



Directional Acoustic Transponder (DAT) Manual

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Abstract

A description of the operation and setup parameters for the Directional Acoustic Transponder (DAT) is given. General operating parameters and setup for the Ocean Server OS5000 compass are also covered. This applies to DAT software version 3.8.0 on the Benthos 4th generation ATM-88X OEM board set.

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1 Description

This document covers the operation of setup parameters for the Directional Acoustic Transponder (DAT). The DAT is essentially the same as a standard ATM-88X modem with the added ability to determine the direction from which a message arrived. This information is made available in response to a range request to a remote non-DAT unit, or when a DAT is queried for range by another modem.

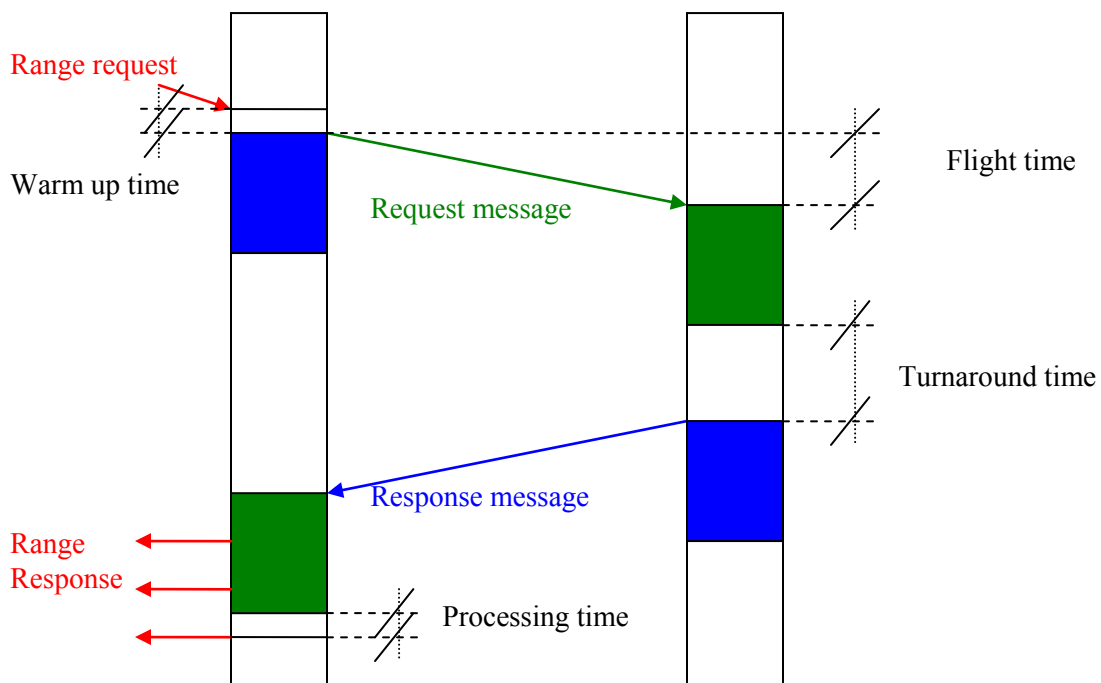


Figure 1: Timing diagram for ranging transaction

1.1 Ranging transaction

The full ranging transaction between two modems is illustrated in Figure 1. It starts with a request via the serial port of one. This causes the local modem to transmit an acoustic message. The remote modem hears this and replies after a fixed period of time. When the local modem hears the reply, it can then deduce the distance between the two and send the result back out the serial port.

