NavCommand

Software to Operate and Configure
iMAR Inertial Measuring and Surveying Systems

Operation and User Instructions

Operation of an iNAV-IMU via Ethernet / RS232 under Windows™

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1 Introduction

The following tutorial is intended to acquaint the user with the operation of the iDIS/iNAV-series inertial measurement systems using the *NavCommand* Windows™ program which is delivered together with the inertial measurement equipment. iMAR manufactures several lines of inertial measurement systems that can be operated with the NavCommand software:

a) iDIS-FP-series devices (updates from 10/2001)
b) iDIS-FMS-series devices (from 6/2001)
c) iNAV-FMS-series devices (from 6/2001)
d) iNAV-RQH-series devices (from 6/2001)
e) iNAV-FJI-series devices (from 6/2002)

In order to operate the devices through NavCommand, the iNAV-XIO protocol based Navigator must be implemented on the inertial measurement system (IMS). The iNAV-XIO Navigator provides a significantly greater range of commands than the previous devices of the DIS-FC or DIS-FP series with the earlier software DISTERM, WinTerm or DIS_Command.

iNAV-FMS: Example for an Inertial Measurement System with XIO-Navigator Software inside

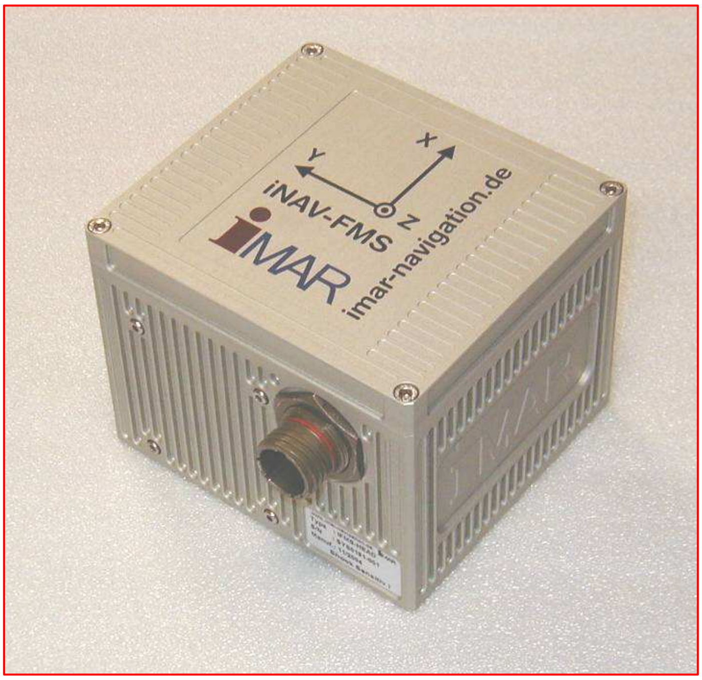
NavCommand supports full operation of inertial measurement systems. Supported are systems of all classes of accuracy from low-cost systems with vibrating gyros up to high end true north reference systems with laser gyros and fiber optic gyros. NavCommand allows time-related data recording and - if an odometer is connected to the inertial measurement system or if the system is in free inertial mode - distance-related data recording as well. If the measurement system features analog data output, it can be activated in addition to or as an alternative to data recording on hard disk. When an odometer is connected and for distance-related data collection, a so-called PPD output (pulse per distance), with which any external sensors can be triggered, is also available for certain systems. Furthermore a so-called PPT (pulse per time) can be generated as an option by hardware. One of the main usages of NavCommand is to configure and operate INS/DGPS coupled inertial navigation systems.

Data output via CAN-Bus and Ethernet / TCP/IP is optionally supported, configurable in the NavCommand configuration file.

NavCommand is primarily a program for controlling, visualising and storing of data. Furthermore settings on the IMS can be modified using NavCommand. It therefore requires relatively little PC resources, the entire calculation of the inertial algorithms being performed in the IMS itself. It is thus usually possible to run several Windows applications together with NavCommand, if those do not permanently allocate interrupts etc.

1.1 Installation / Deinstallation

Installation:
The software NavCommand has to be installed with the included setup tool (see installation CD). On request the latest version of NavCommand is available on the iMAR web server (please ask iMAR for details).



NavCommand is operated under Windows 98/2000/NT/XP/Embedded. For installation you should have administration rights on your computer to be able to de-install the software properly later. Before starting installion procedure all other running applications must be shut-down on your computer. User specific data will be stored in the folder "ApplicationData" of the actual user, if nothing else is indicated during the installation procedure. Therefore it is highly recommended also under ***Windows 9x to login with a specific user name.*** To install the NavCommand software no connection to the IMS is required. But to start the software the first time it is reqired to connect your IMS via RS232 or Ethernet.

Folder structure (only for system programmers and administrators:

Definition of Path and Folders: The configuration of program settings is saved in the subdirectory

“NavCommand\Cfg\<UserName>

of the Windows default directory “Application Data”. The path of this directory can be found in the Windows Registry under the key

“HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer\User Shell Folders“ or:

“HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer\Shell Folders“

in the “AppData” entry. <User Name> is the name of the login string when starting Windows.

