SEADIFF

Differential GPS Software

User's Manual v.7.01

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1. INTRODUCTION

1.1Disclaimer

This program and supporting information are finished by Seatex AS, and are accepted and used by the recipient with the understanding that Seatex AS makes no warranties, expressed or implied, concerning the accuracy, completeness, reliability, or suitability of this program, of its constituent parts, or any supporting data. Seatex AS shall be under no liability whatsoever resulting from any use of this program. The entire risk as to the quality and performance of the program and supporting information is with the purchaser.

This program should not be replied upon as the sole basis for solving a problem whose incorrect solution could result in injury to persons or property.

1.2General

Seadiff v.7.01 is a PC based software for GPS positioning and quality control. Extended functionality and access to all relevant parameters are offered through this software. Seadiff offers multiple reference station processing as well as relative positioning of external GPS transponders (Seatrack TBUs). Quality measures for differential GPS according to UKOOA recommendations are implemented.

1.3Revision History

Revision	*Date*	*Description*
0	97-08-04	Issued for the first revision of Seadiff v.7.01 and replacing all previous Seadiff manuals

1.4 Applicable Documents

[1] ICD-GPS-200, NAVSTAR GPS Interface Control Document

[2] RTCM Recommended Standards for Differential NAVSTAR GPS Service, v.2.1

[3] Quality Measures for Offshore Differential GPS, July 1993, UKOOA

[4] NMEA 0183 Standard for Interfacing Marine Electronic Devices, January 1992

2. INSTALLATION

2.1Hardware and Software Requirements

Seadiff v.7.01 will run on any 486 or Pentium based PC with a math co-processor. Since the math co-processor is included in the DX versions of 486 and the Pentium no extra processor will be required for PCs based on these processors.

At least 8.0MB of memory (RAM) will be required for running this version of Seadiff.

External communication with GPS receivers, RTCM links or other sensors are done via RS232 or RS422 serial lines. Standard COM1 and COM2 ports can be used, but it is not recommended to use these ports for high speed transmission, unless they are base on 16550 UART's (or equivalents).

The RS232 / RS422 multiple boards from Digiboard are supported. Standard or intelligent boards with up to 16 ports can be used. If intelligent Digiboards are used the driver must by loaded in accordance with the guidelines specified in the appurtenant documentation. Standard Digiboards can either be equipped with 16450 UART chips or 16550 UART chips. The 16450 UART is not recommended due to poor performance for high baud rates. The 16550 UART reduces the load on the PC processor significantly, hence, Digiboards with the 16450 UART should be upgraded with 16550 UARTs.

PCMCIA based RS232 cards for Quatech with 1,2 or 4 ports are also supported by Seadiff.

The Seadiff v.7.01 program will run under MS-DOS v.4.01 or later. To by-pass the well known 640Kb memory barrier in DOS, the Phar-Lap 286|DOS extender is used. This allows the program to access more than 640Kb of memory if EMS is available.

To prevent unlicensed use of Seadiff a hardware key has to be connected to the LPT1 port on the PC to be able to run Seadiff in real-time mode. The hardware key can be removed as soon as the communication with the GPS receiver is established.

2.2Start-Up

Prior to starting the program the hardware key has to be plugged into the LPT1 port (parallel) port of the PC. The Seadiff hardware key is marked *N 4PEA BH-B*.

The Seadiff v.7.01 are started be typing the name of the .EXE file (SDV701.EXE) followed by the name of a set-up file containing values for all parameters. A set-up file can be generated at any time saving the current set-up of all parameters (see description of menu F9).

When the filename is entered and the <Enter> key is pressed the following text will appear on the monitor:

```
D:\SEADIFF\sdv701 setup
      +-----------------------------------------------+
      |              Extended-DOS Power by            |
      |  Phar Lap's 286|DOS-Extender(tm) Version 3.1  |
      |     Copyright 1993 Phar Lap Software Inc.     |
      |           Available Memory = 30326 Kb         |
      +-----------------------------------------------+
```

Figure 2.1: Loading the Seadiff program

After a few seconds the start-up Seadiff window will appear:

```
 SEADIFF version 7.01      |           |           | 97-08-04 | 21:12:52




              +-----------------------------------------------+
              |  SEADIFF version 7.01          (c) SEATEX A/S |
              |                                               |
              |  1995 SEATEX A/S                              |
              |  User no: SC-000  Serial no: 000-97  97-08-04 |
              |-----------------------------------------------|
              |                                               |
              |  F1 - F9     Configuration menus              |
              |  F10         Exit to DOS                      |
              |  •-+         Start system                     |
              |                                               |
              |  Setup file: SETUP                            |
              +-----------------------------------------------+




1Comm  2Mode  3Config 4Format 5Monitr  6TBuoy  7TsPlot 8Geodet 9Files 10Quit
```

Figure 2.2: Seadiff start-up window

The top-line is displaying the program name and version number, the upper half part of the text window is displaying user number, revision number and production date. Either of the configuration menus (see chapter 5 for details) indicated by the bottom line can be accessed by pressing one of the function keys (F1 - F9).

Program execution is started by pressing <Enter>. If <Enter> is not pressed within 10 seconds Seadiff will automatically start with the current parameter set-up.

The following page is displayed when program execution is started:

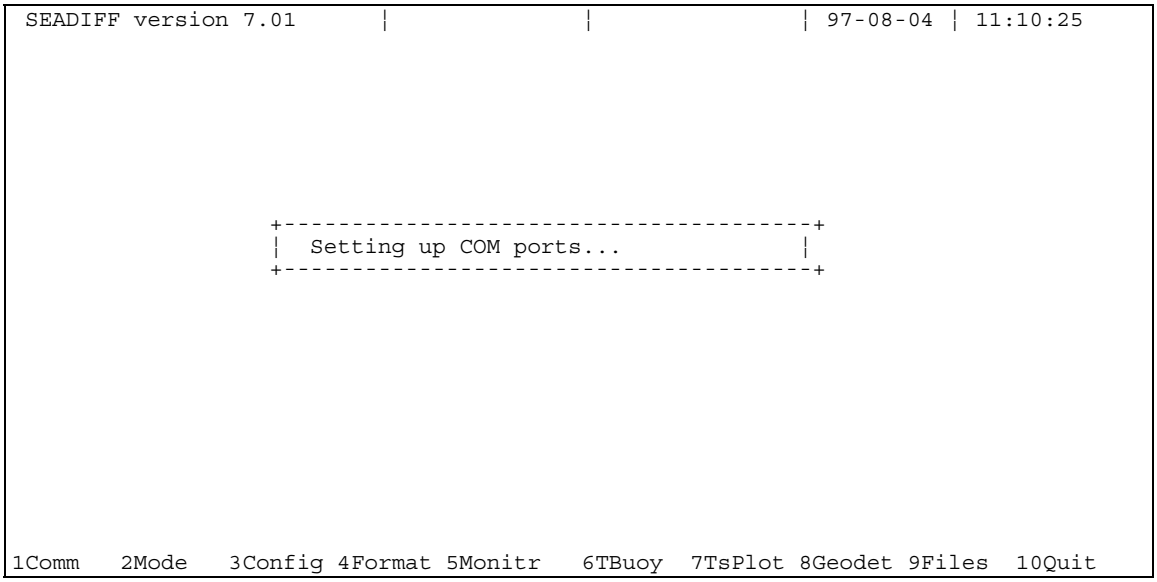

Figure 2.3: Initialisation of COM ports

This display indicates that initialisation of COM ports is executed. If the software COM port configuration (see chapter 5, F1-menu) is in conflict with the physical hardware configuration an error message will be displayed. An example is presented in figure 2.4. If this message is displayed the software COM port configuration should be inspected by pressing F1.

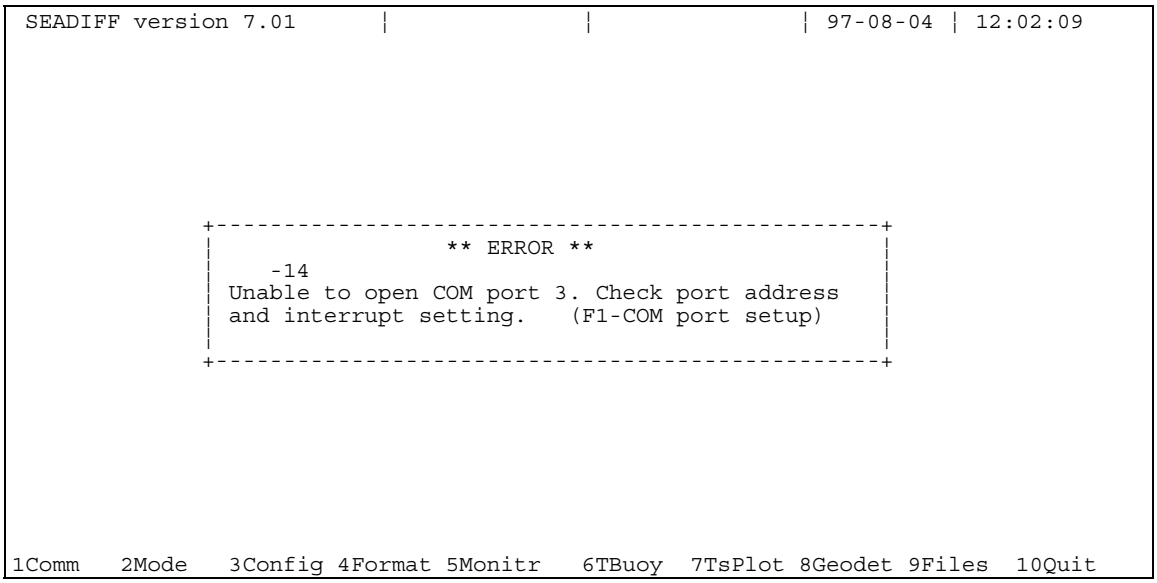

Figure 2.4: Error message for illegal COM port configuration

When the COM port settings are accepted and the program not is running in replay mode, the following display will appear:

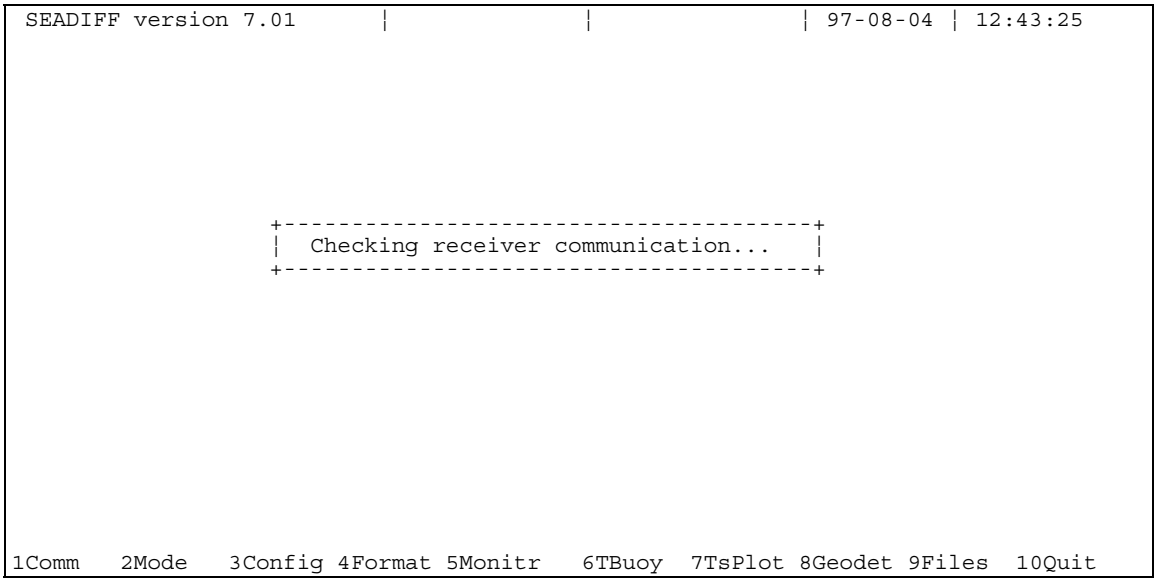

Figure 2.5: Checking GPS receiver communication

This is an indication of the execution of starting the communication process with the GPS receiver. If this communication fails the following display will appear:

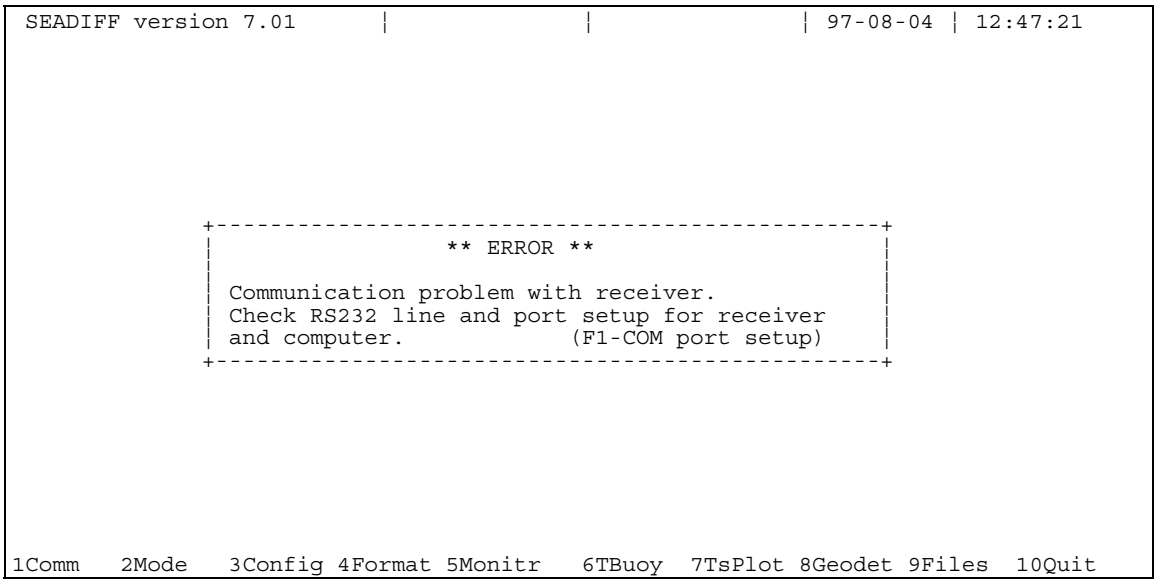

Figure 2.6: Error message - unsuccessful communication with the GPS receiver

If this happens the physical connection and software configuration of the COM ports should be checked. A successfully established contact with the GPS receiver is followed by:

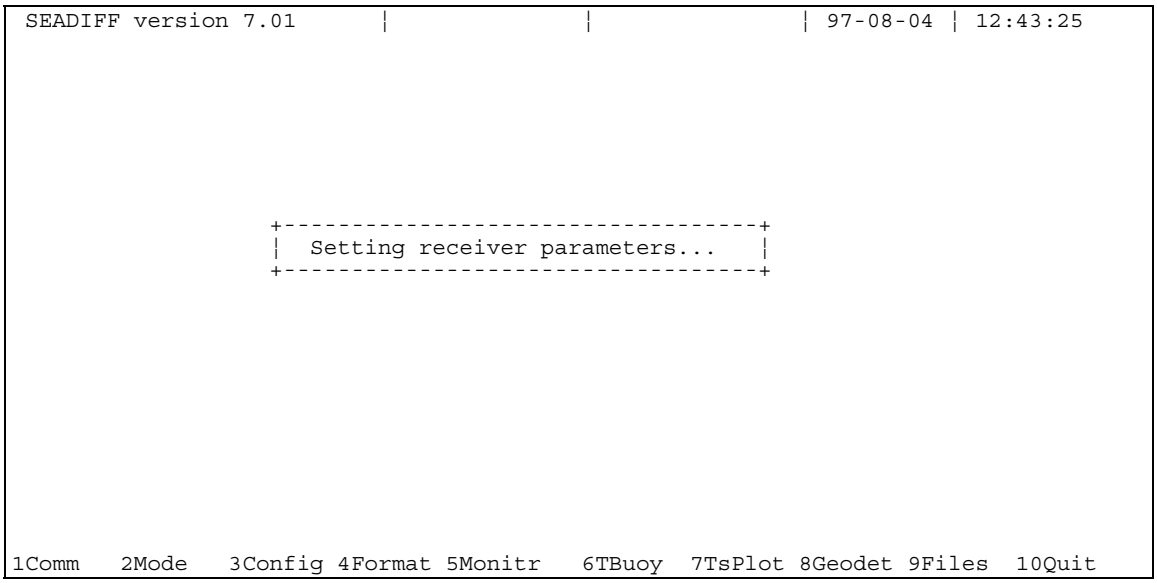

Figure 2.7: Setting GPS receiver parameters

The display showed in figure 2.7 is indicating that parameters are transmitted to the GPS receiver and that data is collected from the receiver. Depending on the baud rate and the receiver type this mode will last for some seconds.

When this mode is finished GPS navigation automatically will start.

3. MAIN FEATURES AND FUNCTIONALITY

GPS pseudo range corrections in RTCM or SCF (Super Compressed) format are applied to observed pseudo-ranges by the Seadiff. It is also possible let Seadiff re-transmit RTCM corrections via up to 4 ports.

Seadiff is able to decode data from up to 24 reference stations, and position fixes with data from up to 12 reference stations are calculated simultaneously. Which reference stations to monitor are selected by the user.

The program provides real-time screen presentation of position fix and correction data, as well as continuous monitoring of satellite quality parameters. Comparison between the reference stations is also possible Possibilities for data recording on disk, output to printer and output to main navigation systems are offered. The program provides time-series graphical plots of several types of data as e.g. differential corrections received by the reference systems, historical HDOP and VDOP values. The Seadiff also provides a time-series graphical plot with prediction of HDOP, VDOP and satellite coverage for the next period.

The position may be filtered based on Kalman filtering. The user can select different filtering parameters.

Seadiff may also be run in a replay mode with previously logged data and reproduce the same situation as in real-time operation.

3.10.1. Displays and Menus

Both text and graphics are exploited to give the user the necessary information of navigation and program status.

Different display pages are selected simply by pressing a number key from 0 to 9.

Historical data, real-time data and status or predictions of expected GPS performance will then be displayed. For the real-time pages the screen will be updated every program cycle, which normally means approximately once per second.

Due to the built in flexibility of Seadiff, the user is given the opportunity to change a wide range of parameters affecting the program mode and configuration. In real-time operation the user may select one of nine different menu pages for doing this. The menu pages are selected by pressing the function keys from F1 to F9.

The function key bar at the bottom of every display/menu page indicates the type of data contained by the different parameter menus.

Above the function key bar a status bar is displayed, containing error messages, warnings and simple status information.

A top bar common to all display and menu pages will tell the name and number of the display/menu page, program operation mode, logging (hard disk) status, date and time in UTC (Universal Time Co-ordinate).

Examples of the layout of menu pages and display pages are enclosed in chapter 4 and 5.

3.2RTCM 104/SCF Decoding

The Seadiff program can decode data from up to 6 different RTCM or SCF links. RTCM v.1.0, 2.0 and 2.1 are supported. Automatic detection of RTCM byte coding (6of8 or 8of8) and byte roll ON/OFF is done. See ref. [2] for details. Data from more than one reference station transmitted at the same RTCM link will also be decoded as long as the total number of reference station not exceeds 24. The program will also automatically detect whether corrections are received as RTCM or SCF data.

3.3Position Processing

Seadiff automatically calculates an estimate of the accuracy of each observed pseudorange based on the following information:

- URA broadcast via the ephemerides

- Distance to the reference station
- Age of differential corrections
- Satellite elevation angle
- Receiver measurement noise parameters

This estimate is used to weigh the observations relative to each other. Observations are combined by a least-square estimate or to a 3D or 2D position.

When the ellipsoidal height of the GPS antenna is known to a certain degree of accuracy the height can be used to aid the GPS position. This can either be done automatically or by operator interaction. The uncertainty of the height must also be entered. See menu F2 and F3 in chapter 5.

A filter for averaging the height solved by GPS is also included. The time-constant is extremely low due to the low dynamic height variations experienced at sea. When geometry or satellite constellation is bad, this averaged height can be used for aiding the position.

When data from more than one reference station is available several differential GPS positions will be calculated, one for each reference station. Several of these positions can be combines to obtain a system position (SYS). The system position will be calculated as a weighed middle of one or more of these positions. The weight is calculated both due to apriori estimates of accuracy and the residuals of the pseudorange measurements contributing to the position solution.

An alternative set of reference station data may be combined into an multiple reference station position (MULT). This position can be compared with the system position or any of the individual position solution based on corrections from only one reference station.

Virtual monitoring between reference stations can be done by selecting one station as a master. Then corrections from the other stations are subtracted from the master corrections. This correction differences are transformed to position errors which represents the absolute position error observed if the mobile receiver was co-located with the master reference station. The purpose of virtual monitoring is to be able to detected an ill behaving reference station independent of the local GPS observations.

3.4Tracking of Transponder Units

Seadiff will be able to track up to 24 remote transponder units of Seatrack type. Up to 4 Seatrack VCUs (Vessel Control Unit) can be connected via RS232 ports. Raw GPS observables will be received from each transponder unit, and the relative range / bearing vector calculated with an update rate of one per two seconds.

The calculation of range / bearing to a transponder will not be dependent on the reception of differential corrections. Even if the system position stops to update due to failure of the RTCM link, transponder position will still continue.

3.50.2. Quality Assessment of GPS Data

Quality assessment of GPS data is equally important as high accurate positions. The methods for quality assessment implemented in Seadiff is in accordance with the recommendation of the United Kingdom Offshore Operators (UKOOA). See ref. [3] for details.

The different parameters used are:

Type of measure	***Parameter***	***Definition***
Precision	95% a posteriori horizontal error ellipse	An ellipse describing the 95% confidence level of the position i.e. 95% of the position solutions will have an error less than the boundaries of the ellipse
Internal reliability	Marginally Detectable Errors (MDE)	Given a significance level and a power of the MDE test, the MDE is the largest outlier error to remain undetected in the position fix. The significance level describes the probability of rejecting good data along with the errors, and the power of the test describes the probability of detecting small outliers.
External reliability	Positional MDE	The positional effect of a MDE in one observation.
Outlier rejection	w-test	If the normalised residual (residual divided by its standard deviation) exceed a tabulated value given by a normal distribution an observation is rejected.
Position fix quality indicator	F-test	The unit variance statistics, largely driven by the weighted sum of squares of residuals, are used to indicate that a position solution is unreliably due to possible outliers in the observations. The square root of the unit variance is the standard deviation of unit weight (SDUW).