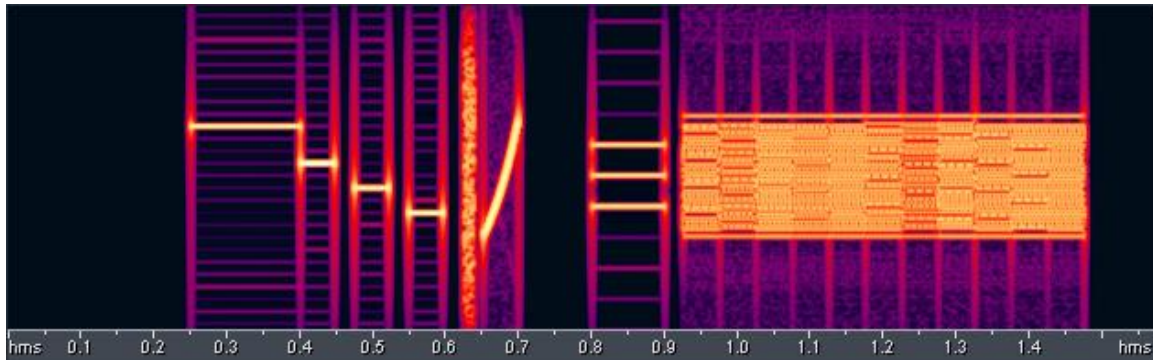


Figure 2: Make up of acoustic packet

The acoustic message as illustrated in Figure 2 consists of 5 sections:

1. 4 wake up tones
2. A noise burst for presetting the AGC
3. An chirp for timing
4. 3 100ms tones
5. An MFSK header packet

In normal operation, the wakeup tones are always sent with the ranging transaction, but in the DAT, we have removed them to shorten the message length, and thus increase the maximum repetition rate. The removal of these tones saves 375ms from each message and 750ms from a two way transaction.

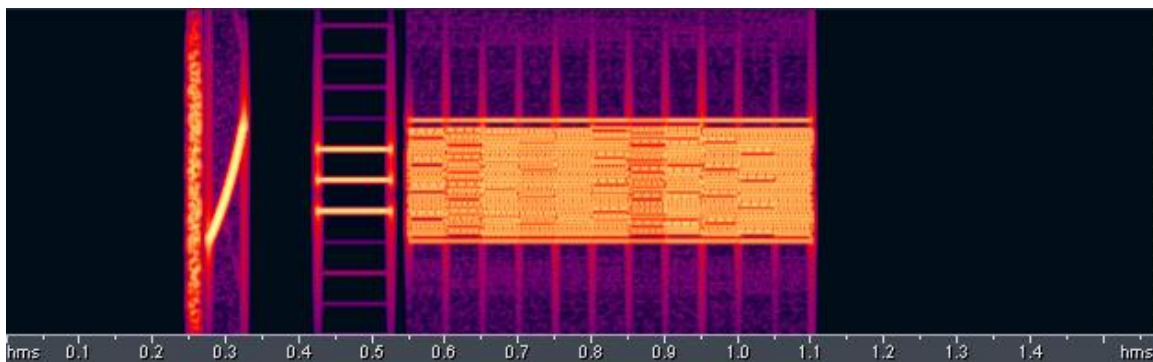


Figure 3: Acoustic packet with wakeup tones removed

1.2 Time measurement

The modem has the capability to transmit only on a 640Hz timing granularity, but can measure a reception to a 10240Hz timing granularity.

1.2.1 Departure time

The local modem schedules a departure time for the request message that will be on the next available transmit slot 250ms after the reception of the serial command. The 250ms is the warm-up time that the transmitter circuit requires to get the high voltage circuits stabilized and ready for transmission. The reported time for a transmission is the time the first part of the sound is in the water, so either the first wakeup tone or the AGC set noise burst.

1.2.2 Reception time

On the remote side, the response is scheduled to go out 1.6 seconds after the reception of the chirp in the request message. Since the outgoing time resolution is less than the transmit time resolution, an offset number in 10240Hz units is sent back as part of the reply so that it may be accounted for in the total turn around time. The reported reception time is the start of the chirp.

1.2.3 Range calculation

The range is calculated from the measured time between the two messages and the known turn around time (Eqn. 1).

$$R = c \cdot \frac{T_{RX} - T_{TX} + T_{offset} - T_{TAT}}{2} \quad \text{Equation 1}$$

Since we have to wait for the packet to be decoded before the T_{offset} number is available, it is not possible to report the accurate range until the entire message is received, 825ms after the reception of the chirp in the reply. The timestamp reported in the MMP header notification message is $T_{RX} + T_{offset}$.

1.2.4 Validity times

If the DAT and the querying modem are moving relative to one another, it may be useful to know exactly the time at which the Range and Bearing values were valid.

