Racing Ahead with Instruments

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Note
It is strongly advised that this handbook be read carefully. Both the accuracy and reliability of this instrument are dependent upon correct installation, calibration and operation.

CHAPTER I

INSTRUMENTATION AND THE MODERN YACHT

1.1
The correct used of a good yacht instrumentation system can produce very considerable advantages for the racing and cruising yachtsman. This B&G manual will go through the basic principles of yachting tactics in so far as they are affected by instrumentation and how best use can be made of those instruments to improve your performance on the water. The two fundamental factors which are affected by your instrument systems are the accuracy of information on:

Performance data

b: Wind data

Most members of the crew will need to have access to at least some of the instruments on the yacht. However, they will mostly have different requirements, such as:

Helmsman and Trimmers	– Performance Oriented.
Tactician and Navigator	– Positional (both to other yachts and the next mark) and Depth Oriented.

1.2
To achieve this a yacht's instrumentation package should have the following characteristics:-

a: **Reliable Hardware** Nothing is more disruptive or annoying than having extensive, not to say expensive, equipment which either never works or only does so intermittently. The whole instrumentation system ranging from the sensors, the displays and the controlling units in the navigation section should all be designed and built to withstand the very adverse environment on board a yacht.

b: **Accurate Sensors** However reliable your instrumentation system, it is verging on the dangerous having inaccurate information and this will be the case if the sensors are not up to the job. The most important of these sensors are the boat speed, wind angle and compass, and wind speed units. They must not be affected by heel angle, leeway, vibration or any of the other myriad problems which could affect their accuracy.

Moreover sensors should be able to read absolute values and not be dependant on exact alignment. An example of this is the B&G Sonic Speed, when compared with a conventional paddle wheel or impeller. The latter can give erroneous figures if they or their housings have become slightly misplaced.

c: **Correct Calibration** It is no use having a boat speed measuring device accurate to 100th of a knot if the calibration is incorrect and the same applies to the other functions of the instrumentation system. The calibration must be easy to accomplish and should not involve having to strip down the entire system to make a minor change. Nor should it be necessary to re-calibrate every function if one part of the system has been changed.

d: **Good displays** The displays, be they on deck or down below, should be easily read and understandable in all conditions, both day and night.

e: **Flexible Configuration** Not only should the system be compatible with other devices such as LORANs, DECCAs, or SATNAVs but, if the original system is enhanced at a later date, there should be little if any redundant hardware. One should be able to add on extra facilities without major system rebuilds. (see chapter IV para 4.12)

CHAPTER II

WIND DATA AND TACTICS

2.1 INTRODUCTION

One cannot understand yacht racing tactics without at least a rudimentary knowledge of the geometry of wind shifts, hence its effect on tactics between yachts. Without trying to preach to the converted or the expert we will consider:

a: The basics of tacking and gybing towards a mark.

b: The effects of a wind shift on two or more yachts.

c: The means of plotting wind shifts.

d: The nature of different categories of wind shift patterns.

2.2 Laylines/Overstanding/Tacking Zone

When considering the behaviour of wind shift patterns and its relationship to yacht racing tactics, the understanding of laylines, overstanding and tacking zones are critical.

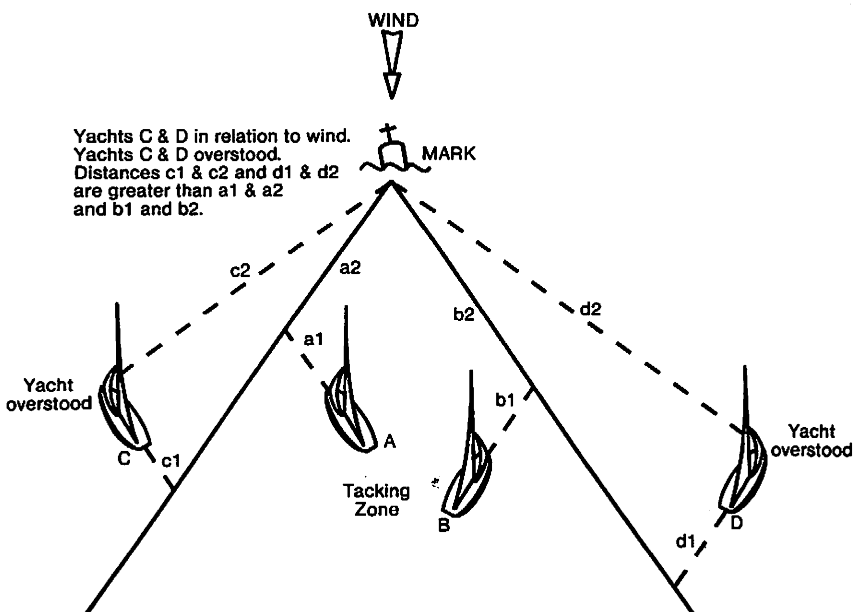


FIG. 1

a: **Laylines** These are imaginary lines beyond which it is not necessary to go to tack/gybe directly to a mark.

b: **Overstanding** This refers to sailing beyond those lines and thus wasting time and distance.

c: **Tacking Zone** This is the safe area in which to approach a mark, where it is necessary to either tack or gybe at least twice (once on the layline) to reach the mark.

2.3 GEOMETRY/TACTICS OF WIND SHIFTS

If one could guarantee that the wind would remain constant, it would always pay to sail direct to the layline and then tack or gybe. However these conditions would be exceptional to say the least. It would not matter whether one sailed left or right, both yachts would be equal in the following diagram.

