L A T E R A L

NAVAL ARCHITECTS

DYNAMIC POSITIONING CAPABILITIES FOR SUPERYACHTS

SUMMARY

Dynamic Positioning (DP) systems are a mature and well proven technology. The Superyacht industry has embraced DP as a concept and many large yachts now feature some level of station-keeping capability. However as DP is not widely understood beyond the basic principles, capabilities are frequently over specified and the resulting impact on the level of installed power is often severe or at odds with the propulsion system specified for the yacht.

This paper provides background to the principles of basic station-keeping, typical thruster arrangements, and how DP is used in practice. Various fundamental methods of controlling the degree of DP capability are discussed, along with the impact on the vessels' design of implementation. A case study is used to explore a range of power generation and propulsion systems each with specific attention to the impacts on the primary design variables for large yachts.

Suggested levels of station-keeping / DP capability suitable for application to large yachts are explored allowing a better informed system specification to be made.

1. INTRODUCTION

In 1961, the drill ship 'Eureka' was launched from Orange shipyard. Built and owned by Shell, she was designed to drill in waters up to 3600 feet deep, a feat made possible only by the inclusion of a pioneering onboard system; Eureka was the first true dynamically positioned vessel in the world.

Since '*Eureka*' the field of Dynamic Positioning (DP) has exploded in terms of complexity, reliability and uptake. Whilst it was undeniably the offshore industry that pioneered and developed DP systems, it is now widely installed on cable and pipe laying vessels, survey ships, cruise ships and increasingly, yachts.

In 1997 Lurssen's 96m '*Limitless*' became one of the first luxury motoryachts to be fitted with a full DP system, allowing a yacht to keep station without dropping anchor for the first time. It was several years before DP became a commonplace in yachts of *Limitless*'s size, however as diesel-electric installations have become more commonplace in the yachting world the inclusion of a DP system in the vessel's specification has become more prevalent. Nowadays, it is a feature that is expected of most large yachts.

It is often difficult to determine exactly what level of station-keeping capability to specify for a vessel. Of course, from an operational standpoint every yacht captain would love to command a yacht capable of accurately and reliably holding station in a Force 8 wind with associated sea state and current, however the practical implications of this would significantly detriment the vessel's design. It is important therefore to specify an appropriate level of DP capability when commissioning a vessel, such that the operational profile may be fulfilled with minimal impact to the vessel's overall function as a piece of luxurious real estate.

2. PRINCIPLES OF DP

It is important to make the distinction between DP and station-keeping, as used in this paper. Dynamic Positioning refers to the process whereby a computer controls the various thrusters and propulsors installed on the vessel to result in the desired thrust vector, in response to a joystick input from the bridge. DP systems account for external forces acting upon the vessel, such as wind, waves and current. One common feature of a DP system is a station-keeping function. This is the vessel's capability to react to external loading to maintain a certain position and heading, and is a good indicator of the vessel's overall DP capability.

The essence of designing a DP system capable of adequate station-keeping can be summarised in the following sentence; the vessel must be able to produce a force and moment equal and opposite to the force and moment acting upon it by environmental factors.

In practice this means that the vessel must have a thruster configuration whereby forces and moments about the vertical axis can be produced. Furthermore, the installed power plant must be capable of providing the required power to the thrusters.

At some point, the environmental factors will overcome the thrust offered by the vessel. At this point, the vessel will begin to drift or yaw, and the edge of the station-keeping envelope will have been reached.

DP capability analysis involves finding the maximum wind speed at each heading that a vessel is able to maintain position and heading. Successful station-keeping at a specific wind heading requires the vessel to be capable of adequately opposing the environmental forces and moments imposed on the vessel by wind, current and wave forces. Typical station-keeping analysis software calculates the wind force and moment at each heading for a specific vessel, and iteratively increases the wind speed until the maximum available thrust from the thruster configuration is reached. As a result, an operational envelope is developed, showing the vessel's maximum station-keeping capability at each wind heading.