The bearing reported is the average bearing over the duration of the chirp received at the DAT. It can be considered to be a valid representation of the bearing at the mid-point of the chirp, whose time is the start of transmission, plus the duration of the AGC set noise burst and following gap (25ms), plus the one way flight time, and half way into the chirp (25ms)

$$T_{bearing} = T_{TX} + T_{flight} + 50ms \quad \text{Equation 2}$$

The range is calculated from the start of request chirp to the start of response chirp so is the start of transmission, plus the AGC set to the time of reception.

$$T_{range} = \frac{T_{TX} + 25ms + T_{RX}}{2} \quad \text{Equation 3}$$

1.3 Bearing calculation

The bearing calculation on the DAT is based on the chirp in the message header. The bearing information is sent in the return header of a range response message so it is available to the local modem at the same time as the full range information.

1.4 Transducer orientation

The standard definition of the sound arrival angles as calculated by the DAT transducer are shown in Figure 4. The orientation is with the transducer facing downward with respect to the plane of the compass.

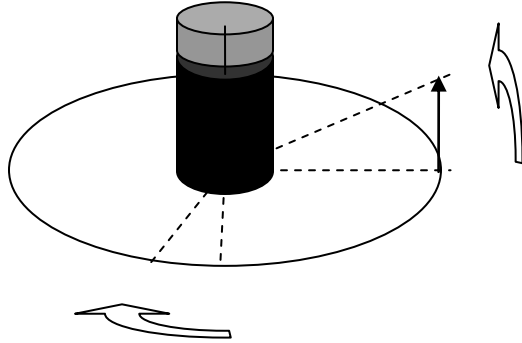


Figure 4: Positive angle directions

1.4.1 Rotation

If the transducer is mounted such that the reference mark is not forward relative to the platform, a rotation value must be applied. This value is such that a transponder directly ahead of the platform will return a bearing of zero degrees.

The stored **@rotation** value is subtracted from the measured bearings to give the corrected result. No elevation correction value is provided for.

1.4.2 Orientation

The angle directions will change in the alternate orientation where the transducer is facing up. First the transducer is rotated from the view in Figure 4 to that in Figure 5, and then we redraw to have the same viewpoint as in Figure 4.

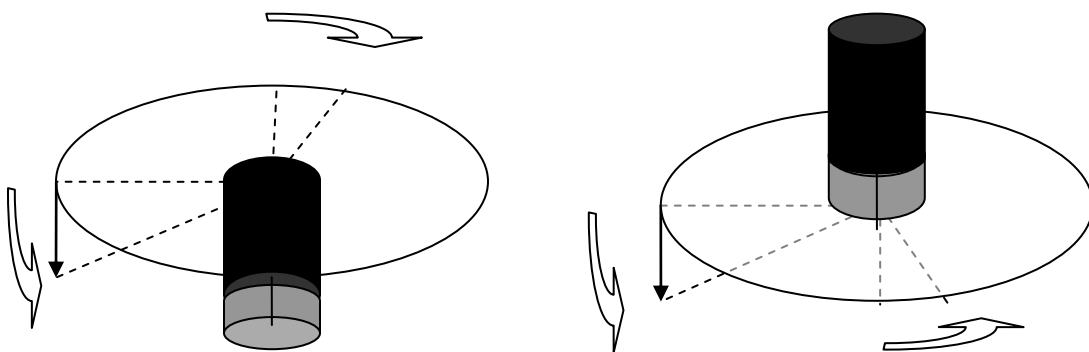


Figure 5: Transducer in 'up' orientation

To restore the meaning of the angles it is necessary to negate both the azimuth and elevation as shown in Figure 6.

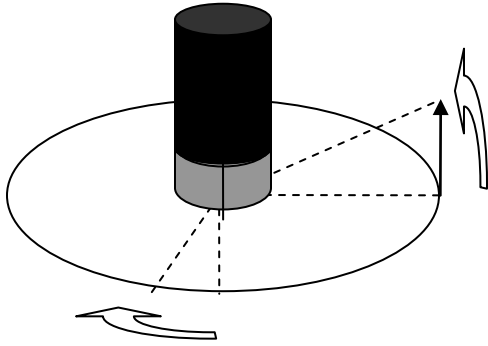


Figure 6: Both angles negated

1.5 Compass corrections

Compass corrections cover both pitch and roll and magnetic heading corrections. In order to perform the calculations it is necessary to convert Azimuth ϕ and Elevation θ to a vector representation.

$$v = \begin{bmatrix} \cos(\theta) \cdot \cos(\phi) \\ \cos(\theta) \cdot \sin(\phi) \\ \sin(\theta) \end{bmatrix} \quad \text{Equation 4}$$

