

VALEPORT LIMITED
MIDAS SVX
Combined CTD & Sound Velocity Profiler
Operation Manual

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INTRODUCTION

This manual covers the operation and basic maintenance of the Valeport MIDAS SVX Combined CTD & Sound Velocity Profiler (previously known as the Model SVXtra), and contains instrument specific documentation such as calibration details and guarantee certificate. The manual is split into two Sections, as follows:

SECTION 1 MECHANICAL DETAILS

- Sensor specification
- Mechanical specification
- Installation details
- Basic maintenance procedures
- Wiring information
- Calibration information
- Guarantee certificate

SECTION 2 SOFTWARE

The DataLog 400 software supplied is suitable for use with any Valeport Series 400 instrument (including the MIDAS SVX), regardless of specification. This section of the manual is therefore written with this in mind, but specific examples of displays may differ slightly, depending on the sensors fitted. Functions of the software covered include:

- Installation
- Establishing communications
- Instrument setup
- Data extraction
- Data display

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MIDAS SVX Combined CTD & SVP

Section 1 - Mechanical Operation

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1 INTRODUCTION

This section of the manual describes the specification, construction, wiring diagrams and basic maintenance procedures of the Valeport MIDAS SVX Combined CTD & Sound Velocity Profiler.

As standard, the MIDAS SVX system consists of the following components:

- Titanium housed instrument
- Stainless steel deployment cage
- 3m Y lead (interface to PC)
- Switching Plug
- Basic maintenance tools and spare o-rings
- DataLog 400 Software
- Operating Manual
- Transit case

In addition, the following components may be supplied as optional extras:

- RS485 communications adaptor
- RS422 communications adaptor
- FSK modem communications adaptor (includes pcb in instrument)
- Various lengths & types of signal cable are also available

Please refer to Section 2 of this manual for details of software operation.

2 SPECIFICATIONS

2.1 SENSOR SPECIFICATIONS

The unit is fitted with the following sensors:

Sound Velocity

| | |
|--------------------|--|
| Type: | Valeport "time of flight" sound velocity sensor |
| Range: | 1400 to 1600m/s standard. Factory fit option of 1600 to 1850m/s is available |
| Accuracy: | ± 0.03m/s (rms) |
| Resolution: | 0.001m/s |

Conductivity

| | |
|--------------------|--|
| Type: | Valeport inductive coil |
| Range: | 0.1 to 80mS/cm |
| Accuracy: | ± 0.01mS/cm |
| Resolution: | 0.002mS/cm (up to 4Hz sampling, 0.006mS/cm at 8Hz) |

Pressure (standard)

| | |
|--------------------|--|
| Type: | Strain Gauge |
| Range: | 500Bar absolute (approx 5000m water depth) standard. Others available. |
| Accuracy: | ± 0.04% Full scale |
| Resolution: | 0.005% Full scale |

Pressure (option)

| | |
|--------------------|---------------------------|
| Type: | Resonant Quartz |
| Range: | Various up to 10,000 psi. |
| Accuracy: | ± 0.01% Full scale |
| Resolution: | 0.001% Full scale |

Temperature

| | |
|--------------------|-------------------|
| Type: | Fast response PRT |
| Range: | -5 to +35°C |
| Accuracy: | ± 0.01°C |
| Resolution: | 0.002°C |

2.2 MECHANICAL SPECIFICATIONS

Materials

| | |
|----------------------|--|
| Housing: | Titanium |
| Exceptions: | Sound velocity sensor uses carbon fibre composite rods. Note that some earlier systems used treated Invar rods and zinc anode instead. |
| Cage: | Stainless steel (316 grade) with polypropylene clamping brackets |
| Dimensions: | Instrument - 210mm Ø, 590mm long (including connector) |
| Weight: | 15kg (air), 8kg (water) |
| Depth Rating: | 5000m (unless smaller pressure sensor fitted) |

Connectors

| | |
|------------------------|--|
| Instrument: | 10 pin female Subconn bulkhead type (MCBH10F) with lock ring, data and power |
| Comms Cable: | Valeport 3m Y lead. 10 pin male Subconn line type (MCIL10M) to instrument, 2 x 4mm banana plugs to external power, 9 pin female D type to PC. |
| Switching Plug: | 10 pin male Subconn line type (MCIL10M), with lock ring. Note that the switch cap contains wiring links to activate the instrument – it is not a dummy plug. |

2.3 PERFORMANCE SPECIFICATIONS

| | |
|------------------------|---|
| Memory: | 8Mbyte solid state memory (upgradeable in 8 Mbyte steps to 32 Mbyte) |
| Internal Power: | 8 x 1.5v alkaline D cells. The unit will accept 8 x 3.6v Lithium D cells with no alterations required. <u>Do not mix battery types.</u> |
| External Power: | Between 8 and 30v DC. |
| Current Drain: | 60mA at 12v when running, and 0.25mA when in sleep mode. |
| Sampling Rate: | 1, 2, 4 or 8Hz (synchronised) |
| Data Output: | RS232, RS485 or RS422, depending on pin selection. Baud rate is user selectable from 2400 to 115200 |

2.4 SAMPLE LIFETIME CALCULATIONS

2.4.1 BASED ON MEMORY

Lifetime based on memory is simple to calculate. Conductivity, temperature and pressure values use 2 bytes of memory per sample, and sound velocity uses 4 bytes. Therefore total memory used per record is $4 + (3 \times 2) = 10$ bytes. Note that in Trip mode, each record is also assigned a date/time stamp, which uses a further 7 bytes.

The 8 Mbyte memory actually contains 8,388,608 bytes. Allowing a small amount of memory usage for header files, the memory will store over 490,000 records in Trip sampling mode, and over 830,000 records in all other modes.

The length of time that this will last for obviously depends on sampling scenario. Here are three examples:

Continuous data sampling, 8Hz:

Memory used per second is 8×10 bytes = 80 bytes.

Total memory fitted is 8,388,608 bytes.

Number of seconds before memory full is $8,388,608 / 80 =$ (approx) 104,500 seconds.

This is equivalent to 29 hours.

This period can be doubled by sampling at 4Hz.

Burst sampling, 4Hz, sampling for 1 minute every 10 minutes, recording all data points:

Memory used per burst is 10 bytes \times 4Hz \times 60 seconds = 2400 bytes.

The memory will therefore be full after $8,388,608 / 2400$ bursts = 3495 bursts. At a 10 minute cycle time, this is 34950 minutes, which is equivalent to 24 days.

Trip sampling, 5000m cast, measuring every 1 metre:

In this example, the instrument will take 1 reading every metre of both descent and ascent. This means 5000 data points descending, and a further 5000 ascending. Each record consists of 10 bytes of data and 7 bytes of time stamp. Each record therefore uses 17 bytes. A single cast will take 10,000 such records, and will therefore use 170,000 bytes.

The 8Mbyte memory will therefore hold approximately 49 casts of data.

2.4.2 BASED ON BATTERIES

The Model SVXtra will function with a voltage supply of between 9 and 30vDC. The voltage output of the 8 x D cell battery pack will vary according to the type of cell fitted. The most likely cells to be used will be standard alkaline type (1.5v each) or Lithium cells (3.6v each), giving a 12v nominal output for alkaline cells, or 28.8v nominal for Lithium cells. The following calculations are based on the same sampling scenarios as the memory calculations, using figures for a 12v alkaline battery pack. Each example also gives a figure for a Lithium battery pack, calculated from a basic ratio of alkaline to Lithium performance.

In all examples, it is taken that an 8 D cell alkaline battery pack will have a nominal capacity of 14Ah, and will be 75% efficient (total available charge, 10.5Ah), and that an 8 D cell Lithium pack will have a nominal capacity of 17.5Ah, and will be 95% efficient (total available charge, 16.6Ah).

Continuous data sampling, 8Hz:

At 12v, the instrument draws 60mA when sampling.

Total charge available is 10500mAh.

Number of hours available is therefore 10500mAh / 60mA = 175 hours.

This is equivalent to just over 7 days.

For Lithium cells, a similar calculation gives over 27 days.

Note that the instrument is effectively operating continuously when in Trip sampling mode, so similar calculations will apply.

Burst sampling, 4Hz, sampling for 1 minute every 10 minutes:

At 12v, instrument draws 60mA when sampling, plus 60mA for 5 seconds at the start of each burst. It draws 0.25mA when in sleep mode between bursts.

In this scenario then, the instrument will draw 60mA for 65 seconds, and then 0.25mA for 535 seconds. On average, it will draw:

$$\frac{(60 * 65) + (0.25 * 535)}{(65 + 535)} = 6.72\text{mA}$$

Total charge available is 10500mAh.

Number of hours available is therefore 10500mAh / 6.72mA = 1562 hours.

This is equivalent to approx 65 days.

For Lithium cells, a similar calculation gives approx 156 days.

Note that the above examples are intended as guides only. Valeport accepts no responsibility for variation in actual performance. Note that performance of individual battery cells is not always consistent.

3 INSTALLATION

The standard system is supplied in an ABS transit case, together with any communications adaptors ordered. Any additional lengths of signal cable are packed separately.

3.1 COMMUNICATIONS WITH PC

The MIDAS SVX can be set up and interrogated using the DataLog 400 software supplied. Please refer to Section 2 of this manual for details of how to use the software.

To connect the instrument directly to a PC for RS232 communications, use the 3m Y lead supplied. This lead is fitted with a 10 pin Subconn type connector, which should be plugged directly into the connector on the top of the housing (or to a length of signal cable). The lead also features 2 x 4mm banana plugs for application of external power if required and a 9 way D type connector which should plug directly into a spare comm port on the back of the PC. Note that a 9 - 25 way adaptor may be required, depending on PC configuration.

If non-RS232 communications are to be used, via the optional RS485, RS422 or FSK methods, then the appropriate adaptor should be used. Each adaptor is supplied with a switched 3m Y lead (different to the standard RS232 Y lead), which should be connected as follows:

| <u>Comms Method</u> | <u>Adaptor Part no.</u> | <u>Connections</u> |
|---------------------|-------------------------|---|
| RS485 | 0400029 | Connect 15 pin D type and 4mm plugs from Y lead into adaptor. Connect 9 pin D type from adaptor to PC, and 4mm plugs from adaptor to external power, as indicated on adaptor housing. |
| RS422 | 0400030 | Connect 15 pin D type and 4mm plugs from Y lead into adaptor. Connect 9 pin D type from adaptor to PC, and 4mm plugs from adaptor to external power, as indicated on adaptor housing. |
| FSK | 0400005 | Connect 4mm plugs from Y lead into adaptor, leaving D types unconnected (FSK uses power and signal on just two wires). Connect 9 pin D type from adaptor to PC, and 4mm plugs from adaptor to external power, as indicated on adaptor |

3.2 DEPLOYING THE MIDAS SVX

All parts of the standard system (with the exception of the top part of the 3m Y lead) are designed for immersion. All communications adaptors (RS485, RS422, FSK) are splash proof, but should be sited in a dry place, as close to the PC as possible.

The MIDAS SVX is supplied with a stainless steel protective cage, but care should still be taken not to damage the instrument. For profiling work, the recommended deployment method is to suspend the instrument using the stainless steel wire strop. For fixed deployments, the user may wish to remove the steel cage, and use the grooves in the titanium instrument housing as clamping points.

3.2.1 REAL TIME OPERATION

For real time data output, connect the signal cable to the 10 pin Subconn connector on the instrument. All Valeport signal cables include a suspension point for strain relief, and a similar arrangement is recommended for other cable types. Connect the top end of the cable to a PC using the appropriate method as described above.

3.2.2 SELF RECORDING OPERATION

For self recording only deployments, the instrument is switched on by insertion of the Subconn style switch plug. This plug must be inserted for the unit to operate.

3.3 RECOVERY

On recovery, data can be extracted to PC via the 3m Y lead. This is covered in Section 2.

To prolong the lifetime of the instrument the following procedures should be carried out once the instrument has been recovered:

- Remove any significant growth from the instrument, taking care not to damage transducer face or reflector plate of the sound velocity sensor. A high pressure water jet or stiff (not metal) brush is recommended.
- Remove any significant growth from the pressure sensor port. Take care not to introduce any sharp objects onto the sensor face – this may result in sensor damage.
- Remove any growth from the conductivity cell
- Check instrument for signs of damage.
- Rinse the instrument in fresh water
- Dry the instrument if possible, paying particular attention to the sensors and connector.
- Repack the instrument in the transit cases provided.

4 MAINTENANCE

The MIDAS SVX is completely solid state, and therefore requires very little maintenance. Other than keeping the instrument relatively clean, the only procedure that the customer will be required to carry out on a regular basis is to change the batteries. This Chapter also covers replacement of the zinc anode fitted to some earlier models, and details of the o-rings that are fitted to the instrument, and which should be checked regularly for damage and replaced if necessary.

4.1 CHANGING BATTERIES

The MIDAS SVX accepts 8 x D cells, of either 1.5v alkaline or 3.6v Lithium type. These cells are arranged in series, so the output voltage is 12v (alkaline) or 28.8v (Lithium). Some example scenarios for lifetime of these batteries are given in Chapter 2.4.2.

The batteries are located in a holder in the top of the instrument, and should be accessed by removing the connector bulkhead.

1. Remove the instrument from the protective cage by loosening the M10 nuts on the polypropylene clamps. Gently lever these clamps apart, using a screwdriver if necessary.



2. Slide the instrument out of the cage, in either direction.



3. Remove the 3 M5 x 20 socket cap screws in the connector bulkhead, using the Allen key provided. Note that these screws are titanium, and should be replaced with titanium screws if lost. Other materials will suffer galvanic corrosion and may be destroyed.

4. Without twisting or putting undue stress on the Subconn connector slide the bulkhead and attached battery pack out of the main housing. A slot between the tube and the bulkhead allows levering with a screwdriver if necessary. Take care not to scratch the bore of the tube.



5. A lead connects the battery pack to the electronics inside the tube. This may be disconnected at the battery pack if required, for ease.
6. Replace the batteries.
7. Check the condition of the bore seal o-rings, and apply a light coating of silicon grease. Ensure that both they and the anti-extrusion rings sit in the groove correctly, and are free from damage.
8. Reattach the connector to the electronics if necessary, and gently slide the battery pack back into the tube, ensuring that the fixing holes are correctly aligned. Again, take care not to scratch the bore.
9. Replace the 3 x M5 titanium screws, using a small amount of copper grease (supplied). Do not force the screws, just tighten firmly.
10. Finally, slide the instrument back into the protective cage. Note that the clamping brackets are offset, and that the sensor end of the instrument should lie at the long end of the cage.

4.2 O-RING SIZES

The Model SVXtra is kept watertight by using o-ring seals. Double o-ring seals are used at each end of the titanium housing, although the customer should have no reason to open any seal other than that at the battery end. To help preserve the watertight nature of the equipment, please observe the following guidelines:

- Ensure that all o-rings are free from cuts, abrasions or perishing.
- Ensure that all-o-rings are free from dirt, grit, sand, hair and other foreign objects.
- Ensure that an anti-extrusion ring is fitted on the pressure side of each o-ring. With the concave surface towards the o-ring.
- Whenever an o-ring seal is opened (e.g. when changing batteries), ensure that a light coating of silicon grease is applied to the o-ring before the seal is closed.
- Ensure that all o-ring protected seals are tightened.

A set of spare o-rings and anti-extrusion rings is included with the equipment. If an o-ring needs replacing, be sure to use the correct size. If obtaining further spare o-rings from an alternative source, be sure to obtain the correct material (signified by the last 4 digits of the o-ring code number).

| | |
|---------------------------|--------------|
| O-ring size: | 200-158-4470 |
| Anti-extrusion ring size: | 158 |

4.3 ZINC ANODE

The Valeport “time of flight” sound velocity sensor relies on having a very precisely defined path length between the transducer face and the reflector plate. This is now achieved by using a carbon fibre composite material for the rods, which has a thermal expansion coefficient of practically zero. This means that the path length is maintained, irrespective of the environmental temperature.

Earlier versions of the sensor were designed to automatically compensate for variations in sensor length caused by thermal expansion of materials, rather than eliminating the effects altogether. Part of this design required the use of a material called Invar for the rods of the sensor. A drawback of using Invar, which is a steel type alloy, is that it is susceptible to corrosion. For this reason, all Invar rods are plated and coated to inhibit corrosion. As an additional safeguard, however, a zinc anode was positioned on the end of the sensor. From time to time this may require replacement – the frequency of replacement will depend very much on operating environment and usage.

To replace the zinc anode, simply unscrew the M5 x 10 socket cap head screw holding it in place, and replace the anode with a new one. Note that this screw is made from titanium, and should be replaced with like if it is lost.

Please note that while every effort is made to safeguard the condition of the Invar, the user may notice rust spots on the rods after a period of time. These have no effect on sensor performance or recalibration, but will be replaced as a matter of course during service and recalibration procedures at Valeport.

The user may also help to maintain the Invar rods in good condition by rinsing the sensor with fresh water after deployment.

No maintenance at all is required on carbon fibre rods, other than cleaning after deployment.

5 WIRING INFORMATION

5.1 3M Y LEAD (RS232)

| 10 Way Male Subconn | 3m Blue Polyurethane Cable | 1m White Cable | 4mm Banana Plugs | 1m Grey Cable | 9 Way D Type | Function |
|---------------------|----------------------------|----------------|------------------|---------------|---------------------|---|
| 1 | WHITE | BLUE | BLACK | | | Power Ground |
| 2 | PINK | BROWN | RED | | | Power +V |
| 3 | N/C | | | | | |
| 4 | N/C | | | | | |
| 5 | N/C | | | | | |
| 6 | N/C | | | | | |
| 7 | GREY | | | YELLOW | 2 | RS232 Tx (To PC) |
| 8 | BLUE | | | BLUE | 3 | RS232 Rx (From PC) |
| 9 | GREEN | | | GREEN | 5 (link to 1,6,8,9) | RS232 Ground |
| | SCREEN | | | SCREEN | SHELL | |
| 10 | YELLOW | | | | | Internal Battery Enable Link to RS232 Ground |

5.2 3M SWITCHED Y LEAD (RS485 & RS422)

| 10 Way Male Subconn | 3m Blue Polyurethane Cable | SWITCH BOX | 1m White Cable | 4mm Banana Plugs | 1m Grey Cable | 15 Way D Type | 0.2m Grey Cable | 9 Way D Type | Function |
|---------------------|----------------------------|-------------------|----------------|------------------|---------------|---------------|-----------------|-------------------------|--------------------|
| 1 | WHITE | | BLUE | BLACK | | | | | Power Ground |
| 2 | PINK | | BROWN | RED | | | | | Power +V |
| 3 | RED | | | | RED | 9 | | | RS422 TxA |
| 4 | BLACK | | | | BLACK | 10 | | | RS422 TxB |
| 5 | ORANGE | | | | VIOLET | 11 | | | RS422 RxA |
| 6 | BROWN | | | | BROWN | 12 | | | RS422 RxB |
| 7 | GREY | | | | YELLOW | | YELLOW | 2 | RS232 Tx (To PC) |
| 8 | BLUE | | | | BLUE | | BLUE | 3 | RS232 Rx (From PC) |
| 9 | GREEN | | | | GREEN | 5 | GREEN | 5 (link to 1,6,8,9) | RS232 Ground |
| | SCREEN | | | SCREEN | SHELL | SCREEN | SHELL | | |
| 10 | YELLOW | | | | | | | Internal Battery Enable | |

6 CALIBRATION INFORMATION

Inserted After This Page

7 **EQUIPMENT CHECKLIST**

| | |
|-----------------|--------------------------|
| Serial No. | Model No. |
| Customer: | Con Number: |
| | Customer Ref: |
| | Del. Note:..... |
| | Calibration Cert.: |

| ITEM | Quantity | Serial Number | Initials |
|-----------------------------------|----------|---------------|----------|
| <i>Hardware</i> | | | |
| MIDAS SVX Sound Velocity Profiler | 1 | | |
| 1.5v alkaline cells fitted | 8 | | |
| Stainless steel deployment frame | 1 | | |
| 3m Y Lead Standard / Switched | 1 | | |
| Switching Plug | 1 | | |
| Tools and Accessories Kit | 1 | | |
| Comms Adaptor FSK / RS485 / RS422 | | | |
| Signal cable on hand reel (m) | | | |
| Transit Case | | | |
| <i>Software</i> | | | |
| DataLog 400 CDROM | 1 | | |
| <i>Documentation</i> | | | |
| Operating Manual | 1 | | |
| Calibration Certificate Enclosed | 1 | | |

SIGNED

DATE

8 GUARANTEE CERTIFICATE

The following guarantee periods shall apply:

| | |
|--|--|
| <i>Pressure Transducers and semiconductors</i> | <i>12 months from date of despatch</i> |
| <i>All other system components</i> | <i>36 months from date of despatch</i> |

During the above periods, Valeport Limited warrants that (at their option), they will replace or repair any faulty items caused by bad workmanship or materials.

