To plot a polar diagram

Voyage Recorder is an affordable, miniature "black box" for a yacht. A Digital Voyage data recorder (VDR) connected to the NMEA 2000 network on your boat serves to record and store boat data. It collects GPS data wind, depth, temperature, AIS and all other data that flow through the network backbone.

Data collected with the Voyage Recorder can be used to analyze your travels including, for example, the creation of a polar diagram for your sailing vessel.

Polar diagram of yacht speed — this is a graphical representation of yacht speed in relation to heading relative to the true wind direction and speed. Using this diagram, one can determine the speed of the yacht under any wind speed and heading relative to the wind, as well as the angle of vanishing stability (also called the limit of positive stability) for the yacht.

To build an exact polar diagram, we need to perform some test trials at varying wind speeds: vary vessel course under steady wind conditions. In our example, we demonstrate the principles of building a polar diagram using data that was collected not during purposeful trials, but simply some appropriate data collected by the Voyage Recorder.

Using the YDVRCONV program, we can generate a CVS file from this data to use for building a polar diagram in Microsoft Excel (the program and test data can be downloaded here: http://www.yachtd.com/downloads/ — PC Software for Voyage Recorder. In our example, we are using data from the folder named "Baltijsk") (see Figure 1 at the next page).

Since the transmitter of the anemometer sends data 10 times per second, to avoid incidental values, we take a measurement interval of 30 seconds ("Time interval between points or record" = 30 seconds). When the test file is generated, we take data starting at 10:25:00, so that we do not use data taken when the yacht was moving under engine power.
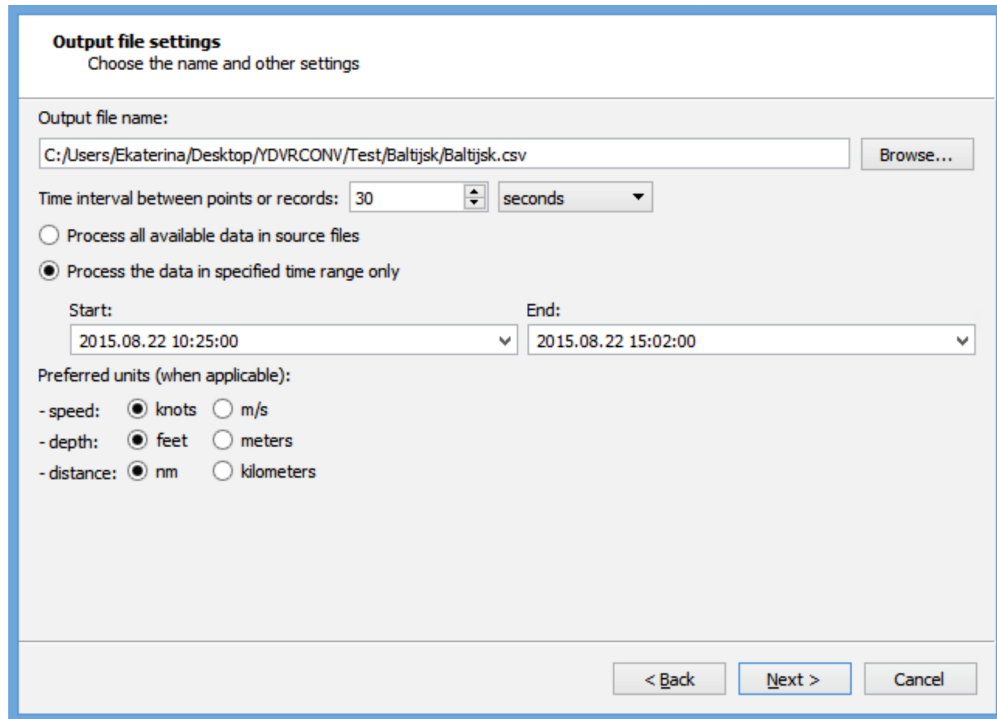
Figure 1

The generated file is opened in Excel. To construct a polar diagram, we will need columns with STW (speed through the water) and AWA(med) (apparent wind angle) values from the created file. For convenience, we copy these two columns into a new sheet. We will make the polar diagram for each value of AWA(med) with an increment of 10 degrees. For this we create another column called «AWAROUND(med)», in which we use the excel's formula:

=ROUND(A2/10;0)*10 to fill in the value for AWAROUND(med).