1.5.1 Pitch and Roll

Pitch ψ is relative to the horizon and roll ρ is relative to the fore and aft axis of the DAT platform. Roll must be taken out first using Equation 5 followed by pitch using Equation 6.

$$v' = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \rho & \sin \rho \\ 0 & -\sin \rho & \cos \rho \end{bmatrix} \cdot v \quad \text{Equation 5}$$

$$v'' = \begin{bmatrix} \cos \psi & 0 & -\sin \psi \\ 0 & 1 & 0 \\ \sin \psi & 0 & \cos \psi \end{bmatrix} \cdot v' \quad \text{Equation 6}$$

Now we convert back to the polar representation using Equations 7 and 8.

$$\phi' = \tan^{-1} \left(\frac{v''_y}{v''_x} \right) \quad \text{Equation 7}$$

$$\theta' = \tan^{-1} \left(\frac{v''_z}{\sqrt{v''_x^2 + v''_y^2}} \right) \quad \text{Equation 8}$$

1.5.2 Compass heading

The heading from a compass device is usually given relative to the horizon, so the heading value is added to the bearing at the last stage to give the compass relative bearing.

1.5.3 Overall tilt

A value for the overall tilt of the platform can be derived from the pitch and roll angles. This angle represents how far off vertical the mast of the ship would be.

$$\alpha = \cos^{-1}(\cos(\psi) \cdot \cos(\rho))$$

Equation 9

1.6 Order of application of rotations

The rotations are applied in a specific order and each stage is available in the DAT debug output as listed in Table 2 in Section 3.2.3. At each stage the values are an azimuth and elevation pair.

1. The direct output from the transducer is available as the **RAW** field
2. The RAW values have the calibration applied and are available as the **CAL** field. This represents the Transducer-Relative bearing.
3. The **@rotation** values is applied
4. The **@orientation** is applied and the values are available as the **ROT** output. This represents the Vehicle-Relative bearing
5. The compass readings are applied in the order, roll, pitch, heading and are available as the **BRG** output. This is the bearing in Absolute World terms and is the value normally reported.

2 Operation

In general, the DAT will report bearing information along with range information on the serial port following a range request to a remote modem. The bearings will also be returned to a modem querying the DAT for range. The two numbers given are the bearing clockwise from North and the elevation relative to the horizon with positive being up.

2.1 Local operation

```
user:1>atr0
Bearing: 52, 35
Range 3 to 2 : 20.0 m
```

Figure 7: DAT ranging on a remote modem

There is additional information available about bearings on any received packet via the direct output selected by the **@DatDebug** configuration parameter (see section 3.2.3).

2.2 Remote operation

```
user:1>atr2
Bearing: 232, -35
Range 3 to 2 : 20.0 m
```

Figure 8: Modem ranging on a remote DAT

In addition to the standard **atr** command, there are three additional variants the can give alternate angular information in addition to the range. In all cases, the modem address must be specified, and all angles are returned with a precision of one degree.

	Response	Description	MMP
atr#	Bearing: 232, -35	Bearing with respect to magnetic North, and elevation	0
attrr#	Azimuth: 38, 27	Relative bearing with respect to the body of the DAT	1
atrc#	Compass: 194, 2	Reading on the Compass plus tilt from horizontal	2
atrt#	Tilt : 1, -2	Pitch and Roll readings on the compass	3
atrah#	Bearing 231.8	Absolute bearing, high precision	4
atrai#	Inclination -35.1	Absolute inclination, high precision	5
attrrh#	Azimuth 38.1	relative azimuth, high precision	6
atrre#	Elevation 27.4	Relative elevation, high precision	7
atrch#	Compass 194.1	Compass bearing, high precision	8
atrcp#	Pitch 1.0	Compass Pitch, high precision	9
atrcr#	Roll -1.9	Compass Roll, high precision	10

Table 1 - Range commands

2.3 Fast turn around

To specify the very fast turn around time of 1.1 seconds between the start of the received chirp and the beginning the response, the letter 'f' should be added to the end of the **atr** commands before the address. This applies to any of the variants in Table 1.

```
user:1>atrff2
```

Figure 9: Ranging with a very fast turn around

3 Configuration system

The DAT software uses the Benthos Command Line for Acoustic Modem Shell (Clam shell) and configuration system. This is broken down into groupings of parameters covering related functions. The sections of unique interest to the DAT are **dat** and **gps**, but all of the other standard modem configurations still apply.