Any such claims must be submitted in writing during the above warranty periods.

Valeport Limited shall be under no liability for:

- 1) Any consequential loss or damage of any kind whatsoever.
- 2) For any defect or deficiency judged by Valeport Limited to be caused by wear and tear or of improper or unskilled handling of the goods or by any repair or attempted repair or dismantling by any one other than Valeport Limited or persons authorised to do so by Valeport Limited.
- 3) Batteries and other consumables supplied with the equipment, which are not covered by this guarantee.

Due to the specialised nature of the instrument it should, if possible, be returned to the factory for repair or servicing. The type and serial numbers of the instrument should always be quoted, together with full details of any fault or the service required.

Equipment returned to Valeport Limited for servicing must be adequately packed, preferably in the special box supplied and shipped with transportation charges prepaid. Return transport charges are also to the account of the customer.

Note: Any items supplied as part of a system which are not manufactured by Valeport Limited are covered by the individual manufacturer's guarantee of the equipment supplied.

MODEL NUMBER SERIAL NUMBER

DATE OF DESPATCH SIGNATURE.....

MIDAS SVX Combined CTD & SVP

Section 2 - Software Operation

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1 INTRODUCTION

DataLog 400 is the user interface program supplied with all 400 Series systems from Valeport Ltd, including the MIDAS SVX Combined CTD & SVP. The program is written in Delphi, and will run on all PCs operating Windows 95 or above. As is the nature of all software, the faster the computer, the better the software will perform. As an absolute minimum, we recommend the following PC specification:

- Pentium 100MHz (or equivalent)
- 32Mbyte RAM
- CDROM Drive
- 1 spare comm port
- 100Mbyte Disk Space

Note that installation of DataLog 400 itself requires only 5.4Mbyte of disk space. However, Windows will utilise a large amount of disk space as “virtual memory” (upwards of 20Mbyte), which must be taken into account. Further, note that an 8Mbyte binary file from the instrument will translate to over 55Mbyte of calibrated text files – make sure that there is enough hard disk space to allow for translation of any uploaded files.

This manual will guide the operator through all the functions that DataLog 400 and the MIDAS SVX have to offer, including the wide variety of sampling regimes (including conditional sampling), data extraction and data viewing. Please note that although DataLog 400 offers a variety of data display modes, users may wish to utilise a standard spreadsheet package such as Microsoft Excel for data manipulation.

1.1 INSTALLATION

As with all installation programs, we recommend that all other applications be closed before commencing installation.

DataLog 400 is supplied on a single CDROM. It does not feature an Auto-run facility, so users will be required to insert the CDROM into their CD drive, and run the Setup.exe program manually. This can be done either by selecting Run from the Start menu, and browsing for the Setup.exe file under the CD drive (typically drive D or E), or by clicking on the Setup.exe program under the CD drive in Windows Explorer.

The Setup.exe program will launch a wizard that will guide the user through the remainder of the installation process. By default, the installation program will create a new directory in which to install DataLog 400, although you may change this if you wish:

C:\Program Files\DataLog 400


On completion of installation, a window will appear with a shortcut icon to the program. This may be dragged onto the desktop if required:

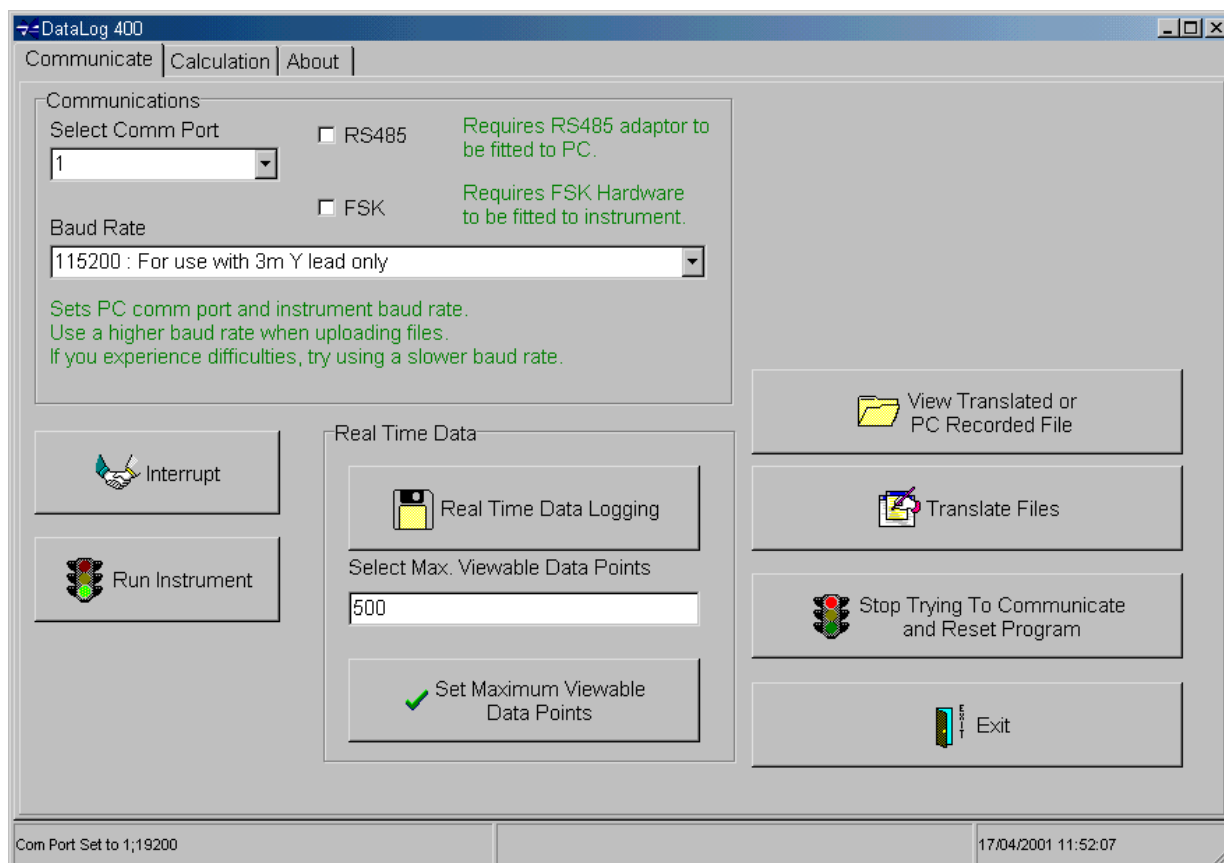


Note that DataLog 400 software is distributed free with the equipment – therefore no password or software key is required for installation.

To Run the software, simply double click the Desktop icon. The following pages describe the operation of the software.

2 OPENING DATALOG 400

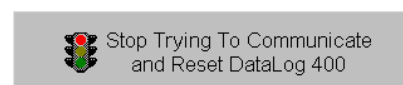
Double clicking the desktop icon (), or running the DataLog 400.exe program through Windows Explorer, will reveal the following screen, which allows access to all major DataLog 400 functions. Note that all features are accessed through a selection of tabs at the top of the page – there is no menu bar. Also note that at any point in the software, only tabs which are relevant will be visible. The Calculation and About tabs, which are less important in terms of instrument operation and data viewing, are covered in later Chapters.



If the user wishes to close down DataLog 400 at any time, simply click on the Exit button:



If for any reason communications are lost, the “Stop Trying” button may be used. Clicking on this button will return the user to this point in the software:

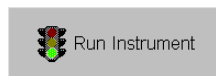


The major functions that DataLog 400 will allow at this point are as follows. Each function is described fully at subsequent chapters in this manual. Note also the section of the screen titled “Real Time Data”. Please refer to Chapter 5 for details of this section.



Interrupt

Establishes communications with the instrument, and causes the unit to wait for further instructions. See Chapter 3.



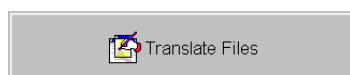
Run Instrument

Puts the instrument into Run mode. This button should only be used if the user is confident of the current instrument settings. See Chapter 5.



View Translated or PC Recorded File

View an existing data file, either previously uploaded and translated, or saved from the real time output. See Chapter 7.



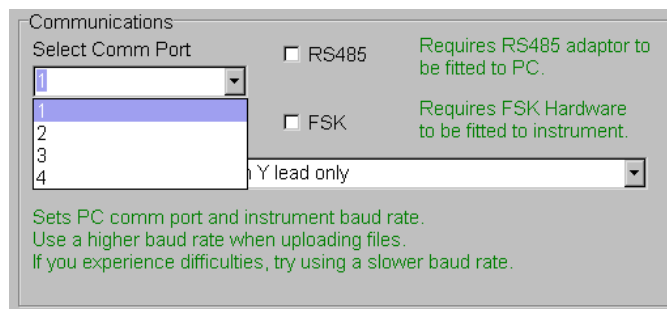
Translate Files

If the user wishes to translate any previously uploaded binary files into viewable text files, click on this button, and refer to Chapter 6.2.

3 ESTABLISHING COMMUNICATIONS

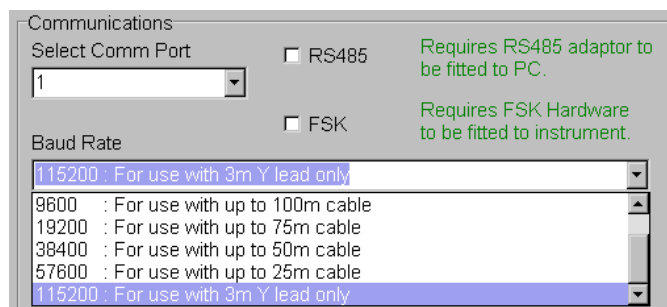
After connecting the instrument to the PC using the 3m Y lead as described in Section 1 of this manual, the first step in establishing communications with the instrument is to select the correct communications (comm) port. A drop down menu allows the user to select from up to 4 available comm ports.

Selecting the incorrect comm port is the most likely reason for any failure to communicate.



Note that all Valeport 400 Series instruments (i.e. instruments designed to work with DataLog 400) are fitted with three standard digital data outputs – RS232, RS485 and RS422 – and one optional output, FSK modem. RS232 format can be read directly by a PC comm port. If using any of the other 3 methods, the PC will need to be fitted with a suitable interface, which will either be a special adaptor unit supplied by Valeport, or in the form of an additional circuit board added to the PC. If using RS485 or FSK communications, please check the box next to the comm port selection box. This will slightly alter the protocol that DataLog 400 uses to communicate with the instrument (note that FSK comms defaults to 19200 baud rate). It is important that the boxes are left unchecked if just standard RS232 communications or RS422 communications are being used.

The next step in establishing communications is to select the required baud rate. The instrument will automatically detect which baud rate is being used, but note that the longer the cable being used, the slower the rate that will be required. A guide to suitable baud rates is given in the drop down menu. Note also that even some new PCs may be fitted with low quality comm ports – users may find that a lower baud rate is necessary.



Next, ensure that the instrument is turned on! If running on internal batteries, turn the switch on the 3m Y lead to the INT position. If running on external power, turn the switch to the EXT position, and make sure that the power supply is turned on.

All Valeport 400 Series instruments (i.e. instruments designed to work with DataLog 400) can be interrupted at any point during their operation, whether they are actually in the process of sampling or in a sleep mode between bursts.

Finally, click on the Interrupt button:



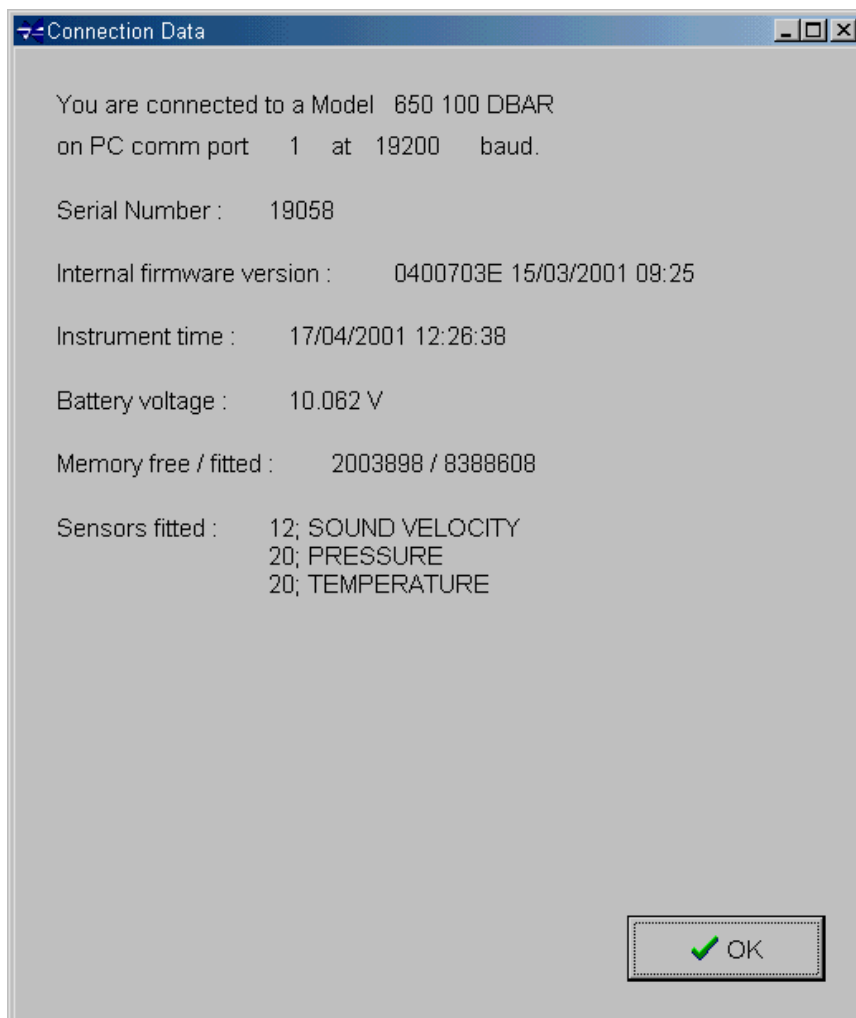
During operation, DataLog 400 will show the current status of the software at the bottom of the screen:



The left hand section shows the software status, the centre section shows the last response from the instrument, and the right hand section shows the PC date and time.

The Autobauding procedure by which the instrument detects which baud rate is being used may take up to 15 seconds to complete – please be patient while the software shows “Attempting to Communicate”. After the baud rate has been established, the instrument will send various pieces of information to the software, including Serial Number, type and number of sensors fitted, current sampling setup and so on. Again, this may take some seconds to complete, so please be patient!

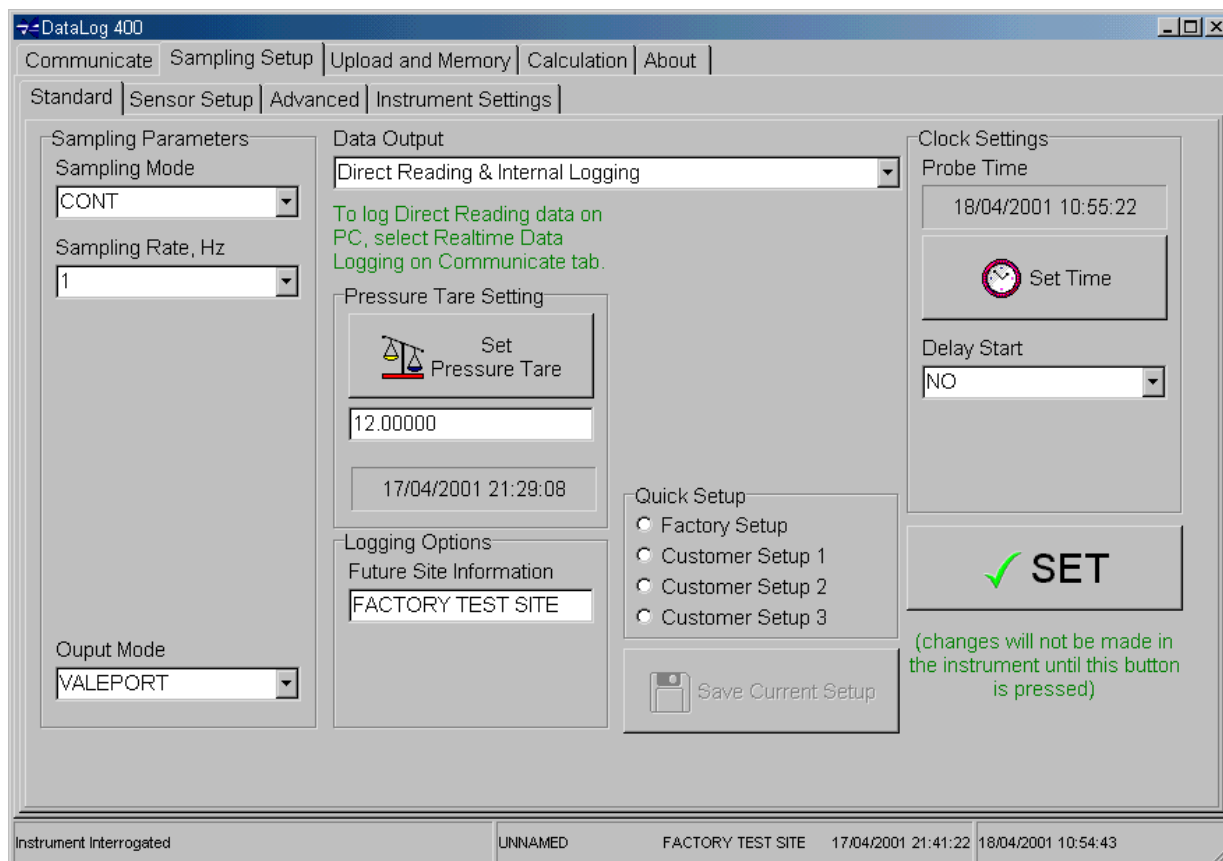
Once DataLog 400 has communicated with the instrument, an information screen appears detailing connection information, and basic sensor information such as serial number, code and name of all fitted sensors, and software version. To clear this screen, simply click on OK.



4 INSTRUMENT SETUP

Once the Connection Data screen has been cleared, the Sampling Setup page will appear. Note also that the “Upload and Memory” tab is enabled once the unit is interrupted. See Chapter 6 for more details.

The Sampling Setup tab allows the user to set the instrument’s sampling regime. The MIDAS SVX will allow six different sampling modes, plus a conditional sampling mode which is explained in further detail in Chapter 4.3. There are four sub-menus, labelled Standard, Sensor Setup, Advanced and Instrument Settings.



