INNOVATUM REFERENCE MANUALS

Section 4-2

Smartrak Operations

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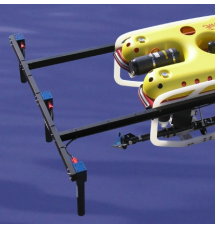

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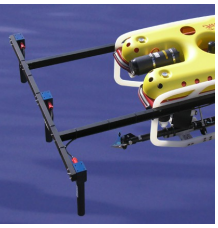

SUPPORT INFORMATION

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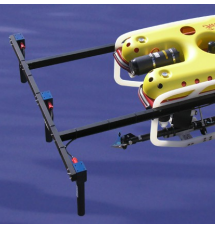

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SYMBOLS

The following symbols are used within these manuals

Important Note: items of particular importance.

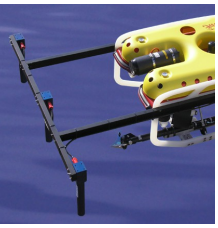
Caution: items where care is required.

Danger: items where a hazard may exist.

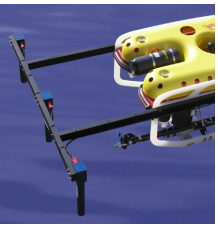
ESD Hazard: items where ESD precautions may be required.

ERRORS and OMISSIONS

Innovatum will be pleased if errors or omissions are notified to our offices in **Bury St Edmunds.**



Date	Issue	Amendment	Section	Page
1 Mar 11	1	Initial Issue	All	
23 Nov 12	2	Review	All	
15 Mar 13	3	Change to use of grads for AC Tone tracking		



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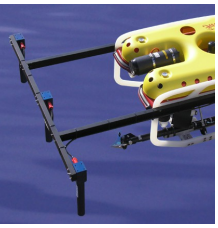
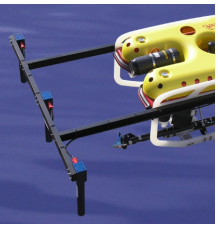
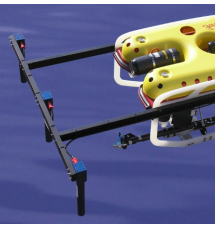






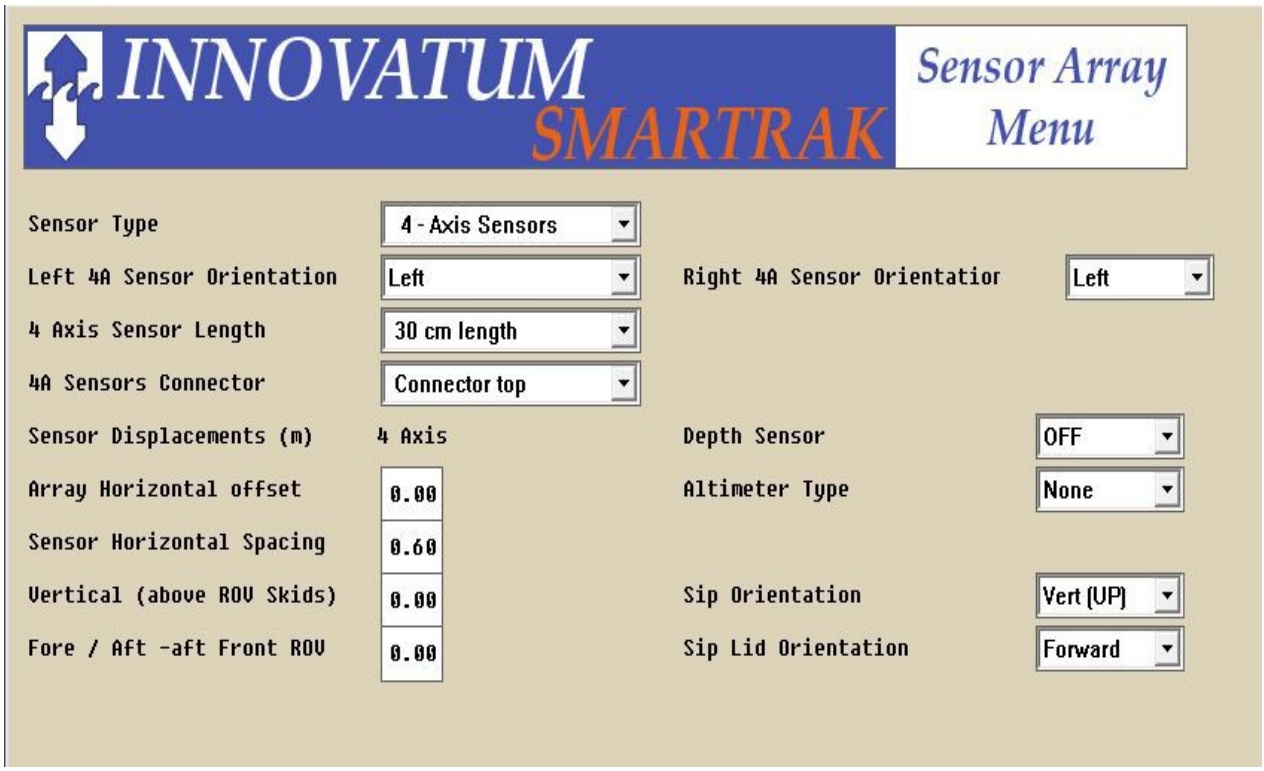
4-2.1 SYSTEM TURN-ON AND SET UP

4-2.1.1 VEHICLE POWER UP

After completing the wiring of the SUBCONN 8-pin connector between the vehicle and the SMARTRAK SIP according to the instructions given in Section 4-1.5.1, use a voltmeter to check the 24 volt power at the SUBCONN connector to the SIP (+24 v.d.c. on pin 5 and power common on pin 6). After verifying that the power connection is correct, turn off the 24 volt power from the vehicle and connect the SUBCONN connector to the SIP, then turn on vehicle 24 volt power again.

4-2.1.2 "PC" POWER UP AND SYSTEM LOAD

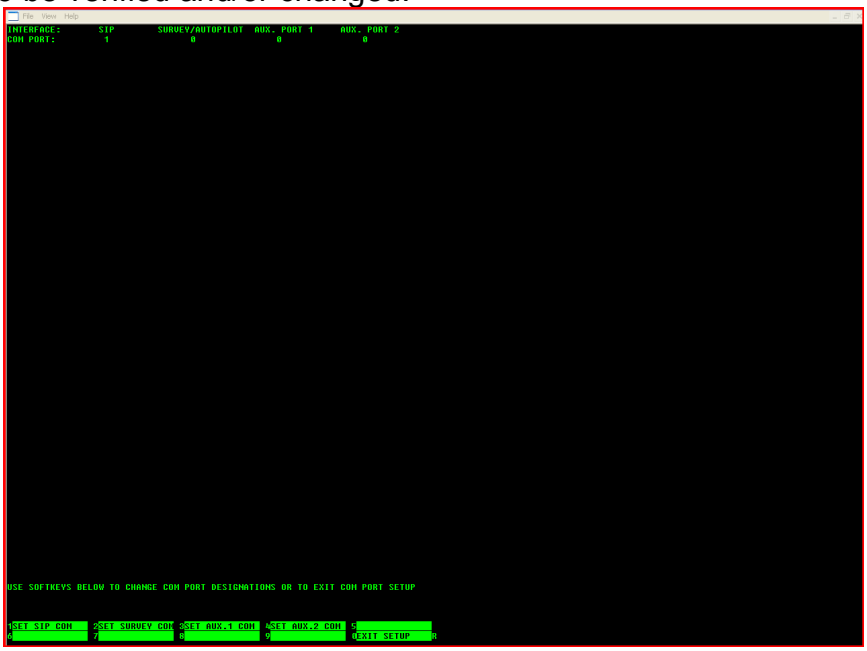
Set up PC in a suitable location. Plug in the USB to RS232 converter and (if necessary) the USB to RS485 converter. Connect power supply and switch on the PC. After the program has finished loading, the "Sensor Array Menu" will be displayed



4-2.1.3 COMM PORTS

If the comm ports are not set up correctly the system WILL NOT RUN.

To check and/or set up the comm ports, click on the “Options” MENU at the top left of the screen. A program called “COMPORTS” will now run, enabling the existing port settings to be verified and/or changed.

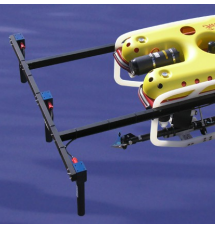


After input of the correct ports for **ALL** ports press the EXIT SETUP soft key. The following message will appear:

COM PORT SETUP FINISHED. CLOSE HTBasic AND THEN REOPEN HTBasic.

Click on “ File/Exit” on the HTBasic command line at the top of the screen. The program will then exit to WINDOWS, and correctly register the serial ports. Selecting HTBasic with the mouse will then restart the ULTRA program.

Failure to allocate a number to ALL serial ports will result in programme errors or **THE PROGRAMME NOT RUNNING**



4-2.1.4 MENUS

The SMARTRAK System program will display three system "MENUS" in succession.

Examples of menus are shown on the following pages.

The “SENSOR ARRAY MENU” appears first. Changes to this menu will only normally be required during a mobilisation or after a configuration change.

SENSOR ARRAY MENU - EXPLANATION OF ITEMS.

SENSOR TYPE:

SMARTRAK can accept the following sensor types:

“GRADS” This is a combination of 4 fluxgate gradiometers arranged as a single axis magnetic gradiometer. 2 fluxgates are utilised for the gradiometer function in the z axis (vertical), and the other two fluxgates are mounted, one in “x” and one in “y”. These are used to correct internal calibration errors in the sensor. The grads are used for Passive Magnetic, D.C. current and magnetic heading sensing. Gradiometer sensors are also be used for AC (Tone) sensing

“TRIAXIAL SENSORS” This is a fluxgate triaxial sensor, used for providing magnetic heading information and A.C. mode signals only. ***TRIAXIAL SENSORS ARE ONLY USED IN SPECIAL APPLICATIONS, AND SHOULD NOT NORMALLY BE SELECTED.***

The drop down box allows setting up of each type of installed sensors.