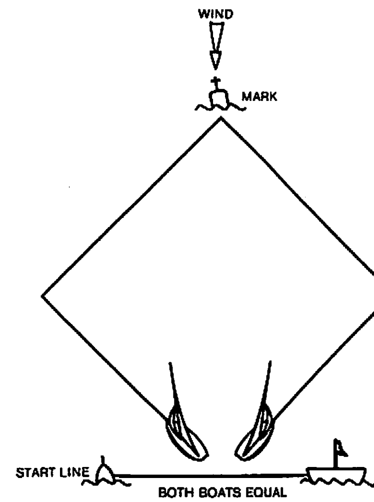
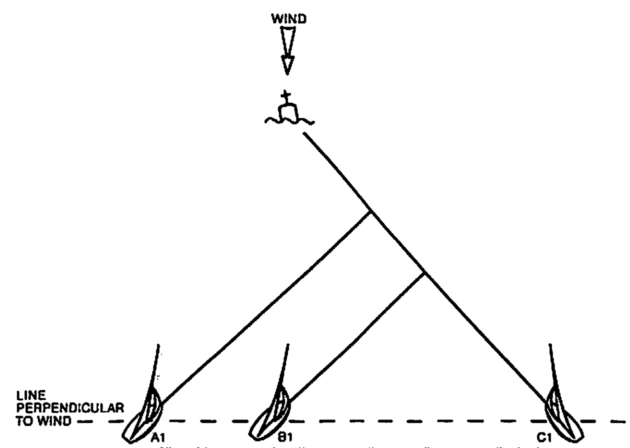


FIG. 2

However this rarely occurs and the greater the distance between the yachts or the greater the shift, the greater the loss/gain from a wind shift. If two yachts are on the same line, perpendicular to the wind, they are equal, and the one closest to the mark is not necessarily ahead.



All yachts are equal as they are on the same line perpendicular to the wind regardless of their distance from the mark.

FIG. 3

However, as soon as a wind shift occurs, the situation is changed dramatically. The yachts are still the same distance and bearing from the mark as they were before; but the perpendicular line has swung with the wind. Thus they are not on the same line, nor are they equal.

The further the lateral separation or the greater the shift, the greater the gain/loss from a shift.

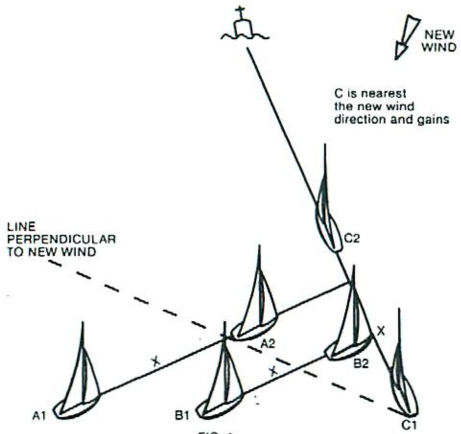
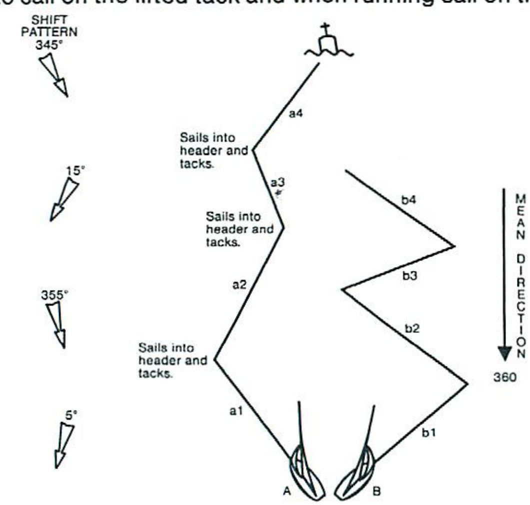


FIG. 4

Degrees Windshift	Gain/Loss 100ft separation	Gain/Loss 200ft separation	Gain/Loss 300ft separation
5	12ft	24ft	37ft
10	24ft	49ft	73ft
15	37ft	73ft	109ft
20	48ft	97ft	145ft

2.4
When beating, assuming that one is sailing in an oscillating wind pattern (see para 2.10), it pays to sail on the lifted tack and when running sail on the headed tack.

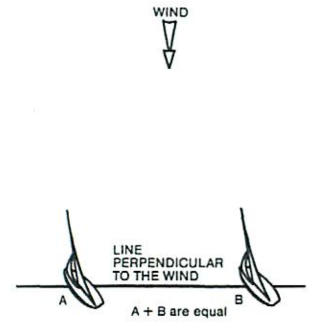


A sails on the lifted tack and takes a much shorter course to the next mark.
The distance a1 – a4 = distances b1 – b4 but it can be seen how A is much further ahead.

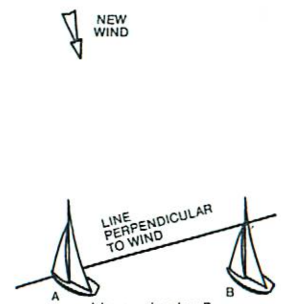
FIG. 5

Therefore the next wind shift is likely to be a header when beating, or a lift when running. Thus one should always be sailing towards the next wind shift.

2.5
From the above one can see that it is one's position compared to other yachts that determines whether or not a lift or header is advantageous. The following two diagrams illustrate the point:-



A + B are equal
FIG. 6



A is now ahead as B is behind A's line perpendicular to the wind
FIG. 7

With the gains/losses to be made from a wind shift being directly related to lateral separation, it can be seen that it is a high risk strategy to go right to the corner, i.e. sail straight to the layline on one tack. This is the tactic of DUFFER and helps explain why normally she is at the back of the fleet but just occasionally comes out at the front. A far safer approach is to tack/gybe up the middle of the course sailing in the 'safe' sector of the 'tacking' zone.

