USE OF WEB-BASED DECISION SUPPORT TECHNOLOGY FOR IN-TRANSIT UNDER KEEL CLEARANCE MANAGEMENT

DR. TERRY O'BRIEN OMC INTERNATIONAL, AUSTRALIA, TERRY@OMC-INTERNATIONAL.COM

PETER O'BRIEN OMC INTERNATIONAL, AUSTRALIA, PETER@OMC-INTERNATIONAL.COM

CHRIS HENS OMC INTERNATIONAL, AUSTRALIA, CHRIS@OMC-INTERNATIONAL.COM

SUMMARY

The Dynamic Under Keel Clearance System (DUKC®) is a real time under-keel clearance (UKC) system used by ports and shallow waterways to maximise port productivity and safety. The DUKC® considers all factors that affect the UKC of a vessel transiting a channel to determine the minimum safe UKC requirements. With a track record of 19 years and more than 60,000 vessel transits globally without incident, DUKC® has a strong history as an operational tool.

OMC has now developed the next generation of the DUKC® product suite, DUKC® Series 5, which integrates the proven core calculation engines from previous DUKC® releases with a new web interface thus allowing easy accessibility to the system for approved users world-wide. DUKC® users are now able to successfully execute under keel clearance related tasks via the web rather than the traditional desktop-based user interface.

Further the DUKC® Series 5 seamlessly interfaces probabilistic UKC planning (maximum draught & tidal windows) up to 12 months in advance with short term transit planning utilising real time environmental and vessel specific information and also with UKC monitoring throughout the transit to deep water.

This paper outlines important features of this next generation product suite through example outputs selected from three waterways for which DUKC® Series 5 developments have been completed: the international waterway through Torres Strait between North Queensland and Papua New Guinea and the port approach channels into Port Hedland, Western Australia and the Port of Melbourne, Victoria.

1 INTRODUCTION

The Dynamic Under Keel Clearance System (DUKC®) is a real time under-keel clearance (UKC) system used in ports and shallow waterways to maximise channel productivity and safety. The DUKC® considers all factors that affect the UKC of a vessel transiting a channel to determine the minimum safe UKC requirements. With a track record of 19 years and more than 60,000 vessel transits globally without incident, DUKC® has a strong history as an operational tool.

Melbourne-based OMC International (OMC) continues to be the only specialist maritime firm in the world whose core focus is providing proven technology for determining and managing real-time UKC in depth-restricted waterways, commonly approach channels to ports.

OMC's clients have become increasingly interested in installing DUKC® for safety and risk management purposes and this has been one of the primary drivers of recent DUKC® research and development.

The DUKC® product suite has been adapted in response to customer feedback and availability of new software technologies undergoing many releases and versions (Series) since the first installation (DUKC® Desktop) in 1993. New applications developed and deployed include the integration of the technology onto laptops (or smaller devices) carried by pilots (DUKC® PPU) and into VTS Centres (DUKC® PPS) enabling vessel speed and predicted under keel clearance ahead to be monitored on board and ashore.

The following sections describe the different functional modules in DUKC Series 5 and provide example outputs selected from three waterways for which DUKC® Series 5 developments have been completed: the international waterway through Torres Strait between North Queensland and Papua New Guinea and the port approach channels into Port Hedland, Western Australia and the Port of Melbourne, Victoria.

2 DUKC SERIES 5 - REAL-WORLD EXAMPLES

TORRES STRAIT (AUSTRALIA)

Torres Strait lies between Papua New Guinea and the northern tip of the Australian continent and is a vital shipping route for the Asia-Pacific region. It is used by numerous large vessels which face many navigational challenges due to numerous reefs, shallow waters, complex tides and strong tidal streams.

The International Maritime Organisation (IMO) has promulgated Torres Straits as a "Particularly Sensitive Sea Area" due to its proximity to the Great Barrier Reef and its significance to the national and international community.

Due to restricted water depth a draught restriction of 12.2m has been imposed by the Australian Maritime Safety Authority (AMSA) on all vessels transiting the area. This bottle neck restriction imposes significant cost penalties on a wide range of commercial shipping.

In December 2009, AMSA commissioned OMC International to implement a DUKC® Series 5 System as the Under Keel Clearance Management (UKCM) system for Torres Strait. The system was declared operational by AMSA on 16 December 2011 in Marine Notice 17/2011.

Once sufficient operational experience has been obtained, the Torres Strait DUKC® Series 5 System is expected to permit vessels to safely transit Torres Strait with draughts greater than 12.2m at most times, offering significant economic benefits to the Australian economy. Further the system will increase safety by ensuring adequate under keel clearance is maintained at all times through this complex and vital international waterway.

PORT HEDLAND (AUSTRALIA)

Port Hedland is one of the largest bulk export ports in the world, exporting almost 200 million tonnes of iron ore in 2010/11, an amount which is expected to quadruple in the next few years. The DUKC system has been assessed as contributing about 7% of this tonnage, as compared to the amount which would have been shipped under the pre-existing static UKC rule. Port Hedland has a 44 km approach channel and has a tidal range in excess of 5.8m for springs.

PORT OF MELBOURNE (AUSTRALIA)

The Port of Melbourne is Australia's largest container port. The entrance channel through Port Phillip Heads is recognised as posing, under certain conditions, one of the most challenging waters for ship navigation anywhere in the world. Swells up to 5m significant wave height and 16 second peak period, interacting with tidal currents up to 6 knots, over an extremely complex bathymetry with a rock bottom can combine to cause vessels in excess of 250m length to plunge several metres downwards.

These three examples illustrate the varied nature of the UKC management tasks for which operational DUKC Series 5 systems have already been customised.

3 DUKC SERIES 5 - PRODUCT OVERVIEW

OMC International has developed the next version of the DUKC product suite, DUKC Series 5 which constitutes a major upgrade of the DUKC product suite. DUKC® Series 5 integrates the proven core calculation engines from previous DUKC® releases with a new web interface. DUKC® users are now able to successfully execute under-keel clearance related tasks via the web rather than the traditional desktop-based user interface.

The DUKC Series 5 is built on proven DUKC Series 4 engineering models but has been redesigned to provide:

- Optimisation of multiple vessels on a tide
- Improved work flows, including web-based access
- The ability to control user access and permissions
- New business modules
- The ability for clients to select the modules they require with the potential to procure additional modules in the future should the need arise

Compared to DUKC Series 4, the DUKC Series 5 is divided into different functional modules, which are integrated into a single web portal. Each module is self-contained, developed and tested under ISO standards. An overview of the various modules is shown in Table 1 below.

DUKC Optimiser extends port throughput optimisation to include incoming, as well as departing ships. Thus, DUKC Optimiser can assist port authorities, not only in optimising outward sailings, but by managing the whole marine logistics task, including managing tugs and inward bound shipping.

A more detailed technical description of the various modules and components is given in the following sections.