General Information about Configuration Files and IP Address:
The configuration files of NavCommand are text files, which also can be edited by NavCommand. Here you can choose some parameters which are not available from the NavCommand standard screens (e.g. you can define whether a CR or a NL or a CRNL is used at the end of data sets which are stored in the data result files by NavCommand). The corresponding comments can be found in the parameter file.

For communication via Ethernet (recommended) the protocol „TCP/IP“ is required[1]. It is assumed that your computer is configured correctly to operate the TCP/IP protocol (e.g. have a look to your IP address [does it fits to the IP address of the IMS?] and your firewall). The default setting of the IMS IP-Address is 192.168.1.199 where the IMS supports the automatic address handling by an external DHCP server (if available on your side). The connection between IMS and your computer has to be done via a cross-over Ethernet cable. A corresponding manual describes how to change the default IP address on the IMS if required.

As an alternative you can use the RS232 for communication. In this case use a cross-over cable (3 wire) between the IMS (RS232 port COM1) and your computer. The transmission rate via RS232 is much slower as via Ethernet.

Start the inertial measurement system (IMS) and your computer and adjust your computer to the following settings (peer-2-peer connection without DHCP server assumed; please notice your actual settings before changing them!):

[1] Elder IMS communicate via IPX / NetBEUI "IPX"

Laptop IP-Address:	192.168.1.110	(instead of 110 every number, but not 199 or 198)
Mask:	255.255.255.0	
Gateway:	192.168.1.200	
DNS-Server:	192.168.1.208	
alt. DNS-Server:	192.168.1.200	

For DHCP-Server: Use the name of the IMS (e.g. 0169_001 or the system SYS0169-001)!

Important: It is recommended to operate the Inertial Measurement System (IMS) via an Ethernet point-to-point link to achieve highest data transmission rates. The machine is set to **IP 192.168.1.199 as default** but can operate at a DHCP server. To change the IP address please see the corresponding manual.

Operation via RS232 with a high baud rate (115.2 kBd) requires PC hardware that is capable of supporting this baud rate without limitation. One necessary condition (but not the sole condition) is that the serial interface features a UART with FIFO (typically UART 16550 or comparable).

As an alternative the communication can be driven via Ethernet (recommended). Nevertheless make sure that computing power consuming tasks like virus shields or battery checking tasks are disabled during performing data acquisition with high data rate.

The further usage is described in the following chapters.

Important Hint: If you have installed a Firewall on your computer (using Windows XP, the Windows Firewall is activated by default!), under special conditions (e.g. web operation for service) it may be necessary **to allow the Firewall to pass the software NavCommand**. Go into Windows SystemControl -> SecurityCenter and click to Windows-Firewall. Select the Exception pan, then search for the NavCommand software and introduce those as an Firewall exception. Due the same with the software iMonLog (if you intend to use those to identify the IP address of the IMS in your network.

Integration of the IMS into user specific applications:

The standard operation of an IMS is done via the NavCommand software. Nevertheless it is possible for advanced users to write his own command interface with the open XIO interface structure of the inertial measurement systems. On request iMAR can give support with a LabView interface or an DLL.

Only of relevance if using the XIO4Windows software:

Connect the IMS via RS232 or Ethernet with your computer. Start the XIO4Windows.exe application on your computer. Further information can be found in the XIO4WINDOWS manual. Via Xio4WINDOWS some additional parameters of the IMS can be adjusted. The software should only be used under feedback of the iMAR office.

Deinstallation:
For deinstallation at first the user data are to be deleted. This must be done by selecting the tool "Start->Programms->NavCommand->Deinstallation". Afterwards the software can be deinstalled under "Start->Settings->System Settings->Software->NavCommand".

Important hint: NavCommand is designed to work under Windows using the well-known and proven multi-tasking environment of Windows. NavCommand itself does not perform inertial algorithm calculation (this is done on the hardware of the IMS itself!) and therefore NavCommand does not need much CPU resources of the used laptop where it is installed. If third-party software shall be used together with NavCommand, then those software must also operate under real multi-tasking conditions. If those software blocks e.g. interrupts for longer duration, a cooperative operation of both software is not possible.

Integration of the IMS control panel into a customised application: Standard operation of the measurement system is carried out via the NavCommand program. It is also possible, however, for the advanced user to establish a connection to the measurement system via the XIO interface (e.g. via an optionally available XIO DLL) directly from his/her own application.

ONLY for operation of systems of the series iDIS/iNAV with XIO4Windows software (XIO interface): Connect the inertial measurement system to the PC via a null-modem (cross-over) serial interface cable (pins 2, 3, 5). The XIO4Windows.exe program should now be started on the external PC. The baud rate of the measurement system is preset at 115.2 kBd for time triggered data output. Additional information can be found in the “XIO4WIN” documentation. For example, XIOCmd can be used to modify IMS internal parameters and settings. However, this should only be done following consultation with iMAR.

