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A Consultative Approach to Charter Party Agreements Based on Virtual On Time Arrival

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ABSTRACT: Charter Party agreements underpin the relationship between ship owners and charterers. The agreement guarantees the performance of a vessel in terms of speed and fuel consumption. On this basis the charterers plan the arrival of their cargo and their profit margin. However, ship performance is degraded by age, periods between maintenance and many vessels fail to perform as expected. Moreover the performance is only warranted during the specific conditions stated in the charter party which are not always clear. These usually refer to Beaufort Force (BF) and the Douglas Sea and Swell (DSS) scale which is archaic in the age of Numerical Weather Prediction. Given these conditions, the stage is set for conflict and there are often disputes over the weather conditions experienced. Moreover ships' often do not arrive on time because the charterer has assumed that the ship will make good its warranted speed and not taken account of the forecast weather conditions. The authors propose a new way of approaching charter agreements with the emphasis on consultation rather than confrontation facilitated by a new web based software platform.

1 CHARTER PARTY AGREEMENT

The terms under which vessels are chartered are contained in the Charter Party Agreement. These tend to have a similar format regardless of who has drafted them and they contain similar provisions. This includes information on bunkers, charterers' rights and obligations covering speed and performance warranted by the owner and the Charterer' rights should they not be met. As such Charterers generally pay for the fuel consumed over the voyage and the Charter Party Agreements in common usages contain clauses warranting vessel performance in terms of fuel consumption and speed. Clearly both Speed Made Good and fuel consumed are dependent on the weather conditions experienced, in particular currents and waves. Therefore the Charter Party Agreements also contain definitions of 'Good Weather Periods' under which the performance and speed will be achieved. Usually this is achieved by placing upper limits on winds, waves and adverse currents. If the conditions experienced exceed these, then the vessel does not have to perform as per the Charter Party. However, the performance description applied for "good weather" and how/when currents should be taken into account is not always made clear. Furthermore speed and performance provisions are not normally consolidated in one clause or contractual document, and can be poorly constructed, leading to the potential for costly disputes over speed and performance warranty.

2 METHOD OF CALCULATION

The Performance Evaluation method is based on a Good Weather Analysis, a methodology for speed and bunker analysis calculations in good weather, as set out in three English Law precedents – The Didymi Case [1] (Lloyds Report 108, 1988), The Gas Enterprise Case [2] (Lloyds Report 352, 1993) and The Gaz Energy Case [3] (English Commercial Court: 2011 High Court of England and Wales 3108 and 2012 High Court of England and Wales 1686). The performance of a vessel is assessed in good weather period only in order to determine the good weather performance speed, or her speed capability in good weather. Thereafter the good weather performance speed is applied on the entire voyage, as if the vessel has performed the entire voyage in good weather conditions, the underpinning assumption being that if the vessel did not perform to the Charter Party in good weather then she would not have done so in worse conditions.

The key to this calculation is therefore to establish the good weather periods. These are usually determined by a weather service provider, appointed by the charterer and specified in the Charter Party Agreement. The good weather periods are identified after the voyage by reconstruction of the ship's track from the noon day reports and/or by AIS reports. The ship positions are then matched to the gridded output from Numerical Weather Prediction (NWP) models and the corresponding values for wind, waves and current extracted. The good weather periods are identified and speed and consumption calculated. If the performance achieved in good weather is less than that specified in the Charter Party, then the good weather speed and consumption is extrapolated to the entire voyage to calculate the additional bunkers consumed and the additional time taken for the voyage.

The weather reported by the vessel plays no role in this process. It is therefore not unusual for disputes to develop regarding the weather conditions reported by the vessel as compared to those assessed by the weather service provider.

The current transactional approach to charters sets up a conflict situation in which:

1 Ship owners cast the vessel consumption and performance in the most favourable light in order to win business.
2 Masters are under pressure to perform and incentivised to exaggerate the weather conditions experienced; this can be exacerbated by poor quality reporting of the actual weather and poorly calibrated weather instruments.
3 Charterers cannot rely on the vessel to deliver the cargo to time and cost.

The authors will propose an alternative collaborative approach to ship charters, but first it is worth exploring the inherent problems with the current approach.

