Span

Windows Version 11.1

User Manual

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Contents

About this Manual

This manual describes Span, an application which may be used to predict the sailing performance of yachts designed using Maxsurf. The manual is organised into three chapters.

Chapter 1 Introduction
Contains a description of Span, its use and its interaction with Maxsurf designs.

Chapter 2 Using Span
Explains how to use Span's performance prediction VPP to best advantage.

Chapter 3 Span Reference
Gives details of each of Span 's windows, toolbars and menu commands.

Chapter 4 Theoretical Reference
Contains a list of key words and abbreviations used in this manual and provides a literature list for the interested reader.

Chapter 1 Introduction

SPAN (**S**ailing **P**erformance **An**alysis) is a program for predicting the performance of sailing yachts in a variety of wind conditions. Based on the published algorithms for the IMS Velocity Performance Prediction Program, SPAN solves the equations for lift and drag for hull and rig and finds an equilibrium velocity and angle of heel.

Integrated into SPAN is a hull form measuring module that performs the function of the IMS Lines Processing Program (LPP). This allows the designer to read in a Maxsurf design and automatically perform the measurements required for input into the performance analysis. Alternatively measurements may be input directly from an IMS certificate although only a small number of key values are required.

Once a hull and rig have been fully specified the designer may calculate an entire table of performance values from 6 knots through to 20 knots true wind speed. A variety of true wind angles are used and performance is calculated with both spinnaker up and spinnaker down.

The output from SPAN is in the form of a table of values for each wind strength and wind direction with results given for apparent wind direction and apparent wind strength, hull velocity, VMG, heel angle and the various lift and drag forces involved. Velocity data can also be viewed in the form of performance polar curves.

In general the results from SPAN are very close to those produced by the current IMS VPP. The speeds predicted by SPAN tend to be more conservative than those predicted by IMS, usually by approximately 0.1 knot, however the shape of the polar curves produced by both programs tend to be very similar.

SPAN provides a valuable tool to the yacht designer, both for the estimation of performance during the design process, as well as the ability to produce polar curves of performance for the yacht owner once the design is launched.

Chapter 2 Using Span

You have been introduced to the way in which Span works and can now go on to learn in detail how to use Span by following the example outlined in this chapter.

The example uses measurements from a simple yacht hull form (‘SPAN sample.spd’). The corresponding Maxsurf design file is also supplied (‘SPAN sample IOR Yacht.msd’). These files may be found in the ‘Sample Designs’ folder.

The following example goes through the steps needed to generate a polar performance curve.

Getting Started

Installing SPAN

Install Span from the CD. Span may then be started and will display seven windows containing: Polar performance graph; Results table; Upright resistance graph; and four views of the current design (if any). These are: Perspective, Plan, Profile and Body Plan.

Opening a Measurement File

Choose Open Measurement Data from the File menu. Select the file titled ‘SPAN sample’ and open it. This file contains the hull and rig measurement data for a simple yacht hull form. When it is read in, the data may be modified if necessary.

Entering Data

The data to be entered is the measurement data of an IMS certificate. The following data is required:

- **Hull Data**
- **Rig Data**
- **Mizzen Data**
- **Wind Data**

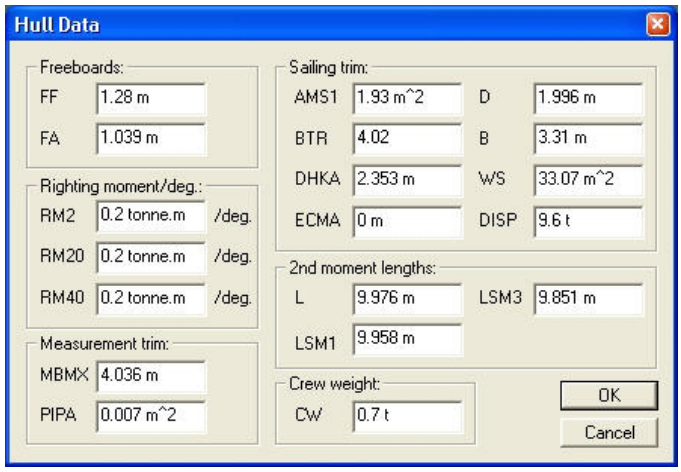
The data is entered by selecting the appropriate dialog from the Data menu:

Note:

If you are entering data from an existing IMS certificate, you will notice that not all the measurements listed on the IMS certificate are required, SPAN only needs the essential data.

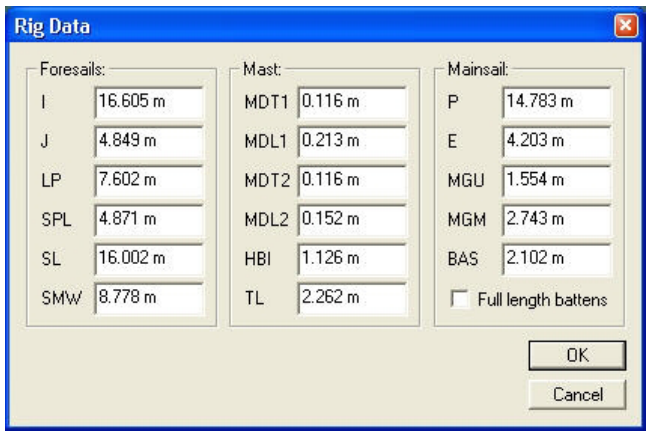
Hull Data

In the following sections we will show you how to enter the hull data manually. However in most cases, it is much simpler to have the data measured from a Maxsurf design, this is described in the Measuring a Maxsurf Design section below.



