

MAVS-3
Operations
Manual

Version 4.6

**Nobska Development
Corporation**

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Operating MAVS3 Under Software Version 4.6	4
The Power-up Sequence	4
Initialization	4
Asserting Control vs. "Throw and Go" Operation	5
Setting the Clock	6
Completion of the Power-up Sequence	7
Points to Note	8
Responding to Prompts	8
Logging Interactions with MAVS3	8
[CTRL]-[C]	9
Shipping	9
Powering-down	9
Main Menu	10
<1> Set Time	10
<2> Flash Card Ops	11
<3> Calibration	13
Velocity Calibration	14
3-Axes Compass Calibration	18
Solid State Tilt Calibration - Offsets	20
Solid State Tilt Calibration - Temperature and Scale Coefficients	21
Analog Channel Calibration Examples	26
<4> Low Power Sleep	32
<5> Bench Tests	33
<6> Deploy System	42
The Deployment Definition Parameters	42
Measurement Averaging (Measurements / Sample)	47
Measurement Cycle Timing	48
Setting Bursts / File	48
Consistency and Capacity Checks	49
Monitoring the Deployment	52
<7> Offload Data	53
<8> Contact Nobska	57
<S> Changing the System Configuration	58
Changing Sensor Orientation	60
System Configuration (continued)	61
Changing the Baud Rate and the Clock Frequency	62
The Passwords	62
<Q> Exiting to the Monitor (TOM8>)	62
Emergency Boot Recovery Procedure	63
Analog Velocity Output	65
Power Consumption In MAVS3	66
A Parting Word	68

<i>Example Configurations: Considerations for Accurate Measurement</i> _____	69
Long Duration Current Mooring _____	69
Wave Measurements from a Fixed Platform _____	72
<i>Operating MAVSPack</i> _____	74
<i>Operating Crosscut</i> _____	77
First Time Operation _____	77
Normal Operations _____	77
To Start Crosscut _____	77
To Capture a Data File _____	78
To Load a Software Upgrade _____	78
To Load and Run LOADRATE.RHX _____	80
To Exit Crosscut _____	80
Additional Documentation _____	80
<i>Serial Offload Using YModem</i> _____	81
<i>Sound Speed Tables</i> _____	83
<i>Revision History</i> _____	85
New Features of Version 4.6 _____	85
Bug Fixes _____	85
Flash Card Change - SanDisk to SiliconSystems _____	85
Profiler Mode _____	85
New Features of Version 4.5 _____	86
SCP Version Numbers _____	86
Version 4.5 _____	86
Tilt Calibration _____	87
New Features of Version 3.5 _____	88
SCP Version Numbers _____	88
Version 3.5 _____	88
Faster Serial Offload _____	89
New Features of Version 3.4 _____	90
New Features of Version 3.3 _____	92
New Features of Version 3.2 _____	93
SCP Version Numbers _____	93
New Features of Version 2.2 _____	94
New Features of Version 2.1 _____	95
New Features of Version 2.0 _____	96
New Features of Version 1.9 _____	97
New Features of Version 1.8 _____	99

Operating MAVS3 Under Software Version 4.6

The Power-up Sequence

Initialization

When power is applied to a MAVS3, by connecting either the internal battery or an external source of power, the system automatically begins execution of the system control program, MAVS34_6. The system control program resides in non-volatile flash memory on the Tattletale®8 (TT8) board.¹ The TT8 micro-controller supervises the operation of the MAVS3 hardware under the direction of the system control program.

The first step is an initialization routine to place the TT8 in a default state and prepare it for MAVS3 operation. After the TT8 is initialized the program verifies the presence of a flash card for data logging. When the card is detected the system will determine its size and the number of data files that can be accommodated by the file system.² Flash card data storage is a common option with the MAVS3. However, if the hardware to support the flash card is not present (or if the hardware is present but the operator has chosen not to install a card), the system will detect the absence, display a warning message, and disable all flash card operations.³

After sizing the flash card the system loads configuration and deployment definition information. The system configuration includes a list of enabled/disabled auxiliary sensors (e.g., conductivity, temperature, depth), the calibration constants for the velocity and auxiliary sensors, the intended orientation for use (e.g., vertical with the velocity sensor down), the unit serial number, the communication port baud rate, and the default system clock speed. The system configuration is set by Nobska Development before shipping and is stored in serial EEPROM on the TT8. The configuration can be altered manually when necessary (see Changing the System Configuration). It may also be changed when the sensor calibration routines are run (see Calibration). The system configuration information is stored in the serial EEPROM so that it "travels with" a particular MAVS3 unit.

Deployment definition information includes the header (textual information entered by the operator), deployment timing, the velocity frame, logging and display options, and the sampling schedule. Deployment definition information is changed whenever an operator enters new deployment parameters (see Deploy System). Deployment information is also stored in the serial EEPROM so that it travels with a particular MAVS3 unit, permitting "throw and go" operation as described below.

The system configuration and the deployment definition are also stored on the flash card so that they travel with the data. This feature enables both flash card exchange and data unpacking on another MAVS3 and also MAVS3 independent data unpacking on a DOS/Windows compatible, PCMCIA equipped PC.

¹ The Tattletale®8 (TT8) is a product of Onset Computer Corporation, Pocasset, Massachusetts, USA, www.onsetcomp.com.

² MAVS3 PCMCIA flash cards are compatible with MS-DOS® systems. MS-DOS places limits on the number of files that can exist in the root directory on a disk. To conform to this specification MAVS3 flash cards have size dependent limits on the number of data files.

³ Execution of flash card operations in the absence of supporting hardware can crash the Motorola 68332 micro-processor on the TT8. Power cycling is generally required to re-establish control. Disabling all flash card operations protects the system from this failure mode.

Loading the system configuration and deployment definition information means the system has recovered all of the settings programmed during its last use. In particular the calibration constants and the sampling schedule have been retained and the system is ready for immediate deployment. Complete retention of the previous system state is an important and convenient feature of the MAVS3 design.

A typical example of this portion of the power-up sequence is shown below.

```
Sizing flash card (~2 seconds / 100 Mbytes) . . . done.
300.057 Mbyte flash card installed
299.905 Mbyte currently free
File system can accommodate 4090 data files

Initializing . . . done.
Loading system configuration information . . . done.
Loading deployment definition information . . . done.

The MAVS3 operating system is
initialized and running.
```

Asserting Control vs. "Throw and Go" Operation

Having completed initialization, the system will begin a 30 second countdown during which the operator will normally assert control of the system by typing [CTRL]-[C] (hold down the Control key and press 'c'). The duration of the countdown is part of the system configuration information and can be set from 0 to 30 seconds by the operator (see Changing the System Configuration).

```
Type <CTRL>-<C> within 30 seconds
to assert operator control.

28 seconds                               ← countdown timer
```

If the operator does not assert control, the system will begin a deployment using the configuration and deployment definition information loaded from the serial EEPROM. This is a design feature of MAVS3 and is referred to as "throw and go" operation. If the programmed deployment parameters are satisfactory (having been set in the laboratory before embarking on a deployment cruise for example) the operator has the option of simply powering-up the unit and deploying it. It is not necessary for an operator to connect a PC to the MAVS3 and enter a full set of deployment parameters to initiate data collection. However, the operator should have previously verified that the desired deployment parameters were programmed and stored in the serial EEPROM and that all enabled sensors are working and satisfactorily calibrated.

It is also important to note that the internal real-time clock (RTC) of the MAVS3 does NOT run when the power is disconnected. When power is re-applied to the MAVS3, the RTC is reset to January 1, 1970, 00:00:00 and begins counting from there. The operator has the option of setting the RTC (see below), but in "throw and go" mode that option is not exercised. Data record time tags from a throw and go deployment will bear a 1970 date and the operator will need to provide a suitable offset during post-processing.

Typically, the operator will assert control of the system and a prompt to set the clock will be presented (see below). We strongly suggest that you gain some experience with normal operation before using the throw and go operational mode for a deployment.

Setting the Clock

The final steps of a standard power-up sequence are shown below. It is not necessary to set the clock at this time. There will be ample opportunity later and the system does not require a current time to operate. However, we have found that setting the clock accurately reduces the incidence of operator error and we recommend that you do so.

```
Current clock time: 01/01/1970 00:00:00
Change time & date (Yes/No) [N] ? y

Enter date as MM DD YY HH MM SS
Enter year 2001 as 1, 01, 101, or 2001

Enter correct time [01/01/1970 00:05:16] ? 3 28 02 9 37 20 ← operator entry of date
and time
Current clock time: 03/28/2002 09:37:20 [ENTER] sets the RTC
Change time & date (Yes/No) [N] ?
```

The example above shows how to set the RTC. The date and time should be entered using the US convention of month followed by day followed by year: MM/DD/YY HH:MM:SS. Years can be entered using 1, 2, 3, or 4 digits (99 or 1999 for 1999 and 1, 01, 101, or 2001 for 2001). Years between 1970 and 2038 are allowed. Spaces, as used in the example, are acceptable delimiters between values, however slashes and colons can also be used. Leading zeros are not required, but are acceptable. The RTC is actually set to the entered date and time when the operator presses [ENTER] after typing the six date and time values. Typically the operator will type a time that is 5 to 10 seconds in the future, and then press [ENTER] as the external clock used for reference reaches that time.

Completion of the Power-up Sequence

Setting (or choosing not to set) the clock completes the power-up sequence and system initialization. The MAVS3 system has loaded the configuration and deployment definition settings that were last used and, with the exception of changes to the value of the RTC, is in the state the operator last programmed. If, for example, the sampling schedule used during the previous deployment must be exactly matched during the current deployment because of experimental requirements for data compatibility or for direct comparison during analysis, then you can deploy the system immediately. The parameter match has already been made by MAVS3 and there is no need for manual parameter entry under the time and other adverse constraints of a research cruise.

The power-up sequence will not be repeated unless the system is re-booted. A "cold" re-boot can be accomplished by disconnecting the power and then reconnecting it after 5 to 10 seconds. (The delay allows capacitors in the system to fully discharge. If the RTC does not reset to 01/01/70 00:00:00 you should wait longer before reconnecting.) A "warm" re-boot can be executed by exiting the system control program to the TT8 monitor (TOM8) and then re-starting the program manually (see Exiting to the Monitor).⁴

The Main Menu will be displayed once initialization is complete. All further system operations will be initiated by the operator from the Main Menu.

⁴ Failure on the part of the operator to follow established protocols can "crash" the system. Under software Version 1.7 this could cause an "exit on exception" to the monitor. To re-start the system control program type 'g' or "go" followed by [ENTER] at the TOM8 prompt. This will start the normal power-up initialization sequence. An example of a failure to follow established protocols would be booting or re-booting a PC while it was connected to the MAVS3 communications port and the TT8 was running. Under software Version 1.8 and later the crash will (probably) call the critical fault handler, placing the system in low power sleep. On screen instructions will direct you to re-start the system by pressing [CTRL]-[C]. The process is operationally equivalent to a warm re-boot.

Points to Note

Responding to Prompts

Character case does not, in general, matter. Upper and lower case alphabetic characters used in response to various prompts are equivalent.⁵ Many prompts have default answers that can be selected simply by pressing [ENTER]. The default answer, if there is one, will be displayed in square brackets.

Prompts for numerical values will only accept numbers that fall within a displayed range. The displayed upper and lower bounds are included in the acceptable range. When an out of range or otherwise unacceptable entry is made the system will re-prompt the operator. Numerical prompts discriminate between integer and floating point values in the sense that floating point values will be truncated or otherwise altered or rejected when an integer value is sought. Integer values are, of course, acceptable when a floating point value is anticipated as long as the integer is inside the displayed range. It will generally be clear from the context and the displayed range when a floating point value is expected.

Similarly, prompts for alphanumeric input, such as those following a menu display, will only accept characters from a restricted list, the visible (and protected) menu options. Unrecognized characters will cause the system to re-prompt the operator.

Logging Interactions with MAVS3

This manual includes a section, Operating Crosscut, that describes how to install and operate the serial communications program distributed with each MAVS3 system. Other communication programs can also be used. We recommend Crosscut because it was written specifically for the TT8 and has a number of useful features. More important, Crosscut will not crash the 68332 micro-processor on the TT8. Some other communication programs, generally modem based programs such as ProComm, can crash the 68332 under some circumstances. Other safe alternatives are TattleTerm, Crosscut for Windows, and, so far, HyperTerminal. As a general rule, to avoid a system crash only connect and disconnect the communications cable when the PC and the terminal emulator are up and running. Further, do not boot either the PC or the communications program while connected to a running TT8. Finally, make and break the connection as cleanly as possible. Do not wiggle the connector, making repeated intermittent contacts.

Nobska has installed a hardware modification that will generally prevent crashes induced by activity on the communications port even if you neglect the operational recommendations above, however, we still advocate the recommendations. Contact Nobska if you need further information or assistance.

Whichever communications program you use, we recommend that you use it to **log all of your interactions with MAVS3**. Logging (file capture) is described in the Operating Crosscut section. This utility is essential if data from the flash card are to be recovered by spooling them out through the communication port using the on-board data offload utility (see Offload Data). However, a complete record of your session programming the system for a deployment can be invaluable during (and often before) data analysis. We strongly recommend this use of the file capture utility of your communications program.

⁵ The exceptions are password protected portions of the operator interface. Passwords are case sensitive. They are used to prevent accidental changes to critical system parameters, not to restrict intentional access by a knowledgeable operator. The passwords are documented in the sections below.

[CTRL]-[C]

The key combination you will find most useful when running the MAVS3 system control program is [CTRL]-[C]. It is executed by holding down the Control key and then pressing 'c'. [CTRL]-[C] will gracefully terminate whatever operation the system is conducting and return to the Main Menu. Several [CTRL]-[C]s will be necessary in some cases. There may be other, less drastic, options, but [CTRL]-[C] will always work, and, as long as terminating the current operation is not a problem for the operator, [CTRL]-[C] is a benign action that will cleanly terminate the active process before returning to the Main Menu.

For example, [CTRL]-[C] is the only way to manually terminate sampling when the instrument is recovered. After a [CTRL]-[C] is received during a deployment the system will complete any critical steps, such as terminal data storage operations, and return to the Main Menu. Thus the "graceful termination" characterization. Those critical operations are generally completed within a small fraction of a second. Further, [CTRL]-[C] will not harm the hardware in any way. [CTRL]-[C] will exit cleanly from a prompt during parameter entry without altering the variable. [CTRL]-[C] is the only way to manually wake the system from the low power sleep condition (three [CTRL]-[C]s are required). When in doubt, [CTRL]-[C] will take you to the Main Menu where you can take control of system operation.

Shipping

It is generally a good idea to ship MAVS3 units with the battery disconnected. This practice can prevent physical damage from improper handling from becoming even more serious electrical damage. Disconnecting the battery also means that the battery cannot become completely drained. Fully discharging the battery may occur, for example, because the system took longer to recover from the shipper than anticipated or because the system was left to continue a deployment rather than being placed in the low power sleep mode. However arrived at, the problem with fully discharging the battery is not the cost of battery replacement, but the cost of replacing the electronics damaged or destroyed when the battery begins to leak due to being completely drained. There is only one exception to the battery disconnected shipping rule. If the system is programmed in the lab, perhaps with a delayed start, for a communications free deployment at some distant destination, then the battery must stay connected. Undertake such an approach with caution. Try to determine your time limits in advance so that you can anticipate when problems may occur and act to prevent them.

Preserve the shipping box in which you received your MAVS3. The box will provide protection for your system anytime it is stored or shipped. The box was specially designed and fitted to safely cradle a single MAVS3 unit and protect it from damage. Always ship MAVS3 units in the shipping box. Always store MAVS3 units in the shipping box.

Powering-down

To turn the system off simply disconnect the internal battery and/or the external power source. As a general rule, remove power only after stopping whatever operation the system is performing ([CTRL]-[C]) and returning to the Main Menu. Powering down while an operation is in progress is not in any way detrimental to the hardware, however, it does put active data files at some risk and may skip the recording of any configuration changes that are being made. For these reasons it is especially important that you **do not remove power to stop a deployment**. Always use [CTRL]-[C] first. This is akin to running "shutdown" on a PC before switching it off; it allows the processor to protect the file system and exit cleanly.

Main Menu

The Main Menu is the operational control nexus of the MAVS3 user interface. All system operations are initiated by the operator from the Main Menu. This section of the MAVS3 manual describes each of the visible (and protected) Main Menu options. The MAVS34_6 Main Menu is shown below. To select an option press the appropriate alphanumeric character key followed by [ENTER].

```
Nobska Development MAVS3
Modular Acoustic Velocity Sensor
Model 3
Version: mavs34_6.c S/N: 10414

Main Menu

Fri Mar 29 11:11:15 2002

<1> Set Time          <5> Bench Tests
<2> Flash Card Ops   <6> Deploy System
<3> Calibration      <7> Offload Data
<4> Low Power Sleep  <8> Contact Nobska

selection ?
```

<1> Set Time

The Set Time option allows the operator to set the system's real-time clock. The date and time should be entered using the US convention of month followed by day followed by year: MM/DD/YY HH:MM:SS. Years can be entered using 1, 2, 3, or 4 digits (99 or 1999 for 1999 and 1, 01, 101, or 2001 for 2001). Years between 1970 and 2038 are allowed. Spaces, as used in the example, are acceptable delimiters between values, however slashes and colons can also be used. Leading zeros are not required, but are acceptable. The RTC is actually set to the entered date and time when the operator presses [ENTER] after typing the six date and time values. It is pressing [ENTER] that should be synchronized to some reference. The time of exit from the RTC routine does not affect the clock. Typically the operator will type a time that is 5 to 10 seconds in the future, and then press [ENTER] as the external clock used for reference reaches that time.

```
selection ? 1                                     ← press '1' followed
Current clock time: 03/29/2002 11:11:18           by [ENTER]
Enter as MM DD YYYY HH MM SS
Year 2000 = 100, 2001 = 101, . . .
Enter correct time [03/29/2002 11:11:18] ? 3 29 02 11 11 35 ← operator entry of date
Current clock time: 03/29/2002 11:11:35           and time
Change time & date (Yes/No) [N] ?                [ENTER] sets the RTC
                                                    ← exit RTC routine
```

The accuracy of the RTC is approximately 1 minute per month, comparable to the accuracy of a quartz wrist watch. There are variations from one unit to the next and there is some dependence on temperature. Reasonable baseline values are 2.5 seconds per day at 25°C and 2.7 seconds per day at 0°C. Contact Nobska if additional information is required.

<2> Flash Card Ops

Flash Card Ops gives the user access to the files on the flash card through an MS-DOS®-like interface called PicoDOS®.⁶ The Flash Card Operations menu is shown below with example selections. Where necessary, instructions or supplementary information will be displayed on the screen when a selection is made. **The Flash Card Ops menu allows the operator to delete data.** Exercise appropriate caution.

Option 1 determines the size of the flash card and calculates the number of files the file system will support. (This is the same subroutine run during the power-up sequence.) Option 2 is equivalent to "dir" in MS-DOS. Option 3 is equivalent to "del *.*", which acts only on the file allocation table. The files are "deleted", but the physical sectors are not actually written and commercially available data recovery utilities could reconstruct the files. Option 5 performs a full format of the card, writing to each sector and permanently deleting all files. Option 4 allows the operator to remove or install a flash card without disconnecting system power. Option M returns the program to the Main Menu.

```
Flash Card Operations

<1> Flash card size/free
<2> List flash card files
<3> Delete all files
<4> Exchange flash cards
<5> Format flash card
<6> Command line interface
<M> Main Menu

Selection ? 1                               ← Option 1 example

sizing flash card (~2 seconds / 100 Mbytes) . . . done.
300.057 Mbyte flash card installed
299.905 Mbyte currently free

File system can accommodate 4090 data files

Press any key to continue.
```

⁶ PicoDOS® and the Persistor flash card board are products of Persistor Instruments, Incorporated, Bourne, Massachusetts, USA, www.periph.com.

```

Selection ? 2                                     ← Option 2 example

Directory of A:
CONFIG.BIN           142 07-20-01 11:23
DEPLOY.BIN          262 07-20-01 11:23
DATA0001.BIN       38000 07-20-01 11:31
F_COUNT.BIN         4 07-20-01 11:40
DATA0002.BIN       38000 07-20-01 11:40
DATA0003.BIN       38000 07-20-01 11:48

299,905,122 bytes free

Press any key to continue.

Selection ? 4                                     ← Option 4 example

This utility permits a flash card exchange
without disconnecting the battery. Hit any
key TWICE after the exchange. The utility
is reasonably robust, however, if the system
crashes, simply follow the instructions or
disconnect the battery, wait 5 seconds, and
reconnect the battery.

Exchange card after ellipsis
is displayed and system pauses.
Press [ENTER] twice when
card exchange is complete.
↓
Ready for card change (CS2), hit any key to continue ... Card Installed

sizing flash card (~2 seconds / 100 Mbytes) . . . done.

300.057 Mbyte flash card installed
299.905 Mbyte currently free

File system can accommodate 4090 data files

Press any key to continue.

```

Option 6 provides full access to PicoDOS. While this may be useful to some users, we suggest that you exercise caution and restraint. It is possible to corrupt or delete data files using this portion of the interface. It is also possible to alter the MAVS3 system in a way that compromises proper system operation. In particular, it is possible to delete MAVS34_6, the system control program. Again, exercise caution and restraint. We suggest that you not use the Command Line Interface if you are not thoroughly familiar with the TT8 and with PicoDOS. Contact Nobska Development as necessary for assistance.

Selection ? 6

```
===== PicoDOS Intrinsic Commands (plus .RUN and .BAT Files) =====
COPY      source dest          DATE      (prompts)
DEL       filename            DIR       [file | wildcards]
ERASE    filename            FORMAT    [/Q][/E][/F]
TIME     (prompts)           TYPE     filename
REN      oldname newname     VER      (PicoDOS version)
G        or GO[address]      LO       [ofs][;Bx[+]] [;G]
MD       [address]          MM       [address]
XS       [/Q][/X][/C]file    XR       [/Q][/X][/C][file]
YS       [/Q][/G]file[,file...] YR      [/Q][/G]
BAUD    [newrate] [/Q]      SAVE     file[start][end]
DUMP    file[start[,end]]   CAPTURE  file[delim] [/N]
BOOT    [PICO][TOM8]       CCC      (card change)
RESET   (hard reset)       TOM8    (exit to TOM8)
```

CAUTION - Some of these commands can erase, halt, damage, or hide the system program resident in flash memory.

<?>-<ENTER> for list of commands
<CTRL>-<X> to exit

Enter command >>

Note that all flash card operations (except the card exchange option) are disabled during the power-up sequence if a flash card and/or the supporting hardware are not detected.

<3> Calibration

The Calibration menu allows the operator to calibrate enabled sensors. The calibration constants, determined empirically or entered manually, become part of the system configuration information stored in the non-volatile serial EEPROM if the operator chooses to accept them. The Calibration menu is shown below.

Calibration

```
<V> Velocity Offsets
<C> Compass Offsets
<T> Tilt Offsets
<M> Conductivity
<S> Single Thermistor
<P> Pressure Sensor
<A> Thermistor Array
```

<X> Save Constants and Exit

Selection ?

If a sensor is not enabled in the system configuration array, the system will not perform that calibration procedure. Each option includes complete on-screen directions for performing the calibration. To view the documentation simply select the desired option. Once the directions have been displayed the operator can proceed with the calibration or exit without changing the calibration constants by responding negatively to a "continue procedure" prompt or by pressing [CTRL]-[C]. Exiting from the Calibration menu with a [CTRL]-[C] will also preserve existing constants. (As always, [CTRL]-[C] returns immediately to the Main Menu.) The only way to store any new constants determined through a calibration procedure is to press 'x' or 'X' followed by [ENTER] at the "Selection ?" prompt. The system will indicate whether or not calibration information is being stored as it exits the Calibration menu.

Each MAVS3 system is delivered with individual calibration constants already installed in the system configuration array. The calibrations are relatively stable, however, as with any instrument, pre- and post-deployment calibration by the user is strongly recommended. A permanent record of all calibrations should be kept for each MAVS3 system. Log files can be generated using the file capture utility of your serial communication program (see Operating Crosscut.)

Velocity Calibration

Velocity calibration is discussed here in full because of its central importance to the MAVS3. There are two constants of which to be aware. The first of these is the scaling constant that converts raw counts to a positive or negative velocity measured in centimeters per second. The scaling constant is 0.0056066 cm/s/count. While it can be changed (see Changing the System Configuration), one would only do so if the MAVS3 hardware had been modified to alter the sensitivity of the system or to pre-scale the measurements for a sound speed that is known in advance and that differs significantly from the assumed value of 1500 m/s.⁷ The "raw counts" are hexadecimal, 2s complement (integer) values that are proportional to fluid speed along each acoustic axis. The articles accompanying this manual contain a more complete description of the MAVS3 differential travel time technique for acoustic velocity measurement.

The second calibration constant is the zero offset. There is a zero offset associated with each acoustic axis. The zero offsets are measured and applied in counts. It is the zero offsets that are determined by the velocity calibration procedure. The offsets are a strictly additive correction to the extremely linear MAVS velocity measurement. They are most easily determined by making a velocity measurement in fluid that is not moving. The (in general) non-zero value returned by the sensor at zero flow is, by definition, the offset. Once calibration is accurately completed the offsets are available to be subtracted from the raw velocity measurements made along each path. More information can be found in the accompanying articles and in the articles they reference.

A good zero offset calibration is critical to accurate velocity measurement.