Table 1: DUKC Series 5 modules

	Module	Description
PLANNING	Voyage Planning Service	The long-range (>24 hours) under-keel clearance planning component. This component uses environmental forecasts and climate statistics to estimate what the short-term (0-24 hrs) sailing advice of the DUKC® will be at some future date.
PLANNING	Transit Planning Service	Real-time to short-term predictions of under-keel clearance, maximum sailing draughts and sailing windows. The predictions are automatically updated from latest met-ocean observations. Can be used for one or more vessels simultaneously but does not consider scheduling conflicts.
PLANNING	Optimiser Service	Assist optimal scheduling of multiple transits on a tide.
OPERATIONS	Transit Monitoring Service[1] Shore Version	Automatically and seamlessly tracks the under-keel clearance of one or more vessel transits simultaneously using the latest met-ocean observations, vessel load state information and AIS positions.
OPERATIONS	Transit Monitoring Service Onboard Version[2]	OMC is developing the next generation of on-board UKC solutions. These solutions will seamlessly integrate with the DUKC Series 5 product suite. UKC information will be provided as a marine overlay in charting packages. This overlay will also consider the horizontal aspects of under-keel clearance and show 'go' and 'no-go' areas on a chart.
OPERATIONS	Met-ocean Data Service	QA's, filters, displays and archives met-ocean observations and predictions from many different sources. Allows authorised users to view data in real-time.
BUSINESS	Vessel Service	The authoritative source of vessel information within the system. The Vessel Service can be linked up to external vessel data sources such as port information systems or vessel databases.
BUSINESS	Reporting Service	Provides searching and retrieval of archived outputs, previous calculations, errors and diagnostics.
BUSINESS	Business Message Service	Provides logging, auditing and notification of important events. Messages can be delivered to users via email or SMS[3].
BUSINESS	System Health Service	Pro-actively monitors system components to ensure constant operation and timely notification of problems. This allows early notification of issues to the OMC support team before they escalate. Notifications can be routed to other recipients such as UKC management personnel/contractors and port users.
BUSINESS	User Management Service	Provides powerful user permissions control and account management. Allows UKC managers to expose only those functions and modules relevant to the user's role. This includes external users such as agents, terminal operators or vessel masters.

[1] The Transit Monitoring Service requires an active AIS feed to be connected to the DUKC Series 5

[2] Under development

[3] Requires additional SMS service to be procured from a telecom provider

3.1 PLANNING - VOYAGE PLANNING SERVICE

The long-range (>24 hours) under-keel clearance planning component of the DUKC® product suite uses met-ocean forecasts and climate statistics to estimate what the short-term (0-24 hrs) sailing advice of the DUKC® will be at some future date. The Voyage Planning Service calculates probability distributions of waves and tides from astronomical tide forecasts and historical wave and tide statistics, and uses these to calculate a probability distribution of what the operational DUKC® will say when run closer to sailing time.

The Voyage Planning Service allows the user to specify a probability that the operational DUKC® result (close to sailing time) will have a lower maximum draught than predicted by the Voyage Planning Service result. This allows a scheduler to specify the level of certainty for the ship to sail on time. The scheduler may select different levels of certainty for different ships, or for different types of cargo, etc. (By contrast, if a static rule is used to determine draughts to load to, the static rule has some implicit level of certainty of the ship being allowed to sail with this draught, but the scheduler does not know what this level of certainty is, and cannot modify the level of certainty for different situations).

The Voyage Planning Service also allows specification of a Minimum Window Duration, which can be used to specify the shortest duration sailing windows the user will accept. For example, if the user is not interested in windows shorter than 15 minutes because these are too short to allow for the practicalities of arranging ship departures, the Minimum Window Duration can be set to 15 minutes to ensure that the Voyage Planning Service only returns sailing windows (or maximum loading draughts) corresponding to sailing windows of this size or greater.