See Hull Measurement Definitions on page 26 for explanation of terms

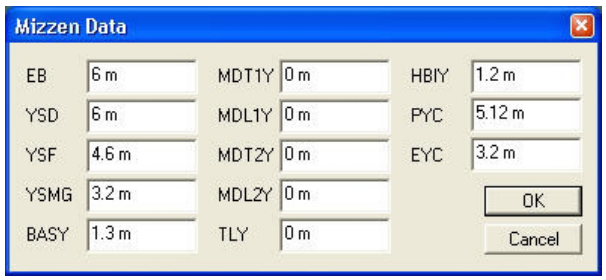
Rig Data



Also see

Rig Measurement Definitions on page 28 for explanation of terms
Figure 1, Rig data parameters on page 28

Mizzen Data



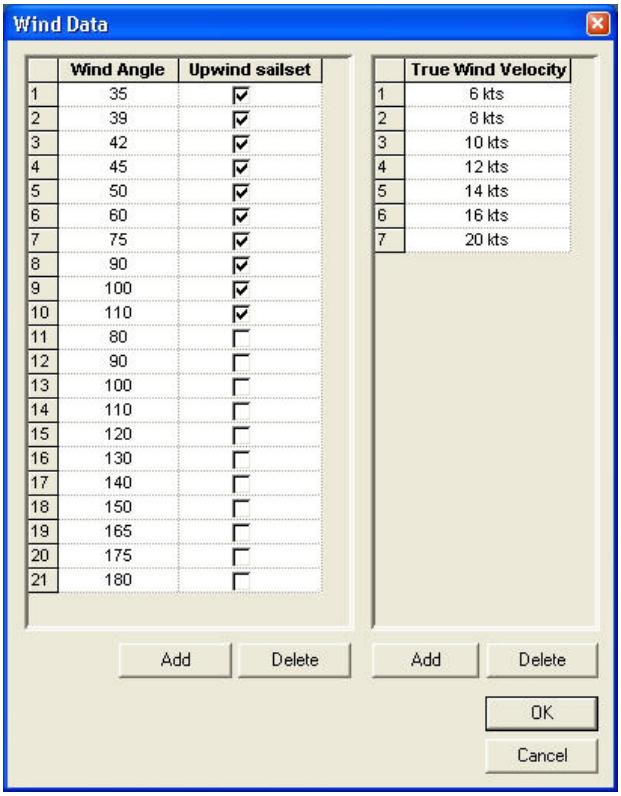
NOTE:

Y character denotes a mizzen measurement.

Also see

Rig Measurement Definitions on page 28 for explanation of terms
Figure 1, Rig data parameters on page 28

Wind Data



The Wind Data dialog is used to define the wind conditions for which you wish to calculate the performance data. The default values of the dialog are set to those of the IMS VPP.

A maximum of 7 wind velocities may be defined. Two sets of true wind angles may be defined. The first is the wind angles for which the upwind sail set will be used, and the second the wind angles for which the downwind sail set will be used. Wind angles must have a minium spacing of 3 degrees. Upwind sailing angles may be defined from 35 degrees to 110 degrees and downwind sailing angles may be defined in the range of 80 degrees to 180 degrees.

Rig sketch

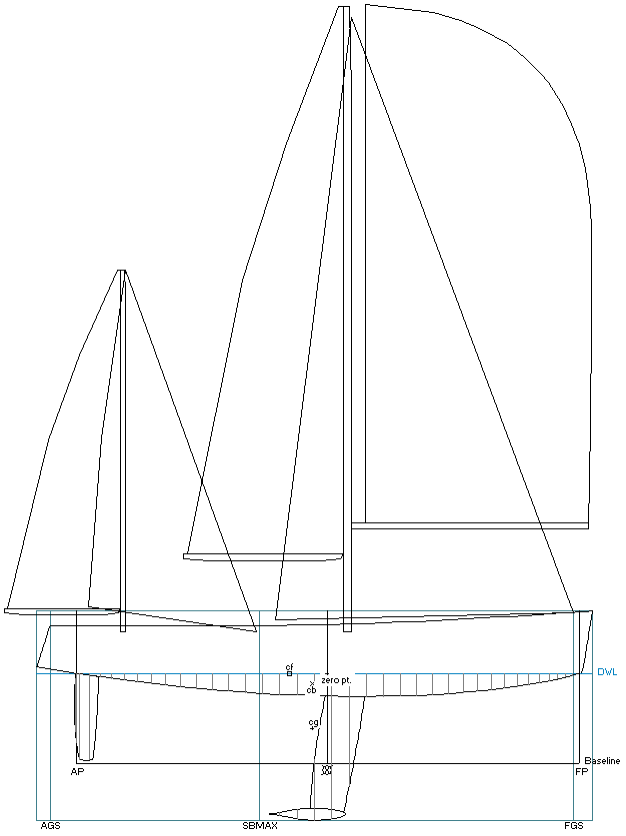
If a Maxsurf model has been loaded, then a sketch of the rig will also be displayed once the rig parameters have been entered.

SPAN produces a graphical representation of the rig data as specified in the Rig and Mizzen dialogs. This provides useful visual feedback of the rig parameters specified.

You can display the rig sketch using the  -button on the display toolbar.