3 GOOD WEATHER DEFINITION

Typically good weather is defined as "up to Beaufort Force 4 and Douglas Sea State 3…no adverse effects of Swell/Currents".

The obvious problem with this definition is that it is very unusual for these conditions to be met on an ocean voyage. Figure 1 shows the probability of winds in excess of Beaufort Force 4 occurring in the North Atlantic during the month of August. During the winter months Beaufort Force 4 is exceeded nearly 100% of the time across huge swaths of ocean north of 35N. It is unrealistic for charterers to expect vessels to make an 'on time arrival' without excessive consumption. It is perhaps not widely understood by shore based staff that despite their size that ships cannot overcome the laws of physics.

Fuel consumption is a function of the resistance that the vessel has to overcome. In turn resistance is a function of the vessel block coefficient, loading, and trim, water density, currents, waves, winds and biofouling.

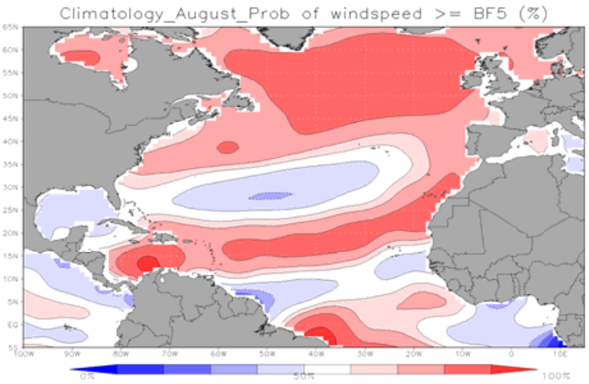

Figure 1. North Atlantic - Probability of wind speed exceeding Beaufort Force 4 in August (Source COADS)

Speed is a function of power and drive train efficiency and is impacted by engine racing, slamming and propeller racing which are affected by relative wave direction and magnitude. The impact of speed made good can be considerable as shown in Figure 2.

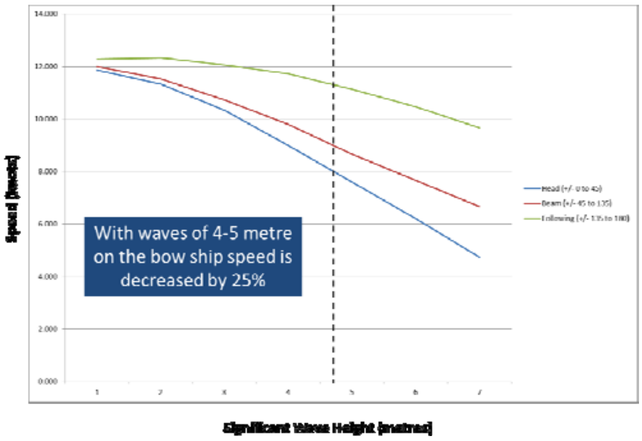

Figure 2. Speed Made Good by a Tanker making revolutions for 12 knots for Head, Beam, Following seas (Source: NIMA Pub No 9 2009)

4 DOUGLAS SEA SCALE (DSS)

The DSS is a two-digit scale (proposed by Captain Douglas, Hydrographer to the Royal Navy in the 1920s) for reporting the height of waves as observed at sea. It allows for the distinction between the sea and swell. While the generating wind blows, the resulting waves are referred to as 'sea' or 'sea state'. When the winds stops or changes direction, waves that continue on without relation to local winds are called 'swell' . The WMO give these definitions as:

- Wind wave or wind sea: Waves raised by the wind blowing in the immediate neighbourhood of an observation site at the time of observation.
- Swell: Any system of water waves which has left its generating area (or observed when the wind field that generated the waves no longer exists).

Waves are generated at a broad spectrum of frequencies and sea does not have a period associated with it only a height. In contrast, swell is composed of gravity waves that have been generated elsewhere and have propagated. Gravity waves experience frequency dispersion, i.e. waves of different frequencies travel at different speeds and swell becomes sorted into waves of different frequencies as it propagates away from the generating area, with long period swells arriving first.

There may be a heavy swell present even though the winds are light. The DSS was created specifically to address this by treating sea and swell separately. By definition swell is not related to the local wind and it is therefore quite incorrect to link the Douglas Sea Scale Sea State 3 with the Douglas Sea Scale swell description.