4.1 STANDARD

This page gives access to all the basic setup functions required to control the instrument operation – The more advanced setup features are accessed through the Sensor Setup and Advanced tabs.

DataLog 400 will only allow the user to set sampling parameters relevant to the selected mode – for example, in continuous sampling mode (CONT, above), the user is not required to select an interval for BURST sampling, so that section is not displayed. Later pages explain the different sampling patterns available, and show the parameters which the user will need to set for each mode. However, there are some functions which apply to all sampling modes, and these are discussed first:

4.1.1 SET BUTTON

Any parameters which are changed in this screen will not be sent to the instrument unless the SET button is pressed, with the exception of Pressure Tare Setting and Set Time.

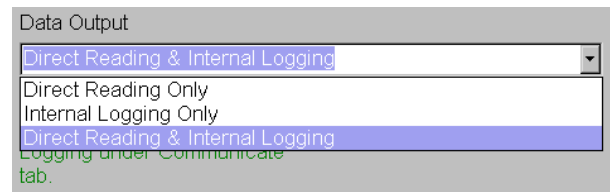


If the user leaves this screen without confirming any changes with the SET button then the following warning will be displayed:



4.1.2 DATA OUTPUT

The MIDAS SVX can operate in three data output modes. The data may either be logged to the internal memory (Internal Logging), output in real time (Direct Reading), or both of these together (Direct Reading and Internal Logging). Simply select the required data output mode from the drop down menu.



Note the green information point under this part of the screen – if real time data is being output to PC, it can be logged as a separate text file – please refer to Chapter 5.3.1.

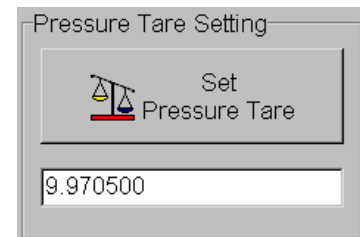
4.1.3 PRESSURE TARE SETTING

The user may wish to set a Pressure Tare value. In underwater instruments, pressure sensors are usually of the absolute type – that is to say, they measure the total pressure exerted on the transducer face, including atmospheric pressure.

It is often the case that the user wishes to disregard the atmospheric pressure, particularly in short term deployments where it is unlikely to change significantly over the deployment period. If this is the case, then a Tare value can be set. This is done by positioning the instrument at sea level, and taking a pressure reading. This reading is recorded in the instrument as being the atmospheric pressure at time of deployment, and may be subtracted from all subsequent pressure readings.

Press the Set Pressure Tare button to take a Pressure Tare reading. The current Pressure Tare value is indicated in the text box below the button.

Alternatively, the user may enter their own desired value for the Pressure Tare by simply typing in the text box and then clicking the Set Pressure Tare button. This is particularly useful for resetting the Tare value to zero.

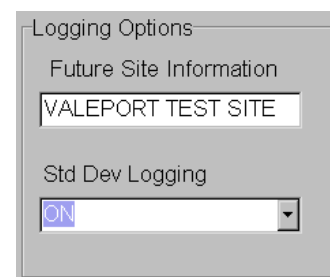


Having taken a Pressure Tare reading, the user still has the choice of whether or not to actually subtract this value from the subsequent pressure readings, or just keep it as a record of the atmospheric pressure at time of deployment. Please refer to the Sensor Setup tab to confirm whether the Tare value should actually be used or not (Chapter 4.2.2)

4.1.4 LOGGING OPTIONS

The user also has control over some of the data that is logged by the instrument. Two parameters that can be set in this screen are Site Information, and Standard Deviation Logging.

Each data file logged by the instrument can have a short (up to 60 characters) description associated with it, describing for example, the location of a deployment. Such information can only be added to a file in advance. Text entered in this box will therefore apply to any subsequent files, but not to any that already exist in the unit's memory.

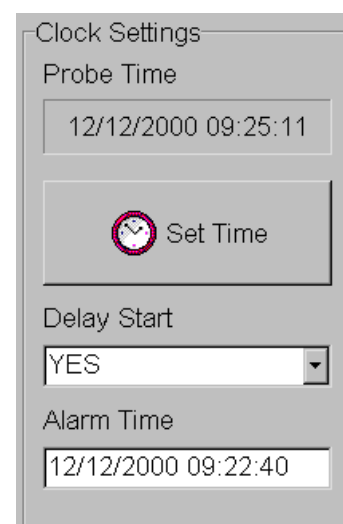


Standard Deviation data is calculated by the instrument at any time that a data average is calculated. The user may decide whether this value should be logged along with the data. Note that data averaging, and therefore Standard Deviation calculation, is only available if the instrument operates in BURST mode (see Chapter 4.1.7.5). Note also that even if Standard Deviation logging is not selected, the Standard Deviation value will be output in real time data strings.

4.1.5 CLOCK SETTINGS & DELAY START

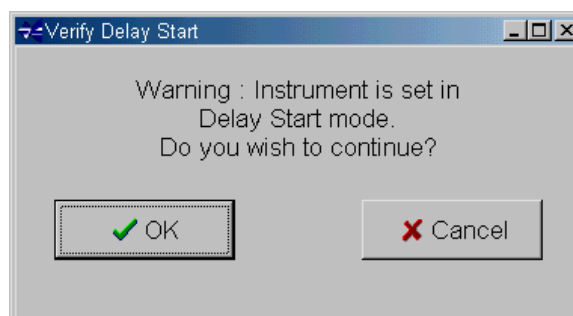
The instrument is fitted with an internal clock that controls all sampling patterns. To synchronise the clock with your PC, simply click on the Set Time button.

The MIDAS SVX also has a Delay Start feature, to allow the instrument to be programmed well in advance of the deployment date, but without sacrificing memory or battery power on wasted data sampling. To enable the Delay start feature, simply select YES from the drop down menu. A text box will appear, in which you should type the required start time in the format dd/mm/yyyy hh:mm:ss, as shown.



When confirming the sampling setup with the SET button, the following message will appear IF the Delay Start function has been enabled:

If you enter a Delay Start time as a time that has already passed, DataLog 400 will allow this to be set. However, the sampling program will be initiated immediately.



NOTE:

The MIDAS SVX is fitted with a 20ppm clock – that is to say it will drift by a maximum of 20 seconds in every million (approx 50 seconds per month). This is significantly more accurate than the clocks fitted to most PC's. The user may well find that there is discrepancy of several minutes between the PC time and the instrument time after a long deployment – please be aware that most of this drift is likely to be due to the PC clock rather than the instrument clock.

4.1.6 QUICK SETUP

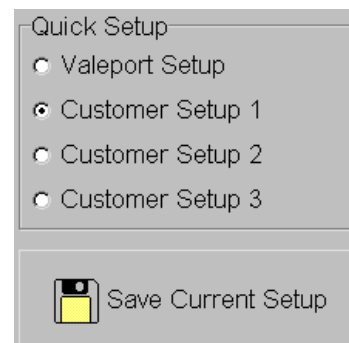
Many work schedules require that standard customer specified sampling regimes are used. To allow for this, DataLog 400 will store up to three such regimes, as well as Valeport's own factory default setup.

4.1.6.1 SAVING A QUICK SETUP REGIME

Select one of the Customer Setup buttons as shown. Then setup the required sampling regime – note that all setup parameters are recorded, with the exception of the Pressure Tare value. When the screen shows the required sampling regime, click on the Save Current Setup button. The displayed setup will be recorded under whichever Customer Setup button is currently highlighted.

NB: Save Current Setup BEFORE using the SET button.

Note that the user cannot alter the Valeport Setup configuration.



4.1.6.2 SELECTING A QUICK SETUP REGIME.

Simply select any of the four Quick Setup buttons. The screen will automatically display the saved Setup. Then simply click on the SET button to confirm.

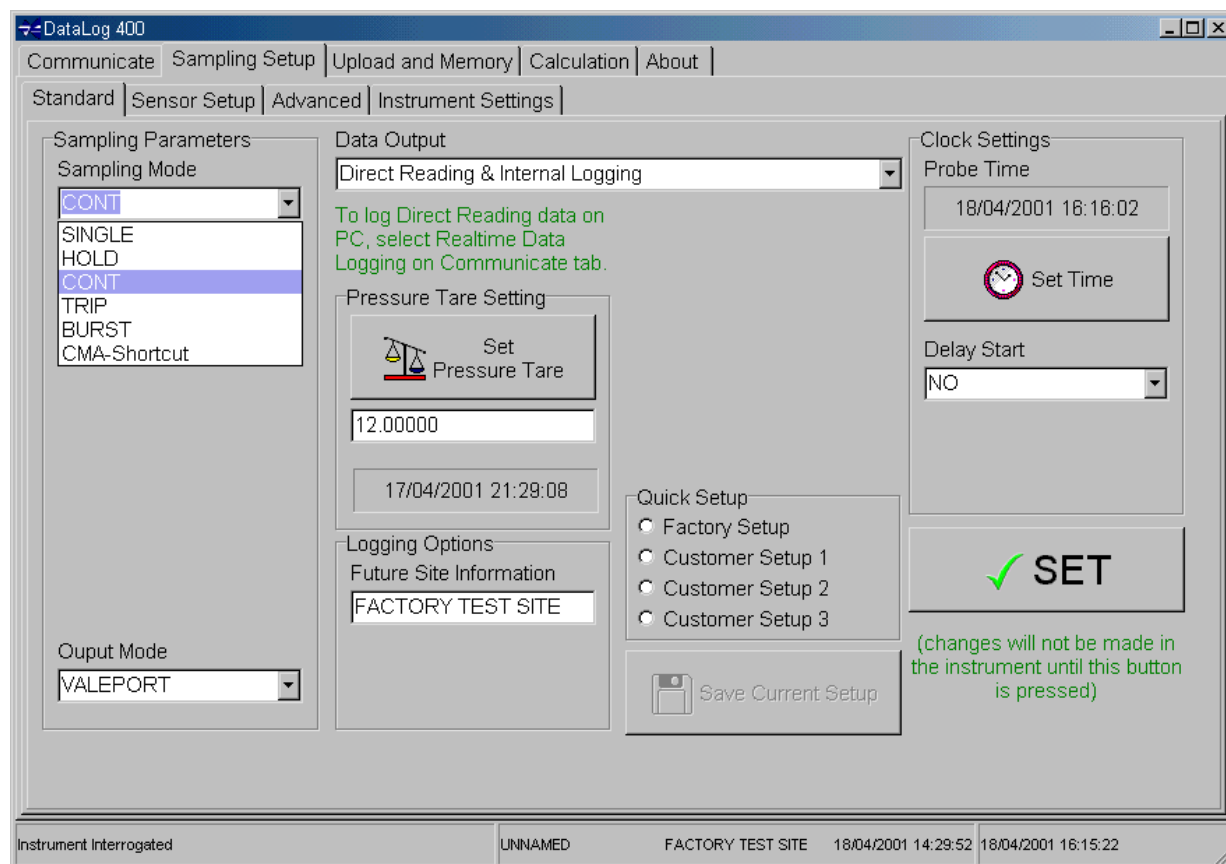
4.1.7 SAMPLING MODES & PATTERNS

The MIDAS SVX has 6 different basic sampling modes. These are explained in detail over the next few pages. Conditional Sampling, which is treated as a separate function, is set up under the Advanced tab (see Chapter 4.3).

One of the key features of the MIDAS SVX (and indeed all other Valeport 400 Series instruments) is the synchronised sampling pattern. Most other similar products on the market (including older Valeport products) sample the fitted sensors in sequence – that is to say, the microprocessor samples data from Sensor 1, then Sensor 2, then Sensor 3 etc., before repeating the sequence. As technology advances, these sampling sequences are becoming more and more rapid, but they still result in non-synchronised data.

The Valeport system works differently. It sends a single command to all fitted sensors at exactly the same time, meaning that each sensor samples at exactly the same time. The microprocessor then collects data from the sensors to produce the full data record. This pattern is repeated up to 8 times per second, and the result is absolutely synchronised data. This synchronised sampling pattern is a feature of all the sampling modes available.

To select a sampling mode, simply highlight the required mode in the drop down menu under Sampling Parameters, as shown:



4.1.7.1 SINGLE MODE

The Single sampling mode means that when the unit is set to Run, it takes a single measurement of all parameters fitted, and either outputs the single data string in real time or logs it to memory (as set under Data Output). This operation will happen every time the Run command is sent to the instrument (Run command is described in Chapter 5.2.3)

Note that a new file will be created in the instrument memory every time the Run command is used. This will use the memory quite rapidly, since each file also contains a 416byte header record, as well as the actual data itself.

When using the Single mode, no other functions under the Sampling Parameters section are required, and are therefore not visible.

4.1.7.2 HOLD MODE

Hold mode is similar to Single in that it will take a single set of measurements each time the Run command is used. However, the data is held in instrument RAM until requested by a separate command (Get Held Data command is described in Chapter 5.2.3.2).

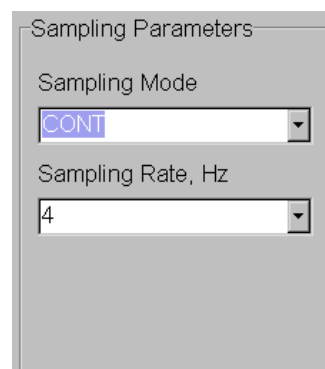
Again, no other functions need be set under Sampling Parameters.

In Hold mode, data is only available in real time, and is not logged in the instrument. Data may, however, be recorded on PC as described in Chapter 5.3.1.

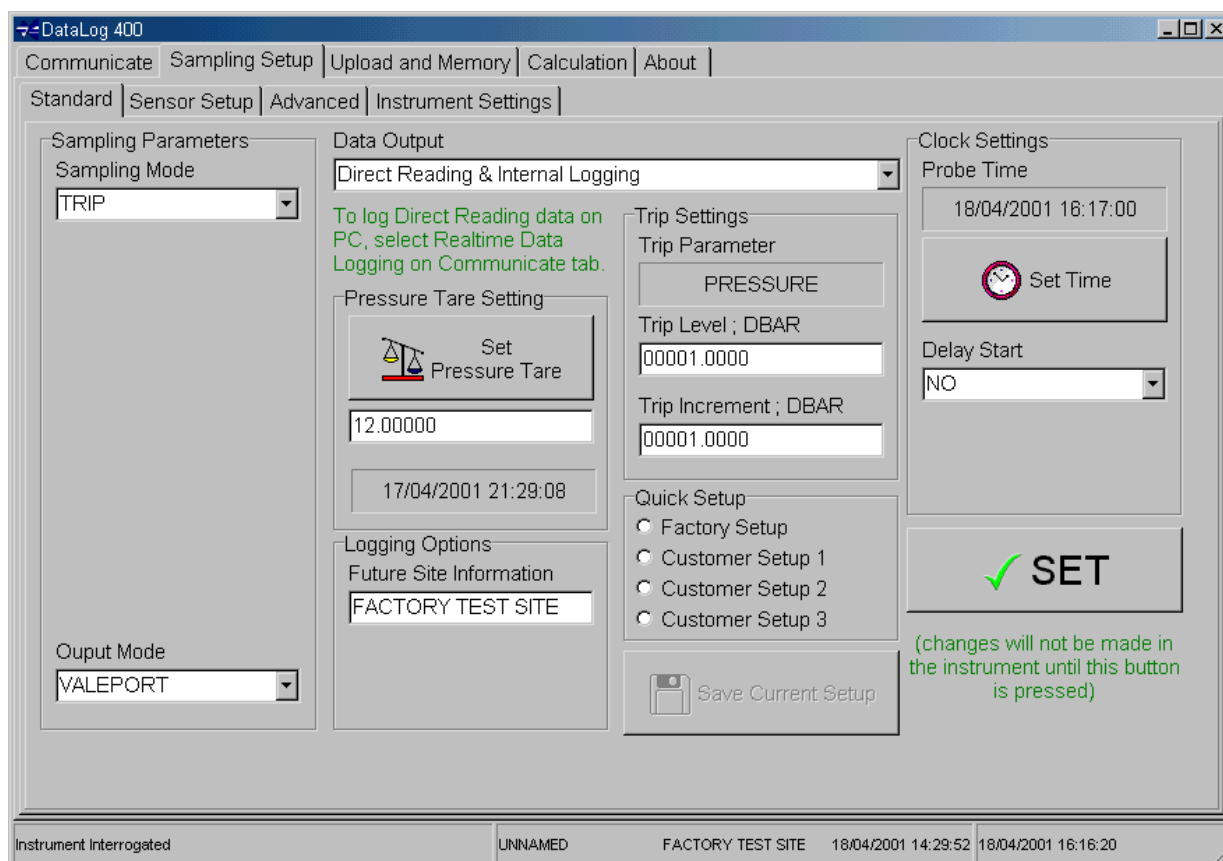
4.1.7.3 CONTINUOUS MODE

Continuous Mode (CONT) causes the instrument to sample data at a fixed rate until it is interrupted, or power is removed. As can be seen, the user is also required to select the sampling rate.

All data is available in both Real Time and for Logging, and will be stored in a single file in the instrument.



4.1.7.4 TRIP MODE



Trip mode is an event triggered mode, typically used during profiling. In this mode, data will be sampled only once a trigger value on a chosen sensor has been reached, and then again at regular incremental changes of that parameter. A good example is using a Pressure Trip on a profile. The instrument may be set to monitor the Pressure sensor, and when the output reaches the Trip Level (i.e. the instrument reaches a certain depth), sampling will begin. Subsequent samples will then be taken every time the pressure changes (i.e. instrument descends or ascends) by the Trip Increment (maximum sampling rate is 8Hz).

When Trip mode is selected, a separate section of the screen will become visible, showing the Trip Parameter (Pressure in this case), Trip Level, and Trip Increment. In the above screen, the Trip Level is 12 dBar (approx 12m), and the Trip Increment is 0.25dBar (approx 0.25m). Note that the Trip Level takes account of any pressure tare that has been set.

The user should simply type the desired Trip Level and Trip Increment values in the text boxes.

Note that use of the Trip mode is not restricted to the Pressure Sensor, even though it is the most commonly used. Any sensor fitted to the instrument may be used as the Trip Parameter; the desired sensor may be selected in the Sensor Setup screen (Chapter 4.2).

4.1.7.5 BURST MODE

Burst Mode offers the user the greatest flexibility in sampling setup. Generally speaking, the sampling programme causes the instrument to take a set number of samples at a chosen rate, then go into sleep mode for a defined period of time before waking up and repeating the sequence. The user may set the desired sampling rate, the number of samples in the burst, and the interval between bursts. In this way, the deployment time of the instrument may be greatly extended. Burst mode is particularly suitable for long term studies, where specific parameters do not change rapidly and overall trends are more significant.

