# Data acquisition system "NavDat"

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# Contents

# 1 Software purpose and main functions

"NavDat" is software solution for survey computational tasks adapted for IBM PC compatible on-board computer.

"NavDat" main functions are:

- Navigation support. Based on modern satellite navigation technology "NavDat" provides real-time registration of navigation parameters, automatic solution of wide range of navigation tasks, routing control through pilot's indicator, and interactive control of a flight plan.
- Interaction with on-board geophysical hardware. Using on-board computer interface "NavDat" provides data and command exchange between all devices to guarantee data integrity.
- Data saving. Data are recorded on a hard drive of an on-board computer.
- User interface. Software provides full control of interaction with hardware.

"NavDat" is designed in such a way that only one technician is able to provide navigation and survey control. Program work was organized in a way to prevent fatal data loss or damage by reason of technician mistakes.

Hardware platform for "NavDat" is IA-64 compatible computer with Operating System GNU/Linux.

# 2 Program installation

"NavDat" is delivered as a software package from Geotechnologies server. The package is created to be used on GNU/Linux system Ubuntu 16.04.3 LTS. First, you should install 64-bit Ubuntu Operating System, installation guide could be found here: http://tutorials.ubuntu.com/tutorial/tutorial-install-ubuntu-desktop. Second, start Terminal and run the following commands:

```
wget -qO - https://dist.gtcomp.ru/key.gpg | sudo apt-key add -
```

```
sudo tee /etc/apt/sources.list.d/navdat.list <<EOF
deb https://dist.gtcomp.ru/navdat-xenial-common stable/
deb https://user_name:password@dist.gtcomp.ru/navdat-xenial-user_name stable/
EOF
```

```
sudo apt-get update
```

```
sudo apt-get install navdat-user
```

Your user_name and password are provided by Geotechnologies. After the System reboot a new account "NavDat session user" will appear (password is "qwerty"). It is strongly recommended to use this account to work with "NavDat" only.

Some recommendations:

- Not less then 10 GB is required for root file system
- Not less then 1 GB is required for swap
- Separate volume is preferable for data saving and storage (i.e. for /home directory)
- Recommended file systems: ext3, ext4

# 3 Visualisation and user interface

User interface is based on Awesome environment.

At the left of the top panel there is a list of Desktops, CPU and Memory usage indicators. At the right ther is a Bort Server idicator (on\off). You can main menu by pressing **Alt-F1** or left mouse button. This menu contains applications for data visualisation and flight control.

Some useful system parameters can be seen in chart window (see Section B.1).

# 4 "NavDat" settings and staring up

During first launch of "NavDat" please check that navdat user session is running in Awesome mode. The mode is chosen during logging in.


Figure 1: Mode selection

To run settings utility tool use application menu.

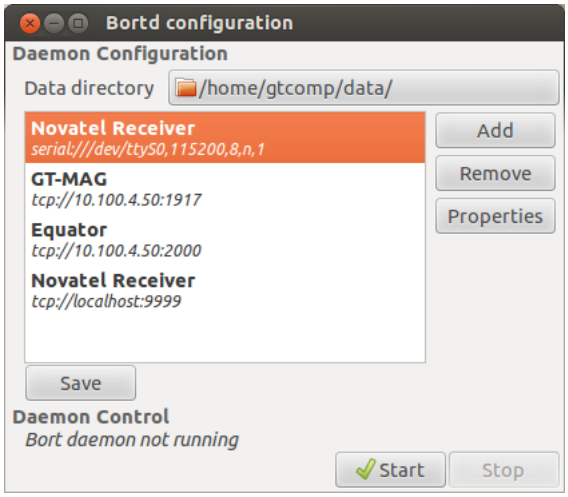


Figure 2: Settings utility tool window

This utility allows to add devices, select destination folder for data storage and control on-board server parameters.

After adding new device select interface type its parameters (ip, port etc), save settings and restart server. Push Settings button to set these parameters. Some devices have additional parameters, which can be set on the corresponding tab of appeared window.

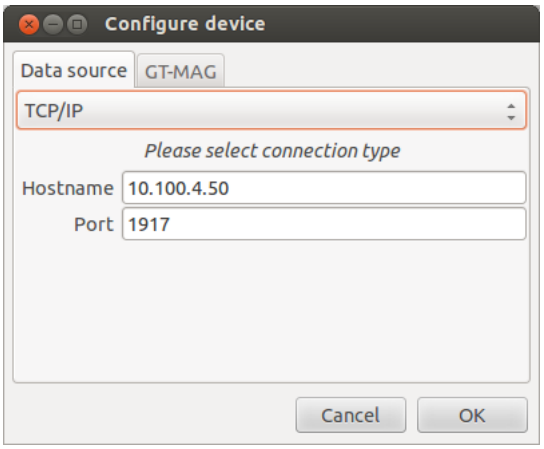


Figure 3: Parameters setting window

**Warning** The first GNSS reciever in the devices list will be always used as a source of navigation data for flight control.

Using application menu you can change desktop configuration of the on-board computer: select a program from the applications menu and drag it on the desktop. Saved configuration (Settings->Session: save or **Ctrl+Alt+S** ) will be loaded next time (Settings->Session: restore or **Ctrl+Alt+R** ).

# 5 Navigation support

"NavDat" uses point coordinates (latitude,altitude) obtained by the first GNSS-receiver in the devices list to solve following navigation tasks:

- Distances calculation. All distances are calculated as lengths of orthodromic lines (the arcs of great circles). Distances are measured in kilometres.
- Azimuths calculation. Azimuths are calculated as angles (in degree) between orthodromic lines in the point of intersection.
- Estimated time calculation. For time calculation current speed measured on the basis of GNSS-receiver data is used.
- Navigational altitude control, i.e. altitude to be kept by pilot. It can be measured by any device: GNSS-receiver, GT-MAG etc.
- Flight task implementation control.

# 6 Interaction with on-board devices

## 6.1 TCP/IP connection

All devices connected using TCP/IP have their ip-address and port. Note that if they have no DHCP-server, the user should configure a corresponding network manually. Check device's manual for details.

## 6.2 Serial port connection

Serial communication port should be also configured: address, rate, data bits, parity, stop bits. Usually RS232 devices are connected using USB to COM adapter. The "NavDat" allows to choose assignment method. One can assign COM-port by device, by ID or by path. For example:

```
/dev/ttyUSB0> /dev/ttyUSB0
    /dev/ttyUSB0: by-path
    /dev/ttyUSB0: by-id
```

By devise. If there are more than one RS232 device the user should connect them in the same order every time.

By path. The user should connect devices always in the same USB-ports.

By ID. This method is possible only if there are no USB to COM adapters with similar ID.

## 6.3 On-Board Server

By default "NavDat" uses Unix Domain Socket for internal communications between different applications and devices. To be able to use other means of control and visualization (smartphone, tablet, another PC) you must configure the local network and use the corresponding IP adress for communications. In this case, you need to add the "On-Board Server" device and assign the IP-address and the port number on the server-computer. The same parameters must be specified in the environment variable BORT_SERVER on the client-computer.

To provide the correct value of the variable you must add the following string to the '/etc/environment' file (root rights are needed):

```
BORT_SERVER="tcp://ip_adress:port"
```

## 6.4 GNSS-receiver Javad/Topcon

"NavDat" is compatible with any *Javad Positioning Systems* or *Topcon Positioning Systems* receiver, that has RS232 serial port and supports GRIL protocol.

Program interacts with a receiver in data-command interchange mode. That is why you need to turn receiver on and connected it to computer before starting "NavDat". In most cases the receiver has the same power-supply source with the computer, so this requirement is satisfied automatically. But if you ran program when receiver was turned off do not try to connect it while program is running. Otherwise saved data may be damaged, because essential titles will not be created. While connected to a receiver "NavDat" saves full navigation data produced by a receiver in a special file `*.jps`. This is necessary for differential correction software, which supports this data format only.

Variables list for monitoring of this device is in Section B.4.


Figure 4: Javad/Topcon Parameters

The device has one setting parameter - 'Initialization Commands', which defines initialization sequence to be sent to receiver. In case of empty parameter all necessary commands for differential correction and correct visualisation will be sent automatically. If the parameter is set or the receiver can't receive commands note that full functionality is possible only if the following messages are received: RT, SI, PG, VG, EL, AZ, DP.

The default commands sequence is as follows.

```
dm
em,,/msg/def:0.1
em,,/msg/jps/PG:0.1
em,,/msg/jps/VG:0.1
em,,/msg/jps/AZ:1
```

It is supposed that 'def' includes all necessary for differential mode messages, and RT, SI, EL, DP as well

## 6.5 GNSS-receiver Novatel

"NavDat" is compatible with any *Novatel* receiver, that has RS232 serial port. For today the company *Novatel* didn't make drivers for their USB-adapter to provide functioning in OS Linux.

Program interacts with a receiver in data-command interchange mode. That's why you should turn the receiver on and connect it to the computer before starting "NavDat". In most cases the receiver has the same power-supply source with the computer, so this requirement is satisfied automatically. But if you ran program when receiver was turned off do not try to connect it while program is running. Otherwise saved data may be damaged, because essential titles will not be created. While connected to a receiver "NavDat" saves full navigation data produced by a receiver in a special file `*.nov`.

Variables list for monitoring of this device is in Section B.4.

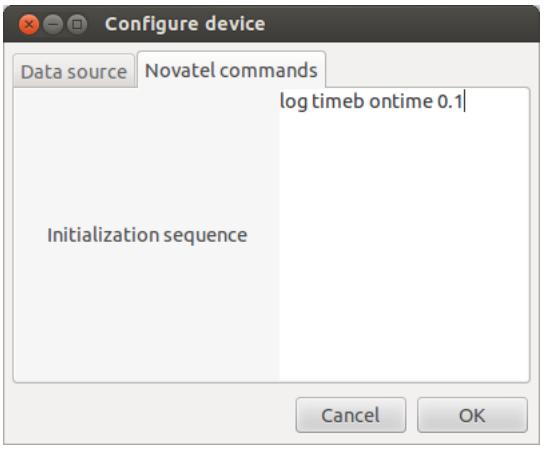


Figure 5: Novatel Parameters

The device has one setting parameter - 'Initialization Commands', which defines initialization sequence to be sent to receiver. In case of empty parameter all necessary commands for differential correction and correct visualisation will be sent automatically. If the parameter is set or the receiver can't receive commands note that full functionality is possible only if the following messages are received: bestposb, bestvelb, gpgsa, gpgsv.

The default commands sequence is as follows.

```
unlogall
log bestposb ontime 0.1
log bestvelb ontime 0.1
log GPGSA ontime 1
log GPGSV ontime 1
log rangecmpb ontime 0.1
log almanacb onchanged
log ionutcb onchanged
log rawephemb onnew
log versionb ontime 100
log gloalmanacb onchanged
log gloclockb onchanged
log gloephemerisb onchanged
log glorawephemb onchanged
log rxstatuseventb onchanged
```

While configuring receiver it is recommended to set bitrate as 115200 and also

```
nmeatalker auto
pdpfilter enable
pdpmode relative dynamic
selectchanconfig 4
```

The last instruction is actual only for OEMStar receivers (8 GPS, 6 GLONASS configuration)

## 6.6 Infrared scanner

Infrared scanner is an automatic device connected through Ethernet. You should remember, that writing speed of scanner data is about 1MB/sec(3,6 GB/hour) and available disc space should be enough. Scanner has built-in inertial orientation system. Usually infrared scanner has a built-in GNSS receiver, and interfaces necessary for radar altimeter and pilot's indicator. So, all these devices are connected using one Ethernet cable.