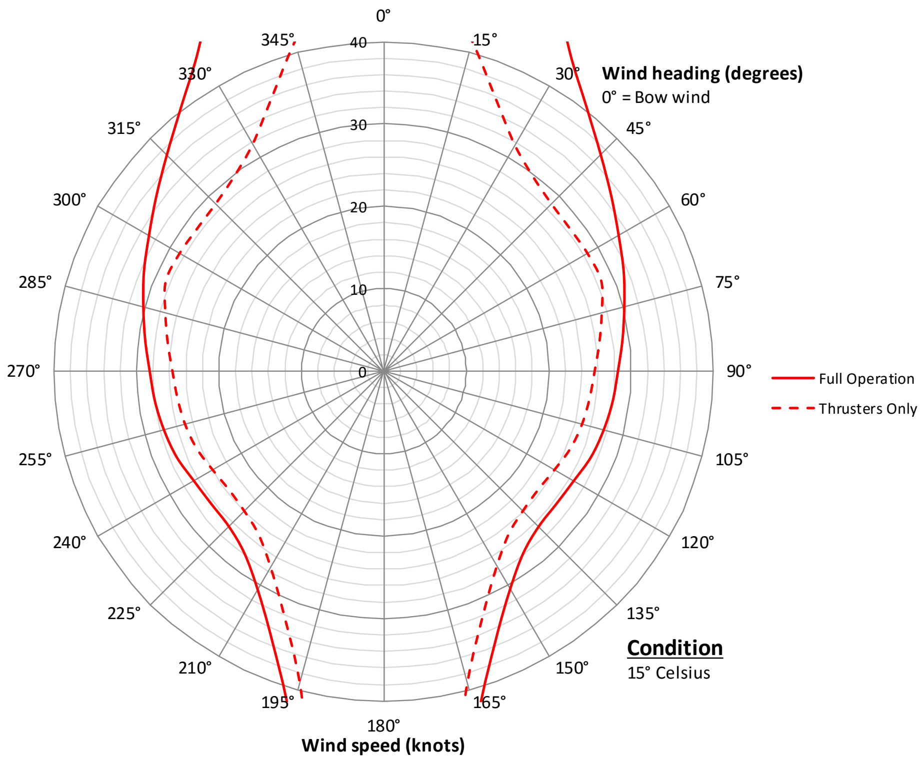

Figure 1 - *Typical station-keeping capability analysis for a large motoryacht*

Whilst a station-keeping plot shows the maximum wind speed the vessel is able to hold position and heading in, this also implies that if the wind speed being experienced is lower than the limiting value, then the vessel has adequate manoeuvring capacity. This is how station-keeping plots also define the capability of the DP system as a whole.

Within the type of analysis used in large yacht design it is often only wind loading that is considered. More advanced analysis including the hydrodynamic performance is needed to include loadings from wave forces and currents.

The early specification of required station-keeping capability by yacht clients typically does not consider the effects of wave or current loadings. It is an important aspect to understand as withstanding a 30 knot beam wind in sheltered harbour conditions requires a significantly different system specification to one designed to withstand 30 knots in open ocean conditions in a fully developed sea state.

3. TYPICAL THRUSTER ARRANGEMENTS ON LARGE YACHTS

The typical thruster arrangement for large yachts tend to follow a common configuration; twin CP screw propellers, with one or two fixed tunnel bow thrusters. Larger yachts may also have a stern thruster, commonly also fixed tunnel thrusters but occasionally retractable azimuthing units. Vessels fitted with fixed pitch main propellers (FPP) often use an azimuthing stern thruster, as the propellers are not usually part of the DP system (due to the low slow-speed torque characteristics of the main engines). Whilst azi-pods, which offer a greater degree of manoeuvrability, are becoming more common, the overwhelming majority of vessels follow the conventional arrangement.

This arrangement has remained unchanged for many years mainly because it makes use of space which has little practical use within the hull; bow thrusters are placed in the fore peak, immediately aft of the collision bulkhead, while stern thrusters are placed below the deck in the stern-rise section of the hull (and skeg). This arrangement is also well suited to provide the transverse forces and yawing moments required by a DP system.

The purpose of this paper is not to develop or evaluate new methods of providing manoeuvring thrust, but to analyse the power requirements of a yacht fitted with a 'standard' arrangement. However, it does seem that in modern yachts the naval architect is constrained in the arrangement that can be fitted, and that DP and manoeuvring is a rather secondary consideration. As will be shown, there is a practical limit to what the standard arrangement of thrusters can achieve in terms of DP capability.

4. PRACTICAL USE OF DP SYSTEMS

How DP systems are actually used in yachts is a somewhat subjective topic, with each captain using his system differently, depending on his experience with DP, the reliability and capability of the system.

One constant however is that using a DP command module to 'park' a vessel at sea without an anchor, and have it remain in a fixed position by using computers to automatically control the thrusters, is a very energy intensive operation, using a lot of fuel. It is also undesirable as with the vessel operating in this mode, there is little or no human element involved in the control over the thrusters and when they operate. Consequently it is difficult to conduct tender operations or swimming activities around the vessel when it is operating in such a mode. This functionality only really comes in useful when the water is very deep, as occurs close to shore around several Mediterranean islands, or when dropping anchor would not otherwise be a feasible option.

A more common use of the system is when used in conjunction with an anchor to keep the vessel headed into any incoming swell in order to reduce motions. This provides the security of having weighed anchor, with the additional comfort of maintaining an optimum or desired heading.

In practice DP systems provide an enhanced manoeuvring capability, with a computer controlling the thrusters to achieve the motion vector requested by the captain via joystick control. When used in ports and harbours, and manoeuvring in tight spaces, this feature is highly effective.

5. DRIVERS OF DP CAPABILITY

Increasing the DP capability of a vessel may be achieved in four distinct ways;

- Increasing the longitudinal or transverse separation between thrusters
- Increasing the range of thrust vectors achievable by a thruster
- Increasing the power available to a thruster
- Decreasing the environmental loading on the vessel (i.e. reduce the windage area, streamline the superstructure, or optimise the below waterline hull form for seakeeping capability).

As the latter option has a dramatic effect on the overall design of the vessel, it is omitted from this study – it is therefore assumed that the superstructure and wind profile of the vessel remain unchanged. In reality if extreme DP capability were desired, the designer should work to streamline the above waterline hull and superstructure to minimise the wind forces acting upon it. The impact on vessel design investigated here is strictly with respect to vessel arrangement and machinery options.

The impact of each method of increasing station-keeping capacity is studied in the following chapter.

6. METHODS OF INCREASING DP CAPABILITY

6.1 Increasing Thruster Separation

When there is a lateral separation in the centre of drag of the above waterline area and the below waterline area, the yacht will experience a yawing moment. In order to maintain heading, the vessel must be able to produce an equal and opposite moment to counter the environmental loading. On a yacht, this is most efficiently provided by either a pair of bow and stern thrusters (longitudinal separation), or by twin screw propellers (separated transversely). Consequently, any increase in separation of these thrusters, either longitudinally or transversely will increase the moment-producing capacity of the thrusters, and therefore potentially an increase in DP capability, with no increase in required power.