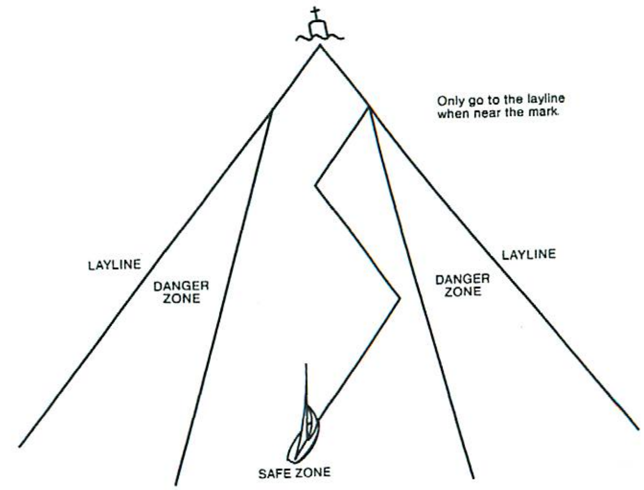


FIG. 8

As one approaches the mark the 'safe' sector angle is increased until it coincides with the laylines. Obviously you do not want to be tacking up the last few boat's lengths of the windward leg!

2.6 PLOTTING WIND DATA

From the previous paragraphs the vital importance of wind shifts is self evident; but how can one hope to gain from them consistently? Only by understanding wind patterns and this is done by plotting. To the racing yachtsman with an instrumentation system, plotting wind data is easy, but it is necessary to understand how this is done. The information depends on the following fundamentals:-

a: True Wind Speed (TWS)

b: True Wind Angle (TWA)

c: True Wind Direction (TWD)

These functions are derived from:-

d: Apparent Wind Angle (AWA)

e: Apparent Wind Speed (AWS)

f: Course

g: Boat Speed

2.7 APPARENT AND TRUE WIND DATA

The yacht's movement through the water creates an apparent wind effect and this is the wind measured by the wind sensors on a yacht. Imagine the situation with no wind and a yacht motoring at six knots. The wind sensor should show a reading of six knots AWS, with a zero AWA reading.

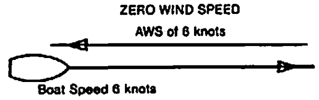


FIG. 9

As yachts rarely move directly into or away from the wind, the apparent wind angle also has to be considered, as does leeway.

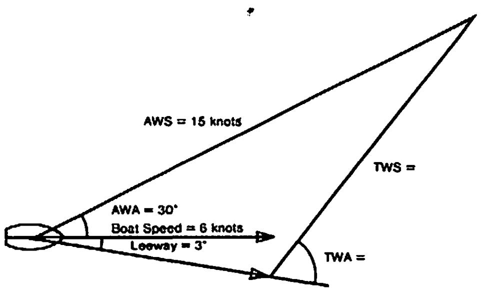


FIG. 10

Note that when beating, the True Wind Speed is less than the Apparent Wind Speed, and vice versa when running.

2.8 TRUE WIND DIRECTION (TWD)

Providing the yacht's instrumentation system includes an electronic compass, the magnetic wind direction can be calculated by applying the TWA to one's course. The function of TWD is absolutely critical to the correct use of sailing instrument systems, as it is a far better means of detecting wind shifts than observing a compass course. The principle reasons for this are:-

a: If the helmsman alters course for a tactical reason rather than a boatspeed related reason, such as pinching to avoid problems with another yacht, the tactician could be mislead into believing that a wind shift is taking place.

b: While it is easy to sail in the groove upwind and hence detect shifts early and accurately, it is much harder to do so when gybing downwind.

2.9 PLOTTING TWD

In order to be able to analyse the nature of wind shifts, it is absolutely vital that TWD is plotted both before and during a race. If this is not done then one will be reacting in a haphazard manner to wind shifts instead of being able to create a strategy, which will at least be a guide during a race. Before going into the nature of wind shifts, the methods of plotting wind trends will be discussed. These are:-

a: **'Guesstimate'** This is the method used on DUFFER and is quite definitely not to be recommended. It consists of haphazard glances at a TWD indicator or, even worse, the compass and attempting to remember the relevant figures!

b: **Timed Plots** Every few minutes at planned intervals, note time, TWD and TWS and anotate the results. A good method is to write down the results with a wax pencil on a piece of boat tape stuck to the deck, or some other suitable place.

c: **Computer Plotting** Automatic and continuous plotting of TWD over a set period of time gives the easiest and by far the most accurate plot of TWD. With a computer it is also very easy to produce a graph of the results which will make interpretation of wind trends much quicker and more accurate.

SHIFT PATTERNS

2.10 DECIPHERNING THE RESULTS

Having carefully plotted the TWD over a period, one then has the task of trying to decipher the results in order to recognise a pattern in the behaviour of the wind. Broadly speaking there are three main categories of wind shift patterns:-

a: Oscillating

b: Persistent

c: Oscillating Persistent

2.11 OSCILLATING WIND SHIFT

In this category the mean wind direction remains fairly constant but shifts about that mean. A graph drawn from wind plots would look like this:-

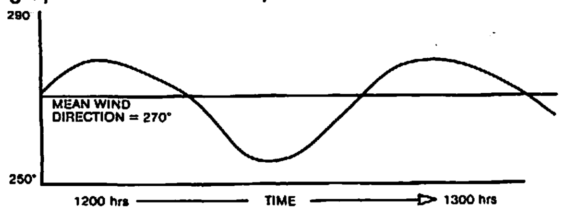


FIG. 11

Hence the use of the word 'oscillating'. However, the following pictorial representation gives a bird's eye view of this on the race course.

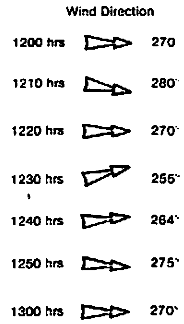


FIG. 12

2.12

It is important to try and get some idea of the duration of the phase of each oscillation. This is because, if one's time to the next mark falls within that duration, one is sailing in a persistent shift pattern (see para 2.13). Once one has recognised the existence of an oscillating wind shift pattern it is obviously preferable to sail on the lifted tack when beating and on the headed tack when gybing downwind. (see para 2.4)

By knowing the mean wind direction one can almost instantly know whether one is actually headed or not and by how much. The tactician should also know the left and right limits of each oscillation, which is especially important in calculating the laylines.