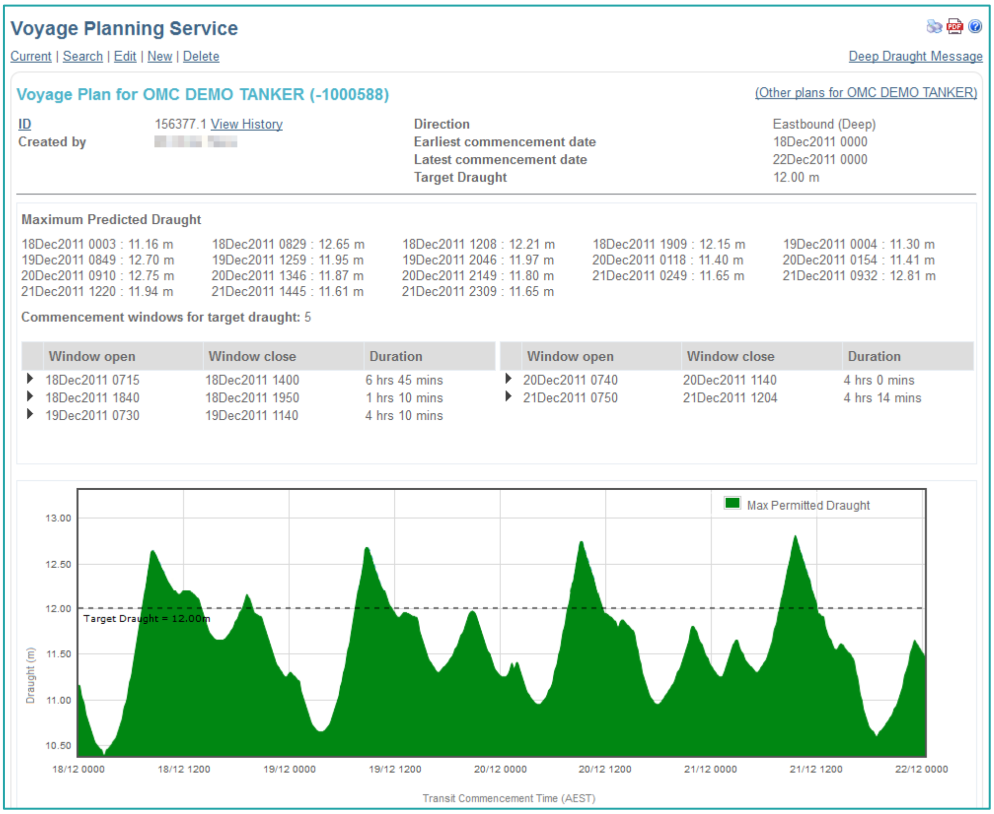


Figure 1 Sample maximum sailing draught vs. departure time output

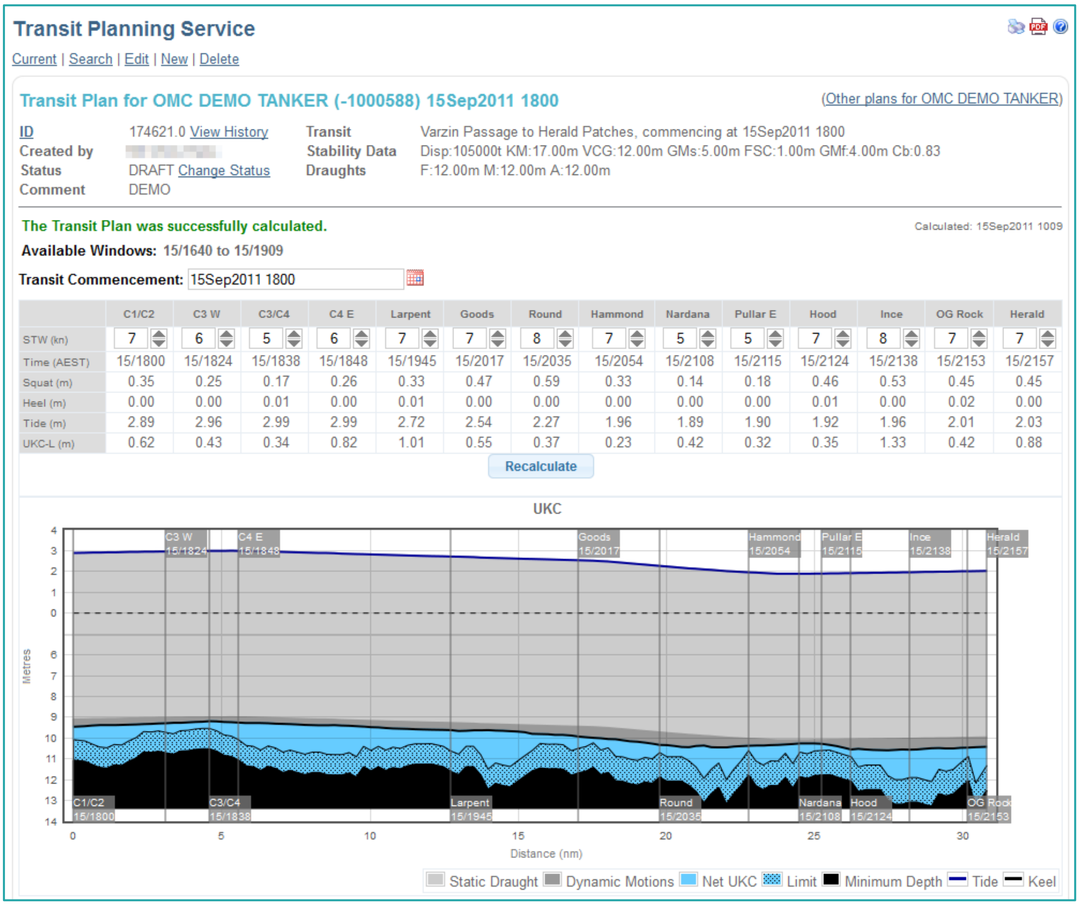
Figure 1 shows a sample maximum sailing draught vs. departure time from the Vessel Planning Service. Green areas indicate combinations of departure time and vessel draughts for which there is sufficient UKC to safely complete the transit from port to sea.

Note that Voyage Plans can also be calculated for inbound vessels or for vessels transiting along a river or a strait.

3.2 PLANNING - TRANSIT PLANNING SERVICE

The Transit Planning Service manages real-time to short-term predictions of under-keel clearance, automatically updated from latest met-ocean observations. The Transit Planning Service is used to plan vessel transits (including providing speed control functionality in the planning) through the specified waterway using the latest met-ocean observations and accurate vessel load state information and AIS positions. Sample questions that are able to be answered by the transit planning service are:

a. Between what times can I safely enter this waterway on this vessel?
b. What speeds should I be travelling at to safely pass all waypoints?
c. What happens to the UKC if I slow down, or speed up?
d. How much is this vessel predicted to heave, roll or pitch at various locations along the waterway?
e. What is the minimum UKC along the transit?


Transit Planning Service

Current | Search | Edit | New | Delete

Transit Plan for OMC DEMO TANKER (-1000588) 15Sep2011 1800 (Other plans for OMC DEMO TANKER)

ID 174621.0 View History
Created by
Status DRAFT Change Status
Comment DEMO
Transit Varzin Passage to Herald Patches, commencing at 15Sep2011 1800
Stability Data Disp:105000t KM:17.00m VCG:12.00m GMs:5.00m FSC:1.00m GMf:4.00m Cb:0.83
Draughts F:12.00m M:12.00m A:12.00m

The Transit Plan was successfully calculated. Calculated: 15Sep2011 1009

Available Windows: 15/1640 to 15/1909

Transit Commencement: 15Sep2011 1800

	C1/C2	C3 W	C3/C4	C4 E	Larpent	Goods	Round	Hammond	Nardana	Pullar E	Hood	Ince	OG Rock	Herald
STW (kn)	7	6	5	6	7	7	8	7	5	5	7	8	7	7
Time (AEST)	15/1800	15/1824	15/1838	15/1848	15/1945	15/2017	15/2035	15/2054	15/2108	15/2115	15/2124	15/2138	15/2153	15/2157
Squat (m)	0.35	0.25	0.17	0.26	0.33	0.47	0.59	0.33	0.14	0.18	0.46	0.53	0.45	0.45
Heel (m)	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00
Tide (m)	2.89	2.96	2.99	2.99	2.72	2.54	2.27	1.96	1.89	1.90	1.92	1.96	2.01	2.03
UKC-L (m)	0.62	0.43	0.34	0.82	1.01	0.55	0.37	0.23	0.42	0.32	0.35	1.33	0.42	0.88

Recalculate

Figure 2: Sample output from Transit Planning Service

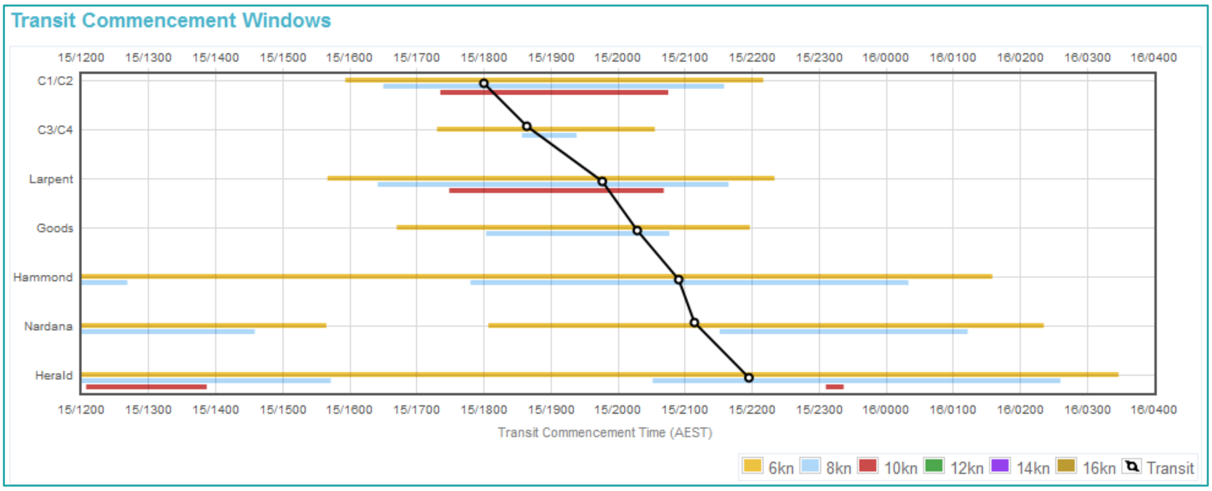


Figure 3: Sample output from the Transit Planning Service

Figure 2 and Figure 3 show sample output from the Transit Planning Service for Torres Strait.