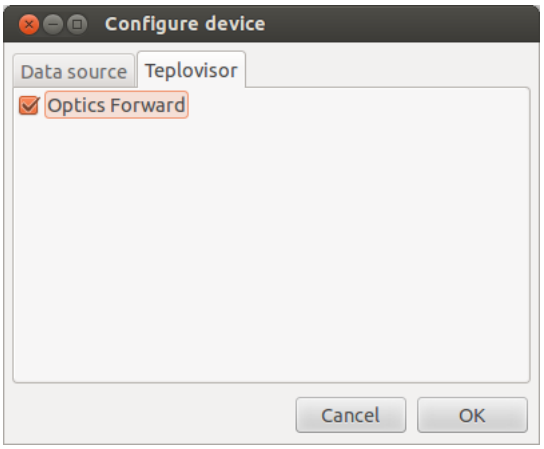


Figure 6: Infrared Scanner Parameters

The device has one parameter - 'Optics Forward', which defines installation method with respect to flight direction. This only affects the attitude system behaviour.

## 6.7 GT-Mag system

GT-Mag system is an automatic device connected through USB. Usually GT-Mag has at least one built-in GNSS receiver, and interfaces necessary for radar altimeter and pilot's indicator. So, all these devices are connected using one USB cable. Default connection settings are as follows: ip-adress 10.100.4.50, port 1917 - GT_Mag, port 4444 - GNSS receiver, port 3333 - pilot arrow. It is necessary to set corresponding network as 10.100.4.yyy, mask 255.255.255.0.

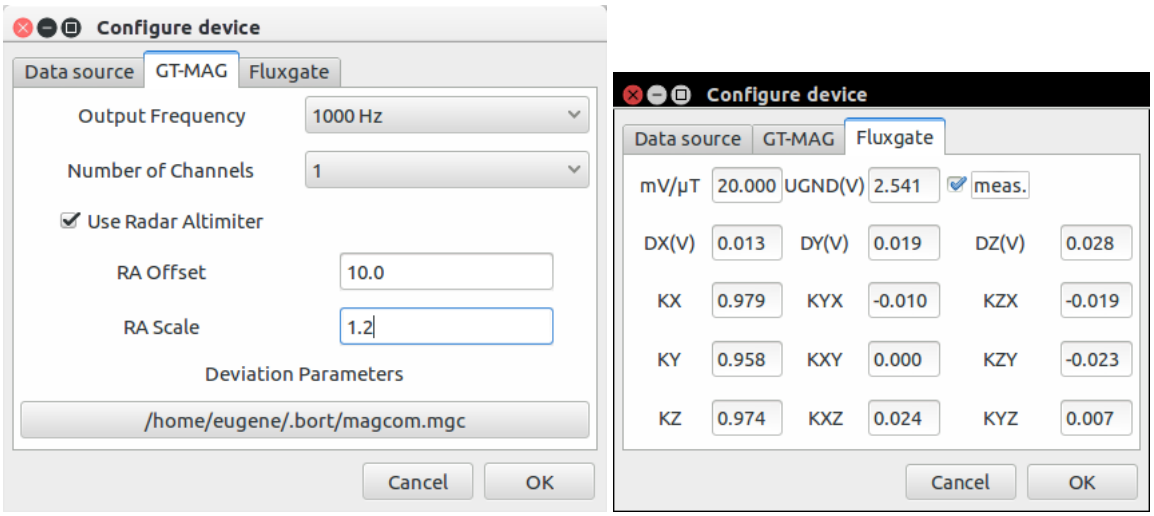


Figure 7: GT-Mag Parameters

The device has the following parameters. GT-MAG group:

- Output Frequency - allows to change data sample rate for 1000 Hz version of GT-Mag
- Number of Channels - allows to visualize only selected number of channels; it doesn't change data stream file
- Use Radar Altimeter - GT-Mag radar altimeter channel will be used as navigational altitude for pilot indicator, if selected
- RA Offset - radar altitude offset in meters, to be applied if it is selected (DRA)

- RA Scale - radar altitude scale factor, to be applied if it is selected (KRA)
- Deviation Parameters - deviation parameters file (mgc-file made by ReinMag software) can be selected; these parameters will be applied to first GT-Mag channel only; due to fluxegate channel derivation the compensated value will be delayed for 0.2 sec.

The calculation rule for the corrected radar altitude is as follows

```
H = (RA + DRA) b''·b'' KRA
```

Fluxgate group allows setting parameters for different sensors, accounting calibration results:

- UGND(V) - common signal zero, the default value is 0 (volts)
- mV/μT - common scale factor, the default value is 100 (millivolts per microtesla)
- DX(V), DY(V), DZ(V) - offset for each channel, Volts, the default values are 0 (volts)
- KX, KY, KZ - scale factor for each channel, the default values are 1s
- KYX, KZX, KXY, KZY, KXZ, KYZ - cross channel influence; KXY is the X-component factor in Y-component, for example; the default values are 0s

CT-MAG allows measurement of common signal zero instead of radar altitude. In this case it is necessary to set flag 'meas.' and to clear 'Use Radar Altimeter'. UGND will not be used.

The calculation rule for fx, fy, fz in nanotesla is as follows

```
x = X - UGND + DX
y = Y - UGND + DY
z = Z - UGND + DZ
fx = (x + y b''·b'' KYX + z b''·b'' KZX) b''·b'' KX b''·b'' 10^6 / K
fy = (y + x b''·b'' KXY + z b''·b'' KZY) b''·b'' KY b''·b'' 10^6 / K
fz = (z + x b''·b'' KXZ + y b''·b'' KYZ) b''·b'' KZ b''·b'' 10^6 / K
```

where X, Y, Z are measured values in volts, K is the common scale factor in mV/μT.

Variables list for monitoring of this device is in Section B.5.

## 6.8 Equator system

Equator system is an automatic device connected through Ethernet. Data will be recorded at high speed - 4 Mb/s (14 Gb/hour). Please, check disk free space before start. Equator has built-in GNSS receiver and radar altimeter. So, all these devices are connected using one Ethernet cable. Default connection settings are as follows: ip-adress 10.100.4.50, port 2000. It is necessary to set corresponding network as 10.100.4.yyy, mask 255.255.255.0.

## 6.9 EM4H system

EM4H system is an automatic device connected through ethernet or RS232. In case of ethernet connection data will be recorded at high speed - 4 Mb/s (14 Gb/hour). Please, check disk free space before start. It can have built-in GNSS receiver and radar altimeter. It also can have pilot's indicator interface. Radar altimeter data will be integrated in EM4H data stream.

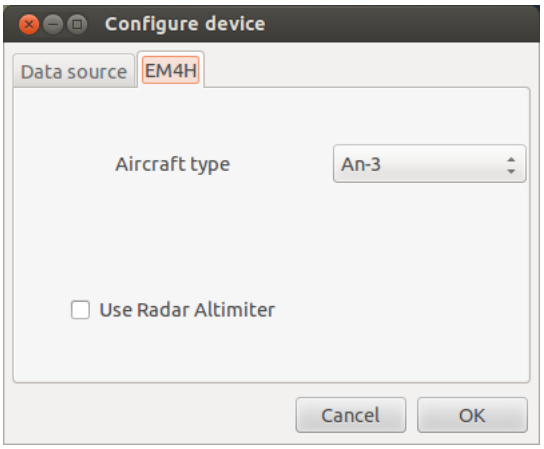


Figure 8: EM4H Parameters

The device has following parameters:

- Aircraft type - allows to select between An-2, An-3 and Mi-8: the type defines the compensation algorithm (see Section 18). Note, that choosing An-3 means usage of additional compensation coil mounted on a stinger, not the aircraft itself. If there are no such coil on An-3 you should set An-2. And if it is used on An-2, than set An-3 type.
- Use Radar Altimeter - GT-Mag radar altimeter channel will be used as navigational altitude for pilot indicator, if selected

Variables list for monitoring of this device is in Section B.6.

## 6.10 Spectrometer RSx

"NavDat" is compatible with spectrometers from *Radiation Solutions Inc*, such as RS-501, RSX4, RSX5 etc which are communicate using RSI protocol. Up to three devices simultaneously. Usually connection settings are 192.168.1.xxx, port 4000. It is necessary to set corresponding network as 192.168.1.yyy, mask 255.255.255.0.

For monitoring of this device see Section 17, Section B.7

## 6.11 Spectrometer GRS410

"NavDat" is compatible with spectrometers GRS410 from *Pico Envirotec Inc* registering individual spectra. Up to three devices simultaneously. Connection to Concentrator or Superconcentrator can be established via serial port.

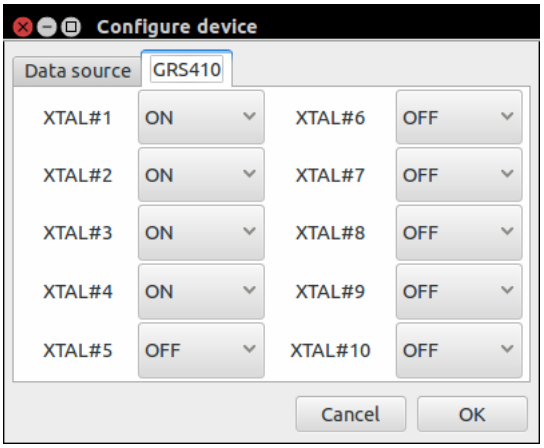


Figure 9: GRS410 Parameters

The device has following parameters:

- XTAL#* - allows to switch on/off spectrum visualization for crystal # * (* - 1,...,10). Being switched off the corresponding spectrum will be invisible. But it will be registered in data file.

For monitoring of this device see Section 17, Section B.8

## 6.12 Spectrometer GSA2000

"NavDat" is compatible with spectrometers GSA2000. Up to six devices simultaneously. Connection can be established via serial port.

**Warning** The device works by request and must be initialized. That is why the device has to be started before the software.

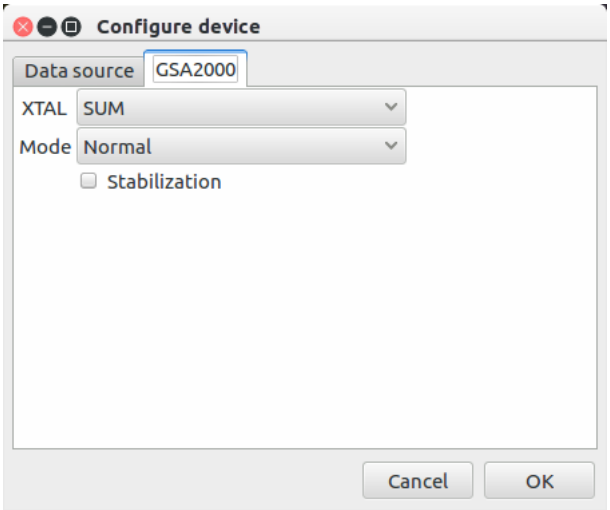


Figure 10: GSA2000 Parameters

The device has following parameters:

- XTAL - allows to select crystal #1, #2 or their sum.
- Mode - allows to select ordinary spectrum or the spectrum of the light.
- Stabilization - allows to switch stabilization on/off.