⁷ Re-scaling for sound speed is normally carried out during post-processing, when measurements of the *in situ* temperature and salinity are available. MAVS3 assumes a sound speed of 1500 m/s. Slower sound speeds increase the differential travel time on which the MAVS3 measurement is based and inflate the velocity measurement. Similarly, sound speeds faster than 1500 m/s produce a measurement that is too small. The conversion from differential travel time to velocity is proportional to the square of the sound speed. Therefore, to correct measurements during post-processing, simply multiply by the square of the ratio of the actual sound speed to 1500 m/s,

$$V_{\text{corrected}} = (V_{\text{measured}}) (c/1500)^2,$$

where *c* is the sound speed in m/s and the velocities are in a consistent set of units, either counts or cm/s. Multiply by the same factor, $(c/1500)^2$, to pre-scale the scaling constant, 0.0056066 cm/s/count. Tables of sound speed as a function of temperature, salinity, and depth are provided at the end of the manual. Fresh water is included as a special case.

The quality of the calibration depends strongly on the care with which it is conducted by the operator. Make sure that flows in the water in which the calibration is conducted have had time to decay to background levels and that air bubbles have not formed on the transducers. MAVS3 can easily resolve thermal currents below 1 mm/s in buckets, so stay away from strong thermal gradients and radiant sources of heat. Avoid vibration. The velocities in smaller containers will tend to be smaller, however, acoustic reflection can be a problem if the container is too small or is poorly shaped. A large tank avoids problems with acoustic reflections, but commonly has large background currents (mm/s to cm/s). A container with slightly sloping rather than square sides and linear dimensions in the 20 cm to 50 cm range is a good choice. In the case of a reflection the system will generally detect and reject the measurement, but an incomplete set of measurements is not optimal for zero offset calibration. It is also possible the system will not detect the odd value and that will certainly compromise the calibration. The system will flag measurements that are out of the allowed range (see below) and remove those measurements from the offset calculation. The operator is notified when this occurs. The system also calculates and displays the standard deviation of the measurements. This provides the operator with a quantitative measure of the combined noise level of the system and the bucket. Ultimately, it is the operator who must assess the quality of the zero offset calibration.

We commonly use an open plastic container with a capacity of approximately 10 liters. When possible we use "old" water, water that has been left standing for several days. Aging the water allows most of the dissolved gas to escape, which effectively inhibits the formation of bubbles on the transducers. When an extremely precise zero offset is required the calibration should be conducted in a carrageenan agar gel (Morrison, Williams, and Martini, *Proceedings of OCEANS 1993*, IEEE/OES). Calibration in carrageenan eliminates the noise contribution from the movement of water in the bucket.

Zero offsets typically fall inside a ± 3 cm/s window around zero. The measured offsets must fall inside a ± 10 cm/s window. Larger offsets are an indication of a problem in either the execution of the calibration or in the MAVS3 hardware. In either case you should contact Nobska for assistance. In terms of raw counts (hexadecimal, 2s complement, 16 bits) the typical values run from FC00 to 0400 and the maximum values run from F300 to 0D00. The system will verify that all of the values used in the calculation of the offset are within the wider window. Measurements that are outside the window are tagged and rejected.

The operator should also examine the noise level for each acoustic path. The system calculates the standard deviation of the measurements associated with each path. Standard deviations are typically less than 0.25 cm/s. Contact Nobska if standard deviations exceed 0.50 cm/s. The operator should also examine the measurements manually. Variations between the measurements of a particular acoustic path should be largely confined to the two least significant hexadecimal positions. The four offsets will, in general, not be the same. The example below shows a clean velocity calibration. The offsets are large, but not so large that they are of concern. At 0.06 cm/s and less, the standard deviations of this MAVS are excellent.

Selection ? v

velocity offsets:

<M> Measure

<S> Set

Selection ? m

Immerse the velocity sensor in a container of still water and allow the disturbance induced by the insertion of the sensor to dissipate.

Press any key when ready to proceed.

collecting 32 measurements, 16 seconds . . .

000	02D8	0318	0348	0338	← measurement count and the four acoustic axes
001	02E8	0320	0340	0348	
002	02E0	0320	0338	0338	
003	02E0	0310	0340	0340	
004	02E8	0310	0338	0338	
005	02D8	0320	0330	0348	
006	02E0	0308	0338	0348	
007	02E8	0310	0340	0338	
008	02D8	0320	0338	0338	
009	02E8	0320	0340	0338	
010	02E0	0320	0330	0338	
011	02E0	0310	0340	0330	
012	02E8	0318	0338	0340	
013	02D0	0328	0340	0348	
014	02F0	0310	0330	0330	
015	02D8	0308	0338	0330	
016	02E0	0318	0340	0338	
017	02D8	0318	0340	0338	
018	02E0	0318	0340	0340	
019	02E8	0328	0340	0338	
020	02F0	0300	0348	0338	
021	02D8	0308	0348	0338	
022	02F0	0310	0348	0328	
023	02E0	0320	0340	0330	
024	02D8	0308	0350	0328	
025	02E8	0310	0330	0340	
026	02D8	0320	0338	0340	
027	02D8	0310	0340	0340	
028	02E8	0328	0338	0328	
029	02F0	0320	0348	0330	
030	02E8	0308	0338	0338	
031	02E8	0328	0338	0338	

Axis A: all 32 measurements were clean. ← part of a high quality calibration:
Axis B: all 32 measurements were clean. no rejected measurements
Axis C: all 32 measurements were clean.
Axis D: all 32 measurements were clean.

Mean:	02E2	0317	033D	0339	counts	← offsets in hexadecimal
Mean:	+4.07	+4.36	+4.57	+4.55	cm/s	← offsets in cm/s
Stdv:	0.05	0.06	0.04	0.05	cm/s	← standard deviation in cm/s

The zero offsets can also be entered manually. The example below shows them being reset to zero.

```
selection ? v

velocity offsets:
  <M> Measure
  <S> Set
selection ? s
Current path offsets: 02E2    0317    033D    0339
Enter path A offset (F300 to 0D00) ? 0
Enter path B offset (F300 to 0D00) ? 0
Enter path C offset (F300 to 0D00) ? 0
Enter path D offset (F300 to 0D00) ? 0
```

When calibration is complete press 'x' or 'X' at the Calibration menu selection prompt to save the results and return to the Main Menu. The system will store any changes to the calibration constants to the system configuration in the serial EEPROM and also apply them to the active program. If more than one sensor has been calibrated all the results will be saved. **Calibration procedure results are NOT stored until the operator exits from the Calibration menu by pressing 'x' or 'X'.** To reject the results and leave the calibration constants unchanged, press [CTRL]-[C]. The system will return immediately to the Main Menu without making any changes to the system configuration in either the serial EEPROM or in active RAM.

```
selection ? x
Storing system configuration information . . . done.
```

It is important to conduct and record the results of a zero offset calibration both before and after a deployment to check for drift. Small changes can be used for linear corrections to the data during post-processing. The zero offsets must be applied directly to the raw axes velocities. **Zero offset corrections cannot be applied to vector velocity data**, the mapping from raw axes to vector velocities cannot be run backwards. For this reason, it is always desirable to log the raw axes velocities with the components of the velocity vector in one of the instrument or Earth frames (see Bench Tests). Logging the raw axes will also permit data recovery in the unlikely event one of the acoustic axes fails during a deployment and corrupts the vector velocity data.

Large changes in the zero offset were observed for an early version of the velocity sensor head. The shift was traced to the bonding properties of a polyurethane formulation that is no longer in use. The affected systems were exposed, during deployment, to seawater at a depth of more than 2000 meters. The shifts in the offsets were up to 4 cm/s and appear to be both fixed and permanent. Shallow water deployments did not experience a zero shift.

The shifts apparently occurred when the systems were first deployed. Because the raw axes were recorded, it was possible to successfully post-process the velocity measurements using the post-cruise zeros. While there have been no problems with the new polyurethane formulation, Nobska strongly recommends that investigators planning deployments below 1000 meters plan to log the raw acoustic axes as a precaution and use the post-cruise zeros during data processing if a shift has occurred.

3-Axes Compass Calibration

Compass calibration compensates for the portion of the total magnetic field carried by the instrument itself. The most notable contribution to the instrument's magnetic field comes from the battery pack. Thus, the compass calibration will change whenever the battery pack is changed, shifted, or twisted, even if the battery has been degaussed to reduce the strength of its magnetic field. **The compass should be re-calibrated whenever a new battery pack is installed. The compass should also be re-calibrated whenever a battery pack is re-installed or otherwise physically shifted or twisted** because those changes move the magnetic field of the battery pack relative to the compass. We recommend taping the battery pack in place before performing the calibration. Battery packs should always be thoroughly degaussed before use in a system equipped with a compass. The compass should also be re-calibrated whenever the sensor orientation is changed. The compass should always be calibrated in the orientation in which it is to be deployed. Contact Nobska for more information about compass calibration and battery degaussing.

Two 180° rotations of the system must be performed by the operator during the calibration procedure. Begin by placing the system in the orientation in which it will be used. The first rotation should be around the long axis of the pressure housing. This is the Z-axis of the instrument frame for either of the vertical orientations and the Y-axis of the instrument frame for any of the horizontal orientations. The second rotation should be around the X-axis of the instrument frame (perpendicular to the long axis of the pressure housing). See Bench Tests for a definition of the instrument frame associated with each of the possible sensor orientations. The quality of the calibration depends on the precision with which these rotations are executed. Marking the housing and a stable and level surface to aid alignment is strongly recommended.

Working in an area that is free of magnetic anomalies will significantly improve the result. Note that the hull of a research vessel and the steel reinforcing bars hidden in concrete floors and walls often induce strong, local magnetic variations. Such anomalies can be detected using a simple magnetic hand compass; if the orientation of the needle changes as you move the compass vertically and horizontally, calibrate the 3-axis compass someplace else.

The quality of the compass calibration is also improved if the compass module is not translated horizontally or vertically during the two 180° rotations. The compass module is mounted on the end of the MAVS3 circuit board furthest from the velocity sensor. It can be identified by the three blue-green cylindrical magneto-inductive sensors mounted orthogonally on a small circuit board. Each sensor is approximately 1 cm in length. The location of the compass, roughly the midpoint of the pressure housing, should be the pivot for both rotations.

A sample compass calibration is presented below. Portions of the numerical display have been excised to keep the example brief.

```

      Calibration

<V> Velocity Offsets
<C> Compass Offsets
<T> Tilt Offsets
<M> Conductivity
<S> Single Thermistor
<P> Pressure Sensor
<A> Thermistor Array

<X> Save Constants and Exit

Selection ? c                               ← Compass calibration
```

```

Compass Offsets:
  <M> Measure
  <S> Set

  Selection ? m                                     ← Measure the offsets

This MAVS3 is currently configured for deployment
with a Vertical/Down sensor orientation.
Position the MAVS3 in the configured orientation.
Precise 180° rotations around the long axis of the
pressure housing and the x-axis of the instrument
frame will be necessary during the calibration. The
result will be significantly improved if the area
is free of magnetic anomalies.

Press any key when ready to proceed.
Set 1 of 3, 32 measurements, 16 seconds . . .

000      -350      934      -38
001      -350      936      -38
002      -350      936      -38
. . .
029      -352      934      -38
030      -352      934      -40
031      -352      934      -40

Rotate the MAVS3 180° around the long axis          ← First rotation
of the pressure housing. Limit translation
of the compass module.

Press any key when ready to proceed.

Set 2 of 3, 32 measurements, 16 seconds . . .

000       226       928       -14
001       228       926       -16
002       228       928       -14
. . .
029       230       924       -26
030       228       924       -26
031       234       924       -30

Rotate the MAVS3 180° around the x-axis of          ← Second rotation
the instrument frame. Limit translation of
the compass module.

Press any key when ready to proceed.

Set 3 of 3, 32 measurements, 16 seconds . . .

000       296      -924        6
001       298      -922        8
002       286      -930        2
. . .
029       300      -922        2
030       300      -924        0
031       300      -924        4

calculated compass offsets:      -61      1      0

Accept offsets (Yes/No) [Y] ? y

```

You can assess the accuracy of the calibration by sequentially aligning the instrument with the cardinal points of the compass (magnetic, not true) while scrolling compass heading (see Bench Tests). The assessment should be conducted well away from local magnetic anomalies.

Solid State Tilt Calibration - Offsets

Six calibration constants, three each for pitch and roll, are needed to characterize the solid state tilt sensor. The three pitch-roll pairs are the physical offsets, the scaling coefficients, and the temperature correction coefficients. The temperature and scale coefficients are determined by Nobska and, in general, do not need to be re-determined; they are fixed values for each tilt sensor and independent of system orientation, re-positioning of the sensor, and other physical changes that may commonly occur. Note, however, that the tilt calibration utility described below can be used to determine new temperature and scale coefficients if necessary. That relatively complex procedure is described in the next section, Solid State Tilt Calibration –Temperature and Scale Coefficients.

The pitch and roll offsets are primarily associated with the physical placement and orientation of the tilt sensor within the instrument. The offsets should be recalculated when the Sensor Orientation is changed in the System Configuration. Tilt calibration measures the offsets, using the stored temperature coefficients and a dynamic measurement of the actual temperature to automatically reference them to 0°C. The operator need only position the system in the desired orientation and hold it steady while the system makes the measurements.

A sample tilt calibration is presented below. Portions of the numerical display have been excised to keep the example brief. During calibration the system measures the raw analog output of the tilt sensor, calculates the temperature corrected output (referenced to 0°C), further calculates the temperature and offset corrected output, and measures the actual temperature using the standard MAVS3 thermistor. Averages are calculated and displayed after the measurements are acquired. The temperature range over the course of the calibration is also displayed.

```

      Calibration

<V> Velocity Offsets
<C> Compass Offsets
<T> Tilt Offsets
<M> Conductivity
<S> Single Thermistor
<P> Pressure Sensor
<A> Thermistor Array

<X> Save Constants and Exit

Selection ? t                               ← Tilt calibration

Tilt Offsets:
    <M> Measure
    <S> Set
    Selection ? m

This MAVS3 is currently configured for deployment
with a Vertical/Down sensor orientation.
Place MAVS3 on a level surface and in the configured
orientation.

Press any key when ready to proceed.
```

```

Collecting a set of 32 measurements, 16 seconds . . .

```

	Uncorrected		Temperature		Complete		
	Raw mV		Corrected		Correction		
	Pitch	Roll	Pitch	Roll	Pitch	Roll	TdegC
000	8947	9384	8947	9384	-59	-54	24.77
001	8950	9383	8950	9383	-56	-55	24.81
002	8946	9385	8946	9385	-60	-53	24.79
029	8917	9382	8917	9382	-89	-56	24.81
030	8911	9383	8911	9383	-95	-55	24.79
031	8910	9386	8910	9386	-96	-52	24.81
Measurement set complete.							
Avg:	8936	9384	8936	9384	-69	-53	24.81
Range:							0.05
Calculated offsets:			8936	9384			
Accept offsets (Yes/No) [Y] ? y							

The pitch and roll offsets are averages of the temperature corrected measurements. The calculations are automatic and the operator only needs to accept or reject the results. Look for stable values down each of the six pitch and roll columns. The quality of the calibration is also improved if the temperature is stable during measurement acquisition. A temperature range less than 0.1°C is also a good indicator of the quality of the calibration.

Solid State Tilt Calibration - Temperature and Scale Coefficients

Note that, in general, it will not be necessary for you to perform this part of the tilt calibration. We include this description of the procedure for completeness and “just in case”. Note that a full temperature and scale calibration takes upwards of 12 to 24 hours to complete and requires access to a MAVS sized refrigerator that allows you to communicate with the system while the door is closed and the instrument is inside. You may need to make a jumper using ribbon cable which can pass easily under the sealing gasket of the refrigerator door.

Determining the temperature coefficients requires that you run the tilt calibration utility once at each of two stable temperatures, preferably one near 0°C and the other near room temperature (~25°C). The system must be placed in its configured orientation and then not moved until both calibration runs have been completed. Shifting the unit between runs invalidates the calibration. We typically place the system in an un-powered refrigerator at room temperature to perform the first calibration pass. We then run the refrigerator overnight, reaching a stable temperature (i.e., thermal equilibrium) within a few degrees of 0°C, and perform the second calibration pass.

Condensation on the tilt sensor will invalidate the calibration; condensate will form within seconds if you remove the still cooled system from the refrigerator and expose it to ambient room temperatures and more humid air. Placing a desiccant inside the housing and/or flushing the housing with dry air or nitrogen before sealing it may help. Doing the high temperature pass first and allowing several hours for temperature equilibration after the low temperature test will also help. We actually use cooling fins and other massive heat sinks in a special calibration jig to reduce problems with condensation. Consider simply leaving the system in the refrigerator with the door closed and the power (to the refrigerator) disconnected for several hours or overnight before proceeding to the determination of the scale coefficients. A hair dryer may help, but we do not recommend it as standard practice. Patience and care generally produce better results.

With these caveats in mind, place the system in the configured orientation (e.g., Vertical/Down), make sure it is level (a carpenter's level will help), and secure it in place. Doing this means the tilt sensor itself is level. Close the refrigerator door, allowing the communications cable to pass under the gasket, and scroll the temperature using the Bench Tests analog channels utility (see Bench Tests) to verify that the temperature is stable. Run the tilt calibration utility after reaching thermal equilibrium and manually record the average values of uncorrected raw millivolts for pitch and roll and also the average temperature. It doesn't matter if you save the calculated offsets or not.

Turn on the refrigerator and wait for the system to reach a stable temperature near 0°C. You can check the temperature using Bench Tests. Turn off the refrigerator so that it won't start a cooling cycle in the middle of the calibration and run the tilt calibration utility a second time. Again, manually record the average values of uncorrected raw millivolts for pitch and roll and also the average temperature.

The temperature coefficients for pitch and roll, C_P^T and C_R^T , can now be calculated:

$$C_P^T = \frac{mV_H - mV_L}{T_H - T_L}$$

$$C_R^T = \frac{mV_H - mV_L}{T_H - T_L}$$

The H and L subscripts denote values from high and low temperature runs. The quantities in the numerators are the manually recorded averages of the uncorrected raw millivolts and the quantities in the denominators are the manually recorded average temperatures. The calculated values may be either positive or negative. Generally they will be in the range ± 5.0 mV/°C. The calculated values must be in the range ± 10.0 mV/°C.

You must now enter the temperature coefficients in the system configuration array. See Changing the System Configuration or follow the example below. Note the use of default scale coefficients at this stage. You should also use 0.02 for the scale coefficients.

```

Nobska Development MAVS3
Modular Acoustic Velocity Sensor
  Model 3
Version: mavs34_6.c S/N: 10414

Main Menu

Fri Mar 29 11:11:15 2002

<1> Set Time           <5> Bench Tests
<2> Flash Card Ops   <6> Deploy System
<3> Calibration      <7> Offload Data
<4> Low Power Sleep  <8> Contact Nobska

selection ? s Password: whipr ← select system configuration

```

System Configuration

Velocity:

<C> Binary to SI Conversion 0.0028033
<A> Analog Velocity Outputs Disabled

Analog Channels:

<W> warm up interval Fast (1 sec)
<1> 3-Axis Compass Enabled
<2> Solid State Tilt Enabled
<3> Conductivity Disabled
<4> Thermistor Enabled
<5> Pressure Enabled
<6> Auxiliary 1 Disabled
<7> Auxiliary 2 Disabled
<8> Thermistor Array Disabled

System Parameters:

<O> Sensor Orientation Vertical/Down
<S> Serial Number 10414
<Q> Query Character
<T> Power-On Time-Out 30 [sec]

Exit:

<X> Save Changes and Exit

Selection ? 2

← select tilt

Solid state tilt enabled (Yes/No) [N] ? y

Load default tilt coefficients (Yes/No) [N] ? n

← choose to set values manually

Pitch scale	Roll scale	Pitch tempco	Roll tempco
0.0200	0.0200	000.0000	000.0000

Enter pitch scale (000.0100 to 000.0500) ? 0.02 ← default value

Enter roll scale (000.0100 to 000.0500) ? 0.02 ← default value

Enter pitch temperature correction (-10.0000 to +10.0000) ? 3.448 ← calculated value

Enter roll temperature correction (-10.0000 to +10.0000) ? 1.778 ← calculated value

System Configuration

Velocity:

<C> Binary to SI Conversion 0.0028033
<A> Analog Velocity Outputs Disabled

Analog Channels:

<W> warm up interval Fast (1 sec)
<1> 3-Axis Compass Enabled
<2> Solid State Tilt Enabled
<3> Conductivity Disabled
<4> Thermistor Enabled
<5> Pressure Enabled
<6> Auxiliary 1 Disabled
<7> Auxiliary 2 Disabled
<8> Thermistor Array Disabled

System Parameters:

<O> Sensor Orientation Vertical/Down
<S> Serial Number 10414
<Q> Query Character
<T> Power-On Time-Out 30 [sec]

Exit:

<X> Save Changes and Exit

Selection ? x

← save the temperature coefficients

Storing system configuration information . . . done.

Wait for the system to return to the ambient temperature of the room before you begin the determination of the scale coefficients. Take care that condensation does not form on the tilt sensor or other portions of the electronics. Continue with the calibration only when the system is dry and is in thermal equilibrium with the room.

Place the system near its configured orientation and precisely measure its pitch and roll angles with a machinist's level. Adjust the orientation as necessary so that the measured pitch and roll angles are both 0° and secure the system in place. Run the tilt calibration utility and save the automatically calculated offsets. Note that these are the required physical offsets, taken at 0° of tilt and properly referenced to 0°C by the automatic temperature measurement.

Now tilt the system precisely 45° in pitch only. Scroll compass and tilt using the Bench Tests utilities and estimate the average pitch (displayed in degrees) by eye or by recording a series of readings and calculating the average. Manually record the average pitch. Stop the scrolling display and return the system precisely to the configured orientation, 0° of tilt. Now tilt the system precisely 45° in roll only. Scroll compass and tilt using the Bench Tests utilities and estimate the average roll (displayed in degrees) by eye or by recording a series of readings and calculating the average. Manually record the average roll.

The temperature coefficients for pitch and roll, C_P^S and C_R^S , can now be calculated:

$$C_P^S = \frac{\sin(45^\circ)}{\sin(A_P)} N_P^S$$

$$C_R^S = \frac{\sin(45^\circ)}{\sin(A_R)} N_R^S$$

A is the manually recorded average reading at 45° of actual tilt. N^S is the pitch or roll scale factor that was in use when the A value was being acquired, nominally 0.02. The calculated scale coefficients should be positive and should be approximately equal to the nominal values. They must be in the range 0.1 to 0.05.

You must now enter the scale coefficients in the system configuration array. See Changing the System Configuration or follow the example below. Note that the previously entered and stored temperature coefficients must be re-entered.

```

System Configuration

Velocity:
  <C> Binary to SI Conversion    0.0028033
  <A> Analog Velocity Outputs    Disabled

Analog Channels:
  <W> Warm up interval           Fast (1 sec)
  <1> 3-Axis Compass             Enabled
  <2> Solid State Tilt           Enabled
  <3> Conductivity               Disabled
  <4> Thermistor                 Enabled
  <5> Pressure                   Enabled
  <6> Auxiliary 1                Disabled
  <7> Auxiliary 2                Disabled
  <8> Thermistor Array           Disabled

System Parameters:
  <O> Sensor Orientation         Vertical/Down
  <S> Serial Number              10414
  <Q> Query Character
  <T> Power-On Time-Out         30 [sec]

Exit:
  <X> Save Changes and Exit

Selection ? 2                               ← select tilt

Solid state tilt enabled (Yes/No) [N] ? y
Load default tilt coefficients (Yes/No) [N] ? n ← choose to set values manually

Pitch   Roll   Pitch   Roll
scale  scale  tempco  tempco
0.0200 0.0200 000.0000 000.0000
Enter pitch scale (000.0100 to 000.0500) ? 0.01962 ← calculated
Enter roll scale (000.0100 to 000.0500) ? 0.02025 ← calculated
Enter pitch temperature correction (-10.0000 to +10.0000) ? 3.448 ← calculated
Enter roll temperature correction (-10.0000 to +10.0000) ? 1.778 ← calculated

```

System Configuration

Velocity:

<C> Binary to SI Conversion 0.0028033
<A> Analog Velocity Outputs Disabled

Analog Channels:

<W> warm up interval Fast (1 sec)
<1> 3-Axis Compass Enabled
<2> Solid State Tilt Enabled
<3> Conductivity Disabled
<4> Thermistor Enabled
<5> Pressure Enabled
<6> Auxiliary 1 Disabled
<7> Auxiliary 2 Disabled
<8> Thermistor Array Disabled

System Parameters:

<O> Sensor Orientation Vertical/Down
<S> Serial Number 10414
<Q> Query Character
<T> Power-On Time-Out 30 [sec]

Exit:

<X> Save Changes and Exit

Selection ? x

← save the temperature coefficients

Storing system configuration information . . . done.

This completes the full calibration of the tilt sensor. You should now scroll compass and tilt readings using the Bench Tests utilities to test the calibration. Vary the temperature and the pitch and roll. After a good calibration pitch and roll errors will typically be less than 0.5° over $\pm 45^\circ$ of tilt and 0°C to 25°C .

As always, feel free to contact Nobska if you require assistance.

Analog Channel Calibration Examples

Sample, conductivity, single thermistor, and pressure calibrations are presented below to give the reader greater familiarity with these procedures. Portions of the numerical display have been excised to keep the examples brief.

Calibration

<V> Velocity Offsets
<C> Compass Offsets
<T> Tilt Offsets
<M> Conductivity
<S> Single Thermistor
<P> Pressure Sensor
<A> Thermistor Array

<X> Save Constants and Exit

Selection ? m

← Conductivity calibration . . .