2.13 PERSISTENT SHIFT

This occurs when the wind will be steadily shifting in one direction during any particular leg of a course. A graph of such a wind pattern over a 30 minute windward leg would be as follows:-

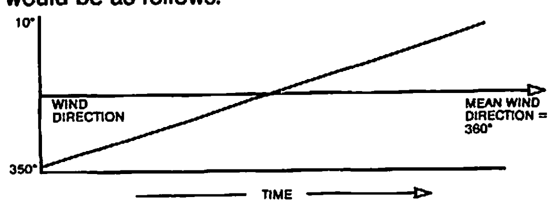


FIG 13

Following the rule to sail towards the next shift (para 2.4), it pays to sail initially on the headed tack until one reaches the layline, allowing for the subsequent lift along the layline.

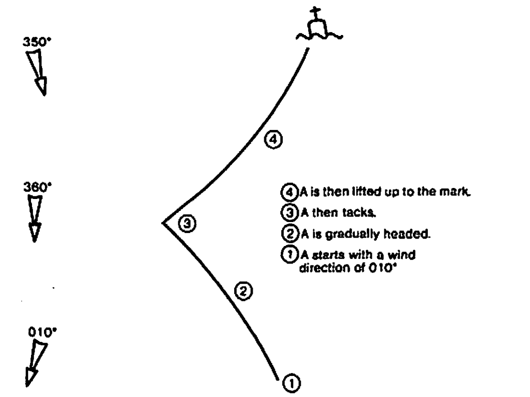


FIG. 14

How many times have you been overtaken by a yacht that has crossed astern and then been lifted inside you? A persistent shift is probably what caused this.

2.14 PERSISTENT OSCILLATING SHIFT

It is rare that the wind will shift continuously in one direction; it is far more likely that it will shift about a mean that is moving in one direction. The following graph shows this quite clearly:-

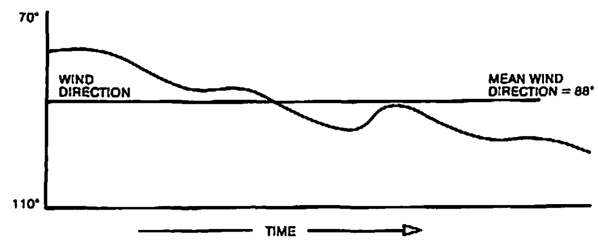


FIG. 15

Therefore if one is having to tack towards a mark during such a wind pattern, it will still pay to sail on the lifted tack, which will tend to bring one towards the next shift beating and vice versa when running. The difficulty comes in finding the layline accurately, as it is harder to calculate what the extent of the next oscillation will be.

SUBSIDIARY WIND PATTERNS

2.15 LAND AND SEA BREEZES

One cannot predict these major wind shifts from observing TWD and maintaining a plot, but only through local knowledge or weather lore. A typical example is Manila Bay. In the inshore races of the China Seas series, one can nearly set one's watch by the sea breeze coming in at 1300 hrs.

2.16 WIND SHEAR

This is not really a wind shift but causes all manner of heartache and bad language however well behaved and holy the crew! In essence there is a significantly different wind direction at the masthead to deck level. From a sail trimmer's point of view, it is probably best to attempt to twist the sail as required and for the helmsman to sail the yacht to the middle set of tell-tales. The tactician should note that in all probability the wind will fill in from the direction of the wind at the masthead. It is difficult to judge from instruments under these circumstances, but with intelligent observation one can still follow the wind trends.

2.17 VELOCITY SHIFTS

These are not really wind shifts at all but have some of their attributes, particularly for the unwary. Assuming one is beating and the wind dies, the AWA will come ahead so the helmsman bears away. The tactician on DUFFER calls 'header' and the helmsman tacks, as the yacht is slowing and wind dying. In the unlikely event that he has been watching compass courses, he will probably call for a further tack as his heading will be lower on the new tack than before. DUFFER will probably be virtually stopped at the back of the fleet by the end of this series of blunders. Meanwhile on 'HOTSHOT' the tactician will have been monitoring TWD and TWS and the helmsman will slowly bear off to achieve optimum Vmg, Target Boat Speed and % Performance (see Chapter III). (The extent to which the helmsman bears away will be limited to the increase in the correct TWA for the new TWS). If the lulls are only of a short duration the helmsman may be able to ghost through them at a very close AWA with his sails heavily lifted. He could well gain on Vmg.

CHAPTER III

YACHT PERFORMANCE DATA

3.1

To obtain the best from your yacht you need to know what is the best! Normally one has a reasonable idea of probable boat speed in most conditions, but without some reference it is all but impossible to know whether or not one is slightly off the pace. Maybe your sails have stretched just a touch or the underwater hull surface is not quite as it should be. The only way to determine this accurately is to have an absolutely reliable base line to work from.

3.2

There are three main aspects concerning yacht performance data, when related to an instrumentation system.

a: The crew need to know whether or not the yacht is sailing at its optimum performance.

b: The yacht's performance should be known for all sail combinations for all relevant sea and wind conditions.

c. Therefore there must be some means of holding and retrieving data concerning the yachts performance. This is done by the use of POLAR PERFORMANCE CURVES.