The impact of increasing thruster separation on a yachts' design are generally unfavourable. The position of the vessel's main shaftline is determined primarily by rudder positioning, propeller separation and the practical constraints of the engine room layout. Whilst it would be marginally beneficial to station-keeping to increase the distance between the propellors, it is difficult to justify potentially jeopardising the performance of the propeller to marginally increase DP performance.

A more realistic method of increasing capability may be to increase longitudinal separation of the bow and stern thrusters. However traditional tunnel thrusters have a minimum tunnel length (function of diameter) which limits the extent to which the thruster can be moved forward.

Stern thruster positioning is also largely determined by spatial constraints – moving the stern thruster as far aft as possible is advantageous, but not if this means having to extend the skeg such that its proportions become extreme.

6.2 Increasing Vector Range

In a DP system, the vector angles that a thruster can achieve are very important. They increase the versatility of the thruster, and the capability of the entire vessel to produce a force and moment combination that will counter the environmental force.

Increasing the range of vectors that a single thruster can achieve can take many forms. The vector range of a screw-propeller may be increased by adding a rudder directly behind it, increasing the turning range of an existing rudder or using high-lift rudders. A water-jet may be improved by increasing its turning range. Instead of a tunnel thruster, an azimuthing thruster could be fitted. Anything that increases the range of angles at which the thruster can produce thrust, will inevitably increase the DP performance of the vessel.

Typical de facto large yacht systems are configured with twin FPP or CPP propellers married with fixed funnel thrusters fore and aft. In some cases the use of azimuthing stern thrusters are used. Such a systems are limited in their capability to produce a full spectrum of effective thrust. However in the greater majority of cases such configurations are more than sufficient. Where a higher level of station-keeping is required, or full DP capability, then there is a strong case of the adoption of a fully azimuth propulsion system.

6.3 Increasing Thrust Capacity

In reality the most common method of improving DP performance of a de facto yacht arrangement is to increase the power developed by the thrusters. By increasing the amount of thrust available, both translational and rotational manoeuvring capabilities are enhanced.

The impact of increasing power delivery of the thrusters is seen across many facets of the vessel;

Hydrodynamic; More powerful thrusters are invariably physically larger. For tunnel thrusters, this results in enlarged cut-outs at the bow, impacting the streamlines around the hull, and causing an increase in drag.

Arrangement; Larger units take up more space within the vessel. Bow thrusters may be located in a compartment beneath a chain locker or deck, limiting the vertical space for a tunnel thruster, whilst stern thrusters are typically tucked away beneath the tender bay deck. This is often a fairly large space within the vessel which has no practical use other than as a technical space, however sufficient vertical space must exist between the deck and the keel to allow for the unit. As bow thruster units get larger they need to be positioned further aft, due to the minimum tunnel length being a function of the diameter. This either has an impact on the vessel's arrangement, or drives a move towards using two smaller units, which again takes up more space, and causes more drag. Where thrusters are electrically driven, supporting electrical equipment volumes (such as frequency drives) will also increase in size to handle a higher power, as will cooling and ventilation requirements.

Mechanical; Thruster sizing is often a significant factor driving the size of the installed electrical generating machinery. It is commonly seen that whilst a vessel may meet its' operational hotel load using one or two generators, to supply the peak manoeuvring electrical load three or four generators are required. Thruster sizing will also impact the selection of main switchboard sizing, along with electrical distribution systems from the generators to the thrusters.

Noise & Vibration; It might be expected that larger bow and stern thruster units result in more noise and vibrations. However, the largest source of N&V emanating from thrusters is not from the machinery itself, but rather from the pressure pulses and potential cavitation caused by uneven pressure distributions over the propeller. Whilst resiliently mounted tunnels are used to attenuate this vibration, the dominant noise source is structure-borne vibrations. As pressure pulses can occur on both large and small units it is not necessarily true that larger units create more noise, and a well-designed tunnel inlet can significantly reduce the vibrations experienced.

There comes a point that the improvements in system performance are not proportional to the increase in power level and the impacts outlined above become nonsensical or overly constraining to the design. It is at this point that the adoption of a fully azimuthing propulsion system should be considered.

7. SPECIFIED PERFORMANCE

It is important to consider the level of performance written into the specification carefully. The majority of build specifications call for a station-keeping capability at a certain wind speed in beam seas.

There are several reasons for this, most commonly that it is often assumed that the most onerous condition for station-keeping is a beam wind; This is not normally the case, particularly when a stern thruster is fitted (as is shown below).

The intent of the station-keeping specification is often to ensure the vessel has adequate manoeuvrability in port, rather than a true requirement of at-sea station-keeping. Consequently, one of the most onerous manoeuvres undertaken would be to move away from a berth in a beam wind; if the wind were quartering, the required thruster load could be reduced by swinging the bow or stern into the wind prior to moving off.

Additionally, a beam-wind thruster calculation can be done relatively simply and easily, using an Excel sheet and various assumptions. At the preliminary stages of design this is important, when some of the factors affecting DP system performance may be unknown.