For monitoring of this device see Section 17, Section B.9

## 6.13 Pilot's indicator ("Arrow")

This device was designed to display lateral and vertical deviations. Also current flight mode is shown on the indicator (route approaching, surveying). Data transfers through RS232 serial port using CTS and RTS mechanism (classic type). ( RS232 interface description). Modern type of pilot indicators uses only DTX. Tvisor type is connected only to Infrared scanner. Pilot's indicator is described in details in Section 12.1.

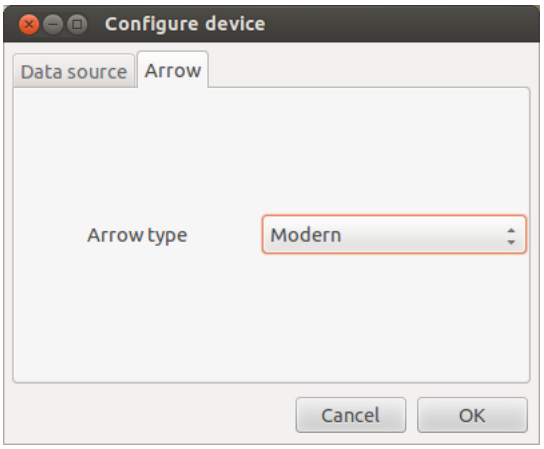


Figure 11: Arrow Parameters

Pilot indicator allows to chose it's type: classic, tvisor or modern.

## 6.14 Radar Altimeter

This device is connected to "NavDat" not directly but through some other devices. In some cases connection sheme allows sending commands to radar altimeter: on, off, test. For this purpose "NavDat" has special application RA Control Panel.

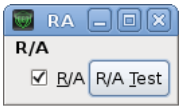


Figure 12: Radar Altimeter Control Panel

## 6.15 Free Flight Radar Altimeter

"NavDat" is compatible with radar altimeters from *Free Flight*, that have RS232 serial port: TRA-4000, TRA-4500. They use 56000 bit rate, so the corresponding serial port should be configured to 57600.

Variables list for monitoring of this device is in Section B.10.

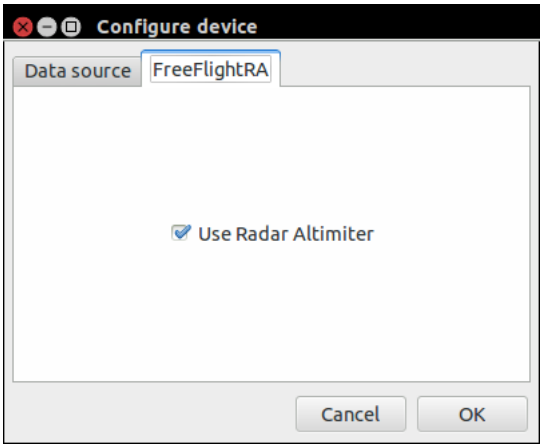


Figure 13: Free Flight RA parameters

The device has one setting parameter - 'Use Radar Altimeter' - it's measurements will be used as navigational altitude for pilot indicator, if selected

### 6.16 Geotechnologies ADC

"NavDat" is compatible with any *Geotechnologies ADC*, that has RS232 serial port.

Variables list for monitoring of this device is in Section B.11.

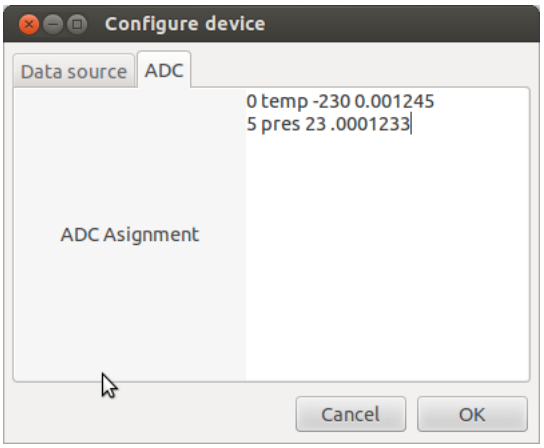


Figure 14: ADC parameters

The device has one setting parameter - 'ADC Assignment', which defines scaled variables. Each string must have a following format: "number_of_channel name offset scale". The two last values should be measured in ADC units.

## 7 System health monitoring

All devices connected to the "NavDat" have their own health flag, as well as the "NavDat" itself. All these flags are monitored by the appropriate application 'Status'. Each flag is visualized using an indicator which is grey while the corresponding device is working correctly, otherwise it's red. Indicators are configured automatically. They are arranged in a row or a column depending on window form. If any indicator is red for a minute or so, current survey should be stopped for recovering.

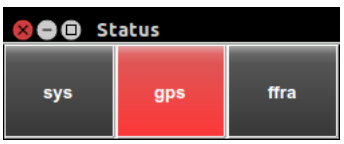


Figure 15: Status panel

Flags values are defined as follows

- **sys** - It is red if data write error is occurred, no bytes written or low free disk space (for 10 hours or fewer).
- **gtmag** - It is red if there are no synchronization with GNSS-receiver, not enough satellites in view, low sensor signal amplitude, low or extremely high consumption current or no data at all.
- **gps** - It is red if there are no data or no position in corresponding GNSS-receiver.
- **spec** - It is red if there is no signal or data stream error is occurred. For GSA2000 the device control byte is also used.

- **em4h** - It is red if there is no signal, induction is off, any ADC is overranged or data stream error is occurred.
- **equator** - It is red if there is no signal, induction is off, any ADC is overranged or data stream error is occured.
- **ffra** - It is red if there is no data from altimeter, there are errors in the stream, or it is in test mode.
- **gtadc** - It is red if there is no signal.
- **e502** - It is red if there is no signal.

# 8 Navigational and geophysical data registration

"NavDat" creates following files:

- `*.dlg` (Data Logging). This binary file contains data from all devices of the system. Format of this file is rather complicated. It will be used by extraction programs while processing later on. You should only remember that synchronization text string is writing in this file periodically, its prefix is $POS:

```
$POS,12,094301.0,5539.9828751,3736.3127569,237.31,41.1,41.12,0.1,21,03,2009,54.11
```

After prefix goes a number of visible satellites, GPS time (HHMMSS.s), latitude, longitude (DDMM.mmmmm), altitude above geoid, heading in degrees, velocity in m/s, PDOP, day, month, year (GPS date), navigation altitude in meters. This information could be read from the file by eyes. If there are more then one GNSS receiver, each of them will have it's own pos-message. $POS - number one, $PO1 - number two, etc. All these parameters can be seen in chart window (see Section B.3). Name of file is a composition of date and time of program start-up. First symbol corresponds to current month (1 - January, ..., 9 - September, a - October, ..., c - December). After it follow two digits - day, next two digits - number of program start in current day. Data saving process lasts from program start-up till shut down continuously. To ease backup process if file size goes beyond 100Mb it will be closed and data will be saved into the next file. New file gets the same name with additional 'b' at the end of its name, then'c', then 'd', etc.

- `*.jps` (Javad Positioning Systems, several devices may be). As it was mentioned above data produced by GNSS-receiver of Javad or Topcon type are stored in this binary file. It is used in differential correction procedures. It is divided into 100 Mb parts also. File's name is same as the name of dlg-file.
- `*.nov` (Novatel, several devices may be). Data produced by GNSS-receiver of Novatel type are stored in this binary file. It is used in differential correction procedures. It is divided into 100 Mb parts also. File's name is same as the name of dlg-file.
- `*.tep` (Infrared scanner). Scanner data are saved into files of individual format. Scanner produces 3,6 Gb of data in hour. These files are divided into 100 Mb parts also. And it is clear that more then 30 files will be created every hour. 27th file and following will get two-symbol identification ('ba', 'bb', 'bc' etc) at the end of their names. File's name is the same as for dlg-file.
- `*.mag` (GT-Mag, several devices may be). GT-Mag data are saved into files of individual format. These files are divided into 100 Mb parts also. File's name is the same as for dlg-file.
- `*.rad` (Equator). Equator data are saved into files of individual format, it's data stream is about 4 Gb per hour. These files are divided into 100 Mb parts also. File's name is the same as for dlg-file.
- `*.rs` (RSx, several devices may be). Spectrometer data are saved into files of individual format. These files are divided into 100 Mb parts also. File's name is the same as for dlg-file.
- `*.grs` (GRS410, several devices may be). Spectrometer data are saved into files of individual format. These files are divided into 100 Mb parts also. File's name is the same as for dlg-file.
- `*.gsa` (GSA2000, several devices may be). Spectrometer data are saved into files of individual format. These files are divided into 100 Mb parts also. File's name is the same as for dlg-file.
- `*.em4` (EM4H). EM4H data stream is recorded in these files. To provide compatibility with old programs the same data are saved in dlg according to EM4H manual. File's name is the same as for dlg-file.

- `current.fpl` (Flight Plan). When you quit the program this file contains flight plan information saved in a computer memory by the time of shutting down. This format is described in details in (Section 9).

Similar devices write to different files: `*.rs`, `*.rs1`, ... or `*.jps`, `*.jp1`, ...

# 9 Flight plan file

This is a text file, that contains formalized description of a flight plan. There are several ways to create this file: you can use text editor or use Geosoft Oasis Montaj utility or even use "NavDat" itself. But present syntax rules must be satisfied anyway.

## 9.1 Terms

Flight plan consists of records. Each record has a type, a name and a list of points (may be empty). Points description includes name (optionally), latitude and longitude. Every record in the file should begin a new line and comply with following template:

```
 RECORD_TYPE RECORD_NAME =
(POINT_NAME, LATITUDE, LONGITUDE),
(POINT_NAME, LATITUDE, LONGITUDE),
..........
(POINT_NAME, LATITUDE, LONGITUDE),
```

All names (RECORD_NAME, POINT_NAME) in the file shouldn't start with a number or contain "+-/*.,$#@!%^&()[]|\<>" symbols. Symbol '_' is valid. Records with identical names are acceptable.

Points coordinates should follow "DDDMMmmmm" format, i.e. degree-minutes-parts_of_minute without spacing. Degrees are on the first place (up to three characters for longitude and up to two for latitude), then goes minutes integer part - two characters, then minutes fractional part- exactly four characters. Sign depends on a hemisphere. Negative latitude value corresponds to the Southern Hemisphere, negative longitude to the Western Hemisphere.

Note, Flight plan and aboard navigation system should use the same coordinate system. Usually GNSS receivers operate in WGS84 system.

Possible values of RECORD_TYPE field are:

- `LINE` – if record contains ordered list of route points.
- `POSITION` – if points of these record don't describe a route, e.g. airports (then record name may be AIRPORTS) or obstacles (then record name may be OBSTACLES).
- `REGION` – if record contains ordered array of polygon vertex, which bounds survey area or any other area in operation zone.

Flight plan file may include comments. Comments should be located on the right side of the line and should have two ';' symbol at the beginning. An example of `*.fpl` file is given below. Syntax rules are not applied to records order and it depends only on reading and work convenience. Here is an example:

```
;;;;;;;;;;;;;;;;savedFPL. it is COMMENT
POSITION AIRPORTS=
(-3815,3815), ;;ONE MORE COMMENT
 (CONTROL,-0,-0),
 (3815,-3815);
LINE RKM=
 (CONTROL,-5396,-0),
 (CONTROL,-0,-0),
 (CONTROL,5396,-0);
POSITION OBSTRUCT=
 (-3815,-3815),
 (CONTROL,-0,-0),
```

```
 (3815,3815);
LINE RKM=
 (CONTROL,-0,-5396),
 (CONTROL,-0,-0),
 (CONTROL,-0,5396);
```

All points in this example are located near the equator, because all significant characters are interpreted as minute fractions.