Parameters that the user must set are therefore:

- Sample Rate** Select 1, 2, 4 or 8Hz from the drop down menu
- Period** This is the number of samples in the Burst (minimum 1). In this example, 20 samples at 4 Hz will take 5 seconds.
- Interval** This is how often a burst will occur, in seconds. Note that the instrument requires a minimum of 20 seconds between the end of one burst and the start of the next – DataLog 400 will not allow an interval less than this to be set. If the user tries to set a shorter interval than this, the minimum interval possible with the present Sampling Rate and Period will be entered automatically.
- Average Type** Finally, the user has a choice of three data averaging modes, which require further explanation:

When using Burst mode, the MIDAS SVX is capable of calculating the mean value of data during a measurement burst, for each parameter fitted. The user has the following options:

- NONE** No data averaging is performed over the burst. The instrument will log and output every measurement made during the burst.
- FIXED** The instrument will wait until the end of the burst, and will then calculate the mean value of each parameter over the burst. If the burst is cut short by the user attempting to communicate with the instrument, then the average of that burst will be calculated as the mean of all measurements that were made.
- MOVING** The user can also create a Moving Average window. A new text box will appear asking the user to choose the moving average length required, which may be any number up to the number of samples in the burst. The instrument will log and output the mean value of the previous 'x' measurements made in the burst, where 'x' is the Moving Average length. The output will be updated with every sample until the end of the burst. For example, in the above screen, if a Moving Average length of 5 samples were set, the output would be as follows:

| Sample No. | Output | Sample No. | Output |
|------------|-------------------------|------------|--------------------------------|
| 1 | Mean of Sample 1 | 5 | Mean of Samples 1,2,3,4,5 |
| 2 | Mean of Samples 1,2 | 6 | Mean of Samples 2,3,4,5,6 |
| 3 | Mean of Samples 1,2,3 | 19 | Mean of Samples 15,16,17,18,19 |
| 4 | Mean of Samples 1,2,3,4 | 20 | Mean of Samples 16,17,18,19,20 |

Finally, if either the Fixed or Moving Average option is selected, the instrument will also calculate the Standard Deviation of the data. This value will always be output in real time, but the user may decide that in order to conserve memory, it does not need to be logged. Please refer to Chapter 4.1.4 for details of how to turn the internal logging of Standard Deviation On/Off.

4.1.7.6 CMA (CONTINUOUS MOVING AVERAGE)

This mode is a specific configuration of the Burst mode, where data is output continuously. Users may wish to use this output instead of the standard Continuous mode if data averaging or Standard Deviation data is required.

The user is simply required to enter the Sample Rate (1,2,4 or 8Hz), and the length of the Moving Average window in samples.

In this mode, the instrument will run indefinitely, always outputting the mean of the last 'x' samples, where 'x' is the number of samples in the Moving Average window.

As with the standard Burst mode, the user may select whether or not to log the Standard Deviation of the data (see Chapter 4.1.4).

Note that a continuous moving average regime can be setup manually by the user using the Burst mode. This mode is simply a shortcut to such a setup.

Sampling Parameters

Sampling Mode
CMA-Shortcut

Sampling Rate, Hz
4

Moving Average, Samples
5

Sampling Parameters

Sampling Mode
BURST

Sampling Rate, Hz
4

Period, No. of Samples
4

Interval, Seconds
1

Average Type
MOVING

Moving Average, Samples
5

Note also that the instrument interprets CMA mode as a Burst mode. If an instrument is setup in CMA mode, the sampling regime will be recorded in the instrument as a Burst mode. This means that when the instrument is subsequently interrogated, the screen will show that the instrument is set in Burst mode, as shown left.

Note that the screen shows the key points for setting a Continuous Moving Average manually:

1. The sampling period must be the same as the sampling rate, giving a duration of 1 second.
2. The Sampling Interval must be set to 1 second.

4.2.1 TRIP MODE

As described in Chapter 4.1.7.4, the MIDAS SVX can be programmed to operate in a TRIP mode, where regular changes in output from a particular parameter will cause data to be sampled. There are two types of trip mode, Absolute and Relative:

Absolute This should be used where the selected parameter will be changing from zero (or another known value), for example, a pressure based profile through the water column. The pressure sensor will be reading zero at sea level, and the output will increase as the instrument is lowered through the water column. Also, the user is able to select whether the Trip Level will be reached as data Increases or Decreases. Select the required direction using the drop down menu. For standard pressure profile, the Direction should be set to INCREASE.

Relative This should be used where the initial value of the Trip parameter is unknown. For example, the user may wish to take a reading whenever the temperature of the water changes by 0.1°C. However, the temperature of the water will not be known until the instrument begins sampling. The relative trip function will therefore use the first measurement as its baseline, and refer the trip increment to this initial reading. Neither Trip Direction nor Trip Level (standard setup screen) are required if RELATIVE trip mode is set, and are therefore not visible.

Note that only one parameter may be selected for use as a Trip sensor – as soon as another sensor has a Trip mode assigned to it, the currently selected Trip Sensor will cease to be so.

4.2.2 TARE OPTION

As mentioned previously the user has the option to decide whether or not the pressure sensor is subjected to the Pressure Tare value. The pressure sensor will show either TARE or NOT_TARE in the right hand column. To change this, simply highlight the sensor, and select either TARE or NOT_TARE in the section at the right hand side of the screen. Note that this section of the screen is only visibly when the Pressure sensor is selected.

4.2.3 USER CALIBRATION

Data from all sensors on the MIDAS SVX is output in calibrated format – however, the calibrations are factory set. If the user wishes to input their own calibration data, or even change the units in which the data is presented, this can be done by means of a secondary calibration (or USER calibration).

To enter the new required units, simply type into the Set User Units text box (all characters will be stored in CAPITALS).

The new calibration string must be entered in a specific format. First of all, the user must determine the equation that will convert the standard output format into the desired units. A good example is converting pressure data in deciBar (DBAR) into data in metres. This can be performed to a good level of approximation by a quadratic equation:

$$y = 2 * 10^{-6} x^2 + 0.9943x$$

The instrument will accept up to a fifth order polynomial equation as a secondary calibration:

$$y = ax^5 + bx^4 + cx^3 + dx^2 + ex + f$$

The calibration string must be entered in the format

15;a;b;c;d;e;f

The format of the secondary calibration string for converting deciBars to metres is therefore:

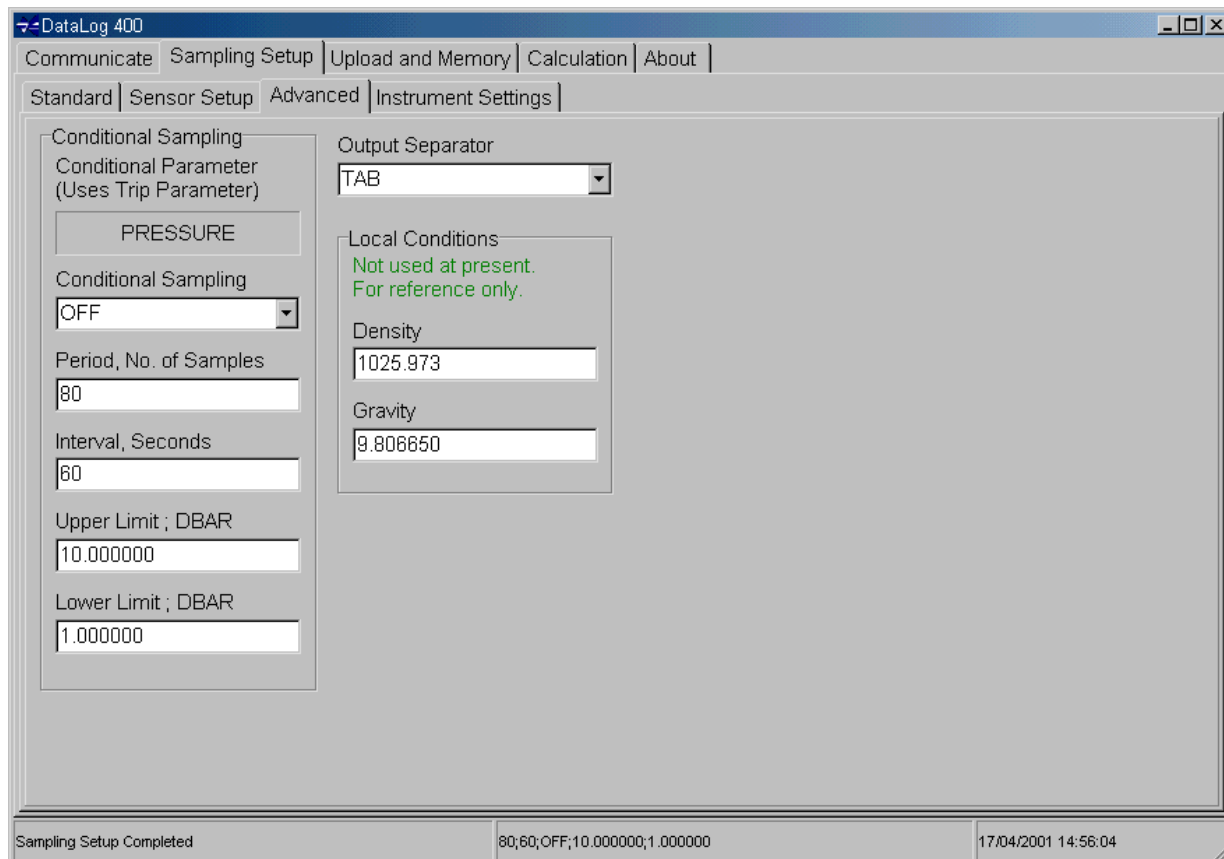
15;0;0;0;2e-6;0.9943;0

NB: The initial figure 15 indicates to the instrument that the following information is a calibration string. It must be included in the string. Note that the separators are all semi-colons (;). The instrument assumes that all equations are fifth order polynomials – blank values must therefore be padded out with zeros.

Since data from Pressure sensors is often required in metres or feet, these secondary calibrations are included as options in a pull down menu (visible only when selected sensor is a Pressure sensor).

4.3 ADVANCED

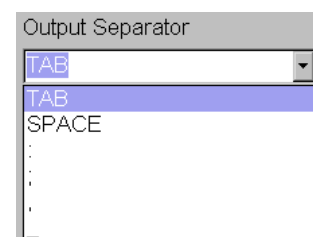
The Advanced page of the Sampling Setup tab is laid out as shown. **Note that any changes made in this page must be confirmed by using the Set button in the Standard page:**



4.3.1 OUTPUT SEPARATOR

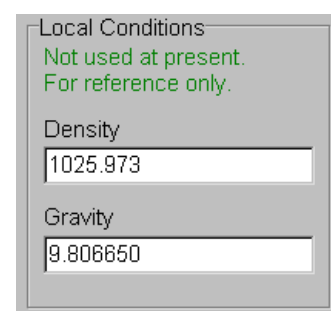
The standard data strings from the MIDAS SVX are output in the format of tab separated data, that is to say each data value is separated from the next by a TAB. However, the user may wish to use an alternative separator so that data is compatible with other systems. A choice of separators is available, selectable from the drop down menu. Choose between:

- TAB
- SPACE
- : (colon)
- ; (semi-colon)
- , (comma)
- _ (underbar)



4.3.2 LOCAL CONDITIONS

These values are included for reference only, and are not included in any onboard calculations. The Gravity value shown is the local Gravity at Valeport's premises in m/s². The Density value is the Density of Standard Seawater at 35 Salinity and 15°C. The user may alter these values if required by simply typing in the text boxes.



4.3.3 CONDITIONAL SAMPLING

Conditional Sampling is one of the most powerful features of Valeport range of 400 series instruments. Put simply, the instrument will monitor any specified sensor, and only begin full sampling if the output from that sensor reaches a specified level. The conditional sampling feature therefore allows long-term deployment of instruments, but restricting data gathering only to periods of specific interest. Examples may include monitoring of a pressure sensor so that logging only occurs when the instrument is submerged, or of a fluorometer to restrict sampling to only happen during a plankton bloom.

Conditional Sampling is only available if the instrument is set to run in Burst or Continuous modes. In both cases, the chosen sensor will be monitored in a simple Burst pattern, set up as described below. If the mean value of data gathered during that burst exceeds the designated limit, then the full sampling regime (either Burst, Continuous or Continuous Moving Average) as set in the Standard Setup screen (Chapter 4.1) will begin. **Note that during a conditional burst, no data is logged.**

4.3.3.1 SETTING UP CONDITIONAL SAMPLING

The first point to note is that the selected sensor for Conditional Sampling is the same sensor as is chosen for monitoring in TRIP mode – refer to Section 4.2 for details of how to change this. The currently selected sensor is shown at the top of this screen section. It is PRESSURE in this case.

Below this, the user must select whether the Conditional Sampling function is switched ON or OFF. Select the required status using the drop down menu.

Next, choose the required number of samples to take in the Conditional Sampling burst. Note that sampling in the Conditional mode will be at the same rate as during normal sampling. The length of this burst cannot be more than the length of the burst used in normal sampling.

Then, select how often this Conditional Burst should occur. Remember that a minimum of 20 seconds is required between the end of one burst and the start of the next.

4.3.3.2 CONDITIONAL SAMPLING TRIGGERS

Finally, select the limits past which the standard sampling routine should be triggered. Note that there are two limits to set - an Upper and a Lower limit. If only one applies to the particular scenario to be used, then set the other well outside the expected range. Here are two examples:

Example 1

A fluorometer sensor is being monitored to detect a plankton bloom. Output from the sensor is in mg/l of chlorophyll α , and it is known that a level above 10mg/l is of interest – below this level is not important. Set the Upper limit to 10mg/l, and the lower limit to -1mg/l. Do not set zero, since it is possible that a zero value may be measured, and trigger sampling when nothing of interest is happening.

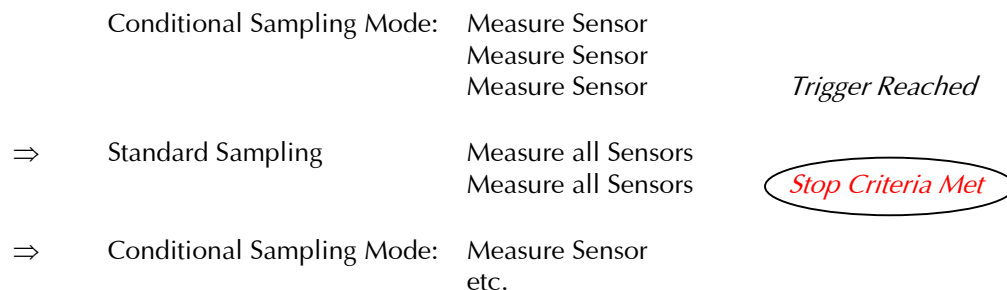
Example 2

A conductivity sensor is being monitored, and data is only of interest if there is a fresh water plume. Standard seawater conductivity levels are approximately 40mS/cm, but logging is required if this falls below 35mS/cm. Set the Lower limit to 35mS/cm, and the Upper limit to 50mS/cm. Do not set the upper limit to a value near 40, since this may occur naturally and trigger sampling.

Alternatively, data may only be of interest if a particular parameter is between two limits rather than outside them. As an example, data may only be of interest if the water temperature is between 0 and 4°C. Data outside these limits is not required. In this case, set the LOWER limit to 4°C and the UPPER limit to 0°C. By setting the values this way round, the instrument will only be triggered to enter its normal sampling regime if the temperature data is between these numbers.

4.3.3.3 CONDITIONAL SAMPLING 'OFF' TRIGGERS

The previous page details how to set up Conditional Sampling, and how to set the trigger values for the conditional sampling. This page details the mechanisms by which the normal sampling is stopped, and the conditional monitoring regime is re-entered. The conditional sampling programme can be represented as:



There are effectively 4 different sampling modes in which conditional sampling can be used:

Continuous
Burst, Moving Average (including Continuous Moving Average)
Burst, Fixed Average
Burst, No Average

The Stop Criteria for each are as follows:

- Continuous:** The instrument calculates a moving average on the data, with a window size equal to the number of samples in the conditional burst period. Continuous sampling terminates when this moving average windows returns a reading back within the conditional sampling limits. Note that this moving average window is not logged – it is merely a method used for deciding Stop criteria.
- Burst, Moving Average:** Burst moving average terminates when any of the moving average results is back within the conditional sampling limits.
- Burst, Fixed Average:** Burst fixed average terminates when the fixed average result is back within the conditional sampling limits.
- Burst, No Average:** This mode uses a similar technique to continuous sampling, by creating a moving average window of length equal to the conditional burst period. Sampling terminates when this moving average windows returns a reading back within the conditional sampling limits. Note that this moving average window is not logged – it is merely a method used for deciding Stop criteria.

5 RUNNING THE INSTRUMENT

Once the user has set the instrument up as required, the instrument may be set into Run mode. There are three methods of doing this:

5.1 HARDWARE SWITCH ON

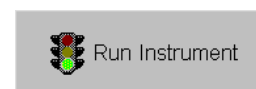
If the user intends to deploy the equipment to only log data, and does not intend to view data in real time, then use this method. Once the instrument has been set up as required, turn it off by removing any external power supply, or disconnecting the 3m Y lead. Then, simply fit the 10way Subconn style switch plug that is supplied with the instrument. There is a link in this plug that serves to turn the unit on using the internal batteries. The designated sampling regime will then begin.



5.2 SOFTWARE SWITCH ON

5.2.1 METHOD 1

If the user is confident of the current instrument settings, and wishes to Run the instrument whilst it is connected to PC, then the Run button may be pressed as soon as DataLog 400 is opened. The software will communicate with the instrument automatically, in order to determine which sensors are fitted, and in which mode the instrument is set up.

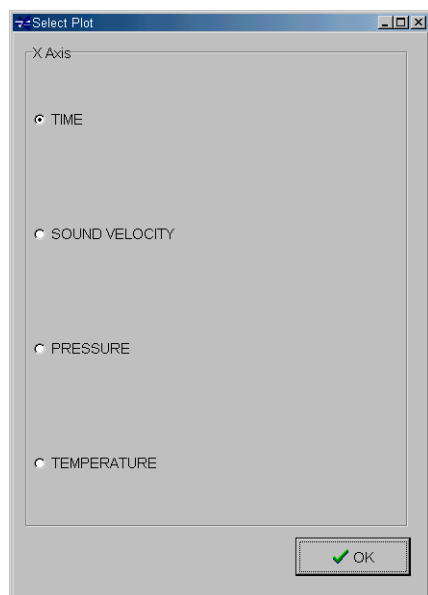
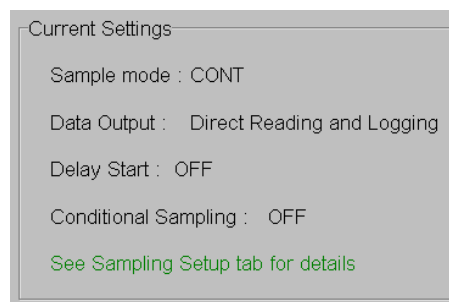


5.2.2 METHOD 2

If the user has used the Interrupt button to communicate with the instrument, and subsequently viewed and/or Set the sampling regime, then the Communicate tab should be selected to allow access to the Run button.

5.2.3 RUN

Note that once DataLog 400 has established communications with the instrument, a separate section will become visible in the Communicate screen, indicating some brief details about the current setup. Users will only notice this once they press the Run button, or when they return to the Communicate screen after Setup.



As soon as the instrument is set into Run mode, DataLog 400 will display this screen. The graphical display facility within the software can plot any of the parameters against any of the other parameters on the x axis, or against time. The user is required to select which parameter should be used as the x axis before any data viewing is possible. Then click on OK to proceed.

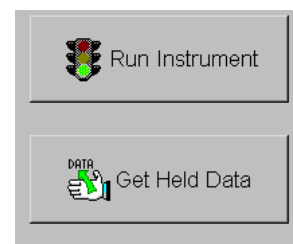
What happens next depends on the sampling mode that has been selected:

Single Mode

Display screens will be updated every time the Run button is pressed.

Hold Mode

If the instrument is set in Hold mode, a new button will be shown on the Communicate screen, just under the Run button. As with Single mode, data is available for display in all screens, but update will occur every time the Get Held Data button is pressed. The sequence of operation should therefore be Run button, Get Held Data button, Run button, Get Held Data button, etc.



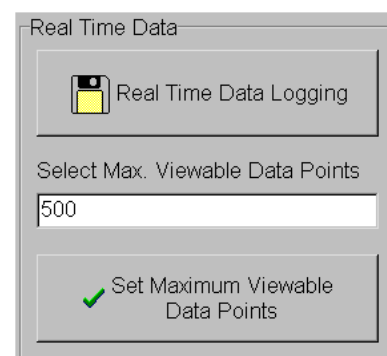
All Other Modes

Display screens will be updated automatically as data is received

All display screens will be available under separate tabs – to view data, simply click on the desired tab. Refer to Chapter 7 for a description of each screen.