When “Triaxial Sensor” is selected, four further boxes appear for “TRIAXIAL SENSOR ORIENTATION” allowing the user to select the orientation of each triaxial sensor.

LEFT 4A ORIENTATION:

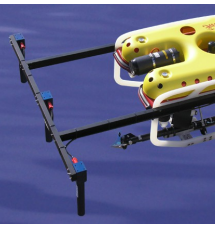
Use this box to set the orientation of the LEFT fluxgate gradiometer sensor. The direction is that which the connector points to. This information is used to measure magnetic heading correctly. Only **“Cable to LEFT”** and **“Cable to RIGHT”** are allowed.

RIGHT 4A ORIENTATION:

Use this box to set the orientation of the RIGHT fluxgate gradiometer sensor. The direction is that which the connector points to. This information is used to measure magnetic heading correctly. Only **“Cable to LEFT”** and **“Cable to RIGHT”** are allowed. The orientation of any remaining grads may set for best cable routing.

GRAD LENGTH:

Either 30 cm (normal) or 60 cm sensors (higher sensitivity) units may be used. All must be of the same type. Only the normal length grads may be used for AC sensing.



GRAD CONNECTOR:

Grads may be mounted with the connector at the bottom of the sensor or at the top of the sensors. All sensors must be oriented identically.

SENSOR DISPLACEMENTS:

Input the measured displacement for each sensor array, either grad, triaxial or both, ***measured to 1mm***. Note that all sensor long axes should be vertical, ***to within 1 degree***.

DEPTH SENSOR:

Current allowed settings are “ON” or “OFF”.

ALTIMETER TYPE:

Current allowed settings are “TRITECH” or “NONE”.

VERTICAL (m) ABOVE ROV SKID:

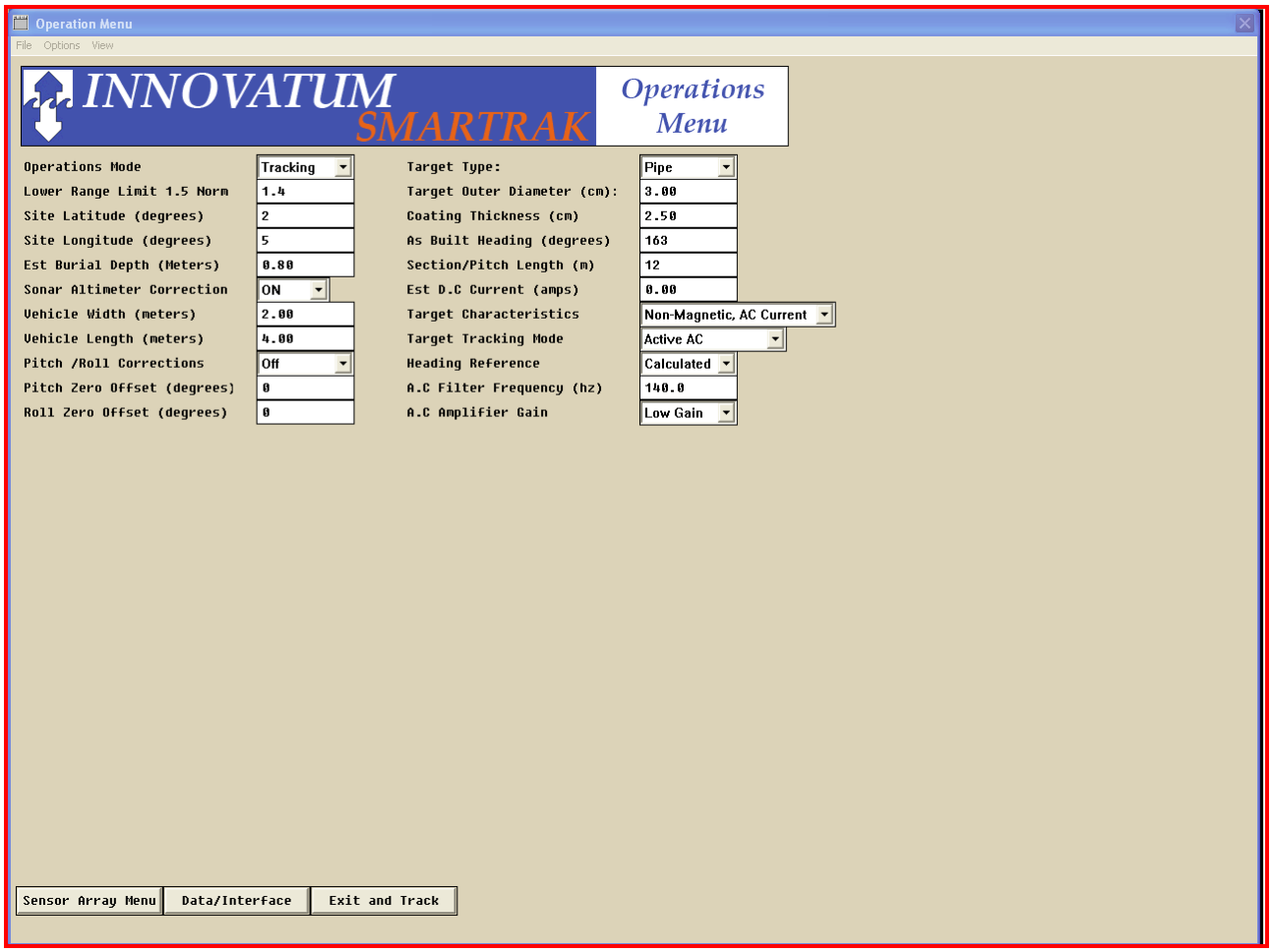
Input the measured displacement for the altimeter, measured from the horizontal plane of the ROV skids to the transducer face of the altimeter, ***measured to within 1mm***.

SIP (SENSOR INTERFACE POD) ORIENTATION:

Select the correct SIP orientation. Note that if the SIP orientation is Forward, Aft, Left or Right, no other selections are possible and the cylinder axis MUST be horizontal with the arrow pointing UP. If the SIP orientation is Vert (UP) a further selection of the arrow direction is possible. These inputs allow the system software to correctly interpret and apply the outputs from the internal pitch and roll sensors in the SIP. The SIP LID arrow **MUST BE UP IF CAN AXIS NOT VERTICAL**

The boxes at the bottom left of the screen may be used to select the other menu pages.

OPERATIONS MENU - EXPLANATION OF ITEMS.



This menu allows selection of operational parameters, including target type and size, mode etc.

OPERATING MODE:

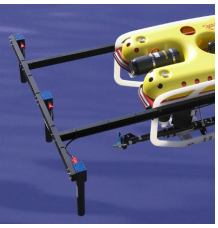
This mode can currently only be "TRACKING".

LOWER RANGE LIMIT:

The lower range limit specifies the signal level at which the system will "Turn On". It may be adjusted to "gate out" noise. During "NEUTRALISATION" the system will indicate a minimum setting for this parameter, which is vehicle background noise dependant. Weak signal detection will be inversely proportional to this limit setting.

SITE LATITUDE & SITE LONGITUDE:

These parameters are used to calculate the effect of the Earth's magnetic field in "PASSIVE" and "ACTIVE D.C." modes. They need to be input to the nearest degree. West and North are positive, East and South are negative.



BURIAL DEPTH DETERMINATION:

Input the estimated distance from the Sensor Array Reference point (which is the lower face of the centre grad, or the place of the bottom of the triaxial sensors) to the top of the target product. **THIS INPUT IS VERY IMPORTANT, AND IT SHOULD BE UPDATED REGULARLY.**

SONAR ALTIMETER CORRECTION:

This may be either “ON” or “OFF”. It may be advisable to turn off this correction if altimeter data is erratic due to poor acoustic returns, suspended debris or excessive vehicle stability problems.

VEHICLE WIDTH (meters):

Enter the vehicle width between the limits of 1 and 9.9 meters. Used for an drawing outline which will be displayed on the screen.

VEHICLE LENGTH (meters):

Enter the vehicle length between the limits of 2 and 20 meters. Used for an drawing outline which will be displayed on the screen. If the vehicle Width and Length are the same, a circle will be drawn to represent the vehicle. This is applicable to “FALL PIPE ROVs”.

PITCH/ROLL CORRECTIONS:

Toggles between “HEADING” and “OFF”.

PITCH ZERO OFFSET (degrees):

Allows for an offset in pitch due to errors in SIP mounting or vehicle trim. Limited to a value of +20 to -20 degrees.

ROLL ZERO OFFSET (degrees):

Allows for an offset in roll due to errors in SIP mounting or vehicle trim. Limited to a value of +20 to -20 degrees.

TARGET TYPE:

Toggle the “CHANGE” softkey until the correct target type is shown: either “PIPE”, “CABLE” or “OBJECT”.

TARGET OUTER DIAMETER & COATING THICKNESS:

These inputs are used to give the correct scale of the target for the graphics screen.

AS BUILT HEADING:

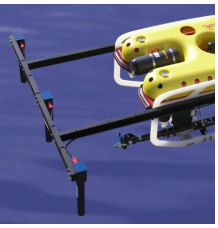
Enter the “AS-BUILT” heading of the target pipeline or cable in degrees magnetic.

SECTION PITCH/LENGTH:

Input the pipe joint length or the “pitch” of the cable armour in metres.

ESTIMATED D.C. CURRENT:

When passively tracking pipe or armoured cables which carry steady D.C. electric current, the D.C. magnetic fields produced by these currents interfere with the passive magnetic fields of the target itself. Entry of the current magnitude in amperes D.C. allows the effects of the current to be



calculated and compensated for. Current flow in the direction given in the menu for cable as-laid heading is defined as positive (+).