For convenience it is possible to load flight plan as Geosoft `*.xyz`:

```
Line 101
   LATITUDE LONGITUDE
   LATITUDE LONGITUDE
   ..........
   LATITUDE LONGITUDE
Tie 201
   ..........
```

Points coordinates should follow "DDDMMmmmm" format, i.e. degree-minutes-parts_of_minute without spacing, the same as in `*.fpl`. Points names will be automatically set to A0, A1, A2 etc, and all routes will be loaded as LINEs. After loading the flight plan can be saved in `*.fpl` format only.

## 10 Flight Plan panel

Flight plan panel is used to display flight plan file and for plan control. At startup single empty line is displayed on the panel. If you move cursor right or down to panel borders then panel will scroll. To start working with flight plan load its file.


Figure 16: Flight plan panel

## 10.1 Flight plan loading and viewing

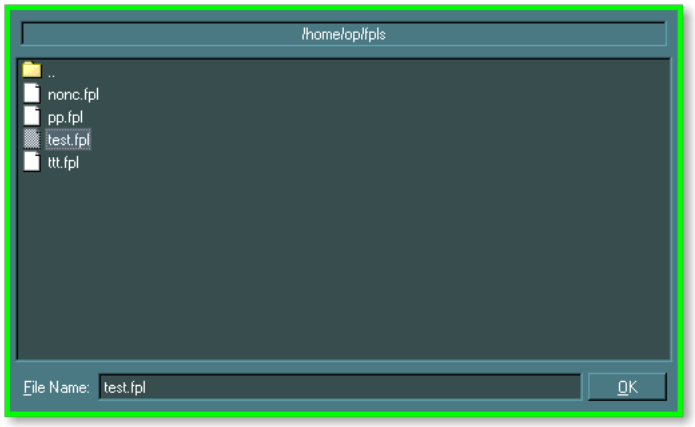


Figure 17: Open file dialog box.

To load flight plan file press **F3** when the flight plan panel is active. Now you can see a traditional file system window. Select a `*.fpl` file. It is also possible to select Geosoft `*.xyz` file. It will be converted to `*.fpl` format. After flight plan loading the previous one will be lost.

To append new flight plan to the current press **Ctrl+F3** when the flight plan panel is active. All new lines will be appended to the end of current list.

After loading you can see a list of records in the flight plan panel. Lines in this list are marked with different colors.

---

**Warning** A huge flight plan loading leads to system resources overloading. To clear current flight plan stop the daemon and delete file 'current.fpl' in data directory.

---

Beige is for records of LINE type, green for REGION type, rose for POSITION type. Please note, list of points is not displayed yet, there are only titles on the panel. For POSITION and REGION types number of points is shown on the right side of the lines. For LINE type there is a small triangle on the left, number of points and some extra parameters on the right: entry course value(in degree), total route length and time required to pass it with current speed.

A triangle indicates direction in which routes will be passed (from top downward or bottom-up) and route status. Triangles change their color during a flight: green means flown route, gray -not flown yet. If a triangle twinkles green and red - this is the current route. You can invert this flag for selected routes pressing **Ctrl+D**. To display a list of route points direct a cursor on an appropriate line and press **Enter**. Now you can see a list of route points. Points indicators also change their color: gray for not passed points, twinkle for current point and green for passed points. To hide the list press **Enter** again.

Extra parameters for routes points and routes titles are described below. Entry course value corresponds to direction of the vector from the first point to the second in a list.

For each point following parameters are shown:

- Direction of a vector from previous point to this point(in degree). For the first point 0 is shown.
- Length of this vector (km), 0 for the first point.
- Time needed to pass this distance with current speed, 0 for the first point.
- *azimuth from aircraft point to this point (degree).
- *distance from aircraft to this point(km).

- *time needed to pass this distance with current speed.

For REGION and POSITION types only parameters marked with * are shown in a list of points.

## 10.2 Flight plan editing.

Flight plan editing is available in "NavDat". With regard to the experience in system use and taking into account danger of a mistake, next options were made available:

- *Edit record title.* Press **Alt+M**(modify) on a title. Red line will appear with name and type of the record in it. L means LINE type, R means REGION and P means POSITION. After editing press **Enter** to save changes. In case of mistake you'll see a syntax rule and changes will be discarded.
- *Edit point parameters.* Move cursor to the required line, press **Alt+M**. In the red line you'll see: name of the point, its latitude and longitude (exactly in this order). Format for coordinates is "DDDMMmmmm" without spacing. Degrees are on the first place (up to three characters for longitude and up to two for latitude), then goes minutes integer part - two characters, then minutes fractional part- exactly four characters. Sign depends on a hemisphere. Negative latitude value corresponds to the Southern Hemisphere, negative longitude-to the Western Hemisphere.
- *Delete record/point.* Move cursor to the required line or select several lines, then press **Ctrl-Delete**.
- *Copy record/point.* Move cursor to the line or several select lines you are going to copy then press **Ctrl-Insert** Then move cursor to the line you are going to insert copied lines and press **Shift-Insert**.

## 10.3 Creation of the system of parallel routes

This option allows to cover a surveying region with a grid of parallel routes. A record for this region should be created before calling the procedure. Move cursor to the title of this record and press **Alt+G**. Edit bar will appear, where following fields should be filled:

- Name mask. All created routes will be given a name beginning with this mask. After mask goes a number of a route.
- Routes direction in degrees.
- Distance between neighboring routes in meters.
- Latitude and longitude of a point, through which central route will go. By default this point is the centre for vertex of the region.

Procedure of routes creation is next. Through the central point an orthodromic line A is drawn at right angle to the given route direction. Then two segments are intercepted along A from a central point to the both sides. Their length is equal to the distance between neighboring routes. Then through ends of these segments orthodromic lines are drawn at right angle to A. These lines are routes lines. And their ends lay at the boundary of the region. Routes with even and odd numbers are of opposite direction.

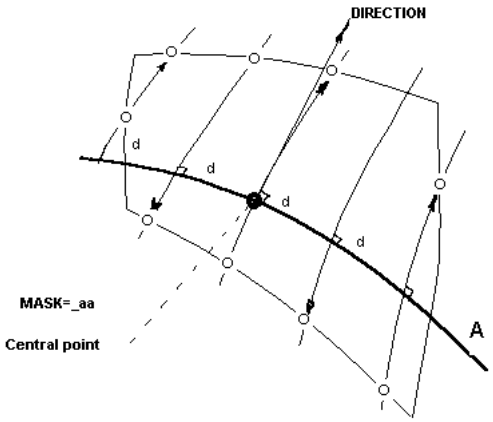


Figure 18: Marking of parallel lines

As a result of this operation list of created routes will be shown in the main list after record of corresponding region.

Creation of parallel routes also has commercial aspect. Every unnecessary route means unnecessary flight time. That's why we advise to be thoughtful during the process. And better use Geosoft Oasis Montaj solution - as smarter product for such tasks.

## 10.4 Creation magnetic compensation routes system

This option allows to create a magnetic compensation routes system. All these routes have different directions and pass through one central point. Move cursor to the place where you want these routes to appear and press **Alt+R**. Edit bar will appear, where following fields should be filled:

- Name mask. All created routes will be given a name beginning with this mask. After mask goes route's heading in degrees.
- One of the routes direction in degrees. All other directions will be calculated automatically.
- Routes radius in meters. Total route length will be equal to two radii.
- Angle between parts of one route.
- Latitude and longitude of central point, through which all routes will pass. By default this point corresponds to current position.

If the angle between parts of one routes is not zero, the result will be as the variant 1 (Figure 19). There will be four routes with 90 degrees between them. Otherwise, the result will be as the variant 2 (Figure 20). There will be eight routes with 45 degrees between them.

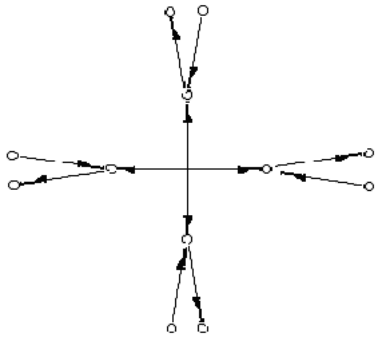

Figure 19: Magnetic compensation routes. Variant 1.

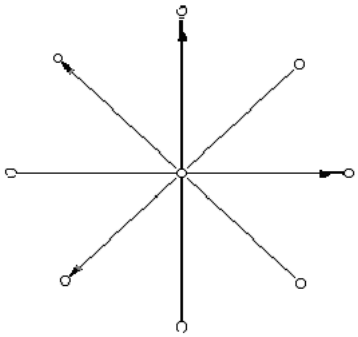

Figure 20: Magnetic compensation routes. Variant 2.

## 10.5 Adjustment, start and stop of a routing

So, flight plan was created, edited and checked. Now it's time for take-off and routing. But before start point for routing should be chosen:

- Press **Ctrl+Backspace** to choose reading direction of list of routes.
- Next step is specifying order of points for each route. Press **Alt-Backspace** to invert direction of all routes or **Backspace** to invert direction of selected routes.
- Select line of the start point. If you've selected a title of a route then routing will start from the first point of highlighted route in given reading direction.
- Check everything one more time and press **Ctrl+S**. Then "NavDat" will start routing. Routing will be realized in full accordance with specified reading order.

In case of forced route entry procedure is the same, but instead of **Ctrl+S** press **Ctrl+L** (direct start). Then the program will start routing directly from the start point without approaching procedure.

To stop routing press **Ctrl+K**. This option is available even if flight plan panel is not active.

## 10.6 Position fix

All navigation system in the world use this important option to register coordinates of the current point. Because "NavDat" was developed for quite specific survey tasks, this option was realized in specific way too. To activate this option press **Ctrl+F**. Then the program will do follow steps:

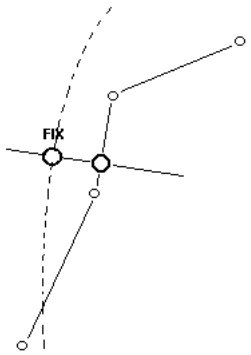


Figure 21: Position fix

- New record named FIX will be created. If such record already exists it won't be duplicated.
- Point with current coordinates will be saved into this record under the name composed of date and time.
- If this option is activated while routing, new point with the same name, which lays on the traverse of current point, will be added to the list of route points.(Figure 21)

## 10.7 Flight plan panel control

- Use **Arrow-keys** to move through a list also you can use standard hot keys for selection. (**Shift up/down** - move and inverse selection, **Ctrl up/down** - move and save selection, **Ctrl Space** - inverse selection without moving)
- **Enter** Show/hide list of points.
- **F3** Load flight plan file instead of current.
- **Ctrl+F3** Load flight plan file to append to the end of current list.
- **F2** Save flight plan file.
- **Backspace** Invert points order of a highlighted route
- **Alt-Backspace** Invert points order of all routes.
- **Ctrl-Backspace** Invert routes order
- **Alt-M** Modify highlighted line, **Esc** - discard changes.
- **Alt-G** Cover highlighted region with parallel routes
- **Alt-R** Magnetic compensation routes system creation
- **Ctrl-Delete** Delete selection
- **Ctrl-Insert** Copy selection
- **Shift-Insert** Paste copied selection
- **Ctrl-D** Invert 'done' flag for selected routes.
- **Ctrl-S** Start routing with approaching to the first point.
- **Ctrl-L** Start routing without approaching
- **Ctrl-K** Stop routing - global option, it works from any window.
- **Ctrl-F** Fix current point, it works from any window.