Table 3.1: GPS quality parameters

3.60.3. Error and Warning Messages

The following error and warning messages can be generated by Seadiff:

Error or warning message	***Explanation***
Warning: No free disk space	The logging device (hard disk) is full. Stop the Seadiff program and remove data from the disk.
Warning: No new GPS position fix	Seadiff has been unable to solve a new position due to errors in data from the GPS receiver or the RTCM corrections.
Warning: No new tailbuoy position fix	Seadiff has been unable to solve a new range / bearing to one of the transponder units due the errors in data from the GPS receiver or the transponder.
Warning: HDOP above limit - no position	The HDOP limit set by menu F3 is exceeded and the position rejected.
Warning: VDOP above limit - no position	The VDOP limit set by menu F3 is exceeded and the position rejected.
Warning: SDUW above limit for position	The upper limit if the standard deviation of residuals set by menu F2 is exceeded. Possible indication of reduced accuracy of the position fix.
Warning: HDOP above limit - 2D position	Automatic switching from a 3D to a 2D position solution due to a high HDOP value (see menu F3).
Warning: VDOP above limit - 2D position	Automatic switching from a 3D to a 2D position solution due to a high VDOP value (see menu F3).
Invalid ephemeris PRN 3	Ephemeris for this satellite contains values out of range. Try to reset the GPS receiver and the Seadiff computer.
Need 3 SVs for tailbuoy position fix	Not enough common satellites observed by the GPS receiver and the transponder unit to calculate a range / bearing solution.
Warning: System-Mon ID Diff > Limit	The position difference between the system position and the position solved by using data from one of the reference stations has exceeded the limit specified by menu F2.

Warning: RTCM age exceeded Link	The age of RTCM corrections exceeds the limit specified by menu F2. Corrections are rejected.
Error: No echo TRIMBLE receiver	The Trimble receiver does not respond to commands from Seadiff. Check the connection and COM port configuration.
Error: UTM central meridian, check F8	Since Seadiff not will change central meridian for UTM positions automatically it will be necessary to enter an allowed value via menu page F8. Seadiff will always remember the previous value.
Error: Read - replay file	The raw-data file is of wrong type or destroyed.
End of replay file. Alt-R restarts.	The replay of a logged data file is finished. To re-run the same file press <Alt-R>.
Printer is NOT READY	Unable to execute printing of data.
Printer is OFF LINE	Unable to execute printing of data.
Parity check Tailbuoy: message failed	Parity check failed for transponder data. This will occur relatively often due to radio noise or difficult transmission conditions.
Invalid Trimble measurement Ch n	Invalid measurements from one of the channels of the GPS receiver is detected. Data will be rejected.
Warning: Data > 8 sec old from TBU	When the time difference between data from the GPS receiver and the transponder exceed 8 seconds the data will be rejected.
No convergence in Tailbuoy pos.fix	Unable to solve transponder range / bearing. It may be necessary to restart the program if this happens.
Tailbuoy position rejected	The range / bearing calculation from one of the transponders is rejected due to errors in the data.
High HDOP = 99.9 - no new pos. TB 12	HDOP is above the limit for position calculation for TBU no. 12.
Tailbuoy link: Checksum error	A TBU message has failed the checksum algorithm.
Warning: Historical plot error	Unable to create time-series plots.

SCF data overflow !	The SCF data is received to fast to be decoded. This may be caused by a slow computer.
No output of RAW data. Turn logging ON!	Raw data is only output via an RS232 port if logging is turned ON. Logging rate (F9) will also apply for raw data output via serial port.
Unable to read SCF, change to RTCM	If SCF is selected for correction link input, the program automatically will try to interpret the data as RTCM after some time.
Unable to read RTCM, change to SCF	If RTCM is selected for correction link input, the program automatically will try to interpret the data as SCF after some time.
Illegal def. of TBU ID for GECO format!	Output of GECO format requires TBU ID defined as a number in the range 0-99. Seadiff will basically allow any string of up to 5 characters.
ASYNCH ERROR - PORT no: n	COM port communication error. If this message occurs often it indicates a marginal COM port configuration
RTCM parity check L1 failed	Parity errors in the RTCM message is detected and the message rejected.
No IODE match PRN = 3	No match between IODE for corrections and raw data for satellite PRN 3.
Warning: Wild point edited	The system position is rejected due to bad match between solved and predicted position (see menu F2).
Warning: Buffer L1 full, data removed	Input buffer overflow from COM port 1. May indicate marginally COM port configuration or a slow processor
Warning: Unable to decode RTCM data	Correction data not coded in accordance with RTCM

Table 3.2: Seadiff error and warning messages

4.DISPLAY PAGE DETAILS

4.1GPS Coverage Prediction

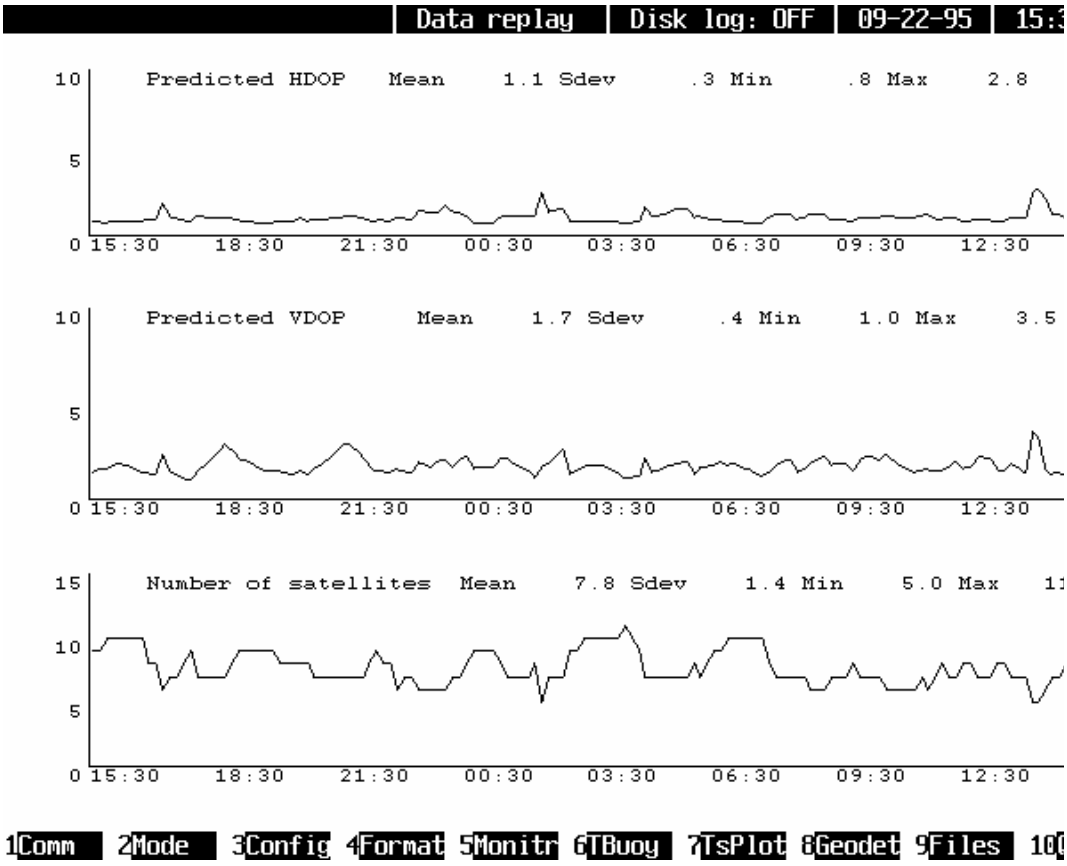

Figure 4.1: GPS Satellite Coverage Prediction

Page 0 presents time-series plots of predicted HDOP, VDOP and number of visible satellites for the next 24 or 4 hours. The GPS mask parameters (elevation mask, disable PRN and ignore health) at menu page F3 will affect the plots. To alter between a 24 hour and a 4 hour prediction period press 0.

4.2DGPS Position and Quality Control

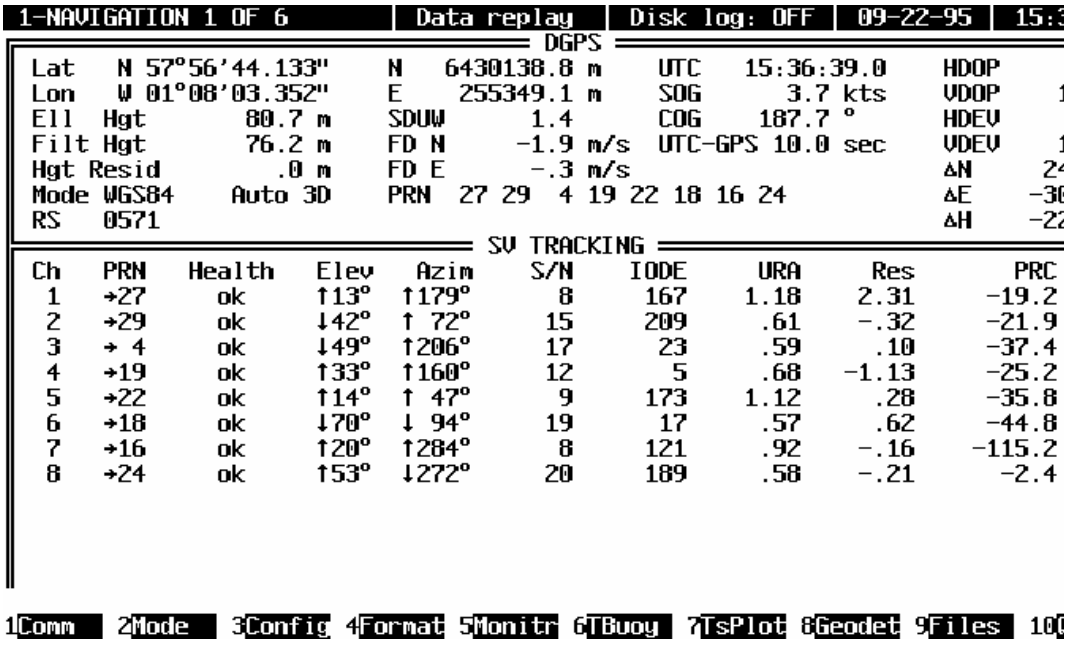

Figure 4.2: DGPS position and satellite information page

The DGPS position and quality control display page will be displayed by pressing the 1-number key and is divided in two windows, where the upper window shows system position and pertinent data. The contents of the lower window will be one of six different types, which can be altered by pressing the 1-number key.

The upper window will show the latest update of the system position both in geographical (latitude / longitude) and projection (Northing / Easting) co-ordinates. Height (*Ell hgt*) is given relative to the selected ellipsoid (default is WGS84) and does not indicate the height above sea-level. The filtered height (*Filt hgt*) is also displayed.

In 3D and height aiding mode the height residual is shown if an over determined fix is solved. This is a good indicator of an erroneous input of height in height aiding mode.

The *mode* parameter is indicating which datum that is used and if 3D or Height Aiding mode is selected.

The active reference stations (*RS*) are listed by the RTCM ID numbers. The nearest station is first and the most distant station is the last station listed.

The standard deviation of unit weight (*SDUW*) is based on the SDUW for the nearest, valid reference station. SDUW is including height residuals also when height aiding is selected.

FDN and *FDE* is the first differences based on the system position in Northing and Easting respectively. The first difference is defined as the difference between two adjacent positions divided by the intervening time (equal to speed made good).

A list of the *PRN* numbers for the satellites used in the position fix based on corrections from the nearest reference station is given.

UTC indicates the time-tag for the latest update of the system position in the UTC time reference system. UTC differs from GPS time by an integer number of seconds.

SOG and *COG* is speed-over-ground and course-over-ground based on adjacent DGPS position fixes. Units are knots and degrees from north respectively.

LOG and *GYRO* readings will be displayed if external input of such data is available.

UTC-GPS presents the time difference between the UTC and GPS time scales. (A leap second is added to the UTC time scale typically every 18 month.)

HDOP and *VDOP* are based on data from the nearest reference station. These values will also reflect the effect of using the height in height aiding mode. If height aiding is turned ON both HDOP and VDOP are expected to be reduced.

HDEV and *VDEV* is the horizontal and the vertical component of the expected 1σ value of the position. These are apriori values based on geometry and weight of individual observations.

ΔN, *ΔE* and *ΔH* are the position difference between an un-corrected GPS position and the DGPS position for the nearest reference station.

4.2.1SV Tracking Parameters

The first of the bottom window options is showing several status parameters related to the tracking of GPS satellites. Each row is allocated data from one of the GPS receiver channels as indicated by the *CH* column title.

PRN is the pseudo random noise code identifying the individual satellite. An arrow is indicating that a satellite is used in the position fix based on data from the nearest reference station.

Health is either OK or BAD indicating the contents of the health flag transmitted via the ephemeris data.

Elev/*Azim* is the elevation and azimuth angle for each satellite. The arrow indicates whether the value is increasing or decreasing.

S/N is the signal to noise ratio reported by the GPS receiver.

IODE is the Issue-of-Data reported by the ephemeris. This number is used to identify the individual ephemeris data set and must match the IODE used to calculate the DGPS corrections at the reference station.

URA is the User Range Accuracy which is an indicator of the accuracy (1σ) differentially corrected pseudo-range observation. This number is calculated as a function of elevation angle, age of corrections, distance to the reference station and GPS receiver independent parameters. If single station GPS mode is used, this number will mainly reflect whether SA is turned ON or OFF on individual satellites.

Res is the residual of the individual satellite pseudorange observation when an over determined solution is calculated. The unit is metres.

PRC is the value of the pseudorange correction applied to each pseudorange measurement. Data from the nearest, valid reference station are displayed.

4.2.2Multiple Reference Status 1

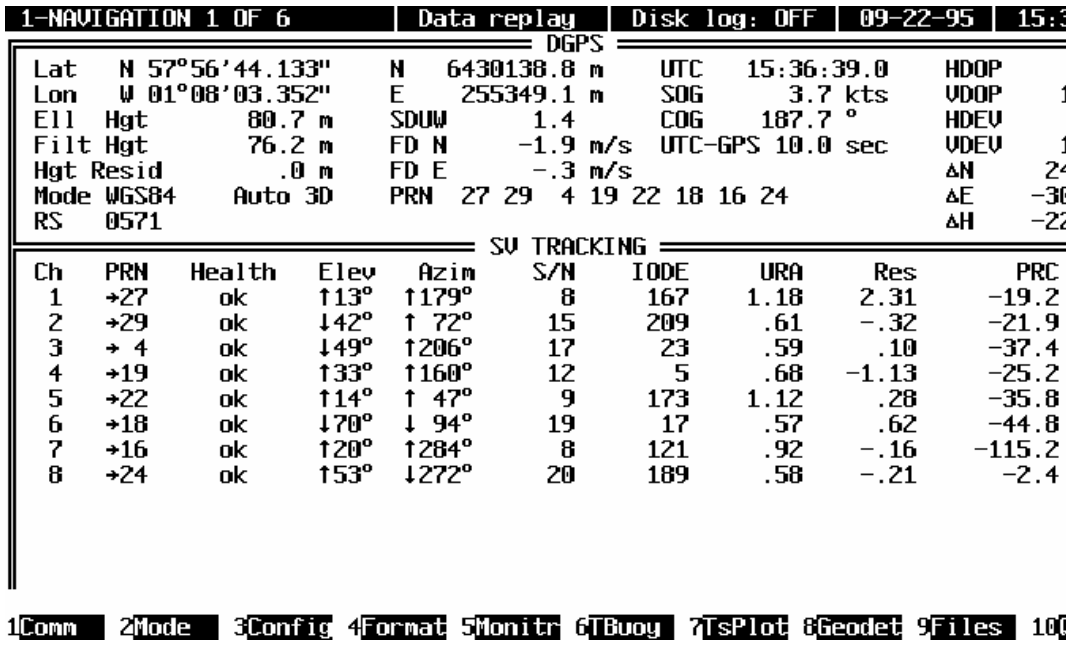

Figure 4.3: Multiple reference station information - page 1

REF is showing the ID for each reference station observed. The list is sorted with the nearest reference station at top and the most distant station at bottom.

ΔN, *ΔE* and *ΔH* is the position difference between the individual position solution using data from a reference station and the system position (see the upper window).

PRN simply shows which satellites that are tracked by the different reference stations.

SDUW is the Standard Deviation of Unit Weight for the position fix based on individual reference stations.

The instantaneous value of SDUW can be close to 0 or much larger than 1, but averaged over time the value should approach 1. If the average value of SDUW approaches a value different from 1 the accuracy estimates can not be trusted. Therefore, *FSDUW*, shows a filtered value of SDUW. The filtered value of SDUW includes information from approximately 1000 samples.

Because different satellites are observed by the reference stations in a wide-area network, the *HDOP* will vary for each reference station. The HDOP will normally show a larger value for more distant stations than for close stations.

4.2.3Multiple Reference Status 2

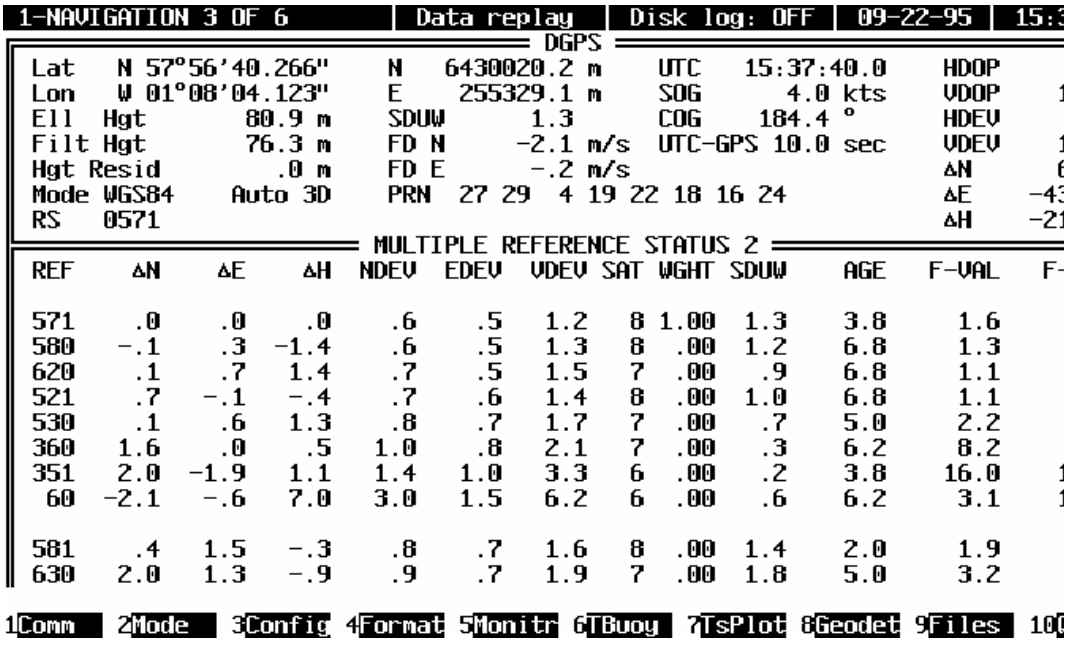

Figure 4.4: Multiple reference station information - page 2

REF is showing the ID for each reference station observed. The list is sorted with the nearest reference station at top and the most distant station at bottom.

ΔN, *ΔE* and *ΔH* is the position difference between the individual position solution using data from a reference station and the system position (see the upper window).

NDEV, *EDEV* and *VDEV* shows the apriori 1σ estimate of position accuracy in Northing, Easting and height. No information of residuals is coupled back to these values.

SAT shows the number of satellites used for the position fix. It is typical that close stations shows a larger number that remote stations.

Data from several stations can be combined into the system position. This is done by giving each station individual weight based on information about apriori accuracy and the residuals. The *WGHT* column is displaying the relative weight for each station contributing to the system position. The sum of this column is 1.

SDUW is the Standard Deviation of Unit Weight for the position fix based on individual reference stations.

The *AGE* of the differential correction when they are applied is shown in a separate column.

F-VAL and *F-TAB* is the measured F-Test value and the tabulated value respectively. No rejection is done if the calculated value exceeds the tabulated value. This should only be used as an indication of an unreliable position fix.

4.2.4W-Test Information

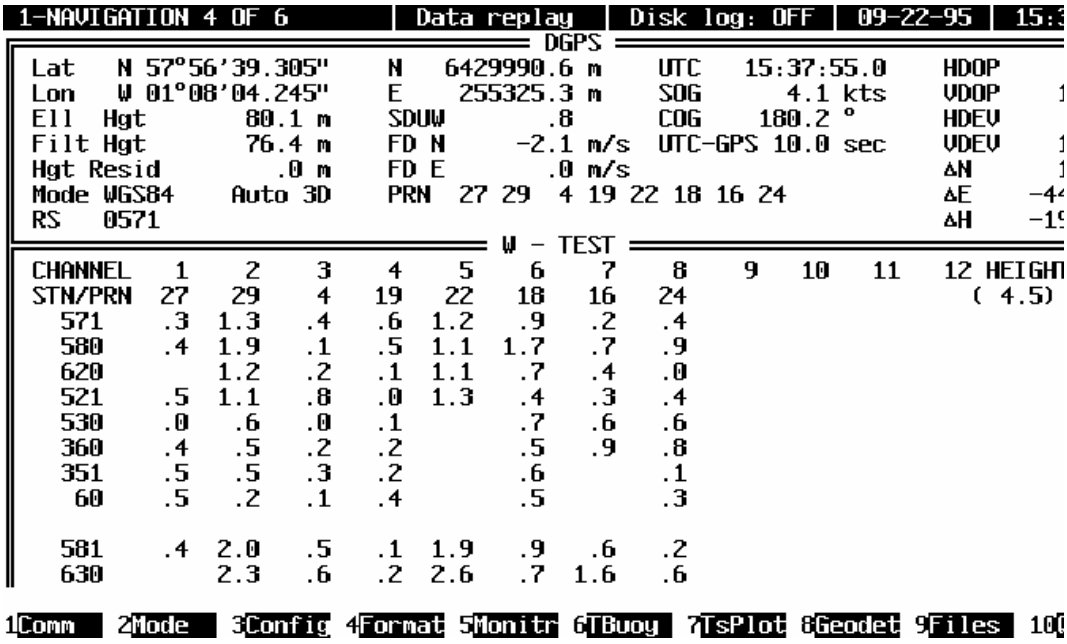

Figure 4.5: W-test information

This page shows the W-test values for each station and each satellite. If height aiding is ON and the height is used as an observable, the w-test value for the height input also is showed. The tabulated W-test value us shown in parentheses beneath the HEIGHT text. Up to one satellite (or the height) from each station will be rejected if the tabulated value is exceeded. The text REJ will then replace the W-test value.