Conductivity Offset and Scale:

<R> Measure using a precision resistor
<W> Measure using water of known conductivity
<S> Set manually

Selection ? r

← . . . using a precision resistor

This routine allows the operator to measure the offset and scale coefficients of a conductivity sensor and store them in the system EEPROM. The zero offset will be determined by averaging 32 measurements taken while the sensor is exposed to a zero conductivity environment (air).

After measuring the offset the system will begin to scroll conductivity measurements from which the calculated offset has been subtracted. The operator should expose the sensor to an environment of known conductivity using either a precision resistor looped through the cell or a sample of standard seawater. When the scrolling values are stable, press <CTRL>-<X> and the system will calculate the average of the next 32 measurements.

The operator will then be prompted to enter the resistor value in Ohms or the conductivity of the water in mmho/cm and the system will calculate the scale factor. The offset and scale factors are used to fit a model of the form

$$\text{mmho/cm} = (\text{mV} - \text{offset}) * \text{scale}$$

to the data.

It is important to note that a more accurate calibration will be obtained using a sample of standard seawater with a precisely known conductivity. Calibration in seawater automatically takes into account the variations in cell form factor due to cell to cell variations and due to the proximity of the pressure housing. Resistor calibration is convenient, however, it necessarily assumes a nominal value for the cell form factor in converting the resistor value to a conductivity. Resistor calibration yields an accuracy level no better than 1% of the 75 mmho/cm full scale range of the cell. Seawater calibration can approach an accuracy level of 0.1% of the full scale range.

Continue with calibration (Yes/No) [Y] ?

Press any key to start measurement of zero offset.

Collecting a set of 32 measurements, 16 seconds . . .

```
000      17
001      16
002      18
. . .
029      17
030      16
031      16
```

Offset measurement set complete.

Calculated conductivity offset: 17
Accept offset (Yes/No) [Y] ?

Scrolling values have had the offset removed.

Expose the sensor to a known conductivity. Press
<CTRL>-<X> when the values have stabilized to
begin scale factor calculation.

```
1
-1
0
609
3006
3048
3054
3054
```

← This scrolling display can be paused and restarted by pressing any key. This is true for any of the calibration routines that have a scrolling display between the offset and scale measurements.

Collecting a set of 32 measurements, 16 seconds . . .

```
000      3053
001      3054
002      3055
. . .
029      3053
030      3052
031      3052
```

Scale measurement set complete.

Calculated average: 3053
Accept average (Yes/No) [Y] ?

Enter resistor value [Ohm] (0.0 to 1000.0) ? 50

← The conductivity in mmho/cm is given by $2840/R$, where R is the size of the resistor in Ohms. 2840 is a nominal value for this model conductivity cell. It assumes the cell constant is not altered by the MAVS3 housing.

Calculated scale factor: 0.018605
Accept scale factor (Yes/No) [Y] ? y

Selection ? s

← Single thermistor calibration

This routine allows the operator to change the calibration offset stored in the system EEPROM for a single external thermistor. Place the thermistor in a stirred ice bath at 0degC. This routine provides a scrolling temperature display. The displayed values are not calibrated - the current value of the offset has not been applied.

When the thermistor and ice bath have reached equilibrium and the readings have stabilized, press <CTRL>-<X> and the system will calculate the offset as the average of the next 32 measurements.

Continue with calibration (Yes/No) [Y] ?

Press <CTRL>-<X> when the values have stabilized.

22.38

← The calibration procedure was run at room temperature to

22.38

create this example for the manual. Any actual

22.38

calibration of the thermistor should be conducted with

22.38

the thermistor in equilibrium with at ice bath at 0°C.

Collecting a set of 32 measurements, 16 seconds . . .

000 22.38

001 22.36

002 22.38

. . .

029 22.38

030 22.38

031 22.38

offset measurement set complete.

Calculated thermistor offset: 22.383

Accept offset (Yes/No) [Y] ? n

Selection ? p

← Pressure calibration

Pressure offset and scale:

<M> Measure
<S> Set

Selection ? m

This routine allows the operator to measure the offset and scale coefficients of a pressure sensor and store them in the system EEPROM. The zero offset will be determined by averaging 32 measurements taken while the sensor is exposed to ambient surface (sea-level) pressure.

After measuring the offset the system will begin to scroll pressure measurements from which the calculated offset has been subtracted. The operator should expose the sensor to a known pressure, preferably one similar to those anticipated during the deployment. When the scrolling values are stable press <CTRL>-<X> and the system will calculate the average of the next 32 measurements.

The operator will then be prompted to enter the actual pressure in dbar and the system will calculate the scale factor. The offset and scale factors are used to fit a model of the form

$$\text{dbar} = (\text{mV} - \text{offset}) * \text{scale}$$

to the data.

Continue with calibration (Yes/No) [Y] ?

Press any key to start measurement of zero offset.

Collecting a set of 32 measurements, 16 seconds . . .

000	67
001	65
002	66
. . .	
029	66
030	66
031	65

Offset measurement set complete.

Calculated pressure offset: 66
Accept offset (Yes/No) [Y] ?

scrolling values have had the offset removed.

Expose the sensor to a known pressure. Press
<CTRL>-<X> when the values have stabilized to
begin scale factor calculation.

```
-1  
-1  
0  
-1
```

← The calibration procedure was run without a high pressure
source to create this example for the manual. Note
that the system detects the problem and rejects the
calibration.

Collecting a set of 32 measurements, 16 seconds . . .

```
000      -1  
001       1  
002      -2  
.  
029       0  
030       0  
031       0
```

Scale measurement set complete.

Calculated average: 0

WARNING -- Calculated average for scale calculation
must be non-zero. You must expose the
sensor to a pressure other than that used
for offset determination.

Pressure Offset and Scale:

```
<M> Measure  
<S> Set
```

selection ? s

```
Current pressure offset: 66  
Enter pressure offset (-500 to 4096) ? 66
```

```
Current pressure scale: 0.156447  
Enter pressure scale ( 0.0 to 10.0) ? 0.156447
```

<4> Low Power Sleep

MAVS3 systems are generally battery powered, so responsible energy management has been inherent in the design of the hardware and software from the beginning. The current drain of the MAVS3 depends strongly on what the system is doing and what auxiliary sensors are connected to the system. For example, the acquisition of an actual velocity measurement requires 400 mA. However, that drain lasts only 20 ms so that the actual energy used is quite small. For a measurement rate of 2 Hz (velocity, compass, tilt, and a thermistor) the average current drain is ~25 mA (this includes the RS-232/screen display current). Values for other situations can be found on the log sheet associated with a particular MAVS3. See also Power Consumption in MAVS3.

The typical drain while the system is waiting for input from the operator is ~2 mA. This is an acceptable level for the relatively brief periods of time required to test a system and program it for a deployment. However, it is too high when deployment duration is measured in weeks or months. For this reason MAVS3 has a low power sleep (LPS) mode in which the power drain is typically 0.5 - 0.7 mA (500 - 700 μ A).

During a deployment the system will enter the LPS mode whenever the sampling schedule makes a transition possible. The system will wake from LPS based on an alarm signal from the RTC or when commanded to wake by an operator. The system will also enter the LPS mode to await recovery when it completes a deployment. (The system will declare a deployment complete if the stop time is reached, if the flash card is full, or if the maximum number of data files has been reached.) When under the control of an operator the system will transition to LPS whenever it has waited more than 20 minutes for input from the user. As the system transitions to LPS it will display the current time and then indicate that it is sleeping.

To wake the system from LPS send three [CTRL]-[C]s. A prompt with a blinking '?' will be displayed after the second [CTRL]-[C]. You need to enter the third [CTRL]-[C] inside a 3 second window while the '?' is blinking or else repeat the entire sequence. The first two [CTRL]-[C]s can actually be almost any two keystrokes. The third character must be a [CTRL]-[C].

The Low Power Sleep option of the Main Menu commands a transition to LPS mode, allowing power conservation at the discretion of the operator. When the Low Power Sleep option is selected the system will display the current time and then indicate that it is sleeping. An example is shown below.

```
03/29/2002 12:02:15 Sleeping . . .  
Enter <CTRL-C> now to wake up?           ← send [CTRL]-[C]
```

<5> Bench Tests

The MAVS3 Bench Tests are a suite of scrolling displays of sensor output in various forms. The Bench Test utilities can be used both to verify the accurate operation of sensors before a deployment and as a training aid to familiarize the operator with sensor operation. For example, trigger one of the velocity displays, move the velocity sensor in a container of water in a controlled manner, and observe the changes to readings on the screen. Similarly, scroll compass and tilt or the analog channels, apply changes that the sensors can detect, and observe the result. [CTRL]-[X] terminates scrolling and returns to the Bench Tests menu. ([CTRL]-[C] terminates scrolling and returns to the Main Menu.) The display interval can be set by the operator using Option I. The Bench Tests menu is shown below.

```

      Bench Tests

Display:
<1> Raw Path Velocities (HEX)
<2> Calibrated Path Velocities (HEX)
<3> MAVS3 Frame (U, V, W)
<4> Earth Frame (E, N, W)
<5> Earth Frame (S,  $\theta$ , W)
<6> Compass and Tilt
<7> Analog Channels
<I> Display Interval [0.50 sec]
<U> Path Velocity Units [HEX]
<M> Main Menu

selection ?
```

The first five options present several forms of the MAVS3 velocity measurement.⁸ Option 1 displays the forward, reverse, and differenced velocities from each of the four acoustic axes in hexadecimal, 2s complement counts (see the attached articles for more information about the differential travel time technique). The differenced velocities are "raw" in the sense that the calibrated zero offsets have not been removed from them.

Option 2 scrolls calibrated velocities, differenced values from which the zero offsets have been removed. The velocities can be displayed in hexadecimal, 2s complement counts, decimal counts, or SI units of cm/s. Use Option U to select a format. The decimal counts (integers) are simply a different presentation of the 16 bit hexadecimal format with -32767 representing the maximum negative velocity and +32767 representing the maximum positive velocity. -32768 (8000_{HEX}) retains its role as the bad measurement flag. To convert from decimal counts to cm/s multiply by 0.0056066 cm/s/count. All three formats are available during deployments and data offload. The decimal and SI formats are particularly useful when used with numerical analysis software that is unable to read hexadecimal notation. Examples are shown below.

⁸ If the hardware is present and the option is enabled, the analog velocity outputs are active whenever any of the first five Bench Tests options are run.

<CTRL>-<X> to exit.

VA_F	VA_R	VB_F	VB_R	VC_F	VC_R	VD_F	VD_R	VA	VB	VC	VD
4510	46A8	4330	43A8	43A0	43F0	4288	4350	FE68	FF88	FFB0	FF38
4520	4620	4300	43A8	43B0	4400	4290	4348	FF00	FF58	FFB0	FF48
4508	4620	4308	43A0	43B8	4420	42A0	4330	FEE8	FF68	FF98	FF70

VA	VB	VC	VD	
FFA5	FF90	005B	FF9C	← calibrated velocities, hexadecimal, 2s complement
FF95	FFA8	005B	FFAC	
FF9D	FFA0	0063	FFB4	

VA	VB	VC	VD	
-91	-112	91	-100	← calibrated velocities, decimal counts
-107	-88	91	-84	
-99	-96	99	-76	

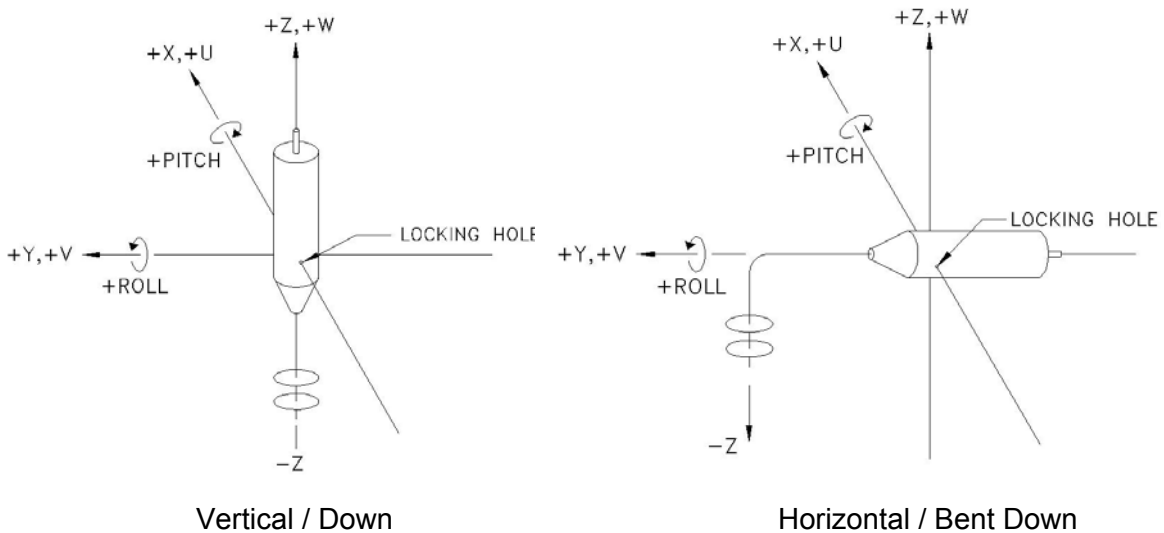
VA	VB	VC	VD	
-0.5	-0.6	0.5	-0.6	← calibrated velocities, SI units, cm/s
-0.6	-0.5	0.5	-0.5	
-0.5	-0.5	0.5	-0.4	

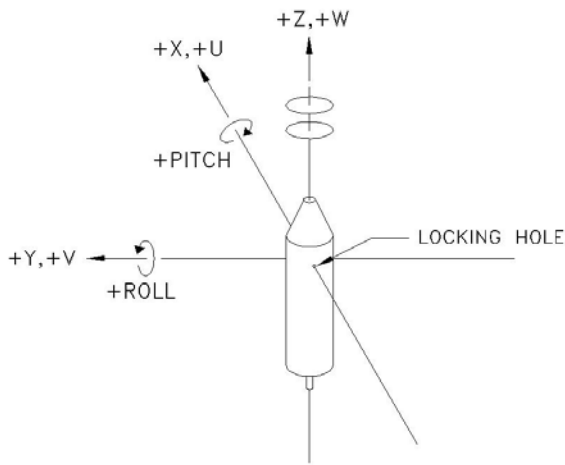
The four acoustic axes are each defined by a pair of transducers, one located on the proximal sensor ring (the ring closest to the pressure housing) and one located on the distal ring (the ring furthest from the pressure housing). Each axis crosses the ring planes at a 45° angle. The axes are spaced 90° apart around the circumference of the rings. Flow along an acoustic axis is defined to be positive when it flows from the transducer on the distal ring towards the transducer on the proximal ring.

The easiest way to identify a particular physical axis with a column on the screen display is to place the sensor in a bucket of water and begin scrolling velocity measurements using Option 1 or 2. While velocities are scrolling, block each transducer on one of the rings in sequence using a finger or thumb. The blocked axis will be flagged on the screen with a value of 8000.

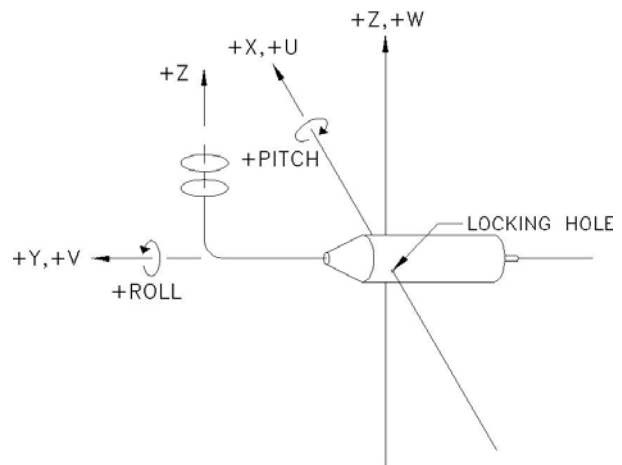
Options 3, 4, and 5 display three forms of the velocity vector using physical units. Option 3 scrolls the three Cartesian components, U, V, and W, of the velocity vector in the instrument frame. The orientation of the instrument frame with respect to the instrument housing depends on the sensor orientation selected in the system configuration (see Changing the System Configuration). Figures depicting each of the available sensor orientations are shown on the following pages. The directions of positive X, Y, Z, U, V, W, Pitch, and Roll are indicated in each figure. In all cases the co-ordinate frame is defined as follows:

1. The radial alignment hole for the end cap's flexible, nylon, retaining rod points along the negative X-axis. This is the direction of negative U velocities.
2. The +Z-axis points "up" (away from the center of the Earth) in the local Earth frame. (The X- and Y-axes are horizontal in the local Earth frame.)
3. The +Y-axis is such that +X, +Y, and +Z form a "right-handed", Cartesian co-ordinate system (thumb of right hand points along the +Z-axis, curled fingers of the right hand follow the 90° arc from the +X-axis to the +Y-axis).
4. Pitch is defined to be rotation about the X-axis. Positive pitch is defined by the "right hand rule" (thumb of right hand points along +X-axis, curled fingers of right hand show direction of positive pitch).
5. Roll is defined to be rotation about the Y-axis. Positive roll is also defined by the "right hand rule" (thumb of right hand points along +Y-axis, curled fingers of right hand show direction of positive roll).

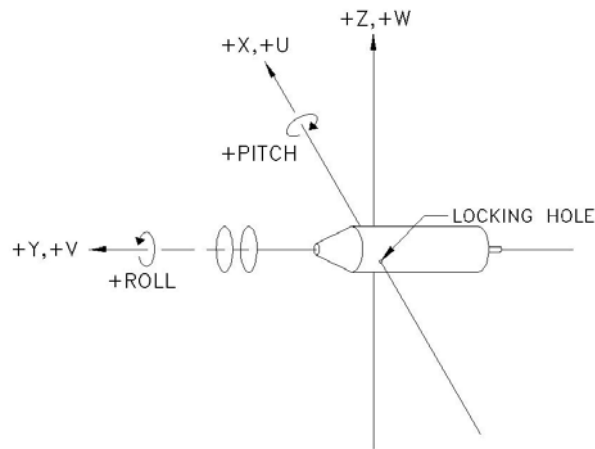




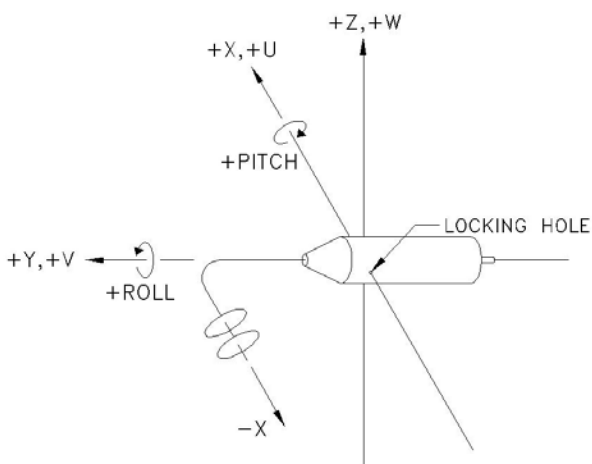
Vertical / Up



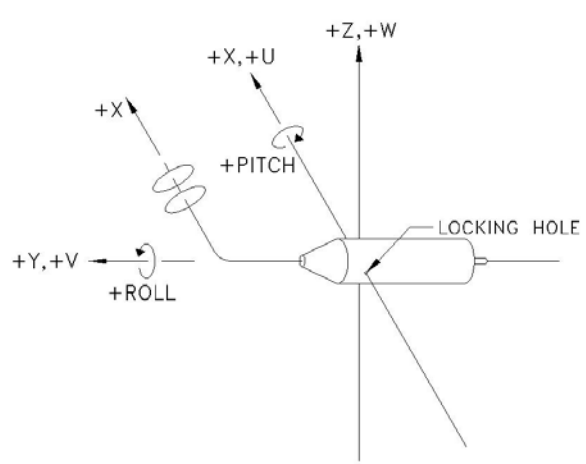
Horizontal / Bent Up



Horizontal / Straight



Horizontal / Bent Left



Horizontal / Bent Right

Raw path velocities, V_A , V_B , V_C , and V_D , are mapped to U , V , and W of the instrument frame by applying the following case dependent formulas:

Vertical / Down or
Horizontal / Bent Down

$$U = (-V_A + V_B + V_C - V_D) \cdot \beta$$

$$V = (-V_A - V_B + V_C + V_D) \cdot \beta$$

$$W = (+V_A + V_B + V_C + V_D) \cdot \beta / \sqrt{2}$$

Vertical / Up or
Horizontal / Bent Up

$$U = (-V_A + V_B + V_C - V_D) \cdot \beta$$

$$V = (+V_A + V_B - V_C - V_D) \cdot \beta$$

$$W = (-V_A - V_B - V_C - V_D) \cdot \beta / \sqrt{2}$$

Horizontal / Straight

$$U = (-V_A + V_B + V_C - V_D) \cdot \beta$$

$$V = (-V_A - V_B - V_C - V_D) \cdot \beta / \sqrt{2}$$

$$W = (-V_A - V_B + V_C + V_D) \cdot \beta$$

Horizontal / Bent Left

$$U = (+V_A + V_B + V_C + V_D) \cdot \beta / \sqrt{2}$$

$$V = (-V_A + V_B + V_C - V_D) \cdot \beta$$

$$W = (-V_A - V_B + V_C + V_D) \cdot \beta$$

Horizontal / Bent Right

$$U = (-V_A - V_B - V_C - V_D) \cdot \beta / \sqrt{2}$$

$$V = (+V_A - V_B - V_C + V_D) \cdot \beta$$

$$W = (-V_A - V_B + V_C + V_D) \cdot \beta$$

β is a scale and geometry factor, the binary to SI conversion constant, used to convert velocity from counts to cm/s. For the case of path velocities given in counts, β has a nominal value of 0.0028033 cm/s/count, which includes a factor of 1/2 to account for the geometry of the axes. The formulas in this case assume that the raw path velocities have been converted from 2s complement hexadecimal integers to signed decimal integers with units of counts.

For the case of raw path velocities given in cm/s rather than counts, it is only necessary to account for the geometry of the axes because the conversion to physical units has been performed internally. In this case, apply the formulas as given above, but use $\beta = 0.5$. See Changing the System Configuration for further discussion of β .

Option 4 displays the three Cartesian components of the velocity after rotation into a Cartesian Earth frame (East, North, Up or U_E , V_N , W_U). The rotation requires an enabled compass. Tilt information is used if it is available. Small tilt angles are assumed. The rotation is accomplished by executing the formulas below in order. If tilt information is not available, the tilt equations may be left out of the calculation or the pitch and roll can be set to zero.

$$\left. \begin{aligned} v_1 &= V \cdot \cos(P) - W \cdot \sin(P) \\ w_1 &= W \cdot \cos(P) + V \cdot \sin(P) \\ u_2 &= U \cdot \cos(R) + w_1 \cdot \sin(R) \\ w_2 &= w_1 \cdot \cos(R) - U \cdot \sin(R) \\ U &= u_2 \\ V &= v_1 \\ W &= w_2 \end{aligned} \right\} \textit{tilt equations}$$

$$\left. \begin{aligned} u_3 &= U \cdot MY - V \cdot MX \\ v_3 &= U \cdot MX + V \cdot MY \\ w_3 &= W \\ U_E &= u_3 \\ V_N &= v_3 \\ W_U &= w_3 \end{aligned} \right\} \textit{compass equations}$$

The lower case sub-scripted variables are simply place holders during the calculation. P and R are the pitch and roll. MX and MY are the normalized horizontal components of the 3-axis compass (see below).

Option 5 is also an Earth frame display, listing the velocity in terms of the 3-axes magnitude, the horizontal direction, and the vertical magnitude (Speed, Angle, Up). The magnitude is calculated as:

$$speed = \sqrt{U_E^2 + V_N^2 + W_U^2}$$

where U_E , V_N , and W_U are the east, north, and up components of the velocity in the earth frame. The angle is given in degrees and indicates the direction of flow in traditional compass co-ordinates (0° indicates flow to the north, 90° indicates flow to the east, 180° indicates flow to the south, and 270° indicates flow to the west). The angle can be calculated from the east (U_E) and north (V_N) components of the horizontal velocity in the Cartesian Earth frame as:

$$angle = \left(-\tan^{-1} \left(\frac{-U_E}{V_N} \right) \right) \cdot \left(\frac{180}{\pi} \right)$$

Be sure to use a four quadrant arctangent routine that returns radian values between $-\pi$ and $+\pi$. Add 360° to angles less than zero after the conversion from radians to degrees to convert the heading to traditional compass co-ordinates.

The units of all velocity components and magnitudes are cm/s. The Earth frame options are only enabled if the compass is enabled in the system configuration. Examples of the three velocity vector displays are shown below.

U	V	W
0.9	0.7	-1.7
0.5	0.7	-1.5
0.5	0.7	-1.5

East	North	Up
-0.5	0.9	-1.7
-0.6	0.8	-1.6
-0.8	1.0	-1.7

Speed	Angle	Up
1.9	332	-1.6
2.1	327	-1.6
1.9	326	-1.5

The velocity frames available from the Bench Tests menu are also available during deployments. The same calibration constants, physical units, and rotation calculations are used in both cases.

Option 6 scrolls compass and tilt readings when either or both are enabled in the system configuration. An example is shown below.

MX	MY	HDNG	Pitch	Roll	TdegC
0.971	0.240	283.9	2.9	-5.3	24.67
0.972	0.233	283.5	2.9	-5.2	24.69
0.972	0.235	283.6	2.9	-5.2	24.67

MX and MY are the horizontal components of the local magnetic field of the Earth. They are calculated from the three components of the compass measurement and the two components of the tilt measurement (if enabled). The three compass components are measured in the instrument frame, which may be tilted from the horizontal.