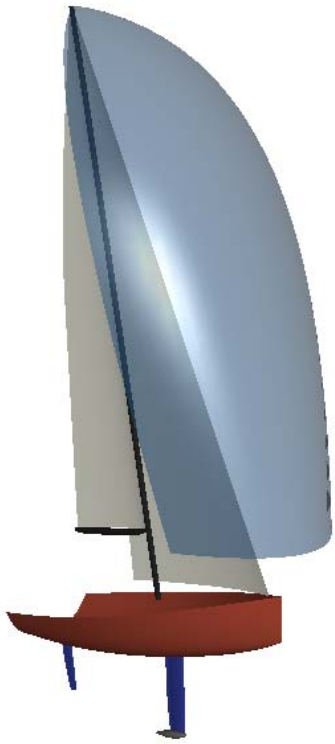
Profile view

The colour of the rig sketch can be set in the colour dialog from the view menu, by editing the label colour.



Perspective view

The rendering toolbar can be used to switch rendering on/off and adjust light-settings. See the Maxsurf manual for more information.



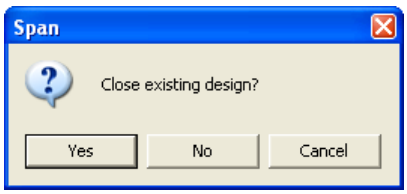
Measurement File

Saving a Measurement File

Once you have entered the required data it is a good idea to save your work. This may be done by selecting Save Measurement Data from the File menu. This will overwrite the original file. If you wish to save the new data with a new file name select Save Measurement Data As… from the File menu and type in a new file name.

Opening a Measurement File

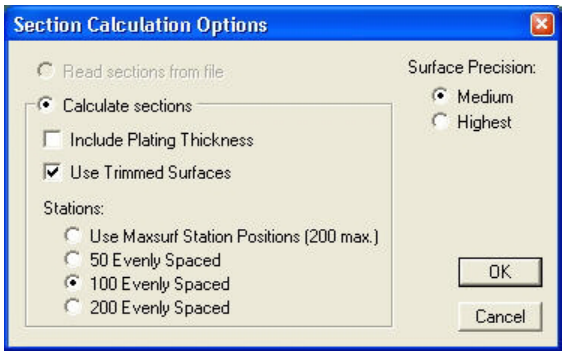
Once you have saved measurement .data, these may be read back into SPAN using the File | Open command. This will read in the rig (and mizzen data), if you do not have a Maxsurf file open in SPAN, the hull data will also be read in automatically. If, however, you have a Maxsurf file open in SPAN, you will be asked if you want to close the design. If you choose "yes", the hull data will be loaded (as well as the rig data) and the Maxsurf file closed; if you choose "no" the hull data will *not* be loaded from the file and you will be left with the original hull measurements. This is to facilitate analysis of the same hull with different sail sets, or to preform analysis on a hullform which has been modified.



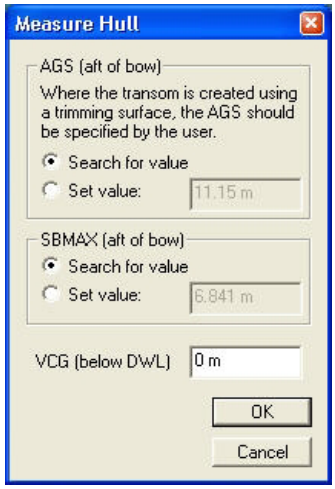
Prompt when opening a SPAN data file (.spd) when a Maxsurf design is already open

Measuring a Maxsurf Design

If you wish to measure a Maxsurf design, select Open Design from the File menu, and select a design. You will be presented with a dialog to read or calculate the hull sections. If the design has been used in Hydromax, the sections may have already been calculated and may be read from the file, if not they must be calculated; refer to the Hydromax Manual, section: Opening a New Design, for further details.



Once the design has been read in and the sections calculated, Span will measure the hull to find the data required for the VPP. You will be asked whether you wish Span to search for the values of AGS and SBMAX (See Hull parameters on page 26 in the Nomenclature for meanings) or you specify these values at this point. (This may be useful if the design is an IOR type, however this is not essential.) Span also requires the position of the VCG - this is important as it affects the calculation of righting moments for the design and therefore the hull's stiffness. Note that AGS and SBMAX are measured aft of the bow, and VCG is measured below the DWL, positive down.



SPAN will now measure your design, floating it to several different heel and trim conditions. Once the measurement is complete you will need to enter values for the rig via the Rig Data dialog, unless they have been loaded from a previous Span Measurement file; loading a. Span Measurement file will overwrite all data, measuring a Maxsurf design will only overwrite the hull data.

The hull data may be re-measured at any time by selecting Measure Hull from the Data menu.

Note On Hull Input Parameters

Almost all the hull input parameters used by SPAN are derived from a number of hydrostatic calculations with the hull in several conditions and various weighted integral quantities. These parameters are not simple linear measurements which can be taken directly from a lines plan. These data can be obtained by using SPAN to measure a Maxsurf design file which includes hull and appendages or from the IMS LPP program or IMS measurement certificate.