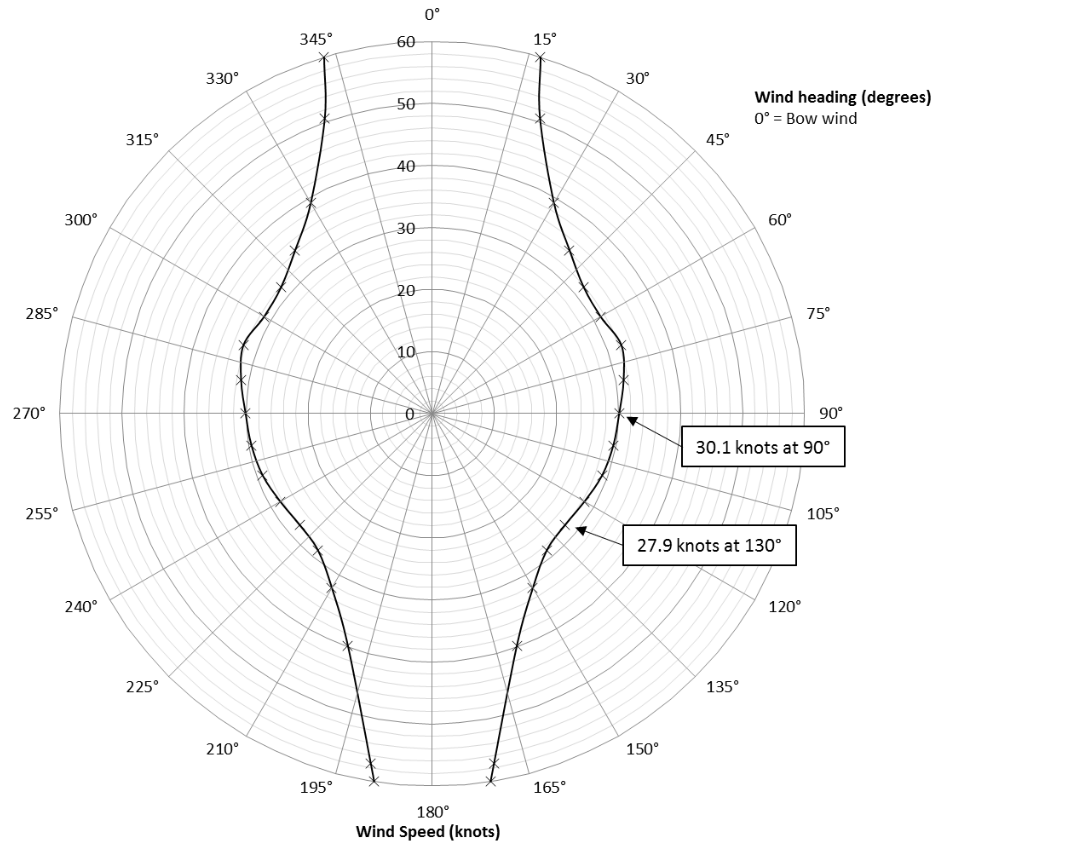

Figure 2 – *Limiting wind speed in a beam-wind is not necessarily the lowest limiting wind speed of the vessel*

There can however be a significant difference between the beam-wind station-keeping performance of a vessel, and the minimum wind magnitude at any angle. Consider Figure 2, where the vessel is shown to be capable of holding station in 30.1 knots of beam wind, however at a wind heading of 130°, (stern quartering), the maximum wind speed is 27.9 knots. The most onerous wind direction for a 'standard arrangement' yacht is normally seen to be a stern-quartering angle, as the rudders behind the main propellers are unable to vector the propellers thrust when operating in reverse, and also due to the reduced thrust achieved by a propeller operating in reverse.

Considering the points above, for the application of yachts, a beam-wind station-keeping specification is the most appropriate in the majority of circumstances. However if the specification is intended to ensure a minimum degree of at-sea station-keeping capability in any wind direction, then more focus should be given to the most onerous wind direction, in conjunction with wave and current loading criteria.

8. CASE STUDY

In order to quantifiably evaluate the impact on vessel design of an increasingly onerous DP capability, a case study is now presented.

As discussed in Section 6, the most realistic method of improving DP capability is to increase the amount of power and hence thrust available to the thrusters. It is considered that allowing the DP requirement to influence main engine selection is nonsensical. Therefore, the extra power will be allocated to the bow and stern thrusters only.

The study aims to relate the power requirement of the thrusters to the level of station-keeping performance. The impact on the yacht of this increased power requirement will then be studied, from an electrical and spatial perspective.

The basis vessel chosen for the study is representative of the size vessel typically seen with DP capability by BMT Nigel Gee Ltd **(Lateral)** and has been chosen as a 'standard' form of motor-yacht.

8.1 Basis Vessel

The vessel studied is a 112m LOA motoryacht, which represents the larger end of the yachting fleet.

Briefly, it features a typical arrangement comprising twin screw propellers (diesel-mechanical CPP drive), an electrically driven bow tunnel-thruster, and an electrically driven stern azimuthing thruster.

Principle Particulars

- LOA: 112m
- LWL: 101.2m
- BOA: 16.2m
- Profile Area: 1200m^2
- Profile longitudinal centroid: 4.5m forwards of amidships
- Frontal Area: 260m^2

Thrusters

- 1 x bow tunnel-thruster, developing a maximum 70kN of thrust, at 480kW. Due to electrical losses, 526 ekW is required from the generators.
- 1 x stern azi-thruster (360°), developing 66kN at 385kW. Electrically driven, this draws 421ekW from the generators.
- Twin-screw propellers with rudders, developing 335kN forwards (235kN in reverse).

Machinery

- 2 x CPP propellers, with a maximum 3300kW shaft power on each shaft.
- 4 x MTU 12V2000M41A, producing a total of 2026ekW.

