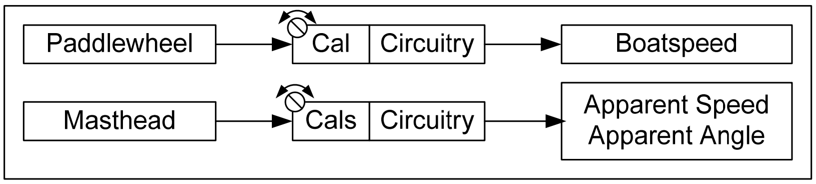
INSTRUMENTS,INC.

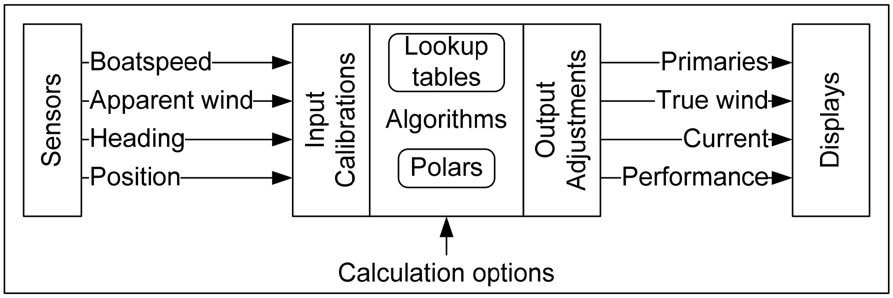
Instrument Calibration Theory and Practice

Calibration of instrument systems is necessary to make displayed information correct and useful. Instrument systems use sensors to measure primary environmental factors (boatspeed, wind, heading, position, heel and others), possibly combine them, and display the results. Stand-alone systems do not combine inputs, while integrated systems do.

Stand-alone instrument system



Integrated instrument system



Most instrument systems provide some means of calibration; either through hardware (screw-turns) or software commands, or both. Some calibrations tend to be static; once set, they pretty much stay where they are, while other calibrations always seem to need changing.

These days, ALL integrated instrument systems (the ones that can output true wind and current) are computerized. They pretty much follow the block diagram, although they might not offer all the adjustments or options shown. A key characteristic of a properly designed integrated system is that all inputs and outputs are available for calibration by all functional channels. For instance, this would allow the effect of heel to change the boatspeed calibration. If the various functions were not available, this could not be done.

Input calibrations correct sensor inputs to make their readings accurate. They adjust for things like boundary layer (paddlewheels), upwash (masthead units), and installation variables such as compass deviation or sensor misalignment. Almost all instrument systems, including stand-alone types, offer some kind of input calibration.

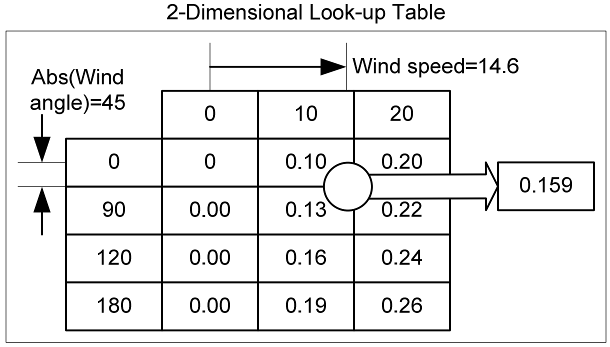
Algorithms are the computer codes that process the inputs to produce outputs. Some outputs (the Primaries) are simply a repeat of the sensor reading, although the digital domain allows better fidelity, modeling and filtering. Other outputs are not directly measurable. For example, true wind angle and speed are a combination of apparent wind and boatspeed, and wind direction is in turn a combination of true wind angle and heading. Instrument algorithms tend to be invariable because they are based on mathematical models, but some systems allow limited control.

Calculation options (when available) change the way the algorithms work. For example, the system might allow switching from paddle to SOG to replace boatspeed, or certain calculations might be disabled to comply with racing rules. Because these features are limited to high end systems, they tend to be controlled by computer commands.

Output adjustments scale or warp outputs to correct for unmeasured or unknown effects (such as wind shear and gradient), or when input calibrations do not completely correct the sensor inputs.

Look-up tables are a flexible way to specify calibrations or adjustments which depend on other measured parameters, e.g. leeway depending on keel extension. But since they are difficult to create and maintain, they should only be used when needed.

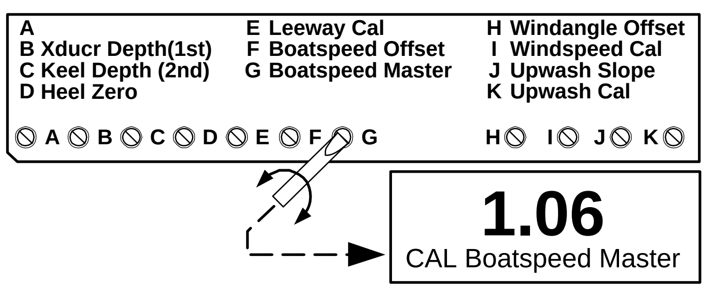
2-Dimensional Look-up Table



Instrument Calibration on the Ockam System

The Ockam Unisyn™ and Tryad™ systems have many types of calibration, options and adjustments providing for all levels of need.