4.2.5Marginally Detectable Errors

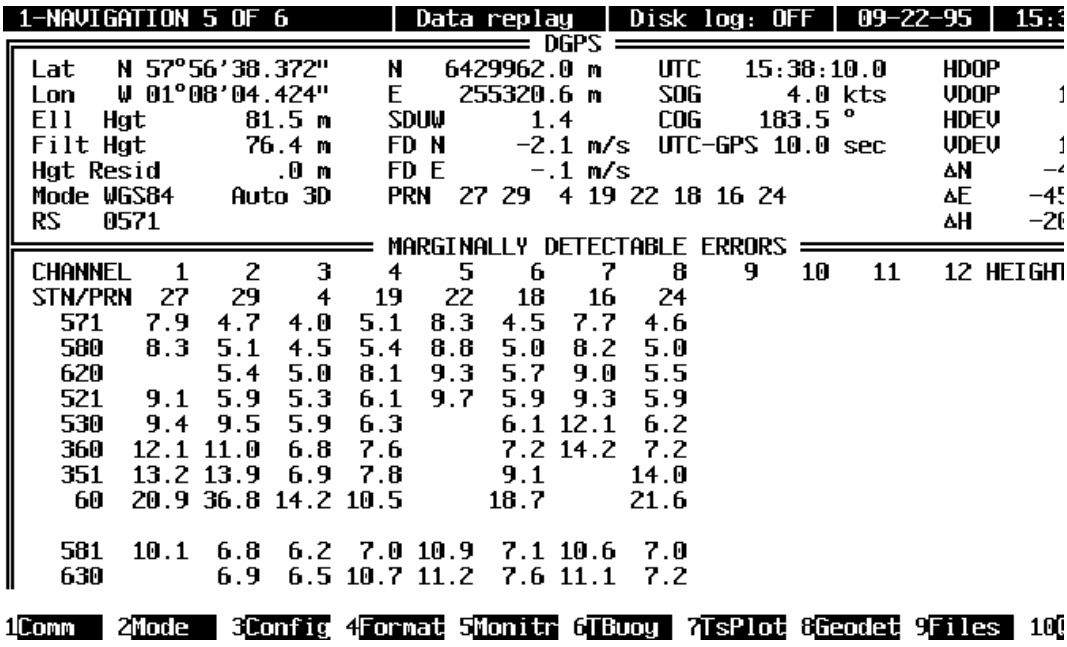

Figure 4.6: Marginally detectable errors

This page shows the marginally detectable errors for each station and each satellite. If height aiding is ON and the height is used as an observable, the marginally detectable error for the height input also is showed.

4.2.6External Reliability

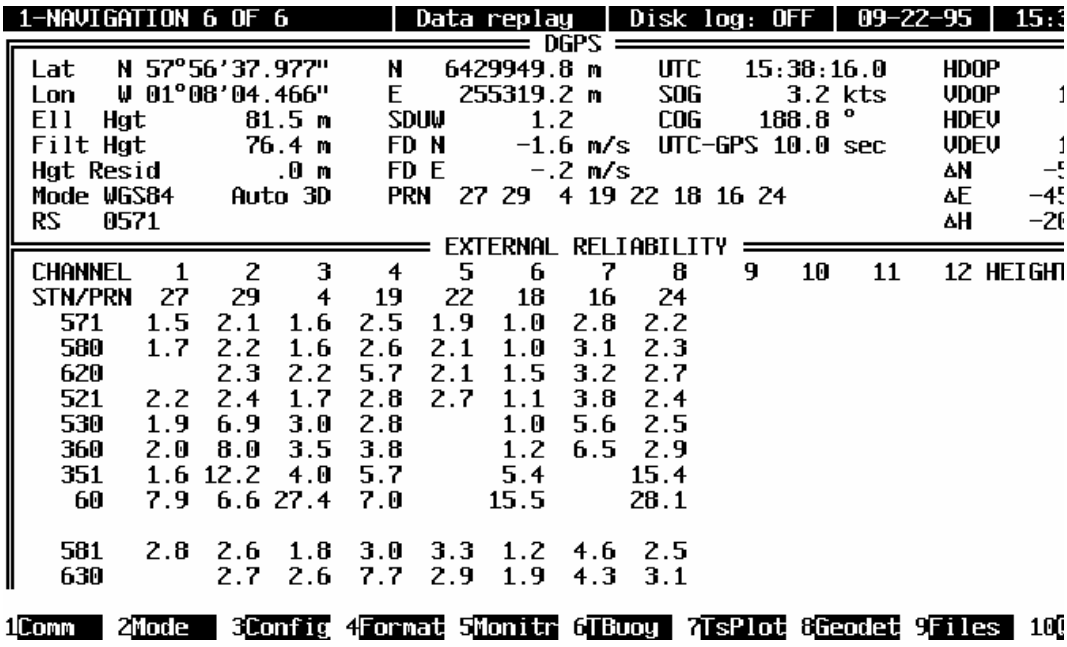

Figure 4.7: External reliability

This page shows the external reliability for each station and each satellite. If height aiding is ON and the height is used as an observable, the external reliability for the height input also is showed. The external reliability shows the horizontal error of the position if an error equal to the marginally detectable error occurs in the measurement from a satellite.

4.3Track Plot and Error Ellipses

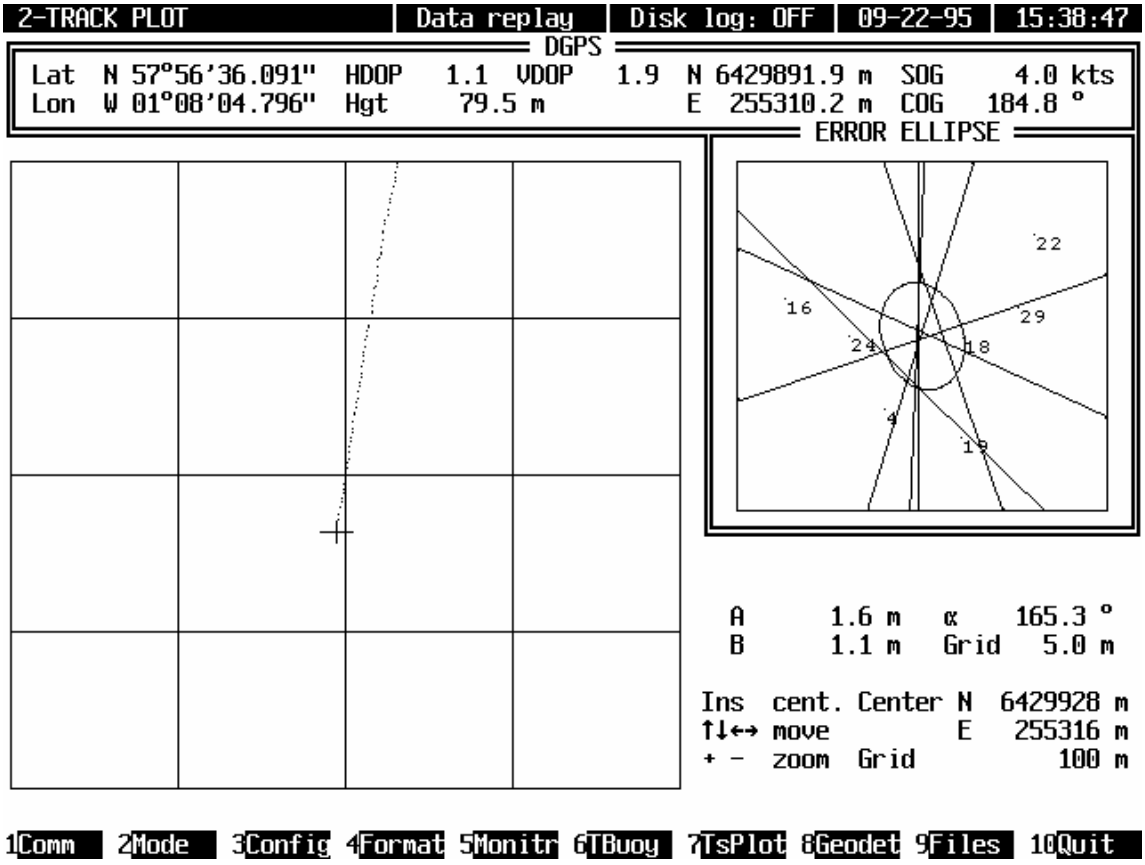

Figure 4.8: Track plot and error ellipse

This page will be available by pressing the 2-number key. Four different options are available by pressing the 2-number key.

4.3.1Track Plot and Error Ellipse for the System Position

The system position will be displayed as a cross relative to a grid. If the program is receiving data from one or more transponders these positions also will be displayed in this plot. The centre of the track plot and the grid spacing is shown in the lower right window. The scale and the centre of the plot can be changes by using the +/- and arrow keys. Pressing the INS key will centre the plot to the current system position.

The right middle window is displaying several types of information.

The error ellipse for the system position is shown in a grid with spacing as defined on menu page F4. Major (A) and minor (B) half-axes and the orientation (α) of the error ellipse is also presented.

The position of each satellite relative to the user antenna is shown in conjunction with the error ellipse. Three circles representing 0, 30 and 60 degrees elevation angles are

drawn and each satellite represented by the PRN number. Straight lines are representing the pseudorange residual for each satellite.

4.3.2Reference Station Error Ellipses and Location - 1

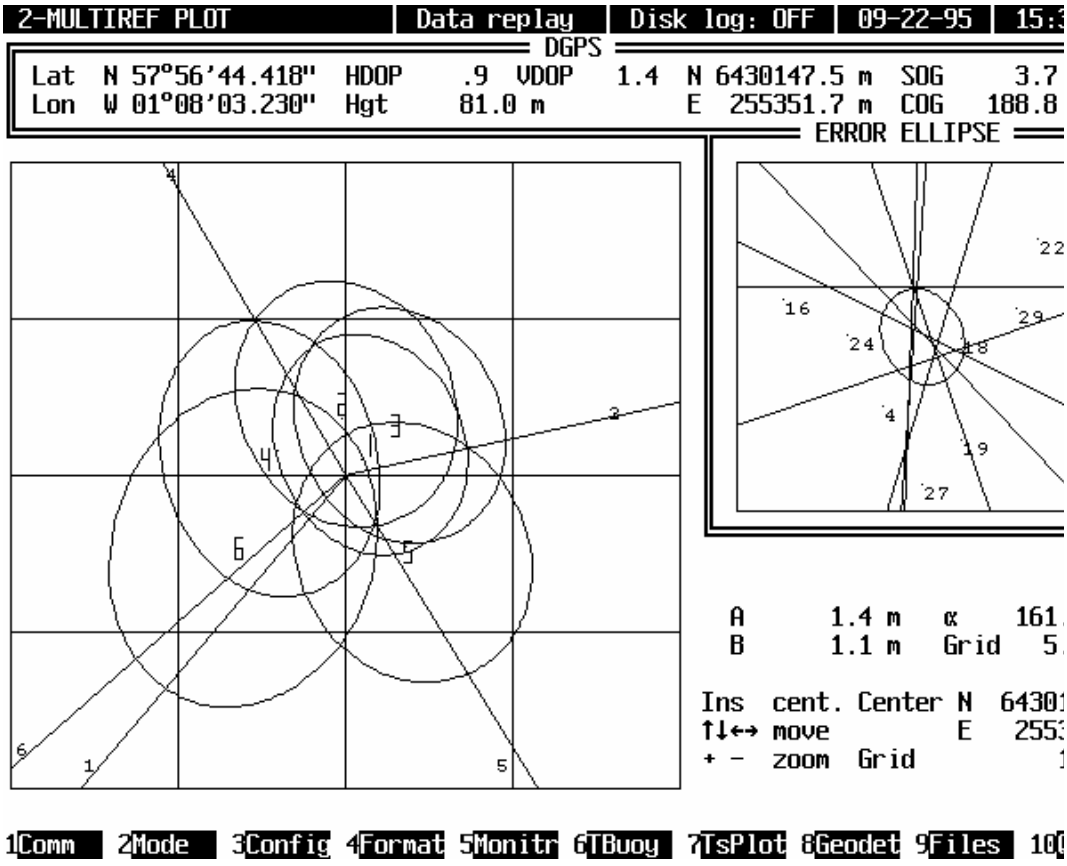

Figure 4.9: Reference station error ellipses and location-1

The main window is presenting the error ellipse for each reference station. Up to 12 stations can be displayed. The stations are numbered as 1,..,9,A,B,C sorted by the distance from the mobile unit. A straight line from the system position to each reference station is also drawn. All positions are presented relative to the system position.

The system position error ellipse and satellite positions are shown as for the previous plot.

4.3.3Reference Station Error Ellipses and Location - 2

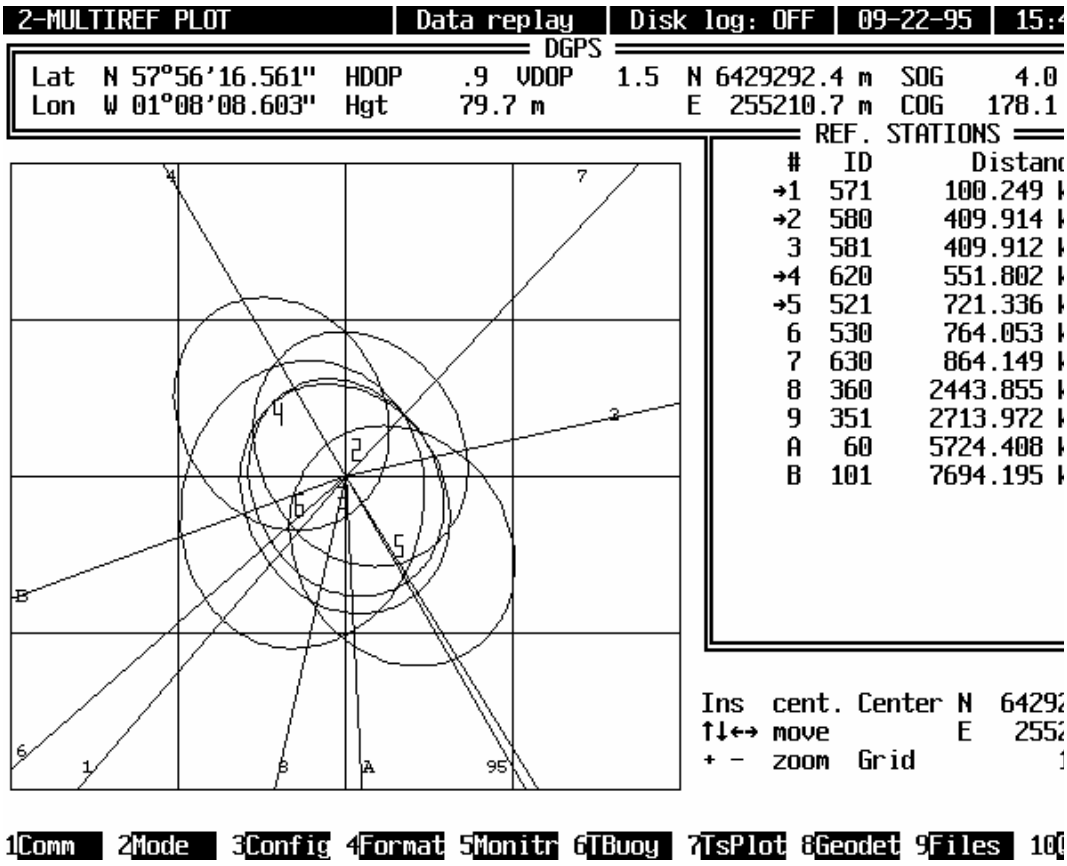

Figure 4.10: Reference station error ellipses and location-2

This is the same plot as shown in figure 4.9 except from the right middle window that is listing each reference station ID and the respective numbers used in the track plot. The distance to each station in km is also listed. An arrow is indicating which stations that are used for the system position.

4.3.4Track plot of transponders

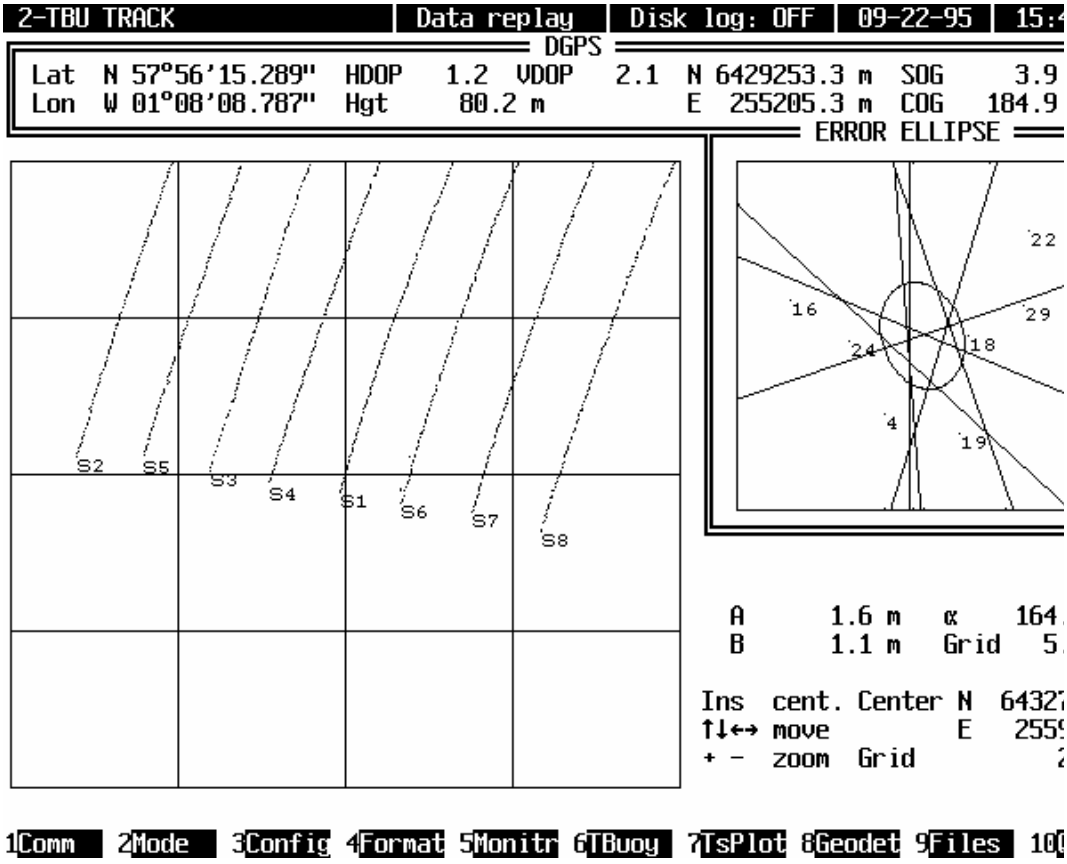

Figure 4.11: Track plot of transponders

It is also possible to centre the plot on one of the Seatrack transponders. This is offered by the last variant of display page 2. The same transponder selected for display page 7 will be highlighted. Opposite to display page 7, this page will not display positions relative to the vessel, but transponder absolute transponder positions.

4.4DGPS Corrections and Status

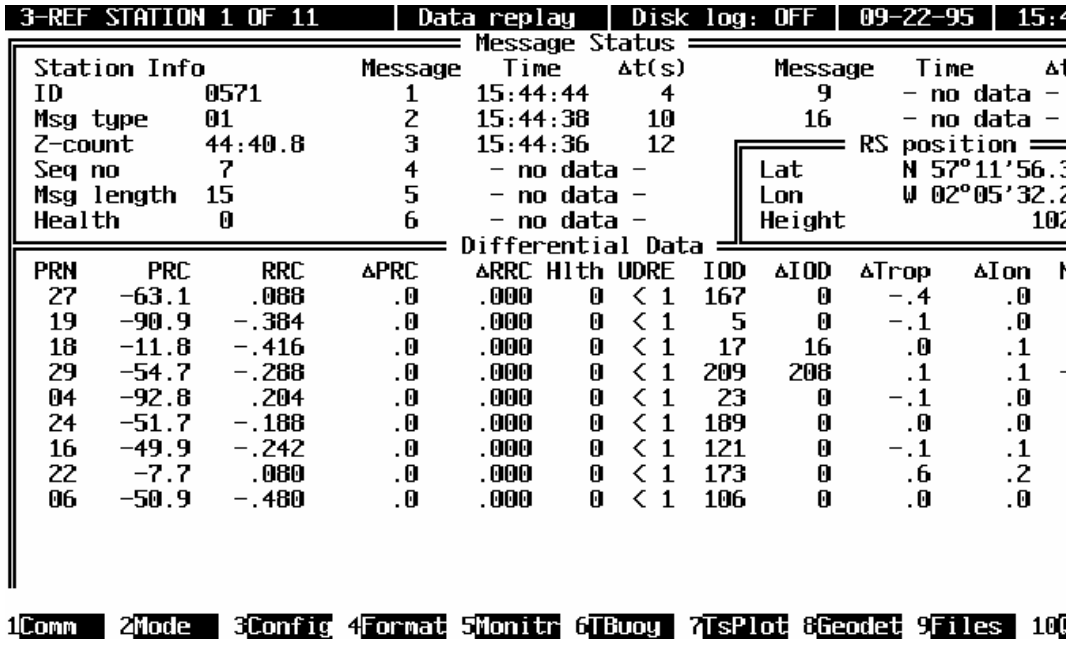

Figure 4.12: Reference station data

Data and status from the reference stations are displayed when pressing the 3- or 4-number key.

4.4.1Reference Station Data

Each time 3 is pressed data from a new station is presented as shown in figure 4.10.

The upper window contains information on which RTCM message types (see ref. [2]) that are received and the time since the last update of each message type. As indicated in figure 4.11 message types 1,2,3,4,5,6,9,16 and 17 are implemented.

The reference station position is displayed in geographical co-ordinates when a type 3 message is received.

PRC and *RRC* is the pseudorange correction and range rate correction transmitted by type 1. *UDRE* is an estimate of the uncertainty of the pseudorange corrections calculated at the reference station. *IOD* is the Issue of Data for the type 1 message.

ΔPRC and *ΔRRC* is delta pseudorange correction and delta range rate correction transmitted by type 2 data. *ΔIOD* is the Issue of Data for the type 2 message.

Hlth is the data health indicator transmitted by type 5 data.

ΔTrop and *ΔIon* is the differential values of tropospheric and ionospheric delay calculated at the mobile unit. Since these values are calculated by the Seadiff software they are not connected to any of the RTCM messages.

The last column is listing the normalised residual for each pseudorange observation.