3.3 POLAR PERFORMANCE CURVES

These are graphical representations of boat speed graphs for all wind angles and a variety of wind speeds. A simple graph of Boatspeed (Vs) for a given True Wind Speed (TWS) (see para 2.6) against True Wind Angle (TWA) would look like this:

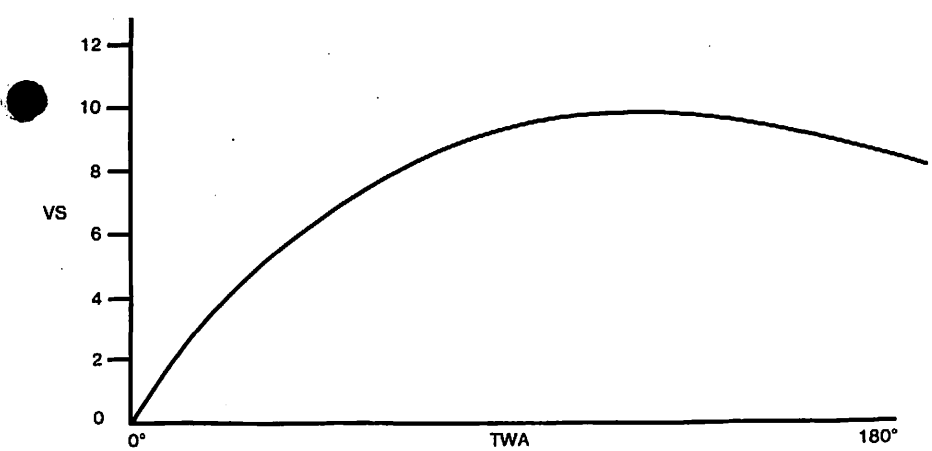
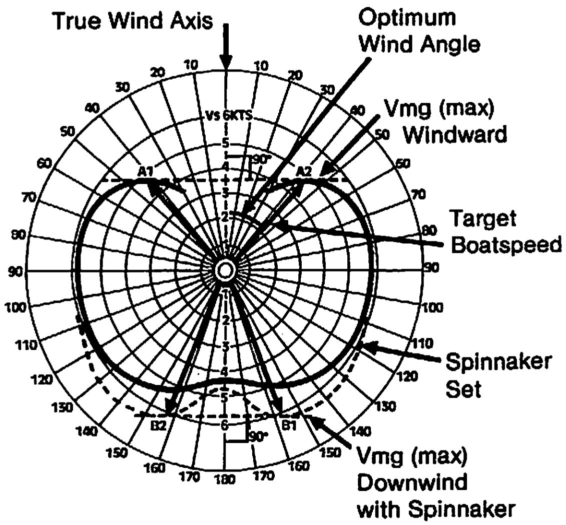
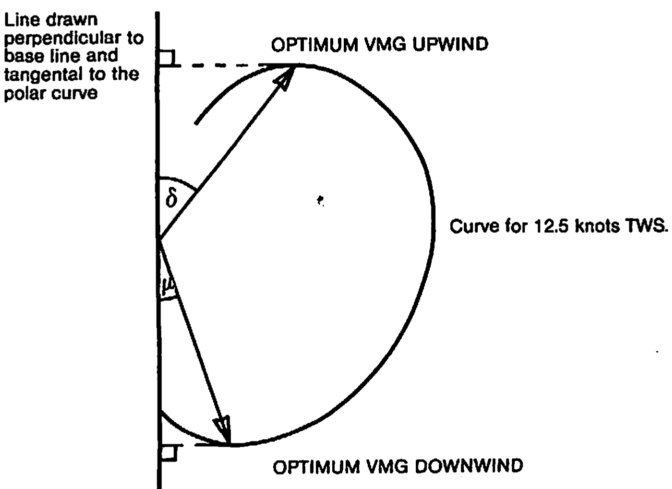


FIG. 16

One could add other curves for different wind speeds on the same graph but a more useful picture can be painted by transferring these graphs onto a set of polar performance curves, which would appear thus:



From Polar Performance Curves one can obtain a good overall view of the yacht's potential performance as well as Velocity Made Good (Vmg) data both upwind and downwind.



δ = Optimum VMG Angle Upwind
μ = " " " Downwind
Just as VMG will vary with TWS so will the VMG Angle.

FIG. 18

3.4 VMG

When one is either tacking or gybing towards a mark it is essential to know what speed one is making towards the mark, and in relation to the wind. The principles are the same in both cases.

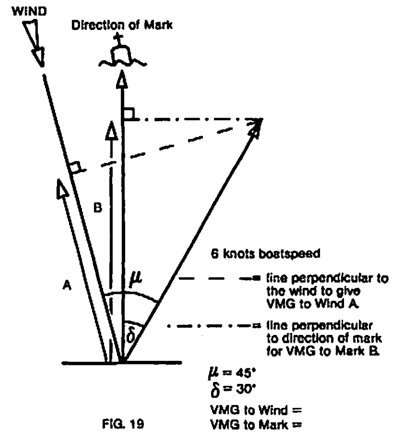


FIG. 19

One can determine whether or not it pays to head up when beating and sail more slowly or bear away and go more quickly, the converse being true when gybing downwind.

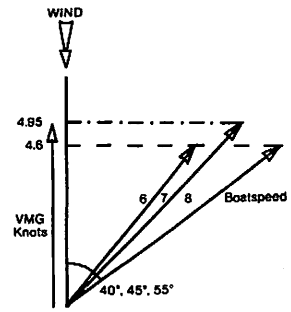


FIG. 20

NOTE: Dotted lines are at right angles to direction of mark/ wind & is tangential to the boat speed vector.

	Wind Angle to Mark (δ)	Boat Speed	Vmg
A	40 degrees	6	4.6
B	45 degrees	7	4.95
C	55 degrees	8	4.6

Vmg can be established graphically as above or mathematically by:

COS δ x Boat Speed.

To establish optimum Vmg upwind and downwind from a set of polar curves, for each wind speed draw a line at right angles from the base line tangential to the relevant curve, see figure 18.