8.2 DPCalc Program

BMT **(Lateral)** have internally developed software (DPCalc, v.1.3) which predicts the station-keeping capability of a vessel, based on specific principle parameters, environmental conditions and thruster arrangements. Currently the program is capable of considering wind loads only, but development plans include the addition of current loading. It should be noted that DPCalc offers a static analysis of station-keeping capability. No consideration is given to wind gusts or yacht motions, which may negatively impact the station-keeping performance of the vessel.

The software uses inputs of the vessel such as lateral above-waterline projected area, frontal above-waterline area, and LOA alongside empirically derived values of drag coefficients (taken from literature) to predict the wind loading on the vessel.

The position, orientation and maximum thrust of the various propulsors on the vessel (bow & stern thrusters and main propellers) are then used in a quadratic solver to find the most efficient combination of thrust allocation (based on minimising overall thrust magnitude) that will counter the external forces, reducing the overall force and moments acting on the vessel to zero. In an iterative process, the program cycles through each wind heading, incrementally increasing wind speed at each heading until the quadratic solver fails to find a solution, indicating that vessel can no longer hold station.

It is important to note that the results calculated by DPCalc are highly dependent on the wind drag coefficients used to calculate the longitudinal, transverse and yawing moments induced by wind. Ideally these coefficients will be collected via wind tunnel tests for each specific yacht – indeed for yachts with DP fitted, wind tunnel tests typically form a part of the model test schedule. However at a preliminary design stage, coefficients specific to the design being developed are not available and coefficients from basis vessels must be used.

For the basis vessel used here wind coefficient data is available, and so has been used for this specific yacht.

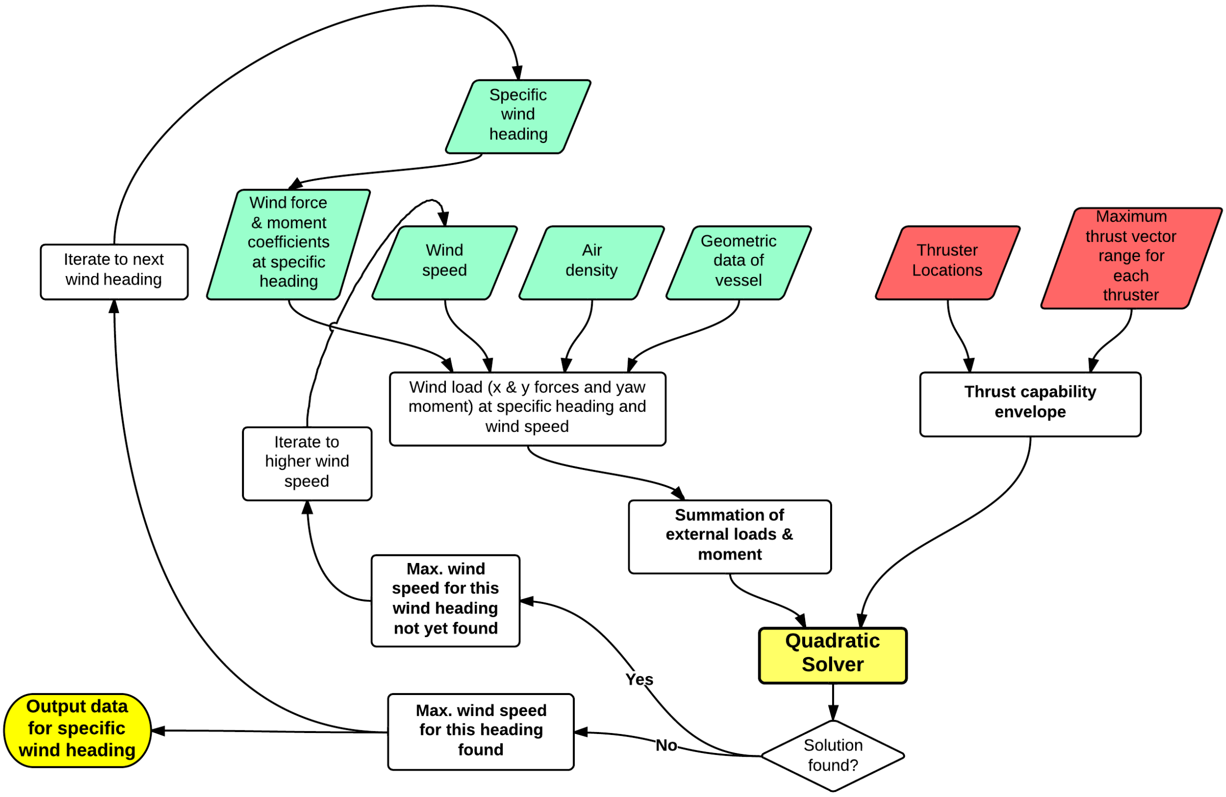

Figure 3 - *Calculation method of DPCalc v1.3*

8.3 Power Requirements

The basis vessel was configured in DPCalc as it is currently designed. The power to the thrusters was then increased at the same rate (such that the ratio of bow thruster power to stern thruster power remained constant). As previously discussed, the thrust developed by the main propellers remains constant.

DPCalc works by equating forces, however to be useable in design force (i.e. thrust) needs to be related to power. In the absence of specific manufacturers' data, thrust has been related to power according to IMCA M.140 guidelines (145N/kW for tunnel thrusters, 171N/kW for azimuthing thrusters and propellers, 120N/kW for propellers running in reverse).

In each case, the capability of the vessel with the thrusters at 10%, 50%, 150%, 200% and 300% of the original designed power has been found.