The compass senses the direction of the Earth's magnetic field with respect to the instrument housing by measuring the strength of the magnetic flux through three magneto-inductive sensors mounted parallel to the X-, Y-, and Z-axes of the instrument. Normalized compass components in the instrument frame, (mx , my , mz), are calculated from the measured magnetic flux vector, (F_x , F_y , F_z).

$$mx = \frac{F_x}{\sqrt{F_x^2 + F_y^2 + F_z^2}} \quad my = \frac{F_y}{\sqrt{F_x^2 + F_y^2 + F_z^2}} \quad mz = \frac{F_z}{\sqrt{F_x^2 + F_y^2 + F_z^2}}$$

Flux strength along a particular axis is proportional to the cosine of the angle between that axis and the Earth's magnetic field. The normalized compass components are, therefore, the direction cosines of the magnetic field in the frame of the instrument.

MX and MY are the re-normalized, horizontal components of the magnetic flux in the (horizontal) instrument frame. These are the quantities that are logged and displayed. The re-normalized components are precisely equivalent to the measurements of the gimbaled, 2-axis compass used in previous versions of the MAVS-3 hardware.

Relative horizontal components are calculated using the pitch and roll. Pitch and roll are assumed to be zero if the tilt sensor is not enabled.

$$MY = my \cdot \cos(P) + mx \cdot \sin(R) \cdot \sin(P) - mz \cdot \cos(R) \cdot \sin(P)$$

$$MX = mx \cdot \cos(R) + mz \cdot \sin(R)$$

Then those intermediate values are re-normalized for display and logging.

$$MY = \frac{MY}{\sqrt{MX^2 + MY^2}} \quad MX = \frac{MX}{\sqrt{MX^2 + MY^2}}$$

Heading is defined to be the orientation of the +Y-axis of the instrument frame with respect to magnetic North in the local Earth frame. In this construction, MX and MY are the direction cosines of the horizontal portion of the magnetic field. They are positive pointing to the north and negative pointing to the south. For example, MY will be +1 and MX will be 0 when the +Y-axis is pointing north (heading is 0°). Similarly, MY will be 0 and MX will be +1 when the +X-axis is pointing north (heading is 270° since the +Y-axis will then point west). In the example above, MY is +0.24, MX is +0.97, and the +Y-axis is oriented $\sim 14^\circ$ north of west.

Note that MX and MY are also, by construction, the (rotated) trigonometric sine and cosine of the heading angle:

$$MY = \cos(hdng) = \cos(284^\circ) = 0.24$$

$$MX = -\sin(hdng) = -\sin(284^\circ) = 0.97$$

Thus the heading of the positive Y-axis of the MAVS3 frame can be calculated from the compass data as:

$$hdng = \left(\tan^{-1} \left(\frac{-MX}{MY} \right) \right) \cdot \left(\frac{180}{\pi} \right)$$

Be sure to use a four quadrant arctangent routine that returns radian values between $-\pi$ and $+\pi$ and add 360° to angles less than zero after the conversion from radians to degrees. The result is traditional compass heading, where 0° indicates the +Y-axis is pointed north, 90° indicates that it points east, 180° indicates that it points south, and 270° indicates that it points west.

Option 7 scrolls the output of any enabled analog channels (conductivity, temperature, pressure, etc.). The TT8 analog-to-digital converter is a 12-bit device with an input range of 0 mV to 4095 mV (1 bit/mV). The outputs of sensors with 0 V to 5 V ranges are scaled to the range of the A/D in hardware with a resistive attenuator. That scaling factor is $3.83/4.83 = 0.793$. Hardware scaling is used for pressure and for the auxiliary channels, A1 and A2. It is not required for conductivity or temperature.

The voltages of the conductivity, temperature, and pressure sensors are normally scaled in software by Nobska for display in physical units (mmho/cm, °C, dbar). The labels are present in the display regardless of the actual scale factor. The two auxiliary channels are also normally scaled by Nobska to display in customer specified units for the particular sensors that have been integrated into the system (Formazin based FTUs for an optical backscatter sensor in the example). A millivolt label is included in the display when the scale constant is 1.0. No label is displayed otherwise.

Under some circumstances a user may wish to set the calibration constants of a channel to read the sensor voltage more directly. This can be done through the System Configuration menu (see Changing the System Configuration) or by using the Set option under one of the Calibration menu options (see Calibration). Set the offset to 0 (the units are millivolts) and the scale factor to 1.0 (mV/mV). Save the changes and write down the calibration values that are being replaced so they can be restored. Further display of that analog channel will be a direct or semi-direct (due to hardware scaling) reading of the sensor in millivolts.

C [mmho/cm]	T [degC]	P [dbar]	A1	A2 [mV]
-0.20	22.28	0.156	367.609497	
-0.20	22.28	0.469	378.959351	
-0.22	22.28	0.000	382.742645	

<6> Deploy System

The Deployment Definition Parameters

Option 6, Deploy System, has two distinct functions. First, it provides a user interface through which the operator enters the parameters that define a deployment. Once the deployment definition information is entered (and stored in the serial EEPROM) the operator can return to the Main Menu or proceed with the second function of this option, conducting the programmed deployment.

When Main Menu Option 6 is selected the system first sizes the flash card and then displays the interactive Deployment menu. The entire menu, shown below, is updated and re-displayed after each change is made.

```
Notes 1|
      2|
      3|

Time  N| Time Now          03/29/2002  11:22:00  [MM/DD/YYYY HH:MM:SS]
      S| Start Time       03/29/2002  11:00:00  [MM/DD/YYYY HH:MM:SS]
      T| Stop Time       03/29/2002  16:00:00  [MM/DD/YYYY HH:MM:SS]
      D| Duration         0  04:38:00  [DDD HH:MM:SS]

Data  F| Velocity Frame     MAVS3 Frame (U, V, W)      TTag FSec Axes
      M| Monitor          Enabled                    On  On  HEX
      L| Internal Logging Enabled          (38 bytes/sample)
      A| Append Mode      Disabled          (0 of 4090 files in use)
      V| Verbose Display  Disabled
      Q| Query Mode       Disabled

Sched 4| Measurement Frequency 2.0 [Hz]
      5| Measurements/Sample  1 [M/S]
      6| Sample Period       0.50 [sec]
      7| Samples/Burst      1 [S/B]
      8| Burst Interval      000 00:00:00 [DDD HH:MM:SS]
      9| Bursts/File         1000 [B/F]

      G| Go (<CTRL>-<G> skips checks)
      selection ?
```

Textual information identifying the deployment can be entered in the three Notes lines. Each line can contain up to 65 characters documenting, for example, the name of the experiment, the location, the cruise station, and whatever else it may be useful to log with the data file that will eventually be produced.

The Time options allow the operator to set the RTC, the start time, the stop time, and the duration of the experiment. These are not entirely independent quantities. When the start time is earlier than the current time, measurements will begin immediately after the operator starts the deployment. If the start time is later, measurement acquisition will be delayed until the start time is reached. Data acquisition is terminated when the stop time is reached if the deployment has not already been terminated by the operator or by the system when the capacity of the flash card or of the file system has been reached. The stop time must be later than the start time and all times must be in the allowed range (years 1970 to 2038). The duration is measured from the RTC or the start time, whichever is later, to the stop time. The duration is recalculated by the system whenever one of the other quantities is changed. The stop time is recalculated from the RTC or the start time, whichever is later, whenever the duration is changed. It is the stop time that terminates a deployment, but the operator has the option of setting that time by entering it directly or by entering a duration for the experiment.

Using the Data options the operator can:

F	Select the frame, if any, to be used for the display and storage of vector averaged velocity data (e.g., Earth Cartesian, see Bench Tests).
M	Enable or disable the data monitor, the screen display of data during the deployment. The monitor can be used when a serial communication link is available during a deployment and during bench testing and operator training.
L	Enable or disable data logging to the flash card (automatically disabled if no flash card is present). The number of bytes in a sample depends on which sensors are enabled, whether a velocity frame is selected, and the state of the TTag, FSec, and Axes flags (see below). Variable record length allows efficient use of available space on the flash card (see below).
A	Enable or disable append mode. Existing data files are preserved and file names are added to the existing sequence as new data are stored when append mode is enabled. When disabled, all existing data files are deleted at the start of a deployment and the sequence of file names for new data begins with DATA0001.BIN. See the discussion below.
V	Enable or disable verbose display mode when the data monitor is enabled. In verbose mode a column header identifying the contents of the column and the physical units used (if applicable) is displayed every ten records. If verbose mode is disabled the column header is displayed only once, at the start of the deployment.
Q	Enable or disable query mode. In query mode the acquisition of each burst must be triggered by an operator through the serial communication link. All MAVS3 units recognize a carriage return as a valid query character. An additional alphanumeric query character can be set for each individual unit in the system configuration. Burst timing is controlled by the burst interval when query mode is disabled.

Data selection for the data monitor and for logging are not independent operations; the data that are displayed are the same as the data that are logged (assuming both the data monitor and data logging are enabled). The exception to this rule is enabling analog velocity outputs, which will force logging, but not display, of velocity measurements from each of the four acoustic axes (see below). Note that the analog velocity outputs can be active without enabling the data monitor.

Whenever the data monitor or logging are enabled or re-enabled the operator will be prompted to set the TTag, FSec, and Axes flags. TTag controls the storage and display of the date and time for each data record (MM/DD/YYYY HH:MM:SS). Similarly, FSec controls the storage and display of the fractional seconds portion of the time tag (SS.SS). The Axes flag controls the storage and display of velocity measurements from each of the four acoustic axes. This selection is independent of the choice of a vector velocity frame. In the Deployment menu above all three quantities are enabled and will be logged and displayed. The acoustic axes velocities will be displayed in hexadecimal, 2s complement counts. The default for all three flags is "On" and the default display format for the acoustic axes is hexadecimal counts. The axes can also be displayed in decimal counts or SI units (cm/s). See Bench Tests.

```
Enable Data Monitor (Yes/No) [N] ? y
Log/display time tag (MM/DD/YYYY HH:MM:SS)
with each sample (Yes/No) [Y] ?
Log/display fractional seconds (SS.SS)
with each sample (Yes/No) [Y] ?
Log/display acoustic axis velocities
with each sample (Yes/No) [Y] ?
Acoustic axis velocities can be displayed in
a Hexadecimal, Decimal, or SI (cm/s) format.
Set acoustic axis velocity format (HDS) [H] ?
```

Variable record length permits more efficient use of the available space on the flash card. Earlier versions of the system control program used a fixed length, 46 byte, record, always stored a full time tag, and could not independently select the acoustic axes and a vector velocity for display and storage. The table below shows the number of bytes per logged sample required for each selected sensor or data option. Data are stored in binary forms which are readily scaled during unpacking to values with meaningful physical units (see Offload Data). The thermistor array (3 thermistors) is assigned to the same analog-to-digital hardware channels as the single thermistor and the two auxiliary inputs. Those selections are, therefore, mutually exclusive.

Selected Option	Bytes Required
Date and Time	4
Fractional Seconds	4
Acoustic Axes	8 (2 bytes / axis)
Velocity Vector	6 (2 bytes / component)
Conductivity	2
Thermistor	2
Pressure	2
Auxiliary 1	2
Auxiliary 2	2
Thermistor Array	6 (2 bytes / thermistor)
Compass	4 (2 bytes / component)
Tilt	4 (2 bytes / component)

When append mode is enabled the Deployment menu displays the existing number of data files and the maximum number of files allowed under DOS/Windows. When disabled the display shows zero files in use. If append mode is enabled or re-enabled or the operator starts a deployment, the system will examine the flash card to determine its unused capacity. Warnings will be displayed if less than 50% of the physical space remains available or if fewer than 50% of the maximum allowed number of files remain available. Warnings will also be displayed if no memory or file system space is available. If the system is deployed with either the memory or the file system full, the deployment will be automatically terminated when the system first attempts to log data. No new data will be stored until the operator clears space on the card, presumably after making an archive, or append mode is disabled. In the latter case the system will reformat the card when the deployment begins.

It is important to note that the data and option/configuration selections may constrain system performance. For example, with the data monitor enabled, the data acquisition rate may be limited by the baud rate of the serial communication port. Similarly, enabling the compass will normally limit the measurement rate to 10 – 15 Hz. As a result, some situations may require tradeoffs to achieve particular science goals. Nobska Development can provide advice, based on our own experience, if you require assistance programming a MAVS3 for one of these situations.⁹

The Scheduling options, described below, are used to control data acquisition. Options 4 to 7 have automatic dependencies within a hierarchy. This means that altering one value may change one or more of the others to maintain logical consistency. For example, the sample period must be equal to the product of the measurement period and measurements/sample.

4	Measurement Frequency: The rate at which measurements are taken to form a sample (applies to all enabled sensors).
5	Measurements/Sample: The number of individual measurements that are averaged to form a sample (applies to all enabled sensors, see the discussion in Measurement Averaging (Measurements/Sample)).
6	Sample Period: The interval between samples.
7	Samples/Burst: The number of samples (single data records) in a burst. Each sample is displayed if the data monitor is enabled and logged if flash card logging is enabled.
8	Burst Interval: The interval between bursts. Set this to zero (more generally set it too small for burst completion) to select continuous sampling. Burst interval selection is disabled when query mode is enabled.
9	Bursts/File: MAVS3 uses multiple data files to protect existing data from system failures and operator errors during recovery. This parameter controls the number of bursts that are stored in the active data file before it is closed and a new active data file is opened. Recall that DOS/Windows limits the total number of files in a directory, so this selection can limit the duration of a deployment (see below for further discussion).

⁹ The performance question we are asked most often is "How fast can a MAVS3 make measurements?" The answer is "somewhere above 35 Hz", a rate that has some utility in the investigation of turbulence. To achieve this measurement rate, all non-essential features must be turned off. First, disable the compass, which cannot run faster than approximately 10 – 15 Hz. Then increase the system clock frequency to 16 MHz and disable tilt and all of the auxiliary sensors. Set the system to log the data. Do not display it through the data monitor or the baud rate will limit sampling speed. Do not use a vector velocity frame because too many calculations are required to convert the raw measurements. Log only the time and the raw axes velocities. Set measurement frequency to its maximum value (the measurements will be almost synchronous), measurements/sample to 1 (no averaging calculations), samples/burst to 1 (or higher, not a strong dependence), burst interval to 0 (continuous sampling), and bursts/file to its maximum value (to minimize file creation operations). The system will "top out" at about 36 Hz with these settings.

With the monitor enabled the baud rate can be set to 38400 at most; the system clock is internally set to 16 MHz during a measurement cycle and the system will not support 57600 baud at 16 MHz. Using the monitor with those clock and baud rate settings (and perhaps a few analog channels enabled, but not the compass) the top sampling rate will be 15 Hz to 30 Hz. There will be some dependence on the selection of a velocity frame and the use of any analog channels. Displaying only the raw axes with all other sensors disabled will be fastest. Further experimentation with the settings is encouraged.

Measurement Averaging (Measurements / Sample)

Averaging is performed when more than one measurement per sample is programmed for a deployment. Averaging scalar quantities such as conductivity, temperature, and pressure is an unambiguous and straightforward operation. This is true whether or not the system experiences changes in position and/or orientation while making the measurements that are used to form a sample. The operator is, of course, responsible for choosing an averaging interval that is consistent with the phenomena of interest. For example, a short interval of a second or less might be used to capture pressure variations caused by wave motions. Alternatively, an interval of a minute or even several minutes might be used to "average out" the wave motions. Similar considerations apply to instruments mounted on moorings.

Somewhat more care must be taken with velocity vectors. Each component of the vector must be computed from the raw velocity, compass, and tilt information of each measurement. It is the components of those velocity vectors that must be individually averaged. This is commonly referred to as vector averaging. Vector averaging is used in MAVS for the two vector velocity frames, the Cartesian instrument frame and the Cartesian earth frame. In the case of the speed and heading earth frame, the velocity is first averaged in the Cartesian earth frame and the final vector average is converted to speed and heading.

Operators should recognize that vector averaging in the Cartesian instrument frame produces meaningless values if the instrument is allowed to change position and/or orientation during the averaging interval. Do not use the MAVS instrument frame on a mooring if you have programmed more than one measurement per sample. Vector averaging in the Cartesian instrument frame should only be considered when the instrument is rigidly mounted.

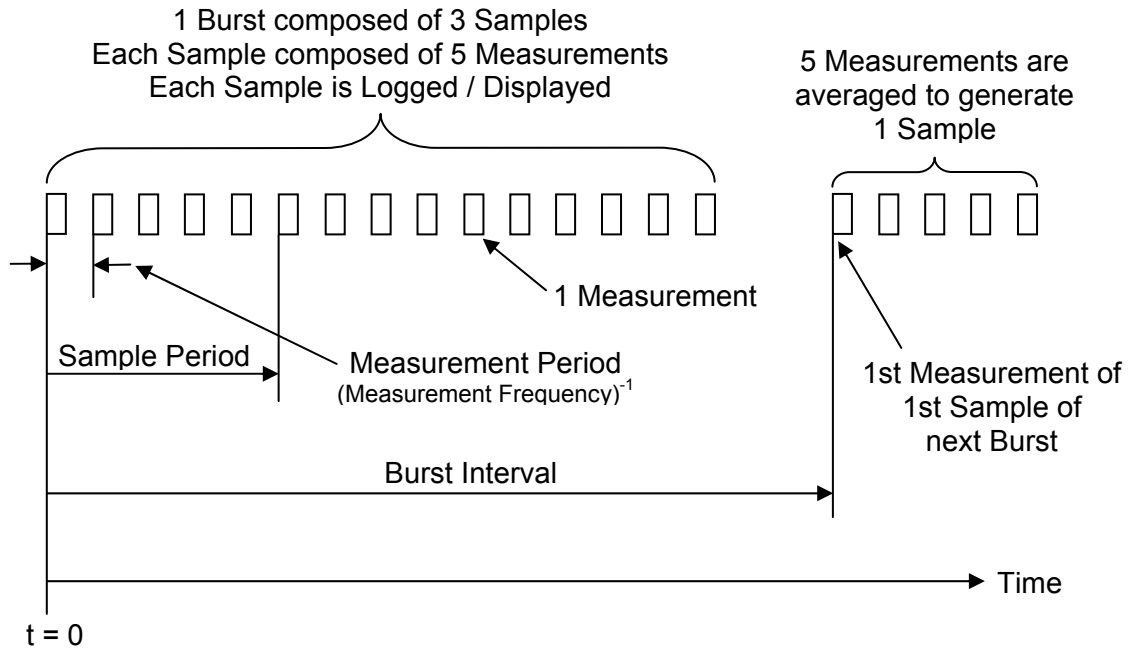
The same restrictions apply to the raw velocity axes and to the compass and tilt measurements. Averaging these measurements will produce meaningless results if the instrument is changing position and/or orientation during the averaging interval. If, however, the MAVS is rigidly mounted, averaging the raw axes can have considerable utility. Compass and tilt averaging could be used, but those values are, at least nominally, not changing over time.

To accommodate these several possibilities, compass and tilt measurements are made and applied during each measurement cycle within a sample. However, it is the last set of compass and tilt measurements, not a set of averages, that is displayed and logged. This is consistent with the needs of both moored and rigidly mounted instruments.

Averaging of the acoustic axes can be enabled or disabled at the discretion of the operator. To display and log averages of each of the acoustic paths set the Velocity Frame to No Velocity Frame on the Deployment menu. This setting can be used when the MAVS is rigidly mounted. On a mooring, where averaging must take place in the earth Cartesian frame, set the Velocity Frame to Earth Frame (E, N, W) and turn on the raw axes. The velocity vector that is displayed and logged is vector averaged. The velocity axes that are displayed and logged are the last set of acoustic axes measurements from the sample acquisition cycle.

Measurement Cycle Timing

A brief discussion of parameter selection for oceanographic investigations can be found in the Example Configurations section of this manual. For clarity, a timing diagram for a hypothetical measurement cycle is shown below. In this example the system has been set to average five measurements in each sample, with three samples in each burst. The burst interval has been set to a value that is longer than the time required to complete the fifteen measurements in the burst, so there is a gap between the end of one burst and the beginning of the next.



Example Timing Cycle
5 Measurements per Sample, 3 Samples per Burst

Setting Bursts / File

As previously noted, the storage of data on the flash card is constrained both by the capacity of the card and by the DOS/Windows stricture of a maximum number of files. The Bursts/File parameter allows the operator to adjust data storage so that both limits are reached at the same time, minimizing unused space and maximizing data protection. The system calculates this optimized value based on current deployment parameters and displays it when Option 9, Bursts/File, is selected. The operator may, of course, opt for greater data protection by placing fewer bursts in each file. Alternatively, more bursts/file may be programmed so that the physical capacity of the card is the sole limit. This may be the preferred choice when the burst interval is zero (continuous sampling) and the sample interval is 0.5 second or less. At those sampling rates there is a delay of ~600 ms in measurement acquisition while one data file is closed and the next one is opened. Storing more data in each file will decrease the number of short gaps in the data stream.

Consistency and Capacity Checks

Select Option G, Go, once the deployment definition is complete. The system will conduct a series of checks on the entries. These include simple consistency checks and also calculations of battery and memory capacity based on the entered parameters. When the results of a check are displayed the operator will be given the opportunity to return to the Deployment menu to make changes or to continue with the deployment. A sample interaction, based on the deployment definition parameters displayed earlier in this section, is shown below.

Selection ? g	← Select Option G [CTRL]-[G] would skip the checks below.
Checking selections for range violations . . . done. Operator selections are within prescribed limits.	
Performing consistency check on selections . . . done.	
Continuous sampling selected.	
Change selections (Yes/No) [N] ?	← Return to Deployment menu ?
Battery longevity calculation (0 for unlimited external power or to skip calculation):	← Battery longevity calculation The calculation is approximate. It <u>does</u> include the drain of the auxiliary sensors.
Enter battery capacity [Ahr] (0.0 to 100.0) ? 4.8	← Capacity of standard MAVS3 alkaline battery pack, use 9.6 Ahr for the available lithium battery pack
The battery will support the programmed sampling schedule for approximately 817794 bursts, a period of 2 days, 23 hr, 40 min, and 3 sec and will expire as shown below:	
Time Now: 03/29/2002 11:22:18 Start Time: 03/29/2002 11:00:00 Expiration Time: 04/01/2002 11:02:21 Stop Time: 03/29/2002 16:00:00	← Consider this value when setting the stop time
Change selections (Yes/No) [N] ?	← Return to Deployment menu ?
The installed flash card has sufficient space for 7896214 bursts (1 Samples/Burst, 38 Bytes/Sample). The file system can accommodate 4090 data files.	← Flash card and file system capacities check
The sampling schedule and the programmed value of Bursts/File will allow storage of 4090000 bursts in 4090 files.	
Acquisition of these bursts will require a period of approximately 45 days, 16 hr, 41 min, and 47 sec, which will expire as shown below:	
Time Now: 03/29/2002 11:22:26 Start Time: 03/29/2002 11:00:00 Expiration Time: 05/15/2002 04:04:13 Stop Time: 03/29/2002 16:00:00	
Change selections (Yes/No) [N] ?	← Return to Deployment menu ?

```

Start time has already passed. Measurements
will begin immediately after operator commits
to a deployment.

Change selection (Yes/No) [N] ?           ← Return to Deployment menu ?
Deployment preparation is complete.

Storing deployment definition information . . . done.   ↓ Deployment definition information
                                                         stored on EEPROM

CAUTION: Append Mode disabled.             ← Last chance to archive any data
      All data on the flash card will be       remaining on the flash card
      deleted when deployment begins.

Deploy system (Yes/No) [Y] ?             ← Operator "commits to the
                                                         deployment"

```

The selection of checks and diagnostic messages depends, to some extent, on the settings of the deployment definition parameters. For example, if append mode were enabled, the system would check the card and file system for remaining space. Warnings would be displayed if less than half of either resource remained. Further warnings that the deployment, if begun, would be automatically terminated would be displayed if the card or file system were full. The warning for append mode disabled is shown in the example.

The capacity of the standard MAVS3 alkaline battery pack is 4.8 Ahr ("Amp-hours"). A comparable lithium battery pack has a capacity of 9.6 Ahr. The battery longevity calculation is fairly accurate, though patterns of use may limit the energy available from a battery. This is particularly true of alkaline cells. The calculation is conservative in that a fresh battery will generally last a little longer than the estimate. The calculation cannot account for the previously expended capacity of a used battery. That is the responsibility of the operator.

The longevity calculation is based on the measured current drain for a baseline system (velocity, compass, tilt, single thermistor or thermistor array, flash card) in each of several possible states (active measurement, low power sleep, etc.). The current drains of various auxiliary sensors (conductivity, pressure, OBS, etc.) have also been measured and are included in the calculation when those options are enabled. The programmed sampling schedule is also factored into the calculation.

The average current drain of each MAVS3 is measured for several standard deployment scenarios during production and testing. Those values are documented on the log sheet provided with each unit. Users are encouraged to make their own measurements of average current drain on the bench with the system executing the sampling schedule they intend to use. The latter is the most accurate approach when determining battery life and deployment longevity.

Three operational warnings are in order. First, disabling a sensor in the system configuration (see Changing the System Configuration) does **not** remove the drain that sensor imposes on the battery. Disabling only removes the measurements of that sensor from the data stream. The sensor must be unplugged from the main MAVS3 circuit board inside the pressure housing to eliminate the current drain. Nobska can provide assistance should you require it.