3.5 ACQUIRING POLAR CURVES

There are three main ways of establishing polar curves:

a: **Velocity Prediction Program** (VPP) There are many of these about and the MHS handicapping system relies on such a system, but their accuracy can vary considerably. Your yacht's designer should be able to supply you with data from a VPP and it will either be in digital format or in the form of a set of polar curves. An example of the former is shown below:

UPWIND						DOWNWIND					
TWS Knots	BS	VMG	AWS	AWA	TWA	TWS Knots	BS	VMG	AWS	AWA	TWA
3	2.75	1.87	5.23	24.5	47.2	3	1.94	1.7	1.57	114	151
4	3.56	2.44	6.89	24.6	46.8	4	2.56	2.25	2.08	116	152.3
5	4.23	2.97	8.48	24.7	46.2	5	3.16	2.79	2.5	117	152
6	4.9	3.44	9.96	24.8	45.4	6	3.74	3.32	3.11	119	153
7	5.48	3.85	11.37	25	45.3	7	4.3	3.8	3.6	120	154
8	6.04	4.22	12.7	25.3	45.7	8	4.8	4.3	4.14	122.6	155
9	6.41	4.52	13.96	25.2	45	9	5.31	4.85	4.66	125	155
10	6.58	4.76	15.05	24.9	43.6	10	5.8	5.26	5.2	125.5	155
11	6.7	4.95	16.09	24.7	42.4	11	6.35	5.74	5.8	126	157
12	6.8	5.1	17.11	24.6	41.4	12	6.7	6.17	6.2	132	157
13	6.88	5.2	18.09	24.6	40.7	13	6.98	6.55	6.7	138	160
14	6.95	5.3	19.06	24.6	40.2	14	7.23	6.87	7.26	144	162
15	7.00	5.39	20	24.7	39.8	15	7.5	7.15	7.9	148	164
16	7.05	5.4	20.9	24.8	39.5	16	7.68	7.4	8.6	150	165
17	7.09	5.49	21.8	24.9	39.3	17	7.9	7.6	9.3	152	165
18	7.14	5.5	22.7	25.2	39.2	18	8.1	7.86	10	154	166
19	7.18	5.56	23.5	25.6	39.2	19	8.3	8.01	10.8	156	166
20	7.2	5.58	24.4	25.8	39.2	20	8.5	8.27	11.6	156	166
21	7.25	5.61	25.27	26	39.3	21	8.7	8.46	12.4	157	167
22	7.28	5.63	26.11	26.3	39.3	22	8.9	8.66	13.2	157	167

b: A more accurate system, but one which requires vast amounts of time, is to log manually the relevant performance data during sailing trials. The main problem associated with this method is, that as it takes so long, the information could be obsolete by the time the task is completed. (Normally the yacht has been sold or at least modified by this time.) A secondary difficulty is finding someone with the patience to do the task!

c: The third and by far the best means of acquiring an accurate set of performance figures is to log the data automatically by means of a computer.

This system has many advantages but the main ones are:-

(i) it is quick
(ii) it is accurate
(iii) the data can be automatically analysed
(iv) the data can be easily stored
(v) there is little or no hassle

3.6 HOW TO USE POLAR PERFORMANCE DATA

Having established a reliable base line for performance comparison in the form of polar performance curves, one has to have an easy means of accessing that data. The situation is complicated because boat speed is dependent not on one factor but two: wind speed and wind angle. (The latter is only of great significance when beating or running). When considering purely upwind or downwind sailing there are three ways of measuring performance.

a: **Percentages** The optimum Vmg upwind or downwind is calculated by the instrumentation system for the actual wind speed and is then compared with the actual Vmg values being achieved and is then presented as a % figure. This has the advantage that wind angle and wind speed are accounted for as well as boat speed and only one figure is required for display. However, it can be misleading if only short term values are considered; % performance figures should be viewed to gather trend information. Supposing the helmsman of the yacht DUFFER is achieving 7.5 knots of boatspeed upwind and then luffs another 5 degrees. The boat speed will be way above any predicted value for the new wind angle; hence the % performance figure will climb. But soon speed will decrease as the helmsman pitches beyond his optimum Vmg angle and the % performance figure will start dropping fast! If the helmsman then tries to rectify the matter by luffing, which apparently improved matters before, DUFFER will slip out of the back door of the fleet so fast it is not true. His % performance figures will climb slightly and then drop drastically and so on. If these figures were plotted during this race losing sequence they might look like this:

	% Performance Figure
Stage 1	100
Luff 5 degrees	100
New % figure	105
After Luff	110
	105
	100
	95
	90
Luff another 5 degrees	80
New % figure after luff	85
	80
	75
	65

b: **Target Boat Speed** To achieve an optimum Vmg figure there is a certain boat speed value which meets that criterian. When beating, if boat speed is above that value, then it can be supposed that one is footing off too much. Likewise if boatspeed is low it would appear that one is pinching too much. The converse is true when running – too much speed sailing too high; too little speed – sailing too low. Therefore one can attempt to match one's boatspeed to the target boatspeed for the relevant wind speed. The best way of doing this is to monitor Target Boat Speed alongside Optimum Wind Angle.

The Optimum Wind angle is derived the boat's polar performance data. It is given for both upwind and downwind sailing and represents the true wind angle at which maximum Vmg to the wind, is obtained. (see Fig. 18 and u). In practice the best way of displaying this is to show the difference between the boat's actual TWA and either δ or μ for up or downwind. So if the helmsman aims to sail with zero difference then the trimmers should react accordingly to achieve target boat speed.