# 11 Panorama

Panorama is a main tool for visualization and control of surveying process. It shows navigation information graphically.

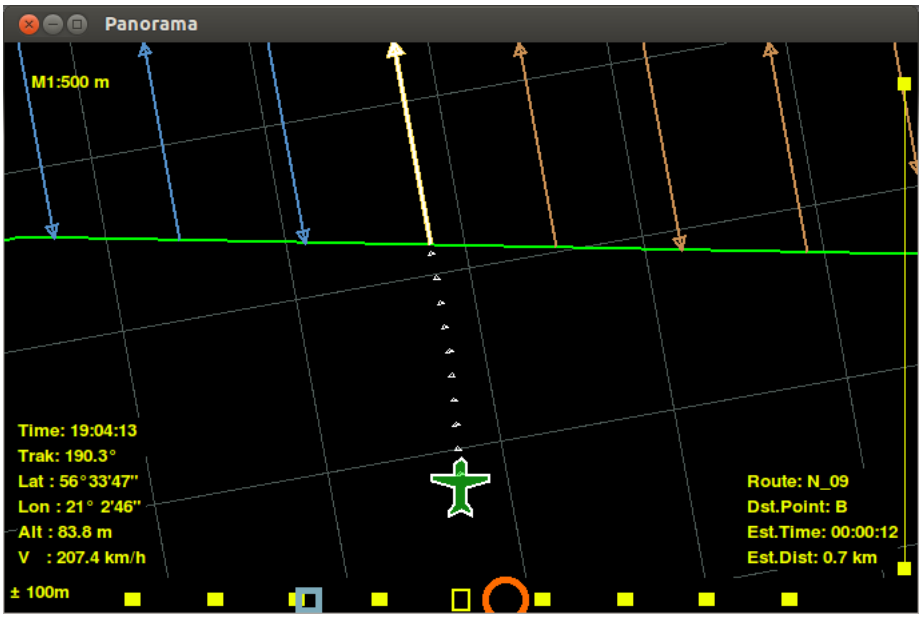


Figure 22: Panorama window

All elements of a flight plan are displayed on the panorama schematically and all operations in the flight plan panel affect on panorama view. (Figure 22)

In the top-left corner there is scale of the map(size of one side of a square in meters). In the bottom-left corner there are following parameters:

- Time - GPS time (hh:mm:ss)
- Track - current course angle (degree)
- Lat - latitude (degree-minutes-seconds)
- Lon - longitude (degree-minutes-seconds)
- Alt - altitude by GNSS (meters)
- V - current speed (km/h)

In the bottom-right corner there are following parameters::

- Route - current route name
- Dst.Point - name of current destination point
- Est.Time - estimated time left till the end of the current route in case of routing or till the beginning of the route in case of approaching to the route(hh:mm:ss)
- Est.Dist - distance to the end of current route in case of routing or to the beginning of the route in case of approaching to the route(km)

Airplane symbol shows current position of the aircraft. Dotted contour means the aircraft is beyond panorama border. Green arrow shows the aircraft direction.

On the right side of the panorama there is route progress indicator. Route is represented by a yellow line and blue circle on it shows current position on the route.

At the bottom of the panorama there is a scale of pilot's indicator. Orange circle duplicates pilot's indicator readings. Blue square shows lateral deviation, scale spacing is 100 metres.

### 11.1 Panorama main elements

To display flight task elements on the panorama flight task file should be loaded. Then flight task elements will be shown schematically on the panorama.

- Routes on the panorama are represented by dark orange lines. Arrow at the end of a route or on panorama border (if the end of a route lies beyond panorama border) shows route direction. Note, titles of routes in flight plan panel are the same color.
- Regions borders on the panorama are green. Regions titles in flight plan panel are the same color.
- Highlighted routes or regions are white on the panorama.
- Highlighted point is represented by white circle and its name is shown near.
- Single points (POSITION type) are rose and their names are shown always.
- Current route or route which the aircraft is approaching is shown with bold light orange line.
- All routes marked as flown ones are shown in blue color.
- Curvilinear parts of routes are displayed by dotted lines which consists of small white triangles. In case of small scale this lines look solid.

### 11.2 Panorama view modes

Panorama has two view modes

- Panoramic. The airplane symbol is fixed, upward direction corresponds to the current direction of a flight.
- Map. North is up, the airplane symbol is moving.

### 11.3 Hot keys

- **Q, A** - zoom in/zoom out
- **M** - Change panorama view mode
- **Z** - Put the aircraft symbol into the center
- **C** - Resize map to the window size
- Use arrow keys to move the map

## 12 Pilot's indicator, routing parameters and pilot's panel

During a flight "NavDat" changes operating modes depending on a flight mode. But anyway control information is displayed on a pilot's indicator.

## 12.1 Pilot's indicator

Pilot's indicator has an arrow pointer and two light-emitting diodes - red and green. Diodes twinkle in different ways depending on a routing regime. The arrow pointer shows deviations from given direction. In all routing regimes main pilot task is to keep pointer in zero position. Please note, zero corresponds to a straight-line motion while routing and to a curvilinear motion while approaching a route.

Direction of pointer deflection is an adjustable parameter. You can adjust it depending on pilot's preferences. Current flight mode is shown on the indicator by using two light-emitting diodes (red and green).

There are four different routing regimes:

1. Routing is off: red diode is lighting.
2. Approaching a point: red is lighting, green is twinkling.
3. Routing is on: green is lighting.
4. Approaching a route(curvilinear routing) : at the beginning of the trajectory red and green flashes in alternate mode. Reds flashes less and less frequently when approaching the route until it stops flashing. That means routing was started.

The program allows to interchange diodes colors.

Arrow parameters related to flight plan can be visualized in chart window, their list is in Section B.2

## 12.2 Routing regimes

There are several routing regimes. During a flight they follows one after another according to a flight plan.

### 12.2.1 Approaching a point

In this case destination point is defined but flight route isn't. In this case pilot's indicator shows an angle between direction of motion and direction to the destination point. For this mode scale range is stated in degrees.

### 12.2.2 Curvilinear routing regime

As a rule in this case route consists of two short line segment connected by segments of a circle. While routing along circular curve pilot's indicator shows an angle between direction of motion and line tangent to this curve. Scale range is stated in degrees.

### 12.2.3 Routing mode

In order to achieve necessary accuracy of surveying some requirements to pilot technique should be met. In routing mode main quality characteristic is lateral deviation from a route. Scale range is stated in meters.

Not only angular and lateral deviations should be measured in order to achieve stable and accurate routing. Inertness of an aircraft and pilot's reaction should be taken into account as well. That's why software controlling pilot's indicator is based on mathematical algorithms and real-time modeling of motion.

## 12.3 Route entry conditions

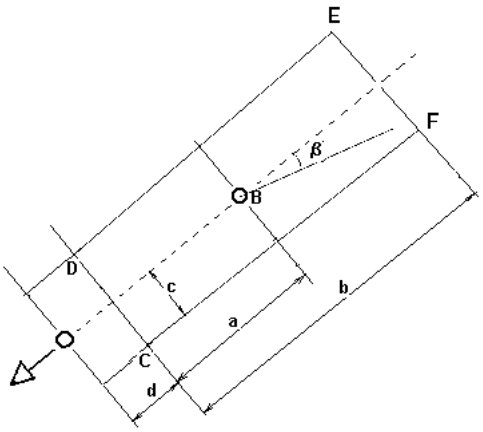


Figure 23: Route entry parameters scheme

"NavDat" provides entry on a route. For switching from approaching regime into routing regime following conditions must be fulfilled:

- Distance between the airplane and the route must be less then b
- An angle between flight direction and route direction mustn't exceed beta
- Lateral deviation mustn't exceed c
- Route entry must be completed within distance d

So the airplane must fly within quadrangle CDEF. Special point B will be described separately.

Point B is a preliminary entry point. If attempt to enter the route in point B fails for any reason the program will put this point closer to the beginning of the route and will make further attempts to enter the route until point B reach segment CD. In this moment program will make a decision about re-approaching.

This parameters and some others parameters are adjustable. Their values depends on given accuracy and scale of surveying, flight conditions, piloting characteristics of the airplane, etc. A special panel is used to adjust them (Figure 24).

## 12.4 Parameters

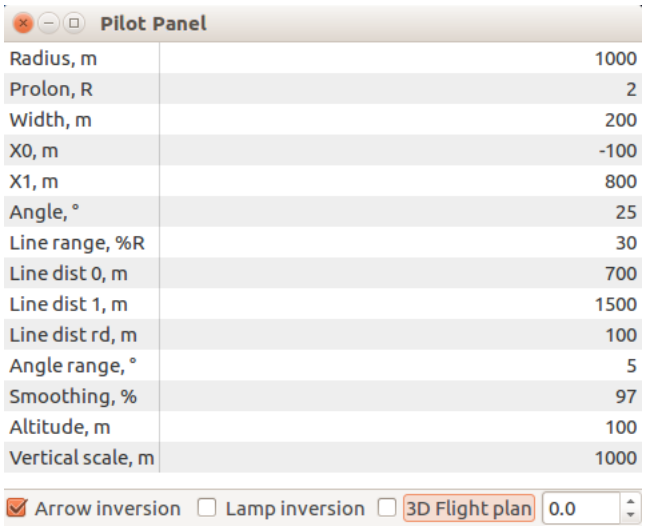


Figure 24: Pilot's panel view

- Radius – given radius of curvilinear routing in meters
- Prolon – distance to the point of preliminary entry (a), in number of Radius
- Width – max lateral deviation (c) at the beginning of a route in meters
- x0 – min entry distance (d) in meters
- x1 – max entry distance (b) in meters
- angle - entry angle beta in degrees
- Line range – scale of indicator pointer for routing mode, in percents of radius. Should be remembered, that a pointer shows predicted value of deviation. Parameters Line dist are used to calculate predicted deviation.
- Line dist 0 and Line dist 1 – distances to prognosis points, in meters. In routing mode this points are plotted on the line of current flight direction. And their deviation affects on pointer position.
- Line dist rd – distance to prognosis point that takes angular velocity into account, in meters. If this parameter is not null Line dist 0 and Line dist 1 are plotted from this point in corresponding direction. Very significant parameter, represents dynamic characteristic of an aircraft If Line dist rd is null parameters Line dist 0 and Line dist 1 are ignored.
- Angle range – scale of indicator pointer for curvilinear routing mode and for approaching mode in degrees. From experience for steady route entry it should be equal 3°-4°.
- Max accel – max level of acceleration (for quality control of GNSS data). From experience 10 m/sec2 is adequate value.
- Smoothing – filtration parameter. From experience 95-97 is adequate value.
- Altitude* – Flight altitude.
- Vertical scale* – Vertical arrow scale.
- Arrow Inversion – inverse pointer deflection. Some pilots prefer left deflection of a pointer in case of right deviation.
- Lamp Inversion – inverse diodes color.