4.4.2Reference Station Overview

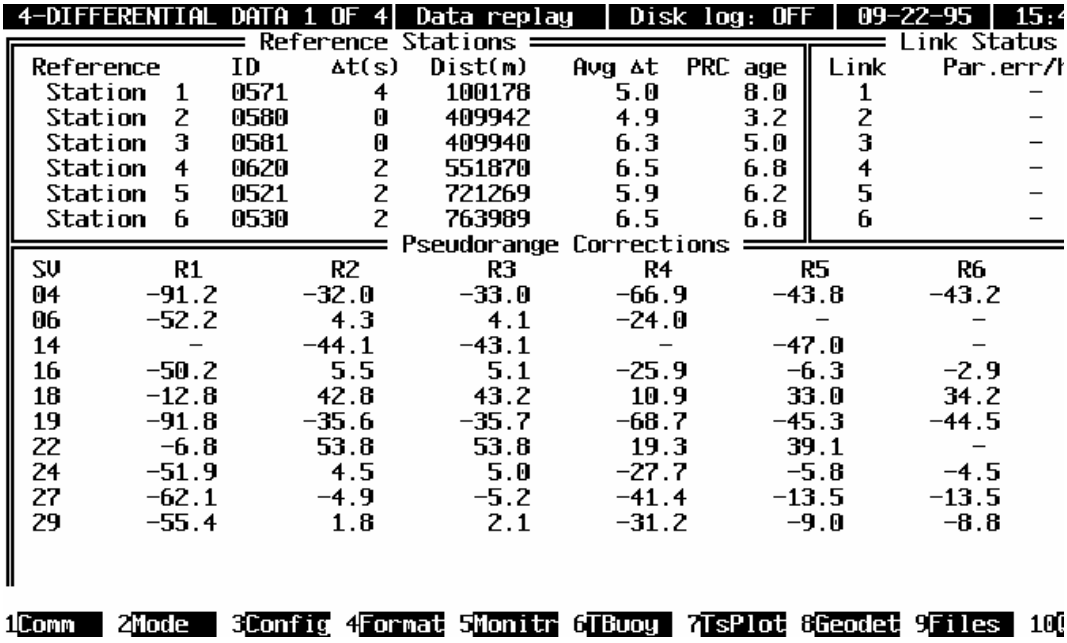

Figure 4.13: Reference station overview

Pressing the 4-number key will toggle between the 6 and 6 stations.

The upper left window shows the reference station ID, time since last update of message type 1 (*Δt*), distance to the station in km (*Dist*), average message type 1 update time over the last hour (*Avg Δt*) and age of the pseudorange corrections when applied (*PRC Age*).

The upper right window shows the number of RTCM parity decoding error per hour for each RTCM link connected.

The bottom window displays the pseudorange corrections from each station and satellite.

4.5Virtual Monitoring

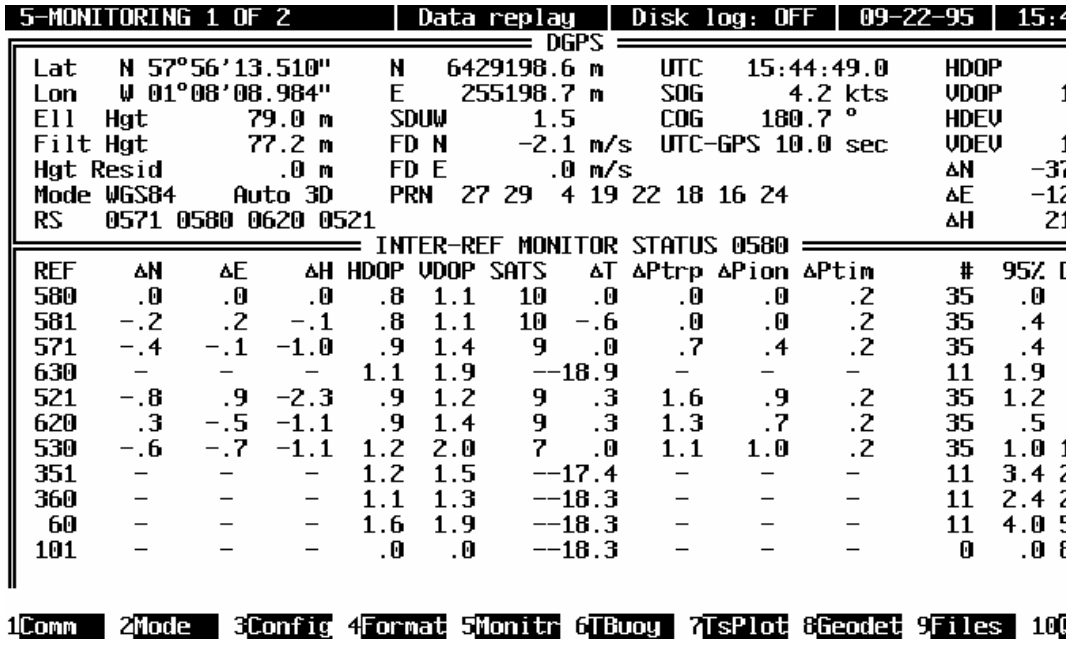

Figure 4.14: Virtual monitoring

The upper window of the virtual monitoring page is similar to display page 1. The bottom window is showing different parameters derived from defining one of the reference stations as monitor (station 580 in figure 4.14). Hence the each line is displaying the following data for the monitored reference stations:

ΔN, ΔE, ΔH are the Cartesian components of the position error using the reference station (*REF*) as reference station at the monitor station site.

HDOP and *VDOP* is the DOP values for the monitor position fix, and *SATS* the number of satellites used. *ΔT* is the time difference between the corrections and the monitor data (virtual propagation delay, as observed at the monitor station).

ΔP_{trp} and ΔP_{ion} is the horizontal positional effect of applying standard GPS model corrections for troposphere and ionosphere to both reference station corrections and monitor data. ΔP_{tim} is the corresponding effect of a virtual time delay (entered in menu F5).

is number of position fixed included in the *95%* values. The *95%* value is the 95 percentile for the horizontal position errors, hence 95% of the included position fixes have an error less than the value in this column.

Dist is the distance in km between the monitor station and the actual reference station.

4.6Transponder Tracking

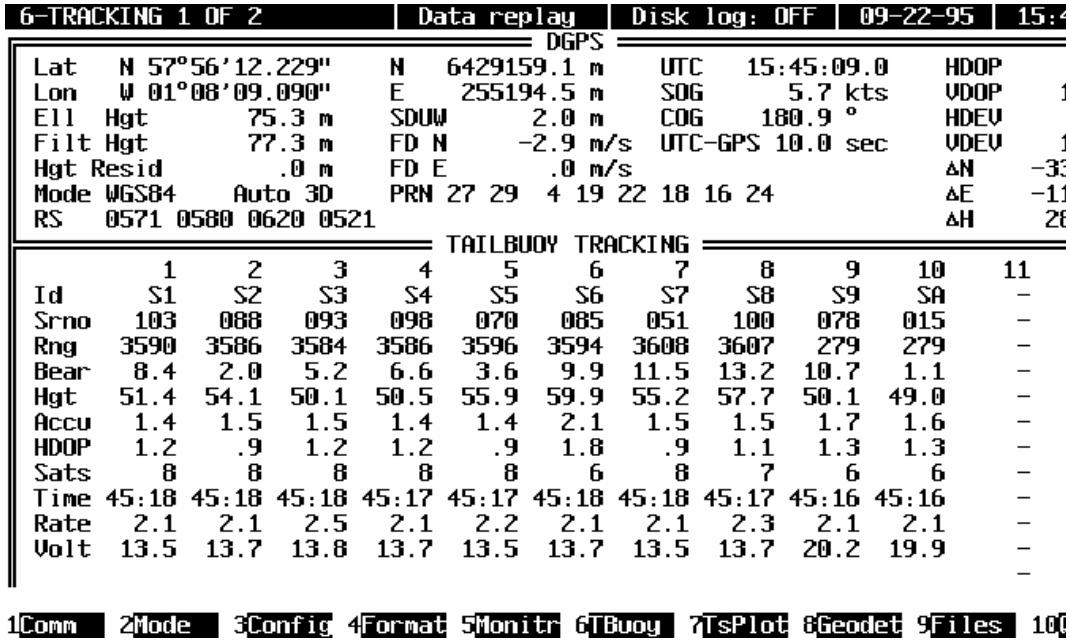

Figure 4.15: Transponder tracking information-1

The upper window of this page (6) is exactly like the upper window of the page (1).

The lower window is displaying data from up to 12 transponder units (Seatrack). By pressing 6 the contents of the lower window will alternate between data from transponder 1-12 and 13-24.

ID is either automatically generated or entered via menu F6. *Srno* is the unique serial number for the Seatrack transponder unit. Range (*Rng*) in meters and bearing (*Bear*) in degrees from the connected GPS receiver antenna to the transponder are also displayed. The *Hgt* parameter shows the ellipsoidal height of the transponder antenna. Estimated accuracy based on a combination of apriori data (geometry and weight) and residuals is presented in the *Accu* parameter. *HDOP* and number of satellites used for the position fix (*Sats*) are included. *Time* represents the time-tag for the last position update in minutes and seconds. *Rate* is the average update rate for data from the transponder unit, while *Par* is a counter for parity errors detected on the transponder radio link. *Volt* is the power voltage measured by the transponder.

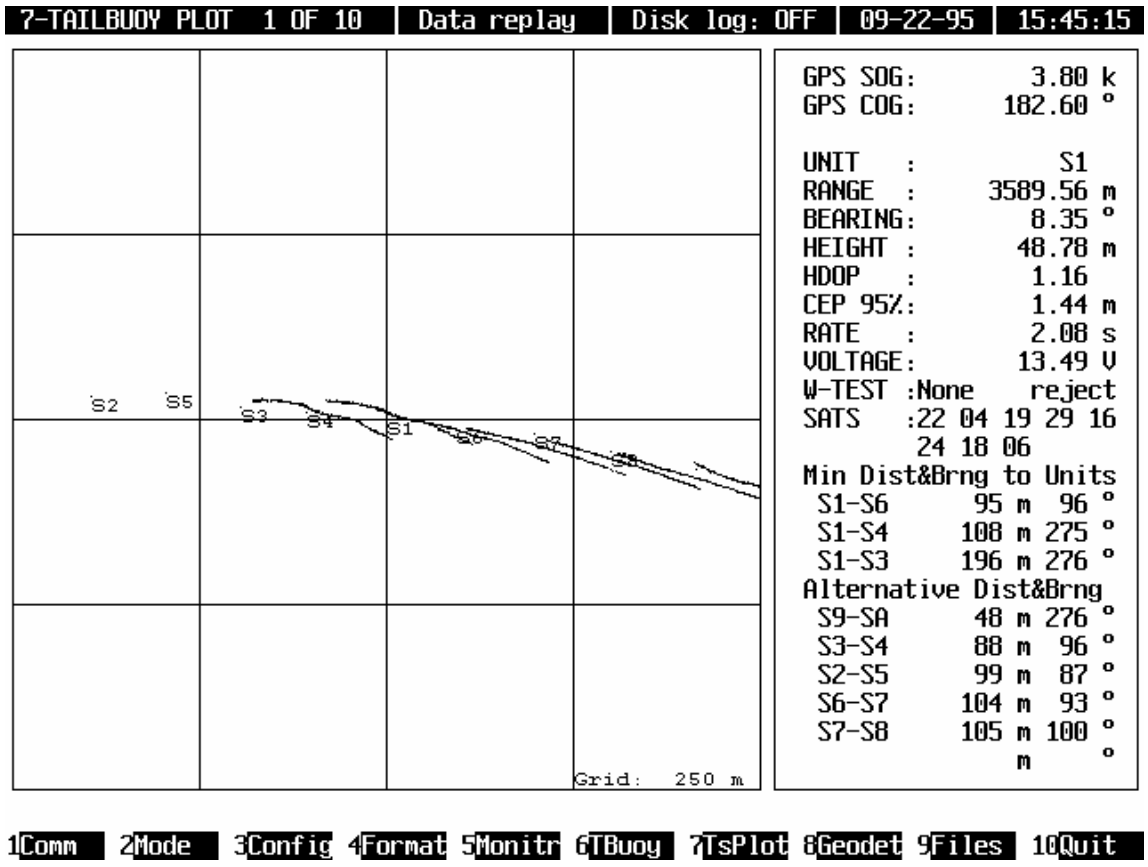

Figure 4.16: Transponder tracking information-2

This page (7) can shows a track plot of one or more transponder unit relative to the system position. The co-ordinates for the centre of the plot and the grid spacing are displayed and can be altered by using the arrow keys and the +/- keys. The transponder positions are represented by the respective ID. The plot will be centred on the unit represented with yellow colour. Pressing 7 or Esc will enable change of centre transponder.

At the top of the right window Speed Over Ground (SOG) in knots and Course Over Ground (COG) in degrees for the vessel are displayed. The next lines displays the ID of the centre transponder, the range from the vessel, bearing from the vessel, transponder antenna height (meters in WGS84) and HDOP for the relative fix between transponder and vessel. The apriori, estimated 95% CEP (m) for the relative fix is following. The mean time between each relative position fix over the last hour and the battery voltage read from the transponder is also presented. Since the w-test is implemented for each transponder position fix, the observation rejected from the solution is presented (either PRN number or height). The satellites tracked by the transponder and used for the relative position fix is displayed by the PRN numbers. If a satellite is tracked by the transponder but not used for the position fix the PRN number is displayed with less intensity.

The distance and bearing from the selected transponder to the three nearest transponders are presented on the next lines. If this distance decreases below 50m the numbers will turn red. At the 6 bottom lines the distance and bearings for other pairs of transponder will be displayed. The pairs are sorted by increasing distance. When a distance decreases below 50 meter the colour will turn red also for these numbers.

A menu for selecting transponder for display page 7 is available by pressing the ESC key.

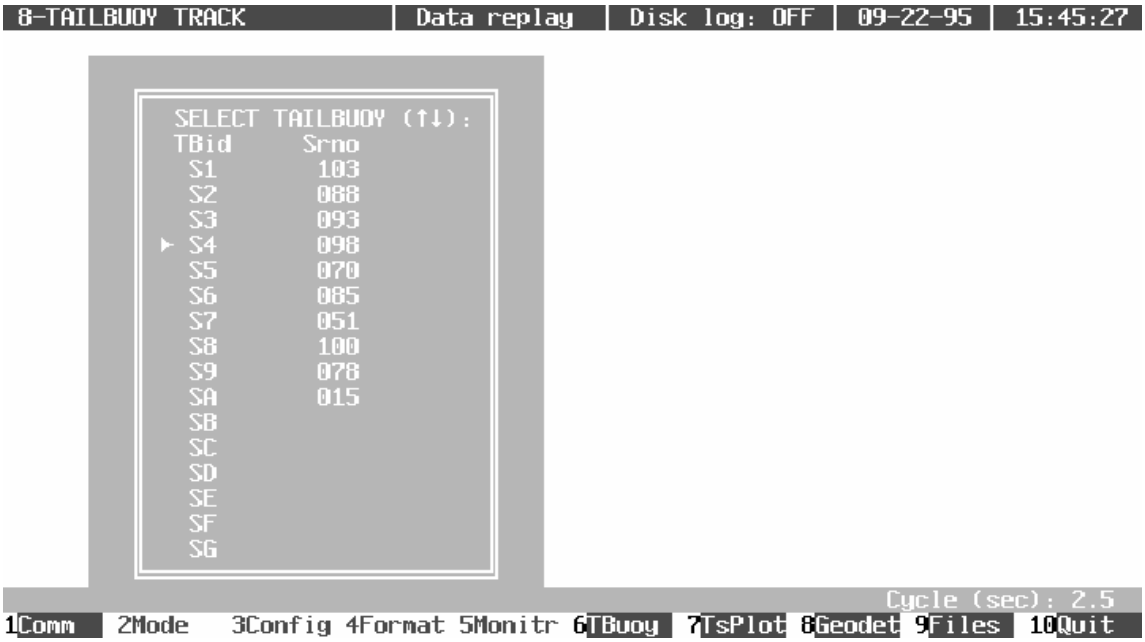

Figure 4.17: Menu for selection of transponder

The arrow keys are used the highlight the correct transponder, and the ESC key is pressed to return to display page 7.

Note that this selection also will apply as the selection of centre transponder in the last version of display page 2.

4.7Time-Series Plots

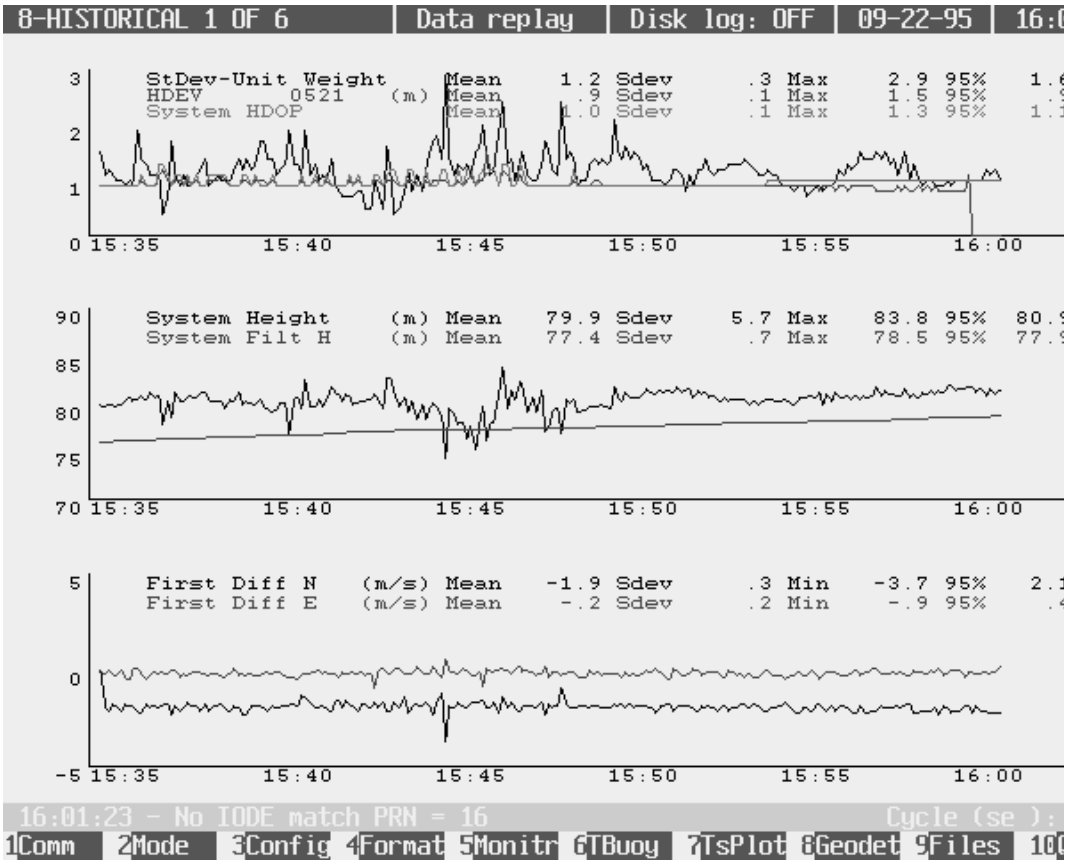

Figure 4.18: Timeseries plots

Seadiff offers a variety of timeseries plots displayed as page 8. An example is shown in figure 4.18. The display can be configured to show 1, 2 or 3 plots with from 1 to 4 curves per plot. Configuration is possible by the F7 menu. The time-series plots are updated in real-time.

Scaling of x- and y-axes can either be done manually (menu F7) or automatic. Assignment of collars to the different curves is also possible. Mean, standard deviation, max. value and min. value is printed for each curve. These values are updated each time the plot is re-initialised, either by pressing the 8-number key, the space bar or by re-scaling.

The time-series plots are based on values stored as a ring buffer in the computer's memory. Up to 720 data points are stored. The maximum interval for the time-series plots can be selected by menu F7. A long period will mean a reduced density of the data points, i.e. a max. value of 60 minutes means that the interval between each record will be 4 seconds as a minimum.

The parameters available as time-series plots are shown in table 4.1:

Parameter name	**Description**
StDev-Unit Weight	Standard Deviation of Unit Weight for the system position
First Diff N (m/s)	First difference in north direction for the system position. The first difference is equal to "speed-made-good".
First Diff E (m/s)	First difference in east direction for the system position. The first difference is equal to "speed-made-good".
System Height (m)	Instantaneous height for system position.
Filtered System Height (m)	Filtered height for system position.
UnCorr Pos Err N (m)	The north component of the difference between the system position and the un-corrected GPS position (influence of the DGPS corrections on the system position).
UnCorr Pos Err E (m)	The east component of the difference between the system position and the un-corrected GPS position (influence of the DGPS corrections on the system position).
UnCorr Pos Err H (m)	The height component of the difference between the system position and the un-corrected GPS position (influence of the DGPS corrections on the system position).
System HDOP	HDOP applicable to the system position
System VDOP	VDOP applicable to the system position
System HDEV	HDEV applicable to the system position
# Obs Satellites	Number of satellites observed by the GPS receiver
# Used Satellites	Number of satellites used in the system position fix
Monitor North Err nnnn (m)	The deviation between the north component of the system position and the position based on corrections from reference station with ID nnnn.
Monitor East Err nnnn (m)	The deviation between the east component of the system position and the position based on corrections from reference station with ID nnnn.
Monitor Hgt Err nnnn (m)	The deviation between the height component of the system position and the position based on corrections from reference station with ID nnnn.
Monitor HDOP nnnn	HDOP for position fix based on corrections from reference station with ID nnnn.
Monitor HDEV nnnn	HDEV for position fix based on corrections from reference station with ID nnnn. (Apriori horizontal position accuracy, 95% CEP).