The Douglas Sea and Swell scale has 2 components: 'sea' and 'swell' which by definition are independent variables. The Douglas Sea Scale is reported as 2 numbers; the first referring to the Douglas Sea State; and the second reporting the swell. For example if the Douglas Sea State height is 1.25m and the swell is described as short and heavy, then the Douglas Sea Scale is 36. The WMO has adopted the Douglas Sea Scale [4] for the reporting of sea state by mariners and recommends that the terminology is used in forecasts for shipping [5]. Unfortunately this format is rarely used and typically only Sea State is provided.

Douglas Sea Scale 3, as commonly referred to in Charter Party Agreements, only refers to the wind generated wave height and frequently omits the swell component. The lack of a quantified value for swell then makes comparison with NWP problematic and creates problems for charter companies who wish to query warranty performance. NWP wave models are spectral models which work by calculating the total level of wave energy in the ocean and then assigning it to a two-dimensional frequency-direction domain (termed the wave spectrum) used to describe the average motion of the sea-surface under waves. Essentially the spectrum decomposes a given sea-state into a set of constituent sine waves, each with a different direction, period (inverse of frequency) and amplitude (energy). Some of these are designated as 'swell waves' whilst others are designated as 'wind waves'.

There is one output parameter that combines sea and swell that can be meaningfully compared to observed wave heights. This is the Significant Wave Height which is a measure of combined 'sea' and 'swell' and is defined as four times the square root of the first moment of the wave spectrum; this is close to the average height of the highest 1/3 of the waves (and has its origins in Munk & Sverdrup 1947 [6]) and is what shipborne observers are expected to report. Measurements of Significant Wave Height are the main source of data for wave models and are derived from remote sensing using space borne Synthetic Aperture Radar (SAR) and altimeters. Measurements of Significant Wave Height from buoys are also assimilated and provide ground truth.

Significant Wave Height therefore represents a 'common currency' between observations and NWP. Weather service providers commonly apply a Significant Wave Height of 2.0 metres as equivalent to a Charter Party entry of DSS 3. However there has not yet been a definitive ruling on this in Arbitration and the use of DSS in Charter Parties continues with the swell part omitted in many cases.

Setting aside issues around height, the period of the swell can also have a bearing on the seakeeping of the vessel and hence impact performance – if successive waves strike the side of a vessel at the same phase of successive rolls, relatively small waves can cause heavy rolling [7]. The IMO has published algorithms and guidance for Masters for avoiding dangerous situations [8] which can readily be applied to predict the impact of swell on seakeeping and ship safety (covering reduction of intact stability, synchronous rolling and parametric roll, etc.).

5 ACCURACY OF NWP

The analysis and forecasts of surface wind are mature and have a high degree of reliability. For example, Figure 3 verifies forecast windspeed against windspeed observed at manned observing stations in Europe where the observations are reliable. It indicates a forecast accuracy of +/- 1 knot at T+72 hours i.e. 3 days. Similarly the most skillful wave analyses when compared to buoys are accurate to +/- 0.3 metre.

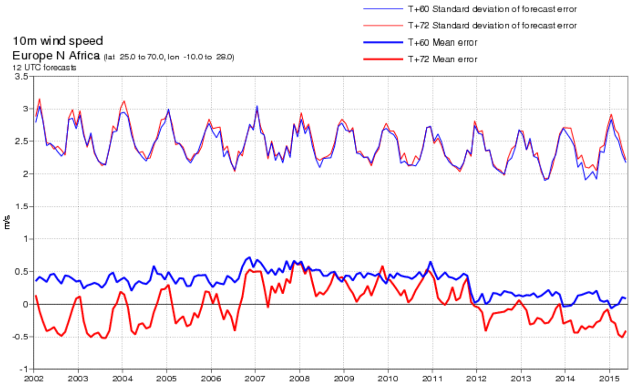

Figure 3: RMS Error of ECMWF forecasts of 10m windspeed at T+48 and 72 (Source: ECMWF)

NWP analyses are based on observations and are the most accurate depiction of the conditions at that time. Wind analyses are readily available at 6 hourly intervals at 0000/0600/1200/1800UTC and waves at 0000/1200 UTC daily. Each model creates 'snapshots of reality' as 3 hourly forecasts from the analysis base time. NWP models therefore have a temporal granularity of 3 hours and if the ship position report does not occur at 00/03/06 UTC etc. then this means that interpolation in time is required between the forecast values or the ship position at the time of the forecast has to be estimated. Similarly the models output on a grid with values at discrete latitude and longitudes. The grids are currently around 0.25 degrees by 0.25 degrees and so if the ship position does not fall exactly onto the grid point then interpolation in space is required between the forecast values at adjacent grid points.