The fields marked by * are used only for pilot's indicators of type 'modern'. In this case Arrow Inversion is applied to both horizontal and vertical indicators.

### 12.5 Adjustment recommendations

Parameters adjustment is a task that needs some practice. There are some simple recommendations on adjustment procedure.

1. Set simplified entry conditions, when even rough route entry will be accepted.
2. Set safe radius of curvilinear routing.
3. Set greater distance for preliminary entry point.
4. Set greater value of scale range of pilot's indicator. For linear routing 150 - 200 meters is adequate.
5. Vary Angle range to change arrow pointer sensibility.
6. Choose values of Line dist using balance of route approaching speed and oscillation along a route. With increasing of Line dist 0 and Line dist 1 values approaching gets slower and softer. Main factor that affects on Line dist rd is pilot's reaction speed.
7. While test flight vary Line dist, Line range and Angle range parameters and watch turns and routing by using panorama or real track lines.
8. When the pilot gets used to indicator working in routing regime, and the operator sets Line dist parameters, it will be possible to set route entry parameters. Scale range of a pointer is a balance between pilot's skill and routing quality. Keeping the pointer in zero position is easier when pointer sensibility is smaller but this increases lateral deviations.

## 13 Pilot's indicator application

There is an application working in the similar way to the arrow device. It can be displayed on the pilot's monitor instead of arrow. Main features are described in Section 12 . The additional features are an ability to show turning direction during curved stage of navigation and to show altitude.

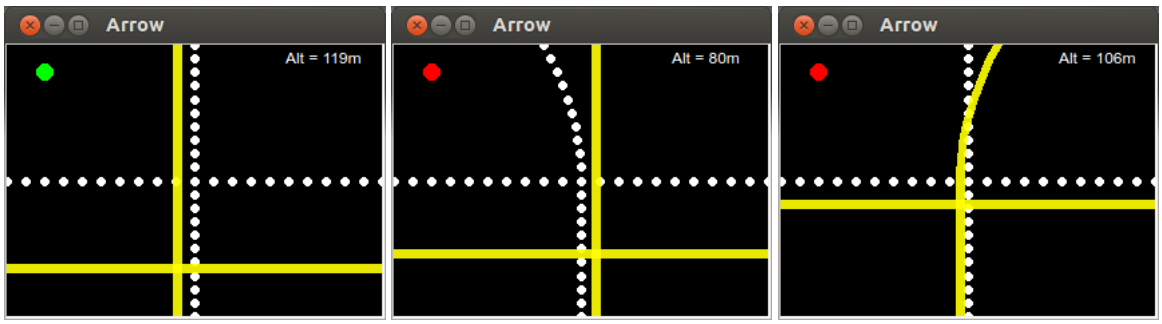


Figure 25: Pilot's indicator

This application was also developed for OS Android, it is availible in Google Play. It can be installed on pilot's smartphone/tablet and communicate via WiFi. The mobile version has additional options. It can show Panporama (see Section 11) to contol the current position with respect to the line. In case of working without operator the pilot can check the equipment using status bar (see Section 7).

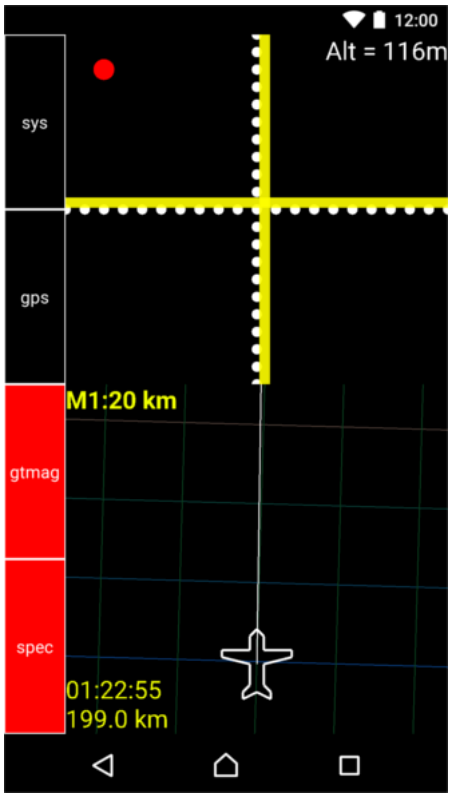


Figure 26: Mobile Pilot's Indicator

To start you must connect to the local network of the On-Board Server and assign the network settings (IP-adress and Port), see Section 6.3.

# 14 Table of satellites

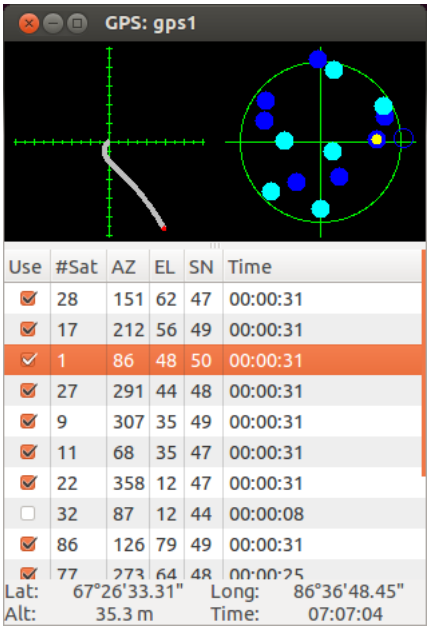


Figure 27: Table of satellites

## 14.1 Celestial Semisphere

Azimuth and altitude for all visible satellites are displayed on the indicator. So the indicator is a kind of satellites map. Azimuth is measured clockwise from upward direction. Altitude - from the border to the center. If a satellite isn't used in calculation then its symbol will be a ring, not a solid circle. GLONASS satellites are cyan and GPS satellites are blue. Highlighted satellite is marked by yellow spot.

## 14.2 Map

Red point shows current position and gray line shows passed trajectory. North is always up. Map scale can be selected using menu after clicking on the map with right button.

## 14.3 Satellites panel

Lines in this panel show status of all visible satellites. In every line there is following information:

- using in calculation
- index number of a satellite
- signal/noise ratio
- time when satellite was used in calculation

## 14.4 Hot keys

- **Ctrl+B** Choose device for visualization

- **Ctrl+T** Show/Hide table of satellites
- **Ctrl+S** Show/Hide satellites panel
- **Ctrl+P** Show/Hide indicator of a constellation
- **Ctrl+M** Show/Hide map
- **F8** Modify size of satellite table

## 15 GNSS emulator


Figure 28: GNSS emulator window

It imitates GNSS data stream from JAVAD receiver and allows to control airplane coordinates and speed. In autopilot mode imitates route passing.

---

**Warning** If emulator mode is on receiver host in program settings must be **localhost:4444**

---

To control an airplane use following hot keys.

- **Left/right arrow keys** - change angular velocity
- **Space** - set angular velocity to zero
- **Up/down arrow keys** - change linear speed
- Pilot Automatic - mark it to turn on autopilot mode

If autopilot mode is on, program keeps an arrow pointer in zero by changing angular velocity while routing. "NavDat" takes into account pointer deflection greater than 10% of hole scale.

## 16 Chart window

In this window registered parameters are displayed as charts.

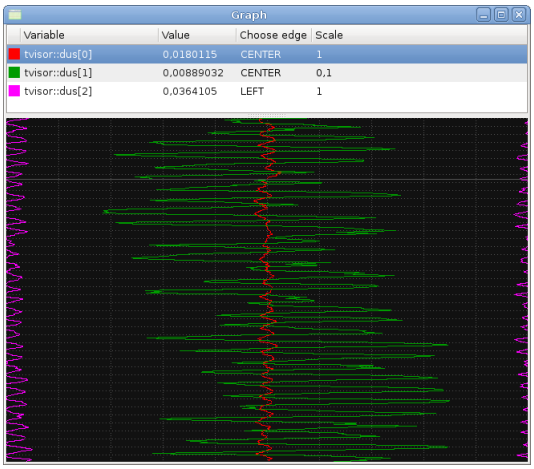


Figure 29: Chart window

Chart window consists of two parts:

- List of variables (see Appendix B) and their view settings
- Chart zone

You can choose a variable for visualization from the list. There are four column in the list: Color, Variable, Value, Choose Edge (alignment) and Scale.

## 16.1 Variables view settings

Following view settings are available for each variable:

- `Color` press **space** to select color; no chart will be displayed for black color
- `Alignment` press **Enter** and select one of following:
  - `OFF` Do not display a variable
  - `CENTER` Center alignment (0 in center)
  - `LEFT` Left alignment (0 on the left)
- `Scale` press **Enter** and set required number - full scale in variable's units

## 16.2 Hot keys

- **F8** Modify table/charts size, after **F8** press **up/down** arrow-keys to set required size; press and hold **Shift** to modify table/charts size with greater step size ; to complete press **Enter**
- **Ctrl+H** Show/hide invisible variables
- **Space** Modify color of highlighted variable
- **Backspace** Do not display highlighted variable

# 17 Spectra

In this window registered spectra are displayed as charts.

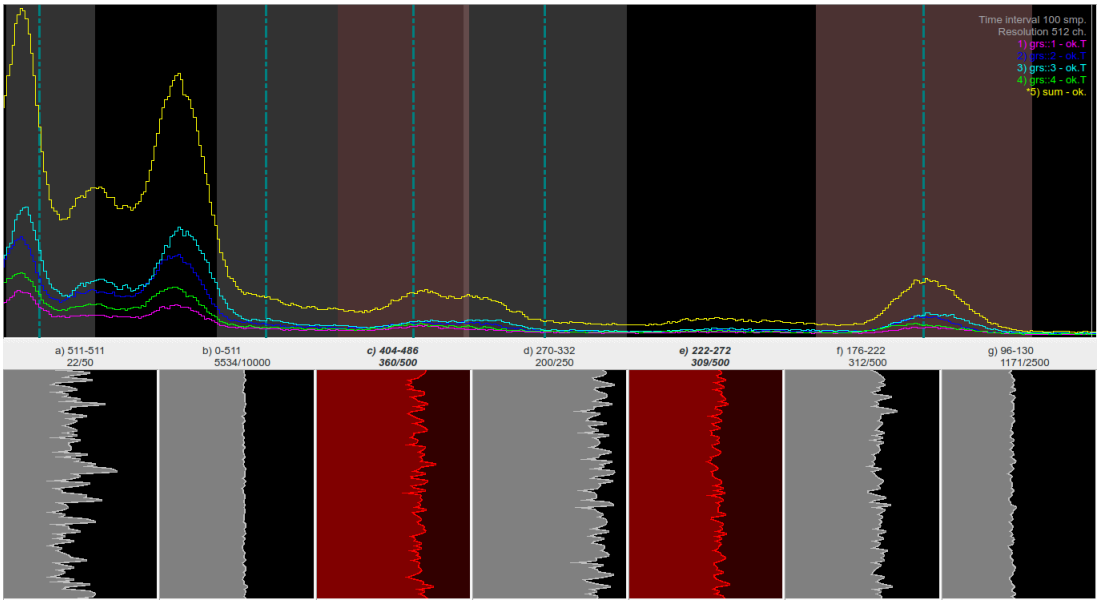


Figure 30: Spectra

Spectra window consists of two parts:

- Spectra view zone
- Windows count zone

You can choose a channel interval for visualization, an accumulation time interval, spectra resolution, turn on/off any spectrum visualization, set markers, select up to ten windows for count monitoring and set scale for their charts, view summed spectrum. You can use cursor to choose any channel, it is signed with channel number and vertical scale which is chosen automatically. Every spectrum state is shown in the string of corresponding color:

- "on" - means that spectrum is visualized and data are obtained
- "off" - means that spectrum is not visualized but data are obtained (not taken into account in windows)
- "no data" - means that data are not obtained (doesn't depend on visualization status)

Every chart headed by strings "left bound - right bound" and "current sample count/current scale". For some devices (GRS410, GSA2000) stabilization mode is displayed (L (light), T (Thorium), K (Potassium), U (Uranium), A (Analyzing), 0 (not connected)).