5.3 REAL TIME DATA

From the opening screen of DataLog 400, the user will have been aware of a section titled “Real Time Data”. This section has two functions – allowing the recording of real time data to disk as it is received, and limiting the amount of data that will be displayed at any one time.



5.3.1 REAL TIME DATA LOGGING

All data is received in real time in ASCII text format. This data may be logged as a text file for subsequent viewing within DataLog 400, or for importing into another software package.

To record real time data as it is received, simply click on the Real time Data Logging button:

A standard Windows type dialogue box will be shown, asking the user to enter a file name under which to save the data. The default extension is *.txt. Once the user clicks on OK, all data received will be added to this file, until the instrument is stopped.

Note that the software will allow existing files to be overwritten. However, the immediately previous contents of any overwritten file will be stored as another text file titled *.bak.

5.3.2 SELECT MAX VIEWABLE DATA POINTS

This feature has been included to prevent the potentially large amounts of incoming data from adversely affecting PC performance. As each line of data is received through the PC comm port, it is held in PC RAM, and also added to the Scroll and Plot display pages (each of which also uses PC RAM). On the Plot page particularly, some older, slower PC's may struggle to cope with plotting these large amounts of data.

The Real Time Data feature therefore allows the user to set the maximum number of data lines that will be viewable in the graphical display of DataLog 400. Once this limit is reached, the oldest data will be removed, so that only the most recent data points are visible. To choose the required number of visible data points, simply type into the text box, and click the Set button.

Note that the number of lines of data in the Scroll screen is automatically set to 16360. Again, once full, the oldest data will be removed.

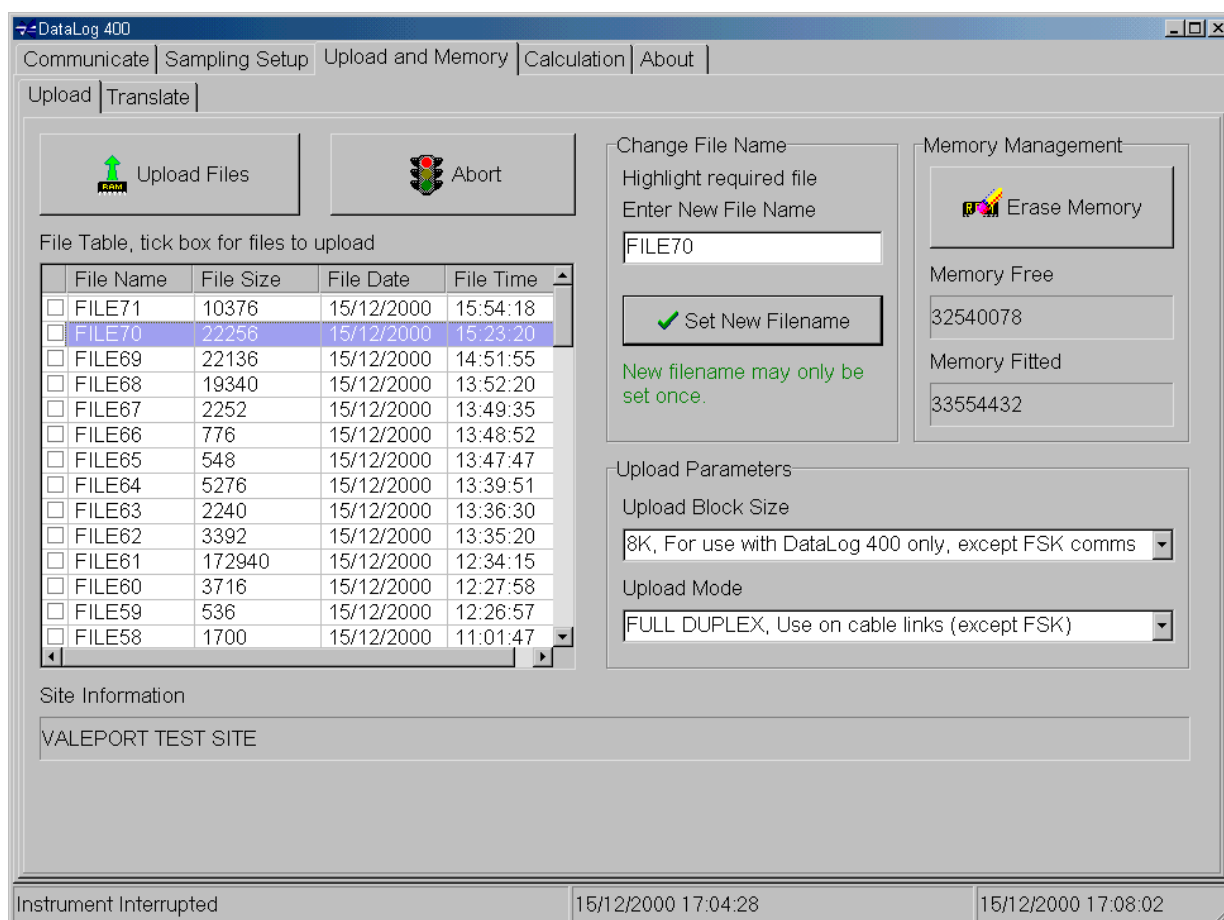
6 UPLOAD & MEMORY

The MIDAS SVX is fitted with a standard 8Mbyte memory. This consists of a single 8Mbyte Flash memory chip. However, there is space on the memory board for up to 4 of these chips, so available memory sizes are 8, 16, 24 or 32 Mbyte. The capacity of this memory depends on the sampling regime chosen. Some sample capacity calculations are given in the first Section of the manual.

There are two stages to accessing logged data, Upload and Translate.

6.1 UPLOAD

In order to upload the memory of the instrument, the user must first establish communications as described in Chapter 3. Once this has been done, the Upload and Memory tab becomes visible. Clicking on it reveals the following screen:



6.1.1 FILE TABLE

This section lists all the files stored in the instrument memory. Note that each time the instrument is set into Run mode, a new file will be created. This will therefore happen at the following points during operation:

- Each time power is applied, unless the instrument is interrupted during the first 15 seconds after switch on.
- Each time the switch plug is plugged in.
- Each time the Run button is pressed in Single mode.

Note that a new file is not created under the following circumstances. Data will be appended to the previous file:

- When instrument enters sleep mode during Burst Sampling
- During Conditional Sampling.

The file table lists all the stored files, with the most recent file displayed at the top of the screen. The table includes the following information about each file:

| | |
|-----------------------|---|
| File Name | This is automatically generated by the instrument, in the form FILE#, where # is the next number in sequence. There is no limit to the maximum number of files that can be stored, apart from the physical capacity of the memory. |
| File Size | This shows the size of each file in bytes. Note that each file contains a certain amount of header information, such as calibration coefficients, date, time and sampling regime. The size of the header information will vary slightly, but is usually in the region of 400 bytes. |
| File Date/Time | These two columns give the date and time at which the file was created. |

Finally, notice that each file has a small check box next to it on the left-hand side. Click on the box next to each file that required uploading.

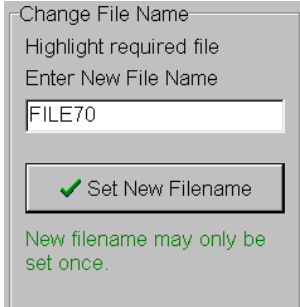
6.1.2 SITE INFORMATION

Before a deployment, the user may enter brief details about the proposed site, to aid in identification afterwards. This section of the screen shows the site information assigned to the highlighted file in the File Table. Please see Chapter 4.1.4 for details of how to enter Site Information.

6.1.3 CHANGE FILE NAME

As mentioned, the instrument will automatically name each file according to the standard FILE# format. However, the user may alter this file name, *once only*, to whatever they wish. When a file is uploaded and translated, it is named according to the same assigned to it in the instrument. Altering the name before upload may therefore allow the user to easily distinguish any particular file.

To rename a file, simply highlight the relevant file in the file table, and enter the new file name (CAPITAL letters). Click on "Set New File Name" to confirm.

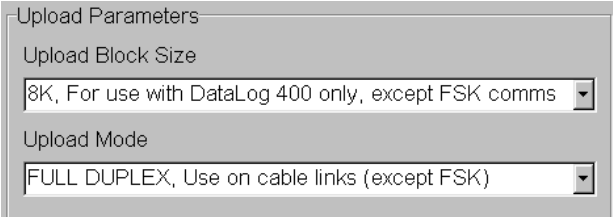


6.1.4 UPLOAD PARAMETERS

DataLog 400 uses an advanced Zmodem protocol for data upload, which features error checking capabilities to ensure that data is not corrupted during upload. Even with this feature, the protocol is reasonably fast. The time taken to upload data can be improved by selecting a higher baud rate (in the Communicate screen), which necessitates use of a short cable (ideally the 3m Y lead).

However, this is not always feasible. For this reason, the user is given the capacity to make minor alterations to the Zmodem protocol to allow the most efficient and reliable data upload method, whatever the deployment circumstances.

In Zmodem, data is uploaded in blocks. Generally speaking, the standard 8K block size should be used. Exceptions are in situation where the user is attempting to upload data using a different program – for example a terminal program such as HyperTerminal or ProComm – or where upload is being carried out over Valeport's 2-wire communications link, FSK modem.



Secondly, most cable links will allow Full Duplex communications (data being sent in one direction and confirmation in the other, at the same time). Exceptions are telemetry methods such as acoustic modems and radios, and again Valeport's FSK modem link, which can only use one direction at once (Half Duplex).

6.1.5 MEMORY MANAGEMENT

This section indicates the total amount of memory fitted to the instrument, in bytes, and the amount which remains unused (again in bytes). It also contains the most dangerous button in the software – the Erase Memory button.

Take care when erasing memory. Although the user is asked twice for confirmation, they should ensure that all required data has been uploaded prior to erasing the memory.

Once memory has been erased, it cannot be recovered.

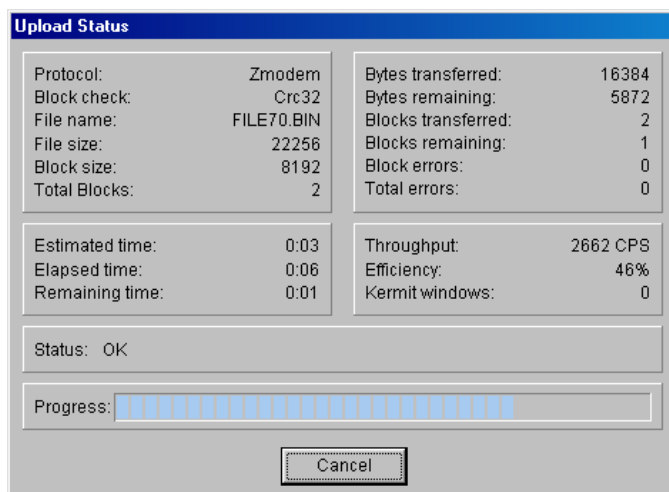


6.1.6 UPLOAD FILES

Once the desired files have been selected, simply click on the Upload Files button to initiate the data upload procedure.



Data will be automatically uploaded into a subdirectory of the DataLog 400 directory, labelled according to the serial number of the instrument. This subdirectory will be created if necessary. The following screen will be shown:

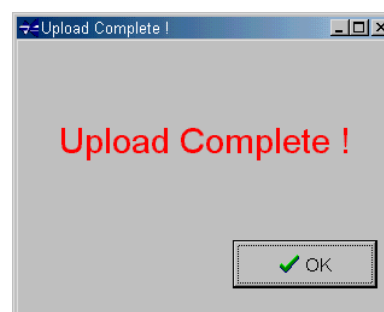


The screen gives an indication of the progress of the upload of the current file – note that this screen will automatically disappear when the current file has uploaded. It will then reappear for each file that is uploaded.

At any stage, upload can be stopped by using the Cancel button on the above screen, or the Abort button in DataLog 400.

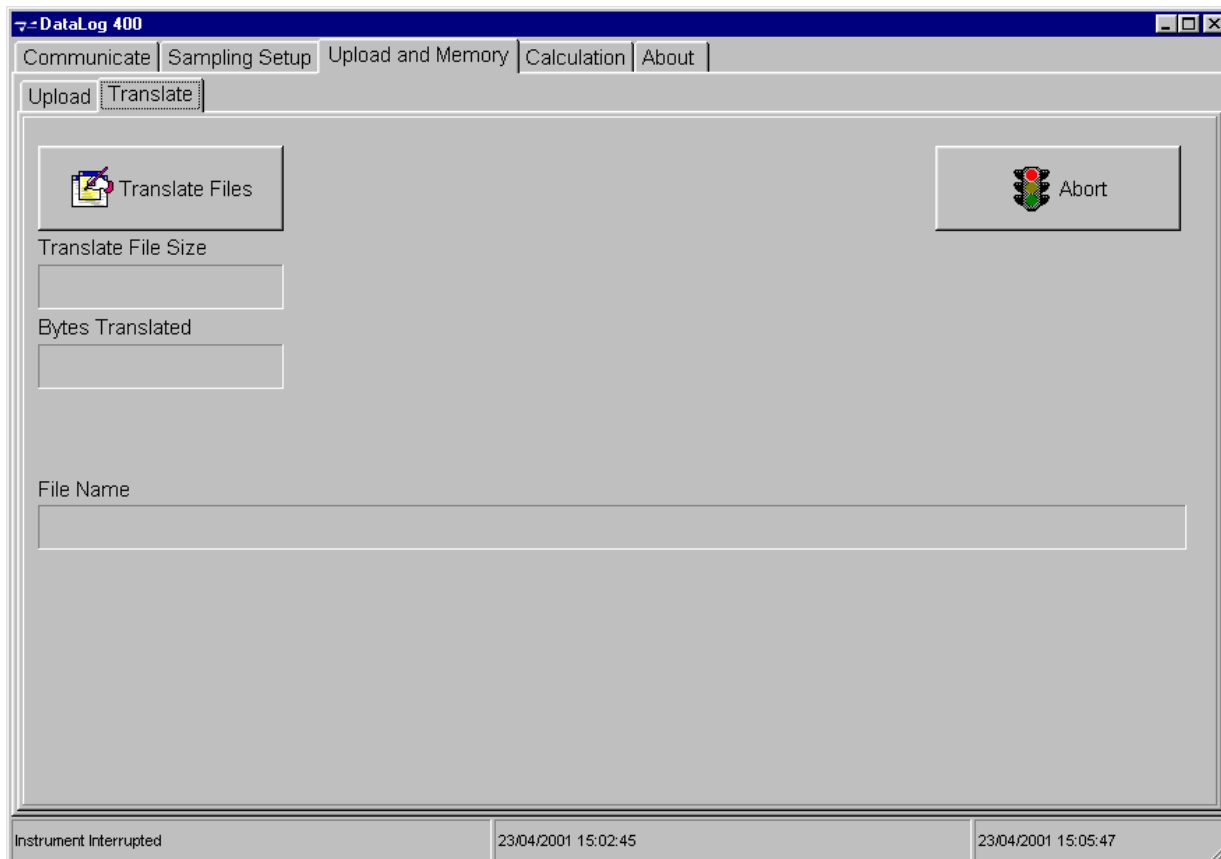


When data has been uploaded the following message will appear:



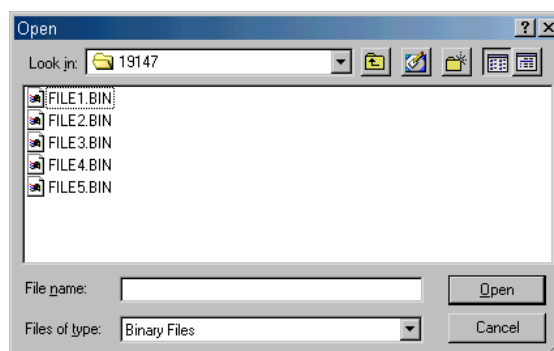
6.2 TRANSLATE

Once files have been uploaded, they are still in binary format, as they are stored in the instrument. Before they can be viewed, they must be translated into ASCII text files. These ASCII text files can then be viewed in DataLog 400, or standard spreadsheet packages such as Microsoft Excel. Click on the Translate tab, and the following screen will appear.



Then click on the Translate Files button to display the following dialogue box:

Select the files that are to be translated. Use the CTRL key on the keyboard in conjunction with the mouse to select more than one file. Clicking on "Open" will initiate the translation procedure. Note that a warning will appear if any existing files could be overwritten.



It is possible, even likely, that certain deployments will result in a single file of 8Mbyte or more. As explained in Chapter 5.3.2, the number of lines of data that DataLog 400 will graph can be set by the user, but it should be noted that some spreadsheet packages have a maximum number of data lines of 16360 (including DataLog 400 itself in Scroll display mode). For this reason, DataLog 400 will attempt to break very large files into several smaller ones. The user is asked to select how many lines of data should be included in each translated file. The screen shows several pieces of information:

The projected file size for the file that is about to be translated, in bytes.

The number of spreadsheet lines. If this is changed then “Set” should be clicked to confirm.

The approximate amount of sampling time that a full 16360 lines of data would contain – this is intended as a guide only, and is based on the sampling frequency of the selected file.

The size of a full 16360 line file. As can be seen, the selected file in this example is only marginally smaller than a full spreadsheet.

Translation will then commence when the OK button is pressed.

The screenshot shows a dialog box titled "Select File Size". It contains the following fields and buttons:

- Total File Size: 907191
- Spreadsheet lines: 16360
- For full spreadsheet:
 - Time, Seconds: 4090
 - File Size, Bytes: 1030680
- Buttons: "Set" (with a green checkmark) and "OK" (with a green checkmark).

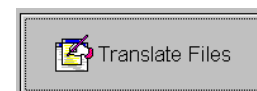
The screenshot shows a window with the following elements:

- A button labeled "Translate Files" with a document icon.
- Translate File Size: 1710
- Bytes Translated: 432
- Translation Progress: A progress bar with 10 segments, the first 4 are filled with blue.
- File Name: C:\Program Files\DataLog 400\19259\File4.000

The screen will show the size of the file that is being translated, and two progress indicators. The first shows the number of bytes of the binary file that have so far been translated, and below this is a visual indicator in the form of a blue bar.

Finally, the name of the file that is being created is shown. As can be seen, the stem of the file name comes from the name of the binary file (File5). The extension in this case is .000. In the case of large files, where the original binary file is broken into several translated text files (see previous page), this extension will increase by one for each separate file. For example, the second file in the sequence would be named File5.001

To translate further files, simply click the Translate Files button to open further binary files.



To abort the translation procedure at any time, click on the Abort button.



Proceed to Chapter 7 for details of how to view translated files in DataLog 400.

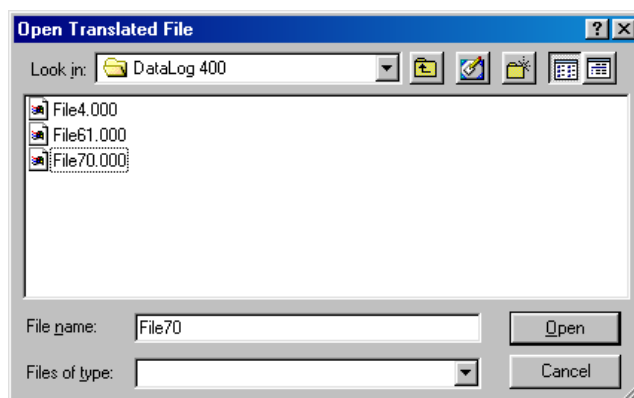
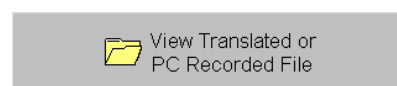
7 DATA VIEWING

DataLog 400 offers three different display modes. All are available for both real time data and for files that have been saved or uploaded.