1.2 Setting to work of an IMS (short description)

- Before switching on the IMS please read the documentation of the IMS carefully.
- Make sure that you have right knowledge about the required supply voltage of the IMS (see type label on the IMS) and check the output voltage of your power supply before connecting it to the IMS.
- Inform yourself which interfaces of the IMS are inputs and which interfaces are outputs (especially analog I/O, marker, PPS, PPX) and which loads/levels are allowed to avoid damaging the IMS.
- Switch on the IMS and observe the red and green LED of the IMS. A green flash code shows the system state of the IMS. The full state can be displayed using the NavCommand software. The red LED indicates warning and error conditions (e.g. GPS missing).
- Start the software NavCommand and follow the instructions in this manual. If the green LED does not begins flashing, check your power supply.

Important steps for the very first connection between NavCommand and IMS:

The NavCommand software has to identify the features which are installed on the IMS. Therefore the IMS must be connected to the notebook if NavCommand ist started the first time:

- Connect the IMS via RS232 (or via Ethernet) with the notebook (use a cross-over cable).
- Start the NavCommand software
- select the “Default” configuration and click on “New” to generate a new configuration. Choose the name “SYSxxxx” where xxxx is the system number of your IMS. Confirm with “ok”
- Select the data transmission medium (RS232 or Ethernet TCP/IP (32 bit IMS) or IPX (elder 16 bit IMS). If you use TCP/IP, check that the IP address of the IMS is set in NavCommand to 192.168.1.199 (if the IMS is in factory set mode, i.e. if no special settings is used)
- For choosing the start-up configuration select the check box for IMS settings “Use configuration stored currently on the IMS ”. **This is very important** to assure that the actual IMS configuration is transmitted on the local notebook (after installation of NavCommand no configuration is available on the notebook!). Confirm with ok.
- Now the actual IMS configuration is read from the IMS. Go to the “Configuration change” button in the main screen and select “store configuration”. After-

wards execute a configuration backup on the same pan by using the default settings.

- Now you have an actual copy of the IMS configuration on your notebook and you have a backup too.
- Never work with the backup configuration because it is your backup!
- Read this manual and continue with your work.

2 Short Introduction into Inertial Measuring Technology

In this chapter we cannot stress the full background of inertial measuring technology. For this you will find all inforamtion in the correponding literature. Also a lot of useful papers can be found on iMAR's web site (www.imar-navigation.de) where you should link to the download area. In the following we will show the definition of the IMS coordinate system.

2.1 Coordinate Systems

The angles of an IMS in space will be output in a so-called East-North-Up (NEU) co-ordinate system.

- world frame (or navigation frame), so-called ENU-system:
  - x-axis directed to East
  - y-axis directed to North
  - z-axis directed to Up
- IMU-co-ordinate system (body or sensor co-ordinate system):
  - x-axis see label on the IMU's housing
  - y-axis see label on the IMU's housing
  - z-axis see label on the IMU's housing
- Vehicle's co-ordinate frame (body frame):
  - x-axis longitudinal in vehicles forward direction
  - y-axis lateral direction
  - z-axis upwards
- RPY-angles (body frame):
  - Roll ϕ: Angle ϕ ("Phi") around the x-axis of body system.
  - Pitch θ: Angle θ ("Theta") around the y-axis of the body system, which is already turned with ψ around the word-z-axis.
  - Yaw ψ: Angle ψ ("Psi") around the z-axis of the world system (start of rotation!).

The order of rotation is Yaw, Pitch, Roll (starting with the world co-ordinate system).

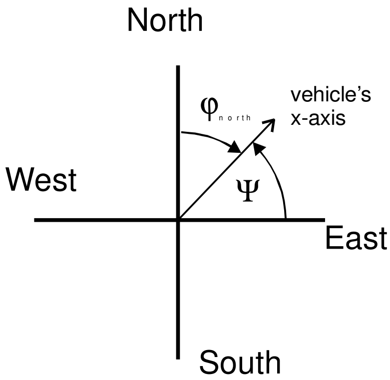
2.2 Definition of the Yaw Angle

Directs the x-axis of the IMU (body system) to East, i.e. in direction of the x-axis of the world system (also named as "navigation co-ordinate system"), then the yaw angle has the value ψ_{IMS} = 0 deg. With a mathematical positive rotation around the z-axis the yaw angle increases.

Take following into account due to the ENU definition

x in East direction:	ψ_{IMS} = 0 deg
x in North direction:	ψ_{IMS} = 90 deg
x in West direction:	ψ_{IMS} = 180 deg
x in South direction:	ψ_{IMS} = 270 deg

$\psi_{IMS} = 90° - \psi_{North,\ compass}$



Yaw angle ψ_{IMS} and right showing compass north angle ψ_{North}

The system can also provide log information in NED (north/east/down) if the corresponding logs are used (only if using XIO interface without NavCommand).

Take following into account due to the NED definition

x in North direction:	ψ_{IMS} = 0 deg
x in East direction:	ψ_{IMS} = 90 deg
x in South direction:	ψ_{IMS} = 180 deg
x in West direction:	ψ_{IMS} = 270 deg

2.3 Hints about the Measurement Point of the IMS

The IMS measures the accelaration in the point(s) where the accelerometers are installed. The angular rates and angles are the same at every point along a rigid body. If acceleration and velocity shall be determined in a so-called virtual measuring point on a rigid body, so the IMS provides the feature to transform those values into this point, which is defined by a lever arm. This lever arm can be set inside of the NavCommand software.