Note Hull measurements which must be entered manually

There are several hull parameters that SPAN is unable to measure from the hull model and which must be entered manually (these are not reset when the hull is measured):

PIPA Propeller installation projected area

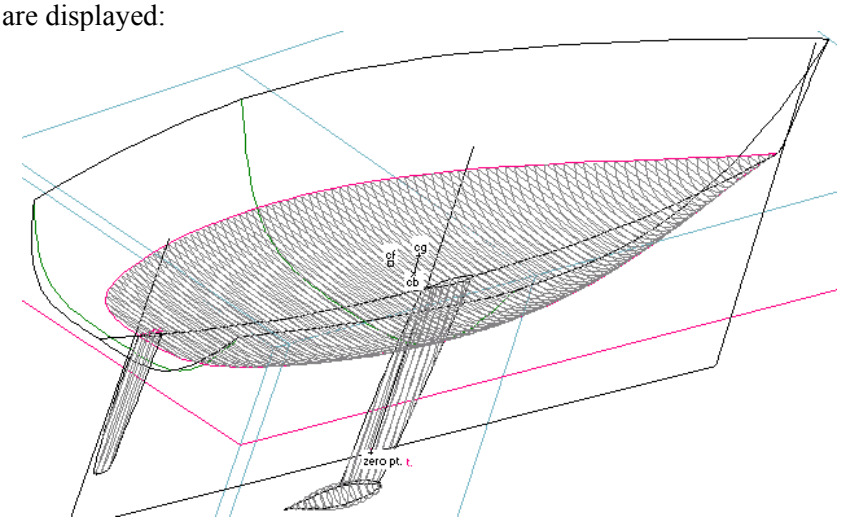
ECMA The vertical difference between board up and board down draft.

Also see

Hull parameters on page 26

Checking the SPAN model

Check that the sections have been formed correctly by viewing the design in the Perspective view with the sections turned on. The immersed sections as well as the girth stations are displayed:



Important notes on SPAN Hull measuring

Since SPAN can automatically calculate the IMS measurement data directly from the Maxsurf surface model, it is important to understand the following:

SPAN's automatic identification of the hull surface

SPAN assumes that the longest surface in the design is the hull surface, and uses this surface to determine the fore and aft girth stations (FGS, AGS), the freeboards at these stations (FF, FA), the station of maximum beam (SBMAX) and the beam at this station (B). If the longest surface in your design is not the main hull, you will need to save a copy of your design for use with SPAN and remove any longer surfaces from the design before reading it into SPAN; you must also ensure that the main hull is made up of only one surface. Alternatively, you can specify the AGS, SBMAX positions and FF, FA and B yourself. (See also note on trimmed surfaces below)

Appendages

It is essential that the Maxsurf design being measured has appendages. If no keel is included the hull data will not produce reasonable values. It is also essential that the appendages fulfil the analysis requirements of Hydromax in that they should form topologically closed surfaces; i.e. they should not have open tips or open trailing edges.

Trimmed surfaces in Maxsurf

The untrimmed hull surface is used to find AGS, FF, FA, SBMAX and B, so it may be necessary to specify these yourself if you are using a trimming transom and/or deck surface. (See also note on appendages above)

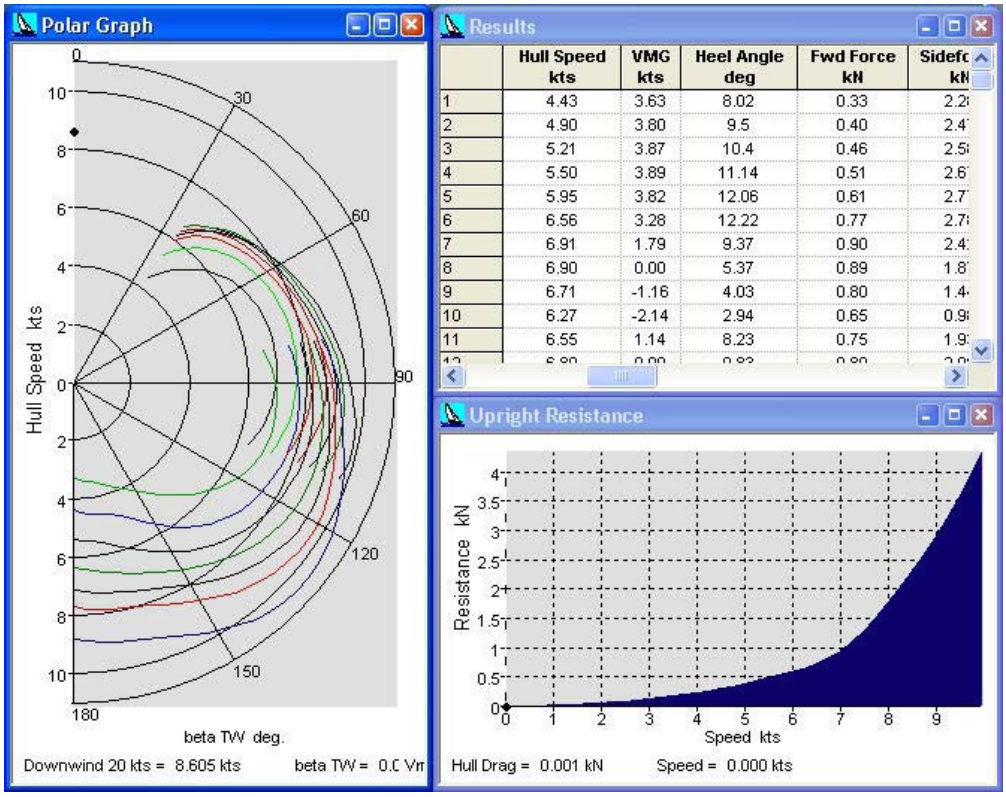
Accuracy

The VPP results can be quite sensitive to hull measurements, so you should use 200 measurement stations under most circumstances. This is especially true if you have a keel bulb.