Figure 4 shows the polar capability plot of the vessel as the size of the thrusters are increased.

By plotting the lowest limiting wind speed at any angle against the power consumed by the thrusters (Figure 5), it can be shown that the relationship is non-linear, with the required power increasing at a greater rate than the limiting wind speed. This would be expected, as wind loading force increases proportionally to the square of the wind speed.

It can be seen however that the disparity between the lowest limiting wind speed (typically seen at 130° for this vessel) and the beam-wind limiting wind speed increases proportionally through the power range.

By using fixed electrical efficiencies to calculate the load on the generators of the thrusters, and a fixed hotel load of 1010ekW, the total required electrical load can be plotted.

It can be seen for the basis vessel that the installed thrusters and generators are predicted to provide a limiting beam wind speed capacity of approximately 30.4 knots.

DYNAMIC POSITIONING CAPABILITIES FOR SUPERYACHTS

By increasing the rated power of the thruster units by 50%, and increasing the installed electrical generating capacity by the equivalent of an extra generator, this speed can be increased to around 35.8 knots. Similarly, by reducing the thruster sizes by 50% the capacity will drop by 6.6 knots, to 23.8 knots.

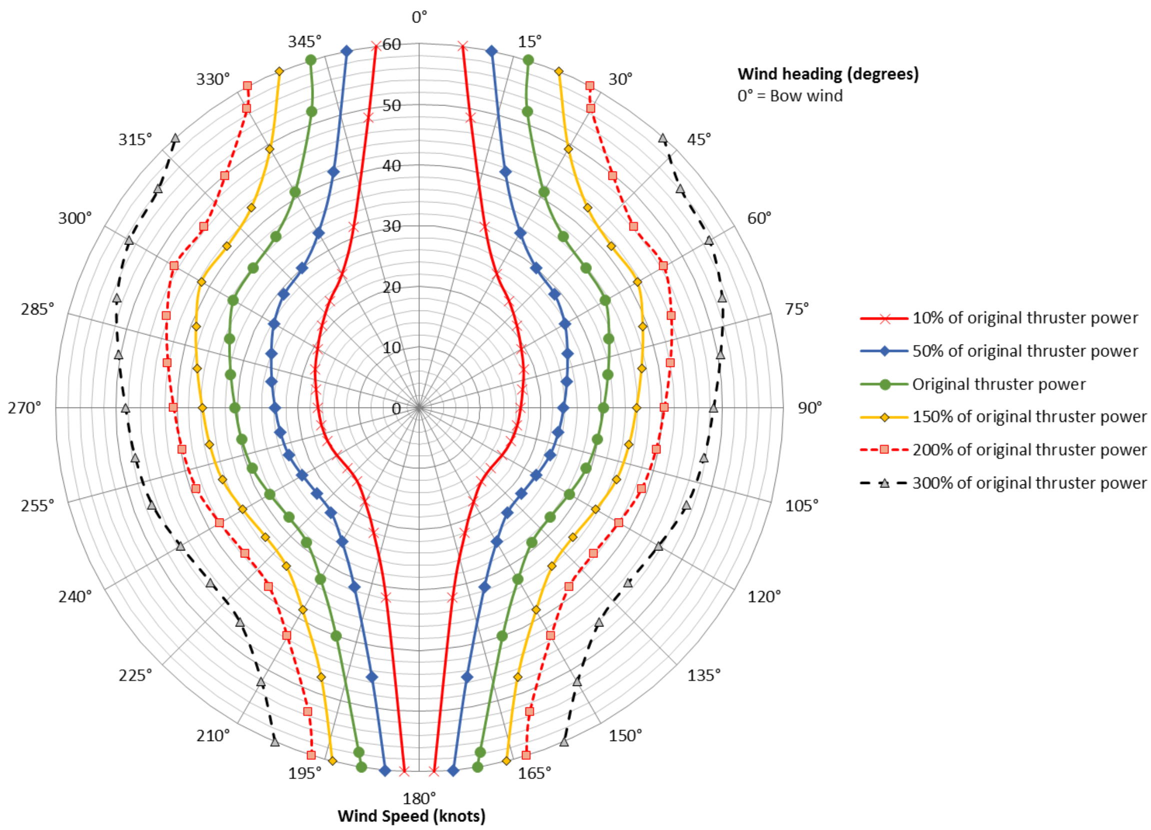

Figure 4 – *Station-keeping capability polar plot at a range of bow and stern thruster powers*