N.B.: *The MIDAS SVX has true Sound Velocity data, measured by the “time of flight” sensor, and calculated Sound Velocity, from CTD data. It is the convention in DataLog 400 that the true “time of flight” data is represented as “Sound Velocity”, and the calculated data is represented as “Speed of Sound”.*

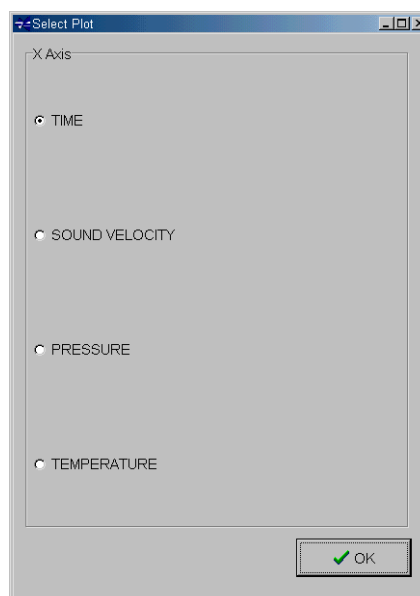
7.1 OPENING STORED DATA FILES

Stored data files may be opened by clicking on this button in the Communicate screen. The following dialogue box will appear, asking the user to select which file to open. Note that only one file may be opened at a time.



Uploaded data files will have a file extension of .000 or similar as described in Chapter 6.2. Files containing data that have been stored from a real time input will have the extension .txt, as described in Chapter 5.3.1.

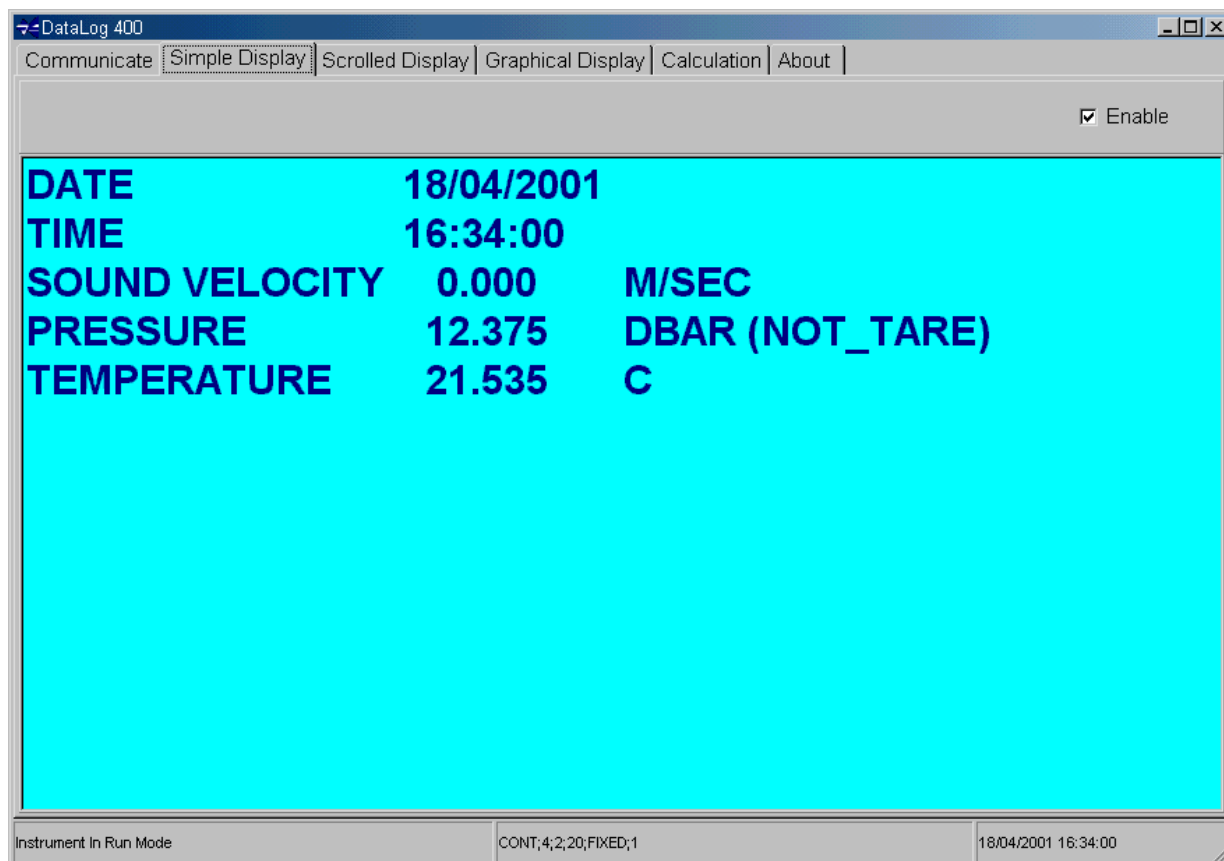
Once the desired file has been selected, click on the Open button. As with viewing data in real time, the user will be asked which parameter to use as the x axis in graphical displays. Select the required parameter, and click on OK.



7.2 SIMPLE DISPLAY

The simple display is designed primarily for real time use. It is available for use with uploaded data files, but will simply display each data point in turn as it is read from memory, and then fix on the final data recorded in the file.

The function of the simple display is to provide the user with a readout of the last set of data received by the PC.



The display gives the date and time of the last data point, and then the last output of each fitted parameter. In Burst modes, the standard deviation of the data is also given.

Note the check box at the top right corner of the screen – while this is checked, the screen will continue to be updated. Some older PCs may struggle to update all displays at fast data rates, so disabling unwanted displays may help. To disable the display, simply uncheck the box. To re-enable, re-check the box – the next data point received will be displayed as normal.

7.3 SCROLL DISPLAY

The scroll display provides the user with a record of all data received by the software (subject to the maximum number of lines, 16360).

The screen shows the date and time at the left-hand side, followed by data from each fitted parameter. Again, if in Burst mode, standard deviation data will be included.

| DATE | TIME | SOUND VELOCITY; M/SEC | PRESSURE; DBAR (NOT_TARE) | TEMPERATURE; C |
|------------|----------|-----------------------|---------------------------|----------------|
| 18/04/2001 | 16:38:09 | 0.000 | 12.375 | 21.498 |
| 18/04/2001 | 16:38:08 | 0.000 | 12.375 | 21.498 |
| 18/04/2001 | 16:38:08 | 0.000 | 12.375 | 21.499 |
| 18/04/2001 | 16:38:08 | 0.000 | 12.375 | 21.498 |
| 18/04/2001 | 16:38:08 | 0.000 | 12.250 | 21.498 |
| 18/04/2001 | 16:38:07 | 0.000 | 12.375 | 21.499 |
| 18/04/2001 | 16:38:07 | 0.000 | 12.375 | 21.499 |
| 18/04/2001 | 16:38:07 | 0.000 | 12.375 | 21.498 |
| 18/04/2001 | 16:38:07 | 0.000 | 12.375 | 21.499 |
| 18/04/2001 | 16:38:06 | 0.000 | 12.375 | 21.499 |
| 18/04/2001 | 16:38:06 | 0.000 | 12.250 | 21.499 |
| 18/04/2001 | 16:38:06 | 0.000 | 12.375 | 21.500 |
| 18/04/2001 | 16:38:06 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:05 | 0.000 | 12.250 | 21.499 |
| 18/04/2001 | 16:38:05 | 0.000 | 12.250 | 21.499 |
| 18/04/2001 | 16:38:05 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:04 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:04 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:04 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:04 | 0.000 | 12.250 | 21.500 |
| 18/04/2001 | 16:38:04 | 0.000 | 12.375 | 21.500 |

Note that the columns of data are sizeable, after the first two lines of data have been received. Simply position the mouse over the edge of a column title, and use the left mouse button to drag the column to a suitable size.

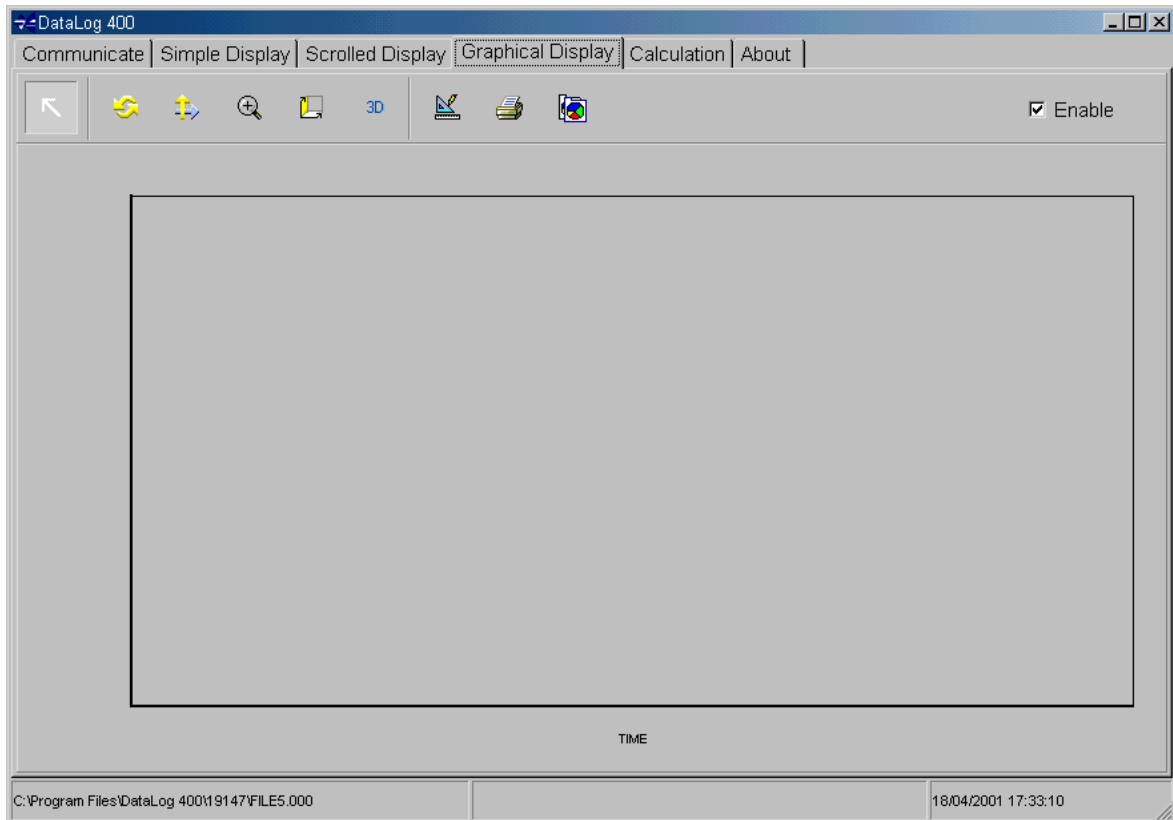
As with the Simple display, this screen can be disabled by unchecking the Enable check box at the top right corner. Re-checking the box re-enables the display, and data will continue to be added when the next data line is received.

7.4 GRAPHICAL DISPLAY

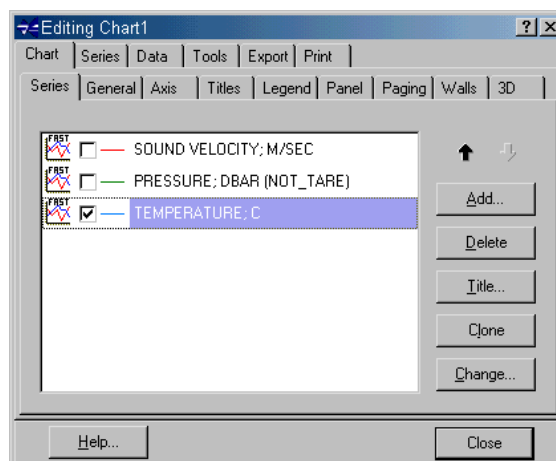
The graphical display facility in DataLog 400 is an integral feature of the Delphi programming language in which DataLog 400 is written. Consequently, there are many features of this display type that are beyond what is absolutely necessary for functional data display. Such features include adding a picture to the background of the graph, and changing the size of the border around the image.

This manual does not cover the majority of these features, but instead concentrates on those features that are necessary to enable standard data displays. Users familiar with standard Windows functions and common programmes such as Microsoft Excel will be able to customise their graphical displays as they wish, simply by exploring the many features available.

When the user first views the graphical display, they will be presented with a blank page:



All graph functions are controlled with the various buttons at the top of the screen. The first button to use is the Graph Edit button – this allows the user to decide which parameters are to be graphed, and in which format. Clicking on this button reveals the following screen:



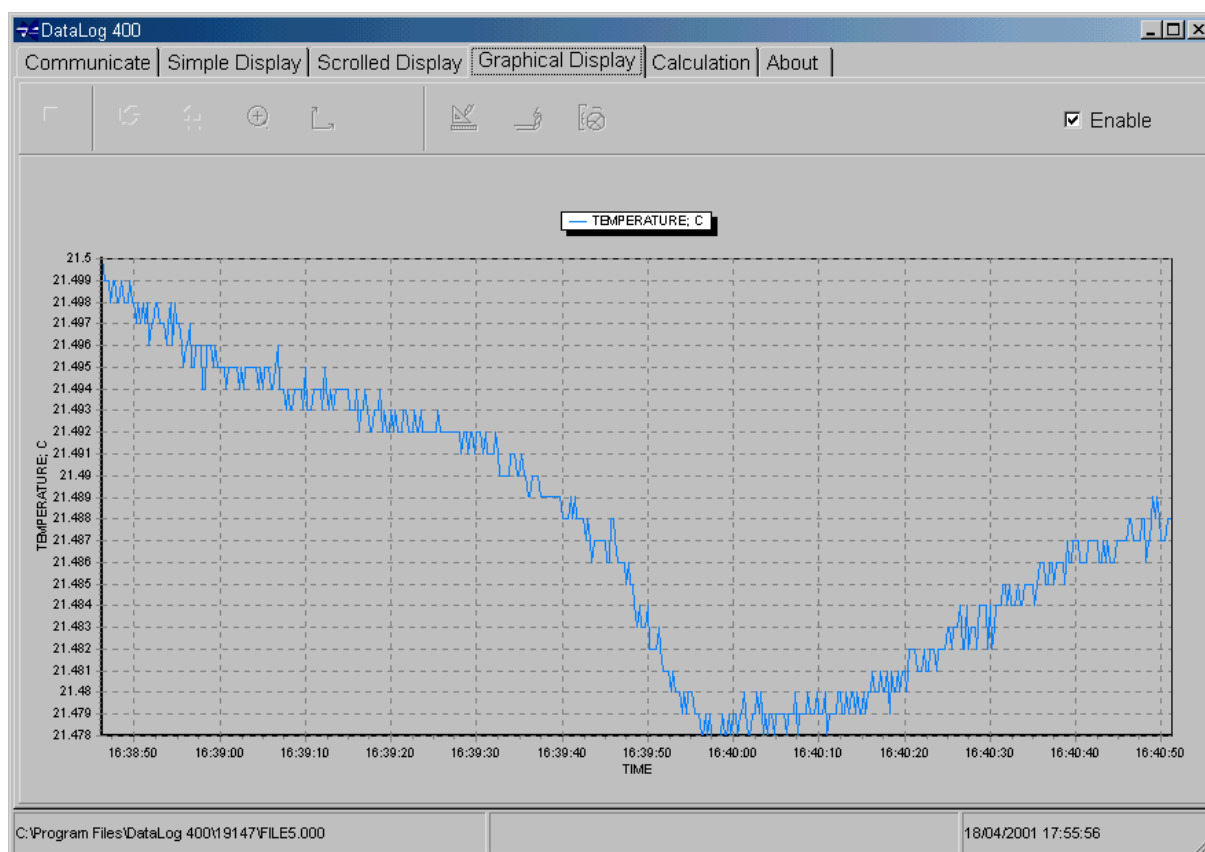
All the fitted parameters are shown as being available for graphing against time. Simply click on the check box against each parameter to indicate whether it is to be graphed or not.

To alter the colour of any parameter, simply double click on the coloured line adjacent to each parameter, and select from the variety of available colours. Further modifications to line style can be made by selecting the upper Series tab, followed by Format, and the Border button.

Finally, users may double click on the icon to the left of each parameter to alter the graph type. DataLog 400 is best able to display data at rapid rates using the “Fast Line” style, which is the default. However, users may wish to select other styles to suit their own preference.

As can be seen from the screen on the previous page, there are several other tabs available to alter the appearance of the graph. This manual does not cover all these options, but be assured that DataLog 400 will revert to its default style if closed down and reopened.

The example screen below shows only a single parameter checked for display, simply for reasons of clarity. Note that secondary y axes will appear for each parameter checked, and each will autoscale to show the full range of data. The scale may be manually set under the Chart, Axis, Scale tab. The x axis will also autoscale as new data is received, and will then slide as the maximum number of viewable data points is reached (Chapter 5.3.2).



Note that once the graph has been set up, the function buttons are inactivated and greyed out. This inactivation is simply to conserve PC RAM for data display, and the buttons may be reactivated simply by clicking on the toolbar.

The functions of the other buttons are as follows:



Clicking on this button will allow the user to print the graph. A preview page is shown, allowing the user to alter page size, margin size and printer. Simply press Print when the page is shown as required.



This button copies the graph as currently displayed to the PC clipboard, for import into other programs as a bitmap.

The remainder of the icons on the graphical display page allow the user to control certain features of the graph using the mouse.

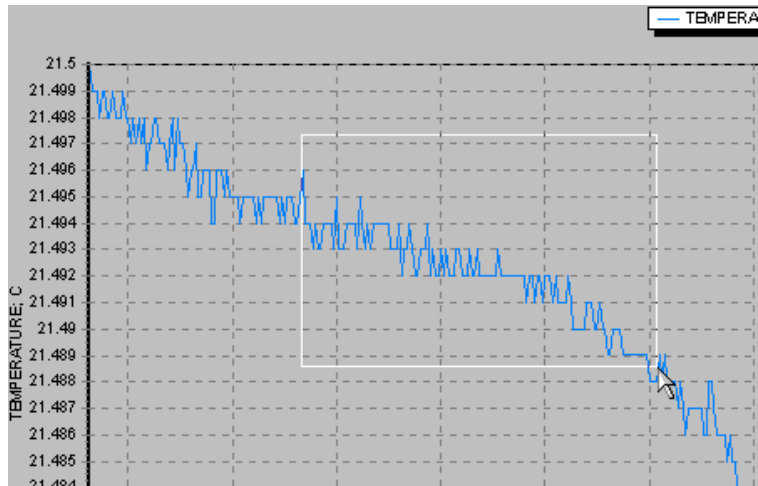


7.4.1 SCROLL & FOCUS

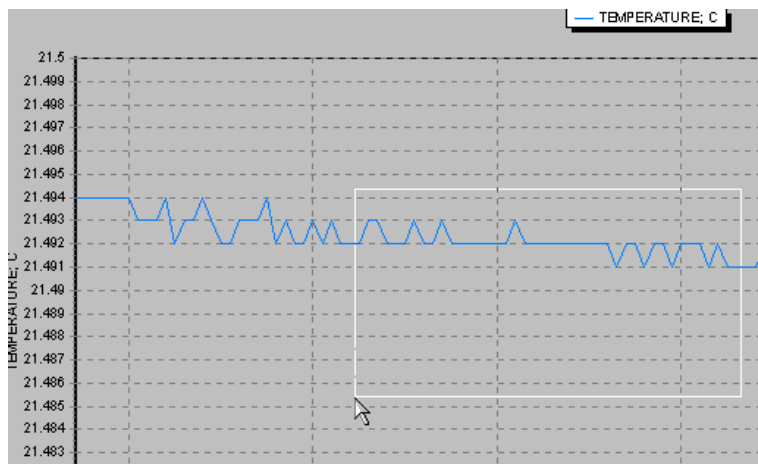


The first icon (default icon when the screen opens) gives the mouse two functions. By holding down the right mouse button, it is possible to scroll both axes of the graph, simply by dragging the mouse in the appropriate direction.