Second, running MAVS3 after the battery voltage drops below ~9.5 V will produce very poor quality velocity data. The system will still run, but the measurements will be extremely inaccurate. The accuracy of some auxiliary sensors will be compromised below ~10 or even ~11 volts. This information is provided on the unit log sheet.

Third, running the TT8 below ~3 V can corrupt the flash memory where the system control program resides. There is a small, but finite possibility that the control program and/or the data files will be corrupted. Another possibility with an extremely weak battery is that the voltage draw-down associated with the current spike of a velocity measurement will be sufficient to restart the TT8. An unattended restart with append mode disabled will delete all files on the flash card and begin a new deployment. **Given the possibility of a delayed recovery due to weather or other cause, Nobska Development strongly suggests that the operator program a stop time that is consistent with the battery longevity calculation.** Using append mode is also recommended. However, if the full capacity of the card is required for the deployment, the operator must manually remove old data and configuration files when append mode is enabled. The flash card can be manually cleared using the utilities on the Flash Card Ops menu.

When the checks are complete the system will store the deployment definition information on the serial EEPROM and display a caution message about data on the flash card. The message depends on the state of append mode. The operator will then be prompted to "commit to the deployment". If append mode is disabled, this is the last opportunity to archive any data remaining on the flash card. The operator can return to the Main Menu or continue with the deployment.

When the entered parameters are known to be satisfactory, the checks can be bypassed at the discretion of the operator. To bypass the checks press [CTRL]-[G] followed by [ENTER] (instead of 'g' or 'G' followed by [ENTER]). The system will store the deployment definition information and proceed directly to deployment initialization. All operator prompts, including the "commit to the deployment" prompt, will be skipped.

WARNING: If the operator chooses to continue with the deployment and flash card data logging is enabled and append mode is disabled, the flash card will be reformatted during deployment initialization. File recovery software will not be able to recover existing files. All data files from the previous deployment will be permanently deleted. If the operator uses [CTRL]-[G] to bypass the checks there will be no prompt allowing a return to the Main Menu. The system will proceed with deployment initialization and any existing data files will be lost. **Always make sure existing data files are properly archived before committing to a deployment.**

If the operator chooses to continue with the deployment the system will run through several deployment initialization steps and begin taking measurements as soon as the start time is reached. (The measurements will begin immediately after initialization if the start time has already passed.)

Monitoring the Deployment

```

Initializing flash card (5 sec / 100 Mbyte) . . . ← System prepares the flash card
  Storing system configuration information . . . done.   to receive data. System
  Storing deployment definition information . . . done. configuration information
  Resizing flash card . . . . . done.                 and deployment definition
                                                    are stored on the flash card.

Initializing data record structures.

Opening data file DATA0001.BIN for storage of MAVS3 deployment data.

Storing initial file count . . . done.

    >>> Remove communications cable <<<
    >>> Attach dummy plug <<<

    >>> MAVS3 is ready to deploy <<<
    >>> <CTRL>-<C> to terminate deployment <<<

                                                    ← Data collection begins

  Date      Time    FS  VA   VB   VC   VD      U      V      W   mmho/   T
MM DD YYYY HH MM SS.SS HEX  HEX  HEX  HEX  cm/s   cm/s   cm/s   cm      degC
03 29 2002 11 24 36.37 FDC5 FF70 FF1B FF8C   0.9    1.0   -2.1 -0.24 22.21
03 29 2002 11 24 36.90 FE25 FF48 FEDB FF84   0.3    0.7   -2.1 -0.19 22.21
03 29 2002 11 24 37.41 FE65 FF50 FF33 FF64   0.5    0.6   -1.8 -0.24 22.21
03 29 2002 11 24 37.90 FE4D FF20 FF23 FF74   0.4    0.8   -2.0 -0.20 22.21
03 29 2002 11 24 38.40 00BD FF28 FF4B FF84  -1.3   -0.8   -0.6 -0.22 22.21

  P          A1          MX   MY   Pitch   Roll
dbar         dbar         deg   deg
0.47         0.630548  0.96  0.28   3.0   -5.1
0.78         0.000000  0.96  0.29   3.0   -5.1
0.63         0.630548  0.95  0.30   3.0   -5.1
0.63         1.261096  0.96  0.28   3.0   -5.1
0.63         0.630548  0.95  0.30   3.0   -5.0

    ← operator sends [CTRL]-[C] to terminate the deployment

```

Five data records are shown in the example above. The lines are displayed in two groups here in the manual because of the length of the records. The width is due to the large number of enabled features and sensors in this example. There would be no wrapping in a Crosscut terminal window on a PC. In the ASCII data stream from the serial port there is only one newline (carriage return/line feed) associated with each record.

The first six columns are the date (MM DD YYYY) and 24 hour time in hundredths of a second (HH MM SS.SS). The following seven columns are the four velocities along the acoustic axes (hexadecimal, 2s complement) and the three components of the velocity vector in the MAVS3 Cartesian reference frame (U, V, W, cm/s). The velocities are followed by conductivity (mmho/cm), temperature (°C), pressure (dbar), and the optical backscatter sensor on auxiliary channel 1 (FTU). The final four columns are the normalized components of the compass (MX and MY) and the pitch and roll from the tilt sensor (°). Calculating quantities such as instrument heading or direction of flow is described under Bench Tests.

The column header identifies the contents and physical units (if applicable) of each column. The column header is displayed at the beginning of each deployment if the data monitor is enabled. If verbose mode is also enabled, the column labels are re-displayed every ten records throughout the deployment.

Deploy System and Offload Data use the same verbose and non-verbose screen formats for data presentation. Verbose mode is useful for human readers while they become familiar with the system, but the format is not suitable for direct loading to most numerical analysis programs. Once familiar with the presentation of a particular sensor suite the non-verbose mode will be more useful as it allows the operator to focus on the running changes of a particular variable of interest.

Deployment complete. Proceed to Offload Data.

<7> Offload Data

The Offload option works with the file capture utility of Crosscut (or other serial communications program). Offload simply unpacks the binary data stored in the data files on the flash card and scrolls the contents to the screen as ASCII text. There it can be read by the operator and captured by the serial communications program for storage in an ASCII text file on the PC. Essentially all numerical analysis packages can work with ASCII text. See Operating Crosscut for more information about file capture.

The speed of offload is limited by the baud rate of the serial communications port. The default baud rate under Version 1.8 and higher of the system control code is 38400. This can be increased to 57600, but not higher (see Changing the System Configuration). Compact flash cards with capacities greater than 300 Mbyte are currently available and can be used with MAVS3. The conversion of binary data to ASCII text expands the number of bytes that must pass through the serial port by a factor of approximately four. At 38400 baud nearly four days would be required to dump 300 Mbyte of stored measurements. Offload will recover the data, but its real utility is clearly for training and bench testing with relatively small data sets.

To solve this problem, Nobska has developed MAVSPack, a DOS/Windows compatible, PC executable, data unpacker for MAVS3. To recover data using MAVSPack, the flash card must be transferred from the MAVS3 system to a PCMCIA slot on a PC. Compact flash card readers that attached through the USB or parallel ports of a PC are commercially available for systems without an internal flash card slot. The binary data, system configuration, and deployment definition files are copied from the card to the hard disk at bus speeds, creating a binary archive for the experiment. The archive can easily be replicated on an optical disk as well. MAVSPack can now operate on the data without the bottleneck of the serial port. 300 Mbytes of binary data can be archived and processed in less than 5 minutes, including the time it takes to open the pressure housing and transfer the flash card. The remainder of this section describes the on-board offload utility. For further information about MAVSPack see Operating MAVSPack.

Offload uses the same data presentation format as the data monitor during a deployment. Both can be operated in verbose or non-verbose mode. In non-verbose mode the contents of the data files are simply scrolled to the screen as ASCII columns of numbers. The column header identifying the contents and physical units of each column is displayed only once, at the beginning of the offload. The column header is re-displayed every ten records in verbose mode. The verbose mode is intended primarily for human readers during training. The non-verbose mode is suitable both for experienced humans and for numerical analysis programs.

Before unpacking and presenting data, offload recovers configuration and deployment definition information from files on the flash card. This information has traveled with the data and records the conditions under which the data were acquired. This approach also supports the fast unpacker.

WARNING: The configuration and deployment definition files on the card, CONFIG.BIN and DEPLOY.BIN, are re-written each time a deployment begins. In append mode they are re-written each time the system is re-started. If the operator makes any changes to either the configuration or the deployment definition information between re-starts the system may be unable to unpack data that has already been recorded. Recreating the original CONFIG.BIN and DEPLOY.BIN may be the only recourse. If configuration or deployment definition changes are necessary when using append mode, all existing files, both data and data definition, should be archived and the flash card should be reinitialized before re-deploying the system.

Note that offload only reads from the flash card. The data remain resident and are not altered by the unpacking process. The data are deleted only when the system is re-deployed and then only if flash card logging is enabled and append mode is disabled.

The example below shows a brief deployment followed by a data offload conducted in non-verbose mode. To recover the data simply start the Crosscut file capture utility and begin the offload.

```
Notes 1| Offload example for version 4.6 manual
      2|
      3|

Time  N| Time Now           03/29/2002  11:25:29  [MM/DD/YYYY  HH:MM:SS]
      S| Start Time         03/29/2002  11:00:00  [MM/DD/YYYY  HH:MM:SS]
      T| Stop Time          03/29/2002  16:00:00  [MM/DD/YYYY  HH:MM:SS]
      D| Duration           0  04:34:31  [DDD HH:MM:SS]

Data  F| Velocity Frame     MAVS3 Frame (U, V, W)      TTag FSec Axes
      M| Monitor           Enabled                   On   On   HEX
      L| Internal Logging   Enabled (38 bytes/sample)
      A| Append Mode       Enabled (0 of 4090 files in use)
      V| Verbose Display   Disabled
      Q| Query Mode        Disabled

Sched 4| Measurement Frequency 2.0 [Hz]
      5| Measurements/Sample 1 [M/S]
      6| Sample Period       0.50 [sec]
      7| Samples/Burst      1 [S/B]
      8| Burst Interval      000 00:00:00 [DDD HH:MM:SS]
      9| Bursts/File         1000 [B/F]

      G| Go (<CTRL>-<G> skips checks)

      selection ? •                               ← [CTRL]-[G] entered to skip checks
```

Storing deployment definition information . . . done.

CAUTION: Append Mode disabled.
All data on the flash card will be
deleted when deployment begins.

Initializing flash card (5 sec / 100 Mbyte) . . .
Storing system configuration information . . . done.
Storing deployment definition information . . . done.

Initializing data record structures.

Opening data file DATA0001.BIN for storage of MAVS3 deployment data.

Storing initial file count . . . done.

>>> Remove communications cable <<<
>>> Attach dummy plug <<<

>>> MAVS3 is ready to deploy <<<
>>> <CTRL>-<C> to terminate deployment <<<

Date	Time	FS	VA	VB	VC	VD	U	V	W	mmho/	T
MM DD YYYY	HH MM SS.SS	HEX	HEX	HEX	HEX	HEX	cm/s	cm/s	cm/s	cm	degC
03 29 2002	11 25 47.12	FE35	FEA8	FE6B	FF1C		-0.2	0.5	-2.8	-0.24	22.16
03 29 2002	11 25 47.66	FDED	FF68	FED3	FF54		0.7	0.6	-2.3	-0.24	22.19
03 29 2002	11 25 48.16	FE6D	FF50	FF33	FF5C		0.5	0.6	-1.8	-0.22	22.19
03 29 2002	11 25 48.66	FE45	FF48	FEFB	FF64		0.4	0.6	-2.0	-0.20	22.19
03 29 2002	11 25 49.16	FEA5	FF40	FF5B	FF4C		0.5	0.5	-1.7	-0.20	22.19

P	A1	MX	MY	Pitch	Roll
dbar				deg	deg
0.00	1.891644	0.97	0.25	3.6	-5.3
0.94	1.261096	0.96	0.27	3.0	-5.1
0.63	1.891644	0.95	0.32	3.0	-5.1
0.47	0.000000	0.96	0.29	3.0	-5.1
0.63	0.630548	0.97	0.26	3.0	-5.2

← [CTRL]-[C] to stop deployment

← Back to the Main Menu

Nobska Development MAVS3
Modular Acoustic Velocity Sensor
Model 3
Version: mavs34_6.c S/N: 10414

Main Menu

Fri Mar 29 11:25:52 2002

- <1> Set Time
- <2> Flash Card Ops
- <3> Calibration
- <4> Low Power Sleep
- <5> Bench Tests
- <6> Deploy System
- <7> Offload Data
- <8> Contact Nobska

selection ? 7

← Start offload

verbose (Yes/No) [N] ?

← Select non-verbose

Date	Time	FS	VA	VB	VC	VD	U	V	W	mmho/	T
MM DD YYYY	HH MM SS.SS	HEX	HEX	HEX	HEX	HEX	cm/s	cm/s	cm/s	cm	degC
03 29 2002	11 25 47.12	FE35	FEA8	FE6B	FF1C		-0.2	0.5	-2.8	-0.24	22.16
03 29 2002	11 25 47.66	FDED	FF68	FED3	FF54		0.7	0.6	-2.3	-0.24	22.19
03 29 2002	11 25 48.16	FE6D	FF50	FF33	FF5C		0.5	0.6	-1.8	-0.22	22.19
03 29 2002	11 25 48.66	FE45	FF48	FEFB	FF64		0.4	0.6	-2.0	-0.20	22.19
03 29 2002	11 25 49.16	FEA5	FF40	FF5B	FF4C		0.5	0.5	-1.7	-0.20	22.19

P	A1	MX	MY	Pitch	Roll
dbar				deg	deg
0.00	1.891644	0.97	0.25	3.6	-5.3
0.94	1.261096	0.96	0.27	3.0	-5.1
0.63	1.891644	0.95	0.32	3.0	-5.1
0.47	0.000000	0.96	0.29	3.0	-5.1
0.63	0.630548	0.97	0.26	3.0	-5.2

Had the offload been conducted in verbose mode the deployment definition information would also have been displayed, as shown in the example below, and the column header would have been re-displayed every ten records.

```

Selection ? 7
Verbose (Yes/No) [N] ? y
Loading data definition information from flash card . . . done.

Software version: mavs34_6.c
Compiled: May 17 2004 13:49:58
Electronics S/N: 10414

NOTES
-----
Offload example for Version 4.6 manual

DEPLOYMENT PARAMETERS
-----
Start time          03/29/2002 11:00:00 [MM/DD/YYYY HH:MM:SS]
Stop time           03/29/2002 16:00:00 [MM/DD/YYYY HH:MM:SS]

Velocity Frame      Earth Frame (E, N, W)      TTag FSec Axes
Monitor             Enabled                                     On On HEX
Internal Logging    Enabled (38 bytes/sample)
Append Mode         Enabled (1 of 4090 files in use)
Verbose Display     Disabled
Query Mode          Disabled

Measurement Frequency      2.0 [Hz]
Measurements/Sample        1 [M/S]
Sample Period              0.50 [sec]
Samples/Burst              1 [S/B]
Burst Interval             000 00:00:00 [DDD HH:MM:SS]
Bursts/File                1000 [B/F]

```

To copy the screen display of the MAVS3 data file to a disk file, initiate your communication program's screen capture utility now and then press any key to start the transfer. The instrument data file will remain resident on the flash card and is not deleted by this procedure.

Opening data file, DATA0001.BIN.

Date	Time	FS	VA	VB	VC	VD	U	V	W	mmho/	T
MM DD YYYY	HH MM SS.SS	HEX	HEX	HEX	HEX	HEX	cm/s	cm/s	cm/s	cm	degC
03 29 2002	11 25 47.12	FE35	FEA8	FE6B	FF1C		-0.2	0.5	-2.8	-0.24	22.16
03 29 2002	11 25 47.66	FDED	FF68	FED3	FF54		0.7	0.6	-2.3	-0.24	22.19
03 29 2002	11 25 48.16	FE6D	FF50	FF33	FF5C		0.5	0.6	-1.8	-0.22	22.19
03 29 2002	11 25 48.66	FE45	FF48	FEFB	FF64		0.4	0.6	-2.0	-0.20	22.19
03 29 2002	11 25 49.16	FEA5	FF40	FF5B	FF4C		0.5	0.5	-1.7	-0.20	22.19

P	A1	MX	MY	Pitch	Roll
dbar				deg	deg
0.00	1.891644	0.97	0.25	3.6	-5.3
0.94	1.261096	0.96	0.27	3.0	-5.1
0.63	1.891644	0.95	0.32	3.0	-5.1
0.47	0.000000	0.96	0.29	3.0	-5.1
0.63	0.630548	0.97	0.26	3.0	-5.2

← there were only 5 records, so the column header is not re-displayed

End of file mark reached for file DATA0001.BIN

Closing data file, DATA0001.BIN, . . . done.

Stop file capture when the offload is complete. As with any data files, make backup copies.

<8> Contact Nobska

This Main Menu option displays contact information for Nobska Development, Inc. It does not, as some have thought, actually place you in contact with us, but it does put our phone number where you can find it at sea when you forgot to pack this manual and really need to speak with us.

Nobska Engineering and Technical Support

Dan Schaaf	941-766-0706	nobska@compuserve.com
Todd Morrison	508-360-2393	atmorrison@nobska.net
Sandy Williams	508-289-2725	awilliams@nobska.net

Fax	941-766-0707
Web	www.nobska.net

Software Version	mavs34_6.c
Compiled:	May 17 2004 13:49:58
Serial Number:	10414

Press any key to continue.

<S> Changing the System Configuration

The system configuration is programmed into the serial EEPROM at Nobska Development before an instrument is shipped. It is not normally necessary to make any changes. Should modification become necessary, disabling a sensor for example, the procedure is straightforward. Password protection is used to prevent accidental and casual alteration of critical system parameters, not to restrict intentional access by a knowledgeable operator.

At the Main Menu prompt press 's' or 'S' followed by [ENTER]. 'S' stands for "system". A password prompt will appear. Type "whipr", no quotes, all lower case, and press [ENTER]. Password entry and the System Configuration menu are shown below.

```
Selection ? s Password: whipr

System Configuration

Velocity:
<C> Binary to SI Conversion 0.0028033
<A> Analog Velocity Outputs Disabled

Analog Channels:
<W> Warm up interval Fast (1 sec)
<1> 3-Axis Compass Enabled
<2> Solid State Tilt Enabled
<3> Conductivity Enabled
<4> Thermistor Enabled
<5> Pressure Enabled
<6> Auxiliary 1 Enabled
<7> Auxiliary 2 Disabled
<8> Thermistor Array Disabled

System Parameters:
<O> Sensor Orientation vertical/Down
<S> Serial Number 10414
<Q> Query Character
<T> Power-On Time-out 30 [sec]

Exit:
<X> Save Changes and Exit

Selection ?
```

To change the system configuration simply make a selection. The velocity conversion constant (a scale factor) should only be changed in conjunction with hardware changes to the sensitivity of the system or to pre-scale the measurements for a sound speed that is known in advance. MAVS3 normally assumes a sound speed of 1500 m/s. Note that the default value, 0.0028033, includes a factor of 1/2 to account for axis geometry in the mapping from along-axis velocities to velocities in the Cartesian instrument frame. Use the factor 0.0056066 cm/s/count to convert along-axis velocities in counts to along-axis velocities in cm/s.

When enabling or re-enabling one of the sensors there will commonly be prompts for calibration coefficients. The operator may select the default values or allow existing values stored on the EEPROM to remain. Nobska recommends running the associated calibration procedure (see Calibration) after enabling a sensor unless the stored calibration coefficients are known with certainty to be accurate. In some cases the operator may need to make a manual entry. Maintaining a history of calibration constants for each MAVS3 system is recommended.

"Offset" values for the analog channels are integers with units of millivolts. Offsets are subtracted from analog readings before they are scaled and are intended to "zero" the reading. Offsets may be negative up to 500 mV to facilitate linearizing the response of a non-linear sensor about some expected operating range. "Scale" values are floating point numbers that convert analog millivolts to physical units.

To observe a reading in millivolts and derive the calibration constants manually, set the offset to zero and the scale to 1.0. Then run the bench test routine for two known conditions. The bench test display will be in millivolts. Regress the data and enter the results as the calibration constants. This procedure is automated in the sensor calibration routines (see Calibration). Some sensor models are more complex than this simple linear model. In those cases the form of the model is provided in the calibration routine instructions. Contact Nobska if you need assistance.

Note that some analog options are mutually exclusive and selection of one will automatically disable the other. For example, the triple thermistor array uses the same analog channels as the single thermistor and the two auxiliary channels, A1 and A2. Note also that disabling a sensor only removes it from the data stream, it does not stop it from drawing power from the battery. The sensor must be disconnected from the MAVS3 mother board to eliminate its power drain.

The warm up interval allows power savings when all of the auxiliary sensors associated with a MAVS3 system have a relatively fast response time. It also allows the system to maintain high accuracy with slower sensors. "Slow" auxiliary sensors must be on for several seconds before they can achieve their rated accuracy. "Fast" sensors achieve their rated accuracy more quickly. The system control code determines sensor power-on times based on the selected warm up interval. The interval is applied to all auxiliary sensors whose power is switched on as needed, e.g., Druck pressure transducers, OBS. Power is applied to these sensors in advance of a measurement so that they can be read accurately. When the measurement interval is shorter than the warm up interval the sensors, and their attendant current drains, remain on continuously.

The sensor current drains used in the battery longevity calculation must be entered manually for sensors connected to Auxiliary 1 and Auxiliary 2. The operator will be prompted to enter a current value in milliamps after enabling either of the auxiliary ports. The necessary information is generally available from the data sheet that accompanies the sensor. Typical MAVS3 auxiliary sensors are the SeaPoint OBS (3.5 mA) and the SeaPoint Fluorometer (15.0 mA).

Changing Sensor Orientation

General MAVS3 systems, those with straight sensor rods, can be deployed with the Sensor Orientation set to Vertical/Down, Vertical/Up, or Horizontal/Straight. For systems without compass and tilt sensors, deployment in a new orientation requires only that the setting be changed on the System Configuration menu. The setting is used in the internal calculations that convert measurements along the acoustic axes into instrument frame velocities.

For systems equipped with a 3-axis compass but no tilt, the operator should first change the Sensor Orientation setting on the System Configuration menu. After saving this change, run the compass calibration procedure, starting with the system in the new orientation. Save the new calibration constants and then proceed with the deployment. No changes to the hardware are necessary.

For systems equipped with a solid state tilt sensor, the Sensor Orientation can be switched between Vertical/Down and Vertical/Up without making any changes to the hardware. First, change the Sensor Orientation setting on the System Configuration menu and save the change. Then, run the tilt calibration utility (and the compass calibration utility if also equipped with a 3-axis compass), save those changes, and proceed with the deployment.

Changing the Sensor Orientation between either of the Vertical modes and Horizontal/Straight does require a change to the hardware, but the change is minor and can be performed by the operator in the field. To begin, disconnect power (battery and external source) and remove the pressure housing to expose the MAVS3 electronics assembly. Locate the compass and tilt module. This is a 10-sided circuit board shaped roughly like a wide and blunted arrow head and with a number of components mounted on it. It is mounted perpendicular to the MAVS3 mother board on the end away from the velocity sensor.

Next, locate the tilt sensor, a 14-pin, surface-mount, integrated circuit (IC). A 4-digit Nobska serial number will be written on it. It should not be confused with a larger IC that has the same identifying number and four additional numbers written on it. Those four values are the temperature and scale coefficients for the tilt sensor. They were determined by Nobska personnel when the system was built. The tilt sensor is soldered to a small adapter board which is plugged into one of two sockets on the module. The other socket will be empty.

For both Vertical/Down and Vertical/Up operation, the tilt sensor and adapter board assembly should be plugged into the "flat" socket so that the adapter board is parallel to the compass and tilt board. For Horizontal/Straight operation, the tilt sensor and adapter board assembly should be plugged into the "right-angle" socket so that the adapter board is perpendicular to the compass and tilt board. Note that in both cases the tilt sensor IC will be oriented horizontally (parallel to the ground) once the system is placed in the intended Sensor Orientation.

A small screw driver can be used to remove the tilt sensor and adapter board assembly from a socket. Insert the screw driver under one end of the adapter board and twist gently. Repeat at the other end. Exercise appropriate caution and patience. To install the assembly in the other socket, carefully align all of the pins and press it into place with a finger, bracing the compass and tilt board as necessary. Pin 1 is marked on the adapter board. Pin 1 of the flat socket is towards the center of the compass and tilt board. Pin 1 of the right-angle socket is towards the compass and tilt board. Pin 1 of each socket is (usually) marked with an indentation or other mark. Please contact Nobska if you need assistance.

Once the tilt sensor has been installed in the appropriate socket you can re-assemble the housing and apply power. Then change the Sensor Orientation setting on the System Configuration menu and save the change. Finally, run the tilt calibration utility (and the compass calibration utility if also equipped with a 3-axis compass), save those changes, and proceed with the deployment.

System Configuration (continued)

Do not change the serial number of the system. To do so makes tracking and maintenance of repair and calibration histories difficult or impossible.

Query mode is described under Deploy System. All MAVS3 systems recognize a carriage return as a valid query character. The Query Character option allows the operator to program an additional alphanumeric character that will also be recognized as valid. This makes units on a shared serial communications bus individually addressable (triggerable) in query mode.

The Power-On Time-Out is the duration of the power-up sequence countdown during which the operator may choose to assert control or let a deployment proceed based on the current values in the deployment definition. The duration can be set from 0 to 30 seconds. Users who intend, for example, to operate in "throw and go" mode and do not wish to wait after each power-up could set this parameter to zero.