The lever arms of the GPS antenna as well as the odometer can also be defined inside of NavCommand.

NavCommand transmits those lever arms to the IMS where they are used for the inertial data processing.

If the coordinate system of the IMS is rotated (e.g. by using the DRPY command to compensate mounting misalignment angles), the lever arms must be coordinated in the rotated coordinate system! It is recommended to mark a rotated coordinate system on the top of the IMS cover graphically.

2.4 Different Kinds of IMS

It is distinguished between north-seeking and non-north-seeking inertial measurement systems.

The systems of type iNAV-FMS, iDIS-FMS or iNAV-FOS are containing gyros of class 0.5 ... 50 deg/hr. These systems are not able to determine the true north from the earth rate, but they are able to determine roll and pitch very accurately they can compensate the earth rate as well as gravity in the output data. Furthermore together with GPS or magnetometer they also provide true north information.

The systems of type iNAV-RQH and iNAV-FJI are true-north indicating systems with a gyro drift of 0.0001 ... 0.1 °/h. These systems are able to dertermine true north without external aiding information.

To keep very high performance even in long duration applications, all systems can be aided by GPS, DGPS, odometer, DVL or other information (e.g. ZeroVelocityUpdate – ZUPT).

3 *NavCommand* Operation

The NavCommand software, which runs under Windows 98/NT/2000/XP, can be used to command an inertial measurement system (IMS) via Ethernet / TCP/IP or RS232, as well as to save measurement data on the local hard disk of the user's PC and output the data in real time via the analog interface or the optional CAN interface.

3.1 General Information

a) If the measurement system is set for PPS triggering in "hard trigger condition", the PPS (pulse per second) of the GPS receiver must also be available. Otherwise no data will be sampled from the internal sensors. Standard operation is "soft triggered".

b) If measurement data is output via CAN at a fixed frequency (i.e. not as remote frames), the receiver must also accept these data (if acknowledging is activated), otherwise the measurement system will switch off the bus due to permanent CAN transmission errors, as it will determine that data is frequently being rejected on the other end. The CAN bus must be terminated with 120 Ohm by the user (no termination inside of the IMS!).

c) The system's error messages (e.g. wrong user entries in the CFG file) are documented in a NAVCOMMAND.ERR file. Before contacting the iMAR hotline, the contents of this file should be analysed (current messages are at the end of the file).

d) A so-called Expert-Mode is available to have extended access to the IMS. The password is only available for iMAR staff.

e) The **installation** of the NavCommand program is self-explanatory (simply start Setup). You should have administrator rights in order to perform the installation. For **uninstallation** always first run the uninstall software to delete all configuration files (if desired) and then uninstall the software under the Windows "Software" menu! If you want to install an NavCommand update, it is not necessary to uninstall the old software. Previous edited configurations can be used furthermore if no problem in compatibility occurs (will be checked automatically by the NavCommand software).

f) While the user's PC is booting, the inertial measurement system (IMS) should not be switched on and connected to the PC via RS232, since Windows may then try to identify the IMS as a mouse.

g) In the following manual some information for system administrators are given. For standard operation no internal knowledge about Windows OS is necessary.

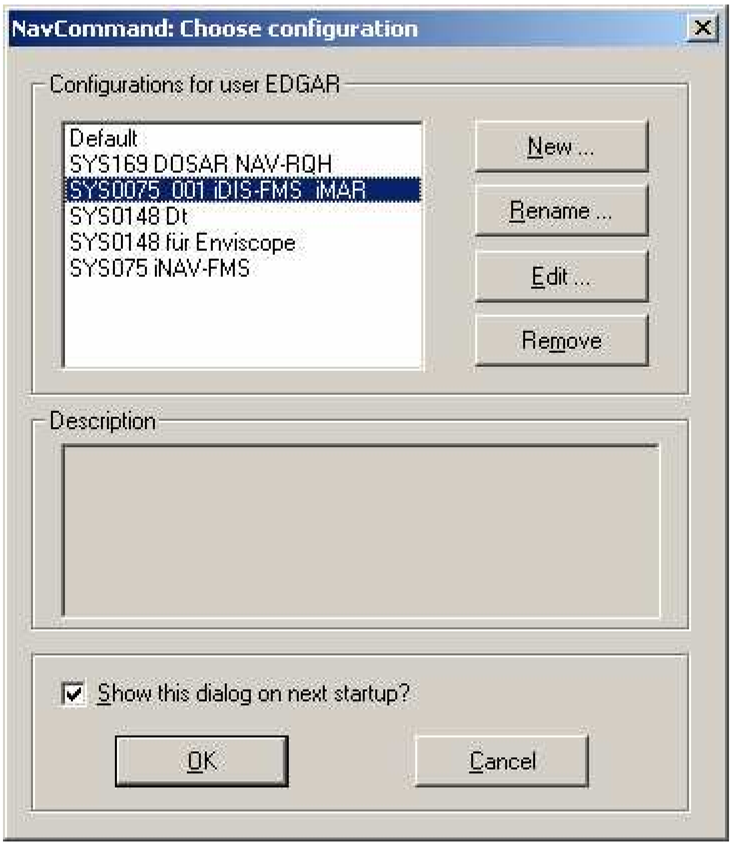
h) The operation of an IMS is described in the following for road/rail/air/navy vehicles / applications and geographical surveying. Nevertheless iMAR has also software available for customer specific applications.

i) The NavCommand analyses the connected hardware and provides the features which are supported by the hardware automatically.

j) ***It is recommended to log on to Windows under a user name***. This means that under Windows 9x, the Sign In dialog box should not be closed with "Cancel." This assures that each user can operate the program with individual configuration setting.