Meteorological and oceanographic phenomena are not linear and are characterised by discontinuities and interpolation is prone to unquantifiable errors. NWP should therefore be used with caution to assess the conditions experienced during a voyage as the temporal and spatial grid is unlikely to match the time and location of ship reports and a degree of interpolation will be required.

6 WEATHER ROUTEING

Notwithstanding the issues highlighted in the previous section regarding the use of NWP to assess the conditions experienced during a voyage, weather forecasts are incredibly accurate. Figure 4 shows the anomaly correlation scores, which are a measure of accuracy, for the 5 day forecasts produced by the leading NWP models. The best models are now better than 90% accurate at 5 days and still show skill in their 14 day forecasts. This accuracy enables optimised ship routeing to avoid bad weather and adverse currents in order to minimise the fuel burned over a voyage whilst ensuring On Time Arrival. The problem is that this process is currently conducted seperately or is not reflected in the Charter Party Agreement.

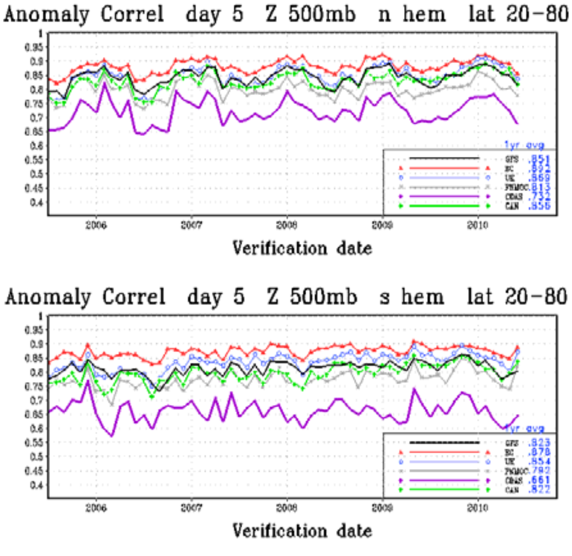

Figure 4. Anomaly Correlation of 5-day forecasts (Northern and Southern hemispheres) (Source NCEP)

The next section proposes a new way of approaching charter agreements with the emphasis on consultation rather than confrontation facilitated by a new web based optimised ship routeing platform.

7 EFFICIENCY

As we have seen, currents, waves and wind increase the resistance that a vessel must overcome to move. Clearly this resistance varies in time and space during a voyage. Therefore, during the voyage either the vessel Speed Made Good or the vessel slip can be expected to fluctuate as a result of the resistance encountered.

Marine diesel engines operate efficiently in a narrow power band and in order to minimise fuel burn constant power should be maintained within this power band for as much of the voyage as is practical. This is clearly demonstrated in Figure 5 which shows the impact of added resistance on the power required to achieve different speeds as measured during an experiment on MV Rotterdam. A small difference in current has a large impact on power required.