Option X saves changes, if any, to the serial EEPROM. It also applies them to the active program and then returns to the Main Menu. [CTRL]-[C] returns to the Main Menu without saving changes to the serial EEPROM or making changes to active RAM.

```
selection ? x
Storing system configuration information . . . done.
```

There is one protected option from the System Configuration menu. Press 'r' or 'R' followed by [ENTER]. 'R' stands for "rates". At the password prompt type "babouche", no quotes, all lower case, and press [ENTER]. This option will allow the operator to change the communications baud rate and the default system clock rate. The default values under Version 1.8 and higher of the system control program are 38400 baud and 1.28 MHz. There are a number of issues (system control and power consumption for example) that depend strongly on these parameters. You should not change them unless you first consult with Nobska Development.

```
selection ? r Password: babouche
Changing the baud rate or the base clock frequency can compromise system operation. ← see below for further discussion
Assistance from Nobska engineers and some degree of technical ability on your part may be needed to recover control of the system. Some combinations of baud rate and clock frequency simply do not work. You should be familiar with TT8 operation or be operating with guidance from Nobska if you wish to make changes.
Continue (Yes/No) [N] ? y
Communication port baud rate may be set to 300, 1200, 9600, 19200, 38400, or 57600 baud.
Current communication port baud rate: 38400
Enter communication port baud rate (300 to 57600) ? 38400
Current system clock frequency: 1280000
Enter system clock frequency (1280000 to 16000000) ? 1280000
```

Changing the Baud Rate and the Clock Frequency

As noted in the warning above, "some combinations of baud rate and clock frequency simply do not work". A 1.28 MHz clock will support 9600 baud, 19200 baud, and 38400 baud. It will not support 57600 baud. A 16.0 MHz clock performs similarly, but a 15.040 MHz clock will cleanly support all four baud rates. The system clock is internally set to 16 MHz during each measurement cycle to support critical timing requirements. This means that a deployment with the monitor enabled can be run with a baud rate of 38400 at most. However, data offload could be conducted at 57600 baud using a 15.040 MHz clock. This is the fastest data can be captured from the system through the serial port. RS-232 communications is reliable at this speed only if the communications cable is kept short (< 3 m).

More information about matching baud rates and clock frequencies can be found in Table 6-8, "68332 Clock Rates for the 40000 Crystal", on pages 6-16 and 6-17 of Onset Computer's "Tattletale® Model 8 Installation and Operation Manual, ANSI-C Version". The manual can be downloaded from the Onset web site at www.onsetcomp.com. Disregard entries for clock frequencies above 16.0 MHz, the upper limit for the TT8. Only the combinations with a stated baud error % can be used. In our experience, only those combinations with a baud error % of 4.0 or less will operate cleanly.

The Passwords

The following background information may help you to remember the passwords. "whipr" is short for "wizards and high priests", a phrase from the keynote address at the 1995 Current Measurement Technology Conference in St. Petersburg, Florida. It was used to describe the demographic into which the MAVS3 engineering team falls. The other categories were the "cognoscenti" and the "happy-go-lucky".

Babouche is a family owned and run Moroccan restaurant in San Pedro, California. The restaurant is on Gaffey Street between 8th and 9th. Babouche is sacred ground for the MAVS3 engineering team and we always take our shoes off when we enter.

<Q> Exiting to the Monitor (TOM8>)

At the Main Menu prompt press 'q' or 'Q' followed by [ENTER]. A password prompt will appear. Type "nobska", no quotes, all lower case, and press [ENTER]. This will halt execution of the system control program (it will remain resident in flash memory on the TT8) and cause an exit to the TOM8 monitor (Tiny Onset Monitor, Tattletale®8).

```
Selection ? q Password: nobska
Tattletale Model 8
Onset Computer, Pocasset MA USA
TOM8 v1.09, PIC v1.00, Copyright 1994
TOM8>
```

When in the monitor, the communications baud rate defaults to 9600. If you are using a different baud rate you must manually reset the baud rate used by your serial communications program to 9600 baud while interacting with the monitor. After you restart the system control program reset the communications port baud rate as necessary. See Operating Crosscut for information about changing the baud rate.

The system draws a relatively high current (>40 mA) from the battery while in the monitor. We recommend that you limit the time the system stays in this state. There are only two reasons to exit to the monitor and neither should occur frequently. First, it is necessary to enter the monitor to load code updates. See Operating Crosscut for a description of this procedure. The second reason to enter the monitor is to perform a "warm" re-boot of the MAVS3, an unlikely need.¹⁰

To re-start the system control program type 'g' or "go" followed by [ENTER] at the TOM8 prompt. This will start the normal power-up initialization sequence. Remember to reset the baud rate used by your serial communications program to the baud rate for which the MAVS3 is set, typically 38400 baud under Version 1.8 and higher of the system control code.

Emergency Boot Recovery Procedure

If the system will not respond at power-up or if the system starts and then goes silent and:

- you have verified that all connectors have been properly mated
- there is no physical damage to the electronics (flooding? impacts? corrosion?)
- the battery/power supply is operational
- the PC and the serial communication program are operational
- the serial communication program and the MAVS3 are set to the same baud rate
- you have, perhaps, just finished adjusting the baud rate and the clock rate in the system configuration (errors in setting these parameters are the leading proximal cause of the emergency boot recovery procedure)

you may wish to undertake the emergency boot recovery procedure. As a precaution, we suggest that you contact Nobska before proceeding. Consultation with Nobska personnel may identify the problem and suggest an alternative solution. As noted above, the most likely reason to be in this situation is adjustment of the baud rate and/or the clock rate in the system configuration to a nonfunctioning combination.

Emergency boot recovery will force the system to boot to the TOM8 monitor. Recall that the monitor uses a baud rate of 9600 and reset the baud rate of your serial communications program as necessary. From the TOM8 monitor you will be able to load and run either MPREP346.RHX or LOADRATE.RHX. MPREP346.RHX will reset all system configuration and deployment definition parameters to their default values in this case. Any stored calibration constants will be lost if this program is run. However, it does place the MAVS3 in a well defined state. LOADRATE.RHX resets only the baud rate and the clock frequency to their default values (38400 baud and 1.28 MHz). All other parameters are left unchanged. It will generally be sufficient to load and run LOADRATE.RHX. Under some circumstances, however, it will be necessary to load and run MPREP346.RHX and then reload MAVS34_6.AHX, the system control code.

See Operating Crosscut for instructions on loading and running these programs. If the programs were not provided on a disk with your system they can be emailed to you from Nobska. If reloading fails to help there is a strong possibility that the cause of the problem is in hardware. Consult with Nobska Development.

¹⁰ There is, conceivably, a third reason to exit to the monitor. An experienced TT8 user may require direct access to either the TOM8 or to PicoDOS®.

To perform the emergency boot recovery procedure, first disconnect MAVS3 power, but leave the communications line connected and the serial communications program running. Locate the TT8 mounted on the "top" of the MAVS3 mother board. The TT8 is electrically connected to the mother board through two connectors, one at each end of the TT8. The "A" connector has a single row of 16 pins and the "B" connector has a single row of 20 pins. On the "bottom" of the MAVS3 circuit board locate the row of soldered pins associated with connector A on the mother board. One end of the row is labeled "A1". This row of pins runs across the mother board and will be partially obscured under the edge of the auxiliary sensor card if one is present.

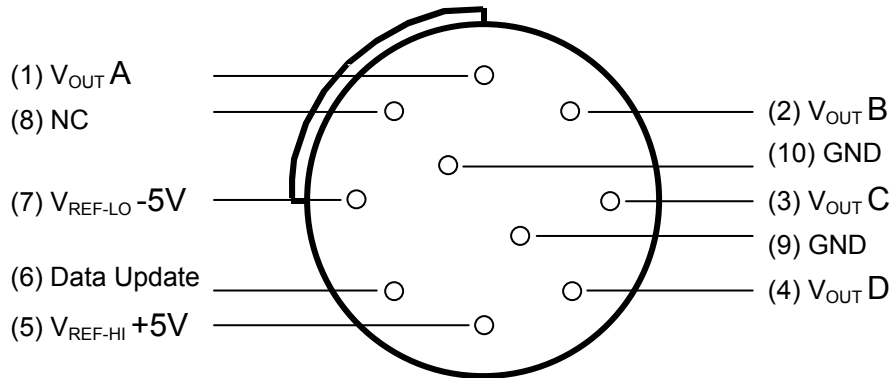
Locate pins A1 (silk screen label, white paint) and A5 (count from A1, the pins are in numerical order). There is also a silk screen label, "-TT8 RESET-", running between the two pins. Connect the pins with a piece of wire. Two hands may be necessary to hold the wire in place, so consider having an assistant perform the next step with you. While A1 and A5 are electrically shorted together, reconnect the power. The system will come up in the TOM8 monitor at 9600 baud. Remove the short from connector A and proceed with the loading of code. Note that if the system does boot cleanly to the monitor there is a good chance that the problem is incorrectly entered parameters and not a hardware failure.

Again, contact Nobska for assistance if you find yourself in this situation.

Analog Velocity Output

Analog velocity output is a MAVS3 hardware option, similar to conductivity or pressure. A suitably equipped system will provide a scaled analog voltage for each of the four acoustic paths. The analog outputs are available in real-time during a deployment and are "played back" from logged data during serial offload. They are also active when any of the velocity options on the Bench Test menu are used.

The face view of the analog velocity output bulkhead connector is shown below.



$V_{OUT A}$ through $V_{OUT D}$ are the four analog velocity outputs. The voltage range for each output is V_{REF-LO} to V_{REF-HI} . The reference voltages are nominally -5 V and +5V. The analog outputs correspond in the obvious linear sense to the velocity range $-V_{MAX}$ to $+V_{MAX}$ (± 183.7 cm/s).¹¹ A hexadecimal velocity of 8000, the digital value used to flag a bad measurement, generates an analog output of V_{REF-LO} (-5 V).

The reference voltages and the ground on the bulkhead connector are connected directly to the digital-to-analog chip that produces the analog velocity outputs; they can be used by an external analog logging system to make ratiometric measurements. Source and sink currents between the logging system and the references should not exceed 5 mA ($-5 \text{ mA} \leq I_{REF} \leq +5 \text{ mA}$).

The data update pulse is a logic level output (0 V and +5 V) that is active high (+5 V). The pulse duration is 1.55 ms. The rising edge of the pulse indicates that the sequential update of the four analog outputs is beginning. The external logger can continue to record the voltages, but it should be understood that while the pulse is high the four outputs are presenting values from two different measurement cycles. The outputs are updated in order, A, B, C, and D. The pulse can be used to either synchronize or "blank out" data acquisition by the external logger. The falling edge of the pulse indicates that the analog voltages on all four channels are stable and ready to be read.

Enabling the analog velocity outputs on the System Configuration menu automatically triggers logging, but not digital display, of the raw axes during a deployment (if logging is also enabled). The axes measurements would otherwise not be available for playback. Display of the raw axes through the Crosscut interface remains under the control of the frame and axes selections made on the Deployment menu. The raw axes will be logged and displayed if the velocity frame is set to "no frame" or the axes are on (hexadecimal, decimal, or SI display) or both. The analog velocity outputs are enabled or disabled from the System Configuration menu, independent of the state of the data monitor on the Deployment menu. The operator can, for example, disable both logging and the data monitor and still have active analog velocity outputs.

¹¹ Note that V_{MAX} depends on the velocity scaling constant, nominally 0.0028033, as entered in the System Configuration menu. V_{MAX} for a particular system is given by $V_{MAX} = 2 \times \text{actual scaling constant} \times 32767$.

Power Consumption In MAVS3

The cost of improved sensor accuracy is often increased power consumption. This is generally not a problem in the laboratory, but oceanographic sensors are typically battery powered and energy limited. Their designs must reflect a balance between the competing constraints of low power and high accuracy. The MAVS3 velocity measurement has extremely high accuracy, approaching or exceeding 0.5 mm/s over a linear range of ± 180 cm/s. That level of accuracy is achieved by using high power components that are also highly precise and very fast. Low effective power is achieved by turning those precise and responsive components on only while the velocity measurement is actually being made, a very brief period of time. MAVS3 draws approximately 400 mA from the battery during a measurement. But it draws that current for only 20 ms. At a measurement rate of 2 Hz the measured effective or average current drain of a MAVS3 is only 15 to 20 mA. As the measurement rate increases the duty cycle, the portion of the measurement cycle during which the high power components are actually on, increases and the average current goes up. For lower measurement rates the average current is lower. Below 0.125 Hz the system can actually enter the LPS mode between measurements.

The 15 to 20 mA at 2 Hz average drain cited above is for a MAVS3 equipped with compass and tilt sensors, a single thermistor (or thermistor array), and a flash card. Additional sensors necessarily increase the average current drain. Conductivity and pressure sensors, analog velocity outputs, and sensors connected to the auxiliary ports do not have response times that are in any way comparable to the speed of the MAVS3 differential travel time circuit. Typically, these devices must be powered for a sizeable fraction of a second or more before their outputs become stable and accurate. This is also true of the MAVS3 tilt sensor. Recall the 1 second time constant of "fast" tilt sensors and the 5 second time constant of "slow" tilt sensors. Those time constants are applied to all of these sensors. If the programmed schedule allows the sensors to be turned off, which occurs if the system is able to enter LPS mode, they are turned on either 1 second or 5 seconds before the next measurement so that they will be accurate. For many measurement schedules the sensors will never be turned off or will only be turned off between bursts. This can have a strong effect on battery longevity.

Calculating current drains and battery longevity is complex because of the number of variables and cases that must be considered. The system control program makes this calculation for the operator. The calculation is based on careful measurements and detailed knowledge of MAVS3 operation. An oscilloscope was used to examine the detailed behavior of current drain during a measurement cycle. Average currents were measured under a variety of conditions. The end result is a reasonably accurate prediction of battery longevity. Alternatively, the average current drain can be measured directly by the operator after programming the deployment definition parameters and starting a bench top deployment. The capacity of the battery in Amp-hours divided by the average current drain in Amps (mA / 1000, e.g., 50 mA is 0.050 A), is the deployment longevity in hours. Be sure to account for burst, sample, and measurement duty cycles if not making continuous measurements.

As an aid to manual calculation of battery longevity, the nominal capacities of the standard MAVS3 battery packs and the current drains of a selection of auxiliary sensors are presented in the tables below. Note that battery capacity depends on temperature – more energy can be withdrawn from a warm battery than from a cold battery. This is particularly true for alkaline batteries. The battery capacity values given in the table below have been somewhat de-rated to be reasonably accurate for a deployment near 0°C. In warmer conditions the actual capacity will probably be greater than stated. However, we recommend a use of the more conservative, de-rated values for deployment planning.

Battery Pack	Capacity [A·hr]
Single Alkaline	4.8
Double Alkaline	9.6
Single Lithium	9.6
Double Lithium	19.2

Sensor or Option	Current Drain [mA]
Conductivity sensor	7.0
Druck pressure sensor	10.0
Analog velocity output	35.0
SeaPoint OBS	3.5
SeaPoint Fluorometer	15.0

A Parting Word

The MAVS3 is a complex, full featured, instrument. Nobska Development strongly recommends the practice of conducting trial deployments in the laboratory under controlled conditions to become accustomed to and comfortable with system operation and capabilities before undertaking investigations in the field. Trials both with and without a communications link to a PC during the autonomous portion of the deployment are recommended. This procedure will help you become familiar with the behavior and response of the MAVS3. Nobska Development is available to provide assistance and advice.

Example Configurations: Considerations for Accurate Measurement

Long Duration Current Mooring

For long deployments, power and memory are practical limits. Mooring motion and turbulence in the flow represent noise rather than signal and must be vector averaged in earth coordinates to avoid aliasing in a measurement of mean current. Burst sampling allows both requirements to be met.

Measurement rate, nominally set to 2 Hz, protects against aliasing for velocities less than 20 cm/s. Aliasing is a sampling error in which fluctuations in the signal at frequencies higher than the sampling frequency appear as signal at a frequency lower than the sampling frequency. The wave number resolved by MAVS3 is $O(10 \text{ m}^{-1})$. Turbulent length scales smaller than 10 cm are not resolved and do not introduce a bias in velocity measurements. However, scales longer than 10 cm can produce a signal when measurements are made less frequently than the rate at which such eddies are advected past the MAVS3 sensor. At 20 cm/s, a 10 cm eddy is advected past in 0.5 second, therefore a 2 Hz measurement rate is the minimum to prevent aliasing.

Sample period is selected to capture the highest frequency of interest, but not higher. Multiple measurements are vector averaged in earth coordinates to reduce the data volume and only the averages are retained as samples. If mooring motions are a possibility and are not of interest, it is sensible to average over several cycles of that motion. Similarly, if waves are present but are not of interest, it is sensible to average over several wave periods. In the case of mooring motions, a 5-second sample period or at most a 10-second sample period should suffice. In the case of open ocean waves, 30 seconds to 1 minute would be required. That is a lot of vector averaging and it might be wiser to keep the sample period shorter, say 5 seconds, and do post process averaging. That decision will be driven by the data capacity constraints.

Burst sampling permits power savings. The effect on data volume is also great. The interval between bursts is chosen to avoid aliasing long period phenomena such as tides and should be 3 hours or less if tidal amplitudes are important. If internal waves or seiches are important, the burst interval should be less than half the shortest period of the internal wave or seiche. Alternatively, if the burst length is longer than the longest period phenomenon of interest, the burst interval can be longer since the structure of the process will be adequately sampled by the long burst. It is only in the interval between bursts that substantial power is saved.

The design of a deployment configuration might start with the measurement rate, then the burst interval, then the burst length, and finally the sample period. Suppose the deployment is to be 6 months on a mooring where there is strumming with a characteristic period of 2 seconds but there are no waves. It is important to resolve tidal and inertial motions. Mean currents are expected to be 10 cm/s. The MAVS3 is equipped with a compass and tilt module and a thermistor. Raw axes are not stored because mooring motions make averaging them meaningless. Each sample will occupy 24 bytes on the flash card.

The measurement rate could be set to 1 Hz, but we will use 2 Hz to be safe. The burst interval should be 3 hours. The burst length can be as short as 1 minute or 12 samples per burst with the sample period being 5 seconds. With a battery capacity of 4.8 Ahr, the power limit will be reached in 251 days, substantially longer than 6 months. With an 8 Mbyte compact flash card there is room for 66440 bursts, which gives a duration of 8305 days, much greater than the power limit. That result suggests another iteration, using the MAVS3 to conduct the calculations.

Sampling period has a major impact on memory requirements. In the case being considered the sampling period of 5 seconds was too conservative. In fact, no averaging is required for this deployment and the sample period can be reduced to 0.5 s. To keep the burst length at 1 minute requires 120 samples per burst. The number of bursts per file is a kind of insurance against loss of data from an interrupted deployment. Splitting the data into the largest number of files that will fit on the compact flash card is the most secure. In this case, the system's suggestion is that 5 bursts per file be selected. That done, there can be 2530 bursts in 506 files and this will be filled in 346 days, well past the 6-month deployment. In fact, there is physical room for 10% more samples to be stored. An increase in the measurement rate will have only a modest impact on power but with the same sample period and burst length will have a significant impact on the data rate. Refining the configuration a final time gives the following deployment definition for this long duration current mooring.

```

Notes 1| Long Duration Current Mooring
      2|
      3|

Time  N| Time Now           07/29/2001  16:26:45  [MM/DD/YYYY  HH:MM:SS]
      S| Start Time         07/29/2001  16:00:00  [MM/DD/YYYY  HH:MM:SS]
      T| Stop Time         02/07/2002  16:26:45  [MM/DD/YYYY  HH:MM:SS]
      D| Duration           193  00:00:00  [DDD HH:MM:SS]

Data  F| Velocity Frame     Earth Frame (E, N, W)      TTag FSec Axes
      M| Monitor           Disabled                   On   On   Off
      L| Internal Logging  Enabled (24 bytes/sample)
      A| Append Mode       Enabled (0 of 506 files in use)
      V| Verbose Display   Disabled
      Q| Query Mode        Disabled

Sched 4| Measurement Frequency 3.0 [Hz]
      5| Measurements/Sample 1 [M/S]
      6| Sample Period       0.33 [sec]
      7| Samples/Burst       180 [S/B]
      8| Burst Interval      000  03:00:00 [DDD HH:MM:SS]
      9| Bursts/File         4 [B/F]

      G| Go (<CTRL>--<G> skips checks)

           selection ?

```

This configuration provides a good match between the requirements of the deployment and the capabilities of the instrument. The battery calculation shows the power limit to be 193 days. The memory limits are 230 days.

Battery longevity calculation
(0 for unlimited external power
or to skip calculation):

Enter battery capacity [Ahr] (0.0 to 100.0) ? 4.8

The battery will support the programmed sampling
schedule for approximately 1547 bursts, a period
of 193 days, 9 hr, 0 min, and 0 sec and
will expire as shown below:

Time Now:	07/29/2001	16:26:55
Start Time:	07/29/2001	16:00:00
Expiration Time:	02/08/2002	01:26:55
Stop Time:	02/07/2002	16:26:45

Change selections (Yes/No) [N] ?

The installed flash card has sufficient space for
1845 bursts (180 Samples/Burst, 24 Bytes/Sample).
The file system can accommodate 506 data files.

The sampling schedule and the programmed value
of Bursts/File will allow storage of 1845 bursts
in 461 files.

Acquisition of these bursts will require a period of
approximately 230 days, 15 hr, 0 min, and 0 sec,
which will expire as shown below:

Time Now:	07/29/2001	16:27:01
Start Time:	07/29/2001	16:00:00
Expiration Time:	03/17/2002	07:27:01
Stop Time:	02/07/2002	16:26:45

Append Mode is enabled. Any existing data files
will limit the storage capacity of the system.

Change selections (Yes/No) [N] ?

Wave Measurements from a Fixed Platform

To measure waves a burst of 1200 samples every 4 hours would be appropriate. If the water is shallow the samples should not be averaged, but if the water is more than 40 meters deep the sample period should be 1 sec to average two measurements and move the spectral range to longer periods. An example of this configuration for waves is shown below. A MAVS3 configured as in the long duration current mooring example is assumed.

```

Notes 1| Wave Measurements from a Fixed Platform
      2|
      3|

Time  N| Time Now           07/29/2001  16:57:43  [MM/DD/YYYY HH:MM:SS]
      S| Start Time         07/29/2001  16:00:00  [MM/DD/YYYY HH:MM:SS]
      T| Stop Time          10/17/2001  16:57:43  [MM/DD/YYYY HH:MM:SS]
      D| Duration           80  00:00:00  [DDD HH:MM:SS]

Data  F| Velocity Frame      Earth Frame (E, N, W)      TTag FSec Axes
      M| Monitor           Disabled                    On  on  off
      L| Internal Logging  Enabled (24 bytes/sample)
      A| Append Mode       Enabled (0 of 506 files in use)
      V| Verbose Display  Disabled
      Q| Query Mode        Disabled

Sched 4| Measurement Frequency 2.0 [Hz]
      5| Measurements/Sample 1 [M/S]
      6| Sample Period       0.50 [sec]
      7| Samples/Burst      1200 [S/B]
      8| Burst Interval       000  04:00:00 [DDD HH:MM:SS]
      9| Bursts/File         1 [B/F]

      G| Go (<CTRL>--<G> skips checks)

      selection ?

```

This sample configuration takes 10 minutes of wave velocities every 4 hours. With a 4.8 Ahr battery, this would last 82 days, well over 2 months, but with an 8 Mbyte compact flash card, the memory will only support 46 days, approximately 1.5 months of wave data.

Battery longevity calculation
(0 for unlimited external power
or to skip calculation):

Enter battery capacity [Ahr] (0.0 to 100.0) ? 4.8

The battery will support the programmed sampling
schedule for approximately 493 bursts, a period
of 82 days, 4 hr, 0 min, and 0 sec and
will expire as shown below:

Time Now:	07/29/2001	17:11:30
Start Time:	07/29/2001	16:00:00
Expiration Time:	10/19/2001	21:11:30
Stop Time:	10/17/2001	16:57:43

Change selections (Yes/No) [N] ?

The installed flash card has sufficient space for
276 bursts (1200 Samples/Burst, 24 Bytes/Sample).
The file system can accommodate 506 data files.

The sampling schedule and the programmed value
of Bursts/File will allow storage of 276 bursts
in 276 files.

Acquisition of these bursts will require a period of
approximately 46 days, 0 hr, 0 min, and 0 sec,
which will expire as shown below:

Time Now:	07/29/2001	17:11:33
Start Time:	07/29/2001	16:00:00
Expiration Time:	09/13/2001	17:11:33
Stop Time:	10/17/2001	16:57:43

Append Mode is enabled. Any existing data files
will limit the storage capacity of the system.

Change selections (Yes/No) [N] ?

Operating MAVSPack

The MAVSPack program is a Windows based executable with an easy to use graphical user interface. The MAVSPack main and options screens are shown on the next page. MAVSPack is used to quickly unpack the compressed binary data files acquired by MAVS3 instruments. These data files are stored on the PC compatible compact flash card mounted inside the MAVS. After the binary files are transferred to a PC, either copied to a hard disk from the compact flash card or resident on the compact flash card while it is mounted in a PCMCIA slot, MAVSPack can create decompressed data files in either "human readable" or "machine readable" formats.

The output file formats are both ASCII text. The human readable format is very verbose, with a fully labeled, multi-line presentation of each record that includes physical units (if applicable) for each datum. The machine readable format displays column identifiers with units on the MAVSPack main screen, but the machine readable ASCII data files contain only columns of numbers. These machine readable files can easily be imported by EXCEL, MATLAB, and other software packages for numerical analysis. In both formats a text file, HEADERS.DAT, with the column header, identifiers with units, is generated for later reference.