## 17.1 Spectra visualization control

Following view settings are available:

- `Spectrum select`: press **spectrum number** (1,2,3,...,0(10),Alt 1(11), ... , Ctrl Alt 1(21)...); selected spectra are marked by '*'
- `Spectrum on/off`: press **Return** to switch all selected spectra

- `Spectrum color select`: press **Space** to change color for all selected spectra
- `Accumulation time interval`: press **T** to switch between 1, 20 or 100 samples
- `Spectra resolution`: press **R** to switch between 1, 2 or 4 channels per point; for example 1024 channels spectra can be downsampled to 512 or 256 (1024 is available only if the input spectra are of such resolution)
- `Left bound`: press **,** to decrease or **Alt+,** to increase the number of channel assigned to left bound; press **Ctrl** to make it faster
- `Right bound`: press **.** to increase or **Alt+.** to decrease the number of channel assigned to left bound; press **Ctrl** to make it faster
- `View all channels`: press **Ctrl+Z**
- `View selected channels only`: press **Ctrl+V**
- `Hide/show windows count zone`: press **Ctrl+H**
- `Move windows count zone bound`: press **Up** or **Down**, use **Ctrl** to make it faster
- `Select/deselect count window`: press **window index** (a,b,c,...)
- `Add/remove count window`: press **Ctrl+Insert** to add selected zone and **Ctrl+Delete** to remove selected window and/or all included in the selected zone
- `Add/remove marker`: press **Ctrl+Insert** to add and **Ctrl+Delete** to remove marker (if no zone is selected)
- `Change count chart scale`: press **+/-** to increase/decrease scale of selected charts

Summed spectrum (sum) shows the sum of all visualized and turned on spectra. It also can be switched on/off.

### 17.2 Hot keys

Following view hot keys are available:

- **F1** - this help
- **1**, **2**, **3**, ... , **0** - select/deselect corresponding spectrum visualization with number from 1 to 10
- **Alt+1**, **Alt+2**, **Alt+3**, ..., **Alt+0** - select/deselect corresponding spectrum visualization with number from 11 to 20
- **Alt+Ctrl+1**, **Alt+Ctrl+2**, **Alt+Ctrl+3**, ..., **Alt+Ctrl+0** - select/deselect corresponding spectrum visualization with number from 21 to 30
- **a**, **b**, **c**, ... - select/deselect corresponding count window
- **Space** - change color of all selected spectra
- **Return** - switch on/off all selected spectra
- **Left**, **Right**, **Ctrl+Left**, **Ctrl+Right**, **Home**, **End** - move cursor by 1 channel, by 20 channels or to the bounds
- **Shift+Left**, **Shift+Right**, **Shift+Ctrl+Left**, **Shift+Ctrl+Right**, **Shift+Home**, **Shift+End** - selection move cursor by 1 channel, by 20 channels or to the bounds
- **Up**, **Down**, **Ctrl+Up**, **Ctrl+Down** - move horizontal splitter by 1 or by 20 pixels
- **','**, **Ctrl+','** - decrease left bound by 1 or by 20
- **Alt+','**, **Alt+Ctrl+','** - increase left bound by 1 or by 20
- **'.'**, **Ctrl+'.'** - increase right bound by 1 or by 20
- **Alt+'.'**, **Alt+Ctrl+'.'** - decrease right bound by 1 or by 20

- **+**, **-** - zoom in or out selected chart scale
- **Ctrl+Insert** - add marker to current cursor position or add count window for current zone if selected
- **Ctrl+Delete** - delete marker from current cursor position, delete selected count window and/or delete all markers and windows inside the selected area
- **Ctrl+H** - hide/show count windows zone
- **Ctrl+Z** - view all channels
- **Ctrl+V** - view selected channels only
- **T** - switch accumulation time interval: 1/20/100 samples
- **R** - switch resolution mode: every channel/summed by pairs/summed by fours

# 18 EM4H

This window allows you to monitor parameters of airborne electromagnetic system EM4H and to manage its work.

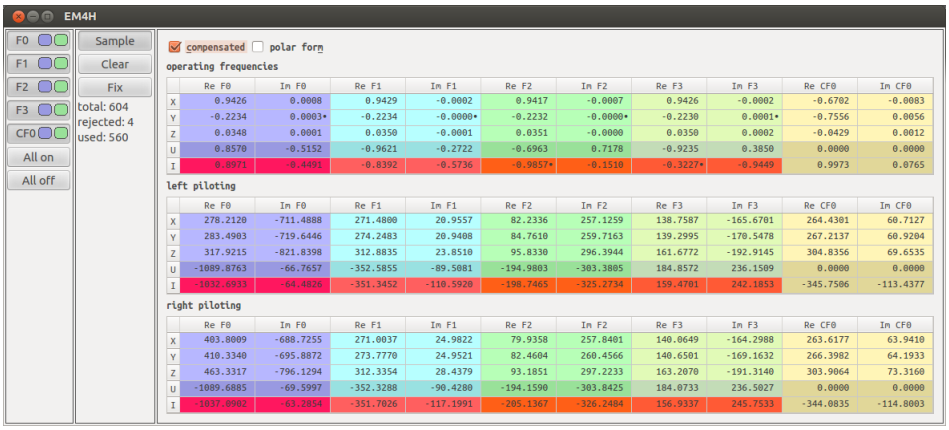


Figure 31: EM4H

Program window consists of three parts:

- Induction control
- Compensation control
- Digital panel

The program allows you to turn on/off operation frequencies, to perform compensation of the aircraft influence and to view in different modes values of measured parameters and output them in the panel of the chart-recorder.

## 18.1 Induction control

Following operations are available:

- `Frequency * on/off`: press **F#**. * denotes frequency number:
  - F0 - 130 Hz, operating frequency 0 in the main loop

  - F1 - 520 Hz, operating frequency 1 in the main loop
  - F2 - 2080 Hz, operating frequency 2 in the main loop
  - F3 - 8320 Hz, operating frequency 3 in the main loop
  - FCO - 667 Hz, operating frequency in the compensation loop
  - FC1 - 833 Hz, operating frequency in the additional compensation loop (for Mi-8 installation only)
- `All frequencies on`: press **All on** to turn all frequencies on
- `All frequencies off`: press **All off** to turn all frequencies off

It should be borne in mind that the state of the F* buttons depends on the data received. In particular, the button will be displayed as pressed only when the program will receive a confirmation from device that the corresponding frequency is turned on. Simultaneously one of the indicators (on the right) turns green. The second indicator turns blue only after the amplitude of the voltage or current in the loop exceeds the minimum acceptable value for the correspondent frequency. It doesn't work properly if any of the indicators is red.

## 18.2 Compensation control

Following operations are available:

- `Sampling on/off`: press **Sample** to start/stop data sampling for compensation.
- `Clearing`: press **Clear** to restart data sampling.
- `Compensation`: press **Fix** to convert current data set to compensation matrix.

Below there are counters:

- `Number of samples in the compensation procedure input`: **total**.
- `Number of rejected samples`: **rejected**.
- `Number of samples used for compensation parameters estimation`: **used**.

Compensation process is as follows: at a considerable flight height, where the influence of the earth can be neglected (600-700m), you should hold data accumulation for compensation. To do this:

- Clear data set, click **Clear**. All the counters are set to zero.
- Start accumulation, click **Sample**. Right after that the **total** counter and, possibly, **rejected** will start to run.
- Perform a series of the bird swings in pitch and roll so that it visited various points of the field relative to the aircraft. Performing this operation requires the operator some experience and concerted action of pilot. Accumulation operation usually takes a few minutes.
- After the counter **total** significantly exceeds **rejected** one, it is necessary to fix data set clicking **Fix**. Thus the counter data used for calculating the compensation parameters shown in the counter **used** .
- If the quality of compensation is good enough, you can stop the selection by clicking **Sample** again. The counters **total** and **rejected** should stop changing.

Note that the onboard compensation mode is used only to ensure that the operator is satisfied equipment performance in the most difficult mode. Accumulation and clearing have no effect on recorded data.

The program "NavDat" stores the last calculated compensation parameters in its system directory. After start "NavDat", if the type of aircraft in the EM4H-device settings wasn't changed (see Section 6.9), parameters will be automatically loaded. In this case, the counters **total** and **rejected** will be zero and **used** will not.

## 18.3 Digital panel

Digital panel allows you to see all system measurements as numbers. It contains three matrices:

- **operating frequencies** - signals measured at operating frequencies F*.
- **left piloting** - control signals at frequencies F*-6 Hz.
- **right piloting** - control signals at frequencies F*+6 Hz.

Each frequency is represented by two columns marked by the same color. They show in-phase and quadrature signal components {Re F*, Im F*} or its amplitude and phase {Amp F*, Ph F*}. Rows represent measurer:

- **X, Y, Z** - sensitivity axes of the EM4H receiver.
- **U** - voltage in the main loop.
- **I** - current in the main loop (for An-2 or Mi-8 installations) For frequencies F0-F3 and in the compensation loop, correspondingly, for FC0 and FC1. In case of An-3 installation at the frequencies F0-F3 there is a signal of additional compensation coil mounted on the stinger.

If any ADC is overranged its fields will be colored in red as I-channel in Figure 31.

Two flags in the upper part allow to choose one of four display modes:

- **compensated** - use **Alt+C** to change.

If set, compensated data are displayed. All the signals in the matrix **operating frequencies** are normalized to one at the moment of **Fix** or **Clear** clicking. After that all the coefficients are kept constant till the next click. If there is no compensation parameters (**used** = 0), only normalization is applied. X, Y, Z are normalized as a vector, i.e. $X^2+Y^2+Z^2 = 1$, while U and I - as scalars. Zero phase at the receiver corresponds to the phase of the primary field (phase of the major semiaxis of the polarization ellipse at the time of normalization). U and I phases stay unchanged. Piloting matrices are also changed - a digital filter result is shown, but no normalization.

If the flag is not set, raw data are displayed. The value is in 16 bit ADC units.

- **polar form** - press **Alt+M** to change.

If set, signals amplitudes and phases are shown {Amp F*, Ph F*}. If the **compensated** is also set and there are no compensation parameters (**used** = 0), receiver signals phase is the phase of major semiaxis of the polarization ellipse at the time of normalization or program start. in case of clear **compensated** flag the phase stay unchanged.

If it is not set, the data are displayed as complex numbers: Re F* - in-phase, Im F* - quadrature components. It is important to remember that if you remove the flag **compensated** , the phase corresponds to zero phase of measurer but not the primary field.