Calculating Performance Data

Once all values have been entered, you are ready to proceed with the calculation of performance data. Select Solve Multiple Angles from the Solve menu. Span will calculate the performance values for the yacht and display the results in the Results table and graphs.

Span will calculate performance for a range of courses at wind strengths of 6,8,10,12,14,16 & 20 knots with the spinnaker up and down.



The data shown in any window can be printed using the Page setup and Print commands from the File menu. Similarly, data from any window can be copied into the clipboard and pasted into other applications.

Results Table

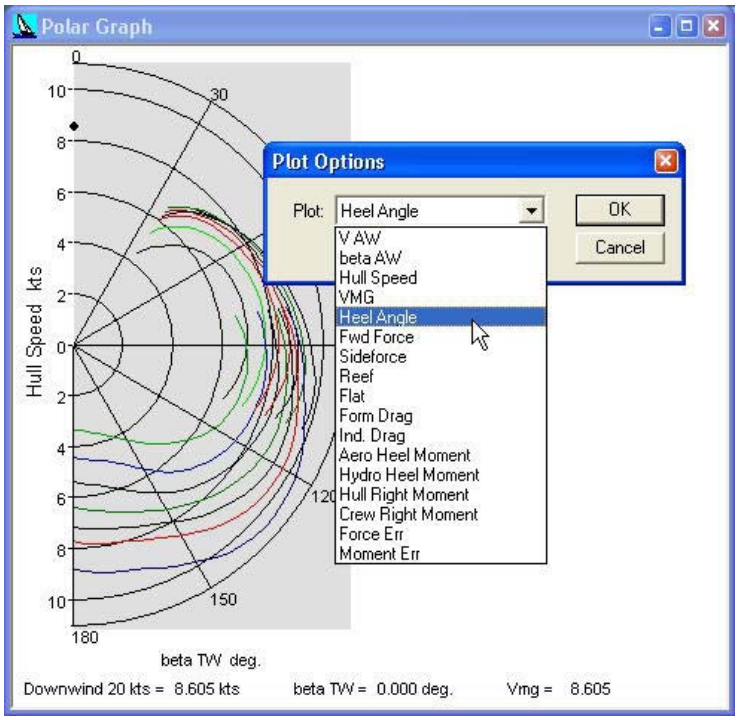
The Results table contains the numerical values of the data plotted in the Polar Graph. Additional data are also included:

See Results Data Definitions in the Nomenclature on page 29 for an explanation of the terms and abbreviations used in the results table.

Polar Graph

The results may also be presented in a polar graph form. This plots the speed of the yacht against the course for different true wind strengths and sail combinations (spinnaker up or down). The yacht velocity is represented by a vector from the centre of the graph.

Polar Plots of all results data are possible, use the Display | Plot Options dialog to select the data to be plotted. (Note that the graphs are only smoothed where it is sensible to do so.)



Upright Resistance Graph

The curve of upright resistance of the hull, as predicted by Span can be viewed in the Upright Resistance window. This does not include the induced resistance due to the appendages generating sideforce.

Chapter 3 Span Reference

This chapter describes the windows, toolbars and menu commands available in Span.

Windows

Span uses a range of windows.

Results/ Performance Data Window

The Results/Performance Data window display's a table with the results of the analysis, including: apparent wind speed and direction, hull speed, VMG, heel angle etc.

Polar Graph Window

The Polar Graph window display's a polar performance graph of yacht speed versus wind direction for the different speeds tested.

Upright Resistance Window

The Upright Resistance window display's a graph of the upright hull resistance against hull speed.

Toolbars

Users of the Windows version of Span can use the icons on the toolbars to speed up access to some commonly used functions. You can hold your mouse over an icon to reveal a pop-up tip of what the icon does.

File Toolbar

The File toolbar contains icons, which execute the following commands:
New Data – Open Design – Save Data | Cut - Copy - Paste | Print Preview

View Toolbar

The View toolbar contains icons, which execute the following commands:
Zoom – Shrink – Pan – Home View

Contour Toolbar

The Contours toolbar contains icons, which facilitate the display of surface contours:
Sections – Waterlines – Buttocks – Intersections – Edges

Window Toolbar

The Window toolbar contains icons, which make the corresponding window come to the front:
Perspective – Plan – Profile – Body Plan – Data Window – Results Window – Graph Window

Menus

Span uses the standard set of menu commands for File, Edit and Window operations. It also has a range of menus for inputting the design data, completing the analysis, and control of data and view displays.

File Menu

The File menu contains commands for opening and saving files, and printing.

Open Design

Span can measure a Maxsurf design to determine the hull parameters necessary for the VPP calculations. Select Open Design to open an existing Maxsurf design.

Close Design

Select Close Design when you wish to finish with the current Maxsurf design.

New Measurement Data

Selecting New Measurement Data will delete the existing hull and rig data from memory. New data may then be entered manually, loaded from a file or measured from a Maxsurf design file.

Open Measurement Data

Span has the ability to save measurement data to disk and recall them at a later date. By selecting Open Measurement Data, a dialog box appears with a list of available Span data files. Select the data file you wish to recall, click the Open button, and the requested data file will be opened. In Windows, the Span data files are given the extension '.spd'.