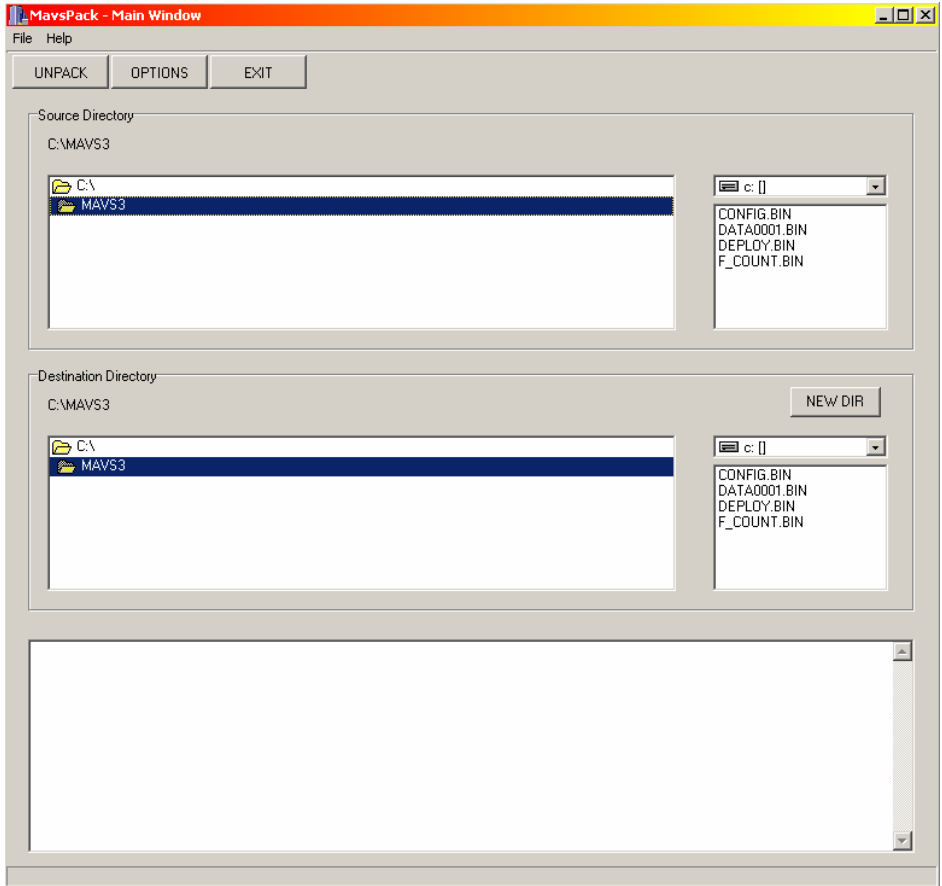
The MAVSPack executable should be resident on your hard disk. The default location is C:\Program Files\Nobska\MAVSPack.exe. You may wish to create a shortcut on your desktop. Double click on the executable or shortcut icon to start the program. The MAVSPack main screen will be displayed and can be dragged to a convenient location on your desktop.

Begin by defining a path to the drive and folder containing the binary data files. Choose the drive from the pull down menu in the upper right corner of the Source Directory frame. Then navigate through the directory tree displayed on the left side of the Source Directory frame to the folder containing the binary data files. The files in the selected folder will be displayed in the small window on the right of the frame. Similarly, in the Destination Directory frame, define a path to the folder in which you wish to place the unpacked ASCII text files. Use the NEW DIR button or the utilities native to your operating system to create a new folder if one is needed. The binary and ASCII files can be placed in the same folder if you wish.

Now click on the OPTIONS button at the top of the main screen. The MAVSPack options screen will be displayed. Select an output file format, either human or machine readable. The human readable format is useful during training and system familiarization. Unpacking to the machine readable format is significantly faster. The default is machine readable.

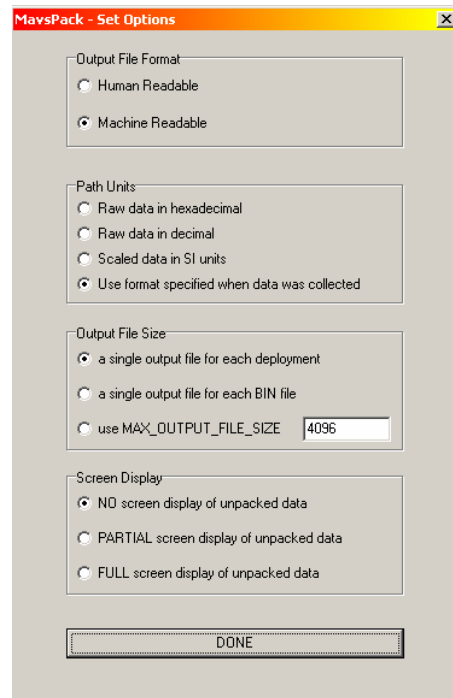
Next, select a format for display of the velocities along the four acoustic paths. The choices are the familiar ones, hexadecimal, decimal, or SI, used during data collection (see Bench Tests). The choice of MAVSPack format is independent of the display format at the time the data were collected; the binary storage format is not changed by the selection. Decimal counts and SI units are useful with those numerical analysis packages that are unable to read hexadecimal values (e.g., EXCEL). The default choice is to unpack the axes with the format used during logging. Note that this parameter is only meaningful if the acoustic axes were logged. Nobska strongly recommends that you always log the acoustic axes.

The options in the Output File Size frame allow the operator to unpack the data from many individual binary files into a single ASCII text file. This option is fastest and a single archival file may be easier to track. However, the potentially large size of a single output file may make it difficult to transfer from one PC to another. It may also be difficult to process such a file on systems with limited memory, storage, and processor resources. Alternatively, a one-to-one association of binary and ASCII files may be selected to simplify data associations in an archive. This may also provide relief from transfer and processing issues. Finally, to support systems with particularly limited available memory, the maximum size of the ASCII files can be set to a fixed limit, independent of the size of the original binary files.



MAVSPack
Main Screen

MAVSPack
Options Screen



MAVSPack
Graphical User Interface
Screens

The screen display options permit the operator to view the data as it is being unpacked. The data are presented in a scrollable pop-up window. The Partial display option presents the first five records from each binary file. The Full display option presents all of the records in the data set. Either form of screen display will slow down unpacking to some extent, but may be useful during training and system familiarization. The default is No display of data during unpacking.

When the options are set, click the DONE button at the bottom of the options screen. This will store your settings in C:\MAVSPACK\MAVSPACK.OPT and return you to the MAVSPack main screen. Each time you start MAVSPack it will load your last options selections from MAVSPACK.OPT; you only need to revisit the options screen when you wish to make a change to your default unpacking options.

Click the UNPACK button on the MAVSPack main screen to unpack the binary data files. As the operation proceeds, column headers, status information, and error messages will be presented in the scrolling display at the bottom of the screen.

Click the EXIT button to close MAVSPack when unpacking is complete.

Like the on-board offload utility, MAVSPack is non-destructive. The binary files are not altered by unpacking and the process can be run repeatedly. **Nevertheless, always make an archival copy of the binary files using a reliable long term storage technology such a CD-R or CD-RW.**

The current version of MAVSPack can process files produced by any version of the system control code. It automatically recognizes which version of the code produced the data and runs the conversion process appropriately.

Contact Nobska if you require assistance with this product.

Operating Crosscut

First Time Operation

Crosscut is a DOS based program running on a PC. It is freely distributed by Onset Computer for TT8 communication. Crosscut will run without modification or difficulty under DOS, Windows up to Windows 98, 1st edition, and Windows NT up to Version 4.0, Service Pack 6. Later releases of these operating systems may require a change to the PC registry to disable power management of the serial port and/or modifications to support use of the mouse. Contact Onset for more information (www.onsetcomp.com).

Place the six Crosscut files from the disk in a directory that is on your path or create a new directory for them and add it to your path. Alternatively, create a Crosscut directory, place the six Crosscut files there, and always operate Crosscut from that directory. For that approach no changes to your path are necessary.

When copying the Crosscut files to your hard disk from a CD-ROM, Windows will normally set the file attributes to Read-only. This setting will prevent Crosscut from running and will also generate a rather cryptic error message. If this happens, right click `crosscut.exe` and select Properties from the menu. Deselect Read-only in the pop-up, click Apply, and click OK. Repeat for each of the Crosscut files. Alternatively, you can simply deselect Read-only for the Crosscut folder and all of its contents. This should relieve the problem.

Type "crosscut" (without the quotes) or double click on the Crosscut icon to run the program. In general, it won't matter if you are already connected to the instrument when you do this. This first time, however, you will be adjusting COMM port parameters and we suggest that you not be connected to the TT8.

Using your mouse, select "CommPort" from the menu bar at the top of the Crosscut window and then "Port setup" from the submenu. If you don't have a mouse use the keyboard combination [ALT]-[P]. Use your mouse or the [TAB] and arrow keys to set the COMM port to 38400 baud, 8 data bits, 1 stop bit, no handshaking, and no parity. When you finish, select "OK" and these values will be stored in the configuration files. They will be used both now and whenever you start the program in the future (unless you change them, of course).

Note that 38400 is the default baud rate for MAVS3 units running under Version 1.8 and higher of the system control code. Faster or slower speeds can be used to meet the requirements of a particular investigation. In all cases the COMM port baud rate must match the rate set in the system configuration file for successful communications with the MAVS3.

You can now connect your PC to the instrument.

Normal Operations

To Start Crosscut

To start Crosscut simply type "crosscut" (without the quotes) or double click on the Crosscut icon. Make sure you are in the Crosscut directory or that the Crosscut directory is on your path when you do this. It doesn't matter if you are connected to the instrument when you start or stop Crosscut. However, **DO NOT RE-START OR POWER UP YOUR PC WHILE CONNECTED TO THE TATTLETALE® 8**. The boot script of many PCs involves COMM port activity that can crash the TT8 just like any modem style terminal emulator. Powering down your PC while connected should not cause a crash, but as a precaution we advise against it.

To Capture a Data File

To capture a data file after a deployment select "CommPort" from the menu bar and "Capture to File" from the submenu. Select a directory and a name for the file using the keyboard and the software buttons on the "Open file" window that will appear in the Crosscut window. [ALT]-[Z] will bring up the "Open file" window from the keyboard and you can simply type the path and name of the file in the "Name" field or use the [TAB] and [ENTER] keys to select the directory and enter the name in the "Name" field. Once the capture is started everything that appears in the Crosscut window, whether from the instrument or the keyboard, will be written to the file. File logging is terminated by selecting "CommPort" and "Capture to File" again or by simply typing [ALT]-[Z]. File logging is not just for data file capture. It can be used during all of your interactions with the instrument to create a log of operations, deployment settings, and recovery procedures. Nobska recommends this use of file capture for all deployments.

To Load a Software Upgrade

MAVS3 software upgrades consist of two programs. The first, MPREP346.RHX, runs in TT8 RAM. MPrep346 can be used to initialize or reinitialize a MAVS3 for operation under Version 4.6 of the system control code. This is accomplished by installing default system configuration and deployment definition information in the serial EEPROM. After initialization the operator will need to configure the system and run any necessary calibration procedures before conducting a deployment.

MPrep346 can also be used to upgrade a MAVS3 that has been operating under an earlier version of the system control program without loss of existing calibration constants and system parameters. The structure of the configuration and deployment definition arrays in the serial EEPROM typically change from one version of the system control code to the next as new features are added. When used to upgrade a system, MPrep346 reads existing information from the EEPROM in the form appropriate to the version of the system control code that is being replaced. The existing parameters are then written to Version 4.6 arrays and any unassigned elements, those associated with new features, are given Version 4.6 default values. The new arrays are then written to the EEPROM. Once MPrep346 has been run, MAVS34_6.AHX can be installed and run. The operator should manually confirm that the expected settings have been retained.

To load a software upgrade into the instrument first go to the Main Menu screen of the MAVS3 system control program. Type 'q' (without the quotes), follow this with the [ENTER] key, then the password 'nobska' (no quotes, all lowercase), and finally the [ENTER] key again. This process exits from the MAVS3 system control program to Onset Computer's Tattletale® 8 monitor. The prompt you will see is "TOM8>", which stands for "Tiny Onset Monitor, TT8". Remember that the Crosscut baud rate must be set to 9600 to communicate with the monitor. The TOM8> prompt will not be displayed if the baud rates do not match.

Once you have entered the TOM8 monitor, select "Tattletale" from the menu bar and "Load S-record" from the submenu. Using the software buttons on the "Load S-record" window and the keyboard (similar to file selection in the "Open file" window) select MPREP346.RHX. Alternatively, [ALT]-[L] will bring up the "Load S-record" window from the keyboard and you can type the path and name of the file in the "Name" field or use the [TAB] and [ENTER] keys to select the directory and enter the name in the "Name" field. A bar graph will show the progress of the load as it occurs. When the load is complete the TOM8 prompt will be displayed. The .RHX extension on the file name instructs the monitor to run the program in RAM, rather than burning it into flash memory.

Type 'g' or "go" (no quotes, lowercase) followed by [ENTER] at the TOM8 prompt to run MPrep346. The MPrep346 menu, shown below, will be displayed.

```

                Nobska Development Corp.
                MAVS-3
    Modular Acoustic Velocity Sensor
                Model 3

    MAVS-3 System Initialization and Upgrade
    for SCP Version MAVS34_6

    <I> Install default parameters for MAVS34_6
    <I> Upgrade system from MAVS34_5 to MAVS34_6

    <Q> Quit

    selection ?
```

Use Option I to initialize or reinitialize a MAVS3 system for operation under MAVS34_6. Use the other options to upgrade from an older version of the system control code without loss of existing calibration constants and system parameters. Option Q will exit to the TOM8 prompt and purge MPREP346.RHX from RAM.

Select "Load S-record" again as described above and load MAVS34_6.AHX. A bar graph will show the progress of the load as it occurs. The .AHX extension informs the monitor that the program should be burned into flash memory and when the load is complete you will be prompted to do this. Type a 'y' in answer to the "write flash?" prompt. Don't worry about the displayed address range. The system control program will always go where it belongs. When the TOM8 prompt reappears after the flash memory write operation is complete type 'g' or "go" (no quotes, lowercase) followed by the [ENTER] key. This will start the new system control program. Disconnecting all internal and external power sources and then reconnecting at least one of them will also start the program, which is now resident in the flash memory. Both options cause a clean boot with complete execution of the power-up sequence and full initialization. A "warm" boot leaves the MAVS3 in the same state as a "cold" boot. Remember to reset the baud rate used by Crosscut to the baud rate for which the MAVS3 is set, typically 38400 baud under Version 1.8 and higher of the system control code. Note that loading new code is a rare operation. Nobska is always available to assist you by telephone or email if you have any difficulty.

If MPrep346 is used to initialize or reinitialize a system, it will be necessary to run through the system configuration procedure, the sensor calibration routines, and deployment preparation before conducting a deployment with your MAVS3. The previous calibration constants can be manually re-entered or new constants can be obtained empirically. If MPrep346 is used to upgrade a system, the operator should manually verify that the calibration constants and system parameters are correct.

To Load and Run LOADRATE.RHX

Exit to the TOM8 monitor from the Main Menu as described above. If necessary, use the emergency boot recovery procedure to reach the TOM8 monitor. Select "Load S-record" and load LOADRATE.RHX. A bar graph will show the progress of the load as it occurs. When the load is complete the TOM8 prompt will be displayed again. Type 'g' or "go" (no quotes, lowercase) followed by the [ENTER] key to run the program. LOADRATE will set the baud rate of the serial port to 38400 and the system clock to 1.28 MHz. No other changes are made to the system configuration and deployment definition arrays.

The program will automatically exit to the TOM8 monitor when execution is complete. Type 'g' or "go" to restart the system control program. Don't forget to adjust the Crosscut baud rate.

To Exit Crosscut

To exit Crosscut select "File" from the menu bar and "Quit" from the submenu or simply type [ALT]-[Q] from the keyboard.

Additional Documentation

A much more detailed and complete description of Crosscut operations can be found in the file "crosscut.doc", which is included in the Crosscut distribution. While Crosscut has many fairly advanced capabilities, you will probably never use any except those described above. Even during instrument development we seldom go beyond this selection of Crosscut options. However, if you have any difficulty operating Crosscut, particularly the "Load S-record" or "Open file" windows, the detailed description in "crosscut.doc" may be helpful. As always, we are available by phone or email to answer any questions you may have and to assist you with the operation of your MAVS3 instrument.

Serial Offload Using YModem

The procedure outlined below allows an operator to offload individual MAVS3 files through the serial port in binary form. The procedure requires manual operator intervention at each step. However, because the binary form requires significantly fewer bytes than the equivalent ASCII text form, the total download time for large files will be reduced when compared to serial download using the on-board offload utility.

TattleTerm, a DOS/Windows terminal emulator, is available for free download from the Nobska web site, www.nobska.net. Simply copy the files from the TattleTerm archive to a folder and double click on the TattleTerm executable to run the emulator.

- 1) Connect to MAVS using TattleTerm (neither version of Crosscut can perform YModem transfers).
- 2) Exit to the TOM8 monitor from the MAVS Main Menu by pressing 'q' followed by <ENTER>. At the password prompt type "nobska" (all lower case) and <ENTER> again.
- 3) The screen may go blank or display odd characters. This is because MAVS normally communicates at 38400 baud, but the TOM8 will only communicate at 9600 baud.
 - a) Go to the CommPort menu of TattleTerm and change the baud rate from 38400 to 9600 and press <ENTER> several times. You should now observe the TOM8> prompt.
- 4) At the TOM8> prompt type "g 28000" and <ENTER> to start PicoDOS.
 - a) Type '?' followed by <ENTER> to see a list of available commands.
 - b) Type "dir" followed by <ENTER> to list files on the flash card. Make note of the file names, particularly the range of data file names.
- 5) Begin by transferring the CONFIG.BIN file:
 - a) Type "ys config.bin" followed by <ENTER>
 - b) From the TattleTerm Transfer Menu select:
Transfer >> YMODEM >> Regular >> Receive
 - c) Select a folder for the data, use file name "config.bin", and click on Save.
 - d) Wait for the transfer to complete.

N.B. The PicoDOS 'ys' process (y-modem send) may time-out while you are selecting a folder and naming a destination file. If this occurs, simply return to Step 5a.
- 6) Repeat this process for DEPLOY.BIN. Note that you will only need to transfer these two files once as long as you do not make changes to the sampling scheme. If you do make changes, keep the various versions of these file pairs in separate folders with the corresponding data files.
- 7) Repeat this process for F_COUNT.BIN. This file contains the file count (the number of files to unpack) and should be downloaded each time. You can just overwrite the previous copy.
- 8) Repeat the download process for the selected DATANNNN.BIN files. Use appropriate folders if changes have been made to CONFIG.BIN and DEPLOY.BIN.
 - a) Type "ys data0001.bin" followed by <ENTER>
 - b) From the TattleTerm Transfer Menu select:
Transfer >> YMODEM >> Regular >> Receive
 - c) Select a folder for the data, use file name "data0001.bin", and click on Save.
 - d) Wait for the transfer to complete.
 - e) Repeat for DATA0002.BIN, DATA0003.BIN, etc.

- 9) Once all of the files have been transferred, type “tom8” followed by <ENTER> at the PicoDOS> prompt. The TOM8> prompt should appear.
- 10) Type ‘g’ followed by <ENTER> at the TOM8> prompt to restart the MAVS program.
- 11) The baud rates will be mismatched and the screen will be blank or display odd characters. Go to the CommPort menu of TattleTerm and change the baud rate from 9600 to 38400. You should now observe the usual countdown for assertion of operator control.
- 12) Assert control (<CTRL>-<C>) and proceed with the next deployment or other operations.

The files on your hard disk are in the mildly compressed binary form used by MAVS. They are precisely the same as the files you would have if you had extracted the compact flash card from the pressure housing and copied its contents to your hard disk. Start MAVSPack to unpack the files into ASCII as describe in the Operating MAVSPack section of this manual.

Sound Speed Tables

Sound Speed [m/s] at 0 meters depth										
	Salinity [‰]									
°C	0 ‰	28 ‰	29 ‰	30 ‰	31 ‰	32 ‰	33 ‰	34 ‰	35 ‰	36 ‰
0°C	1402	1440	1441	1442	1444	1445	1446	1448	1449	1450
2°C	1412	1449	1450	1451	1453	1454	1455	1457	1458	1459
4°C	1421	1457	1459	1460	1461	1463	1464	1465	1466	1468
6°C	1430	1466	1467	1468	1470	1471	1472	1473	1475	1476
8°C	1438	1474	1475	1476	1477	1479	1480	1481	1482	1484
10°C	1446	1481	1482	1484	1485	1486	1487	1489	1490	1491
12°C	1454	1488	1490	1491	1492	1493	1494	1496	1497	1498
14°C	1462	1495	1496	1498	1499	1500	1501	1502	1503	1505
16°C	1469	1502	1503	1504	1505	1506	1507	1509	1510	1511
18°C	1475	1508	1509	1510	1511	1512	1513	1515	1516	1517
20°C	1482	1514	1515	1516	1517	1518	1519	1520	1521	1523
22°C	1488	1519	1520	1521	1522	1523	1525	1526	1527	1528
24°C	1494	1524	1525	1526	1527	1529	1530	1531	1532	1533
26°C	1499	1529	1530	1531	1532	1533	1534	1536	1537	1538
28°C	1504	1534	1535	1536	1537	1538	1539	1540	1541	1542
30°C	1509	1538	1539	1540	1541	1542	1543	1544	1545	1546

Sound Speed [m/s] at 100 meters depth										
	Salinity (ppt)									
°C	0 ‰	28 ‰	29 ‰	30 ‰	31 ‰	32 ‰	33 ‰	34 ‰	35 ‰	36 ‰
0°C	1404	1441	1443	1444	1445	1447	1448	1449	1451	1452
2°C	1413	1450	1452	1453	1454	1456	1457	1458	1460	1461
4°C	1423	1459	1460	1462	1463	1464	1466	1467	1468	1469
6°C	1432	1467	1469	1470	1471	1472	1474	1475	1476	1478
8°C	1440	1475	1476	1478	1479	1480	1482	1483	1484	1485
10°C	1448	1483	1484	1485	1486	1488	1489	1490	1491	1493
12°C	1456	1490	1491	1492	1494	1495	1496	1497	1498	1500
14°C	1463	1497	1498	1499	1500	1502	1503	1504	1505	1506
16°C	1470	1503	1504	1506	1507	1508	1509	1510	1511	1513
18°C	1477	1509	1510	1512	1513	1514	1515	1516	1517	1519
20°C	1483	1515	1516	1517	1519	1520	1521	1522	1523	1524
22°C	1489	1521	1522	1523	1524	1525	1526	1527	1528	1530
24°C	1495	1526	1527	1528	1529	1530	1531	1532	1534	1535
26°C	1501	1531	1532	1533	1534	1535	1536	1537	1538	1539
28°C	1506	1535	1536	1538	1539	1540	1541	1542	1543	1544
30°C	1511	1540	1541	1542	1543	1544	1545	1546	1547	1548

Sound Speed [m/s] at 500 meters depth										
	Salinity (ppt)									
°C	0 ‰	28 ‰	29 ‰	30 ‰	31 ‰	32 ‰	33 ‰	34 ‰	35 ‰	36 ‰
0°C	1410	1448	1449	1450	1452	1453	1454	1456	1457	1458
2°C	1420	1457	1458	1460	1461	1462	1463	1465	1466	1467
4°C	1429	1466	1467	1468	1469	1471	1472	1473	1475	1476
6°C	1438	1474	1475	1476	1478	1479	1480	1482	1483	1484
8°C	1447	1482	1483	1484	1486	1487	1488	1489	1491	1492
10°C	1455	1489	1491	1492	1493	1494	1496	1497	1498	1499
12°C	1462	1496	1498	1499	1500	1501	1503	1504	1505	1506
14°C	1470	1503	1505	1506	1507	1508	1509	1510	1512	1513
16°C	1477	1510	1511	1512	1513	1514	1516	1517	1518	1519
18°C	1484	1516	1517	1518	1519	1521	1522	1523	1524	1525
20°C	1490	1522	1523	1524	1525	1526	1527	1529	1530	1531
22°C	1496	1527	1528	1529	1531	1532	1533	1534	1535	1536
24°C	1502	1532	1534	1535	1536	1537	1538	1539	1540	1541
26°C	1507	1537	1538	1539	1541	1542	1543	1544	1545	1546
28°C	1512	1542	1543	1544	1545	1546	1547	1548	1549	1550
30°C	1517	1546	1547	1548	1549	1550	1551	1553	1554	1555

Sound Speed [m/s] at 1000 meters depth										
	Salinity (ppt)									
°C	0 ‰	28 ‰	29 ‰	30 ‰	31 ‰	32 ‰	33 ‰	34 ‰	35 ‰	36 ‰
0°C	1419	1456	1457	1459	1460	1461	1463	1464	1465	1467
2°C	1428	1465	1466	1468	1469	1470	1472	1473	1474	1476
4°C	1437	1474	1475	1476	1478	1479	1480	1482	1483	1484
6°C	1446	1482	1483	1485	1486	1487	1489	1490	1491	1492
8°C	1455	1490	1491	1493	1494	1495	1496	1498	1499	1500
10°C	1463	1498	1499	1500	1501	1503	1504	1505	1506	1508
12°C	1471	1505	1506	1507	1508	1510	1511	1512	1513	1515
14°C	1478	1512	1513	1514	1515	1516	1518	1519	1520	1521
16°C	1485	1518	1519	1520	1522	1523	1524	1525	1526	1527
18°C	1492	1524	1525	1526	1528	1529	1530	1531	1532	1533
20°C	1498	1530	1531	1532	1533	1535	1536	1537	1538	1539
22°C	1504	1535	1537	1538	1539	1540	1541	1542	1543	1544
24°C	1510	1541	1542	1543	1544	1545	1546	1547	1548	1549
26°C	1516	1546	1547	1548	1549	1550	1551	1552	1553	1554
28°C	1521	1550	1551	1552	1553	1554	1555	1557	1558	1559
30°C	1526	1555	1556	1557	1558	1559	1560	1561	1562	1563

Revision History

New Features of Version 4.6

This manual documents all operational features of Version 4.6 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 4.6 are briefly described in this section.