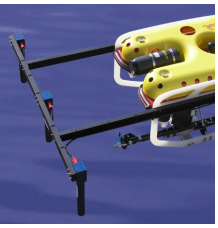
TARGET CHARACTERISTICS & TARGET TRACKING MODE:

The allowable target characteristics are dependant on the selected sensor array in the “SENSOR ARRAY MENU” and the target type in the “OPERATIONS MENU”. With all tracking modes possible enabled, the following target characteristics and tracking modes are allowed. The preferred method is shown first:

TARGET TYPE	TARGET CHARACTERISTICS	TARGET TRACKING MODES
CABLE	UNARMOURED, A.C. CURRENT	ACTIVE A.C. CURRENT
	UNARMOURED, D.C. CURRENT	ACTIVE D.C. CURRENT
	IRON ARMOUR, NO CURRENT	PASSIVE MAGNETIZATION
	IRON ARMOUR, A.C. CURRENT	ACTIVE A.C. CURRENT PASSIVE MAGNETIZATION
	IRON ARMOUR, D.C. CURRENT	PASSIVE MAGNETIZATION ACTIVE D.C. CURRENT TWIN CABLE D.C. CURRENT

TARGET TYPE	TARGET CHARACTERISTICS	TARGET TRACKING MODES
PIPE	MAGNETIC, NO CURRENT	PASSIVE MAGNETIZATION
	MAGNETIC, A.C. CURRENT	ACTIVE A.C. CURRENT PASSIVE MAGNETIZATION
	MAGNETIC, D.C. CURRENT	PASSIVE MAGNETIZATION ACTIVE D.C. CURRENT

TARGET TYPE	TARGET CHARACTERISTICS	TARGET TRACKING MODES
OBJECT	NON-MAGNETIC, A.C. CURRENT	ACTIVE A.C. CURRENT
	NON-MAGNETIC, D.C. CURRENT	ACTIVE D.C. CURRENT
	MAGNETIC, NO CURRENT	PASSIVE MAGNETIZATION
	MAGNETIC, A.C. CURRENT	ACTIVE A.C. CURRENT PASSIVE MAGNETIZATION
	MAGNETIC, D.C. CURRENT	PASSIVE MAGNETIZATION ACTIVE D.C. CURRENT



TRACKING MODES

Three tracking modes are possible with the Smartrak, depending on the model number:

1. Passive Magnetization	**SMARTRAK 3 & 9 only**
2. Active D.C. current	**SMARTRAK 3 & 9 only**
3. Active A.C. current	**SMARTRAK 6 & 9 only**

HEADING REFERENCE:

The heading reference for the target may only be changed when in “ACTIVE A.C.” mode when it toggles between “AS-BUILT” and “CALCULATED”. Selection of calculated mode will allow the system software to decide which reference to utilise for the calculation of heading, and this will be shown during tracking on the status line as follows:

HEADING REFERENCE: AS BUILT
HEADING REFERENCE: FRONT ARRAY

Calculation of target heading is based on the assumption the pipeline or cable is straight. However, in practice this is often not the case, and the heading angle is influenced in unpredictable ways by nearby changes in current geometry (loops, bends, kinks and spirals) at high signal levels.

Consequently, in the active A.C. tracking mode with Smartrak, you may choose to use either:

1. Calculated (but possibly erratic) heading angle for graphics display and data transfer to the autopilot by selecting "CALCULATED CABLE HEADING". (In this case, the compass display will still show cable as-laid heading). The calculated heading displayed is selected automatically by the system software, and will be shown in the status line display of the tracking screen as “HEADING REFERENCE : AS LAID”, “HEADING REFERENCE : FRONT ARRAY” or “HEADING REFERENCE : FRONT/REAR”

2. Assumed cable heading as entered in the menu or modified by soft key by selecting "AS-BUILT HEADING". (This is the only option available in any other tracking mode.)

A.C. FILTER FREQUENCY (hz):

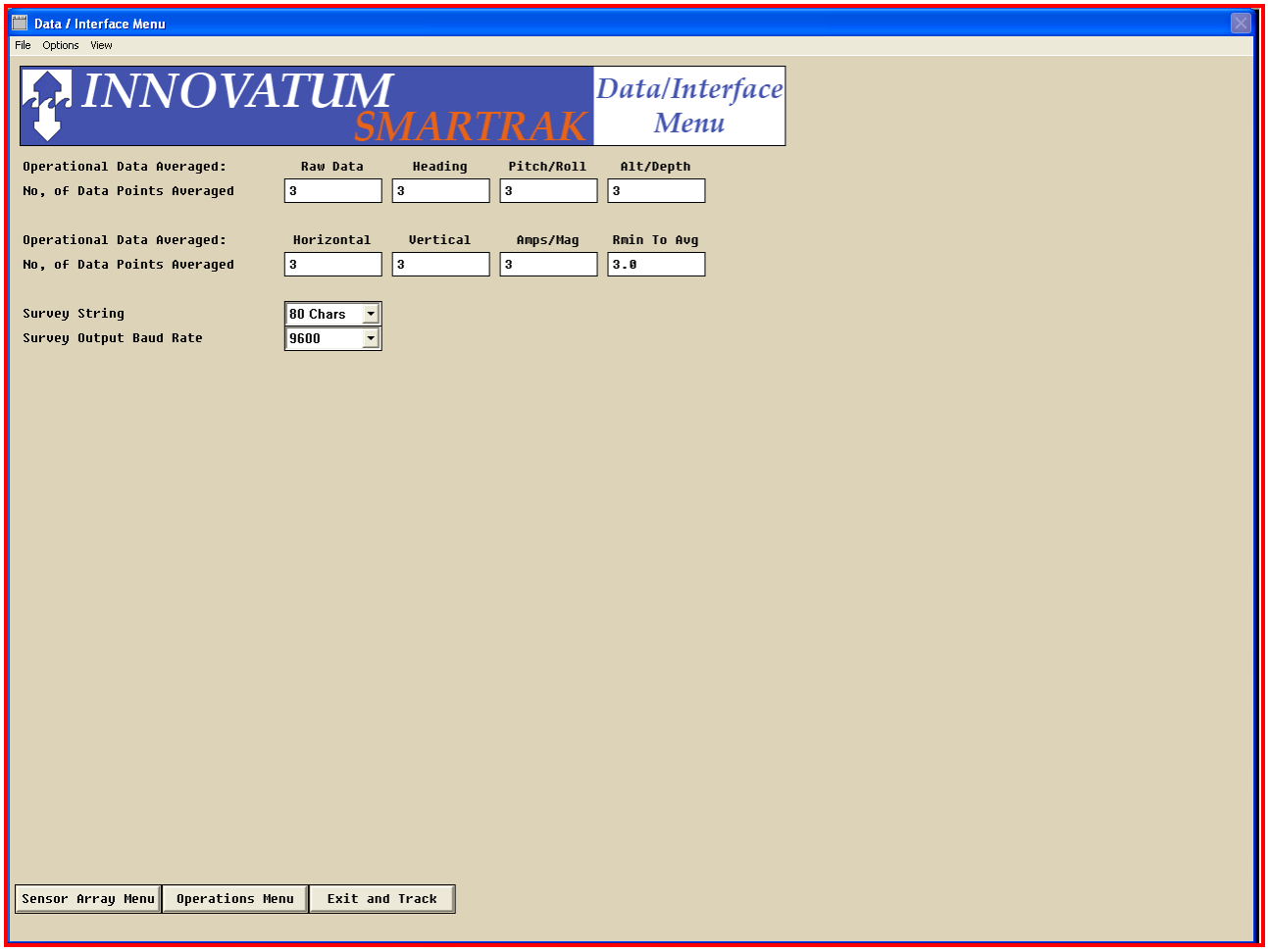
Sets the frequency of the A.C. filter circuits in the SIP, between the limits of 10 hz and 400 hz, in steps of 1 hz.

A.C. AMPLIFIER GAIN:

May be set to values between 1 and 9, plus a “TEST” setting, where stage 1 is the lowest gain. The selection of A.C. amplifier gain is dependant on the level of A.C. signal measured at the sensors, and should only be switched to a lower setting if saturation of the sensor channels occurs. This will be indicated by the sensor diagram on the system mimic display flashing yellow or red.

The boxes at the bottom left of the screen may be used to select the other menu pages.

DATA/INTERFACE MENU - EXPLANATION OF ITEMS.



NO. OF DATA POINTS AVERAGED

Allows input of data point averaging for the eight parameters shown, with an allowable range of 1 to 60 points for each parameter. May be changed to “smooth” noisy data.

SURVEY STRING:

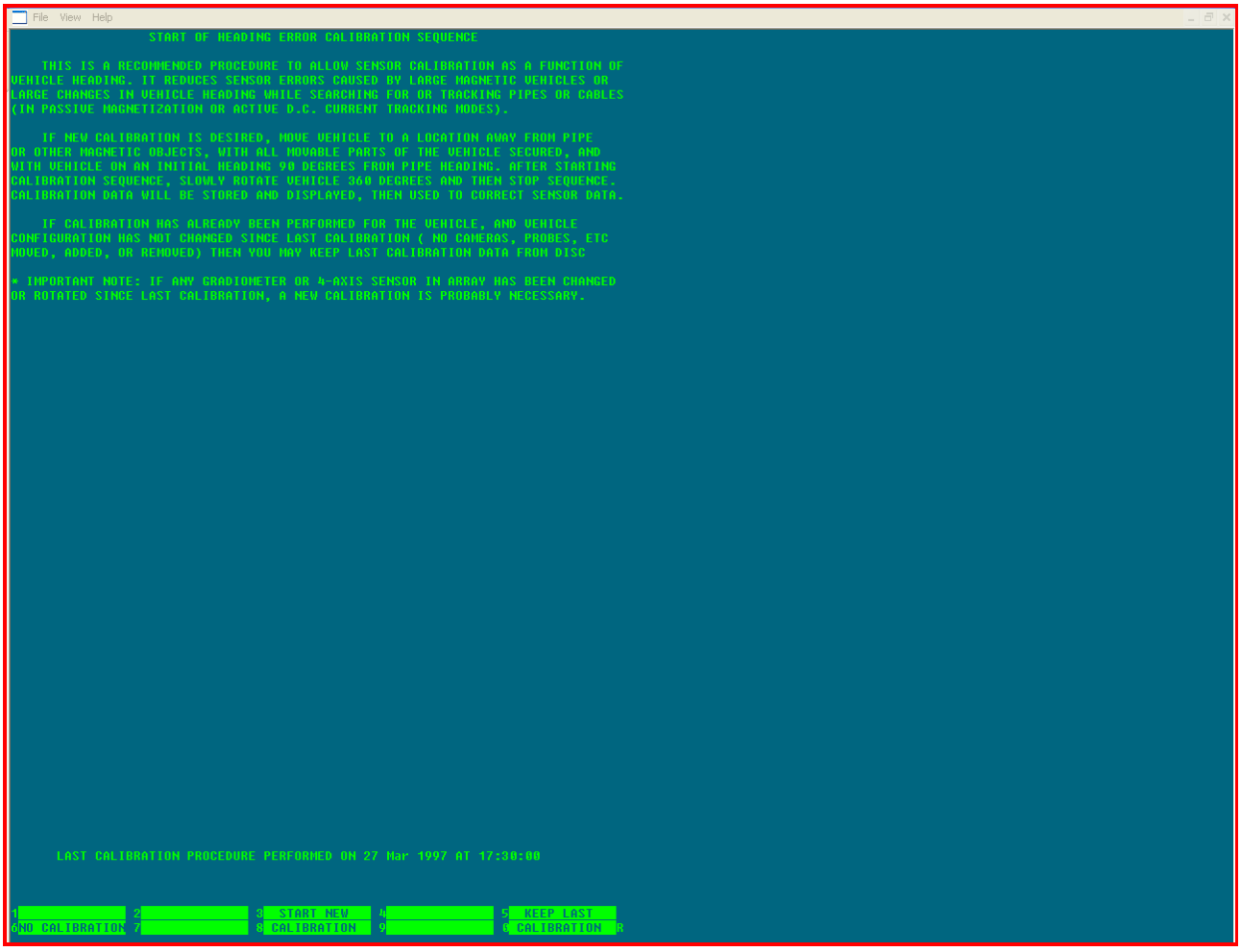
Three selections are currently possible, “None”, “80 Chars” and “New”. Only the 80 character string is currently available.

SURVEY OUTPUT BAUD RATE:

Sets the baud rate for the survey output string.

4-2.1.5 CALIBRATION CHECK

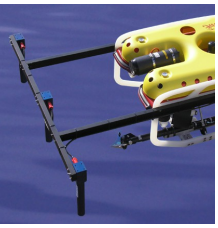
After MENU section is completed and [EXIT & TRACK] is pressed, if the system is properly installed both topside and on the ROV and no system faults are detected, the computer will display:



START OF HEADING ERROR CALIBRATION SEQUENCE

This is an optional procedure to allow sensor calibration as a function of vehicle heading. It reduces sensor errors caused by large magnetic vehicles or large changes in vehicle heading while searching for or tracking pipes or cables in passive magnetisation or active D.C. current tracking modes.

If new calibration is desired, move vehicle to a location away from pipe or other magnetic objects, with all movable parts of the vehicle secured, and with vehicle on an initial heading 90 degrees from pipe heading. After starting calibration sequence, slowly rotate vehicle through a minimum of 180 degrees, without missing any data points as shown by the “filled in” display of heading points, and then stop sequence. Calibration data will be stored and displayed, then used to correct sensor data. The



calibration may be continued for more than 180 degrees if required, up to the completion of a full circle.

If calibration has already been performed for the vehicle and vehicle configuration has not been changed since last calibration (no cameras, probes, etc. moved, added or removed) then you may keep last calibration data from memory.

If the vehicle has an automatic heading hold function and heading is thus kept nearly constant, then calibration is not absolutely necessary and you may choose [NO CALIBRATION].

Refer to section **2-4.2 "CALIBRATIONS-TROUBLESHOOTING"** pages 2-52 for information indicating how to assess the quality of a calibration.

Softkeys initiating the three options are:

NEW CALIBRATION
KEEP OLD CALIBRATION
NO CALIBRATION

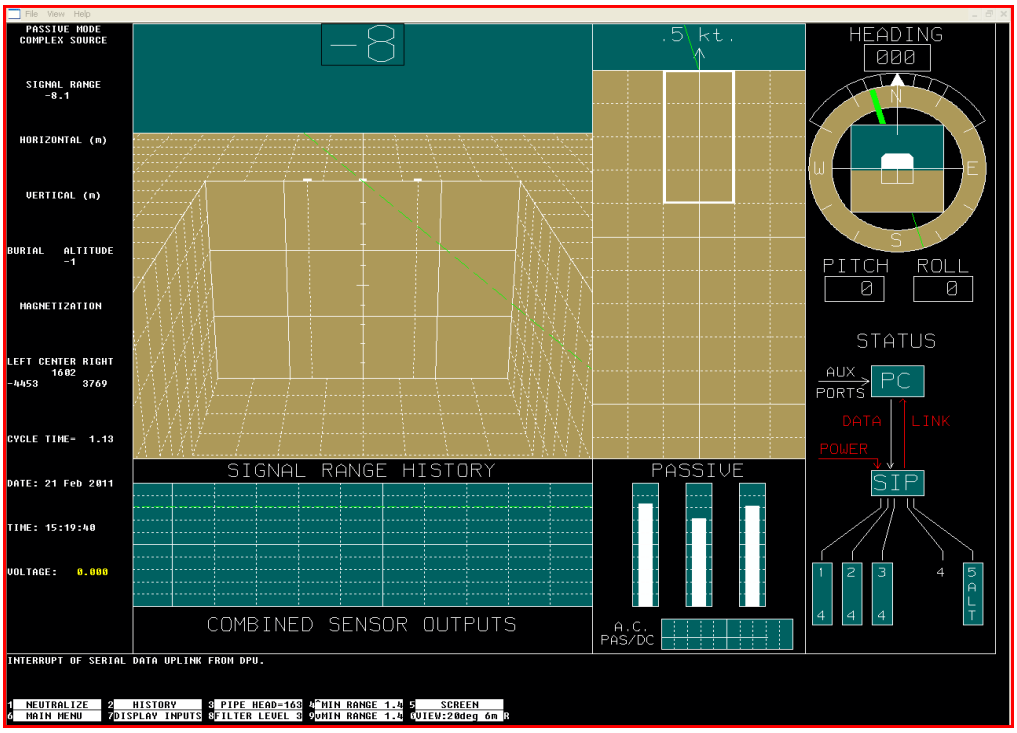
If the vehicle is in the water on the seabed and ready to begin tracking operations, the calibration procedure may be completed at this point, either by starting a new calibration, or if a previous calibration has been performed on the vehicle in its present configuration, by keeping the old calibration.

If the vehicle is still on deck, but a valid previous calibration has been performed, then the calibration procedure may be completed by keeping the old calibration.

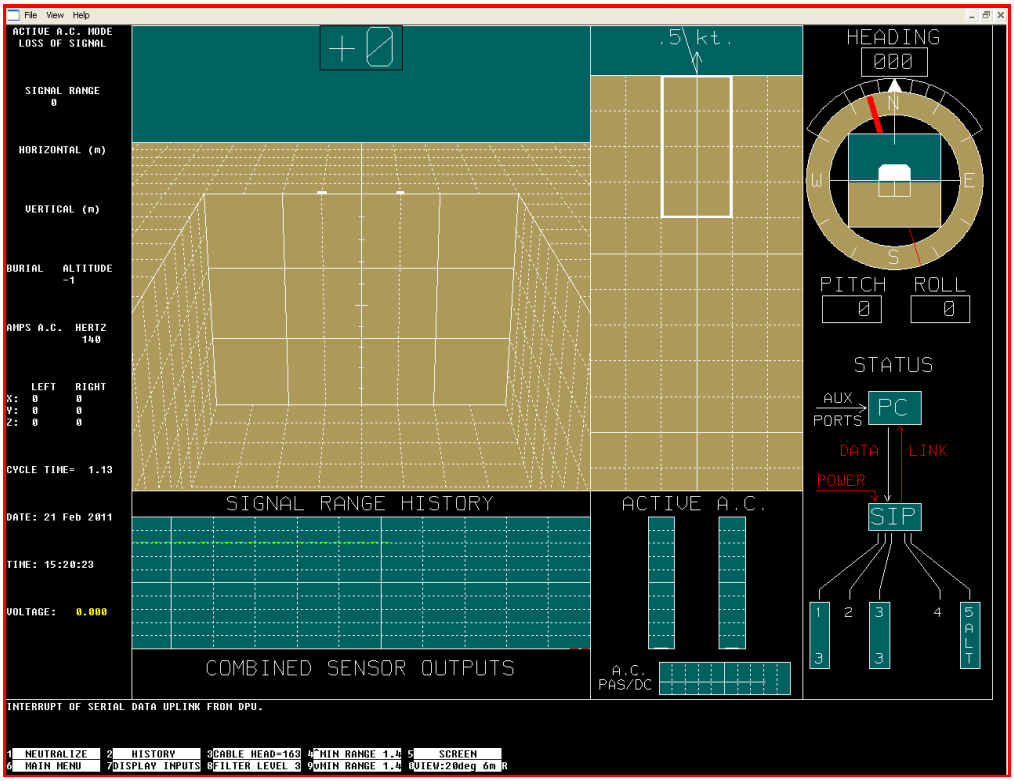
If the vehicle is still on deck or is not at a location where a calibration may be performed and no valid old calibration data exists, then calibration should be deferred until later by choosing [NO CALIBRATION].

Subsequent calibrations may be carried out by invoking the calibration sequence from the "Calibration" tab at the top left of any MENU Screen

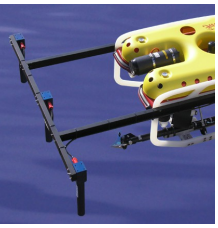
After the calibration check, the computer will set up the 3-D colour graphics display and enable the various softkey control features. The format of the display will change according to the working sensor array:



3D Colour Graphics display in Passive Mode, 3 grads



3D Colour Graphics display in Active A.C. Mode, 2 triaxial sensors



4-2.1.6 NEUTRALISATION CHECK

After the calibration check, the computer will set up the 3-D colour graphics display and enable the various softkey control features. Before tracking operations may begin, the system must be neutralised by using soft key . Regardless of whether the system is on deck or on the seabed, a neutralisation check should be performed to check vehicle fields and noise levels. This is accomplished by pressing soft key [NEUTRALISE] while all vehicle moving parts are secured and activity near the vehicle is kept to a minimum.