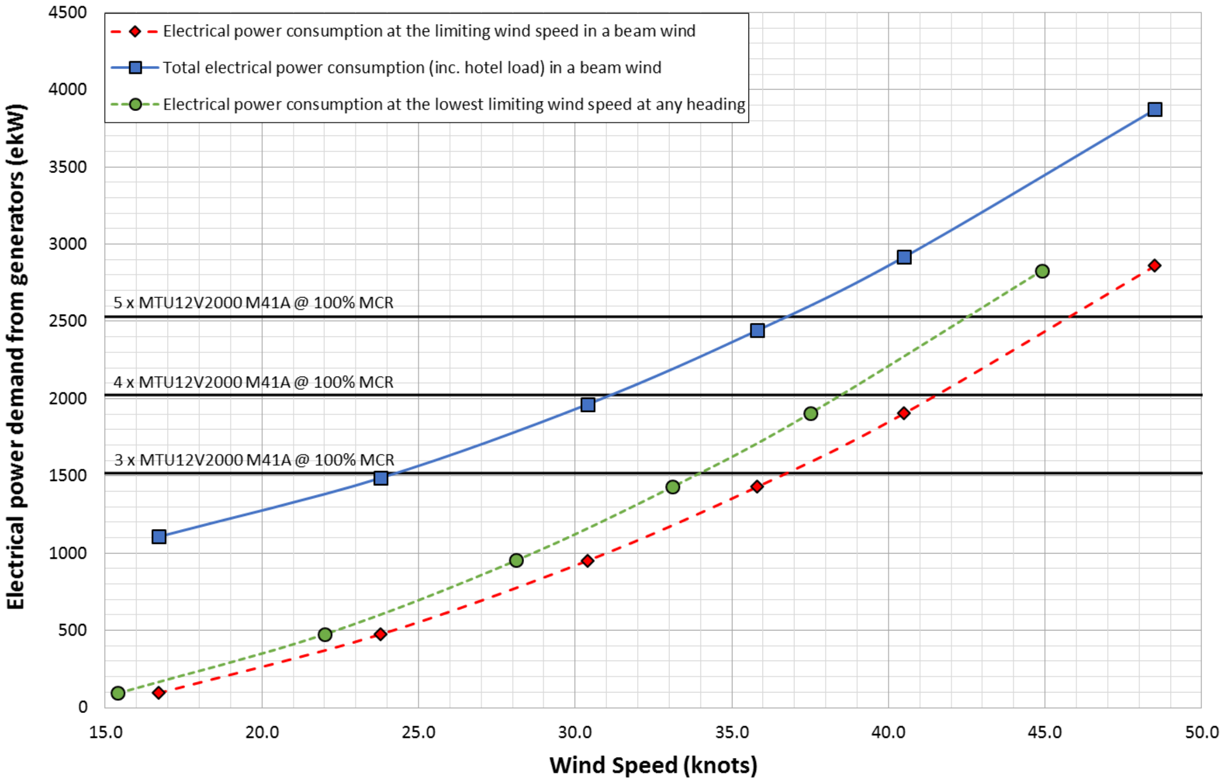

Figure 5 – *Limiting wind speed plotted against electrical power consumed*

8.4 Impact of Power Delivery

This vessel has electrically driven thrusters, and so the impact on the vessel of the DP capability chosen is both mechanical and spatial in nature.

Beam wind specified	Total thruster power required	Bow thruster power	Stern thruster power	Total required Electrical Installation	Total electrical installation capacity minus maximum hotel load	%age of genset installation that is only required for thrusters
knots	*bkW*	*bkW*	*bkW*	*ekW*	*ekW*	-
25	506	260	245	1565	365	23%
30	840	432	408	1932	732	38%
35	1236	636	600	2365	1165	49%
40	1690	870	820	2863	1663	58%
45	2208	1137	1072	3431	2231	65%

Table 1 – *Power requirements of the vessel to hold station at various beam wind speeds*

As the amount of electrical power installed is usually driven by the sizing of the thrusters, the DP capability specified has a significant impact on the number and size of generators installed.

The higher the DP specification, the more electrical machinery the vessel carries purely for DP operations. The maximum anticipated hotel load for this vessel is around 1200ekW. Whilst some level of redundancy in the system is required, (also allowing for hours swapping on the generators), it can be reasonably assumed that the majority of the remaining installed capacity is installed for thruster operations only.

Table 1 shows that for a specification which calls for station-keeping capability in a beam wind of 35 knots, nearly 50% of the installed electrical power is required solely to satisfy this specification criteria.