By holding down the left button, the user may focus onto a particular section of the graph. Simply drag and draw a box over the required section of data, starting at the top left corner.



To focus out again, drag and draw a box on the graph starting at any other corner.



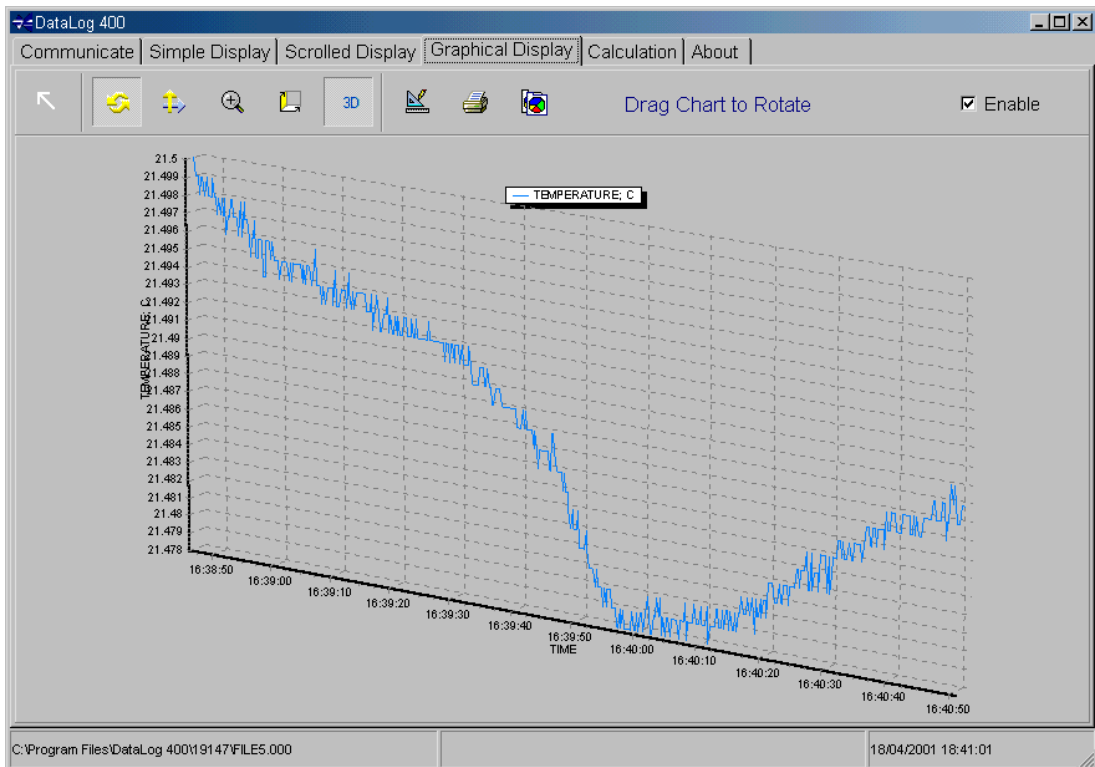
The remaining icons alter the 3 dimensional properties of the graphical display. If any are selected, the graph will automatically switch into 3D mode, but at any time, 3D mode can be toggled on and off by using the 3D button.



7.4.2 ROTATE



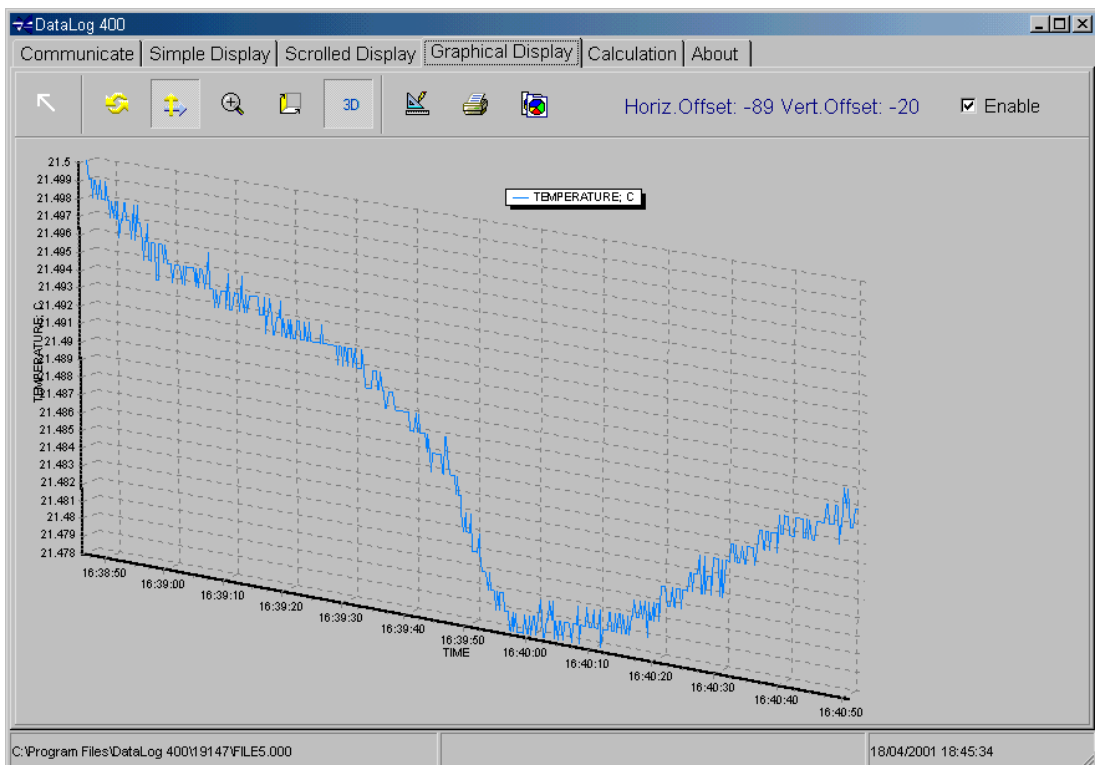
This icon allows the user to rotate the graph so that it may be viewed from any position either above or to the right of the current perspective. Simply use the left mouse button to drag the graph to the desired orientation.



7.4.3 MOVE



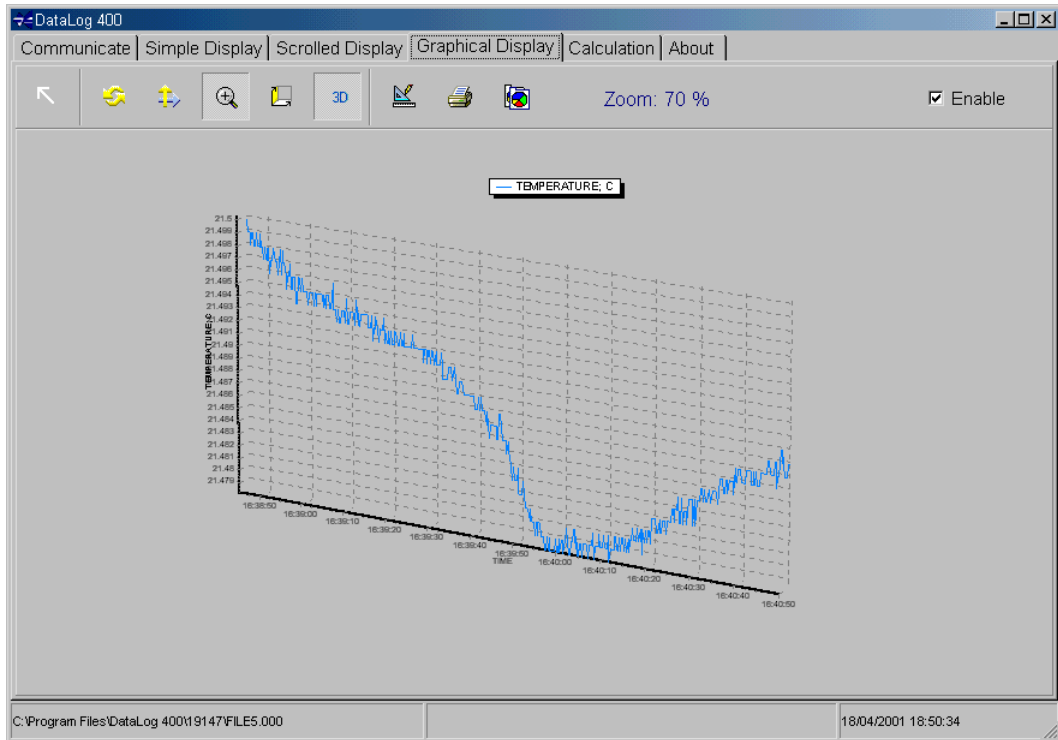
This icon allows the user to alter the position of the graph on the page. Use the left mouse button to drag the graph around the page to the desired position. This picture shows the graph moved to the left hand side of the screen.



7.4.4 ZOOM



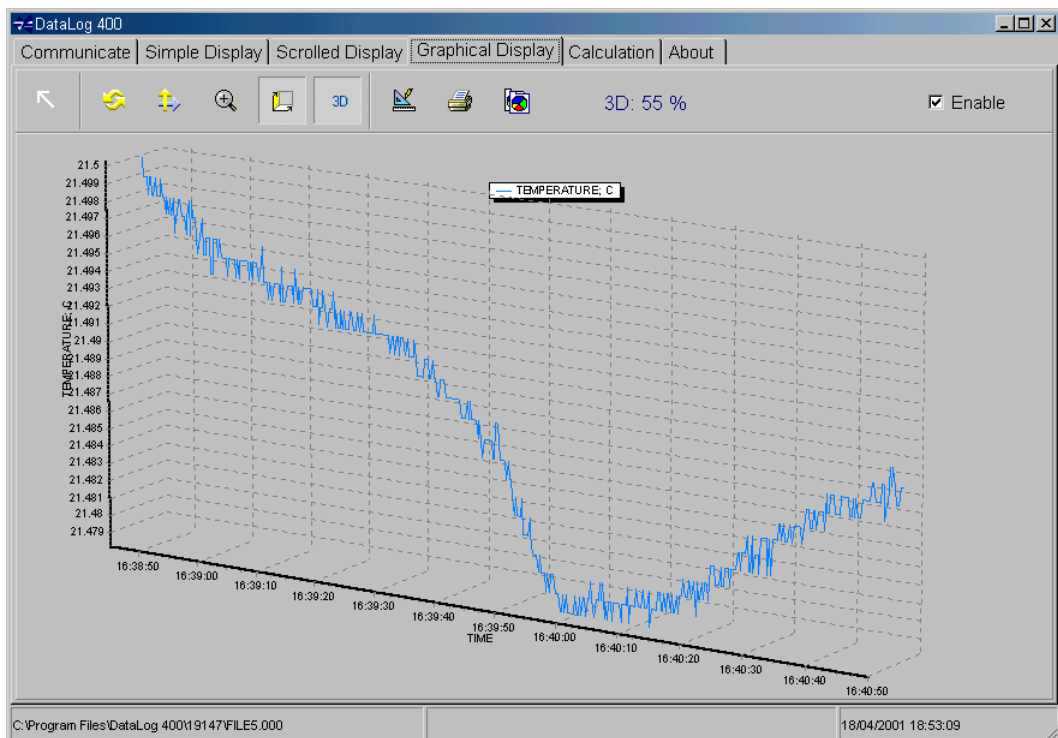
As can be guessed from the icon, this button allows the graph to be zoomed in or out. Holding down the left mouse button, drag the mouse upwards to zoom in, or downwards to zoom out. This picture shows the graph zoomed out:



7.4.5 DEPTH



This button controls the three dimensional depth of the graph. It is best seen in graphs that have been rotated to view from a different perspective.



8 CALCULATION

The Calculation function is provided as a tool for the user to carry out standard oceanographic calculations.

Simply input Conductivity/Salinity, Pressure Temperature (in IPT68 or IPT 90 scales) and Latitude (if known), and click on the Calculate button. The program will calculate and display the following parameters:

- Density Anomaly Gamma (difference between calculated Density and Density of Pure Water)
- Conductivity or Salinity (whichever the user did not enter).
- Sound Speed calculated using the chosen Speed of Sound Formula.
- Depth in metres calculated using the UNESCO standard formula. This is an approximation, and does not account for variations in density distribution throughout the water column. Its accuracy has been estimated at better than 0.1m.

All formulae, including the various Speed of Sound formulae are given in full in Chapter 10

9 ABOUT



The About tab, available for selection at all times, shows Valeport's contact details and software version. If the About tab is selected after the user has interrupted the unit operation, then the instrument serial number and internal firmware version will also be shown.

10 CALCULATION FORMULAE

The following extracts are taken and adapted from "Processing of Oceanographic Station Data", published by UNESCO in 1991.

10.1 SALINITY

The Practical Salinity Scale (PSS-78)

The fundamental step in constructing the practical salinity scale PSS-78 consisted of defining a single reference point ($S=35$) on the scale as having the same electrical conductivity as a reference potassium chloride (KCl) solution at 15°C and atmospheric pressure. The transition from the previous scale was made by selecting a single batch (P79) of Standard Seawater and equating the new scale to the old through the chlorinity relationship $S = 1.80655 C$ for that particular batch. As the salinity on the practical scale is defined to be conservative with respect to addition and removal of water, the entire salinity range is accessible through precise weight dilution or evaporation without additional definitions. However, the practical scale is defined in terms of conductivity ratio and not by its conservative properties. Thus the second part of the definition was constructed by measuring the conductivity ratio to the KCl standard or an equivalent secondary standard over the entire range of salinities (1 to 42) of samples prepared by evaporation or dilution of batch P79 SSW and computing an empirical formula $S = S(R_{15})$, where R_{15} is the conductivity ratio 15°C and atmospheric pressure to the KCl standard. Thus salinities on the PSS-78 scale are defined by conductivity ratios alone. Salinities determined by any other method would not necessarily coincide with the PSS-78 scale and would have to be identified separately. Lewis and Perkin (1981) and Mamayev (1986) discuss differences between PSS-78 and previous scales and provide algorithms and tables to convert existing data to the new scale.

The algorithm for converting conductivity ratio to salinity is constructed in terms of the conductivity ratio R defined as:

$$R = C(S, t, p)/C(35, 15, 0) \quad (1)$$

where $C(S, t, p)$ is the electrical conductivity as a function of salinity S , temperature t and pressure p . The ratio is factored into the functions:

$$R = r_t(t) \cdot R_t(S, t) \cdot R_p(R, t, p) \quad (2)$$

where

$$\begin{aligned} r_t(t) &= C(35, t, 0)/C(35, 15, 0) \\ R_t(S, t) &= C(S, t, 0)/C(35, t, 0) \\ R_p(R, t, p) &= C(S, t, p)/C(S, t, 0) \end{aligned}$$

Salinity is given by the function

$$S = \sum_{n=0}^5 \left[a_n + \frac{\Delta t}{1+k\Delta t} b_n \right] \cdot R_t^{n/2} \quad (3)$$

with coefficients

| | | | | | |
|---------|----------|---------|---------|--------------|----------|
| $a_0 =$ | +0.0080 | $b_0 =$ | +0.0005 | $k =$ | +0.0162 |
| $a_1 =$ | -0.1692 | $b_1 =$ | -0.0056 | $\Delta t =$ | $t - 15$ |
| $a_2 =$ | +25.3851 | $b_2 =$ | -0.0066 | | |
| $a_3 =$ | +14.0941 | $b_3 =$ | -0.0375 | | |
| $a_4 =$ | -7.0261 | $b_4 =$ | +0.0636 | | |
| $a_5 =$ | +2.7081 | $b_5 =$ | -0.0144 | | |

At $t = 15^\circ\text{C}$ (3) reduces to the formula defining the practical salinity scale (Perkin and Lewis 1980).

The factors r_t and R_p are given by

$$r_t = \sum_0^4 C_n t^n \quad (4)$$

where

$$\begin{aligned} C_0 &= +0.6766097 & C_3 &= -6.9698E-7 \\ C_1 &= +2.00564E-2 & C_4 &= +1.0031E-9 \\ C_2 &= +1.104259E-4 & & \end{aligned}$$

and

$$\begin{aligned} R_p &= 1 + \frac{e_1 p + e_2 p^2 + e_3 p^3}{1 + d_1 t + d_2 t^2 + (d_3 + d_4 t) \cdot R} \\ &= 1 + \frac{C}{B + AR} \end{aligned} \quad (5)$$

with

$$\begin{aligned} e_1 &= +2.070E-5 & d_1 &= +3.426E-2 \\ e_2 &= -6.370E-10 & d_2 &= +4.464E-4 \\ e_3 &= +3.989E-15 & d_3 &= +4.215E-1 \\ & & d_4 &= -3.107E-3 \end{aligned}$$

for temperature in °C and pressure in dBar.

Given a measurement of R , t and p , salinity is computed by solving (2) for R_p ; $R_t = R/(r_t R_p)$ and evaluating S from (3). If conductivity ratio R is required given S , t and p , the ratio R_t can be found by numerical inversion of (2), and R can be found by solving the quadratic equation

$$R = r_t \cdot R_t \cdot R_p = r_t \cdot R_t \cdot \left[1 + \frac{C}{AR + B} \right]$$

or

$$R = \frac{\left[(Ar_t R_t - B)^2 + 4r_t R_t A(B + C) \right]^{1/2} + [Ar_t R_t - B]}{2A} \quad (6)$$

This description of PSS-78 has been adapted from Fofonoff (1985)

10.2 DENSITY ANOMALY GAMMA

Equation of State of Seawater (EOS-80)

The equation of state of seawater is the mathematical expression to calculate density from measurements of temperature, pressure and salinity. Virtually all the computations of density of seawater made since the beginning of the century have been based on the direct measurements of density, chlorinity and salinity made by Knudsen, Forch and Sørensen (1902), and of compression of seawater made by Ekman (1908). This equation was obtained from measurements of density of natural seawater in which the proportions of the various ions are not exactly constant. To be consistent with the new definition of the Practical Salinity, 1978, the new equation of state is based on measurements of density of standard seawater solutions obtained by weight dilution with distilled water and by evaporation. As the absolute density of pure water is not known with enough accuracy, the density of distilled water used for these measurements was determined from the equation of the SMOW (Standard Mean Ocean Water) whose isotopic composition is well defined.