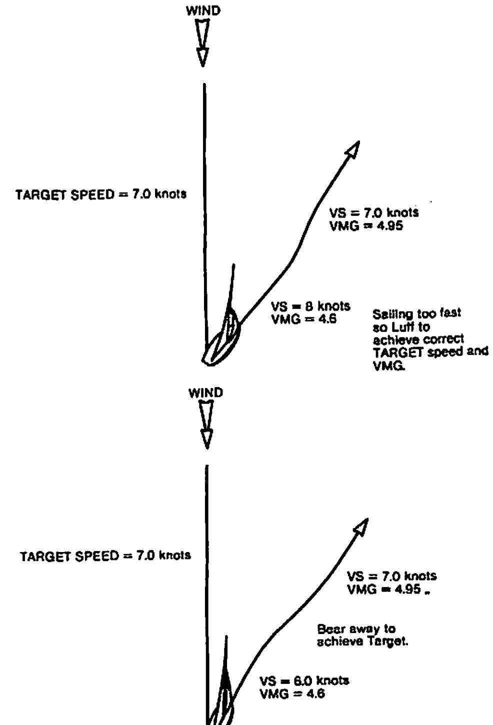


FIG. 21

For this concept to be effective there must be good communications between the helmsman and the trimmers. The following example demonstrates this:

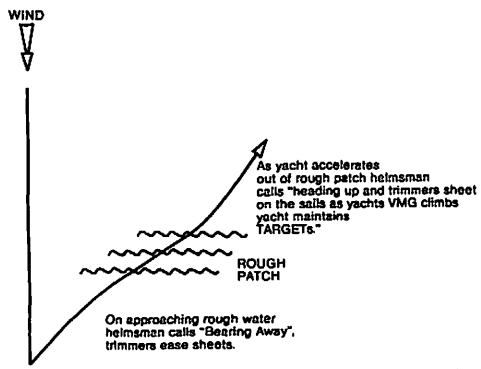


FIG. 22

As yacht accelerates in smooth water helmsman calls "heading up" and trimmers sheet on the sails and yachts Vmg improves.

Yacht maintains target speed. On approaching rough patch helmsman calls "bearing away", trimmers ease sheets.

Meanwhile on DUFFER somewhere at the back of the fleet, one of two things may have happened:

(1) The helmsman might not have born away to hold his speed through the rough patch and DUFFER loses a few more places as she takes so long to build up speed again after the rough patch.

(2) Alternatively there is no communication between helmsman and trimmers. The helmsman is sailing the yacht to the sails and the trimmers are trimming the sails to the helmsman. DISASTER!! Helmsman bears off a touch to power up the yacht and build speed. So the trimmers ease the sheets as they are trimming to the helmsman, who then bears away even further and so on until they are on a reach.

However, the greatest ships single problem with using Target Boat Speed in isolation, is that it relies on very high grade sail trimming and boat preparation. If these are not up to standard then the yacht will not reach its target speed at the optimum Vmg angle. If the helmsman sails at a less efficient angle to achieve the target speed, his Vmg may be worse than if he accepted a slightly reduced target speed but at the optimum wind angle.

3.7 USE OF POLARS AND NEXT LEG DATA

How many times have you rounded a mark and found that you have chosen the wrong sail combination? If one can predict with accuracy the Apparent Wind Angle (AWA) and Apparent Wind Speed (AWS) or True Wind Angle (TWA) for the next leg this problem will be greatly diminished. The only way that this prediction can be made is if one has accurate polar data. TWA is obviously easy to come by but tide has to be considered. If there is a cross tide component, one's course on the next leg will be correspondingly affected.

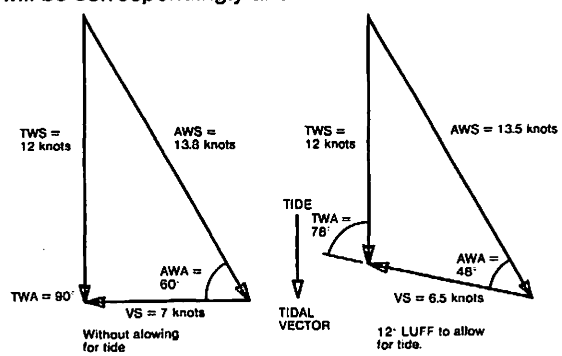


FIG. 23

The diagram demonstrates this. If the polar information shows that on a beam reach with a TWA of 90 degrees your yacht will do 7.0 knots in 12 knots of wind, and one can carry a spinnaker (see para 3.8 for Sail Performance Chart). However, when you allow for the tide and luff by 12 degrees there is no way you can carry a chute. The AWA will have gone from 60 degrees to 48 degrees, AWS from 13.8 knots as the polar tables show a drop in boat speed to 6.5 knots AWA and AWS can be established graphically or calculated. (see para 2.7).

The need to predict the choice of sail highlights the importance of accurate sail performance charts.

3.8 SAIL PERFORMANCE CHARTS

A refinement in achieving polar performance data is to include sail and sail combination information. The data is gathered in exactly the same way as in normal performance monitoring but is repeated for all relevant sail combinations. Eventually a picture such as this will be produced for as many different wind strengths as are practical.

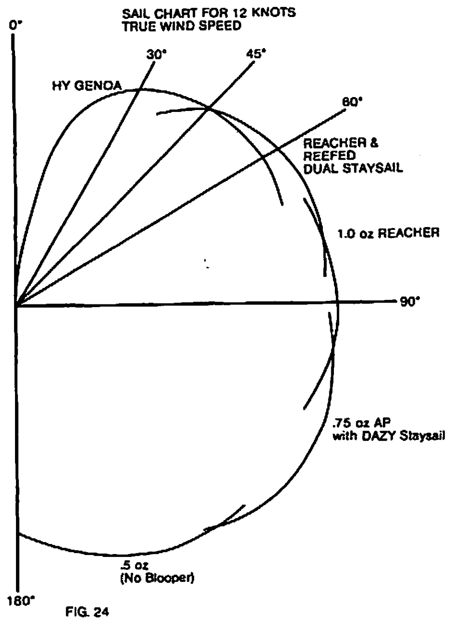


FIG. 24

It can be seen very clearly when it pays to hoist the spinnaker or blooper and this applies just as much on an existing leg of a course to decide on a sail change as it does in predicting sail selection for the next leg.

CHAPTER IV

4.1 INTRODUCTION

A yacht's instrumentation system must be able to provide timely and accurate information in an easily read and understandable form. However, modern systems can provide so much information that the crew can be swamped and not see the wood for the trees. Therefore it is vital that only the relevant data is presented to the correct crew members and that one person is not saturated with too much information.