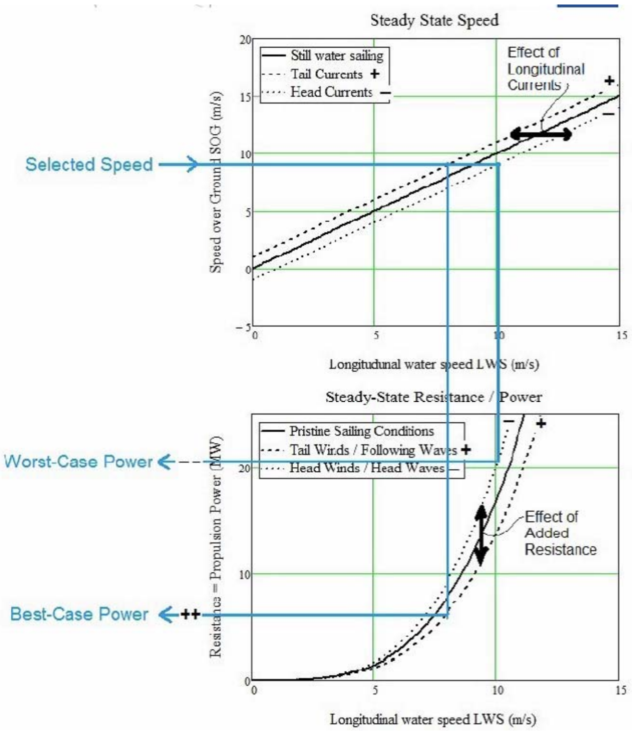

Figure 5. Impact of current on MV Rotterdam power curves (Source: Kessel, Ronald, Empirical Estimate of the Influence of Wind, Current & Surface Waves on Energy Consumption by Ships, 29 April 2013, CMRE-FR-2013)

It therefore makes sense to assess the total resistance that will have to be overcome on the entire voyage for a number of possible routes and to select the least resistance route. Applying basic navigation principles, resistance can be calculated in terms of miles. The average speed that will need to be achieved over the entire voyage in order to make an On-Time-Arrival can then be calculated, the vessel can then make revolutions for this speed, and let the Speed Made Good fluctuate.

A simple example illustrates the principle. Take a vessel making revolutions for 10 knots and encountering a head current of 1 knot. The vessel will only achieve a Speed Made Good of 9 knots and will have to travel 11 miles through the water to make good 10 miles. Over a distance of 100 miles, the vessel can either arrive in 10 hours making revolutions for

11 knots OR arrive in 11 hours making revolutions for 10 knots.

This simple example shows that it is not sensible to estimate arrival times or fuel consumption based on the nominal values and unrealistic weather conditions currently assumed in Charter Party Agreements. There is always likely to be a trade-off between operating at the most efficient running speed and burning least fuel, and arriving at a specific time. This information can be presented to the charterer and ship owner to inform their decision and provide shared assumptions regarding the forecast conditions over the voyage and their impact on vessel performance.

8 TRADING SPACE

Given some basic information about the vessel and the voyage, the resistance and distance through the water can be calculated for the forecast weather conditions during the voyage. The weather conditions (and resistance encountered) are a function of time as well as space, they therefore depend on the vessel's Speed Made Good. In order to simplify the calculation 4 possible vessel speeds and corresponding optimsied routes are considered; ECO, Charter, Maximum continuous rating (MCR) and speed required to achieve On Time Arrival. The possible combinations of speed, consumption and arrival time can then be presented along with the number of bad weather periods and impact of current that are expected. Figure 6 shows an optimum route summary for a vessel sailing between Pembroke and New York in October 2015 which avoided ex-Tropical Storm Joaquin, reduced impact from the adverse Gulfstream/North Atlantic drift currents and minimised the distance in the Emission Control Area (ECA) off the US east coast. While Beaufort 4 and Douglas Sea Scale 3 conditions were expected to exceed 36 hours due to unsettled weather patterns across the North Atlantic, an On-Time-Arrival could be achieved at 12.9kts routing south via the Azores which added some 300nm to the shorter great circle route.

As part of a new consultative approach it is key that all parties view the same information through a web browser prior to sailing. The authors have developed a web interface to enable a consultative approach, as exemplified by the information revealed at Figure 6 which summarises the expected periods of bad weather, the impact of current, the earliest arrival time and other relevant information for an optimised route where the priority is for an on-time arrival.

Constraints such as limiting exposure to High Risk Areas or minimising mileage in Emission Control Areas can be added. Algortihms can also be embedded, for example Seakeeping algorithms or algorithms to calculate the CO_2, SOx and NOx (which is speed dependant) for each of the speed options.