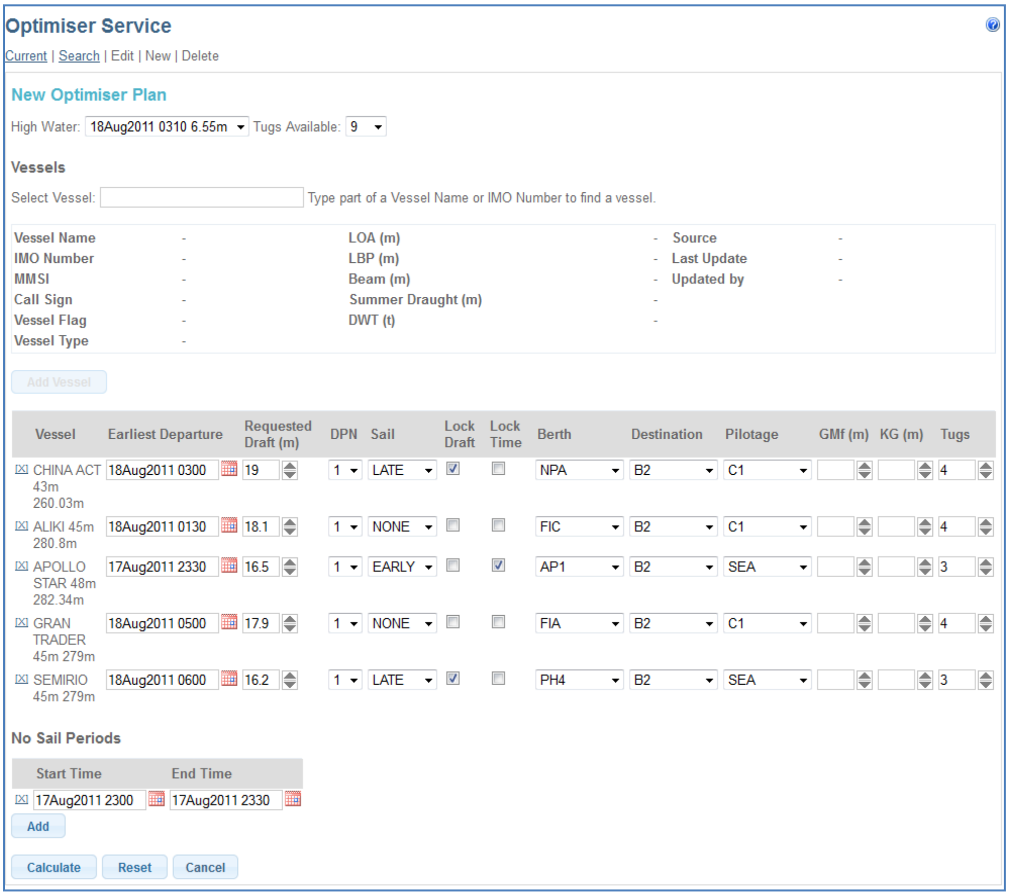
Figure 2 shows how the UKC information is displayed both graphically and in tabular format. Users have the options to change vessel speeds at key way points along the route. The system automatically updates the ETA's of passing waypoint using tidal stream models.

Figure 3 shows for tidal windows for key controlling points (shallow points) along the transit at different vessel speeds. Users can use this information to optimise their sailing plan. For example, the user can visually determine if it is possible to sail an hour later at a higher vessel speeds whilst maintaining UKC safety.

3.3 PLANNING - OPTIMISER SERVICE

The Optimiser Service allows the optimisation of multiple vessel departures on a single tide whilst considering constraints such as tug availability, current restrictions and booking priorities. Sample screenshots are provided in

Figure 4 and Figure 5 for sailing multiple vessels on a high tide at Port Hedland. In the example, five vessels are added with various draughts, berths, priority numbers, specified separation distances between vessels, earliest departure times and required tugs. The Optimiser Service has been used to assist Port Hedland Port Authority to ship 914,881 tonnes aboard five vessels on a single tide, a record



for the port[4].

Figure 4 Sample input screen for the planning of multiple vessels on a single tide.

[4] 2010/2011 Cargo Statistics & Port Information, Port Hedland Port Authority

Optimiser Service

Current | Search | Edit | New | Delete

Optimiser Plan for High Water (18Aug2011 0310 6.55m)

ID	152.0 View History	**Max Tugs Available**	9
Created on	17Aug2011 1618	**High Water**	18Aug2011 0310 6.55m
Created by	OMC User	**Scan Range for High Water**	6 hrs before & 6 hrs after the high water

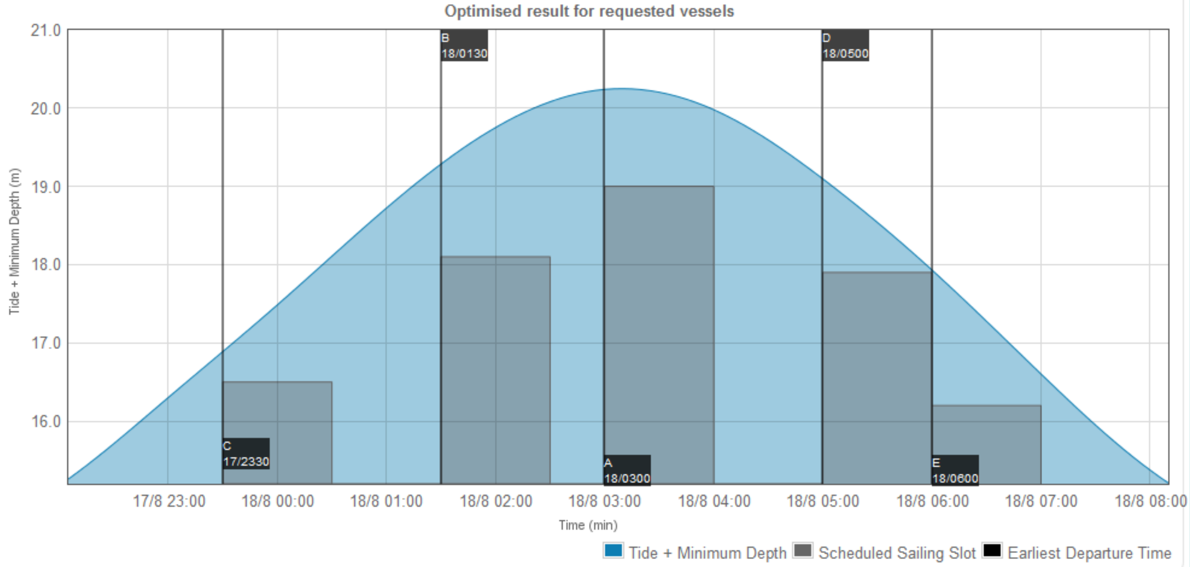
1 No Sail Period(s)