3.1.1 Reading a parameter

Any parameter may be read using the @ symbol followed by the parameter name. Pressing the <TAB> key after the @ symbol will give you a list of parameter names that match what you have typed so far, and will complete the word for you once it becomes unique.

```
user:5>@rotation
116
user:6>
```

Figure 10: Reading a configuration parameter

3.1.2 Setting a parameter

Any parameter may be read using the @ symbol followed by the parameter name, an equals sign and the value. Pressing the <TAB> key after the equals will give you a list of possible values.

```
user:6>@rotation=116
Rotation      | 116
user:7>
```

Figure 11: Setting a configuration parameter

3.2 DAT

The Directional Acoustic Transponder (DAT) section stores values related to the operation of the directional receiver.

```
user:3>@dat
```

S	Dat Params	Value	Range
	PreGain	0	-89..89
	Rotation	32.0	0.0..359.9
	DatVerbose	7	0..65535
	RXonDAT	Ena	Ena, Dis
	WrapRange	0	0..30000
	Orientation	1 (down)	0 (up), 1 (down)
	PhaseA	0.000	radians
	PhaseB	0.000	radians
	PhaseC	0.000	radians
	PhaseD	0.000	radians

Figure 12: DAT configuration section.

3.2.1 PreGain

The PreGain parameter allows an offset between the gain applied to main channel and the DAT hydrophones. The AGC system is driven by the levels on the channel selected by the RXonDAT parameter. The gains are structured so that levels on one should correspond to the other, but physical configuration, especially in a split transducer setup may require a gain offset.

3.2.2 Rotation

The Rotation parameter allows you to define the difference bearing between the zero position of the transducer and the center line of the vehicle to which it is mounted.

3.2.3 DatVerbose

The DAT generates a report for every chirp received, regardless of whether it followed by a valid message, or if that message was addressed to the DAT. The detail shown depends on the sum of a series of bit values in **@DatVerbose**. These bit values and their meanings are summarized in Table 2. All reports are preceded by a time stamp to the 10th of a millisecond.

Output	Description	Bit values
15:10:27.4416,	timestamp of reception event	
GPS=41.123,-71.964	Lat/Long location	0x8000
LVL= 274, 220, 270, 307,	peak ADC level on each of 4 hydrophones	0x2000
AGC= 40,	Automatic Gain Control setting	0x0020
IDX=32 0.50, 0.430,	index of peak in buffer, quadratic fit and phase of peak	0x0010
PKS= 12, 7, 2, 0,	Peak values from matched filter	0x0080
PHS= -2.58, -4.30, -2.98,	Phases on the horizontal phones with respect to top	0x4000
v = 0.951,	Vector magnitude	0x0040
RAW= 334.14, 14.9,	Bearing and Elevation from DAT	0x0100
CAL= 333.4, 13.6,	Bearing and Elevation calibrated	0x0200
ROT= 26.6, -13.6	Bearing rotated to body of platform	0x0800
CMP= 201.2, 0.4, 0.0,	compass Heading, Pitch and Roll	0x0400
15:10:27.4416,	timestamp of compass capture	
BRG= 227.8, 13.6,	Bearing and Elevation relative to compass	0x0001
SPD= 0.0,	speed by Doppler shift	0x0002
RNG= 0.0,	range (one-way mode only)	0x0004

Table 2 - Available output fields

The values in the BRG fields are those reported as absolute bearing by the **atr#** command. The values reported as relative bearings in the **attrr#** command are from the ROT values and give the fully calibrated and aligned bearing and elevation. These numbers are translated from the CAL values using the **@rotation** and **@orientation** values.

3.2.4 RXonDAT

The **RXonDAT** parameter controls which hydrophone is used for the main communication reception. Enabling set the communications to be received through the DAT hydrophones. This can have an impact for ranging results if separate communication and DAT transducers are used.

3.2.5 Orientation

The **Orientation** parameter sets whether the transducer is on top of the platform facing *up* or on the bottom facing *down*.