Bug Fixes

Version 4.6 fixes a problem with sample acquisition timing within a burst when using Query Mode. Bursts are externally triggered in this mode. Previously, samples were acquired faster than the programmed rate. Samples are now acquired at the programmed sample frequency. Note that this was only an issue in Query Mode. Normal autonomous deployments were not affected.

In addition, a small inconsistency in the calculation of flash card endurance has been fixed. This would not have affected an actual deployment, but could have affected deployment planning when using the battery and memory endurance calculator features.

Flash Card Change - SanDisk to SiliconSystems

SanDisk no longer manufactures the industrial grade compact flash cards that have heretofore been used in all MAVS3 instruments. These cards, when purchased through Nobska, have been individually tested and certified for use by Persistor Instruments, the manufacturer of the flash card board used in MAVS3 instruments.

The replacement flash card line selected and certified by Persistor is manufactured by SiliconSystems. While the new product is nominally the same as the SanDisk card, Persistor has detected some timing issues when the card is being powered-up or is coming out of Low Power Sleep on a TT8 V2. Addressing these differences in a robust way across several MAVS3 hardware configurations has required some internal changes to our code. These changes are part of Version 4.6.

Profiler Mode

MAVS is now being deployed on Moored Profilers. To support this ongoing development, a Profiler Mode option has been added under Sensor Orientation on the System Configuration menu. This feature is documented separately and should only be used for deployment on a Moored Profiler.

New Features of Version 4.5

This manual documents all operational features of Version 4.5 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 4.5 are briefly described in this section.

SCP Version Numbers

Nobska now maintains three concurrent SCP code families to support the three compass and tilt module configurations of the MAVS3 that currently exist. The MAVS32_N code family supports original MAVS3 instruments equipped with a 2-axis gimbaled compass and a 2-axis fluid tilt sensor. MAVS33_N codes support more recent instruments built with a 3-axis, solid-state compass and a 2-axis fluid tilt sensor. Instruments currently (June 2004) in production are equipped with a 3-axis, solid-state compass and a 2-axis, solid-state tilt sensor and are operated with MAVS34_N SCPs.

Version 4.5

Version 4.5 supports a fully solid state compass and tilt module. The code is operationally equivalent to Versions 3.5 and 2.5, which support the two other MAVS3 compass and tilt configurations currently in use. However, several differences will be apparent to the operator.

First, the new module is significantly smaller than earlier versions. This has freed sufficient space in the MAVS3 pressure housing to allow routine use of our double-stack alkaline and lithium battery packs. Longer deployments at higher sampling densities can now be conducted without resorting to external power sources.

Second, the new module is much less expensive to manufacture. Tilt is now a standard feature of MAVS3 instruments, rather than an option with an associated additional cost.

Third, it is now possible to change the sensor orientation in the field; there is no need to return the system to Nobska for hardware alterations. In most cases, the operator only needs to change the Sensor Orientation setting on the System Configuration menu and then run the tilt calibration procedure. In some cases it will first be necessary for the operator to move the tilt sensor from one socket in the module to another. See Changing Sensor Orientation for more information.

Finally, the Fast/Slow Tilt setting on the System Configuration menu has been superseded by a Fast/Slow warm up interval. Early versions of the fluid tilt sensor were slow and required a longer warm up time than later versions. The new solid state tilt sensor is fast, but that setting was also used to support optional auxiliary sensors with varying warm up requirements for achieving specified accuracies. Not wishing to lose that feature, we have brought it out as an explicit and separate option on the System Configuration menu. See Changing the System Configuration for more information.

Tilt Calibration

Like all solid state tilt sensors, ours has some temperature dependence. Temperature and scale calibration values for each tilt sensor are determined by Nobska during system qualification and stored in the instrument as part of the system configuration array. These are, in general, fixed values that the operator will not need to determine again. The automated calibration procedure built into the SCP directly determines only the physical pitch and roll offsets. It can be run easily when needed, after a change in sensor orientation, for example. It can also be used to determine the temperature and scale factors if this becomes necessary. See both Solid State Tilt Calibration sections for a complete description of the procedure. Note that accurate tilt determination now requires a dynamic temperature measurement, but a thermistor has always been standard equipment with MAVS, so this measurement is made automatically.

New Features of Version 3.5

This manual documents all operational features of Version 3.5 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 3.5 are briefly described in this section.

SCP Version Numbers

Nobska now maintains three concurrent SCP code families to support the three compass and tilt module configurations of the MAVS3 that currently exist. The MAVS32_N code family supports original MAVS3 instruments equipped with a 2-axis gimbaleed compass and a 2-axis fluid tilt sensor. MAVS33_N codes support more recent instruments built with a 3-axis, solid-state compass and a 2-axis fluid tilt sensor. Instruments currently (June 2004) in production are equipped with a 3-axis, solid-state compass and a 2-axis, solid-state tilt sensor and are operated with MAVS34_N SCPs.

Version 3.5

Version 3.5 is a minor upgrade from Version 3.4. It includes several internal changes to reduce the size of the executable program in TT8 flash memory. These changes are invisible to the operator.

There is also a fix for a logic flaw which made it possible for the operator to disable the compass without forcing the instrument out of the Earth reference frames for a deployment. An automatic check, triggered when the operator selects Deploy System from the Main Menu, now prevents this possibility.

Finally, our “on-board” contact information has been updated. For your convenience, we repeat that information here:

Nobska Engineering and Technical Support		
Dan Schaaf	941-766-0706	nobska@compuserve.com
Todd Morrison	508-360-2393	atmorrison@nobska.net
Sandy Williams	508-289-2725	awilliams@nobska.net
Fax	941-766-0707	
Web	www.nobska.net	
Software Version	mavs33_5.c	
Compiled:	May 17 2004 13:49:58	
Serial Number:	10414	
Press any key to continue.		

Faster Serial Offload

Several users have reported that their operational circumstances make it impossible or inadvisable to recover data files by opening the pressure housing and removing the compact flash card. Unfortunately, as we are all aware, serial offload of large files is painfully slow.

To address this problem, we have developed a faster serial offload procedure using the YModem protocol. The procedure currently requires significant operator involvement - manual command of each file download. We plan to automate this procedure in the next version of MAVSoft. Detailed instructions for the new procedure can be found in the Serial Offload Using YModem section of this manual.

New Features of Version 3.4

This manual documents all operational features of Version 3.4 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 3.4 are briefly described in this section.

The most important change with Version 2.4 is the now definitively established value of the conversion constant that scales velocity measurements from raw counts to SI physical units of cm/s. The new default value is 0.0028033 cm/s/count. Our lengthy investigation into the low-speed non-linearity that precipitated the original change in the velocity scaling constant (see New Features of Version 1.8) is documented in a paper¹² and an internal report¹³. Both are available for download on the Nobska web site, <http://www.nobska.net>. The new value is associated with a component change in the MAVS3 electronics. Nobska can upgrade existing systems for owners who wish to ship them to us. The upgrade is not critical for most users. Operators of systems that have not had the hardware changed should not alter their existing conversion constants.

A very select group of customers was able to point us to a bug in the MAVS3 system control code. An intermediate scaling operation led, in high speed flows, to the overflow of an integer variable. The problem only affects the vector velocity frames and only when the flow along one of the coordinate axes exceeds ~90 cm/s. The raw acoustic axis measurements are not compromised and an accurate velocity time-series can be constructed during post-processing if the raw axes were logged (always recommended). Nobska can provide assistance with the reconstruction. We are aware of only three customers for whom this has been a problem.

In previous versions of the system control code the Delete all files and Format flash card options of the Flash Card Operations menu were equivalent. Both executed a “quick format” operation, altering only the file allocation tables on the flash card. A quick format executes in a short period of time, but does not actually erase the data; files can be recovered using commercially available data recovery utilities. The Delete all files option will continue to execute a quick format. However, Format flash card will now command a “full format”, physically writing to each sector on the flash card. The execution time is significantly longer, but the card is fully erased by the operation. A quick format will prevent fragmentation of the file system and is sufficient in most cases. It is a quick format that is performed automatically by the system before starting a deployment when append mode is disabled.

We are very pleased to announce the latest release of MAVSPack, a PC based executable used to quickly unpack the compressed binary data files acquired by MAVS3 instruments. These data files are stored on the PC compatible compact flash card mounted inside MAVS systems equipped for internal logging. MAVSPack is now controlled through an intuitive and easy to use graphical user interface. The new interface streamlines MAVSPack operation to an enormous degree. It has been a real pleasure to use it and we hope you will like it as much as we do. See Operating MAVSPack for complete instructions.

Finally, some additional comments about internal batteries and compass calibration have been added to the manual. For your convenience, we repeat the comments here:

¹² Williams, A. J., 3rd, Morrison, A. T., III, “Electronic Crosstalk and Linearity in the Acoustic Travel-Time Current Meter, MAVS”, *Proceedings OCEANS 2003*, MTS/IEEE/OES, September 2003, pp. 1510-1515.

¹³ Williams, A. J., 3rd, Irish, J. D., “MAVS3 10081 Tow Calibration of 9/16/03”.

Compass calibration compensates for the portion of the total magnetic field carried by the instrument itself. The most notable contribution to the instrument's magnetic field comes from the battery pack. Thus, the compass calibration will change whenever the battery pack is changed, shifted, or twisted, even if the battery has been degaussed to reduce the strength of its magnetic field. **The compass should be re-calibrated whenever a new battery pack is installed. The compass should also be re-calibrated whenever a battery pack is re-installed or otherwise physically shifted or twisted** because those changes move the magnetic field of the battery pack relative to the compass. Battery packs should always be thoroughly degaussed before use in a system equipped with a compass. The compass should also be re-calibrated whenever the sensor orientation is changed. The compass should always be calibrated in the orientation in which it is to be deployed. Contact Nobska for more information about compass calibration and battery degaussing.

We hope you will take this advice to heart. As always, please contact us if we can be of some assistance.

New Features of Version 3.3

This manual documents all operational features of Version 3.3 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 3.3 are briefly described in this section.

Version 3.3 of the system control program corrects several newly identified deficiencies of Version 3.2, the initial release of the MAVS3 SCP for systems equipped with the new 3-axis compass module. First, during testing of a Horizontal/Bent Up instrument, we discovered that it was necessary to separate the Vertical/Up and Vertical/Down sensor orientation cases from the Horizontal/Bent Up and Horizontal/Bent Down cases. The two up cases and the two down cases had previously been paired. Horizontal/Bent Up and Horizontal/Bent Down options have been added to the sensor orientation selections accessed from the System Configuration menu.

In the course of this investigation, two bugs were discovered in the 3-axis compass calibration routine. First, an incorrectly assigned compass offset is now correctly assigned. Second, the tilt sensor, if present, is now automatically disabled during compass calibration. The compass calibration procedure requires positioning the system at angles well beyond the range of the tilt sensor. Disabling the tilt sensor during calibration prevents these spurious, out of range values from contaminating the result. Our apologies for the QC failure during testing of Version 3.2; we should have caught these problems sooner.

Finally, while qualifying a group of instruments that included Vertical/Down, Vertical/Up, and Horizontal/Bent Up orientations, we were able to demonstrate a small improvement in compass accuracy following a minor alteration to the calibration procedure. Formerly, calibration began with the system in the Vertical/Down orientation, whether or not the system was to be deployed in that orientation. Calibrations should now be conducted beginning with the instrument in the orientation in which it will be deployed. See Calibration for a complete description of the new procedure. Typical compass errors following the new procedure are below 5°. With attention to the precision of the rotations and care for local magnetic anomalies, errors below 1° to 2° can be readily achieved.

New Features of Version 3.2

This manual documents all operational features of Version 3.2 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 3.2 are briefly described in this section.

Version 3.2 of the system control program supports a major change to the MAVS3 hardware. The gimbaleed, 2-axes compass used in previous MAVS3 units has been discontinued by the manufacturer. We have replaced it with a solid state, 3-axes compass. The compass calibration procedure is now somewhat more complex, but that is the only operational change for users. One important advantage of the new compass is that it no longer needs to be rotated and remounted by Nobska when an operator wishes to use the sensor in another orientation. The rotation is performed in software and the operator only needs to change the Sensor Orientation setting on the System Configuration menu.¹⁴ A sample of the new compass calibration procedure has been added to the calibration examples. As with existing MAVS3 calibration utilities, instructions are displayed for the operator when running the procedure.

SCP Version Numbers

Two MAVS3 hardware configurations are now currently in use. Versions 1.X and 2.X of the system control code are for use with MAVS3 units fitted with a 2-axis compass. Version 3.X of the system control code is for use with MAVS3 units fitted with a 3-axis compass. Significant differences in the response speed and serial interface characteristics of the two compasses (and dwindling space in TT8 flash memory) made it impossible to accommodate both types of compass with a single system control program and an entry in the system configuration. To provide continuing support for existing 2-axis MAVS3 systems, all future improvements and enhancements to the MAVS3 code will be applied to both versions and made available to all customers. The last digit of the version number will be common to both series to indicate a matching level of functionality. For example, Versions 2.2 and 3.2 have the same features and operational interface. They differ only in the type of compass supported.

¹⁴ The tilt sensor, if present and enabled, must still be physically rotated and remounted by Nobska if the sensor orientation is changed. We are working to identify a solid state tilt sensor which does not drift to an unacceptable degree with time and temperature. When such a device is incorporated it will be possible to change the sensor orientation entirely in software and without any need for a factory upgrade.

New Features of Version 2.2

This manual documents all operational features of Version 2.2 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Versions 2.2 are briefly described in this section.

There are only two changes moving from Version 2.1 to Version 2.2. The first is internal and largely transparent to the operator. The timing of one of the logic signals that control the differential travel time circuit has been changed. The change has been made to stabilize the reference voltage of the analog-to-digital converter. An intermittently unstable reference has been observed on only one MAVS3 system to date, however, we recommend this software upgrade to all users as a precaution. No changes to system operation are associated with this upgrade. A reduced measurement noise level may result for particular units that currently exhibit an unstable reference voltage.

The second change is equally minor. The Nobska email address on the Contact Nobska display has been changed from Dan-Schaaf@worldnet.att.net to Nobska@compuserve.com. Dan is still with us and the old address is still active, but the new address has considerably more space on the server and we encourage you to make the switch.

New Features of Version 2.1

This manual documents all operational features of Version 2.1 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 2.1 are briefly described in this section.

There are only two changes moving from Version 2.0 to Version 2.1. The first is internal and completely transparent to the operator. The change allows older (slower) PCs running MAVSoft to communicate smoothly with a MAVS3. For the operator there are no operational changes. All menus remain the same.

The second change is equally minor. The name of the MAVSPrep routine has been changed to MPrep321 to make tracking the version easier.

New Features of Version 2.0

This manual documents all operational features of Version 2.0 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 2.0 are briefly described in this section.

The user interface of Version 2.0 is essentially identical to Version 1.9. There are only two changes to note. First is a correction to the calculation of vector velocities from raw path velocities. At high flow speeds that calculation, in earlier versions of the code, could overflow and produce an erroneous result. The calculation has been restructured in Version 2.0 to prevent overflow.

Users who have collected field and laboratory data with previous versions of the code should note that the problem could only occur at very high velocities (80 cm/s to 100 cm/s or more). The actual threshold has an angular dependence. Importantly, the over-scaling can be removed from existing data during post-processing if the raw acoustic axis velocities were recorded. The equations that map raw path velocities to velocity vectors in the instrument and Earth frames are provided in this manual (see Bench Tests). Nobska will happily provide guidance to any users who require assistance with this operation.

Second, the optional analog velocity outputs can now be independently enabled during a deployment. Previously, the data monitor had to be enabled to activate the analog velocity outputs. The change makes it possible to provide analog velocities to a user at a rate of ~36 Hz. With the data monitor enabled the limit is ~27 Hz.

Nobska is also pleased to announce a new utility, MAVSPrep. MAVSPrep replaces the LOADNN_N programs used to prepare a MAVS unit for an upgrade of the system control code. The unfortunate "feature" of LOAD31_9 and its predecessors was the loss of existing calibration constants, system configuration information, and deployment definition parameters. MAVSPrep preserves all existing constants while preparing the MAVS for an upgrade to Version 2_0 of the system control code. MAVSPrep can be used either to initialize a new system or to upgrade from MAVS31_7, MAVS31_8, or MAVS31_9 to MAVS32_0.

New Features of Version 1.9

This manual documents all operational features of Version 1.9 of the MAVS3 system control program. For the convenience of users familiar with previous versions of the program, features that are new with Version 1.9 are briefly described in this section. Features that were new with Version 1.8 are described in the section that follows.

The largest and most visible change associated with Version 1.9 is MAVSoft, a GUI interface that can replace the existing terminal emulators, Crosscut and TattleTerm. MAVSoft does not yet provide access to all of the features of MAVS3 that are available through the Crosscut interface. However, new MAVSoft capabilities are being added steadily and the Crosscut interface will always remain part of the MAVS3 system control program. Beginning with Version 1.9, the MAVS3 system control program also includes support for MAVSoft.

Some numerical analysis packages are unable to read hexadecimal notation. To address this problem, Version 1.9 allows the operator to select the display format for the raw acoustic axes measurements during bench tests, deployments, and data offload. The axes can still be displayed in the hexadecimal, 2s complement, format of previous versions of the system control program. They can now also be displayed as decimal integers or in SI physical units. The decimal integers are simply a different presentation of the 16 bit hexadecimal format with -32768 representing the maximum negative velocity and +32767 representing the maximum positive velocity. The SI physical units are cm/s. This option has also been added to MAVSPack.

Given the existence of the MAVS3 manual, the document you are now reading, we felt the instruction mode, which provided on-screen definitions of the deployment parameters when it was enabled, had become superfluous. It has been removed in Version 1.9.

The velocity calibration routine now includes a calculation of standard deviation for each of the four acoustic axes. The standard deviation is one important measure of the quality of the velocity calibration measurements. Low variability indicates that the instrument is well tuned, that the test conditions are stable, and that the calculated velocity offsets are of high quality.

A bug in the system control program, which doubled the burst interval each time a data file was closed and a new file was opened, has been eliminated. A PicoDOS bug has been identified and eliminated. Under some circumstances PicoDOS Version 1.51 would leave the flash card in a high current state, continuously drawing more than 25 mA from the battery. The current drain would continue until the next file system access properly reset the card. The new revision of PicoDOS, Version 1.52, in which this bug is fixed, is available from Nobska. It can be installed in any existing MAVS3 instrument with or without an upgrade to Version 1.9.

A discussion of the measurement averaging calculations that generate samples for display and logging during a deployment has been added to Version 1.9 of the manual. The new section is included simply to provide the information to users; there have been no changes in the ways the averages are calculated.

In response to customer inquiries a discussion of MAVS3 power consumption has been added to the manual. Additionally, the battery longevity calculation has been upgraded to account for the presence of any auxiliary sensors (conductivity, pressure, OBS, etc.).

Early in 2002, a MAVS user making velocity measurements at 15 Hz noticed that while the average measurement rate was 15 Hz, those measurements were not evenly spaced in time. The MAVS3 engineering team confirmed the measurement clustering, which was evident to some degree whenever the measurement frequency exceeded approximately 10 Hz. The jitter was an unforeseen byproduct of a conditional branch in the system control code that provided some reduction in power consumption. The measurement, sample, and burst interval timing code has been revised to eliminate measurement jitter. One unforeseen and fortuitous byproduct has been a further small reduction in power consumption. Measurements are now synchronous and evenly spaced in time at programmed measurement frequencies up to 35 Hz.

The default tilt offsets are now set to the mid-scale value indicating zero tilt. In previous versions the default offsets were zero, the maximum negative tilt. This means uncalibrated tilt sensors will remain in range and present reasonable values, which can be corrected during post-processing. Of course, calibrating the sensor before deploying the system is still preferred.

The verbose display mode used during deployments and data offload has been made less verbose. Similar to the scrolling displays of the Bench Tests utilities, verbose mode now simply displays a column identification header, with measurement units, every ten samples. When verbose mode is disabled the header is displayed only once, just before the first sample.

The old verbose style, with fully labeled, multi-line records, has been retained by MAVSPack for human readable output. During machine readable unpacking the column header is displayed on the screen. With either MAVSPack output format a file named HEADERS.DAT, containing the column header, is created.

All dates are now displayed with a four digit year rather than the three digit year of earlier versions. For example, the year 2001 is now displayed as 2001 rather than 101. Date and time entry has been improved to match and now correctly recognizes one, two, three, and four digit specifications of the year. For example, the year 2001 can be entered as 1, 01, 101, or 2001 and will be correctly recognized as the year 2001, not 1901 or some other year.

A new hardware option, analog velocity outputs, has been added to MAVS3 in Version 1.9. A suitably equipped system will provide a scaled analog voltage output for each of the four acoustic paths. The output range is -5 V to +5V. The voltages correspond in the obvious linearly sense to the range $-V_{\max}$ to $+V_{\max}$. Also available on the analog output connector are the -5 V and +5 V references, a ground reference, and a data update strobe. The analog outputs are available in real-time during a deployment and can also be played back from logged data during serial offload.

New Features of Version 1.8

This manual documents all operational features of Version 1.8 of the MAVS3 system control program. The manual has been revised and updated to include the new features of Version 1.8 and more complete descriptions of existing features. A number of new examples have also been added. For the convenience of users familiar with previous versions of the program, features that are new with Version 1.8 are briefly described in this section.

As a result of some very exacting tow tank and nanosecond delay tests with MAVS3 systems, we have changed the default value of the conversion constant that scales velocity measurements from raw counts to SI physical units of cm/s. The old value was 0.0029812 cm/s/count. The new value is 0.0027576 cm/s/count. This is a linear change in the velocity calibration of 7.5% that will improve accuracy in flows less than 40 cm/s. Note that default conversion values have always assumed water with a sound speed of 1500 m/s. Tables of sound speed as a function of temperature, salinity, and depth are provided at the end of the manual. Fresh water is included as a special case.

The record length for flash card data storage is now variable, rather than fixed at 46 bytes. The fixed length record contained space for a full time tag, acoustic axes and vector velocity measurements, and all possible auxiliary sensors. The new variable size depends on which sensors are enabled and on several user programmable options. The empty bytes associated with disabled sensors are no longer included in the record, making more efficient use of addressable space on the flash card. At the discretion of the user and constrained by the needs of the investigation, the records size could, conceivably, be reduced to 6 bytes (velocity vector only) or even to 2 bytes (one auxiliary sensor only). In general, of course, the record will be larger than that, but it no longer includes unused bytes.

Data storage now includes an append mode. In previous versions all data files on the flash card were deleted at the beginning of a deployment and a fresh set of files, sequentially named, were created. The operator can now choose to preserve existing data files by enabling append mode. In append mode the system will add new files to the existing sequence as new data are acquired. Append mode can be used in either "throw and go" mode or in the more normal operator present mode.

The verbose mode that enabled several screens of instructions at the beginning of a deployment has been renamed "instruction mode". This was done to avoid confusion with the "verbose display" mode used when the data monitor is active and during data offload. Instruction mode can now be toggled on and off from the Main Menu; it is no longer necessary to exit to the TOM8 monitor to enable or disable instruction mode.

New calibration routines have been added for the optional pressure and conductivity sensors. A "critical fault handler" has also been added. In the event of a system crash, operator induced or otherwise, this feature places the system in a low power state from which the operator can command a re-start through the communication port. Opening the pressure housing to disconnect and reconnect the battery (a "cold" re-boot) is no longer necessary.

The text and formatting of some prompts and messages has been changed for greater clarity and/or to correct labeling errors. The input ranges for some user supplied values have been changed. Sensor offsets can now be negative, for example. Additional automated checks on the quality of measurements used during calibration have been added.

Several programming weaknesses have been identified and fixed during our normal testing of new instruments. Among other changes, we have made sure that the measurements taken by auxiliary sensors during bench testing and calibration are acquired under internal system conditions (timing, system clock speed, order of events, etc.) that are identical to the conditions of a deployment. This was done to improve the reliability and accuracy of auxiliary sensor calibration.

Finally, MAVSPack, a fast data unpacker, is now available. Until recently, binary data had to be unpacked by the MAVS3 system control program running on the TT8, spooled out through the narrow bandwidth of the communications port, and collected using the screen capture utility of the communications program running on the PC. The flash cards installed in MAVS3 systems are formatted for compatibility with MS-DOS/Windows based PCs. The card can be removed from the MAVS3 unit after a deployment and installed in any suitably equipped PC. Once installed, simply copy all of the files to the hard disk, archiving the data at bus speeds. Once the data are copied, run the unpacker, a PC resident executable, to process the binary data into ASCII text files. These files can be read by most numerical analysis and visualization software packages. The processing is accomplished at bus speeds and is not limited by the baud rate of the serial communications port. Unpacking a large data set, which would once have required hours or days to complete, now requires only a few minutes, most of them spent moving the flash card from the MAVS3 to the PC. The unpacker can be used with data from Versions 1.7 and 1.8 of the MAVS3 system control program.