This will initiate reading of a large number of measurements by all sensors in the array of vehicle fields, and vehicle magnetisation and noise levels are calculated. If abnormally large values are detected by any sensor, a warning is given as shown below:

LEFT SENSOR VALUE OF ____ LARGER THAN NORMAL

REMOVE MAGNETIC OBJECTS NEAR SENSORS (SYSTEM O.K. BUT ACCURACY MAY BE AFFECTED).

NOTE: If you are neutralising the system on deck to check system before launch, you will almost certainly get this warning because of the vessel magnetic fields.

If the ROV fields are too noisy for the sensitivity set by the minimum range, a warning will be given as indicated below:

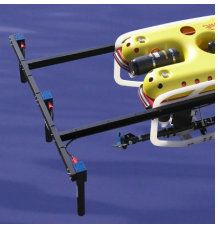
VEHICLE NOISE LEVEL TOO LARGE TO OPERATE IN MINIMUM RANGE LESS THAN ____. NOISE LEVEL AT SENSORS: L=__ C=__ R=__

System operation with a minimum range less than the value suggested in this warning will result in highly erratic (false) track indications even away from target.

If no vehicle noise level warning appears, then the system should be neutralised with no target position indicated either in the pilot's video (only double cursor blinking at top centre of screen) or in the computer graphics. The display should show a message "LOSS OF SIGNAL". If the filter level soft key is set to 3, no steady signal should appear when vehicle is away from target (except for an occasional brief position indication which disappears again).

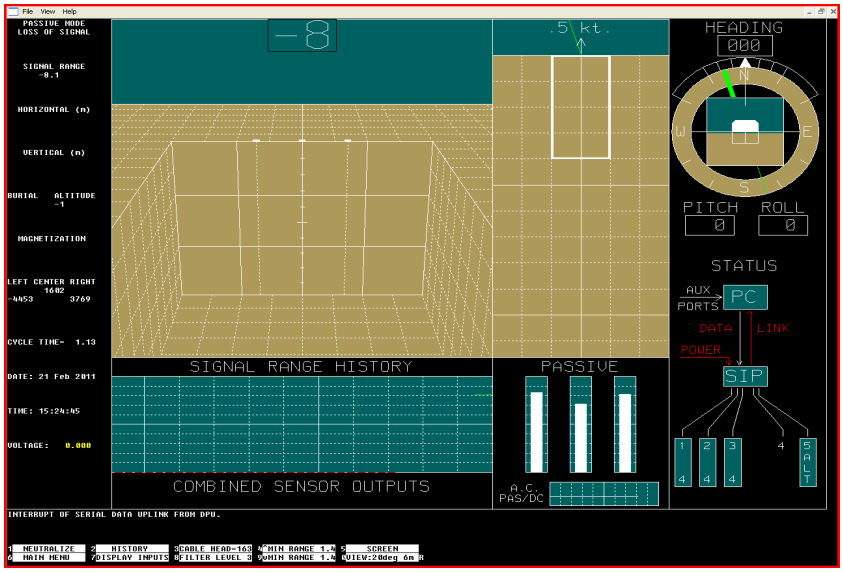
The filter level select key simply determines how many successive measurements must be above the threshold set by the minimum range for the system to accept the signal as real.

If a steady signal appears with constant position indicated after neutralisation while the vehicle is still away from the target, it may be the result of some change in vehicle fields during neutralisation (camera, etc. moved) or of some magnetic object nearby. In such a case, repeat the neutralisation procedure.



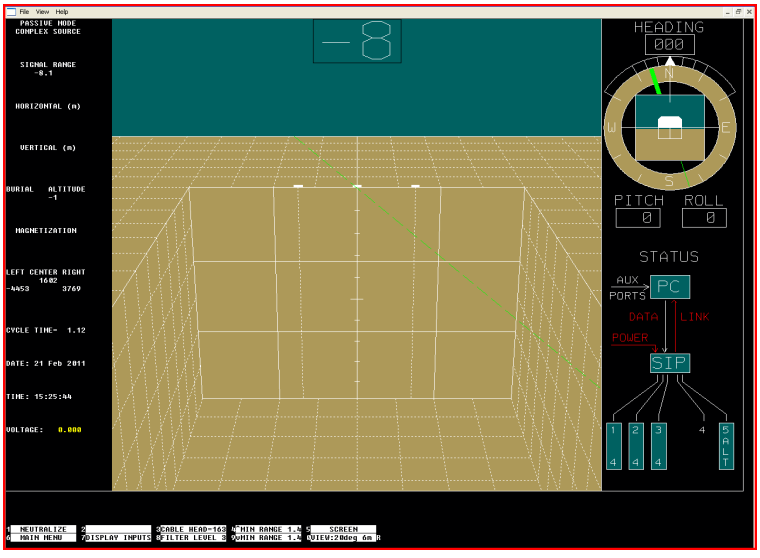
4-2.2 TRACKING DISPLAY AND CONTROLS

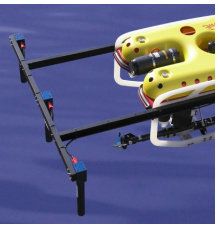
After initial calibration procedure is completed (or skipped), the computer sets up the tracking graphics display, as shown below. This display scene shows typical output for tracking a 12" pipe. Main features of the display are:



4-2.2.1 3-D PERSPECTIVE COLOR GRAPHICS

Two display formats are available: either a comprehensive “4 box” display showing real time graphical data, historical horizontal and vertical positions, and graphical indications of signal strength, or a simpler “single box” display showing only real time graphical data. The picture shown above represents the “4 box” display, and that below a single box display.





REAL TIME PERSPECTIVE GRAPHICS TRACKING DISPLAY

The top left (largest) box shows a 3-D perspective view of the water (upper 1/4 of picture without grid lines), the plane of the seabed and a rectangular "hole" below the seabed. The front face of the hole is the vertical sensor plane, and the sensor position in this plane are shown by the small white rectangles projected to the seabed (the sensors are actually above the seabed, at a height given by the corresponding MENU entry).

The pipe (or cable), shown projecting toward the observer, emerges from the front hole face slightly to the left of the centre line and the top of the pipe is almost exactly one meter below the bottom plane (each square on the front face is 1 meter square). As the vehicle manoeuvres, the pipe position will move (and rotate) corresponding to the instantaneous position during manoeuvres. If the vehicle manoeuvres too far to either side, the Ultra-System cannot determine burial depth and the pipe will disappear, with a single line superimposed on the seabed level indicating direction and orientation of the pipe to allow re-acquisition. If the vehicle moves too far away, loss of signal will occur and the pipe (and indication line) will disappear. The signal strength is indicated by the sign and single digit appearing in the rectangle in upper centre of the picture. This digit is a logarithmic scale, with 0 being the lowest signal level and 9 being the largest. Each integer change signifies a factor of 2.5 in signal amplitude (root-means-square amplitude of all sensors used in the tracking mode). The sign indicates signal polarity and has slightly different significance in the three tracking modes, as indicated:

PASSIVE MAGNETIZATION MODE:

Sign indicates magnetic polarity, with + indicating north pole and - south pole.

ACTIVE D.C. CURRENT MODE:

Sign indicates D.C. current direction, with + indicating current flow in direction of vehicle travel, and - opposite to direction of vehicle travel.

ACTIVE A.C. CURRENT MODE:

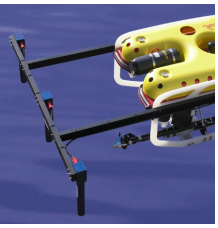
Sign is always +.

An additional indication of polarity is given by the colour of the target representation, with red corresponding to + and green corresponding to -, and with the intensity of colour proportionally related to signal strength.

The picture shown appears as it would be to an observer located along a line inclined 20 degrees above the plane of the seabed at a distance which allows a field-of-view 6 meters wide at the front face of the "hole" (sensor array plane). Both the inclination angle and view width may be adjusted by soft key commands, with elevation angle adjustable from 20 degrees (as shown) to 85 degrees (almost overhead) and view width adjustable from 6 meters (as shown) to maximum of 32 meters. When a view width of more than 6 meters is chosen, the "hole" dimensions change from 4 m wide and 3 m deep to 6 m wide and 6 m deep to allow for deeper burial depths.

HORIZONTAL POSITION BOX

The horizontal position box is to the right of the main tracking display. It shows the historical



horizontal position of the target in relation to the vehicle, with grid boxes at one metre I intervals. The colour of the target display is either red, white or green. Red (and green only displayed in passive modes to show signal polarity) is displayed when horizontal position is calculated, and white when direction only (without an error figure) is calculated. The width of each data point is proportional to the calculated horizontal position error, allowing a rapid visual evaluation of system performance. The “speed” of advance is set at 0.5 knots (approximately 0.25 m/sec).

SIGNAL RANGE HISTORY (ALTITUDE/BURIAL)

This box occupies the lower left area of the central screen display, and may be “toggled”, using the “HISTORY” softkey, to show either the combined signal strength of all sensors, or to display calculated burial depth, and vehicle altitude (if an altimeter is fitted and enabled). The “SIGNAL RANGE HISTORY” function is useful when a target search is required, and will give a reliable indication of the approach of a target. In “ALTITUDE/BURIAL” mode the target position is indicated in colour as per the horizontal display, and with the vertical length of the bars showing the calculated error for each data point.

SENSOR SIGNAL LEVELS

This box occupies the lower right portion of the screen. It shows the real time signal range levels of the sensors used in the selected tracking mode, using vertical bar graphs with graduations from 0 to 9.9. This allows easy monitoring of individual sensor performance. Below the vertical bar graphs is a horizontal bar graph with three parameters - the signal range strengths in A.C. or PAS/D.C. This enables the operator to monitor system performance in modes other than the selected mode, and thus to change modes if appropriate.