3.2.6 Phase

The 4 **phase** parameters hold a phase offset for each channel. The offset accounts for any group delay in the receive channel and is added to the measured phase for each phone prior to the angle calculations being performed

3.3 NAV

The Navigation (NAV) section allows the storage of compass and global positioning system data. It is automatically updated when a compass or GPS unit is attached to a serial port and the **gpsd** daemon is running.

```
user:4>@nav
```

S Nav Params	Value	Range
Latitude	41.638246	degrees
Longitude	-70.609376	degrees
GpsAlt	0.0	WGS84 altitude in meters
Altitude	0.00	meters above sea floor
Depth	0.0	meters below sea level
Compass	93.1	0 to 359.9 degrees
Pitch	2.0	-90.0 to 90.0 degrees
Roll	-1.3	-180.0 to 180.0 degrees
SpeedOfSound	1500.0	speed of sound in meters per second

Figure 13: Nav configuration section.

3.3.1 Latitude, Longitude and GpsAlt

These parameters are read from the GPGLA or GPGGA NMEA strings. They represent the location of the DAT. These values can be automatically set by running the **gpsd** command on the modem then connecting a GPS unit with NMEA output. If no GPS unit is present, as would be the case when the unit is underwater, these values can be set to the results of a position survey for the unit.

3.3.2 Altitude and Depth

The altitude data representing the height above the sea floor may be read from a Benthos PSA916 Altimeter. The **gpsd** command will also provide this translation. Depth information may be derived from a pressure reading and stored as depth below the water surface.

3.3.3 Compass, Pitch and Roll

The attitude parameters are read from the Ocean Server OS5000 compass output and stored for external reference. An external application can set these directly and the DAT system will use them in its calculations.

4 Commands

4.1 Dat

The **dat** command is a shortcut for configuring the **@datverbose** parameter. The command on its own will print out an example of the output, but with invalid data in it.

With the additional argument of **off** all additional output will be suppressed.

With the additional argument of **norm** the output will show the resulting compass-corrected bearings:

```
19:47:13.4147, BRG= 120.3,-67, SPD=-00.5
```

With additional argument of **cal** the output will show signal level information on the DAT hydrophones and the uncorrected bearings

```
19:48:19.4180, LVL= 4592, 4929, 4786, 7827, RAW= 235.77, 9.4
```

Any field can be turned on or off individually by using its name preceded by a Plus or minus. For example to turn off the RAW fields, the command would be **dat -raw**.

The default configuration is to have the additional reports off, so that the only time a bearing is reported is when specifically asked for in response to a range command. With the reports on, information about all messages will be printed, regardless of their type or who they were addressed to.

4.2 Gpsd

The **gpsd** command starts a daemon process that intercepts input from a serial port and parses it for compass or NMEA data. The information that is read will be stored in the **@gps** configuration section.

The serial port read will be the standard input port of the shell that is running the daemon. A shell can be configured to run this at bootup by having the **gpsd** command in the shell startup script. This script file is easily constructed on the modem by following the commands shown in Figure 14.

```
user:12>echo gpsd > /ffs/.clamshrc2
OK
user:13>reboot
```

Figure 14: Setting up gpsd to run on port 2.

4.3 Compass

The **compass** command provides a pass-through to a device connected to the other uart which is running **gpsd**. It allows a user to monitor the activity or to access setup commands for the device.

All keystrokes are passed directly to the port running **gpsd**. The command is terminated by <ctrl-D>

4.4 Remote commands

Any command that can be run locally on a DAT or any other modem can be invoked remotely using the **atec** command. Anything more than a single word after the colon should be enclosed in double quotes otherwise only the first word will be sent. See Figure 15 for an example of how to read a remote configuration parameter.

```
user:5>atec2:"@rotation"  
  
user:6>116
```

Figure 15: Reading a remote configuration parameter

Note that the response comes in as a data packet so may appear after the local prompt.

5 Compass configuration

There are two critical serial port setups for the serial port setup for the compass that must be in place for proper operation. The compass is normally assumed to be attached to port 2 and should have a **gpsd** process running on that port. For setup instructions refer to section 4.2.

The Ocean Server compass comes from the factory with a baud rate of 19200. The uart1 baud rate must be set to match this so that communications can be established. **@p2Baud=19200**.

Running the **compass** command then pressing <Escape> followed by <?> will present you with the OS5000 setup menu. Pressing <Space> will restart data mode. Pressing <Escape> followed by will give you the options for the serial baud rate. Option 6 will select 115200 baud, but this will not take effect until the next power cycle. Exit the compass command with <ctrl-D> then set uart1 serial baud rate to 115200 using **@p2Baud=115200**.

