was determined that 3G broadband would be the best method of communication. The actual requirement was to create a remote desktop session between the pilot's laptop and the server; which required a connection to the internet, then a VPN connection to the server and then running a remote session.

In December 2008 trials commenced with various network cards and aerials. The results were inconclusive as to the optimum setup but what was found was that the supplied modems had about a 10% failure rate and that there was not full, or good, coverage within the bay environ.

The coverage is, as described by telecommunication companies, as 'fortuitous coverage' i.e. coverage that was not intended when installing cell antenna arrays. The result of this is that a modem will seek either the best signal and lock on, or where there are two equal signals the modem 'hunts' between the stations and doesn't lock on to either station. This resulted in modems that would either not connect, or would connect to a 2G band if the signal was strong. However, the problem was solvable if the frequency could be fixed, which required removal of the supplied Telco software and use of the modem manufacturers software and tools.

During the trials the number of 'hops' between internet, Virtual Private Network (VPN) and Remote Desktop resulted in another problem as it required manually starting a number of processes. To overcome this, OMC created in-house tools to provide clear, concise and immediate UKC warnings with minimal input and interpretation required. This automated process also reduced the overheads on the pilot in setting up. OMC simplified the data entry process to such an extent that a vessel that was entered into the system by VTS was immediately available to the pilot with the only requirement on his part being to verify the vessel's data and create a speed profile for the transit.

5.4 PILOT TRAINING

Implementing this software also required extensive training and this was undertaken under the direction of OMC's in-house Pilot, Captain Jonathon Pearce, using group training sessions. These took place one-on-one at the pilot station as well as testing verification and training onboard. VTS personnel undertook similar training which also ensured both groups were familiar with the theory behind the technology and how the program operated. From this, operational procedures were created outlining the requirements and processes expected of all parties.

5.5 PILOT ACCEPTANCE

Whilst there were some initial reservations, this was slowly overcome when the pilots recognised that the results from the program were consistent with their experience and expectations. **These reservations were related to the poor telecommunications coverage in the Bay, and not to the DUKC® In-Transit software.**

In May 2009 the system went live and is now in use daily with the deeper draught vessels that are starting to trade with Melbourne.

Since going live the pilots have maintained feedback and this will result in incorporating their requests with changes to the on-board system. These changes will further simplify and improve the passage planning and decision making processes.

5.6 WHAT'S NEXT?

The latest release, Series 5, is web based thus allowing easy accessibility to the system for approved users worldwide**.** This product has, as before, been adapted in response to customer feedback and availability of new software technologies.

The DUKC® Series 5 Web Services Architecture and its application configurations are described in Ref. 4.

6 CONCLUSION

It is important to note that the DUKC® system has been rigorously and independently tested by specialist risk management consultants to ensure that it satisfies internationally-accepted levels of risk for safely managing the UKC of vessel transits. It is World's Best Practice.

It was only following these studies that PoMC made the decision to commission OMC's world-leading DUKC® navigation technology.

Through a scientific approach to identifying and predicting relevant UKC components, the DUKC® enhances the safety of large vessels passing through the treacherous entrance to the Port of Melbourne.

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