The new equation of state (EOS-80) which was adopted by JPOTS in 1981 (UNESCO, 1981c) is:

$$\left. \begin{aligned} v(S, t, p) &= v(S, t, 0)[1 - p / K(S, t, p)] \\ \rho(S, t, 0) &= 1 / v(S, t, 0) = A + BS + CS^{3/2} + DS^2 \\ K(S, t, p) &= E + FS + GS^{3/2} + (H + IS + JS^{3/2})p + (M + NS)p^2 \end{aligned} \right\} (7)$$

where the coefficients A, B, \dots, N are polynomials in temperature t . Units: salinity, PSS-78; temperature, °C; pressure (p), bar; density (ρ), kg/m³; specific volume (v), m³/kg. These coefficients are given below.

| | A | B | C | D |
|-------|--------------|-------------|-------------|------------|
| t^0 | +999.842594 | +8.24493E-1 | -5.72466E-3 | +4.8314E-4 |
| t^1 | +6.793952E-2 | -4.0899E-3 | +1.0227E-4 | |
| t^2 | -9.095290E-2 | +7.6438E-5 | -1.6546E-6 | |
| t^3 | +1.001685E-4 | -8.2467E-7 | | |
| t^4 | -1.120083E-6 | +5.3875E-9 | | |
| t^5 | +6.536332E-9 | | | |
| | E | F | G | |
| t^0 | 19652.21 | +54.6746 | +7.944E-2 | |
| t^1 | +148.4206 | -0.603459 | +1.6483E-2 | |
| t^2 | -2.327105 | +1.09987E-2 | -5.3009E-4 | |
| t^3 | +1.360477E-2 | -6.1670E-5 | | |
| t^4 | -5.155288E-5 | | | |
| | H | I | J | |
| t^0 | +3.239908 | +2.2838E-3 | +1.91075E-4 | |
| t^1 | +1.43713E-3 | -1.0981E-5 | | |
| t^2 | +1.16092E-4 | -1.6078E-6 | | |
| t^3 | -5.77905E-7 | | | |
| | M | N | | |
| t^0 | +8.50935E-5 | -9.9348E-7 | | |
| t^1 | -6.12293E-6 | +2.0816E-7 | | |
| t^2 | +5.2787E-8 | +9.1697E-10 | | |

Density Anomaly γ is defined as the Density of the water minus 1000 kg/m³.

10.3 SPEED OF SOUND

The following information, discussion and conclusions are taken from Special Publication No.34 of the Hydrographic Society, prepared by JM Pike and FL Beiboer of METOCEAN plc. The report is entitled "A Comparison Between Algorithms for the Speed of Sound in Seawater".

The following abbreviations and units are used:

| | |
|-----------|---|
| V | Computed speed of sound in seawater (m/s) |
| T | Temperature (°C) |
| S | Salinity |
| ϕ | Latitude in degrees |
| $g(\phi)$ | Gravitational acceleration at the given latitude (m/s ²) |
| P_b | Hydrostatic pressure (bar) (1bar = 10 ⁵ Pa = 10/g(ϕ) (kg/cm ²)) |
| P_k | Hydrostatic pressure (kg/cm ²) |
| D | Depth (m) |

10.3.1 STANDARD FORMULAE

10.3.1.1 PRESSURE/DEPTH RELATIONSHIP

Several relationships are identified by Robertson(l), ranging from the approximate ("1 km of seawater generates a pressure of 101 bar"), to the precise (use of the MacKenzie or UNESCO algorithms).

The accurate relationships require computation of the gravitational field at the latitude in question using an appropriate formula for the gravitational field.

The UNESCO pressure/depth relationship has not been the subject of significant academic debate since its introduction, and is stated as follows:

$$D = \frac{(C_1 * (P_b * 10) + C_2 * (P_b * 10)^2 + C_3 * (P_b * 10)^3 + C_4 * (P_b * 10)^4)}{(g(\phi) + \frac{1}{2} g' * P_b)} + \Delta d / 9.8$$

where:

$$g(\phi) = 9.780318 * (1.0 + 5.2788E-3 * \sin^2\phi + 2.36E-5 * \sin^4\phi)$$

$$G' = +2.184E-5 \text{ m.s}^{-2} \cdot \text{bar}^{-1}$$

$$C_1 = +9.72659$$

$$C_2 = -2.2512E-5$$

$$C_3 = +2.279E-10$$

$$C_4 = -1.82E-15, \text{ and}$$

P_b is the hydrostatic pressure (bar)

Δd is the geopotential anomaly, expressed in J/kg. This term is zero for standard seawater (S = 35, T = 0°C).

The geopotential anomaly term (Δd) contains the correction for the actual density distribution within the water column, and can be evaluated for precise computation (or where there are extremes of temperature or salinity) by integrating the specific volume anomaly over the required pressure range. The procedures for this are also included in UNESCO Technical Paper #44.

The DataLog 400 program, however, does not feature the ability to input Δd (which is therefore assumed to be 0).

This assumption is recognised as being legitimate, with the resultant pressure depth algorithm called 'Simple UNESCO Depth':

$$D = \frac{(C_1 * (P_b * 10) + C_2 * (P_b * 10)^2 + C_3 * (P_b * 10)^3 + C_4 * (P_b * 10)^4)}{(g(\phi) + \frac{1}{2} g' * P_b)}$$

This value of D is used in all formulae within DataLog 400.

10.3.1.2 WOOD (1949)

$$V = 1410 + 4.21 * T - 0.037 * T^2 + 1.14 * S + 0.018 * D$$

This formula was recognised before 1960 as being inadequate, and was replaced (at least in US Navy Hydrographic Office operations) in 1962 by the Wilson formula. It is thus not used in DataLog 400.

10.3.1.3 WILSON (OCTOBER 1960)

Full Version

The full version of this formula is:

$V = 1449.14 + V_T + V_P + V_S + V_{STP}$, where

$$V_T = 4.5721 * T - 4.4532E - 2 * T^2 - 2.6045E - 4 * T^3 + 7.9851E - 6 * T^4$$

$$V_P = 1.60272E - 1 * P_k + 1.0268E - 5 * P_k^2 + 3.5216E - 9 * P_k^3 - 3.3603E - 12 * P_k^4$$

$$V_S = 1.39799 * (S - 35) + 1.69202E - 3 * (S - 35)^2$$

$$V_{STP} = (S - 35) * (-1.1244E - 2 * T + 7.7711E - 7 * T^2 + 7.7016E - 5 * P_k - 1.2943E - 7 * P_k^2 + 3.1580E - 8 * P_k * T + 1.5790E - 9 * P_k * T^2) \\ + P_k * (-1.8607E - 4 * T + 7.4812E - 6 * T^2 + 4.5283E - 8 * T^3) \\ + P_k^2 * (-2.529E - 7 * T + 1.8563E - 9 * T^2) \\ + P_k^3 * (-1.9646E - 10 * T)$$

Wilson states that the formula is valid to within ± 0.3 m/s in the ranges:

$$-4^\circ\text{C} < T < 30^\circ\text{C}; 0 < S < 37.1 \text{ kg/cm}^2; < P_k < 1000 \text{ kg/cm}^2.$$

$$\text{where } P_k = P_b \cdot \frac{10}{g(\phi)}$$

Simplified Version

A simplified version of this formula, which is believed to have been used for a number of offshore surveys, is:

$$V = 1.449.14 + 4.5721 * T - 4.4532E - 2 * T^2 - 2.6045E - 4 * T^3 + (1.39799 - [1.1244E - 2 * T]) * (S - 35) + 1.643E - 2 * D$$

The range of validity is likely to be comparable to the full version, with simplification (and inaccuracy) introduced by replacing the pressure terms with a depth term (of unknown provenance), and ignoring 4th order temperature terms (*inter alia*).

10.3.1.4 MEDWIN (1975)

This simple formula was based on the Del Grosso equation and is:

$$V = 1449.2 + 4.6 * T - 0.055 * T^2 + 0.00029 * T^3 + (1.34 - 0.010 * T) * (S - 35) + 0.016 * D$$

Medwin states the formula is valid "for realistic combinations of T , S , P " in the ranges $0 < T < 35^{\circ}\text{C}$, $0 < S < 45$, $0 < D < 1000$ m. The fact that the equation was based on the Del Grosso equation, however, leads to the conclusion that the range of validity cannot be superior to the Del Grosso formula itself, which is deemed to be valid only in a limited temperature and salinity range.

The more likely validity of the Medwin formula is indicated in the matrix below, in which the maximum valid pressure (in bar) is indicated for each temperature and salinity:

| S | $T (^{\circ}\text{C})$ | | | |
|-----|------------------------|-----|------|------|
| | 0 | 5 | 10 | 15 |
| 33 | 100 | 100 | 100 | 69 |
| 34 | 100 | 100 | 100 | 100 |
| 35 | 100 | 100 | 100 | 100 |
| 36 | 100 | 100 | 100 | 69 |
| 38 | 69 | 69 | 100 | 100 |

10.3.1.5 CHEN AND MILLERO (1977)

This formula was adopted by UNESCO in 1983 and is as follows:

$$V = C_w(t, p) + A(t, p) \cdot S + B(t, p) \cdot S^{3/2} + D(t, p) \cdot S^2$$

where,

$$\begin{aligned} C_w(t, p) = & C_{00} + C_{01} \cdot T + C_{02} \cdot T^2 + C_{03} \cdot T^3 + C_{04} \cdot T^4 + C_{05} \cdot T^5 + \\ & (C_{10} + C_{11} \cdot T + C_{12} \cdot T^2 + C_{13} \cdot T^3 + C_{14} \cdot T^4) \cdot P_b + \\ & (C_{20} + C_{21} \cdot T + C_{22} \cdot T^2 + C_{23} \cdot T^3 + C_{24} \cdot T^4) \cdot P_b^2 + \\ & (C_{30} + C_{31} \cdot T + C_{32} \cdot T^2) \cdot P_b^3 \end{aligned}$$

$$\begin{aligned} A(t, p) = & A_{00} + A_{01} \cdot T + A_{02} \cdot T^2 + A_{03} \cdot T^3 + A_{04} \cdot T^4 + \\ & (A_{10} + A_{11} \cdot T + A_{12} \cdot T^2 + A_{13} \cdot T^3 + A_{14} \cdot T^4) \cdot P_b + \\ & (A_{20} + A_{21} \cdot T + A_{22} \cdot T^2 + A_{23} \cdot T^3) \cdot P_b^2 + \\ & (A_{30} + A_{31} \cdot T + A_{32} \cdot T^2) \cdot P_b^3 \end{aligned}$$

$$B(t, p) = B_{00} + B_{01} \cdot T + (B_{10} + B_{11} \cdot T) \cdot P_b$$

$$D(t, p) = D_{00} + D_{10} \cdot P_b$$

with the coefficients defined in the following matrix:

| <i>Subscript</i> | <i>A</i> | <i>B</i> | <i>C</i> | <i>D</i> |
|------------------|-------------|------------|-------------|------------|
| 00 | +1.389 | -1.922E-2 | +1402.388 | +1.727E-3 |
| 01 | -1.262E-2 | -4.42E-5 | +5.03711 | |
| 02 | +7.164E-5 | | -5.80852E-2 | |
| 03 | +2.006E-6 | | +3.3420E-4 | |
| 04 | -3.21E-8 | | -1.47800E-6 | |
| 05 | | | +3.1464E-9 | |
| 10 | +9.4742E-5 | +7.3637E-5 | +0.153563 | -7.9836E-6 |
| 11 | -1.2580E-5 | +1.7945E-7 | +6.8982E-4 | |
| 12 | -6.4885E-8 | | -8.1788E-6 | |
| 13 | +1.0507E-8 | | +1.3621E-7 | |
| 14 | -2.0122E-10 | | -6.1185E-10 | |
| 20 | -3.9064E-7 | | +3.1260E-5 | |
| 21 | +9.1041E-9 | | -1.7107E-6 | |
| 22 | -1.6002E-10 | | +2.5974E-8 | |
| 23 | +7.988E-12 | | -2.5335E-10 | |
| 24 | | | +1.0405E-12 | |
| 30 | +1.100E-10 | | -9.7729E-9 | |
| 31 | +6.649E-12 | | +3.8504E-10 | |
| 32 | -3.389E-13 | | -2.3643E-12 | |

The Chen & Millero expression is based upon comprehensive observations on seawaters in the ranges $0 < T < 40^\circ$, $0 < S < 40$, $0 < P_b < 1000$. Some concern has been expressed, however, at the accuracy of the formula at pressures exceeding 100 bar.

10.3.1.6 DEL GROSSO (1974)

$V = C_{000} + DC_T + DC_S + DC_P + DC_{STP}$, where

$$C_{000} = 1402.392$$

$$DC_T = 0.501109398873E+1 * T - 0.550946843172E-1 * T^2 + 0.221535969240E-3 T^3$$

$$DC_S = 0.132952290781E+1 * S + 0.128955756844E-3 * S^2$$

$$DC_P = 0.156059257041 * P_k + 0.244998688441E-4 P_k^2 - 0.883392332513E-8 * P_k^3$$

$$DC_{STP} = -0.127562783426E-1 * T * S + 0.635191613389E-2 * T * P_k$$

$$+ 0.265484716608E-7 * T^2 * P_k^2 - 0.159349479045E-5 * T * P_k^2$$

$$+ 0.522116437235E-9 * T * P_k^3 - 0.438031096213E-6 * T^3 * P_k$$

$$- 0.161674495909E-8 * S^2 * P_k^2 + 0.968403156410E-4 * T^2 * S$$

$$+ 0.485639620015E-5 * T * S^2 * P_k - 0.340597039004E-3 * T * S * P_k$$

The formula is deemed to be valid only in the temperature and salinity ranges, and up to the pressures (bar), indicated in the matrix below:

| <i>S</i> | <i>T</i> (°C) | | | |
|----------|---------------|----------|-----------|-----------|
| | <i>0</i> | <i>5</i> | <i>10</i> | <i>15</i> |
| 33 | 1034 | 1034 | 275 | 69 |
| 34 | 1034 | 1034 | 207 | 207 |
| 35 | 1034 | 1034 | 414 | 207 |
| 36 | 1034 | 1034 | 275 | 69 |
| 38 | 69 | 69 | 414 | 414 |

10.3.1.7 MACKENZIE (1981)

Based upon widespread oceanographic measurements, the MacKenzie formula is:

$$\begin{aligned}
 V = & 1448.96 + 4.591 * T - 5.304E - 2 * T^2 + 2.374E - 4 * T^3 \\
 & + 1.340 * (S - 35) + 1.630E - 2 * D + 1.675E - 7 * D^2 \\
 & - 1.025E - 2 * T * (S - 35) - 7.139E - 13 * T * D^3
 \end{aligned}$$

and is stated to be valid for naturally occurring seawaters in the intervals indicated in the matrix below:

| P_k | $T (^{\circ}C)$ | S |
|-------|-----------------|-------|
| 0 | 0-30 | 30-40 |
| 50 | 0-20 | 32-40 |
| 100 | 0-14 | 32-34 |
| | 0-16 | 35-38 |
| | 10-16 | 39-40 |
| 200 | 0-12 | 32-36 |
| | 0-16 | 37 |
| | 8-16 | 38-39 |
| 500 | 0-5 | 33-36 |
| | 12-14 | 38-39 |
| 800 | 0-5 | 34-35 |

10.3.2 DISCUSSION

10.3.2.1 DEVELOPMENT OF FORMULAE

A useful overview of the history of seawater speed of sound measurements and formulae is provided by Dulshaw *et al.*

All formulae given above (and the majority of others referred to in the course of this study) were empirically derived from measurements of acoustic velocity of seawater samples whose temperature, salinity and pressure were measured in the oceans and/or varied in the laboratory. The Robertson equation is one of the few attempts to base the equations for the speed of sound on theoretical considerations alone.

The Wood formula, while in use even now, was considered as early as 1960 to be unreliable for the advancing technology and requirements of that era, and was superseded by the Wilson formula in 1961.

The recognition of defects in the experimental methods of Wilson, together with the adoption of the practical salinity scale and the international equation of state for seawater (EOS-80) resulted in the Wilson formula being superseded for oceanographic purposes by the Chen & Millero formula, which still represents the formal standard for oceanographic purposes.

The limitations of the Chen & Millero formula in turn were revealed by precise in situ observations of acoustic velocity with depth, and by the advent of tomographic methods to determine seawater physical properties along very large path-lengths (across oceans) and to great depths.

These observations have led in recent years to the realisation that the Chen & Millero formula has distinct limitations at high pressures, and that the Del Grosso equation may be more realistic for such specialist purposes. The wide validity range for salinity and temperature of the Chen & Millero formula is of value for measurements on the continental shelf, however. The quality of fit of the Del Grosso equation to the modern high-pressure data sets (and the corrections that should consequently be applied to the Del Grosso equation) is currently the subject of some debate.

10.3.2.2 COMPARISON OF FORMULAE

The Wood and Wilson formulae do not fit modern experimental and observational data well, and should no longer be used for precise computations. This probably is the result of improvements in observational and analytical techniques over the years, together with changes in computational methods of salinity and depth.

The remaining algorithms show fairly close agreement with one another, diverging as pressure increases.

The Chen & Millero formula is commonly accepted for oceanographic use, and was derived from measurements over a wide salinity, temperature and pressure range.

At high pressures (>100 bar), however, recent research suggests that the Del Grosso equation is more accurate, although this formula is valid only for a limited range of oceanic waters.

The Del Grosso formula has been used as a benchmark to appraise the accuracy of the other algorithms.

The following order of preference is suggested:

- i) Chen & Millero (only for water depths less than 1000m)
- ii) Del Grosso (only for water depths greater than 1000m)
- iii) MacKenzie (for rapid computations in oceanic waters to 8000m water depth)
- iv) Medwin (for rapid computations in oceanic waters to 1000m water depth)

The Medwin and Wilson (simplified) formulae diverge considerably from the remaining algorithms at temperatures greater than 20°C. This is expected from two simple formulae lacking higher order temperature terms.

There may be some advantages in using the MacKenzie and Medwin formulae where depth is known, and where the computation of pressure for inclusion in the Chen & Millero or Del Grosso formulae would become unnecessarily onerous. The user should be made aware, however, of the limited range of conditions of temperature, salinity and pressure over which these formulae are valid.

10.3.2.3 THE PRESSURE/DEPTH ALGORITHM

An accurate expression for computing pressure from depth (and *vice versa*) may be desirable:

- a) for its own sake, to enable precise pressure and depth computations to be made for a variety of purposes; and
- b) to enable precise speed of sound computations to be made.

When using speed of sound algorithms with a pressure term (Chen & Millero, Del Grosso), the water pressure can be measured directly, estimated from a known depth and inversion of the UNESCO pressure/depth algorithm (possibly based on a carefully calibrated conductivity/temperature/depth cast), or calculated from standard tables. According to Saunders and Fofonoff, who were the originators of the basic method adopted in the UNESCO formula, these estimates should be carried out at 5 bar pressure intervals near the surface and at 200 bar intervals for greater depths.

When using speed of sound formulae with a depth term (MacKenzie or Medwin), the depth may be estimated or measured by some independent means; or computed from a pressure measurement and a conductivity/temperature depth cast. It is more likely, however, that these methods would not be used for precise purposes; they are in any case valid only for oceanic waters in which the errors in the estimation of depth, introduced through ignoring the geopotential anomaly, would not be excessive.

10.3.3 CONCLUSIONS

1. It is recommended that use of the Wood and Wilson formulae be discontinued for precise purposes, as they do not provide good agreement with modern data sets and computational methods of salinity and depth.
2. It is of crucial importance to ensure that the formulae (of whatever origin) are used only for observations made within the ranges of temperature, salinity and pressure for which each expression is deemed valid.
3. It is recommended that the Chen and Millero formula be used for seawaters on the continental shelf. This incorporates a pressure term which should be measured directly; evaluated from a known depth using the full UNESCO formula and data obtained either from oceanographic tables or from a conductivity/temperature/depth cast; or the error in using the simplified UNESCO formula deliberately accepted.
4. In deep ocean waters, the Del Grosso formula is currently favoured, especially for long path-lengths. This also uses a pressure term.
5. Where rapid computations are necessary, or where the depth is known (but not pressure), the simple MacKenzie (9 terms) and Medwin (5 terms) formulations may prove of value. These expressions are strictly valid only for normal oceanic waters. Where depth is computed from pressure, the simplified UNESCO equation for the pressure/depth relationship could be used without introducing significant error.
6. Incorporation of the full UNESCO pressure/depth algorithm (incorporating the geopotential anomaly) would be a useful addition to any software package, although there may be little discernible benefit to the accuracy of the speed of sound computations. The complete formula would, however, enable a full suite of precise applications to be available for use worldwide.