Monitor SDUW nnnn	Standard deviation for position fix based on corrections from reference station with ID nnnn.
Monitor F-test nnnn	The difference between calculated and tabulated value of F-test parameters based on corrections from reference station nnnn.
Monitor Age nnnn mm (s)	Age of DGPS corrections from reference station with ID nnnn for satellite with PRN mm.
Monitor Norm Res nnnn mm	Normalised residuals for pseudoranges corrected with data from reference station with ID nnnn and PRN number mm.
Monitor MDE nnnn mm (m)	Minimum detectable errors for observations corrections with data from reference station with ID nnnn for PRN mm.
Corr nnnn mm (m)	Differential corrections from reference station with ID nnnn for PRN mm.
Range TBU nnn (m)	Range to Seatrack transponder with ID nnn.
Bearing TBU nnn (°)	Bearing to Seatrack transponder with ID nnn.
Height for TBU (m)	Instantaneous height solution for TBU in m.
Accuracy TBU nnn (m)	Estimated (apriori 95%, CEP) accuracy for Seatrack transponder with ID nnn.
SDUW TBU nnn	Standard deviation of unit weight for relative position fix for Seatrack transponder with ID nnn.
Voltage TBU nnn (V)	Reading of voltage for Seatrack transponder with ID nnn.
HDOP TBU nnn	HDOP for relative position fix for Seatrack transponder with ID nnn.
Virtual DN	North component of position error for virtual monitor.
Virtual DE	East component of position error for virtual monitor.
Virtual DH	Height component of position error for virtual monitor.
Virtual HDOP	HDOP for virtual monitor station.
Virtual VDOP	VDOP for virtual monitor station.
Virtual NSAT	Number of satellites observed at virtual monitor station.
Virtual USED	Number of satellites used in virtual monitor position fix.
Virtual DT	Positional effect (m) of time delay entered on menu page 5.
Virtual TROP	Positional effect (m) of applying standard tropospheric model for both reference station and virtual monitor
Virtual ION	Positional effect (m) of applying standard ionospheric model for both reference station and virtual monitor

Table 4.1: Parameters available for time-series plots

4.8External Communication

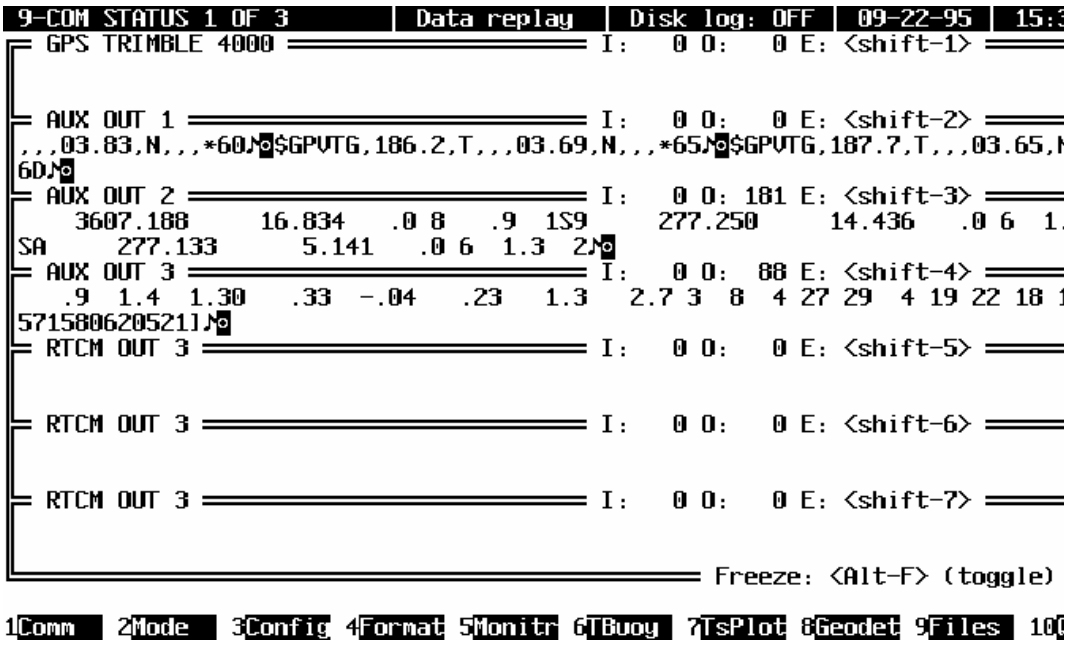

Figure 4.19: External communication inspection window

Data received- or transmitted by the computer is displayed by this page (9). All ports can be inspected, including the port connected to the GPS receiver. Incoming characters are inverted. The number of characters in the input queue and the output queue are displayed for each port.

Pressing <Alt-F> will "freeze" the display if more detailed inspection is to be done. This, however, does not halt program execution.

Pressing <Alt-n> where n is the number of the port configured at menu F1 will expand the information window for the selected port. This is showed in figure 4.20.

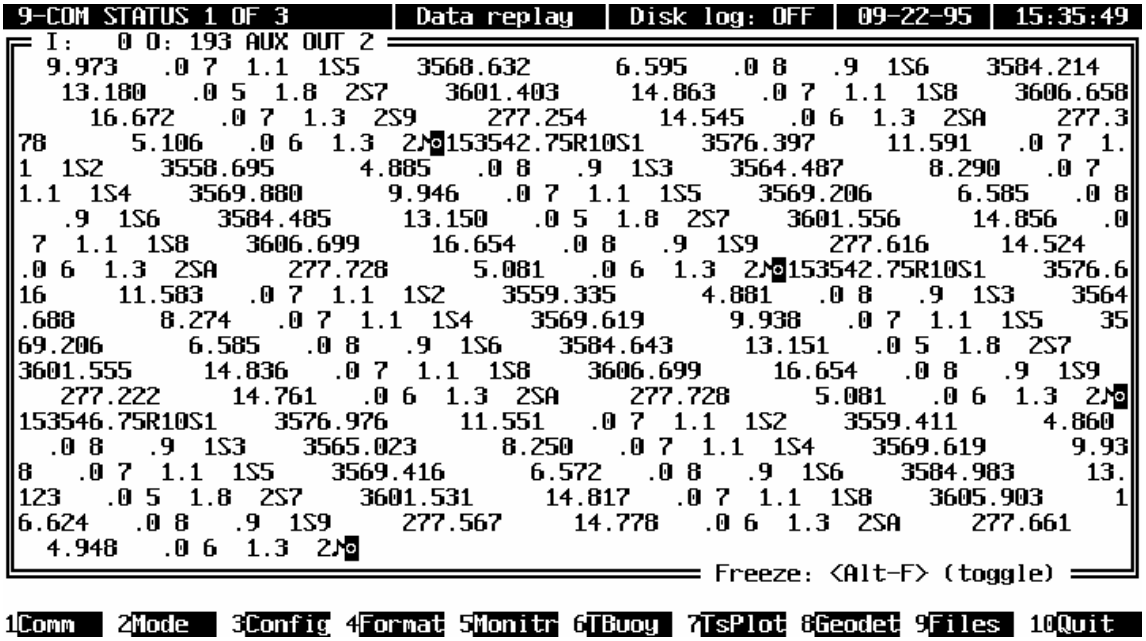

Figure 4.20: Expanded port inspection window

4.9Error and Warning Messages

Pressing E, W or F will recall a list of error messages generated by the Seadiff program.

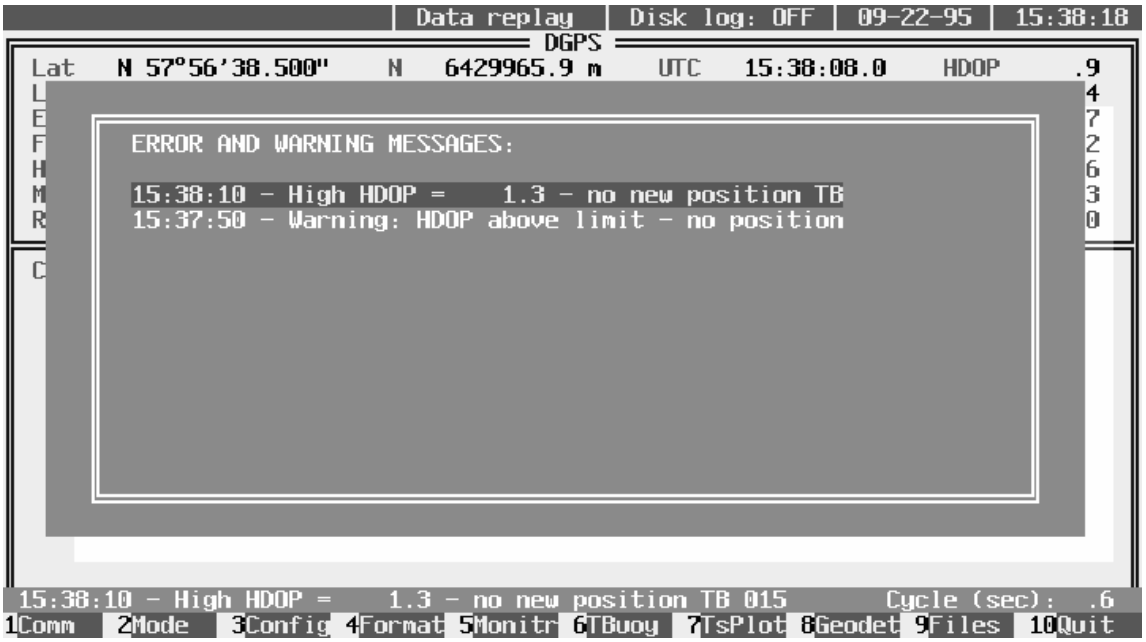

Figure 4.21: Error and warning message list

4.10Seadiff Help Menu

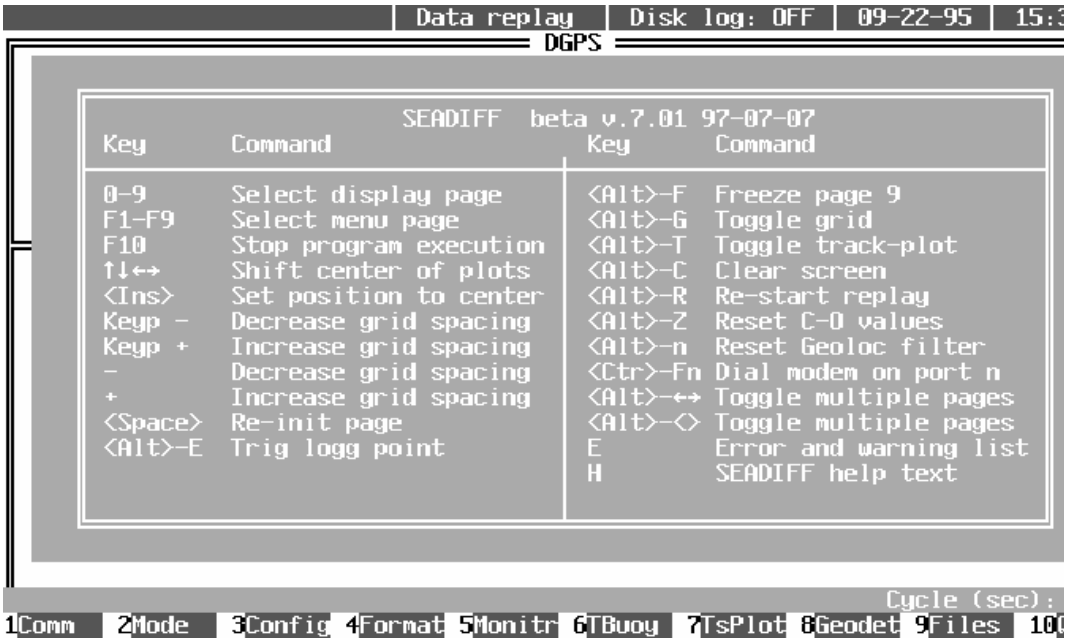

Figure 4.22: Seadiff help menu

The Seadiff help menu are entered by pressing the <h> key on the keyboard. The help menu gives a listing of available keystroke commands.

The available keystrokes are listed in table 4.2:

Keystroke	Description
0-9	Select display page from 0 to 9. Will only work when a display page is active.
F1 - F9	Select menu page from 1 to 9.
F10	Stop execution of the Seadiff program.
Arrow keys	Change centre of plot for display page 2 or 7.
{Ins}	Set centre of plot to current position for display page 2 or 7.
{Keypad} {-} or {-}	Decrease grid spacing for display page 2 or 7.
{Keypad}{+} or {+}	Increase grid spacing for display page 2 or 7.
{Space}	Re-init graphical plot (2,7 or 8).
{Alt} C	Trig logging manually.
{Alt} F	Freeze display page 9.
{Alt} G	Toggle grid on page 2 or 7.
{Alt} T	Toggle track plot on page 2 or 7
{Alt} C	Clear screen 2 or 7.
{Alt} R	Re-start replay
{Alt} Z	Reset C-O values for radionav. calibration
{Alt} n	Reset Geoloc filter for station n
{Ctrl} Fn	Dial modem number on port n
{Alt} arrows	Toggle multiple pages (1,3,6,7)
E	Display error messages
H	Display help text

Table 4.2: Keystroke commands

5. CONFIGURATION MENU DETAILS

5.1Communication Set-Up

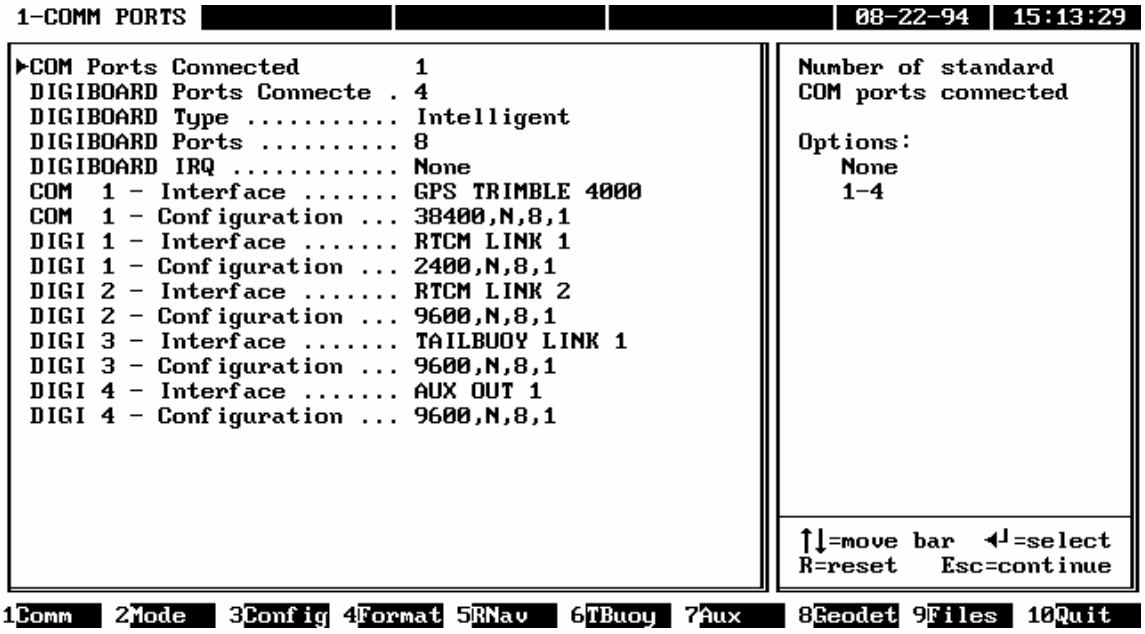

Figure 5.1: Communication set-up

The RS232 ports are configured by this menu. A combination of standard PC COM ports and Digiboard PC/X ports can be used. The configuration of COM ports and Digiboard ports covers settings as e.g. baud rate and a selection among several systems that can be interfaced via RS232 or RS422 ports.

5.1.1Standard RS232 COM Ports

Up to 4 standard COM ports are supported, even if most PCs only have 1 or 2 standard ports installed. (Actually there are no standard for COM3 and COM4.) The selected value for "COM Ports Connected" should be less or equal to the maximum number of standard COM ports installed in the PC.

5.1.2Digiboard RS232 / RS422 Ports

4, 8 or 16 port versions of the Digiboard PC/X, PC/Xe or PC/Xi can be used to extend the total number of ports up to a total maximum of 20.

The PC/Xe and PC/Xi board are "intelligent" board with onboard processors that releases processor power of the main PC processor. These boards need appropriate driver (*.SYS files) to be loaded by the DOS system configuration file CONFIG.SYS (see the Digiboard manual for details).

The PC/X board is an unintelligent board and need no driver to be installed by the CONFIG.SYS. The disadvantage of the PC/X board is that processor capacity is "stolen" from the PC when much data is transferred to- or from the PC at high baud rates. This can partly be cured by replacing the standard 16450 UARTs with 16550 UARTs, which is highly recommended if PC/X boards have to be used.

From a technically point of view the optimal solution is to use an intelligent Digiboard for high speed and reliable serial communication.

Selections of interrupt, number of ports and Digiboard type (intelligent or unintelligent) must match the physical installation of the PC.

5.1.3QSP RS232 Ports

2,4 or 8 port versions of QSP PC-cards (former PCMCIA) can be used to extend the number of serial ports. One or two QSP cards can be used simultaneously. It will be necessary to load the QSP driver prior to starting Seadiff.

An example of how to install two 4 channel QSP cards at interrupts 7 and 5, and base addresses 100 and 120 (hex) is to type:

```
qsp100en (s0,b100,i7)
qsp100en (s1,b120,i5)
```

Note that Seadiff always assumes that the base address for the first QSP card is 100 (hex) and that a second card is following at the nearest available address. Interrupt numbers (e.g. 7 and 5) must be entered at menu F1.

5.1.4Port Interface and Configuration

Each port (COM port or Digiboard) can be connected to one of several external devices communicating via RS232 / RS422 ports. It should be obvious that the baud rate, parity, number of data bits and number of stop bits must be equal with the settings of the device connected to the Seadiff computer.

5.1.5GPS Receiver Selection

Note that optional GPS receiver interfaces will be available upon request. The options are:

- Trimble 4000 (old protocol)
- Trimble 4000 RT Survey protocol
- Trimble TSIP
- Ashtech OEM
- Magnavox 4200
- Novatel

A Seadiff will only be compiled for one of these receivers at a time. If your Seadiff is not configured for the correct GPS receiver, contact Seatex to get a correct version. Selection of an incorrect GPS receiver type will lead to an error message. If this happens, terminate the Seadiff program and start again with the correct selection.

Configuration parameters like baud rate, data bits, stop bits and parity are defined individually for each port. Accepted baud rates are 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, and 57600. However, baud rates higher than 19200 are not recommended for standard COM ports or unintelligent Digiboards with 16450 UARTs.

5.1.6Trimble SPD/HDG Module

It is possible to connect a Trimble speed/heading module to display speed/heading derived from log and gyro. The values read from this port will also be used for the corresponding NMEA sentences.

5.1.7DGPS Correction Link Input

Up to six ports (1-6) can simultaneously be configured to receive differential corrections. Either RTCM or SCF can be decoded. Selection is done at menu F4.

5.1.8Tailbuoy Link

Up to four ports (1-4) can be configured for receiving Seatrack transponder data. Data from up to 8 units can be received at the same port. Normal baud rate is 4800.

5.1.9Auxiliary Output

Up to 6 ports (1-6) can be configured for different types of output via serial ports. Configuration is made at menu F4.

5.1.10RTCM Output

It is possible to configure up to 4 ports (1-4) for re-transmission of RTCM corrections. Configuration is made by menu F4.

5.1.11Other Interfaces

Some other options are available but will only be used in very rare occasions. Contact Seatex for further details.

5.2Navigation Mode Parameters

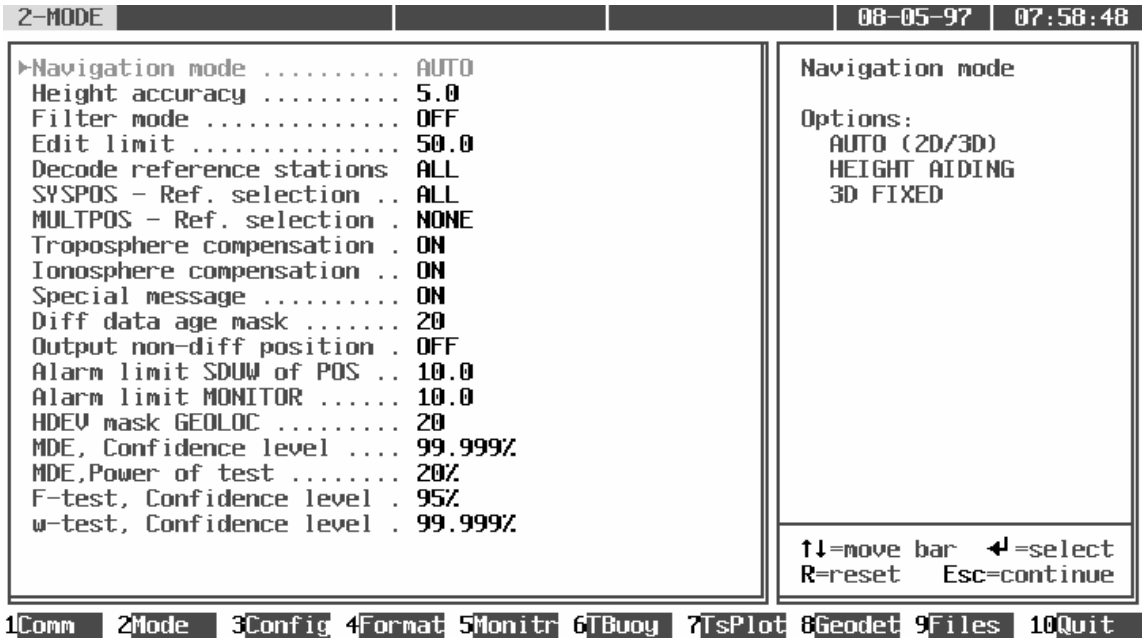

Figure 5.2: Navigation Mode

Special processing modes are selected via this menu. Great flexibility is offered by enabling the user to change these parameters. Some parameters may under certain circumstances change the accuracy performance of the system and should be selected carefully.

5.2.1Height Aiding or 2D/3D Solutions

By choosing the HEIGHT AIDING mode, the height entered as "Ref hgt" (see figure 5.4) in the Config menu will be used to improve the accuracy and the integrity of the DGPS position fix. When AUTO is selected the normal mode will be a 3D position fix. If HDOP or VDOP masks entered in the Config menu (see figure 5.4) are exceeded the program automatically will change to 2D using fixed height. Fixed 3D solution can also be selected.

When HEIGHT AIDING is used, an estimate of the accuracy of the height input has to be entered (HEIGHT ACCURACY). The height accuracy will be used as a 95% significance level for the height input.

5.2.2Filtering and Editing of Position

A Kalman filter is implemented to allow filtering of the DGPS positions. Different modes can be selected depending on the level of movement expected. For high dynamic platforms as aircrafts and automobiles use OFF or HIGH DYNAMICS, for low dynamic platforms like ships use MEDIUM DYNAMICS and for low dynamic platforms use LOW DYNAMICS or STATIC.

User defined filter settings can also be used (contact Seatex for further details), although this should be avoided unless for very special situations.

Since the filter is used to predict the "next" position, this prediction can be used to reject wild measurements. The "EDIT LIMIT" express the maximum deviation between predicted and measured position allowed before the measured position is rejected.

5.2.3Selection of DGPS Reference Stations

Handling of data from up to 24 DGPS reference stations allocates some computer resources. To reduce the computation time with a slow processor it may be desirable to reduce the number of stations decoded. This can be done by entering a list of stations by "DECODE REFERENCE STATIONS". To select the n nearest stations, MAXn is entered.

A subset of the stations listed by "DECODE REFERENCE STATIONS" must be entered by "SYSPOS-REF. SELECTION". The system position will be a multiref. position based on data from these stations. If "DECODE REFERENCE STATIONS" is turned OFF, a non-differential GPS position will be calculated.

For monitoring purposes another selection of reference stations can be entered by "MULTPOS-REF. SELECTION". These stations will contribute to the position referred to as MULTPOS.

5.2.4Differential Compensation of Atmospheric Delays

The standard GPS models (ref. [1]) for tropospheric and ionospheric compensation of the GPS signals are implemented in a differential mode. This means that the models are based on the assumption that no such compensation is done on the reference station data. Turning tropospheric compensation ON normally improves the accuracy using remote reference stations (distance > 100km) while the results using ionospheric compensation is more ambiguous. The normal mode should be to turn the ionospheric compensation OFF.

5.2.5Differential GPS Options

Displaying of messages transmitted as RTCM message 16 can be turned OFF or ON. The normal mode should be ON.