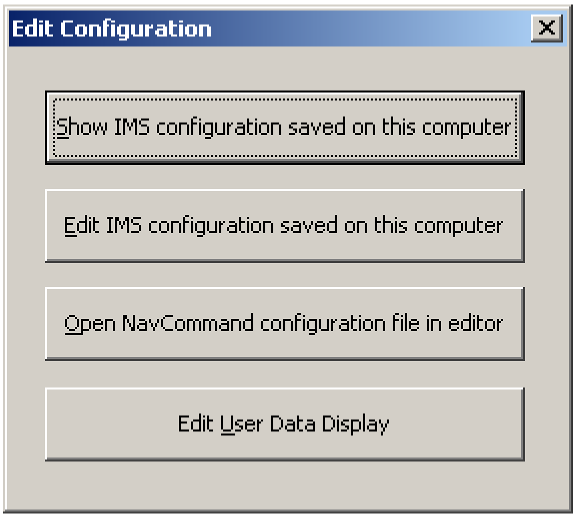
3.1.1 Configuration Selection

After installing the program, only the supplied default configuration is initially available. Using the "New..." button, a new configuration can be created. For this, a new dialog box is opened in which the name of the configuration as well as a description (up to 2048 characters) may be entered. The program then generates a new configuration file based on the values of the current configuration. In this new file all settings entered during the program execution are saved. Using the "Description..." button, you can modify the name and description of the configuration.



With **„configuration"** we describe the entirety of all parameters to be set or used in this program and on the IMS like alignment-mode, sampling frequency, angular displacement error compensation values, serial number of the IMS etc. which can be stored on the IMS as well as on the user's laptop and other parameters like the definition of data storing on the harddisk of the user's laptop which can be stored only in the configuration files on the laptop (all configuration files have the extension *.BIN). This means that configuration files of IMS „A" typically cannot be used simply for IMS „B". With each IMS an installation CD is delivered, where the NavCommand software can be found together with the system-independent BIN-files (so-called Default-Configuration); the system specific parameters will be loaded automatically from the IMS if the default configuration is selected and the IMS is connected.

Usually the user is working with the configuration files locally stored on the user's laptop harddisk. Only for the case that the laptop shall be exchanged, it may be useful to store the actual configuration on the IMS and to re-load it from the second laptop.



Nevertheless also the BIN-files can be easily copied.

<u>Special feature of the "Default" configuration:</u> The Default configuration is a minimal configuration. To create a full configuration on the laptop, select the "Default" and Create a new configuration with "New". In the next menu select the feature "local saved on this computer (only system independent parts)". Now you have generated a new configuration based on the IMS system specific settings.

With **"Edit"** the actual configuration can be opened with an editor. For this three possibilities are available:

a) View a selected configuration in menu-outfit (read-only), also direct selectable with Ctrl-„Edit"

b) Edit a selected configuration in menu-outfit (read-write), also direct selectable with Shift-Ctrl-„Edit"

c) Edit a selected configuration as text-file, also direct selectable with Shift-„Edit"

This editor will be the default program that Windows uses to open text files ("txt" extension). As long as the editor is open, no further actions are possible in NavCommand.

The viewing or editing of a configuration can be performed without connection of an IMS. but it is necessary that the IMS has been connected sometimes before so the IMS specific parameters have already been loaded from the IMS to the laptop's harddisk (e.g. system number).

In the NavCommand-Expert-Modes (password only known by iMAR for internal system setup) before displaying the configuration menu a selection dialog is displayed to select the software modules to be edited/displayed ('Main' and 'Calc' cannot be deleted). If the corresponding configuration does not exist, it will be created and default values will be set. To upload such created configuration to the IMS, with starting the connection to the IMS at first the dialog option 'Use Configuration saved on this computer' must be selected first; afterwards, if this configuration shall be stored on the IMS, after establishing the data transmission to the IMS the option 'Flash Disk On IMS' must be switched on (or with program Exit the 'Shift'-key has to be pressed together with the Exit button).

Use the “Delete” button to delete an existing configuration.