Sr. No.	Start Time	End Time
1	17Aug2011 2300	17Aug2011 2330

5 Vessel Request(s)

Vessel Beam, LBP	DPN	Requested Draft	Sailing Draft	Transit Berth, Destination, Pilotage	Sail	Lock	Stability GMf, KG	No. of Tugs
(A) DEMO 1 (43m, 260.03m)	1	19.00m	19.00m	NPA, B2, C1	LATE	DRAFT	-	4
(B) Demo (45m, 280.8m)	1	18.10m	18.10m	FIC, B2, C1	NONE	NONE	-	4
(C) DEMO (48m, 282.34m)	1	16.50m	16.50m	AP1, B2, SEA	EARLY	TIME	-	3
(D) OMC DEMO (45m, 279m)	1	17.90m	17.90m	FIA, B2, C1	NONE	NONE	-	4
(E)M/V Demo(45m, 279m)	1	16.20m	16.20m	PH4, B2, SEA	LATE	DRAFT	-	4

Optimised result for requested vessels



Current | Search | Edit | New | Delete

Figure 5 Sample output screen for the departure of multiple vessels on a tide.

3.4 OPERATIONS - TRANSIT MONITORING SERVICE SHORE-BASED

The Transit Monitoring Service automatically tracks and monitors the under-keel clearance of 'active' transit plans. Users who have been assigned permissions to access monitoring functionality can track the under-keel clearance of one or more vessels simultaneously.

The under-keel clearance information is updated continuously based using the latest met-ocean observations, vessel load state information and AIS positions. Tracking of vessels occurs automatically once a transit plan has been issued ('active').

The Transit Monitor Service can include a monitoring chart to allow operators to view the UKC status of all tracked vessels in a geographic sense. See also Figure 6 below for shore-based monitoring of vessels through Torres Strait.

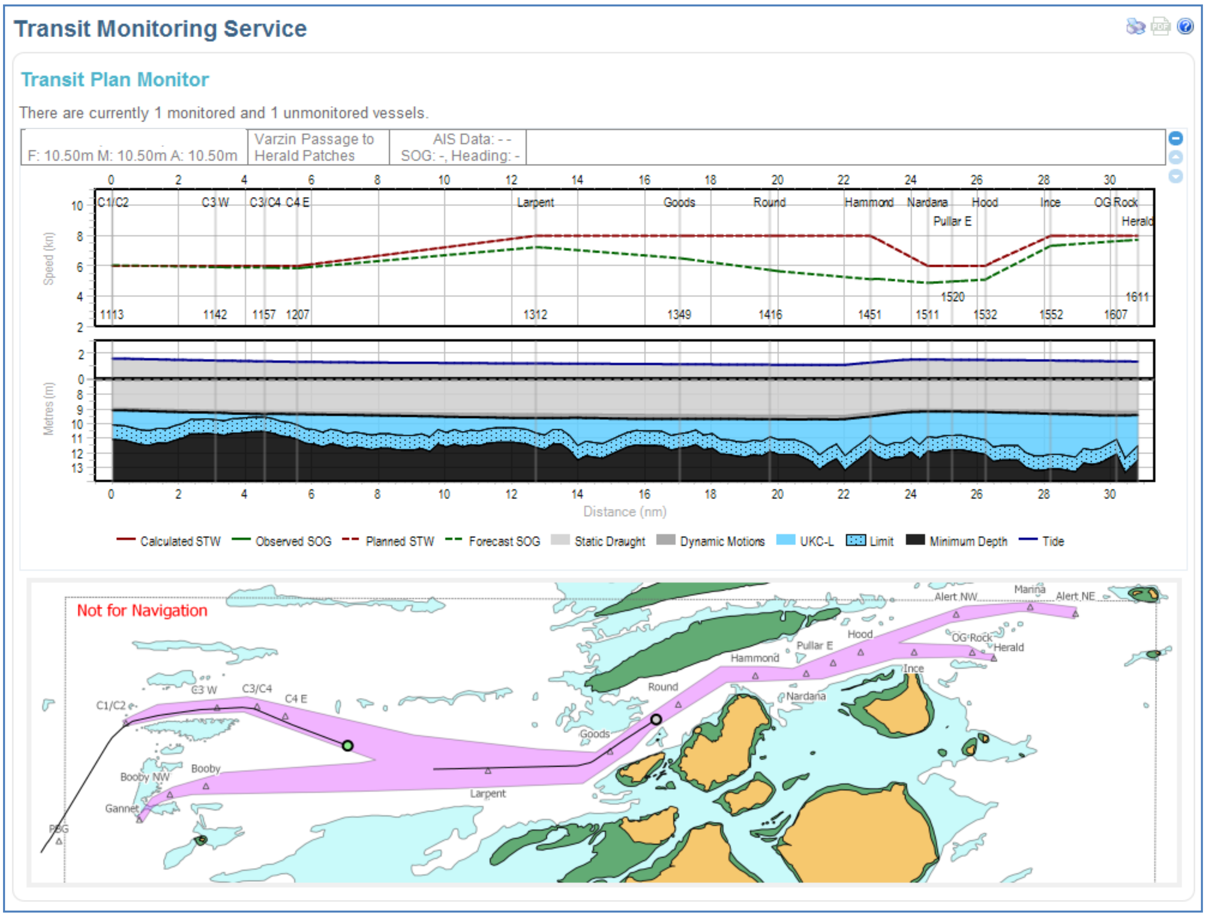


Figure 6: Sample monitoring information

3.5 OPERATIONS - TRANSIT MONITORING SERVICE ON-BOARD

OMC is in the process of redesigning and redeveloping the on-board components of the DUKC product suite. The on-board solution is moving towards displaying UKC related information within a charting package environment as overlay on top of a chart. This allows UKC information to be displayed more intuitively to marine pilots and allows horizontal navigation aspects to be included in the assessment of under-keel clearance.

A rudimentary prototype has been developed by OMC and is currently undergoing pilot trials at the Port of Melbourne.