These are the other settings for the serial port:

1. local echo must be turned off to avoid sending the compasses output back to itself. This is achieved by disabling the p2EchoChar parameter with **@p2EchoChar=Dis**.
2. For the DAT system to enter sleep mode, it must be configured to ignore the serial input on uart1. This is achieved by enabling the p2NoSleep parameter with **@p2NoSleep=Ena**.

Finally store the setting using **@store**, then cycle power to bring everything up at the new settings. Verify the compass is operating by running the compass command again.

A summary of the serial port settings is shown in Figure 16.

```

user:3>@Serial.

```

S	Serial Params	Value	Range
3	P1Baud	9600	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
3	P1EchoChar	Ena	Ena, Dis
11	P1FlowCtl	0 (None)	0 (None), 1 (SW), 2 (HW), 3 (HW-LP)
	P1Mode	0 (Cooked)	0 (Cooked), 1 (Raw)
3	P1Protocol	0 (RS-232)	0 (RS-232), 1 (RS-422)
3	P1StripB7	Dis	Ena, Dis
	P1NoSleep	Dis	Ena, Dis
	P2Baud	19200	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
	P2EchoChar	Dis	Ena, Dis
	P2FlowCtl	0 (None)	0 (None), 1 (SW)
	P2Mode	1 (Raw)	0 (Cooked), 1 (Raw)
	P2Protocol	1 (CMOS)	0 (RS-232), 1 (CMOS)
	P2StripB7	Dis	Ena, Dis
	P2NoSleep	Ena	Ena, Dis

Figure 16: Serial port settings

6 Calibrations

The DAT calibration is unique for every transducer. A file that contains the correct calibration data for the transducer in use must be loaded into the modem. The calibration will be read at boot time from the file `/ffs/datcal`.

6.1 Upload procedure

The calibration file will be supplied with each transducer. It must be loaded onto the board set that it is to be used with using a terminal program. The file is loaded using a terminal program with the x-modem protocol. Type `rx /ffs/datcal` then follow your terminal programs instructions for sending a file via x-modem. For the file to be read, the modem must either be rebooted or the **dat load** command issued.

```

user:12>rx /ffs/datcal

rz: ready to receive /ffs/datcal

OK
User:13>

```

Figure 17: Sending the calibration file to the modem.

6.2 Checking serial number

The serial number contained in the `/ffs/datcal` file is available in the `$datserial` system variable. This should match the serial number printed on the transducer.

```

user:5>echo $datserial
12345
user6:>

```

Figure 18: Reading the DAT transducer serial number

7 Modem Management Protocol (MMP) messages.

All documentation up to this point has referred to Command Line for Acoustic Modem Shell (Clamsh) commands. This section covers the binary machine MMP interface. For a full description of the MMP protocol, refer to the MMP manual.

7.1 Sending Telemetry

A data transmission from any modem is initiated using the MMP message shown in Table 3. The receiving side will produce the data message shown in Table 8 but some of the other notification messages on the receiving side will vary depending on the platform.

sentinel		@	0x40	
XID		0	0x00	
Operation type		'x' execute	0x78	
Parameter Groups = 1			0x01	
	Subsystem	STD		0x01
	Field	REMOTE_SENDDATA		0x07
	Length	10 bytes		0x00
				0x0A
	Payload	To ID	2	0x00
				0x02
		Length	6 bytes	0x00
				0x06
		Data	h e l l o /r	0x68
				0x65
				0x6C
				0x6C
				0x6F
				0x0D

Table 3 - Send Telemetry message

7.2 Telemetry received on DAT

The MMP messages produced in response to a telemetry message being received are shown Table 4 to Table 8. The message in Table 7 gives that bearing information for the received message. You may be able to ignore all but the last one which contains the actual received data

The DAT will also monitor any other transactions in the water and produce the messages in Table 4 to Table 7.

sentinel		@		0x40
XID		0		0x00
Operation type		'n' notify		0x6E
Parameter Groups = 1				0x01
	Subsystem	DATA		0x04
	Field	TIMESTAMP		0x07
	Length	10 bytes		0x00
				0x0A
	Payload	Type	RX	0x00
				0x01
		Hours	15	0x00
				0x0F
		Minutes	48	0x00
				0x30
		Seconds	50	0x00
				0x32
		1/10ms	0.1847	0x07
				0x37