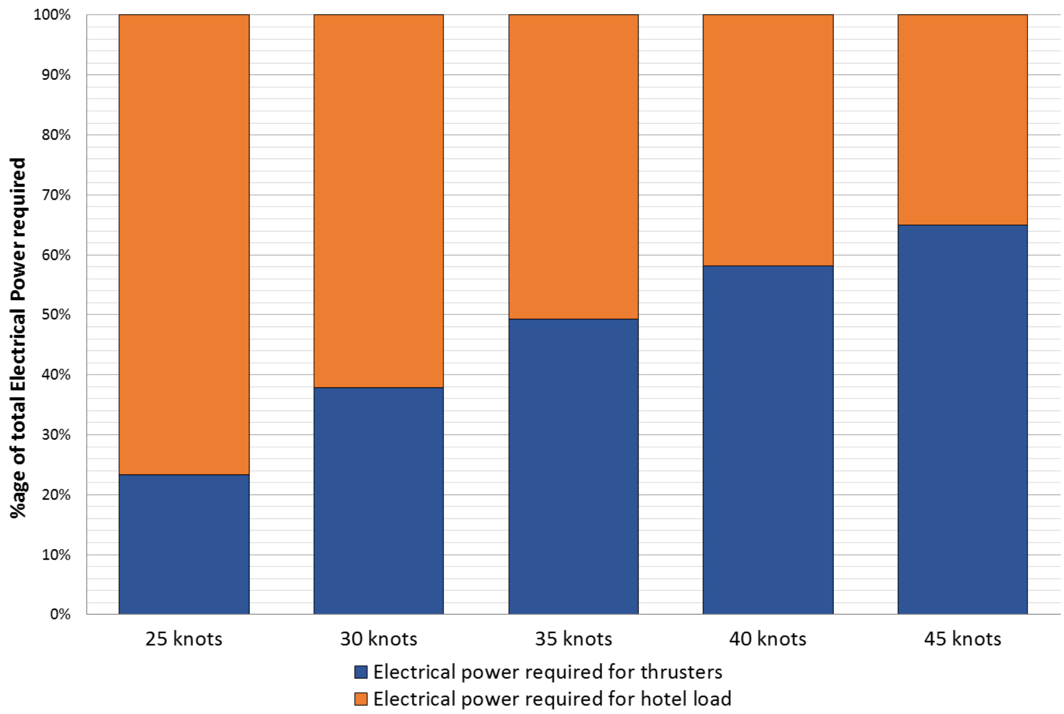

Figure 6 – *Percentage of electrical power required for each application*

The bow thruster motor on this vessel is mounted horizontally, with the electric motor running along the vessel's centreline, aft of the thruster tunnel. The bow thruster room has been designed such that there is very little space between the electric motor and the watertight bulkhead – this is a common arrangement on a yacht where space, particularly on the tank deck, is at a premium.

Any increase in the size of the thruster tunnel or drive unit would therefore require a bulkhead rearrangement, increasing the length of the thruster room by one or more frames. Similarly, if the size of the bow thruster becomes prohibitive, it may be necessary to move to a pair of bow thrusters, requiring even more space. In this situation it may be beneficial to use rim-drive thrusters (a thruster where the motor is integrated into the tunnel, thereby reducing the space required in the bow thruster compartment).

In addition to the increase in size of the unit, if the thrusters are electrically driven (as they are in this vessel) the frequency converters will get larger. The bow and stern thruster frequency converters in this case are combined with the shore power converter (a common arrangement), located roughly amidships on the tank deck. It takes up a considerable amount of technical space, and weighs nearly 7 tonnes. As the size of the converter is approximately proportional to its' rated power, if the thruster power was to double the size and weight of the converter could also be expected to double. This would in turn increase the size and weight of the circuit breakers in the main switchboard, and the cabling weights to the thrusters. Larger frequency converters require a larger cooling circuit, with more wild heat to dissipate.

It becomes clear that by simply increasing the power of the thrusters has many knock-on effects downstream, affecting multiple systems.

9. FURTHER WORK

A useful extension of this study would be to collate a list of typical yacht anchorages and ports around the world visited by large yachts, with typical durations of stay and visitation frequency.

By combining this with appropriately selected spatial and temporal resolutions of wind speed data in these locations, the operational envelope of manoeuvrability may be evaluated against the vessel's capability, effectively giving an operability index for the vessel tailored to its' realistic operating conditions.

There are many areas in which the authors envisage the DP analysis software being developed. Principally, a restructuring of the software to ease further development, modularising elements of the calculation, would be very beneficial. This will then allow individual components to be upgraded, for example, increasing the accuracy of the side force developed by a rudder in a propellers slipstream by using actuator disc theory, or improving the estimation of wind loadings by employing more accurate correlation techniques to estimate the wind drag coefficients.

There are also a multitude of features that could be added, including the modelling of current and wave loading, and the ability to evaluate a vessel's ability to hold specific heading against loadings when anchored by the bow.

Naval architects and yacht designers are invariably not experienced seafarers and opportunities to spend any significant amount of time on the vessels that they design are sparse. Whilst attempts were made during the writing of this paper to engage the skippers of several large yachts, a very limited response was received. It is always important to obtain feedback from seafarers on how systems are used in practice; what works, what is useful, and importantly, what is not. By further engaging the seagoing community, areas of associated research and study are likely to become apparent.

10. CONCLUSIONS

The basic principles of Dynamic Positioning have been introduced, providing a brief insight into how station-keeping capability prediction software operates. Typical arrangements of thrusters within a yacht have been discussed, with the merits of this layout presented. It should be noted that whilst this is a 'standard' yacht layout, it should by no means be considered the only way to achieve manoeuvring capability.

Various methods of increasing DP capability are discussed, with the feasibility and impact on design of each evaluated. It is considered that the option with the least drastic effect on the vessel's design is to increase the power and thrust available to each thruster. If the power consumption to meet the specified criteria becomes large enough that the power installation required is unfeasible, then a move towards a podded propulsion system should be considered.

Yachts are rarely used in a true station-keeping mode of operation. Station-keeping specification criterion are therefore mainly used as a method of specifying an in-harbour manoeuvring capability for the vessel. Consequently, a beam-wind based criteria is considered suitable for use in this specification, despite the fact that a beam-wind is rarely the most onerous wind heading for station-keeping.

For the basis yacht studied, it is seen that to achieve any significant increase in DP capability requires a large increase in thruster sizing and consequently installed electrical power generating machinery. At a beam-wind station-keeping capability above 35 knots, over half of the electrical power installed is installed purely for DP operations.

The level of DP specification should clearly be a carefully considered parameter, with the practical value of a more capable system being evaluated against the various design compromises outlined in this paper.

11. REFERENCES

Holvik, J. (Kongsberg Simrad Inc), "Basics of Dynamic Positioning", *Dynamic Positioning Conference*, Houston, 1998

The International Marine Contractors Association, "Specification for DP Capability Plots", *IMCA M.140 Rev. 1*, June 2000

Original presented at the 23rd HISWA Symposium November 2015

Authors:

J. Calver, Senior Naval Architect, BMT Specialised Yacht Design

J. Roy, Managing Director, Lateral Naval Architects, UK

LATERAL

NAVAL ARCHITECTS

DYNAMIC POSITIONING CAPABILITIES FOR SUPERYACHTS

The authors would like to thank Captain Bill Zinser and Captain AJ Anderson for their valuable contributions to the content of this paper.