The maximum age allowed for the DGPS corrections to be used in the position fix can also be entered by the "DIFF DATA AGE MASK". Corrections older than this limit will be rejected since too old DGPS corrections will degrade the position accuracy. An appropriate value is 20 seconds.

If «OUTPUT NON-DIFF POSITION» is turned ON a standard GPS position will be used as the system position even if no corrections are received. The accuracy of a non-differential solution will mainly be limited to the SA degradation.

5.2.6Alarm Limits

Alarms will be given when the standard deviation of residuals (SDR) for a single position fix or the difference between the system position and one of the monitor positions exceeds specified limits.

5.2.7HDEV Mask for Geoloc Filter Update

When the HDEV limit is exceeded the DGPS position will be rejected from the process updating the Geoloc clock filters. A relatively high value should be selected (e.g. 20).

5.2.8Statistical Testing

Confidence level for Marginally Detectable Errors (MDE) can be selected. If the confidence level is set to 99.999% then 0.001% of observations are expected to be rejected along with bad data. The power of the MDE express the probability of detecting an outlier in the data, i.e. if 20% is selected (recommended value) the probability of detecting an outlier is 80%.

The W-test confidence level is defined equally to the MDE confidence level. The W-test confidence level directly affects the amount of data rejected as outliers.

The F-test confidence level has the same interpretation as confidence level for the W-test and MDE i.e. a value of 99% means that 0.01% of good data is expected to be marked as bad.

5.3GPS Receiver

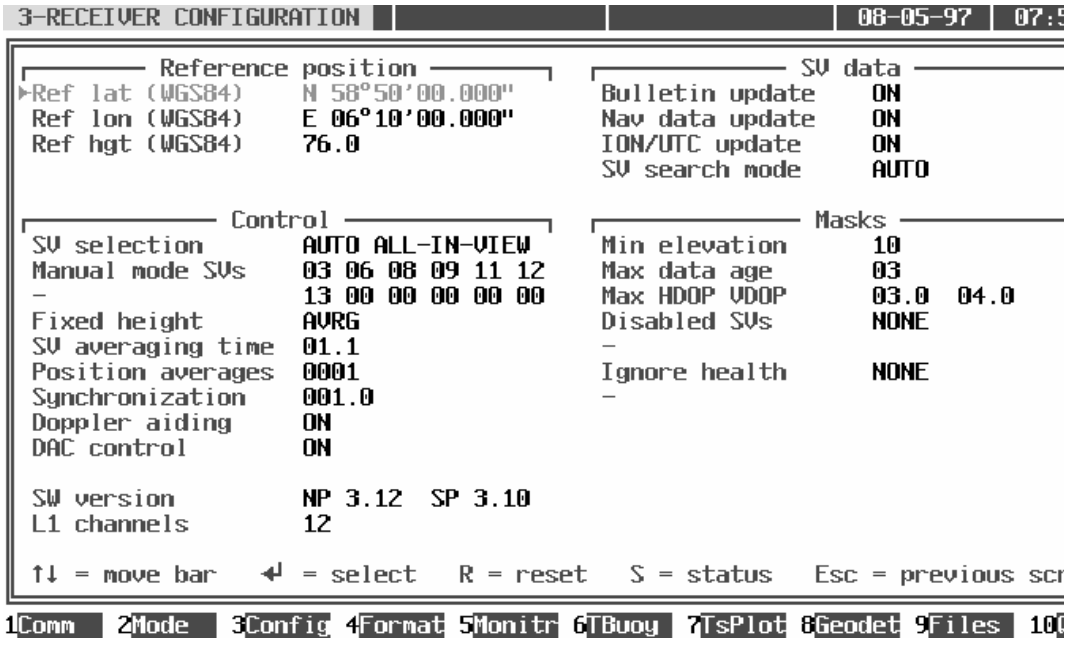

Figure 5.4: GPS receiver configuration

Configuration of the GPS receiver and special parameters connected to the use of data from the GPS receiver are selected via this menu.

5.3.1Fixed Height and Initial Position

The "FIXED HEIGHT" parameter defines if the height used for height aiding is the entered height or the filtered height calculated by the height estimator.

The height used for height aiding by manual input is entered by "REF HGT (WGS84)". It is important to notice that the entered height must be referred to WGS84 datum.

"REF LAT (WGS84)" and "REF LON (WGS84)" is used as the initial position for the GPS receiver and will only have influence on the TTFF after a reset of the GPS receiver.

5.3.2Receiver Control Parameters and SV Data

Most of these parameters are included for the sake of compatibility with older versions of Seadiff not be altered be the user.

The only parameter of interest is the "SYNCHRONIZATION" parameter which specifies the sample rate for the GPS receiver. A selection of e.g. 001.0 means that the GPS receiver is making a new measurement of GPS data at a 1/sec. rate while e.g. 005.0 means that the rate is 1/5 sec.

5.3.3Masks

Minimum elevation mask, maximum ephemeris data age, maximum values for HDOP and VDOP, a list of disabled satellites and satellites where the health flag is ignored not only affects the receiver configuration but also the Seadiff operation mode. These parameters will have full influence also when running Seadiff in REPLAY mode and are considered for GPS coverage prediction.

5.3.4GPS Receiver Status and Commands

The GPS receiver software versions are displayed in this menu (e.g. NP 3.12 SP 3.10). Number of L1 channels is also displayed.

Pressing <S> will poll the GPS receiver for the current settings used.

5.4Data Formats

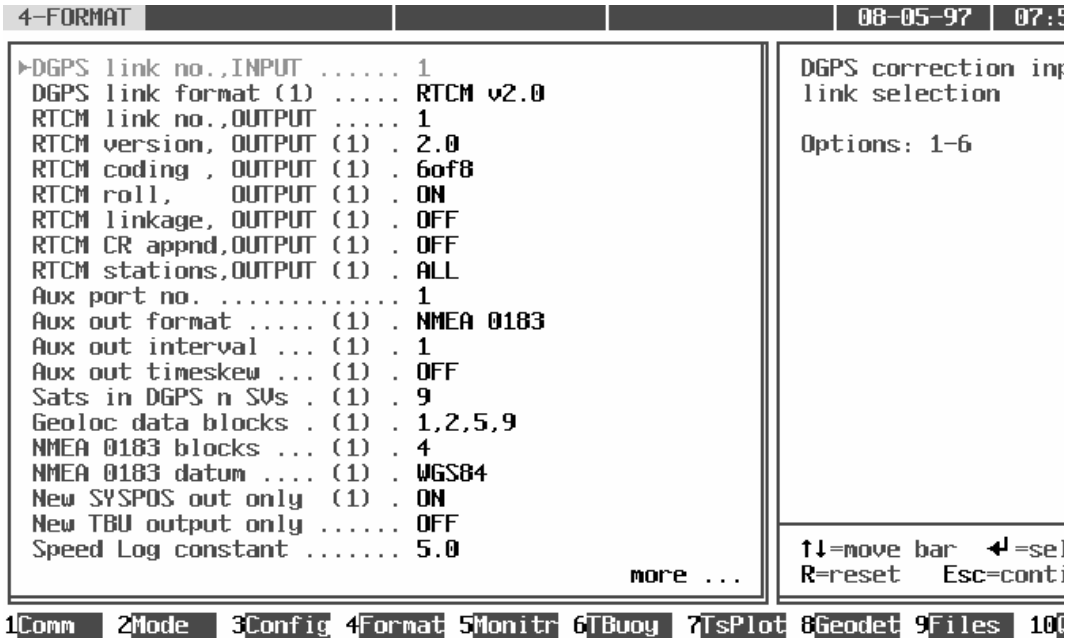

Figure 5.5: Input / output data format configuration

Different format options related to input/output of data are selected by this menu. Figure 5.5 give an example of menu page F4.

5.4.1DGPS Link no

Up to 6 links can be configured for input of DGPS corrections. These links are individually configured, and the DGPS Link no. parameter indicates the link number with the following configuration parameters.

5.4.2DGPS Link Format

The only selection connected to the decoding of RTCM data is RTCM version number. Version 1.0 or version 2.0 can be selected. All possible combinations of byte roll ON/OFF and 6 of 8/8 of 8 coding is automatically detected by the Seadiff and will not be of any concern to the operator. SCF format can also be selected as an alternative to RTCM. If RTCM corrections are received while SCF is selected, or vice versa, the program automatically changes to the right setting after a while.

5.4.3RTCM Output Parameters

Up to four ports can be configured for re-transmission of RTCM data. RTCM will even be generated if DGPS corrections are received on SC format. Menu F4 allows the user to select the following parameters for each port:

Parameter	**Description**
RTCM version	RTCM according to revision 1.0 or 2.0 of the format recommendations can be select.
RTCM Coding	RTCM messages can be coded either as 6 of 8 or 8 of 8 bit per byte.
RTCM Roll	RTCM byte roll may be select ON or OFF.
RTCM Linkage	Parity and inversion of RTCM words can be linked over the message boundaries or not.
CR Append	A CR character (carriage return, ASCII decimal value 13) can be appended to each RTCM message.
Stations	A selection of station IDs for re-transmission can be selected.

Table 5.1: RTCM coding parameters

5.4.4Auxiliary Output Configuration

Six serial ports can be simultaneously used for auxiliary output (Aux out 1 - Aux out 6). Format specifications are given in Appendix A. The available formats are listed in table 5.2.

Data format	Description
DGPS 4 SV's	An ancient GPS position report format limited to report data from only 4 GPS satellites.
DGPS 5 SV's	Revised version of DGPS 4 SV's but able to report data from up to 5 satellites.
DGPS n SV's	Revised version of DGPS 4 SV's and DGPS 5 SV's but able to report data from up to 9 satellites.
Trimble 4000	Trimble position report defined by Trimble and implemented for receivers of Trimble 4000 type.
NMEA 0183	GPS position reports based on an interface standard for marine equipment. Block types need to be defined. GLL, GMS, WHW, VTG, GGA and special implementations of GGA implemented in some Simrad DP software versions (ADP-503/311 rev. 2 and SDP-503/311 rev. 3). Note that datum for ADP-503/311 always is ED 87.
TAILBUOY	Format for reporting of tailbuoy range / bearing implemented in GIN III software.
AHV RELATIVE	AHV - Anchor handling vessel format. Alternative format for reporting of relative (range / bearing) transponder data.
AHV ABSOLUTE	AHV - Anchor handling vessel format. Based on AHV Relative but report absolute positions for the transponder.
GEOLOC AUX	Reports GPS data as Geoloc AUX port "look-alike" data.
SYLEDIS SR3/STR4	Reports GPS data as Syledis SD3/STR4 "look-alike" data.
ARGO	Report GPS data as Argo "look-alike" data.
DIFFSTAR	Format implemented in Diffstar software.
GECO DGPS	DGPS position format invented by Geco.
GECO RELATIVE	Transponder data format invented by Geco.
SPECTRA	Equal to TAILBUOY format but report range as slant range rather than range along ellipsoid.
RAW DATA	Reports raw data as logged on files with extension *.GPS (see appendix D).

Table 5.2: Available serial port data formats

Format, output interval and time skewing mode can be selected for each of the six Aux out ports. When the output interval is set to 0 the program transmits data as fast as the baud rate allows. If time skewing is turned ON the position reported via the Aux out port is adjusted to the time of transmission of the actual message. The time tag is also adjusted if time skew is ON.

To maintain compatibility with different types of navigation computer software it is possible to select maximum number of satellites to be reported by the "DGPS n SVs" format between 4,5 or 9.

If NMEA 0183 (version 2.0) is selected different formats can be used (GMS, WHW, VTG, GLL, GGA). Even three different options for the GGA string is included: the standard GGA and the Simrad Albatross implementation of GGA described in the ADP-503/311 revision 2 and ADP-503/311 revision 3 specifications. It is possible to select either WGS 84 or ED 87 datum for the NMEA position.

If Geoloc Aux Output is specified different message types can be specified (1-9).

If New pos. output only is ON a position will only be sent to the Aux output port when a new GPS/DGPS fix is calculated. Otherwise the same position can be sent more than one if the internal position update time in Seadiff is larger than the output rate specified in this menu. The same option is also available for range/bearing or position from the Seatrack transponders.

5.4.5Interfacing to External Log and Gyro

In case of interfacing to external log and gyro speed log constant and initial gyro heading need to be entered.

5.4.6Gyro Output

For transmission of gyro data Gyro readings or CMG (Course Made Good) can be used as a source for gyro information.

5.5Virtual Monitoring

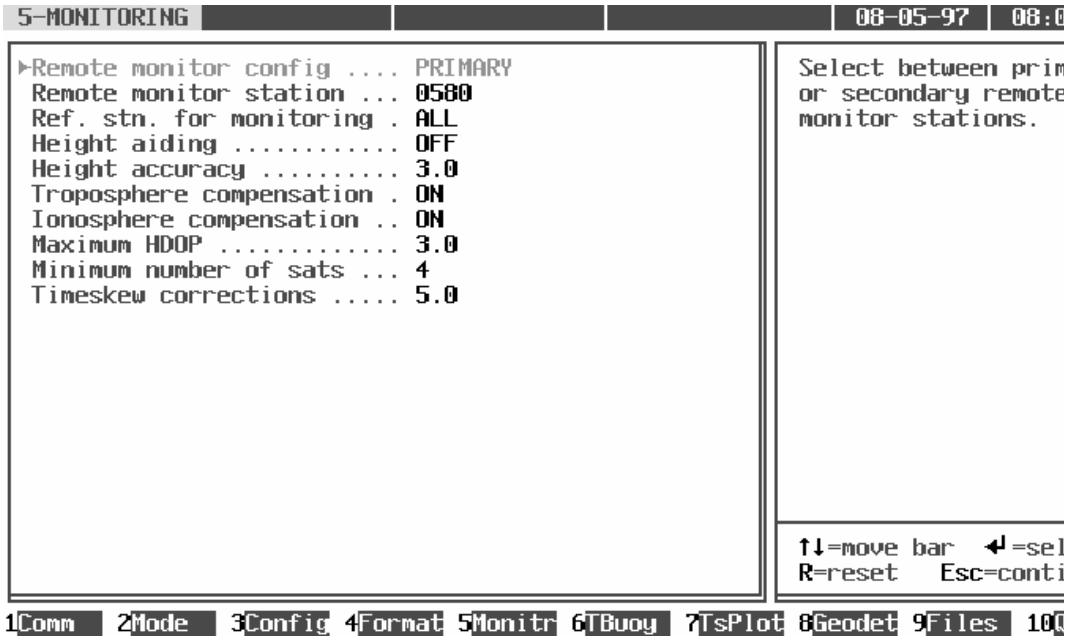

Figure 5.6: Virtual monitoring configuration menu

Two stations (primary and secondary) can be selected as virtual monitor stations. Monitoring of all or a subset of reference stations with these two stations can be configured independently.

Height aiding can be turned ON or OFF and estimated height accuracy can be changed. Tropospheric and ionospheric models (standard GPS models) can be turned ON or OFF. HDOP limit and minimum number of satellites can be entered.

A virtual timeskew of the corrections can also be entered, to study the effect of delays in a transmission link.

5.6Tracking

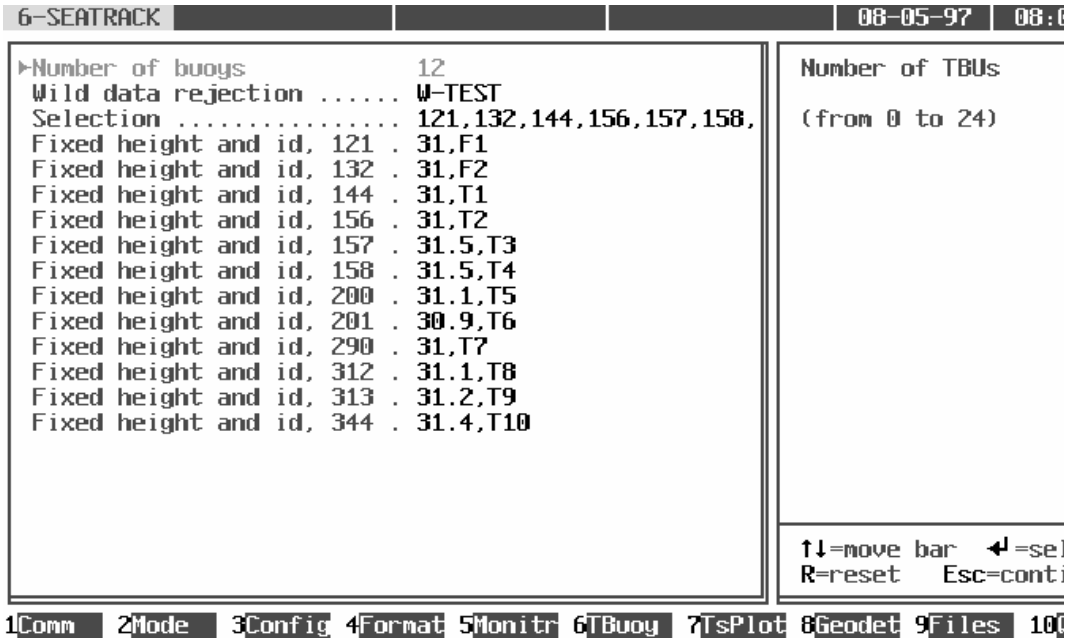

Figure 5.7: Tracking configuration menu

Different parameters regarding configuration of the use of a series of GPS transponders (Seatrack) are offered by this menu.

Number of transponders can at the maximum be set to 24. The GPS antenna height (above the WGS 84 ellipsoid) can be set to a common value for all transponders or individually for up to 20 transponders. Individual setting requires that the ID for each transponder is entered by this menu. If more than 20 transponders are to be configured, the user has to edit the configuration/setup file.

Wild-point rejection of the position solution can either be done by W-test rejection (according to UKOOA recommendations) or by a special multipath rejection algorithm implemented for tailbuoy tracking operations. The multipath rejection method should be avoided because assumptions of almost static ranger / bearing between the transponder and the GPS receiver connected to Seadiff are made.

5.7Plot Parameters

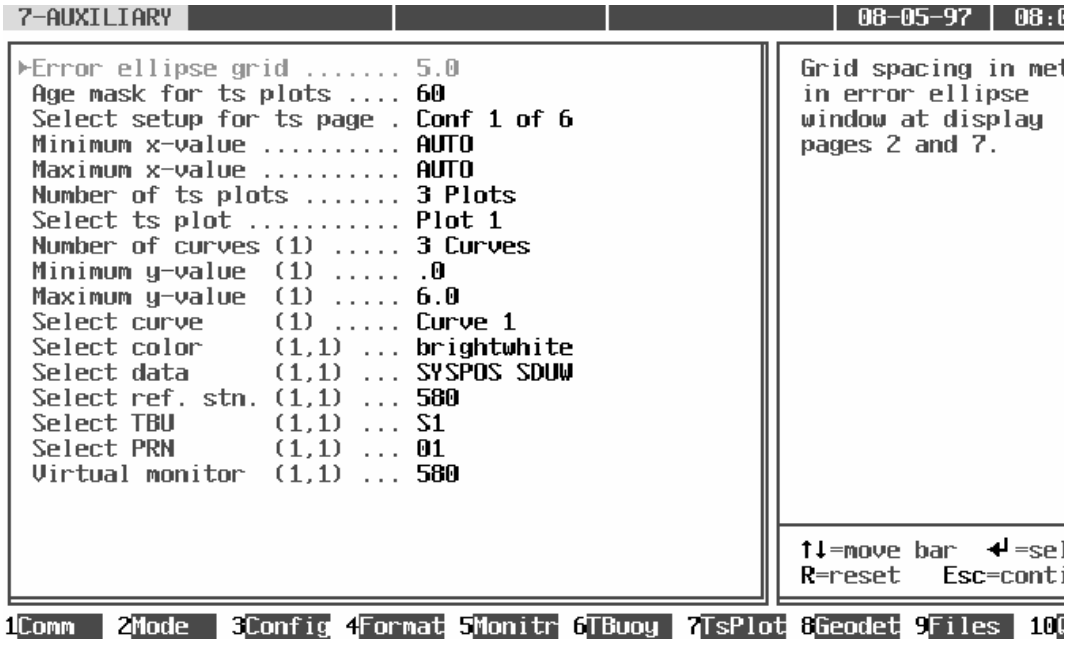

Figure 5.8: Plot parameter menu

The plot parameters mainly contains parameters related to displaying of time-series information.

5.7.1Error Ellipse Grid

The grid spacing for the error ellipse presented on display page 2 is selected in metres.

5.7.2Age Mask for TS Plots

The data for presentation of time-series plots are stored in a ring-buffer variable containing 500 records. The "Age Mask for TS Plots" sets the maximum time-span for time-series plot data. If e.g. a value of 120 minutes is selected, the separation between the time-series plot records is 120*60/500 = 14.4 seconds. This parameter can be changed while the program is running, but will then result in variations of the record intervals.

5.7.3Time-Series Plot Parameters

Up to 6 different configurations of time-series plots can be defined and selected. Therefore, the contents of the menu F7 will vary depending on the selected value for "Select setup for ts page".

The scaling of the x-axis (time) can either be done automatically by the program or manually. The automatic selection will be the normal mode, while the manual selection will be used for inspection of particularly interesting parts of a curve. The x-axis scaling will be common for all curves and plots on display page 8.

From 1 to 3 plots can be presented on the same page. The scaling of the y-axis can either be done automatically by the program or manually. The y-axis range will be common to all curves drawn in the same plot. Up to 4 curves can be drawn into the same plot. The operator can select a colour, which parameter to plot (see table 4.1) and reference station ID, TBU ID, PRN number and virtual monitor station ID appropriate for the selected curve.

5.8Datums and Projections

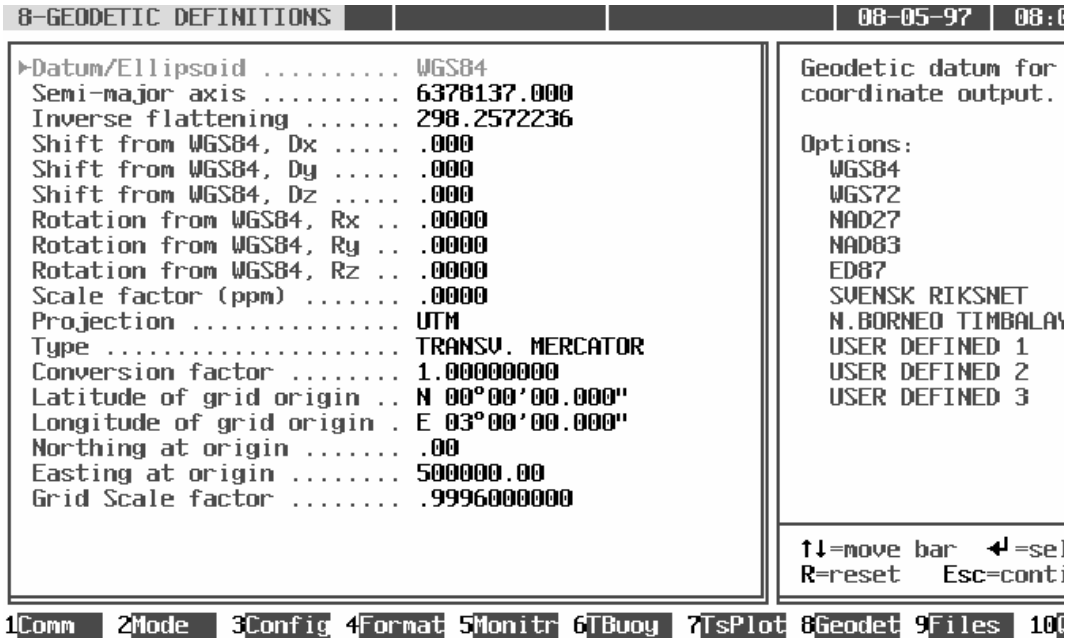

Figure 5.9 Datum and projection conversion factors

Parameters for conversion between different datums and for calculation of projection co-ordinates (UTM) can be inspected or altered by this menu. The selected datum / projection will be used for all positions displayed at the display pages and transmitted

at the Aux output ports. However, all logged raw-data will not be dependent on the selection of datum and projection.