Route Benefit Calculation	**Shortest Route (BP Distance Table)**			**Recommended Route**		
	Total (nm)	ECA (nm)	# of bad weather periods (6hrs)	Total (nm)	ECA (nm)	# of bad weather periods (6hrs)
	2908	1244	36	3115	490	23
Distance through the water (nm)	3314			3115		
CP Speed (kts)	12.5			12.5		
Speed required for OTA (kts)	13.8			12.9		
Total Voyage time (hrs)	256			241		
Saving (nm) [Additional distance through the water]				199		
Additional Slip (%) [Achieved vs theoretical distance per prop rev]				6		
Saving (hours) [Additional time due to bad weather/icebergs]				15		
Reduced distance in ECA (nm) [Difference in ECA mileage]				754		
Earliest arrival time [Shortest voyage time & duration at constant power]				241 hrs		

Figure 6. Example of route benefit calculations for an optimised route from Pembroke, UK to New York.

9 POST VOYAGE

The same approach can be applied once a voyage has been completed where an adapted process using more accurate analysed weather conditions instead of forecasts can be used to verify performance. This process offers a fast and cost-effective evaluation of ship performance related to weather criteria stipulated in Charter Party Agreements. By example, Figure 7 shows an assessment of ship performance against weather criteria which can easily be viewed via a web browser by all parties. This exampe shows that the speed made good rarely achieved the Charter Party speed. If, in this eample, the weather conditions had been benign then this assessment would provide an early indication that the vessel is underperforming – something that any owner/operator would wish to know as soon as possible.

10 LIMITATIONS

Although the options presented are only as accurate as the weather forecasts and the vessel information, the process and the underpinning assumptions are explicit and offer a step improvement over current practice. The assumptions made are shared by all parties and the resulting decisions form a common and mutual consultative audit trail for the voyage. The use of a web based software tool will allow a more consultative rather than confrontational approach to resolving warranty issues that should help reduce the need for costly arbitration in the event of a dispute. Testing of this approach with interested shipping companies and charterers is expected to commence shortly.

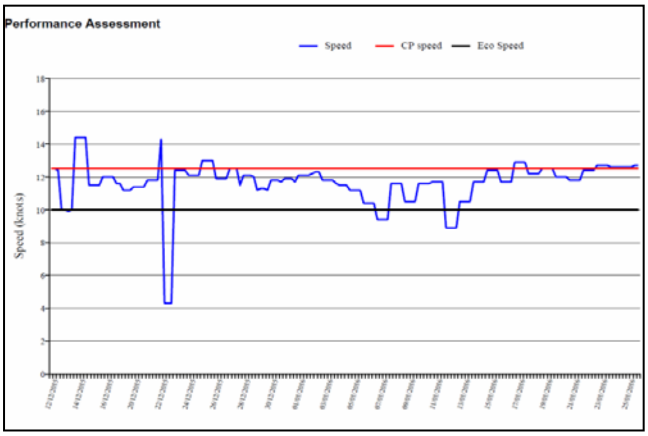

Figure 7. Example of a post voyage performance assessment showing ship speed made good generally being below the Charter Party speed for the majority of the voyage.

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REFERENCES

[1] The Didymi 1998 2 Lloyd's Law Report 108 (Didymi Corporation vs. Atlantic Lines and Navigation Inc.) *The "Didymi" case*

[2] The Gas Enterprise 1993 2 Lloyd's Law Report 352 (B.P. Shipping Ltd. vs. Exmar N.V.) *The "Gas Enterprise" case.*

[3] Hyundai Merchant Marine Company Limited v Trafigura Beheer B.V. 2011. *The "Gaz Energy"* English Commercial Court: Flaux J: [2011] High Court of England and Wales 3108 (Comm) 29 November 2011 and English Commercial Court: Teare J: [2012] High Court of England and Wales 1686 (Comm): 21 June 2012]

[4] CIMO Guide 7th Edition 2014. *Guide to Meteorological Instruments and Methods of Observation*, Chapter 4, para 4.2.2.13.1

[5] https://www.wmo.int/pages/prog/amp/mmop/faq.html

[6] Munk & Sverdrup 1947. *Wind, Sea, and Swell: Theory of Relations for Forecasting*, US Hydrographic Office Pub No. 601.

[7] The American Practical Navigator (2002) (Bowditch, Pub. No.9). Chapter 32.

[8] IMO MSC.1/Circ.1228 11 January 2007. *Guidance to the Master on avoiding dangerous situations in adverse weather and sea conditions.* 7-9