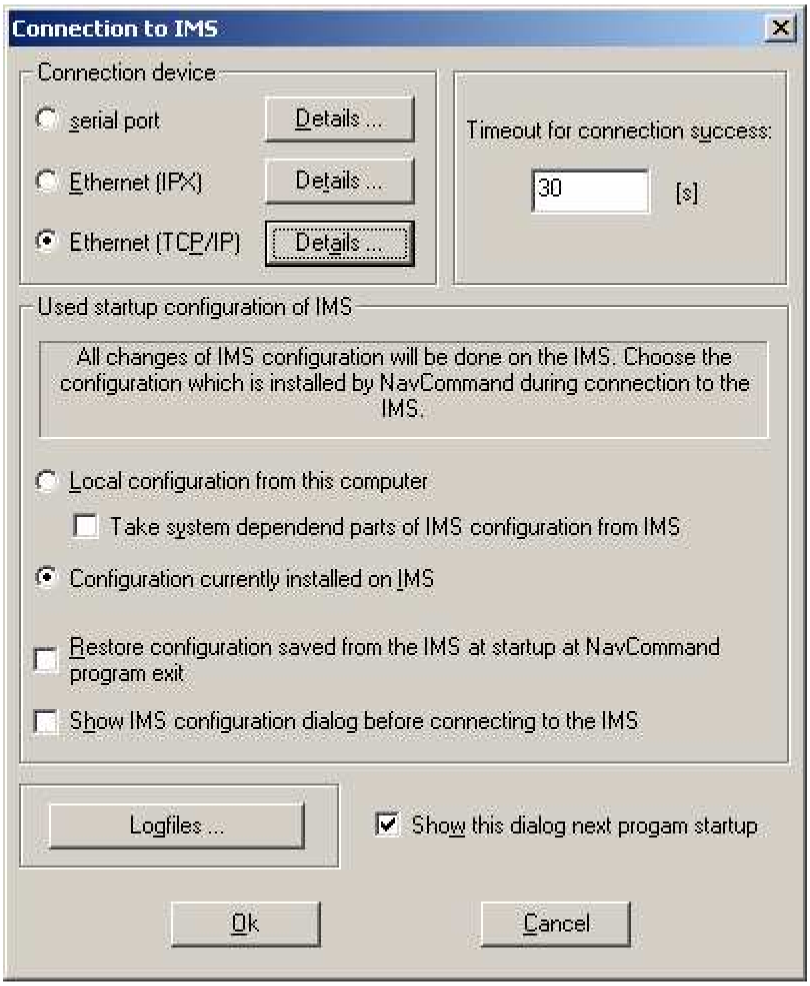
If you uncheck the “Show configuration dialog box at next start?” checkbox, at the next start NavCommand will automatically use the most recently used configuration. If you want to display the configuration dialog box once again, hold down the “Shift” key at program start-up.

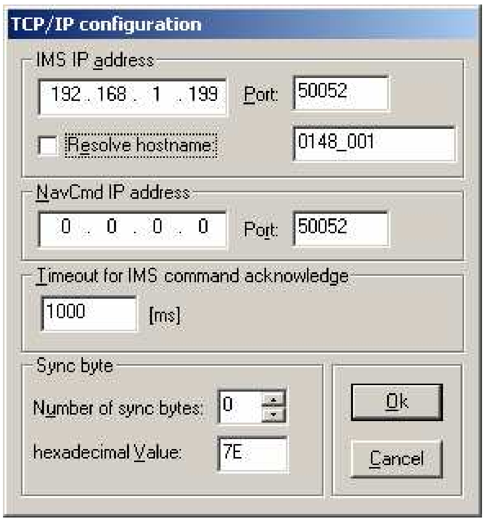
If you check the “Delete log files at next start” checkbox, the NavCommand log files, which by default are written in continuation, will be deleted and newly generated at the next start.

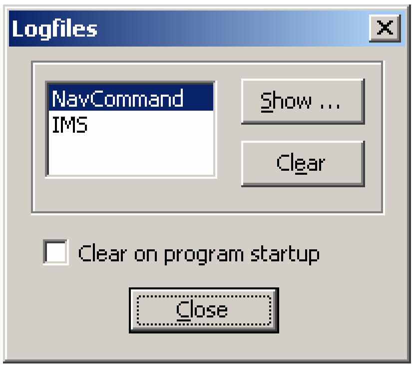
After choosing the configuration, you then configure the serial interface by selecting the port, the baud rate and the timeout for the receipt of data. If a user wishes to display this window again during a subsequent program start, he or she must **hold down the Shift key at program start-up.**

3.1.2 Connecting the IMS

After startup of NavCommand a dialogue is opened to select the interface which shall be used to operate the IMS. If the dialoge will not appear, the check box "Show this dialogue next time" has not been checked. In this case start NavCommand again during press down the Shift key.







The following selection can be made:

Serial Interface, Ethernet (IPX) and Ethernet TCP/IP. The Ethernet interface allows a higher data rate and a safe transmission even in noisy environment and therefore it is preferred against the RS232 interface. The parameters of the interfaces can be adjusted in the „Details" dialog (Baud rate, port, IP address etc.).

As the start configuration of the measurement system it can be selected whether the configuration on from the IMS or the locally stored configuration from your notebook shall be used. If the local configuration is selected, those configuration will be transmitted from the local computer (notebook) to the IMS after building up the first communication. Afterwards always the IMS operates wirth the configuration available on the IMS and the local configuration will never be changed during operation. If the local configuration shall be used as start configuration, it can be selected that nevertheless all system-specific parts of the configuration (e.g. name of the IMS specific internal calibration file, information about serial number etc.) are used from the IMS and not from the local configuration (usefull e.g. to copy the measurement-specific parts of a configuration from one IMS to another IMS). Typically the system-specific settings are not used from a local configuration to avoid any mismatch between IMS and configuration settings.