ORIENTATION AND ENGINEERING DATA (right side of screen)

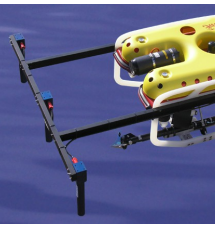
On the right side of the screen are displayed instantaneous vehicle heading (and target heading), D.C. input voltage from the ROV to the Ultra-System SIP and a block diagram of the entire Ultra-System. The functions of these displays are described below:

HEADING (and PITCH & ROLL)

The compass circle shown allows instantaneous determination of vehicle magnetic heading (shown by thin white line and digital readout in centre of compass) and target orientation (as input to AS-BUILT HEADING in MENU), which is shown graphically by the thick bar across the compass centre. Vehicle magnetic heading is determined from the left grad or triaxial sensor in the array. Pitch and roll is shown both graphically by movement of the “ROV” in the compass rose display, and numerically in two boxes labelled “PITCH” and “ROLL” under the graphical compass rose.

STATUS

This is a block diagram of the entire SMARTRAK System and serves as a general fault indicator for any fault detected during operation. Every data set read by the computer is checked for a variety of possible error conditions. These checks include sensor over-range and under-range (saturation), possible (or plausible) combinations of data and check of certain "hard-wired" data bits which monitor the accuracy of analogue-digital conversion and data transmission from the SIP to the topside computer. Detection of any error (or loss of data input) results in the built-in "expert" system performing diagnostics of probable causes and flashing the involved



system components to aid in rapid trouble-shooting and recovery. The most suspect (or the most accessible) system components are flashed red, with the secondary components flashing yellow.

NOTE: Transfer of data to another computer by RS232 results in the display of an arrow to the left of the block labelled "PC".

TRACKING INFORMATION AND SURVEY DATA (left side of screen)

On the left side of the screen are displayed all alphanumeric data related to tracking and position of the target. In order from top to bottom, these data are:

TRACKING MODE

"PASSIVE", " ACTIVE D.C." or " ACTIVE A.C."

TRACK STATUS

This line is a comment on status in the tracking mode, such as "LOSS OF SIGNAL", "TARGET TO LEFT", "OUTSIDE DEPTH CONE", or "COMPUTED MODEL FIT".

SIGNAL RANGE

This line gives the same information as the SIGNAL STRENGTH display at the top centre of the graphics display but further divides the strength range into 0.1 increments.

HORIZONTAL (m)

This indicates the horizontal displacement of the target centre from the array centre line (- is target to left) and gives the estimated probable error (+/-) in horizontal displacement.

VERTICAL (m)

This indicates the vertical distance between the bottom of the SIP and the target centre and gives the estimated probable vertical error.

SKIDS-TO-TOP (m)

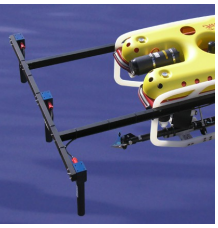
This measurement is derived from the vertical distance by subtracting the sensor height above skids and the target radius (both taken from MENU entries). It has the same error as the VERTICAL measurement and, if the vehicle skids are on the seabed, it gives depth of target burial.

ALTITUDE

This field is only present if an altimeter is fitted and enabled. It indicates altitude of the vehicle above the seabed, measured to the vehicle skids.

MAGNETISATION

In the PASSIVE mode, it indicates the sign and strength of the intrinsic target magnetisation. In either active mode, this line indicates current in Amps and the label is changed to read either "AMPS D.C." or "AMPS A.C."



SENSOR VALUES

In the PASSIVE or ACTIVE D.C. Modes, the values (corrected for calibration and neutralisation) of the gradiometers are displayed,. In the ACTIVE A.C. mode, the 3 A.C. components of the left and right gradiometer or triaxial sensors are displayed.

CYCLE TIME

The time between SMARTRAK updates in seconds. (This time may vary between 0.08 and 0.35 seconds depending on which computer and which tracking mode is used).

DATE and TIME

Date and time as set on internal clock.

VOLTAGE

The values of the internal voltages in the SMARTRAK SIP is shown digitally. This gives a basic check of system health.

4-2.2.2 CONTROL FUNCTIONS DURING TRACKING (SOFT KEYS)

While the TRACKING DISPLAY is being shown and updated, the following soft keys are defined:

NEUTRALISE	HISTORY	PIPE HEAD = 45	∧MIN RANGE .5	SCREEN
MAIN MENU	DISPLAY INPUTS	AUTO LOG 1	∨MIN RANGE .5	VIEW:20deg 6m

Alternative key definitions if “LOGGING” is not enabled:

NEUTRALIZE	HISTORY	PIPE HEAD = 45	∧MIN RANGE .5	SCREEN
MAIN MENU	DISPLAY INPUTS	FILTER LEVEL 3	∨MIN RANGE .5	VIEW:20deg 6m

The functions of these keys are:

NEUTRALISE:

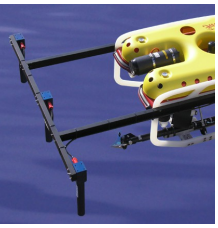
This initiates the reading of data to neutralise vehicle fields and determine vehicle noise level.
(See: Manual section on NEUTRALISATION.)

HISTORY (Blank in large display screen mode)

This key toggles the “HISTORY” display, in the lower centre box, between “SIGNAL RANGE” and “ALTITUDE & BURIAL”. The “SIGNAL RANGE” display shows the total signal on ALL sensors, in the selected tracking mode. This display is very useful when searching for a target. After the target is located and tracking & survey operations are continuing, it will normally be beneficial to toggle the display to show “ALTITUDE & BURIAL”

PIPE (CABLE) HEAD = (VALUE)

This allows keyboard input of a new cable (or pipe) heading without recalling the MENU. However, it does not change the stored value in the MENU. Recalling



MENU by pressing [DEFINE SYSTEM] will restore the MENU value for target heading.

∧MIN RANGE (VALUE)

This raises the MINIMUM RANGE in 0.1 increments, decreasing system sensitivity.

SCREEN

Toggles the screen between the single box and 4 box displays. The single box display is shown below.

MAIN MENU

This ordinarily interrupts tracking operations and recalls the MENUS for system changes.

DISPLAY INPUTS

Pressing this key allows viewing of the SIP data output channels and other information for diagnostic or other purposes. The functions toggled by the **"DISPLAY INPUTS"** key (with re-labelling of the key) are:

D.C. MAGS Volt:

Displays gradient and total field voltages from SMARTRAK sensors in the following order:

dZ1, dZ2, dZ3, X1, Y1, Z1.

D.C. MAGS nT:

Displays gradient and total field values in nanoTesla from SMARTRAK sensors in the following order:

dZ1, dZ2, dZ3, X1, Y1, Z1.

PAS/D.C. NEUT nT

Displays the average neutralisation values of channels 1-8 (AVG:) and the noise values (NOISE:) measured whilst the neutralisation was carried out.

GYRO/ALTIMETER:

Displays Gyro and Altimeter raw values:

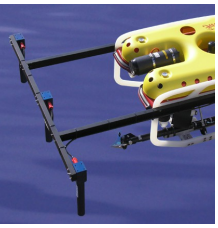
ACCELEROMETERS:

Displays x, y, z values of "g".

A.C. MAGS Volt:

Displays A.C. field voltages from SMARTRAK sensors 1 & 3 in the following order:

X1ac, Y1ac, Z1ac, X3ac, Y3ac, Z3ac.



A.C. MAGS nT:

Displays A.C. field values in nano Tesla from SMARTRAK sensors 1 & 3 in the following order:

X1ac, Y1ac, Z1ac, X3ac, Y3ac, Z3ac.

A.C. NEUT nT:

Displays the neutralisation average values (AVG:) and noise levels (NOISE:) for A.C. channels 1& 3, in the order X, Y, Z for each channel.

MON/IO STATUS:

Shows the A.C. frequency selected, the A.C. gain selected, the values from the Altimeter and Gyro and the bit fail percentage.

STRING OUTPUT:

This displays the ASCII data string assembled from the most recent data update for transfer to another computer. (See: **Section 2-7.21** for data string formats.)

NEUT/CAL DATES:

Shows date and time of most recent stored last neutralisation and calibrations

VIEW: 20deg 6m

This allows changes in the perspective of the view elevation (from 20 degrees to 85 degrees in 1 degree increments). It initiates a call for keyboard entry of new view angle. After entering the new value, a new value for the field of view is requested. After typing in new width, you must press enter to implement the changes.

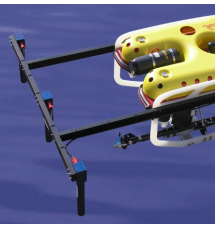
IMPORTANT NOTE: ***The system will NOT calculate a position outside of the selected view parameters. If the target is likely to be deeper than the maximum view dimension selected, a wider display MUST be selected in order to measure vertical position.***

4-2.3 DECK TESTS

Deck tests should be carried out prior to the vehicle launch, in order to ensure, as far as possible, that the Ultra-System is correctly functioning. The system should be set up correctly with all menu items and “EXIT & TRACK” should be selected. As it is not normally possible to carry out a calibration prior to launch, either “NO CAL” or “KEEP OLD CAL” should be selected. The following tests may then be carried out:

4-2.3.1 NEUTRALISATION

SMARTRAK should be neutralised on deck after system power up, as described above. This neutralisation test will almost certainly result in a message indicating ***“ _ Sensor reading higher than normal”***, due to the effect of the ship structure, but will nevertheless give a good indication of system noise. If the vessel is at sea, or if personnel are moving around close to the vehicle, it is normal to see fluctuations of the gradiometer readings. The vehicle hydraulics, various sensors and



equipment on the vehicle can be switched on/off, and pan & tilt units etc. moved to observe any effects or noise at the sensors. It may not be possible to test all functions in this manner, due to vehicle system restrictions.

4-2.3.2 PASSIVE/D.C. CURRENT MODE TEST

SMARTRAK Passive & D.C. mode sensing may be tested on deck by, after neutralisation, introducing a field to each grad in turn and then checking both the sense and magnitude of the readings. The field may be introduced by an object such as a magnetic screwdriver, and care should be taken to align the object in a similar orientation at each gradiometer. Each gradiometer should then indicate a similar reading. Objects with a strong magnetic field may well cause saturation of the gradiometers.