Save Measurement Data

Selecting Save Measurement Data will save the current set of Span measurements to disk.

Save Measurement Data As

Selecting Save Measurement Data As enables you to save the current set of Span measurement under a new name. This is useful if you modify the data, but wish to keep a copy of the old version as well as the new.

Page Setup

The Page Setup dialog allows you to change page size and orientation for printing.

Print

Choosing the Print function prints out the contents of the uppermost Span window.

Recent File

Opens the last file open in Span.

Exit

Exit will close down Span and return you to the Desktop. If Span has a set of markers or a surface open that has not been saved to disk, you will be asked whether you wish them to be saved.

Edit Menu

The Edit menu contains commands for working in the Results window. In addition, graphs or design views may be copied to the clipboard

Undo

Undo may not be used is Span at this point.

Cut

Cut may not be used in Span at this point.

Copy

Copy may be used to copy data from the Results table. It may also be used to copy the contents of one of the view windows or graph windows into a picture or metafile, which may then be pasted into other programs.

Paste

Paste may not be used in Span at this point.

View Menu

The View menu contains commands for changing the way in which the drawing and data windows are displayed.

Zoom

The Zoom function allows you to examine the contents of the Perspective, Plan, Body Plan or Profile window in detail by enlarging any particular area to fill the screen.

Shrink

Choosing Shrink will reduce the size of the displayed image in the front window by a factor of two.

Pan

Choosing Pan allows you to move the image around within the front window.

Home View

Choosing Home View will set the image back to its Home View size. Span starts up with default Home View settings for the view window. However, the Home View may be set at any time by choosing the Set Home View function.

Set Home View

Choosing Set Home View allows you to set the Home View in the View window.

To set the Home View, use Zoom, Shrink, and Pan to arrange the view as you require, then select Set Home View from the View menu.

Colour

The Colour function allows you to set the colour of lines and controls displayed in the view windows. The colours used in the graphs may also be changed. Changes to the default colours will be saved in the program's preferences.

Span will display a list of items that allows you to set any of the items to any colour and intensity by using a colour pallet.

To set the colour of a given line or set of lines:

- **Select Colour from the View menu.**
- **Select the line type from the scrollable list.**
- **Select a colour from the colour picker.**

Font

Font allows you to set the size and style of text used in the windows.

Toolbars

Allows you to select which toolbars are visible, see Toolbar section for more details.

Status Bar

The Status Bar command makes the Status Bar at the bottom of the screen visible. This Status Bar displays information about the current state of what is being viewed in the window, short descriptions of the functions of some commands as your mouse passes over them and indicates the state of some control keys.

Solve Menu

The solve menu is used to solve the VPP for the predefined range of true wind speeds and heading angles.

Solve Multiple Angles

Selecting Solve Multiple Angles sets Span to work solving the VPP for the predefined true wind speeds and course angles. These are as follows:

True wind speed:	6, 8, 10, 12, 14, 16, 20 kts.
True course (upwind, spinnaker down):	35, 39, 42, 45, 50, 60, 75, 90, 100, 110˚
True course (downwind, spinnaker up):	80, 90, 100, 110, 120, 130, 140, 150, 165, 175, 180˚

Display Menu

The Display menu contains commands for turning on and off items displayed in the graphics windows.

Plot Options

The Plot Options dialog allows you to select which data are plotted on the polar graph.

Contours

The Contours option allows you to select which contours are drawn on the screen at any given time. Any combination of contours may be chosen from the contours dialog.

See Maxsurf manual for further details.

Data Menu

The Data menu contains commands for setting the hull and rig parameters used in the VPP.

Hull Data

Use this menu item to open a dialog which will allow you to enter (or edit) the data which defines the hull. The nomenclature used is that of the IMS.

Rig Data

Use this menu item to open a dialog which will allow you to enter (or edit) the data which defines the main rig: mainsail and jib. The nomenclature used is that of the IMS.

Mizzen Data

Use this menu item to open a dialog which will allow you to enter (or edit) the data which defines the mizzen sail. The nomenclature used is that of the IMS.

Wind Data

Use this menu item to open a dialog which will allow you to enter (or edit) the data which defines the wind conditions for which you wish to calculate the performance data. The default values are set to those of the IMS VPP.

A maximum of 7 wind velocities may be defined. Two sets of true wind angles may be defined. The first is the wind angles for which the upwind sail set will be used, and the second the wind angles for which the downwind sail set will be used. Wind angles must have a minium spacing of 3 degrees. Upwind sailing angles may be defined from 35 degrees to 110 degrees and downwind sailing angles may be defined in the range of 80 degrees to 180 degrees.

Units

A variety of metric and imperial units may be used in Span. This command gives you a dialog box where you may choose your preferred units.

Irrespective of the default units specified the Markers window will accept dimensional data in any units. For Example, if the default units were metres, all of the following input would be accepted and converted accordingly:

3 (interprets as 3.00 metres)	
2.5c	3.25"
33cm	4 inches
328mm	5'4"
650.44mil	11.25feet
6ft 3.1in	5f5I

Measure Hull

Selecting Generate Measure Hull instructs Span to calculate the necessary measurements form the Maxsurf design file. A dialog is presented, and the user may specify AGS and SBMAX or ask Span to search for these values. In addition, the VCG must also be specified.

Window Menu

Selecting item in the Window menu brings the appropriate window to the front on the screen.