Figure 7 shows a sample screen shot of a vessel transiting the Port Phillip Bay Heads in low swell conditions. Red areas indicate 'no-go' regions where the DUKC predicts the vessel to have insufficient under-keel clearance.

Figure 8 shows the same vessel travelling into Port Phillip Bay but under higher swell conditions. The area of safe under-keel clearance has reduced and the vessel is restricted to a narrower corridor.

The geospatial display of under-keel clearance information allows pilots to make on the fly navigation decisions from an under-keel clearance perspective. For example:

- Decisions about safe passing areas
- Assessment of the impact of speed increases on the safe travelling corridor
- Assessment of local shoals on the safe travelling corridor (particularly important where high spots remain after capital or maintenance dredging campaigns)

As part of a DUKC Series 5 delivery and services to its many users, OMC welcomes continuing involvement from harbour masters and pilots with the ongoing development of this product.

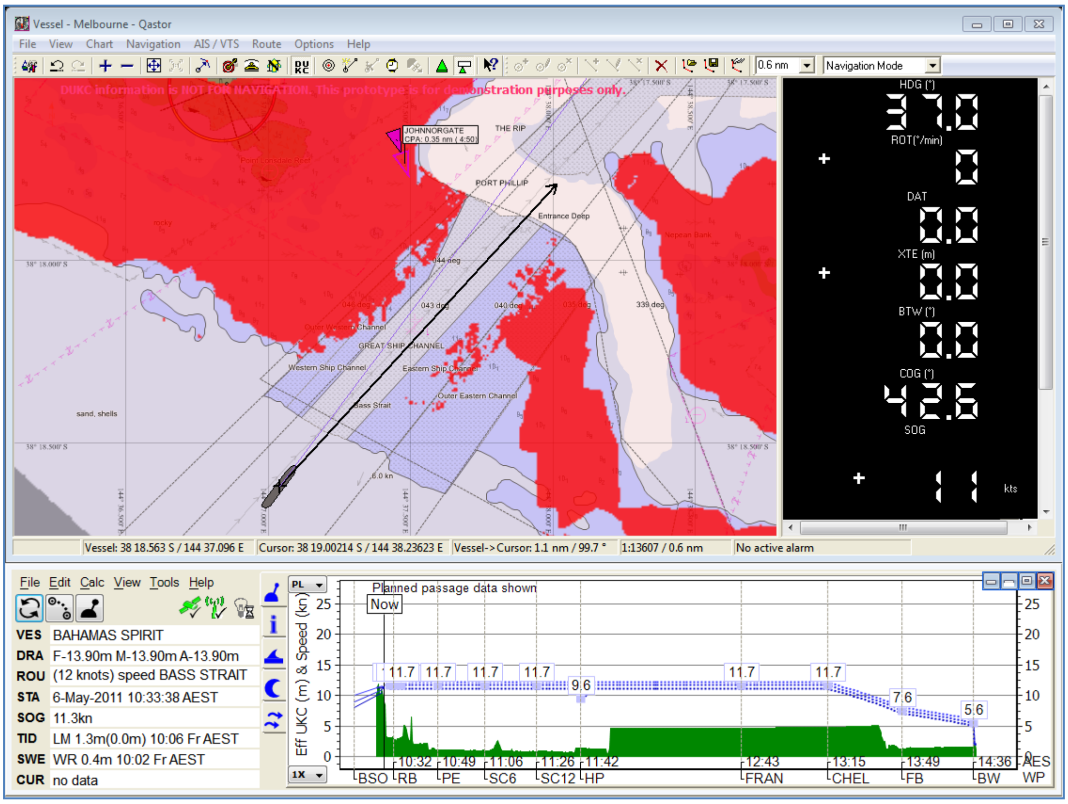


Figure 7 Sample 'no-go' areas in low swell conditions

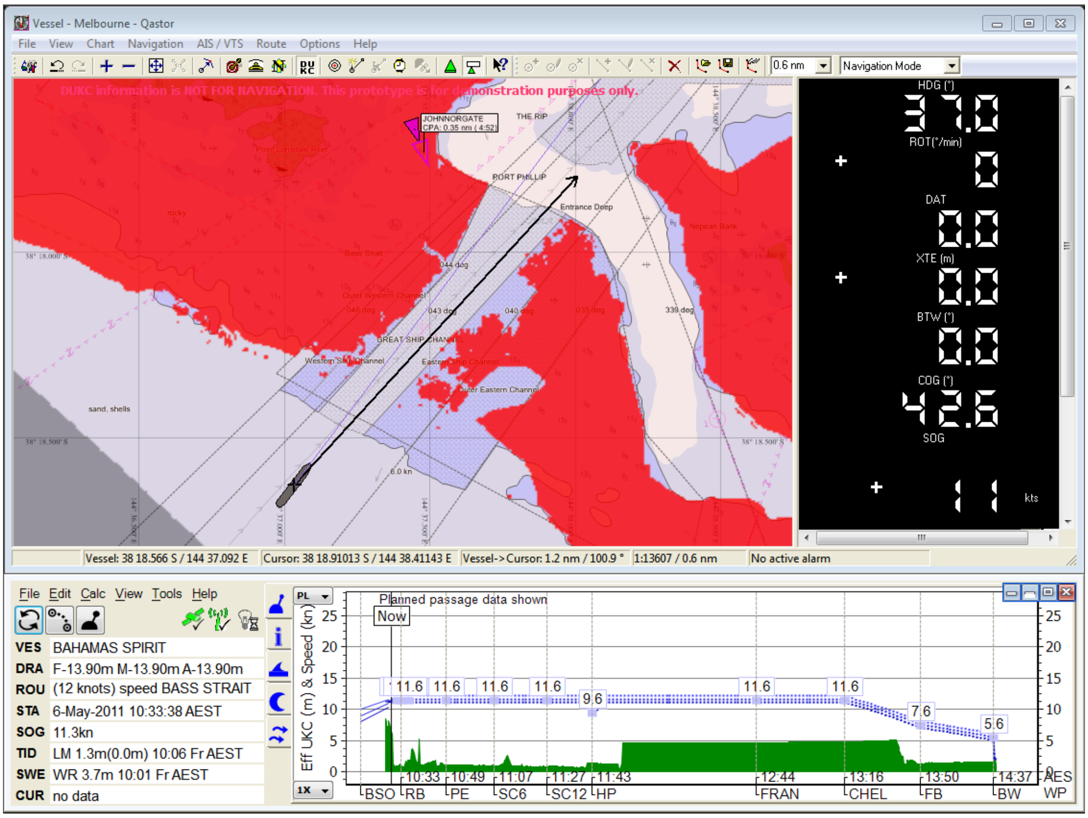


Figure 8 Sample 'no-go' areas in high swell conditions

3.6 OPERATIONS - MET-OCEAN DATA SERVICE

Allows interactions with the met-ocean engine described above and handles all requests related to met-ocean data. OMC has unified met-ocean data displays available which are able to display met-ocean measurements, forecasts and predictions from many different sources within a single view. Sample questions that are able to be answered by the met-ocean service are:

a. What is the latest recorded tide height at location X?
b. How has the tide height varied over recent hours or days?
c. How high are the waves right now? How high were they in last few hours? How are they predicted to change?
d. How strong will the tidal streams be in the coming day?
e. Is this gauge still working?