Hardware Cal

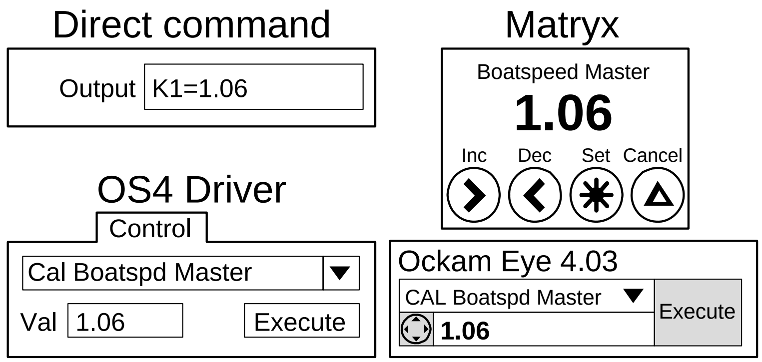


Most Ockam interfaces have Input Cal screws, used for basic instrument calibration. Many deride them as old-fashioned and low-tech. Yes, and they're inconvenient too. We use them because our low-tech clients can relate to them. They're robust, reliable and don't freak out like RAM-based cals can.

Software Cals are a solution to the inconvenience factor, though we recommend turning the screws once the input cals have been figured out.

The Ockam System Manual section 3 covers these calibrations.

Software Cal



Every hardware cal screw has an equivalent software command. For example, sending the command **K1=1.06** sets CAL Boatspeed Master to 1.06 regardless of the hardware screw setting. Sending the command **K1=D** returns the calibration to the hardware value.

These commands can be entered by means of the ***Eye*** PDA application, ***Matryx*** displays, ***OckamSoft 4***, or even a terminal emulator. They greatly speed the calibration process, but the settings are vulnerable to memory loss or processor replacement. Once the calibration settings have been established, it is recommended that the settings be transferred to the hardware screws.

Software cals are described in the Ockam System Manual section 4, and the Tryad T1 document.

AutoCal

CALUW	TW Speed				
|TW<|	0.0	5.0	10.0	20.0	30.0
0	-2.40	-2.32	-1.10	3.20	3.70
30	-2.25	-2.62	-1.58	2.46	2.75
60	-2.10	-2.47	-1.43	2.61	2.90
100	-1.90	-2.27	-1.23	2.81	3.10
180	-1.50	-1.87	-0.83	3.21	3.50

AutoCal is a PC application which automates the output of Software Cal commands based on user-specified independent variable values. In the table above, CAL Upwash (CALUW) is modified depending on the current value of true wind speed and angle.

In addition to Input Cals, AutoCal can adjust true wind to correct out that last bit of wiggle in wind direction and true wind speed.

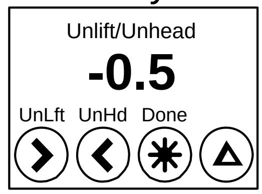
If you need this additional capability, download the AutoCal applet which includes a sample spreadsheet and more documentation.

AutoCal in the T1

When your AutoCal table is complete and debugged, you can move the function into the T1, thereby unloading your PC and the comm channel for other work. The AutoCal applet includes instructions for preparing AutoCal.dat for the T1.

Sailor's Cal
(T1 only)

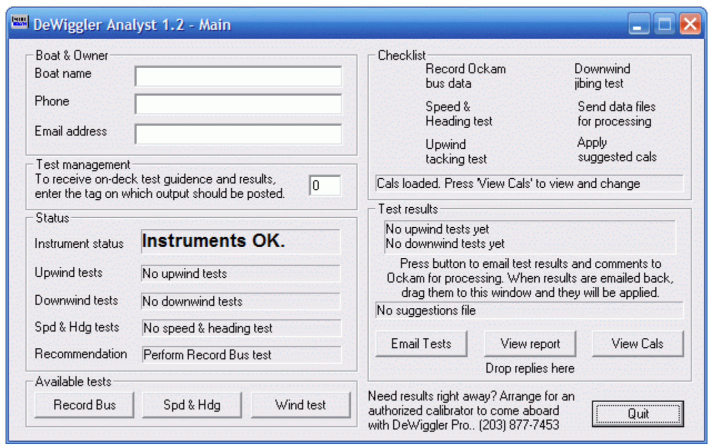
Matryx



When you're racing, it's not the right time to be twirling cal or trying to modify a spreadsheet. In this situation, we recommend using the 'Sailors Cal'. With this function you can quickly adjust true wind angle for a perfect wind direction.

Details on how this works are covered in the Tryad T1 document.

DeWiggler



DeWiggler is an application and process for automatically improving calibration by determining how much the wind direction changes when you tack and jibe. DeWiggler records in the background while you sail. When you send the files in, a recommendation on calibration changes are returned and set into the instruments.

Read more about DeWiggler: Web page. Presentation.