Cascade

This function stacks up all the currently visible windows into the bounds of the screen in a staggered arrangement.

Tile Horizontal

Tiles the open windows horizontally within the application window.

Tile Vertical

Tiles the open windows vertically within the application window.

Arrange Icons

Arranges the closed windows within the application window.

Perspective

A perspective view of the hull.

Plan

A plan view of the hull.

Profile

A profile view of the hull.

Body Plan

A body plan view of the hull.

Results / Performance Data

Display's a table with the results of the analysis including: apparent wind speed and direction, hull speed, VMG, heel angle etc.

Polar Graph

Display's a polar performance graph of yacht speed versus wind direction for the different speeds tested.

Upright Resistance

Display's a graph of the upright hull resistance against hull speed.

Help Menu

Provides access to Span Help.

Span Help

Launches the Span manual.

About Span

Displays information about the current version of Span you are using.

Chapter 4 Theoretical Reference

This chapter contains a list of key words and abbreviations used in this manual and provides a literature list for the interested reader.

Nomenclature

This nomenclature describes the key words and abbreviations used in this manual.

IMS

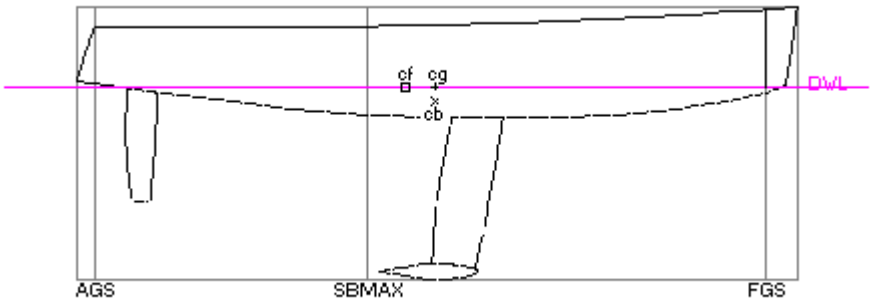
International Measurement System.

VPP

Velocity Prediction Program. A computer program which (normally) balances the sail thrust against the hull drag; the sail sideforce against the appendage sideforce and the heeling moment against the hull and crew righting moment in order to predict the yacht speed for a given true wind speed and course. These results are normally presented in a series of polar graphs.

Hull Measurement Definitions

Span uses the IMS nomenclature for its measurements. All measurements are taken from the position of the headstay base, which IMS assumes to be at the FGS position.



For a more detailed discussion of the hull parameters calculated by SPAN, interested readers are referred to: *(A)IMS – an Almost Ideal Measurement System*, by David Pedrick, presented at Yacht Vision '94, Auckland, New Zealand, 16-20 Feb. 1994.

Back to Entering Data

Hull parameters

AGS	Aft girth station
DWL	Design waterline
FGS	Forward girth station
SBMAX	Longitudinal position of maximum hull beam.
VCG	Vertical centre of gravity

Freeboards

FFM	Freeboard (Vertical distance from the water to the sheerline) at the forward freeboard measurement station.
FAM	Freeboard at the aft freeboard measurement station.

Righting Moments per Degree

Righting Moments per degree RM2 / RM20 / RM40	Righting moment at heel angles of 2, 20 and 40 degrees divided by the heel angle in degrees.

Measurement Trim

MBMX	Maximum beam at shearline
PIPA	Propeller Installation Projection Area represents the equivalent flat plate area of the prop installation used to calculate its drag at various speeds.

Sailing Trim

AMS1	Depth attenuated maximum sectional area. Used to calculate the effect of the hull on the keels ability to generate lift.
BTR	An adjusted beam to depth ratio. A measure of the fineness of the hull which has an effect on added resistance due to heeling.
DHKA	Loaded draft; somewhat deeper than measurement draft.
ECMA	The vertical difference between board up and board down draft.
D	The draft adjusted for hull / keel interaction and end-plate effects and derived from B, below.
B	An integrated value of hull width, using a "second moment" approach and a depth attenuation factor.
WS	Wetted surface area of the hull and appendages.
DISP	Displacement in sailing trim

2nd Moment Lengths

L/LSM1/LSM3	Effective hull lengths of the yacht under different conditions of displacement and heel. These values are derived from the sectional area curve. L is the effective sailing length used to calculate the hull resistance.

Crew Weight Limit

CW	Maximum crew weight

Rig Measurement Definitions

All rig positions are relative to the base of the headstay. The longitudinal position of the headstay base is fixed at the FGS position. See Hull parameters on page 26.