Panel allows you to add any of the parameters in any of the formats defined by flags **compensated** and **polar form**, as a variable of charts recorder (see Section B.6). To do this, select the parameters you want and click **Ctrl+Insert**: they will appear in the charts list. When you select several variables within a matrix, you can use the arrow while pressing **Shift**. Also, you can hold **Ctrl** and move the cursor pressing the space bar to select the next parameter. The variable added to chart list is marked by "•". To delete any variable from the charts list select it in the corresponding matrix and press **Ctrl+Delete**.

The matrices of piloting signals can be hidden (**Ctrl+P**), as well as the whole digital panel (**Ctrl+H**).

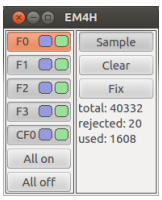


Figure 32: EM4H - compact

### 18.4 Hot keys

Following keys are available:

- **F1** - this help
- **Tab** - elements switch (buttons, flags, matrices)
- **Ctrl+Tab** - window parts switch (induction control, compensation control, digital panel)
- **Alt+C** - switch on/off compensated data view mode in digital panel (flag **compensated**)
- **Alt+M** - data view mode switch: in-phase-quadrature components or amplitude-phase (flag **polar form**)
- **Ctrl+P** - hide/show piloting signal matrices
- **Ctrl+H** - hide/show digital panel
- **Ctrl+T** - hide/show induction/compensation control panel

## 19 Infrared scanner panel

### 19.1 View settings

Real-time image data are displayed on Infrared scanner panel.


Figure 33: Image sample and infrared scanner settings

### 19.2 Work in infrared scanner panel

- **Ctrl-H** Show/hide image parameters
- **Ctrl-L** Show/hide hide extra parameters

At the upper line of the panel there are image view settings. Their modification doesn't affect saved data. To modify one of these parameters (Brightness, Contrast, Zoom) select required parameter using **Tab**, **Shift-Tab** or **Alt-< plus underlined symbol in parameter name>**, e.g. to modify contrast: **Alt-C**. Position allows to choose visible part of a line. Br.Fix means brightness correction, i.e. if Br.Fix is on then average value of a line will be null this allows to ignore scanner head warming-up. Press Pause to stop real-time imaging.

Parameters in status line (from left to the right):

- PPS indicator, if data synchronization process runs normally indicator must twinkle one time per second
- N2 — shows nitrogen presence, must be marked;
- Missed — number of missed lines in image; after some manipulation this parameter can be non-zero bat it must be constant any way;
- Sens — «sensibility», this parameter is calculated approximately; must be about 0,05 when device runs normally; depends on temperature;
- Freq — frequency, must be about 200 Hertz;
- RMS — indicator of image noise level, normal value — from 1 to 2;
- Temp — temperature of the head of the optic block, its value must be plausible;
- Ralt — radio altitude value; can be checked when the scanner is on.

### 19.3 Window of orientation system indicator

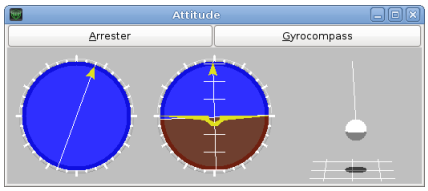


Figure 34: Attitude system

"NavDat" allows to control visualization of parameters of built-in inertial orientation system. In "Arrester" field press **Enter** then gyroscopic course will get value of track angle, pitch and yaw will be adjusted in accordance with accelerometer measurements. Then the system will run in automatic mode and its parameters can be controlled visually.

Due to described procedure long adjustment before a flight isn't required. But "NavDat" provides such adjustment as well. When you press `Gyrocompass` button the system will estimate measured gravitational vector and angular velocity of the Earth. After turn-off systems start working in autonomous mode. This mode is adequate only to control working capacity of sensor elements of the system.

Control of the inertial system has no affect on saved data.

## A Hot keys

### A.1 Workspace and windows administration

- **Alt-F1** Applications menu
- **Alt-Tab** Windows switching
- **Ctrl-Alt-left arrow-key**, **Ctrl-Alt-right arrow-key** Switch to left or right workspace
- **Alt-F4** Close window/application

- **Alt-F8** Change window size. Use arrows to change, also you can press shift while changing to align with other windows. Press Enter when finished
- **Alt-F7** Move window. Use arrows to move, also you can press shift while moving to align with other windows. Press Enter when finished
- **Ctrl-Alt-S** Save program settings (position on the screen).
- **Ctrl-Alt-R** Load saved settings of "NavDat" programs and run aboard server, if it was not run before.

### A.2 Navigation

- **Ctrl-Alt-Q** Zoom in panorama veiw for active workspace
- **Ctrl-Alt-A** Zoom out panorama veiw for active workspace
- **Ctrl-K** Stop routing(Section 10.5).
- **Ctrl-F** Current position fix(Section 10.6).

## B Chart window variables

### B.1 System variables

- sys::bytes_written - total data written during current session (bytes)
- sys::write_errors - number of data write errors
- sys::write_error - data write error flag
- sys::storage_total - total current disk space (bytes)
- sys::storage_avail - current disk free space (bytes)

### B.2 Flight plan processing variables

- fplan::arrow - horizontal pilot indicator value in range from 0 to 100 (50 means no deviation)
- fplan::varrow - vertical pilot indicator value in range from 0 to 100 (50 means no deviation)
- fplan::lamp - current lamp state: 0 - red, 100 - green (colors can be inverted for particular indicator)
- fplan::XTE - cross track error in meters

### B.3 Position variables ($POS message of dlg-file)

- pos::time_ms - time of day in milliseconds
- pos::year - current year
- pos::month - current month
- pos::day - current day
- pos::siu - number of visible satellites
- pos::lat - latitude in degrees for WGS84 or other current geoid
- pos::lon - longitude in degrees for WGS84 or other current geoid

- pos::alt - altitude in meters over WGS84 or other current geoid
- pos::lat_r - latitude in radians for WGS84 or other current geoid
- pos::lon_r - longitude in radians for WGS84 or other current geoid
- pos::track_r - current track in radians
- pos::track - current track in degrees
- pos::hvel - horizontal velocity in m/sec
- pos::pdop - PDOP
- pos::ralt - navigation altitude in meters (it can be radar altitude or other depending on current settings)
- pos::ralt_on - navigation altitude flag (GNSS receiver altitude is used if 0, depends on current settings)

### B.4 Javad/Topcon/Novatel GNSS-receiver variables

- gps::Lattitude - geodetic lattitude in radians
- gps::Longitude - geodetic longitude in radians
- gps::Altitude - geodetic altitude in meters
- gps::HorVel - horizontal velocity in m/sec
- gps::TrakG - geodetic track in radians
- gps::VisSatNum - number of visible satellites
- gps::WeekTime - time of week in seconds
- gps::rectime - GPS time of day in milliseconds
- gps::HHMMSS - GPS time of day in format HHMMSS
- gps::NavErrors - data stream errors number
- gps::PDOP - PDOP
- gps::nodata - GNSS data flag, 1 if no data, 0 otherwise
- gps::nopos - GNSS position flag, 1 if no position, 0 otherwise

### B.5 GT-Mag variables

- gtmag::current* - sensor current in mAmps, * - number of channel
- gtmag::signal* - sensor signal in mVolts, * - number of channel
- gtmag::mag* - magnetic field value (nT), * - number of channel
- gtmag::dif_4* - non-normalized 4th difference of magnetic fuild value (nT), * - number of channel
- gtmag::pps - counter of GNSS receiver pulses per second signals
- gtmag::magc - compensated value of magnetic field (nT)
- gtmag::batt - input voltage in mVolts
- gtmag::outV - output voltage (sensor power supply) in mVolts
- gtmag::siu - number of visible satellites

- gtmag::magf - filtered field value (nT), for Equator
- gtmag::fdif - non-normalized 4th difference of filtered field value (nT), for Equator
- gtmag::fx(fy,fz) - fluxgate magnetometer components (nT)
- gtmag::ra - radar altitude in meters

### B.6 EM4H variables

- em4h::frnum - current data frame number (changes from 0 to 6399)
- em4h::err_cksum - number of errors in check sums for data stream between EM4H and PC
- em4h::err_cable - number of errors in data stream between receiver and transmitter in EM4H
- em4h::err_frnum - number of missed frames
- em4h::Ellipticity_F* - ellipticity (polarization ellipse minor to major axes ratio) for F* frequency (* = 0,..,3)
- em4h::Max* - current maximum value in correspondent ADC (* = X,Y,Z - receiver, GU main loop voltage, GI - main loop current, C0I - first compensation loop current, C1I - second compensation loop current). 32768 means overrange.
- em4h::Bird_27V - 27V voltage measured in the receiver
- em4h::Bird_10V - 10V voltage measured in the receiver
- em4h::Bird_1.2V - 1.2V voltage measured in the receiver
- em4h::Bird_LogicV - logic voltage measured in the receiver
- em4h::Bird_Empty - reserved channel
- em4h::Bird_BoardID - receiver electronics ID
- em4h::Bird_SensorID - receiver sensor ID
- em4h::Bird_BoardTC - receiver electronics temperature (deg. C)
- em4h::Tran_27V - 27V voltage measured in the transmitter
- em4h::Tran_BirdV - receiver power supply measured in the transmitter
- em4h::Tran_1.2V - 1.2V voltage measured in the transmitter
- em4h::Tran_SignalV - receiver signal amplitude (mV)
- em4h::Tran_BirdCurrent - receiver current (mA)
- em4h::Tran_BoardID - transmitter electronics ID
- em4h::Tran_RA - altitude (m)
- em4h::Tran_PowerTC - transmitter power electronics temperature (deg. C)
- em4h::aaa_bbb_ccc_ddd - EM4H data selected by user:
  - aaa - dat (operating data), lpil (left) or rpil (right piloting signal);
  - bbb - Re (inphase), Im (quadrature), Amp (amplitude), Ph (phase);
  - ccc - F*#, * = 0,..,3,C0,C1 - frequency, # = X,Y,Z (receiver), U (voltage), I (current);
  - ddd - raw or comp (compensated).

  See Section 18 for details. Measured in ADC units if raw, otherwise everything is normalized to 1 (as average).

### B.7 RS-50x variables

- spec::errors - number of errors in data stream
- spec::utc_time - internal receiver UTC time in seconds
- spec::roi[*] - regions of interest (from device), *=1,...,10

### B.8 GRS410 variables

- spec::errors - number of errors in data stream
- spec::adc[*] - analog measurements, *=0,...,3

### B.9 GSA2000 variables

- spec::errors - number of errors in data stream
- spec::hard_errors - device control byte (see GSA2000 manual)
- spec::func_errors - device state byte (see GSA2000 manual)
- spec::live_time - live time in ms
- spec::stab_code[*] - stabilization system control code (see GSA2000 manual)
- spec::peak[*] - light peaks position in channels multiplied by 100

### B.10 Free Flight RA variables

- ffra::altitude - altitude (m)
- ffra::errors - number of stream errors according to checksum
- ffra::test - test flag (equals 2 while testing, otherwise 0)
- ffra::status - status flag (equals 4 if unit failure, otherwise 0)
- ffra::invalid - output flag (equals 8 if unlocked/invalid, otherwise 0)
- ffra::strut - strut flag (equals 16 if de-asserted, otherwise 0)

### B.11 ADC variables

- gtadc/e502::raw* - raw value in adc units, * - channel number
- gtadc/e502::user_defined_name - variable defined by user, see Section 6.16