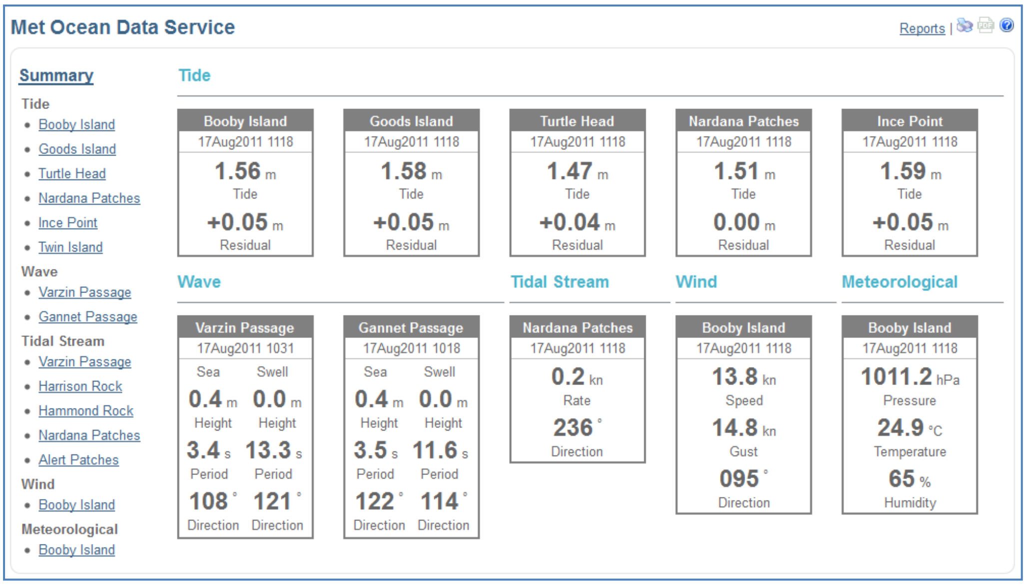


Figure 9 Sample summary screen in the Met Ocean Data Service

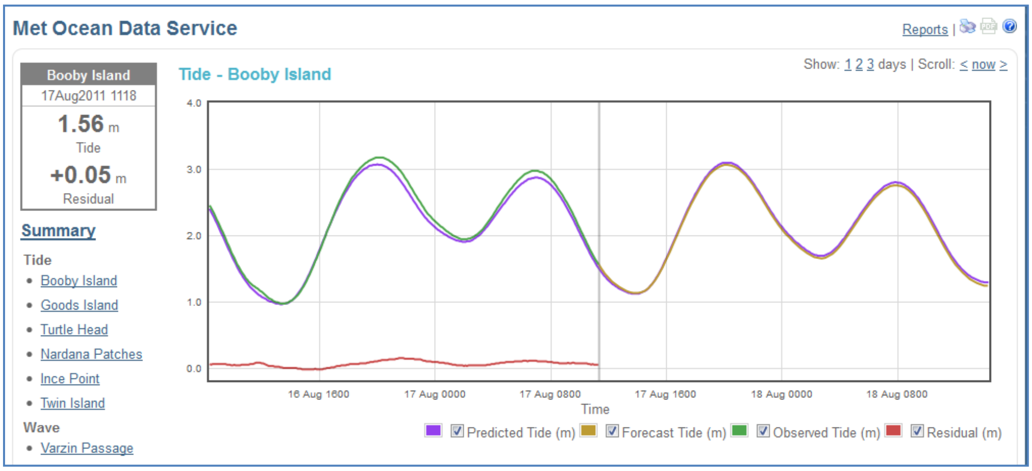


Figure 10 Sample detailed tide information available in the Met Ocean Data Service

3.7 BUSINESS - VESSEL SERVICE

Allows interaction with a comprehensive list of recognised vessels and their particulars which is used as the authoritative source of vessel information within the system. The vessel service can be linked up to external vessel data sources such as port information systems.

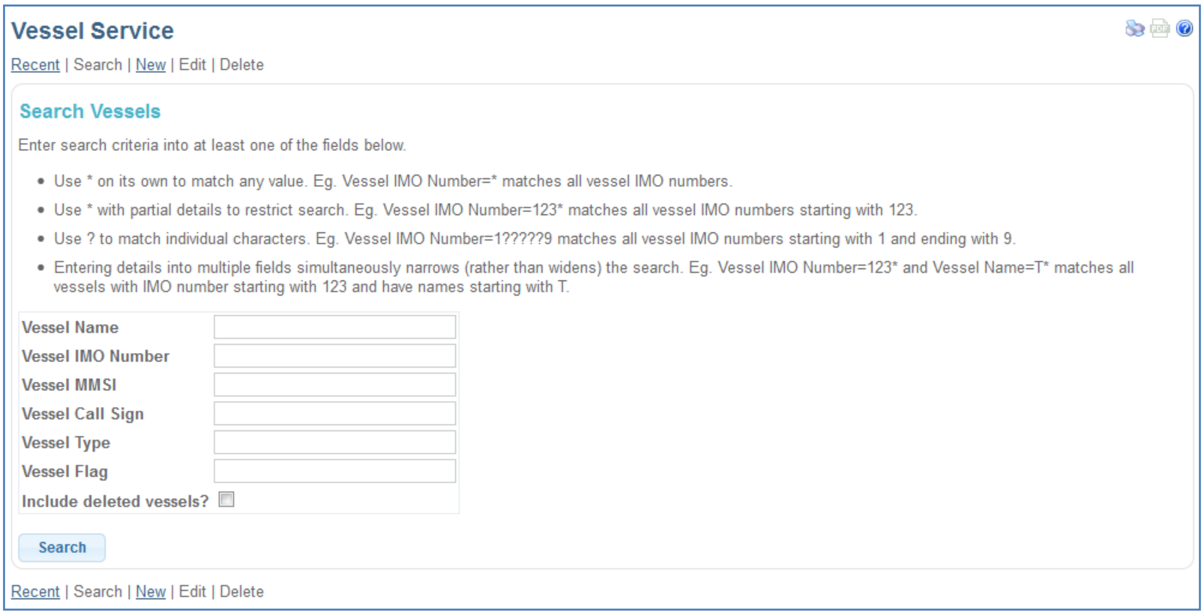


Figure 11: Searching for vessel information

Figure 12: Sample vessel information stored within the Vessel Service

3.8 BUSINESS - REPORTING SERVICE

Allows searching and retrieval of archived outputs, previous calculations, errors and diagnostics. All calculations, errors, system messages and diagnostics are logged and can be queried if desired. Sample questions that are able to be answered by the reporting service are:

a. How many transits has my organisation undertaken in the past 3 months?
b. Which user issued this transit plan? What changes were made to it?
c. How many vessels were monitored successfully in the past year?
d. What was the minimum UKC for all monitored transits?