4-2.3.3 ACTIVE A.C. CURRENT MODE TEST

The Test Tone Generator unit (if supplied) may be used to test Active A.C. current mode functioning on deck. The Test Tone Generator should be set to the correct frequency, and clipped onto the relevant sensors in turn. The test tone generator should be switched on, and readings should be observed on each sensor, and be similar for each type of sensor in a similar position. It is possible to test the triaxial sensors for readings in the X, Y and Z axes, but the gradiometers will only give a single reading. Remember that the Test Tone Generator will switch off automatically after a short time. If no readings are observed, check the correct frequency is set at the generator and/or the menu setting.

4-2.3.4 USE OF TEST TONE GENERATOR

The Test Tone Generator is a battery powered portable “clip-on” test unit for providing test A.C. tracking signals. It has a bank of three frequency select switches, an “ON” push-button and an “OFF” push-button. A 9-volt battery is fitted internally. An automatic timer will switch the unit off after a few minutes use to conserve battery life. The unit may be used to test the functioning of both the sensors and the SIP filter circuitry. **The Test Tone Generator is a function testing device, and is not intended to be a calibration instrument.**

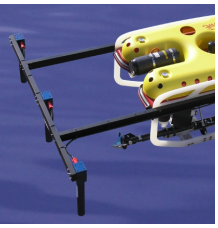
4-2.4 POST-LAUNCH PROCEDURES

After the vehicle is launched SMARTRAK may be properly tested and set up for tracking cable or pipe. The neutralisation and heading calibration procedures are an essential part of this testing.

4-2.4.1 NEUTRALISATION - TROUBLESHOOTING

With the vehicle stationary on the sea bed, and all menu items correctly set up, a “Neutralisation” should be carried out. This neutralisation will provide information as to the correct functioning of the system and the vehicle noise characteristics. Sensor readings should not show noise levels of more than 10 nanoTesla for effective tracking with weak signals. Possible causes of excessive noise are:

a) Noisy sensor(s)
b) Proximity of other sensors, particularly those with scanning heads such as sonars and profilers
c) Mechanical vibration
d) Noise from moving parts such as hydraulic pumps and electric motors.



Many of these causes may be removed by relocation of equipment, or vibration damping of frames etc. It may be necessary to accept operation in a high noise environment on some vehicles, but this will reduce sensitivity and degrade system performance.

4-2.4.2 HEADING CALIBRATION - TROUBLESHOOTING

If the system is to be operated in any mode utilising gradiometers, a heading calibration is almost always necessary. The heading calibration procedure stores the absolute gradiometer readings for each incremental degree of heading change. The calibration procedure is described in para. **2-2.34.** The graphical results of the calibration procedure should be displayed and examined. The calibration curves should be sine waves, not necessarily in phase. Distortion of the calibration curves may be due to one or more of the following:

a) Vehicle system noise.
b) Vehicle pitch and/or roll causing false heading inputs from the fluxgate sensor.
c) Vehicle translational motion during the calibration procedure, particularly if the vehicle is close to a ferro-magnetic target.

Possible solutions are:

a) Relocate other equipment or Innovatum sensors, or in extreme cases change the offending items.
b) Ensure pitch/roll corrections in “OPERATIONS MENU” pages 2-17 are set to “HEADING” to correct fluxgate readings at high latitudes. Consider using analogue input (0 to 3.6 volt) from vehicle gyro if available. Trim vehicle correctly if possible. Request operation at slow speeds to minimise pitch & roll movements if possible.
c) Move location.

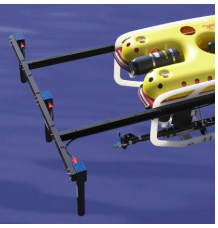
In extreme cases it may not be possible to record a satisfactory calibration, and restricted operation can then be carried out by neutralisation on the target heading and operating the vehicle at constant heading. **“NO CALIBRATION”** must be selected for this to be effective.

The use of incorrect calibration values, and/or operating with a vehicle which has large pitch/roll excursions, whilst using the INNOVATUM generated heading will cause significant degradation of data, particularly target depth data, and must be avoided.

4-2.5 OPERATIONAL PROCEDURES

4-2.5.1 PASSIVE MODE - PIPES & CABLES

1. Set MENU items for sensor array, target description and location.
2. With vehicle on bottom in configuration for operations, start new heading error calibration sequence or use previous (valid) calibration, (following instructions given after exit from menu for calibration options). If a good calibration cannot be obtained refer to **4-2.4.2** above.
3. Neutralise system on target heading while >15 meters away from target (make sure all vehicle components (cameras, manipulators, etc.) are fixed in position and that vehicle is not near magnetic structures or debris.
4. Turn vehicle on heading to cross target and proceed at constant speed.



(When display indicates target near array, turn to cross target at angle of 60 degrees or less to allow array to determine target position.)

5. Use tracking display information to turn parallel to target and follow it. (Choose view angle [20 to 85 degrees] and view width for convenience.)

NOTE: Avoid rapid or drastic vehicle control changes, since large systems transients produce magnetic noise. (Be cool, take it easy.)

4-2.5.11 "GHOSTS"

In passive tracking of pipes it is possible to misidentify the correct target due to the presence of "Ghost" pipe signals. A description of how and why a ghost signal may be present is given in Section **2** Para **2-2.32.** The "ghost" or false track signal may be recognized by the following symptoms:

a) Weaker than expected and erratic signal ranges
b) Excessively deep and unbelievable depth indications

If a ghost is suspected, moving the vehicle further in the same search direction will result in the true tracking signal being located. A second ghost will be present on the opposite side of the pipeline. The ghost signal may also be reduced by moving the vehicle vertically upwards, but this may not always be possible. **The Ghost signal will ALWAYS be of the opposite polarity to the true signal at the same longitudinal position along the cable or pipeline.** Ghost signals are most often encountered on larger pipes where the sensor army is close to the pipe, and are normally too weak to be a serious problem on smaller pipes and cables.

4-2.5.12 PROXIMITY TO VESSELS

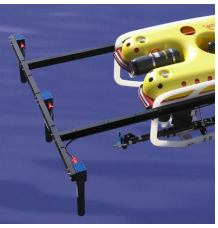
Steel vessels may have large intrinsic magnetic fields, and are usually large dipoles. Passive tracking of any kind may be very difficult due to the presence of these fields. Typically, the influence of the vessel will extend to a distance equal to its length on each beam, with minimum interference directly abeam the vessel. The presence of the vessel's influence may be removed by neutralisation, but this neutralisation will only be valid in the same position relative to the vessel and with the same orientation of the vessel within the terrestrial field. This means practical operation requires the vessel to vehicle relationship, and the heading of the vessel, remains reasonably constant. If these parameters are changed a fresh neutralisation will be necessary. These effects reduce with increasing water depth (typically more than 50m), and may be negated by using a vessel with an aluminium, wood or GRP hull.

4-2.5.2 ACTIVE D.C. CURRENT MODE

1. Set MENU items for sensor array, target description and location.

2. With vehicle on bottom in configuration for operations, start new heading error calibration sequence or use previous (valid) calibration options. If a good calibration cannot be obtained refer to **2-4.2** above

3. Neutralise system on target heading while >15 meters away from target



(make sure all vehicle components cameras, manipulators, etc. are fixed in position and that vehicle is not near magnetic structures or debris.)

4. Turn vehicle on heading to cross target and proceed at constant speed. (When display indicates target near array, turn to cross target at angle of 60 degrees or less to allow array to determine target position.)

5. Use tracking display information to turn parallel to target and follow it. (Choose view angle [20 to 85 degrees] and view width for convenience).

When tracking a monoconductor D.C. powered cable, the magnetic field directly over the cable is horizontal and thus there is no field gradient at this point. In order to obtain vertical data, it is necessary to offset the centre of the sensor array from directly over the cable. If a SMARTRAK System with four or more gradiometers is in use, the system software will automatically select the correct array configuration.

NOTE: Avoid rapid or drastic vehicle control changes, since large system transients produce magnetic noise. (Be cool, take it easy.)

4-2.5.3 ACTIVE A.C. CURRENT MODE

1. Set MENU items for sensor array, target description and location.

2. Heading error calibration is optional in this tracking mode. (Start new calibration or use previous calibration if there is possibility you may switch to passive or active D.C. tracking modes during this dive.)

3. With vehicle on bottom in configuration for operations, turn parallel to expected target heading and neutralize while >50 meters away from target.

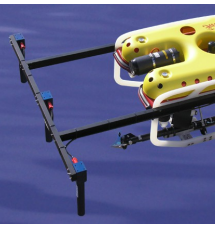
4. Turn vehicle on heading to cross target and proceed at constant speed. (When display indicates target near array turn to cross target at angle of 60 degrees or less to allow array to determine target position.)

5. Use tracking display information to turn parallel to target and follow it. (Choose view angle [20 to 85 degrees] and view width for convenience.)

NOTE: AVOID rapid or drastic vehicle control changes, since large system transients produce magnetic noise. (Be cool, take it easy.)

4-2.5.31 USE OF A.C. TONE SOURCE

The “Tone” for active A.C. tracking may be injected into the cable by either an Innovatum Tone Source or a third party generator. Most telecommunication operating companies will have suitable tone sources at their shore stations, and will not normally allow other persons to inject signals onto their cables. If control of the tone source is possible, the current levels should be set to the highest practicable level, with the best performance requiring the highest possible signal to noise ratio. ***When injecting tones into cables it is vital to ensure there is a correct return path for the tone current flow, otherwise very significant errors can occur. For further information see the manual Section 7 – Tone Generators & Operation.***



4-2.5.4 PASSIVE SEARCH MODE FOR FERROUS OBJECTS

1. Set MENU items for sensor array, target description and location.
2. With vehicle on bottom in configuration for operations, start new heading error calibration sequence or use previous (valid) calibration, (following instructions given after exit from menu for calibration options). If a good calibration cannot be obtained refer to **2-4.2** above.
3. Neutralise system on initial search heading while >15 meters away from target (make sure all vehicle components (cameras, manipulators, etc.) are fixed in position and that vehicle is not near magnetic structures or debris.