Next we sort our intermediate table by the AWAROUND(med) column and count the intermediate results (select **Data/Outline/Subtotal** at the main menu of Excel) according to the following algorithm:

At each change of AWAROUND(med), we look for a maximum value for in the STW column (see Figure 2 Subtotal at the next page).

Figure 2 Subtotal

We copy the resulting table but only the rows with an intermediate result. We then select the AWAROUND(med) and STW columns, and select **Find&Select/Go to** at the main menu of Excel or press F5 button to open the "Go To" window where we click "Special…". In the "Go To Special" window, we choose "Visible cells only" (see Figure 3 at the next page). Then, maintaining the selection, we simply copy it to the new sheet.

Then we remove the word "Max" from the data in "AWAROUND(med)" column, which we can do by replace the space and the word with an empty string. We create a DEGREES column, in which we have degree values from 0 to 350. In the STW2 column, we copy the corresponding STW value; if the source table does not have a equal to the DEGREE value, then 0 is put into STW2. To check that this is correct, we use the following formula:

=IF(ISNA(VLOOKUP(D3;$A$3:$C$30;2; FALSE));0; VLOOKUP(D3;$A$3:$C$30;2; FALSE))
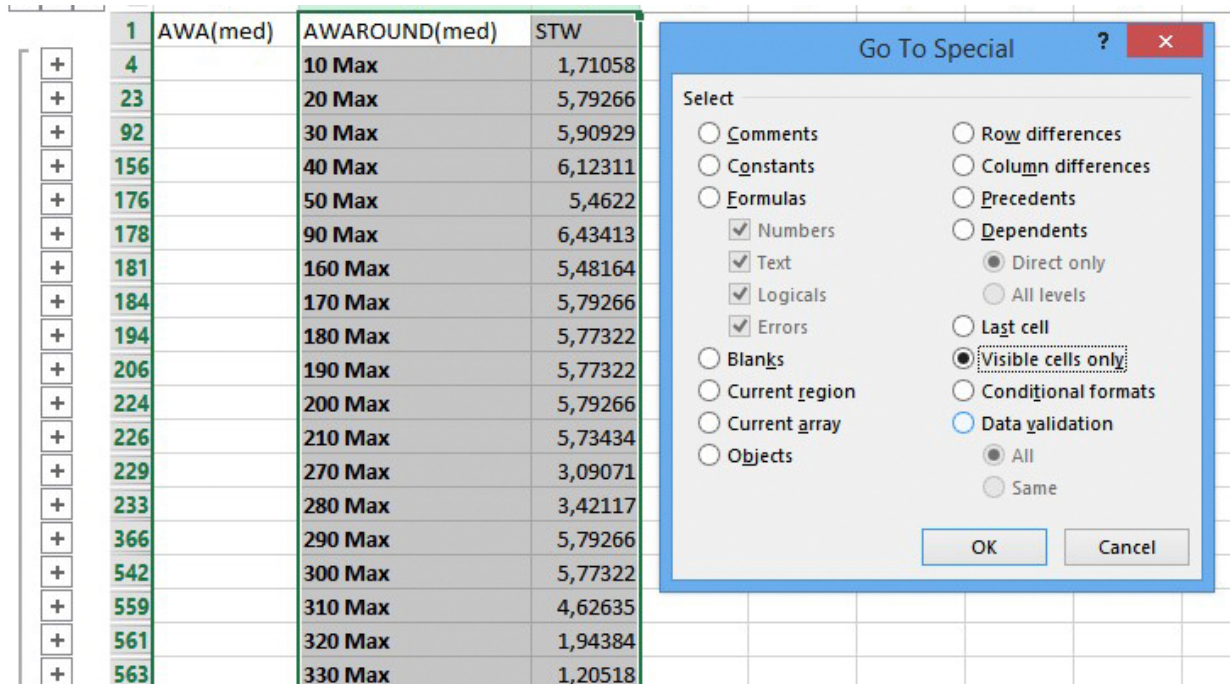
Figure 3

The STW value corresponding to 360 degrees is united with the value corresponding to 0 degrees.