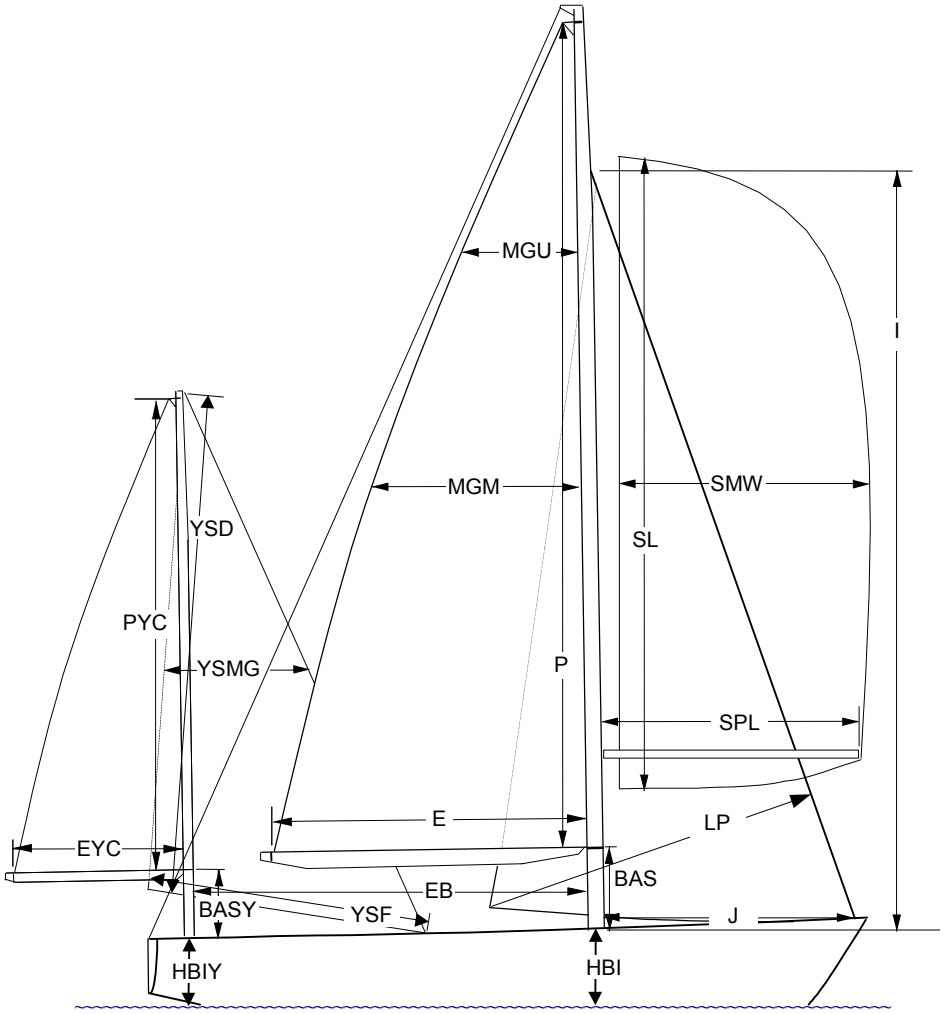


Figure 1, Rig data parameters

Back to Entering Data

Foretriangle Definitions

I	Height from the sheerline to the top of the foretriangle.
J	Distance from the headstay base to the front of the mast.
LP	Jib clew to the luff taken perpendicular to the luff.
SPL	Spinnaker pole length
SL	Spinnaker luff length
SMW	Spinnaker maximum width

Also see:

Figure 1, Rig data parameters on page 28

Mainsail Definitions

P	Mainsail luff length from lower to upper band on the mast.
E	Mainsail foot length from the mast to the boom band.
PC/EC	The IOR "corrected" vales of P and C
MGU/MGM	The upper and middle girth dimensions of the mainsail.
BAS	Height of the lower mainsail luff band above the sheerline.

Also see:
Figure 1, Rig data parameters on page 28

Mast Definitions

MDT 1/MDL 1	Athwartships measurement and fore and aft dimension of the mast near the deck (Below any taper).
MDT 2/MDL 2	The same measurements as above taken at the upper mainsail band. If there is no mast taper, the upper and lower dimensions will match and the TL will be zero.
HBI	Freeboard at the base of the mast.
TL	Taper length of the mast

Also see:
Figure 1, Rig data parameters on page 28

Mizzen Definitions

EB	Distance between the aft side of the forward mast and the forward side of the aft mast
YSD	Aft luff of mizzen foresail
YSF	Bottom luff of mizzen foresail
YSMG	YSMG is mizzen foresail mid girth measured horizontally
PYC	Mizzen mainsail luff length from lower to upper band on the mast.
EYC	Mizzen mainsail foot length from the mast to the boom band.

All mizzenmast definitions (ending in “Y”) are identical to the main mast definitions.
Also see:
Figure 1, Rig data parameters on page 28

Results Data Definitions

VTW	True wind speed
Beta (β) TW	Course relative to true wind
Spinnaker	Whether the spinnaker is set (up) or not (down)
VAW	Apparent wind strength
Beta (β) AW	Apparent wind direction

Hull Speed	Speed of yacht
VMG	Velocity made good to windward (+ve) leeward (-ve)
Heel Angle	Equilibrium heel angle of yacht
Fwd Force	Drive force produced by sails
Sideforce	Side force produced by sails
Reef	IMS Reef parameter, a value of less that 1.00 indicates that the optimum sail size is less than the total available sail area.
Flat	IMS Flat parameter, a value of less than 1.00 indicates that sail coefficients, less than the maximum available, are optimum.
Form Drag	Main drag of hull and appendages
Ind. Drag	Induced drag of appendages
Aero Heel Moment	Heeling moment due to sails
Hydro Heel Moment	Heeling moment due to appendages
Hull Right Moment	Righting moment due to hull weight
Crew Right Moment	Righting moment due to crew weight
Force Err	The VPP algorithm balances the forward drive force against the hull drag. After the maximum number of iterations, any error is given here.
Moment Err	As above but for the heeling/righting moment balance.

Back to Results Table.

Bibliography

The interested reader may enjoy the following articles which describe some of the concepts behind SPAN and velocity prediction programs in general.

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