NOTE: Avoid rapid or drastic vehicle control changes, since large systems transients produce magnetic noise. (Be cool, take it easy.)

Searching for ferrous objects is best carried out using a predetermined survey pattern, with the survey line separation set by the expected field strength of the objects to be located. It is advisable to operate the vehicle in an “Auto Heading” mode if possible, and good navigational information is essential to ensure good coverage.

If possible, object searching is best undertaken with Innovatum SMARTSEARCH Equipment, which is optimised for magnetic mapping functions.

4-2.6 TRACKING PROCEDURES

4-2.6.1 PASSIVE MODE - TROUBLESHOOTING

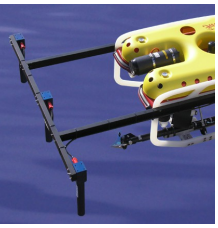
Several problems may be encountered whilst tracking in passive mode:

a) **Problem:** Loss of information at pipeline field joints, or where the armour pitch rotates in armoured cables.
Solution: The loss of coherent data at pipe joints is a normal occurrence, and should be expected. The vehicle operator should maintain a steady track through the joint area, and ignore any rapid variations in signal range or steering commands. The true signals will re-appear as the joint is passed.

b) **Problem:** Better performance on some pipe sections
Solution: As the magnetic field in a pipe is set during manufacture, and not normally monitored by the pipe installer, the orientation of the fields is random in a welded pipe. This results in the earth and pipe field adding together in some sections, and subtracting in others. The signals are thus stronger where the fields add, and weaker where subtraction occurs. Better data usually results when the pipe on the 3-D tracking display is “Green”, with poorer results on “Red” pipe. This is normal, and is most marked where the pipe is aligned with magnetic “North - South”.

c) **Problem:** Loss of signal on deeper sections
Solution: If the pipe or cable is small or weakly magnetised, and/or the vehicle is noisy, the tracking signals may be lost or difficult to follow occasionally. Reducing the range of the sensors to the pipe, either by “flying” the vehicle lower or physically reducing the height of the sensors on the vehicle.

d) **Problem:** Incorrect depth data when pipe is close to sensor array



Solution: Move further from pipe vertically. This problem is caused by two separate effects.

i) Poor geometric resolution when angles of array to pipe are shallow

ii) Local fields in pipe walls causing incorrect solution. Normally only a problem on larger diameter pipes.

4-2.6.11 FALSE TRACK ON "GHOSTS"

Refer to **4-2.5.11** above.

4-2.6.2 ACTIVE D.C. CURRENT MODE - TROUBLESHOOTING

Problems may occur when tracking communications cables with small D.C. currents used to drive repeater amplifiers. Due to the small fields generated by these D.C. currents, it is essential that the vehicle noise is as low as possible, and the sensors are as close as is practical to the target. Cables with a magnetised armour will produce an additional field, and it will then be necessary to track in "PASSIVE MAGNETISATION" mode, with the D.C. current input on the appropriate menu line.

4-2.6.3 ACTIVE A.C. CURRENT MODE - TROUBLESHOOTING

Active A.C. mode tracking is generally the easiest operational mode to use, as all passive and geographic fields are largely of no relevance. It is advisable to have the highest possible A.C. current. The following problems may be encountered:

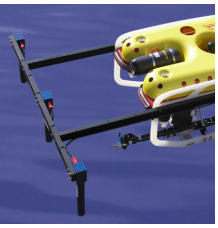
a) **Problem:** Noise.
Solution: The effects of vehicle noise may be minimised by carrying out a system magnetic spectral analysis, and if possible choosing a "Quiet" frequency to operate with.

b) **Problem:** Incorrect tracking and depth indications.
Solution: Incorrect tracking and depth indications are usually the result of conducting "current loops" close to the sensors. These loops may be part of the sensor frame, the vehicle structure or other sensors and equipment mounted on the vehicle. The tone current in the cable may induce a secondary current at the same frequency in the loop(s), and the sensors "see" the sum of the currents which leads t to false readings. Careful inspection of the area around the sensors may lead to identification of problem areas, and action to "break" the loops may then be taken. It should be noted that some loops may not be obvious, such as the internal strength members of water jetting hoses etc., and these can only be identified by relocation.

4-2.7 DATA GATHERING & INTERPRETATION

4-2.7.1 TRACKING SCREEN DISPLAY

To be issued.



4-2.7.2 DATA TRANSFER

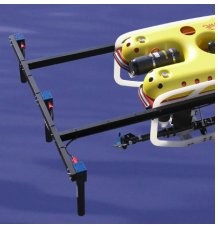
4-2.7.21 INNOVATUM SMARTRAK DATA OUTPUT STRING

Software revision PC2.01 dated 2009

Data is output asynchronously at the end of each computation cycle (0.1 to 0.5 sees) as an ASCII string of 80 characters(operator selected) terminated by <CR> and <LF>.

Default RS232 parameters are 9600 baud, 8 bits, 1 stop bit and no parity. No hardware or software handshaking is implemented. It is strongly recommended that every single output string is logged for subsequent post-processing or at least one every second.

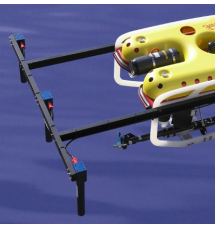
Characters	Description	
1 - 2	Space characters (20h)	
3 - 4	Day of month (1 to 31)	
5	Space character (20h)	
6 - 8	Month of year (first 3 letters)	
9	Space character (20h)	
10 - 13	Year (all 4 digits)	
14 - 15	Hour of day (24 hour clock)	
16	: character (3Ah)	
17 - 18	Minutes of hour (O to 59)	
19	: character (3Ah)	
20 - 21	Seconds of minute (O to 59)	
22 - 24	Relative heading (+ or -) in degrees i.e. vehicle heading minus target heading	
25	Mode	1 = passive 2 = active D.C. 3 = active A.C.
26	Solution	0 = no signal 1 = valid direction only 2 = valid horizontal displacement only 3 = valid horizontal & vertical displacements
27 - 30	Signal strength & polarity (logarithmic scale)	
31 - 33	Video overlay (percentage of horiz. displacement) i.e. -99 to +99 equals full left to full right	



34 - 35	Video overlay (percentage of maximum depth) i.e. 00 to 99 equals minimum to maximum
36	Source type 0 = single 1 = complex
37 - 41	Horizontal displacement of target in metres (from centre of array to centre of target where -ve = target to left and +ve = target to right)
42 - 45	Probable maximum error of horizontal displacement in metres
46 - 49	Vertical displacement of target in metres (from Innovatum reference to centre of target)
50 - 53	Probable maximum error of vertical displacement in metres
54 - 58	Vertical displacement from skids to top of target in metres (equals "depth of bury" ONLY if vehicle skids are level with seabed) ***OR*** Burial ("depth of bury") in metres (ONLY if altimeter option is both installed and enabled)
59 - 64	In ***passive*** mode - total normalised radial magnetisation of target. In ***active*** mode - estimated magnitude of current flowing in target. (in active D.C. mode, +ve indicates current flowing in same direction as vehicle heading)
65 - 69	Altitude in metres referenced to vehicle skids
70 - 72	Pitch angle (+ or -) in degrees
73 - 75	Roll angle (+ or -) in degrees
76 - 78	Absolute heading in degrees (from system's own fluxgate compass or from an external gyrocompass if interfaced and enabled)
79 - 80	Time split in 0.01 seconds if enabled (to be added to time of day if required)
81	<CR> character (0Dh)
82	<LF> character (0Ah)

4-2.7.22 PROCESSING OF SMARTRAK DATA

The Innovatum SMARTRAK data output string contains a large number of parameters in order to allow maximum flexibility in an external data processing system. This in turn means that some quality control checks must be incorporated into the external system before any individual parameter can be used for further processing with other parameters.



The most common requirement is to use the vertical displacement from the bottom of the appropriate sensors to the centre of the target. When combined with fixed offsets, data from altimeters or profilers and pitch/roll sensors, this parameter can be used to calculate "depth of burial" along the length of the target.

The best quality vertical data is always obtained when the sensor array is centered over the target and perpendicular to it - any significant horizontal or relative heading offsets will decrease the accuracy of the calculated displacement. A typical quality control procedure on a data output string might consist of the following checks:

SOLUTION = 3
VERTICAL ERROR < 0.15
-1.00 < HORIZONTAL < +1.00
-20 < RELATIVE HEADING < +20

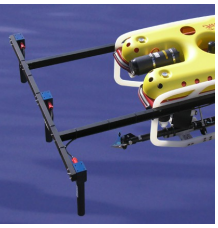
Only if all the tests are passed should the VERTICAL value be used to derive "depth of burial" using fixed vertical offsets and/or pitch, roll and altitude data. Similar quality control checks may also be required on data from the latter three sensors to ensure that the calculation of depth of burial is not compromised by poor quality or invalid components.

If any given string should fail any of these tests, the associated VERTICAL value should not be used to derive any other measurement. It is important that the value of any such measurement, whether displayed, printed or logged, should indicate in some way that the data from that particular string was invalid and not just remain at the previous valid value or be defaulted to zero.

For the majority of applications, it is recommended that any data logging format should include the following parameters as an absolute minimum:

- SOLUTION - ALTITUDE - RELATIVE HEADING
- VERTICAL - VERTICAL ERROR - HORIZONTAL
- PITCH - ROLL

This would allow complete post processing of vertical data at any future date. It may also be useful to record additional parameters from the Innovatum data string (such as SKIDS TO TOP (or BURIAL), MAGNETIZATION (or CURRENT), HORIZONTAL ERROR, SIGNAL STRENGTH, HEADING, SOURCE, MODE etc.) if the logging system has sufficient capacity but these are not normally regarded as essential.



4-2.7.3 DATA LOGGING OPERATIONS

Data logging is normally carried out via export to a “survey” computer, where the SMARTRAK data should be stored with a common survey system time stamp.