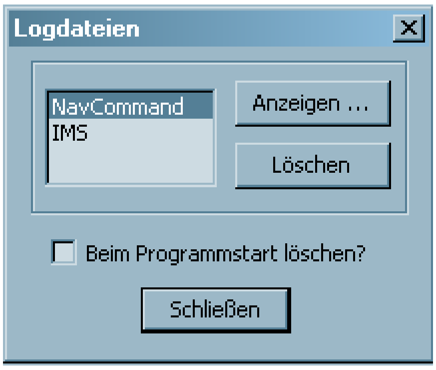
During operation all changes of the configuration are only stored on the IMS. Only on special user command (see chapter 3.2.7. Configuration Change) the IMS configuration will be saved on the local computer or a backup of the IMS configuration will be generated.

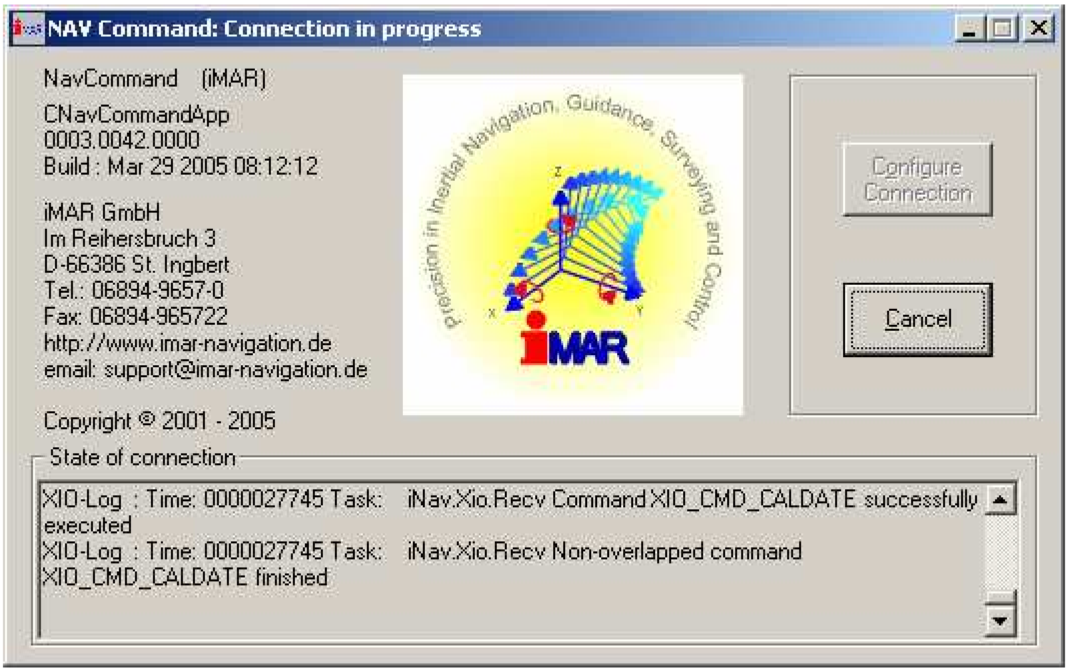
Furthermore it is possible to start the system in a mode where is saves the IMS configuration at start-up and where it installs with the end of NavCommand operation the initial configuration back to the IMS. In this mode (which is only usefull for system testing) all changes are discarded after operation and the IMS has the same configuration after operatioan as before.

To be able to change some configuration settings already during building up the communication between IMS and your local computer, the dialog for changing the configuration can be displayed during communication activation.

The standard operation of the IMS with NavCommand is to use the local configuration stored on your computer for start-up and to store it on your local computer if you have made changes. It is possible and recommended to create several different configurations for several tasks.

The dialog **„Log Files“** starts a dialog to show the internal log files of the IMS and the NavCommand software.