4.2 CREW TASKS AND INSTRUMENT OUTPUTS

It is only on such yachts as DUFFER that the helmsman gazes in awe and wonderment on an instrument panel that would do justice to Concorde. In between looking at True Wind Speed, True Wind Angle, Depth, Boat Speed and a few other pieces of information varying from Battery Voltage to Forestay Loadcell Tension, he actually tries to steer the yacht! On HOTSHOT are properly divided as is the information displayed on the various instruments.

4.3 HELMSMAN'S REQUIREMENTS

Every helmsman has his own ideas on what is required and no hard and fast rules can be made. However, as a guide a helmsman should be satisfied by one of the following options or a combination of them:

a: Boat Speed
Wind Angle (True or Apparent).

b: Vmg
Wind Angle (True or Apparent).

c: Boat Speed
% Performance/Target Boat Speed (and Angle).

The displays should be sited such that he does not have to move his eyes far from the all important view ahead of the waves and the sails. Nor should it be necessary to re-focus his eyes from steering to looking at the instruments. This is of course essential for the helmsman who has to wear bi-focals. Another perennial problem is where to site the instruments so that the crew are not blocking them. This is made doubly difficult because the helmsman will be steering from the side when beating but, with a wheel rather than a tiller, he will be steering from the centre line when running.

4.4 SAIL TRIMMERS

The trimmers have virtually the same needs as the helmsman though the spinnaker trimmer needs special consideration. It is almost certain that he will for much of the time be trimming, when standing on the weather deck amidships.

4.5 TACTICIAN

He has by far the most varied requirements as he needs navigational information, wind data and in some instances boat performance data. When beating or running he will in all probability need the following:

The yacht's relationship to the layline.

The yacht's Vmg to the mark.

a: True Wind Direction.

b: Tidal information.

c: Depth of water.

d: Yacht's position (its relationship to the next mark).

4.6
For the Tactician to have this information without having to do any further calculations, it is necessarey for the yacht's sailing instruments and navigational systems (such as Decca or Loran) to be integrated. Such a system should have the facility to monitor and display tidal or current conditions.

4.7 NAVIGATOR
In many instances he will be the same person as the tactician and will require the same information but with a somewhat different emphasis. But, if the roles are separated, his prime task will probably tend towards meterology and presenting to the tactician/skipper the pros and cons of various tactical options. In the modern day and age the yacht's actual position should be available instantly and accurately. However, it is a foolish person who relies totally on just one navigational system such as Decca, Loran or SatNav. Therefore the yacht's sailing system should provide good and reliable fall back options, the most important features being a log and preferably a built in DR function.

4.8 INSTRUMENT DISPLAYS
There are currently two prime means of displaying information on yachting instrument systems:

a: Digital

b: Analogue

They each have their place and purpose and in some cases displays have been produced trying to combine them. However, there can be no doubt that where accuracy is required digital displays are the better, but where just a general trend is required, the movement of an anlogue needle is the best. One overriding advantage of the digital system is that many different functions can be displayed from the same instrument as and when required.

4.9 LEGIBILITY
Whichever type is used they will need to have clear and unambiguous output with, for night use, an adjustable means of illumination. The needle on an analogue display has to be of the correct size so that it does not blank out the figures on the dial, which also have to be clearly defined. The figures on a digital display have to be as large as possible and it is very helpful to have some easily understandable prefix/suffix so that for instance the user knows whether he is looking at 7.5 ft depth or 7.5 knots of Boat Speed.

4.10 20/20 DISPLAYS
Recently there have come on the market large digital repeaters which are primarily designed to be mounted on the mast just below the boom. They are absolutely invaluable in terms of readability and in cutting down duplication of on-deck displays as so many of the crew can see them from different parts of the boat

(e.g. the spinnaker trimmer and helmsman). There is a further davantage with such displays in that as more crew can see performance parameters they can take a more continuous interest in the sailing of the yacht. They will be an added spur to the trimmers and helmsman in achieving good boat speed.

4.11 GRAPHICS
A picture tells a thousand words or so they say and, in due course, graphic displays will become common place on yachts. At present they are largely limited to separate computer systems. They will be particularly valuable in displaying such data as wind trends and layline information.

4.12 CONFIGURATION
However careful the yacht designer or owner, it is almost certain that the requirements for a particular yacht will change in terms of the overall instrumentation package. Therefore any system should provide flexibility. A digital instrument should be capable of being added to without making any other equipment redundant. Moreover when some new device becomes available such as GPS it should be able to interface with the yacht's instruments.

Interfacing between two or more electronic systems on board a yacht is becoming more and more commonplace. The idea being is to create a completely integrated information network around the boat. Typically a Decca, Loran or Satnav may be interfaced to the sailing instruments to give instant on-deck information to the Navigator/Tactician regarding for instance bearing and distance to the next mark, course and speed over ground or cross track error, particularly relevant when sailing an offwind leg.

In addition vital information like tidal set and drift can be calculated and displayed on deck since a direct comparison between course and speed over ground and course and speed over water can be made.

Apart from keeping the navigator in touch with current tidal conditions, adjustments can be made in the next leg calculations to compensate for tide so more accurate decisions on sail selection are possible.

Sailing instruments can also be interfaced with Satnavs in particular to provide vital log and compass heading information for the Satnav's dead reckoning requirements.

4.13 CALIBRATION
The yacht's instruments are only as good as its accuracy and to a very large extent depends on the ease of calibration. If one needs a computer science degree to calibrate the system or dismantle the equipment to do so, then the chance of the job being done are unlikely, let alone the chance that calibration will be checked. Calibration should be done by 'Software' and not require tricky and inaccurate mechanical adjustments. Trying to align a masthead unit accurately is well nigh impossible. Similarly, unless the actual sensor has to be replaced then the system should not require calibration; the old values should be simply keyed in again.