5.9Data Logging

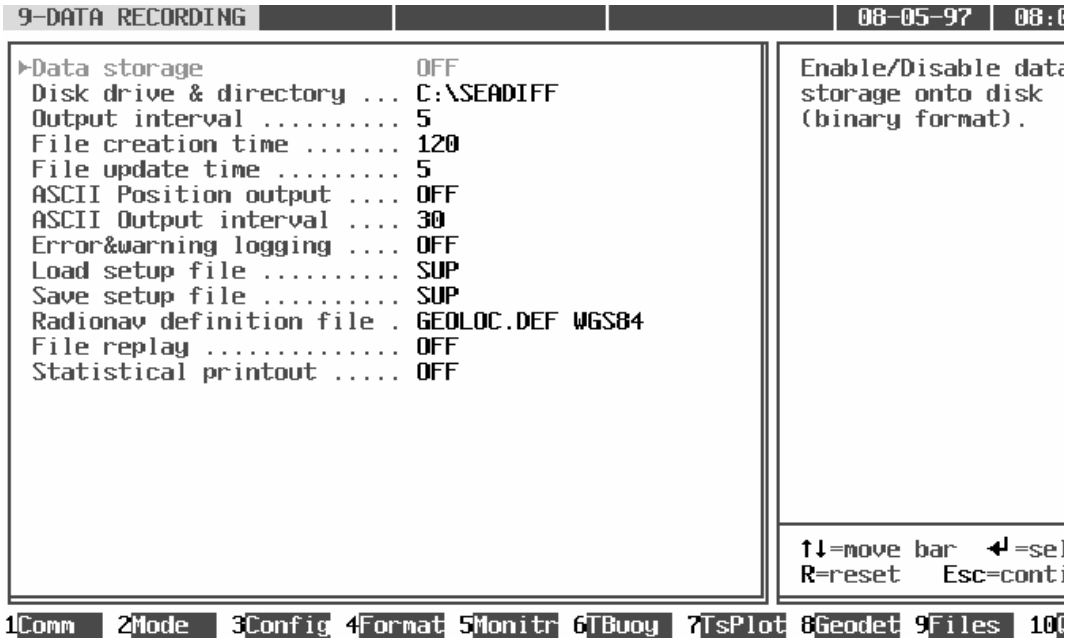

Figure 5.10: Data logging menu

5.9.1Raw Data Logging

Raw data logging (format description in appendix C) can be turned ON / OFF. A valid drive & directory must be entered before turning logging ON. If logging is turned ON the top line displays available KB free on the selected drive. If the available space is less than 200 KB logging is automatically turned off.

For every created logging file, there will also be created a statistical summary file on the entered disk drive and directory.

The name of this file will be the same as of the logging file, but with the extension '.STA' .

Drive and directory for the logging device must be entered before starting logging of data (ex: C:\SEADIFF or C:). Logging on hard disk is recommended even if A: is the default option. Especially with several RTCM links and tail buoys connected to the

Seadiff computer quite large amounts of data will be logged. The desired storage drive and directory will be saved in the set-up file also when logging is turned off.

Logging of data is performed at the interval specified by this parameter (interval in seconds, 0 = every cycle).

If logging by event is wanted, just write 'EVENT' instead of the logging interval. Logging will then be performed only by every contact closure on a CC-unit. This unit must be connected to a port, configured on menu page 1. Logging in this mode may also be trigged by pushing <Alt-E> on the keyboard.

A new file is created at the interval specified by the file creation time parameter. The filename is automatically generated as (ex: 12121000):

DDMMhhmm.GPS

where

DD = day of month (1 - 31)
MM = month (1 - 12)
hh = hour of day (0 - 23)
mm = minutes of hour (0 - 59)

This function is implemented to prevent huge files (over 1.4 Mb) to be generated. A File Creation Time of 30 - 60 minutes is normally selected. Storing every cycle in 60 minutes, will generate a file of approximately 1.1 Mb.

Data is written to the file at the rate specified by the file update time. This enables MS-DOS to close the file between updating it, to prevent loss of data in the case of power failure or other abnormal program termination. A File Update Time of 1 - 5 minutes are usually selected.

5.9.2Logging and printing of DGPS Position

Positions may be sent to a parallel PRINTER (connected to the parallel port on the computer) or a FILE. The filename is generated as for data files but with extension POS (ex: 12121100.POS; generated 12 of December, at 11 a.m.).

Output to printer or file is executed at the interval specified by the output interval parameter (0 = every cycle).

The available formats for output to file are listed in table 5.3.

Format	Description
FILE SEADIFF	Equal to the PRINTER format. See appendix C.
FILE P2/86	DGPS positions logged according to the P2/86 specifications.
AUX 1 - AUX 6	The interface defined as AUX 1 - AUX 6 (see menu page F4) will be logged directly to file.
SPECIAL	Simplified and abbreviated variant of FILE SEADIFF

Table 5.3: Available ASCII logging formats

5.9.3Logging of Error and Warning Messages

Turning this option ON will append all error and warning messages to the WARNING.LOG file. WARNING.LOG will exist under the current disk and directory.

5.9.4Configuration File

The content of a configuration file can be loaded or saved. This includes all parameters that can be changed via the menus.

5.9.5Radio Navigation Definition File

A radio navigation pattern definition file (see appendix D for detailed format) can be entered by using this parameter. A geodetic datum name (defined in menu 8) may follow the name of the file. The station co-ordinates on the file will then be converted automatically from the specified datum to WGS 84 which is the datum internally used for position calculations by Seadiff (Ex: ARGO.DEF ED87; pattern definitions and station co-ordinates are read from the file ARGO.DEF where the co-ordinates are given in ED87 datum).

If no datum is following the file name, WGS 84 is assumed as the co-ordinate datum.

5.9.6File Replay

Seadiff offers the possibility to run replay of previously logged data. A file name containing logged data must then be entered at this line. OFF disables the replay mode and return to the real-time navigation mode. Running in replay the computer clock is synchronised with the time in the raw data file.

If replay running in real-time speed is wanted, write '0' in the 'Output interval' on line 3.

When a new raw data file is opened, the current value of all parameters available via the menu system, is logged. This enables replay with exactly the same parameters as

used in real-time. It is, however, possible to alter any of the parameters by using the menus after the logged parameters setup is loaded.

A fast wind mode for running replay is available by pressing {Ctrl}{→}. Normal mode is re-entered by pressing any key. In fast wind mode no positions are calculated. The clock in the upper, right corner of the screen is, however, indicating the position in the raw data file.

The user may select the drive for storing the historical data file. This gives for instance the user the opportunity to define an area in RAM as a drive. This will speed up the writing and reading of the historical file. Default is storing on the current drive, i.e. the drive where the Seadiff program is started from.

5.9.7Statistical Data Logging or Printing

If the statistical printout parameter is turned ON, the statistical summary file will be printed out every time a new file is created. A printer must then be connected to the parallel port of the PC. This will not affect the storage of the summary file on the specified disk.

5.10Terminating the Program

The decent way to terminate the SEADIFF program is via the F10 command. This ensure proper termination of the Trimble 4000 - SEADIFF communication process and closing of all serial ports and files.

If the program is terminated without using the F10 command the computer may hang after some time. The computer will then have to be reset by turning power OFF and ON.

6. HARDWARE CONFIGURATION

6.1RS232C Connection

Most computer of the IBM PC type offers RS-232 connection of peripherals, either via a 9- or 25-pin male connector. The built in 1 or 2 serial ports can be extended by installing multiple port RS-232C/RS-422 add on cards. The data in (3), data out (2) and ground (7) pins usually are the only pins that need to be connected interfacing electronic navigation equipment.

The pin configuration for standard 9- or 25-pins connectors are described below with pin numbers:

Signal	***25-pins***	***9-pins***
TX (Transmit)	2	3
RX (Receive)	3	2
RTS (Request to send)	4	7
CTS (Clear to send)	5	8
DSR (Data set ready)	6	6
DTR (Data terminal ready)	20	4
CD (Carrier detect)	8	1
Ground	7	5

Table 6.1 RS232C port pin configuration

Some radio transceivers used by Seadiff, however, uses the handshake lines (4,5,6 and 20 for 25-pins connectors) for switching the radio between receive and transmit mode. It is therefore, recommended to connect also these pins interfacing Seadiff radios.

6.2Digiboard PC/X

The intelligent Digiboards carries processor handling the communication processes with external devices and need to be configured via the appurtenant drivers.

If un-intelligent Digiboards are used the driver is built into the Seadiff program. I/O addresses and interrupt level has to be set if an un-intelligent card is used. The recommended setting is setting the status register address to 140h and the I/O port addresses to 100h, 108h, 110h, 118h, 120h, 128h, 130h, 138h (8 channel card) and the interrupt to IRQ 3.

The corresponding addresses and interrupt must be entered on menu page 1 for the desired ports on the Digiboard.

7.APPENDIX A: AUXILIARY OUTPUT FORMATS

7.1DGPS PRECISE POSITION OUTPUT FORMAT

These formats can be selected for AUXOUT interface (menu page F4).

Each output record is 134 characters of ASCII text, including CR-LF at the end. Each field in the record is fixed length. "n" represents a decimal digit, "x" represents a hexadecimal digit. Bits are numbered in a hexadecimal digit as:

0 0 0 0 (hex digit)
3 2 1 0 (bit order)

Bit 3 is the most significant bit (MSB), bit 0 is the least significant bit (LSB).

"hhmmss" represents hours, minutes, seconds
"ddmmss" represents degrees, minutes, seconds

4 SV format:

Name	***Value***	***Format***	***Position***
Start character	[	n	1
Day of Week	(1-7)	n	2
Day of Year	(1-366)	nnn	3
Date		mmddyy	6
Time of Record (UTC)		hhmmss.s	12
Time of Record minus Time of Fix		ss.s	20
(not used)			24
Datum Flag		n	30
Latitude	{N/S}	addmmss.ss	31
Longitude	{E/W}	adddmmss.ss	41
Altitude above Ellipsoid(m)	{+/-}	snnnn.n	52
CMG (Course Made Good) (deg)		nnn.n	59
SMG (Speed Made Good) (knots)		nnn.n	64
3-D Position Error (1 sigma)(m) (not used)		nnn	69
2-D Position Error (1 sigma)(m) (not used)		nnn	72
PDOP		nn.n	75
HDOP		nn.n	79
SV#1 PRN		nn	83
SV#1 S/N		nn	85
SV#1 Range Error (m)		nnn	87
SV#2 PRN		nn	90
SV#2 S/N		nn	92
SV#2 Range Error (m)		nnn	94
SV#3 PRN		nn	97
SV#3 S/N		nn	99

SV#3 Range Error (m)		nnn	101
SV#4 PRN		nn	104
SV#4 S/N		nn	106
SV#4 Range Error (m)		nnn	108
Number of SVs tracked		n	111
Elevation Flag (hex)		x	112
SV Health Flag (hex)		x	113
Operating Mode Flag		n	114
Receiver Code Flag (C/A (L1)+carrier)	7	n	115
Receiver Aiding Flag (course aided)	1	n	116
(not used)		n	117
(not used)		n	118
Differential mode		n	119
Time since last diff correction (min, sec)		mmss	120
(not used)			124
Stop character	]	n	132
Line terminator	CR-LF		

5 SV format:

Name	***Value***	***Format***	***Position***
Start character	[	n	1
Day of Week	(1-7)	n	2
Day of Year	(1-366)	nnn	3
Date		mmddyy	6
Time of Record (UTC)		hhmmss.s	12
Time of Record minus Time of Fix		ss.s	20
(not used)			24
Datum Flag		n	30
Latitude	{N/S}	addmmss.ss	31
Longitude	{E/W}	adddmmss.ss	41
Altitude above Ellipsoid(m)	{+/-}	snnnn.n	52
CMG (Course Made Good) (deg)		nnn.n	59
SMG (Speed Made Good) (knots)		nnn.n	64
3-D Position Error (1 sigma)(m) (not used)		nnn	69
2-D Position Error (1 sigma)(m) (not used)		nnn	72
PDOP		nn.n	75
HDOP		nn.n	79
SV#1 PRN		nn	83
SV#1 S/N		nn	85
SV#1 Range Error (m)		nnn	87
SV#2 PRN		nn	90
SV#2 S/N		nn	92
SV#2 Range Error (m)		nnn	94

SV#3 PRN		nn	97
SV#3 S/N		nn	99
SV#3 Range Error (m)		nnn	101
SV#4 PRN		nn	104
SV#4 S/N		nn	106
SV#4 Range Error (m)		nnn	108
SV#5 PRN		nn	111
SV#5 S/N		nn	113
SV#5 Range Error (m)		nnn	115
Number of SVs tracked		n	118
Elevation Flag (hex)		x	119
SV Health Flag (hex)		x	120
Operating Mode Flag		n	121
Receiver Code Flag (C/A (L1)+carrier)	7	n	122
Receiver Aiding Flag (course aided)	1	n	123
(not used)		n	124
(not used)		n	125
Differential mode		n	126
Time since last diff correction (min, sec)		mmss	127
Stop character	]	n	131
Checksum		cc	132
Line terminator	CR-LF		

If data value is out of range, field is filled with "*".

Datum Flag:
0 = WGS-72, 1 = WGS-84, 2 = NAD-27, 3 = NAD-83, 4 = ED50
5 = NWL10D, 6 = NSWC9Z-2

Elevation Flag:
SV#1 = LSB, SV#4 = MSB: 0 = Above Mask, 1 = Below Mask

SV Health Flag:
SV#1 = LSB, SV#4 = MSB: 0 = Healthy, 1 = Unhealthy

Operating Mode Flag:
0 = No solution, 1 = 4SV, 2 = 3SV+ALT, 3 = 3SV+CLK,
4 = 2SV+ALT+CLK, 5 = ALL-IN-VIEW

Receiver Dynamics Flag:
0 = Static, 1 = Low, 2 = Medium, 3 = High

Differential Quality Flag:
0 = No Correction, 1 = Bad, 9 = Good

This format description is valid for position fixes of up to 5 satellites. If more satellites are used the n SV format must be used, where n is the actual number of satellites.

n SV format:

Name	*Value*	*Format*	*Position*
Start character	[	n	1
Day of Week	(1-7)	n	2
Day of Year	(1-366)	nnn	3
Date		mmddyy	6
Time of Record (UTC)		hhmmss.s	12
Time of Record minus Time of Fix		ss.s	20
Datum Flag		n	24
Latitude	{N/S}	addmmss.ss	25
Longitude	{E/W}	adddmmss.ss	35
Altitude above Ellipsoid(m)	{+/-}	snnnn.n	46
CMG (Course Made Good) (deg)		nnn.n	53
SMG (Speed Made Good) (knots)		nnn.n	58
3-D Position Error (1 sigma)(m) (not used)		nnn	63
2-D Position Error (1 sigma)(m) (not used)		nnn	66
PDOP		nn.n	69
HDOP		nn.n	73
Operating Mode Flag		n	77
Receiver Code Flag (C/A (L1)+carrier)	7	n	78
Receiver Dynamics	1	n	79
Position Quality		n	80
Differential Quality		n	81
Time since last diff correction (min, sec)		mmss	82
Number of SVs tracked		n	86
SV#1 PRN		nn	87
SV#1 S/N		nn	89
SV#1 Range Error (m)		nnn	91
SV#1 Status Flag		x	94
SV#2 PRN		nn	95
SV#2 S/N		nn	97
SV#2 Range Error (m)		nnn	99
SV#2 Status Flag		x	102
:			
:			
SV#n PRN		nn	..
SV#n S/N		nn	..
SV#n Range Error (m)		nnn	..
SV#n Status Flag		x	..
Stop character	]		
Checksum		cc	
Line terminator	CR-LF		

If data value is out of range, the field is filled with "*".

Datum Flag:
0 = WGS-72, 1 = WGS-84, 2 = NAD-27, 3 = NAD-83, 4 = ED50
5 - 9 reserved

Operating Mode Flag:
0 = No solution, 1 = 4SV, 2 = 3SV+ALT, 3 = 3SV+CLK,
4 = 2SV+ALT+CLK, 5 = ALL-IN-VIEW

Receiver Dynamics Flag:
0 = Static, 1 = Low, 2 = Medium, 3 = High

Position Quality Flag:
0 = Bad, 9 = Good

Differential Quality Flag:
0 = No Correction, 1 = Bad, 9 = Good

Status Flag:
Bit 0 = Elevation flag, 0 = SV is above mask
Bit 1 = SV health flag, 0 = SV is unhealthy

7.2TAILBUOY RELATIVE GPS FIX FORMAT

This format can be selected for AUXOUT interface (menu page F4).

Tailbuoy relative GPS information is provided in GIN III format. n represents a decimal digit, a represents a text character

Name	***Value***	***Format***	***Position***
GPS Triggered Measurement Time		hhmmss.ss	1
- - - - - - - Repeated for all buoys -			
Buoy Identifier		aa	10
Vessel-Buoy Range in Metres (ellipsoid distance)		nnnnn.n	12
True Bearing of Buoy/Vessel (degrees)		nnn.nnn	19
Buoy-Vessel altitude difference (metres)		nnn.n	26
Number of Used Satellites		nn	31
HDOP		nn.n	33
- -			
Terminator	CR/LF		

7.3AHV FORMAT - RELATIVE AND ABSOLUTE

Description	*Format*
GPS Triggered Time	hhmmss.ss
Position Output Mode	a*
No. of Units	nn**
Repeat for each unit:	
Indent	aaaa***
Vessel-TBU Range (m) or Easting	nnnnnn.nnn
Vessel-TBU Bearing (degrees) or Northing	nnnnnnn.nnn
Gyro Data String	nnn.n
No. of Satellites	nn
HDOP	nnn.n
Estimated Accuracy	nnn****
Message Terminator	CR / LF

* A - Absolute, R = Relative
** Expected to be in the range 1-12
*** Target Identification
**** Accuracy figure derived by Seadiff for each TBU

7.4TRIMBLE 4000 POSITION FORMAT

This format can be selected for AUXOUT interface (menu page F4).

Seadiff provides output of the Trimble 4000 Position Report. In differential mode the positions given are differential corrected. n represents a decimal digit, a represents a text character and s represents sign.

Name	*Value*	*Format*	*Position*
Start Character	[	n	1
ID (not used)		aa	2
Day		aaa	5
Day of Year (Julian)		nnn	9
Date		dd-mmm-yy	13
Time		hh:mm:ss	23
Latitude		dd:mm.mmmm	32
Latitude North/South	N/S	a	42
Longitude		ddd:mm.mmmn	44
Longitude East/West	E/W	a	55
Height (metres)		snnnn	57
PDOP		nn.n	63
Clock offset (metres)		nnnnnn	68
Vertical Velocity (knots)		snnn.nn	75
Horizontal Velocity (knots)		nnn.nn	83
Heading (relative to true north, degrees)		nnn.n	90
Frequency Offset (ppm)		sn.nnnnEsnn	96
Continuos Measurements (not used)		nnnn	108
Number of Satellites		n	113
PRN number 1-N (separated by commas		N(nn,)	115+
Stop Character	]	a	variable

7.5NMEA 0183 FORMAT

This format can be selected for AUXOUT interface (menu page F4).

1) General sentence format

$GPXXX,data block 1,*SS<CR><LF>,...,$GPXXX,data block n,*SS<CR><LF>

$ - start of sentence
GP - talker identifier
XXX - data identifier
*SS - checksum (exclusive OR of all characters between $ and *, $ and * not included)

2) Data blocks

On menu page 4 in SEADIFF (NMEA 0183 blocks), the GLL, GMS, VHW, VTG blocks and the sequence of them can be selected individually for output.

See the NMEA 0183 Version 2.1 manual for details of the different telegrams. Note that compatibility problems can occurs with equipment assuming older version of the NMEA manual. This is especially often experiences with the GGA sentence.

7.6DIFFSTAR FORMAT

This is the DGPS position report format used by the Diffstar software.

Name	*Value*	*Format*	*Position*
Datumflag	1 or 6	nnnn	1
UTC Time	0 - 604800	nnnnnn.n	6
Latitude (radians)		nn.nnnnnnnn	15
Longitude (radians)		nn.nnnnnnnn	27
Height (m)		nnnnn.nn	39
Angle of HDOP ellipse (degrees)		nnnn	48
ADOP		nnn.n	53
BDOP		nnn.n	59
VDOP		nnn.n	65
RMS of residuals (m)		nnnn.n	71
Termination characters	CR + LF	nn	77

Datumflag:

1 = WGS84
6 = ED87

Latitude and longitude will be according to selected datum and extrapolated forward to true time.

7.7GECO DGPS FORMAT

An description of the "DGPS Computed Position Transfer Format" recommended by Geco-Prakla for third party GPS equipment (release of 15 Mar. 1995) follows.

Content	*Format*	*Byte*	*Unit*	*Comments*
Start Character	A1	1..1	[-]	[
Record identifier	I2	2..3	[-]	= 01
Format version	I2	4..5	[-]	= 01 for this version
Nav. point no.	I2	6..7	[-]	See comments below
System name/version	A10	8..17	[-]	SDIFF7.01
Week number	I4	18..21	[-]	Week no. since Jan 6 1980
Fix time tag (GPS time)	F9.1	22..30	[s]	Seconds into week
Age of fix	F4.1	31..34	[s]	Se comments below
Latitude	A13	35..47	[dm]	^dd^mm.mmmmmN (^=space)
Longitude	A14	48..61	[dm]	^ddd^mm.mmmmmE
Height	F5.1	62..66	[m]	Antenna height above ellipsoid
HDOP	F5.1	67..71	[-]	
VDOP	F5.1	72..76	[-]	
Unit variance	F6.2	77..82	[-]	
Variance Lat	F6.2	83..88	[m2]	
Covariance Lat/Lon	F6.2	89..94	[m2]	
Variance Lon	F6.2	95..100	[m2]	
Variance Height	F6.1	101..106	[m2]	
External Reliability	F6.1	107..112	[m]	See comments below
Fix status	I2	113..114	[-]	See comments below
No. of satellites used	I3	115..117	[-]	No. of Sats. used for this fix
No. of ref. stations	I3	118..120	[-]	No. of Ref. stations used for this fix
Sats. used PRNs	I3*n	121..	[-]	Sats. used for this fix
Ref. station Idents	I3*n	...	[-]	Ref stat. used for this fix.
End character	A1	...	[-]	]
CR LF	A2	...		