Table 4 - RX timestamp message

sentinel		@		0x40
XID		0		0x00
Operation type		'n' notify		0x6E
Parameter Groups = 1				0x01
	Subsystem	DATA		0x04
	Field	DOPPLER		0x08
	Length	2 bytes		0x00
				0x02
	Payload	Doppler rate	0	0x00
				0x00

Table 5 - Doppler speed notification

@ sentinel				0x40
XID		0		0x00
Operation type		'n' notify		0x6E
Parameter Groups = 1				0x01
	Subsystem	DATA		0x04
	Field	REMOTE_HEADER		0x06
	Length	8 bytes		0x00
				0x08
	Payload	, DATA	L2CMD_875D	0x0F
				MODULATION
				0x07
		Length	6 bytes	0x06
				0x00
		To modem	ID 2	0x02
		From modem	ID 7	0x07
		CRC	PASS	0x00

Table 6 - Decoded header notification

@ sentinel			0x40
XID	0		0x00
Operation type	'n' notify		0x6E
Parameter Groups = 1			0x01
	Subsystem	DATA	0x04
	Field	DIRECTIONAL	0x09
	Length	14 bytes	0x00
			0x0E
	Payload	Raw bear	44.5
			0x01
			0xBD
		Raw Elev	25.5
			0x00
			0xFF
		Cal Bear	176.5
			0x06
			0xE5
		Cal Elev	32.2
			0x01
			0x42
		Bearing	315.4
			0x0C
			0x52
		Elevation	32.8
			0x01
			0x48
		Range	not calculated
			0x00
			0x00

Table 7 - Additional Bearing Information

flush			0x00
@ sentinel			0x40
XID	0		0x00
Operation type	'n' notify		0x6E
Parameter Groups = 1			0x01
	Subsystem	DATA	0x04
	Field	REMOTE DATA	0x01
	Length	10 bytes	0x00
			0x0A
	Payload	From	ID 7
			0x00
			0x07
		Length	6 bytes
			0x00
			0x06
		Data	h
			e
			l
			l
			o
			/r
			0x68
			0x65
			0x6C
			0x6C
			0x6F
			0x0D

Table 8 - Message received is "hello"

7.3 Range transactions

A range request is initiated on either the deck box or the DAT using the same message type. A RANGE message may also be used, but the BEARING format allows you to specify absolute or relative bearing angles. See also sections 12.5 and 12.6 of the MMP manual.

@ sentinel				0x40
XID	51			0x33
Operation type	'x' execute			0x78
Parameter Groups = 1				0x01
	Subsystem	RANGE/RELEASE		0x02
	Field	BEARING		0x09
	Length	4 bytes		0x00
				0x04
	Payload	To modem	ID 2	0x00
				0x02
		Absolute bearing	10, -1	0x07
				0x61
		Turn around	2, very fast	0x00
				0x02

Table 9 - Bearing request message

7.4 Range report on UDB or CM

There are 5 messages generated on a deck box or Compact modem in response to a bearing request. These are listed in order below. Most of the messages are the same format as show for the telemetry exchanges, but the additional command result message is detailed in Table 10.

1. **DATA::TIMESTAMP** Time stamp of the request transmission
2. **DATA::TIMESTAMP** Time stamp of the chirp detect for the response
3. **DATA::MMP_DATA_FLD_DOPPLER** Doppler notification in Hz
4. **DATA::MMP_DATA_FLD_REMOTE_HEADER** A full dump of the received packet header giving:
 - Command Type
 - Source & destination ID
5. **IFACE::CMDRESULT::ENDED** The extracted bearing result
 - Range between modems
 - Roundtrip time
 - Azimuth and elevation

@ sentinel				0x40
XID		51		0x33
Operation type		'n' notify		0x6E
Parameter Groups = 1				0x01
	Subsystem	IFACE		0x00
	Field	CMDRESULT		0x03
	Length	12 bytes		0x00
				0x0C
	Payload	Subsystem	RANGE/RELEASE	0x02
		Command	BEARING	0x0A
		Result	DATA	0x00
				0x04
		Range	1.2m	0x00
				0x00
				0x00
				0x0C
		Round Trip Time	1.6ms	0x00
				0x00
				0x00
				0x10
		Doppler	0 m/s	0x00
				0x00
				0x00
				0x00
		Bearing	147.0	0x05
				0xBE
		Elevation	-37.0	0xFE
				0x8E

Table 10 - Bearing response message