Underlying the core engines and services are the various data storage components. Most data inputs and outputs are stored within SQL databases; some are stored in (system) log files. Storing data in SQL databases allows for efficient storage and built-in data query, security and auditing facilities. For example, all vessel information within the system is stored within a single database register of vessels. Other data storage structures include databases for voyage plans, transit plans, met-ocean data and business messages.

Custom interfaces between the DUKC® Series 5 modules and the various met-ocean sources, ship information systems and VTS users are configured (or developed where necessary) by OMC for the DUKC® system. OMC has extensive experience configuring and developing such interfaces and has an extensive library of tried and tested interfaces available.

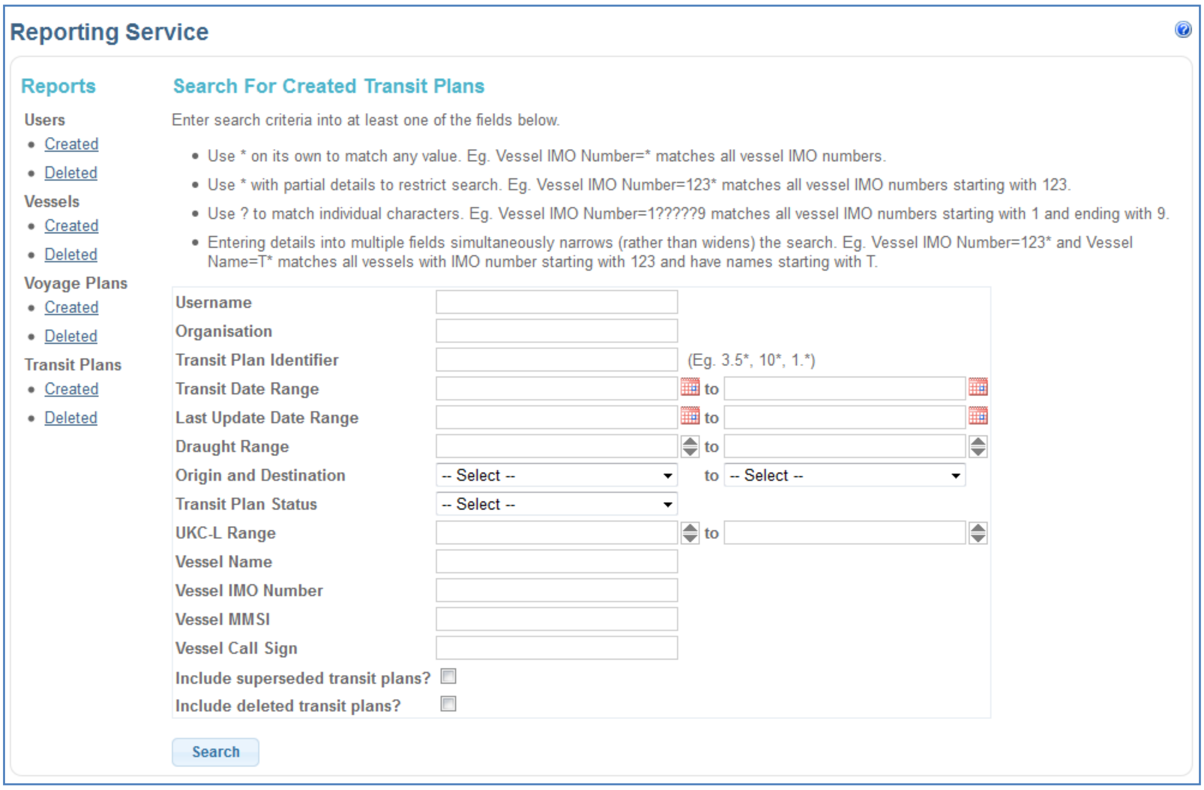


Figure 13: Sample data mining capability within the Reporting Service

3.9 BUSINESS - USER MANAGEMENT SERVICE

The User Management Service allows system administrators to manage user accounts and permissions. Access to most functional aspects in the DUKC Series 5 can be controlled via user permissions. Administrators have the possibility to grant or deny individual users or user groups access to particular functions within the system.

It is possible for administrators to define new user groups, lock user accounts, define new user accounts or configure a password policy.

Figure 14 Sample definition of user groups within the User Management Service

4 BENEFITS OF DUKC SERIES 5

DUKC Series 5 provides a number of significant benefits over the DUKC Series 4. These benefits include:

1. ***Increased safety and efficiency through optimised workflows***
    a. Operator work load is reduced by only exposing those functions and modules relevant to their role.
    b. Authorised users can create multiple 'draught' ('what if') sailing plans. A separate function (and authorisation) is built in that allows authorised users to upgrade a 'draught' sailing plan to an 'active' sailing plan.
    c. Under-keel clearance is automatically monitored for all active transits. The UKC is continuously updated based on the latest AIS positions and met-ocean data. A summary screen containing a monitoring chart shows the UKC status of all active transits.

2. ***Simple access for both internal and external users & clients***

a. Access to the DUKC Series 5 is provided via the internet (or intranet). Users need a modern web browser and an internet (or network) connection.
b. Information can be assessed from mobile platforms (e.g. tablets).
c. The User Management Service allows the UKC manager to only expose those modules and functions relevant to the user's role.

3. ***Optimisation of the scheduling of multiple vessels on single tide***
DUKC Optimiser is seamlessly integrated in the DUKC Series 5 portal. User access to this module can be controlled via the User Management Service.

4. ***Improved auditability and traceability***
Through the Report Service and the Business Message Service, the UKC manager has the ability to data mine a wealth of information stored within the DUKC Series 5 system. All calculations, errors, system messages and diagnostics are logged. Custom reports can be designed should this be required.

5. ***Possible lowering of UKCM IT requirements***
It is possible (though not required) to host the DUKC Series 5 at a dedicated data centre external to UKC management. Hosting at a dedicated data centre provides the opportunity to lower the impact on IT infrastructure and staff.

6. ***Flexible and scalable design***
a. The DUKC Series 5 architecture has been reworked significantly to accommodate client customisations in relatively short turnaround times.
b. Can be integrated with third party systems such as marine information systems, vessel databases, or port information systems.

5 CONCLUSIONS

- DUKC Series 5 has been installed in three ports and waterways: Port Hedland, Port of Melbourne and Torres Strait.

- It is anticipated that all 21 ports and waterways using DUKC systems will have upgraded to Series 5 by the end of 2012. Each upgrade will be customised using those component modules which maximise the economic and safety benefits for that particular port or waterway.