To build a polar diagram for yacht speed, we select the «Radar chart» (**Insert/Charts/Radar Chart** at the main menu of Excel). In this chart, we use the values of the columns of STW2 as the Legend Entries (Series), and for the Horizontal (Category) Axis Labels — the DEGREES column (see Figure 4 at the next page).

We get the diagram shown in Figure 5 at the next page as a result.

As we can see on the diagram shown in Figure 5, port tacking starts from 20 degrees to wind, and starboard tacking starts from 310 degrees (or 50 degrees to wind). In fact, she goes about 35 degrees to wind on both tacks, but the windex has a calibration error of 15 degrees.
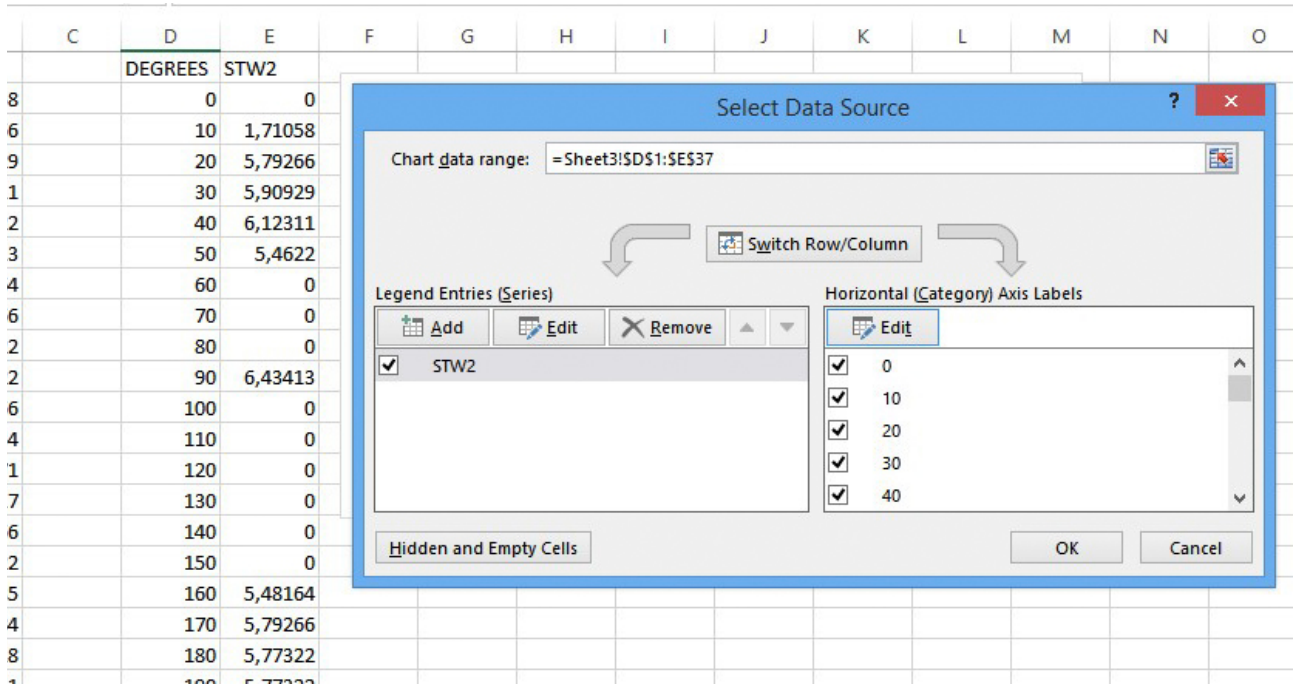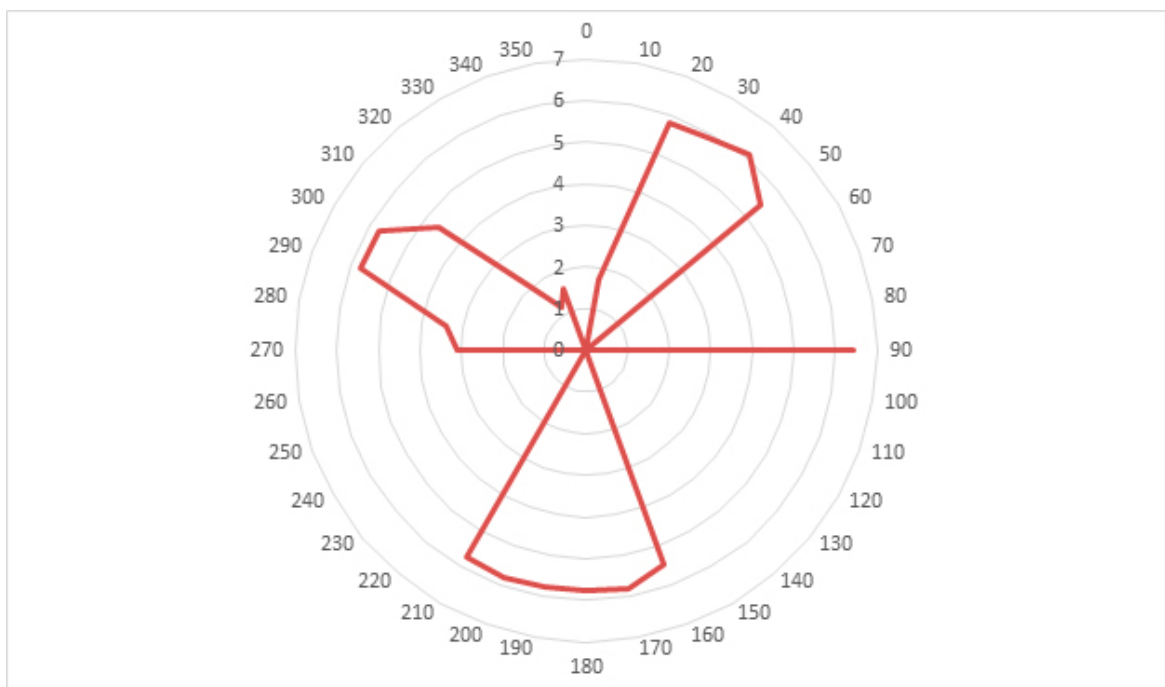
Figure 4

Diagram 1 Polar for yacht

Device parameter	Value	Unit
Operating voltage (from an NMEA 2000 network)	10.5..16	V
Protection against reverse polarity	Yes	—
Average current consumption	23	mA
Load Equivalency Number	1	LEN
Operating temperature range	–25..+85	°C
Weight without MicroSD card	15	g
Recommended MicroSD card	Class 10, 16–32 GB	—
Compatibility of MicroSD card	Unlimited	—
Estimated recording capacity for 16 GB	100..200	days
Automatic overwrite of old data	Yes, by default	—
Recording of data from bus, not less than	99.5	%

The Recorder is intended for storing data from the onboard network of the vessel on a MicroSD memory card. The onboard network of a typical cruise yacht has data about the position, course, speed, depth, water temperature, log, wind speed and direction, and AIS data of nearby vessels. Digital data from the motor, water and fuel tanks, battery level, etc. may also be available.

The Recorder writes all network data into the memory card. It does not analyze the data, leaving that work for the software application that runs on personal computer. Because of that, the Recorder supports all message types broadcasted through the network by any other equipment present on the vessel's network.