Comments:

- The "Age of fix" is the time of the first character of the data string being output to the external navigation system minus time of position.

- The "Nav point no" is an unique integer identifying the position. This is set to 1 in the current Seadiff software version.

- The system name is "SDIFF7.01" for this version of Seadiff.

- The Variance and Covariance terms are elements from the Variance-Covariance matrix of the position fix computation (on-scaled).

- The External Reliability is the max. positional effect of an undetectable error in an observation. This quantity is related to the Power of the test (probability that the MDE would be undetected) and the Significance level used. The values can be selected by the users, but the UKOOA recommended values are Significance level of test 1% and Power of test 80%.

- "No. of ref. stations" gives the number of reference stations in use for this fix, not the number of stations available. This field is set to 0 if the fix is not differential.

- Fix status:
  0 = No or Bad fix
  1 = Altitude aiding (weighted height is used)
  2 = Altitude hold (2D)
  3 = 3D fix

- WGS84 ellipsoid and datum will be used. The Height is the antenna height above the WGS84 ellipsoid.

- Field formats (x = total field length)
  Ax Alphanumeric text
  Ix Integer field
  Fx.y x - gives the total length including the decimal point and decimals
  y - the number of decimals

- Alphanumeric text fields are left justified, and numeric fields right justified.

- There will be a space between each item (except possibly ref. station IDs).

7.8GECO RELATIVE GPS FORMAT

An description of the "Relative GPS Computed Position Transfer Format" recommended by Geco-Prakla for third party GPS equipment (release of 15 Mar. 1995) follows.

Content	*Format*	*Byte*	*Unit*	*Comments*
Start Character	A1	1..1	[-]	[
Record identifier	I2	2..3	[-]	= 02
Format version	I2	4..5	[-]	= 01 for this version
Nav. point no.	I2	6..7	[-]	1,2,3 etc.
System name/version	A10	8..17	[-]	STRCK7.01
Week number	I4	18..21	[-]	Week no. since Jan 6 1980
Fix time tag (GPS time)	F9.1	22..30	[s]	Seconds into week
Age of fix	F4.1	31..34	[s]	
Range	F8.1	35..42	[m]	Horizontal range
Bearing	F9.4	43..51	[deg, 0.0000-359.9999]	
Height difference	F5.1	52..56	[m]	
HDOP	F5.1	57..61	[-]	
VDOP	F5.1	62..66	[-]	
Unit variance	F6.2	67..72	[-]	
Variance dLat	F6.2	73..78	[m2]	
Covariance dLat/dLon	F6.2	79..84	[m2]	
Variance dLon	F6.2	85..90	[m2]	
Variance dHeight	F6.1	91..96	[m2]	
External Reliability	F6.1	97..102	[m]	
Fix status	I2	103..104	[-]	See comments below
No. of satellites used	I3	105..107	[-]	
Sats. used PRNs	I3*n	108..107 +3*n	[-]	Sats. used for this fix
Ref. station Idents	I3*n	...	[-]	Ref stat. used for this fix.
End character	A1	...	[-]	]
CR LF	A2	...		

Comments:

- The "Age of fix" is the time of the first character of the data string being output to the external navigation system minus time of position.

- The "Nav point no" is an unique integer identifying the position. This is set to 2 for the first relative position reported and increased by one for each new relative position (e.g. tailbuoy).

- The system name is "STRCK7.01" for this version of Seadiff.

- Bearing is true bearing from reference antenna to the antenna of the tracked point.

- The range is the horizontal ellipsoidal range between the antennas.

- Height difference is the height of the remote antenna minus the height of the reference antenna, where both refer to the WGS84 ellipsoid.

- The Variance and Covariance terms are elements from the Variance-Covariance matrix of the relative position fix computation (on-scaled), not including the uncertainty of the reference position.

- The External Reliability is the max. positional effect of an undetectable error in an observation. This quantity is related to the Power of the test (probability that the MDE would be undetected) and the Significance level used. The values can be selected by the users, but the UKOOA recommended values are Significance level of test 1% and Power of test 80%.

- Fix status:
  0 = No or Bad fix
  1 = Altitude aiding (weighted height is used)
  2 = Altitude hold (2D)
  3 = 3D fix

- Field formats (x = total field length)
  Ax Alphanumeric text
  Ix Integer field
  Fx.y x - gives the total length including the decimal point and decimals
  y - the number of decimals

- Alphanumeric text fields are left justified, and numeric fields right justified.

- There will be a space between each item (except possibly ref. station IDs).

8.APPENDIX B: STATISTICAL SUMMARY FILE

When the logging function is turned on, a statistical summary file will be generated every time a logging file is generated. The extension of this file is *.STA. See chapter 4.9 (Menu page 9). The file will give statistics about the standard deviation of the residuals at over determined positioning (no. of satellites greater than 3 at 2D).

Example of a statistical summary file:

```
                          STATISTICAL SUMMARY GEO-REF

  SEADIFF version 7.01
  User no: MO-001  Serial no: 001-95  26-06-95

  Start time:       21:45:25    30/05/1995
  Stop time:        22:00:23    30/05/1995
  Start position: N 61ø11'49.300 6805935.3 m   E 01ø49'11.271  114603.2
m
  Stop position:  N 61ø11'47.348 6805648.9 m   E 01ø51'29.474  116651.4
m

  Datum:            WGS84
  Projection:       UTM zone 32

  Reference station used:  0580  N 58ø48'38.0084"  E 05ø40'24.0993
126.0m
  Reference station used:  0581  N 58ø48'38.0455"  E 05ø40'23.9846
127.1m
  Reference station used:  0630  N 63ø40'58.6673"  E 09ø35'21.1035
73.8m

                             Loss of DGPS corrections
    ------------------------------------------------------------------
------
 580
 581
 620
 630
 571
 521
 530
 690
 360
 351
 225
     ------------------------------------------------------------------
-------
      21:46 21:47 21:48 21:49 21:50 21:52 21:53 21:54 21:55 21:56 21:58
21:59


  Navigation Mode:
       Auto 3D

  HDOP mask:  3.0     VDOP mask:  4.0     Elev.mask: 00ø
  Percent of logged data points with redundant information: 100.0 %
```

```
                                          Mean          SD          Max
  Std. Deviation of Unit Weight:           .5          .2          1.5

  Frequency (%)
   60 |
      |
      |
      |
      |
   40 |
      |
      |
      |
      |
   30 |    *
      |    *
      |    *
      |    *
      |    *
   20 |    **
      |    ***
      |    ***
      |    ***
      |    ***
   10 |    ***
      | ** ***
      | ******
      |*******
      |*********     *
      +----+----+----+----+----+----+----+----+----+----+----+----+----+----
+----+-
      0        1.0       2.0       3.0       4.0       5.0       6.0
>7

            Standard Deviation of Unit Weight, Bin size 0.1

  Total number of observations:     50
  Delta T between observations:   30.0 s

  Interval:    0-1     1-2     2-3     3-4     4-5     5-6     6-7
>7
  # of obs:     49       1       0       0       0       0       0
0
```

Explanation of some of the information in the statistical summary file:

The positions are given both in latitude and longitude and in UTM co-ordinates for the selected UTM zone.

"Percent of logged data with redundant observations" is the relationship between the number of over determined observations and the total number of position fixes.

"Total number of observations" is the total number of over determined position fixes.

"Delta T between observations" is the selected logging interval on menu page 9.

9.APPENDIX C: DATA STORAGE ASCII FORMAT

9.1FILE SEADIFF

This format is used for storing on the *.POS file or to printer when the 'ASCII position output' is set to 'FILE SEADIFF' on menu page 9.

"n" represents an integer digit, "a" represents a text character and "r" represents a real value.
"dd/mm/yy" represents day, month, year
"hh:mm:ss.ss" represents hours, minutes, seconds
"ddd:mm'ss.sss" represents degrees, minutes, seconds

Format:
Line 1:
dd/mm/yy_____Nddd:mm'ss.sss_rrrrrrrr.rN_rrrrr.r_rrrr.r_rr.r_rr.r_nn_nn_
aaaaaaaa_rrrrr.r_nnnnn_rrr.r
Line 2:
hh:mm:ss.ss__Eddd:mm'ss.sss_rrrrrrrr.rE_rrrrr.r_rrrr.r__nn_rrr.r
[__nn_rrr.rr_rrrr.r_rr.rrr_nnn_rrr.r **]**

The last part between **[...]** is repeated for each receiver channel

Contents:
Line 1:
Date • Latitude • UTM North • Height • Speed • HDOP • VDOP • Diffmode • Navmode • Datum • Average height • Ref.station id. • Corr.age
Line 2:
Time • Longitude • UTM East • Vertical velocity • Course • No of SVs • SDR **[** • SVno • Residual • Pseudo Range Correction • Range Rate Correction • C/N0 • URA **]**

The values between **[...]** are repeated for each GPS receiver channel. If the channel has no valid measurements, the values are set to zero.

Example:
Line 1:
19/05/92 N 59:55'53.352 6668462.2N 181.8 .2 1.5 2.6 1 1 WGS84 180.0 00630 2.0
Line 2:
12:57:04.04 E 10:38'37.120 926592.7E .0 143.5 05 .9 24 -.57 8.6 .068 016 2.8 20 .03 5.9 -.016 024 .9 25 -.35 17.6 .256 017 3.1 00 .00 .0 .000 000 .0 00 .00 .0 .000 000 .0 12 .22 -3.4 -.008 010 2.9 13 .50 -5.1 .014 007 3.4 00 .00 .0 .000 000 .0 00 .00 .0 .000 000 .0 00 .00 .0 .000 000 .0 00 .00 .0 .000 000 .0 00 .00

9.2SPECIAL

This format is an abbreviated version of the FILE SEADIFF format.

Name	Value	Format	Position
GPS Time (sec)	0 - 604800	nnnnnn.nnn	1
Latitude (degrees)		nn.nnnnnnn	12
Longitude (degrees)		nnn.nnnnnn	23
Height (m)		nnnn.nnn	34
Speed-over-ground (m/s)		nnn.nnn	43
Course-over-ground (degrees)		nnn.nn	51
HDOP		nn.nnn	58
VDOP		nnn.n	65
Age of corrections (sec)		nnn.n	71
Position fix mode		nnn.n	77
Output datum		n	83
Number of satellites		n	85
PRN for 12 satellites		12*(nnn)	87
Standard deviation of unit weight		nnn.n	123

Datum Flag:

0 = WGS-72, 1 = WGS-84, 2 = NAD-27, 3 = NAD-83, 4 = ED50
5 - 9 reserved

Position fix mode:

0 = No solution, 1 = 4SV, 2 = 3SV+ALT, 3 = 3SV+CLK,
4 = 2SV+ALT+CLK, 5 = ALL-IN-VIEW

Example:

```
251169.000 61.1969897   1.821357   81.122   4.627  92.81   .000   1.1   1.8   6.0 1 1  7  7 14 29 24 20  4
25 18  0  0  0  0   1.5
```

10.APPENDIX D: RAW DATA LOGGING FORMAT

This format is used for storing in the *.GPS files when the logging function is turned on menu page 9.

1) General record format

["*"][type][length][data...]
["*"][type][length][data...]
.
.
.

"*" (2Ah)	-	start of record indicator (1 byte)
type	-	record type identifier (1 byte)
length	-	length (in bytes) of the remainder of the record (2 bytes)

2) Record types

Type	***Bytes***	***Data***
00	0	Data block tag
02	2	Number of GPS channels
06	10	Error/Warning message
10	117	Ionospheric/UTC data
11	334	Ephemeris data
20	8	Cycle time tag
25	20	Corrected GPS measurements
26	48	GPS receiver position
27	var	Transponder measurements
60	29	Radionav position
61	var	Radionav measurements
71-94	var	Differential data (RTCM104) Ref 1-24

3) Data formats

Data types:

[B] - byte, 8 bits, range 0-255
[W] - word, 16 bits, range 0-65535
[D] - double word, 4 bytes
[R] - real, 4 bytes float (IEEE-754)
[D] - double real, 8 bytes double precision float (IEEE-754)
[A] - ASCII text

Some of the data records are stored in packed format. For these records a scale factor and a storage offset are given. For this data the stored value must first be multiplied with the scale factor and then the storage offset must be subtracted to obtain the correct value.

02 - CHANNELS (2 bytes)

Bytes	*Type*	*Content(units)*
001-002	[W]	Number of receiver channels

06 - ERROR/WARNING MESSAGE (10 bytes)

Bytes	*Type*	*Content(units)*
001-008	[D]	Time tag (GPS seconds into week)
009-010	[W]	Message ID

10 - IONOSPHERE/UTC DATA (117 bytes)

Bytes	*Type*	*Content(units)*
001-008	[D]	Alpha 0 (seconds)
009-016	[D]	Alpha 1 (sec./semicircle)
017-024	[D]	Alpha 2 (sec./semicircle)
025-032	[D]	Alpha 3 (sec./semicircle)
033-040	[D]	Beta 0 (seconds)
041-048	[D]	Beta 1 (sec./semicircle)
049-056	[D]	Beta 2 (sec./semicircle)
057-064	[D]	Beta 3 (sec./semicircle)
065-072	[D]	A1 (seconds/second)
073-080	[D]	A0 (seconds)
081-096	[D]	T sub OT (seconds)
089-104	[D]	Delta T sub LS (seconds)
097-112	[D]	Delta T sub LSF (seconds)
105	[B]	Ionospheric report time (cumulative GPS seconds)
113	[B]	WN sub T (weeks)
114	[B]	WN sub LSF (weeks)
115	[B]	DN (days)
116	[B]	Ionospheric data checksum (integer)
117	[B]	Checksum (integer)

11 - SV EPHEMERIS DATA (334 bytes)

Bytes	*Type*	*Content(units)*	
001	[D]	SV PRN number	(integer)
002-009	[D]	WN	(see ICD-200)
010-017	[D]	TOW	(see ICD-200)
018-025	[D]	TGD	(see ICD-200)
026-033	[D]	AODC	(see ICD-200)
034-041	[D]	TOC	(see ICD-200)
042-049	[D]	AF2	(see ICD-200)
050-057	[D]	AF1	(see ICD-200)
058-065	[D]	AF0	(see ICD-200)
066-073	[D]	AODE	(see ICD-200)
074-081	[D]	CRS	(see ICD-200)
082-089	[D]	Delta M	(see ICD-200)
090-097	[D]	M sub 0	(see ICD-200)
098-105	[D]	CUC	(see ICD-200)
106-113	[D]	ECCENT	(see ICD-200)
114-121	[D]	CUS	(see ICD-200)
122-129	[D]	SQRT A	(see ICD-200)
130-137	[D]	TOE	(see ICD-200)
138-145	[D]	CIC	(see ICD-200)
146-153	[D]	Omega sub 0	(see ICD-200)
154-161	[D]	CIS	(see ICD-200)
162-169	[D]	I sub 0	(see ICD-200)
170-177	[D]	CRC	(see ICD-200)
178-185	[D]	Omega	(see ICD-200)
186-193	[D]	Omega Dot	(see ICD-200)
194-201	[D]	I Dot	(see ICD-200)
202-209	[D]	AWN	(see ICD-200)
210-217	[D]	AZ Count	(see ICD-200)
218-225	[D]	A ECCENT	(see ICD-200)
226-233	[D]	A TOA	(see ICD-200)
234-241	[D]	A I sub 0	(see ICD-200)
242-249	[D]	A Omega Dot	(see ICD-200)
250-257	[D]	A SQRT A	(see ICD-200)
258-265	[D]	A Omega sub 0	(see ICD-200)
266-273	[D]	A Omega	(see ICD-200)
274-281	[D]	A M sub 0	(see ICD-200)
282-289	[D]	Last SV Lock Time	(Cum GPS seconds)
290-397	[D]	Last Health Check Time (Cum GPS seconds)	
298-305	[D]	Last Bulletin Received Time (Cum GPS seconds)	
306-313	[D]	Almanac Week	(see ICD-200)
314-321	[D]	- Reserved -	
322	[B]	Health Source	(bulletin, ephemeris, almanac)

323	[B]	SV MERIT	(see ICD-200)
324	[B]	ALERT	(see ICD-200)
325	[B]	FIT Interval	(see ICD-200)
326	[B]	HEALTH	(see ICD-200)
327	[B]	SV Config	(see ICD-200)
328	[B]	SV enable/disable Flag (0=enable; 255=disable)	
329	[B]	Ephemeris Checksum 1	
330	[B]	Ephemeris Checksum 2	
331	[B]	Almanac Checksum 1	
332	[B]	Almanac Checksum 2	
333	[B]	- Reserved -	
334	[B]	Last collected sub frame 4 page number	

20 - CYCLE TIME TAG (8 bytes)

Bytes	*Type*	*Content(units)*
001-008	[D]	Data Block Time Tag (Cumulative GPS seconds)

25 - CORRECTED MEASUREMENTS (20 bytes packed format)

Bytes	*Scale factor*	*Storage offset*	*Content(units)*
001	1		SV PRN number
002	1		Channel
003	1		Signal to Noise Ratio
004	1		Valid measurement (0 = not valid; 255 = valid)
005-008	1/4096	-3.024E5	Corrected time tag (GPS seconds into week)
009-011	1/32	+200.0	Corrected pseudo-range (meters)
012-014	1/512	-4.077E6	Corrected frequency
015-016	128	-2.0E7	Distance to Satellite (meters)
017	1/4		Ionospheric delay (seconds)
018	1/4		Tropospheric delay (meters)
019	1/2		SV elevation angle (degrees)
020	2		SV azimuth angle (degrees)

26 - RECEIVER RAW POSITION (48 bytes packed format)

Bytes	*Scale factor*	*Storage offset*	*Content(units)*

001-004	1		Time tag (cumulative GPS seconds)
005-007	1/2**22	+0.5*pi	Latitude (radians)
008-010	1/2**21	+2.0*pi	Longitude (radians)
011-012	1	+1000.0	Height (meters)
013-014	1/2**26	+0.0002	Latitude Velocity (radians/second)
015-016	1/2**26	+0.0002	Longitude Velocity (radians/second)
017-018	1/256	+128	Height Velocity (meters/second)
019-020	16		Clock Offset (meters)
021	1		Number of satellites used
022	1		New position (0 = no new data; 255 = new data)
023	1		Fix mode
024	1		SV Count - number of satellites used
025	1		Channel 1
026	1		Channel 2
027	1		Channel 3
028	1		Channel 4
029	1		Channel 5
030	1		Channel 6
031	1		Channel 7
032	1		Channel 8
033	1		Channel 9
034	1		Channel 10
035	1		Channel 11
036	1		Channel 12
037	1		SV PRN 1
038	1		SV PRN 2
039	1		SV PRN 3
040	1		SV PRN 4
041	1		SV PRN 5
042	1		SV PRN 6
043	1		SV PRN 7
044	1		SV PRN 8
045	1		SV PRN 9
046	1		SV PRN 10
047	1		SV PRN 11
048	1		SV PRN 12

27 - TAILBUOY MEASUREMENTS (variable length (10+nsat*5))

Bytes	*Scale factor*	*Storage offset*	*Content(units)*
001	1		Tailbuoy number
002-004	-		Tailbuoy ID (3 characters)
005-008	1/4096	-3.024E5	Time tag (GPS seconds into week)
009	1		Number of satellites
010	1		Voltage of tailbuoy power supply
For each active satellite:			
001	1		SV PRN number
002	1		SN ratio
003-005	1/32		Pseudo range measurement

71-82 - DIFFERENTIAL DATA (variable length)

Header:
Scale factor: 1, No storage offset

Bytes	*Type*	*Content(units)*
001		Message Type (RTCM SC-104 data type)
002-003		Station ID (v1.0: 0-4095, v2.0: 0-1023)
004-007		Z-count (seconds / 0.6)
008		Sequence Number (0-7)
009		Message Frame Length (2-33 30 bit words)
010		Station Health (0-255)

Message type 1:

Bytes	*Scale factor*	*Storage offset*	*Content(units)*
011	1		SV PRN number
012-013	1		SV health
014-016	1/256	+10485.76	Pseudo range Correction (PRC) (m)
017-018	1/4096	+4.096	PRC rate (m/s)
019	1		IODE

Bytes 011 - 019 are repeated for all active satellites. The number of active satellites is computed from Message Frame Length: #SVs = (Frame_Length–2)*3/5

Message type 2:
Scale factor: 1, No storage offset

RTCM v.1.0:

Bytes	*Type*	*Content(units)*
011-018		Delta Pseudo range Correction (m)

RTCM v.2.0:

Bytes	*Type*	*Content(units)*
011		SV PRN number
012-013		Old SV health
014-021		Delta Pseudo range Correction (m)
022-029		Delta PRC rate (m/s)
030-037		IODE

Bytes 011 - 018(037) are repeated for all satellites in the previous Type 1 message.
The SV PRN numbers are obtained from the previous Type 1 Message.

Message type 3:

Scale factor: 1, No storage offset

RTCM v.1.0:

Bytes	*Type*	*Content(units)*
011-018		Reference Position ECEF X-Co-ordinate (m)
019-026		Reference Position ECEF Y-Co-ordinate (m)
027-034		Reference Position ECEF Z-Co-ordinate (m)
035-042		Clock Offset
043-050		Clock Uncertainty
051-058		Frequency Offset
059-066		Frequency Uncertainty
067-074		Tropospheric Correction
075-082		Average C/NO
083-084		Station Health (see RTCM SC-104)

RTCM v.2.0:

Bytes	*Type*	*Content(units)*
011-018		Reference Position ECEF X-Co-ordinate (m)
019-026		Reference Position ECEF Y-Co-ordinate (m)
027-034		Reference Position ECEF Z-Co-ordinate (m)

60 - RADIONAV POSITION (29 bytes)

Bytes	*Type*	*Content(units)*
001-008	[D]	Time tag
009	[B]	System ID
010-017	[D]	Latitude (radians)
018-025	[D]	Longitude (radians)
026-029	[R]	Standard deviation

61 - RADIONAV MEASUREMENTS (variable length)

Bytes	*Type*	*Content(units)*
001	[B]	Number of measurements
002	[B]	Measurement ID
003-010	[D]	Raw measurement
011-014	[R]	Variable correction
015	[B]	Solution flag
016-023	[A]	Status/SNR
024-031	[D]	Clock bias (GEOLOC)
032-035	[R]	Clock drift (GEOLOC)

Bytes 002 - 023(035) are repeated for all measurements.