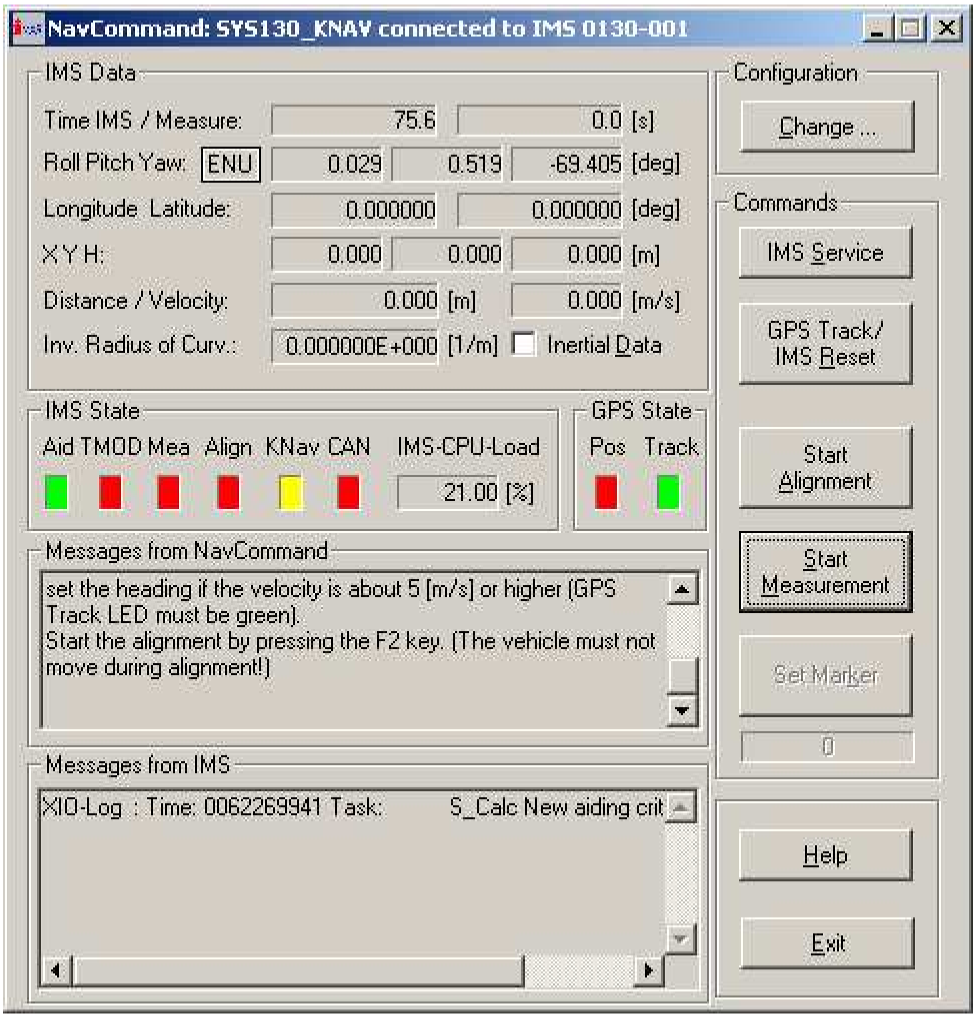
Afterwards the connection will be established. The progress of connecting the PC with the IMS is shown on the next screen.

The first time the program is started, a dialog box will prompt you to select the configuration to be run. A configuration is understood to be the entirety of all parameters to be set in a program (all parameters accessible via the configuration dialog boxes described below, the parameters of the serial interface as well as additional settings accessible only through the configuration files described in Appendix A).

Also system log files (from NavCommand and from the IMS hardware) can be displayed or deleted from this pan.

3.2 Main Screen

Following configuration of the interface, a start-up dialog box appears and the program will attempt to connect to the measurement system (his may take 30 to 60 seconds). Once the connection is established, the navigation main screen will be displayed.



Help: First of all under this button you will find this documentation as a pdf file. Furthermore the short-cuts are described to operate your NavCommand still faster.

3.2.1 IMS Data

IMS Time / **Measuring Time:** In the upper left pane of this screen you find the current data of the inertial measurement system (IMS). If GPS is available, the UTC time will be output as seconds after midnight, otherwise the IMS time is output (time since IMS was started [s]; remember that the IMS performs a re-boot always after changing parameters via NavCommand and then the time starts again at “zero”). Next to that is displayed the duration of the current measurement.

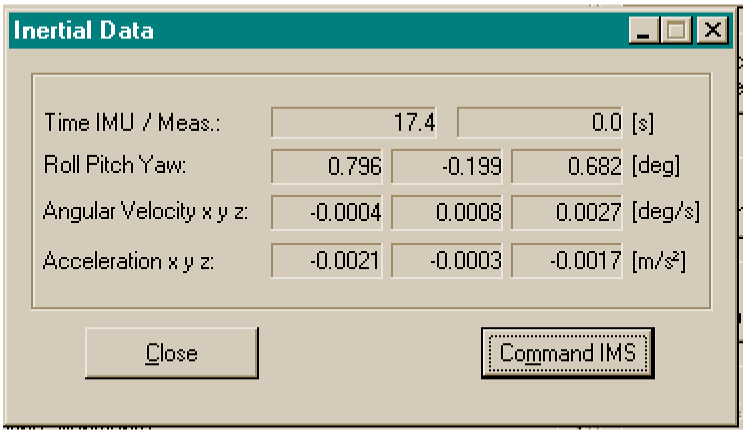
Roll Pitch Yaw: Here the three angles (roll, pitch, yaw) of the measurement system are displayed. The output can be alternated from NEU to NED coordinate frame. This alternation only has an effect on the displayed angles and does not effect the data storing.

Longitude Latitude: Here the present position derived from the GPS receiver is displayed (GPS position).

X Y Z: This shows the current local position of the IMS relative to the starting position of the surveying course (only available for land based applications where an odometer is used), where “X” indicates the West-East path and “Y” the South-North path; “H” is the height (local height calculated from distance travelled and pitch angle[2]). According to that, the starting point has the coordinates (0,0,0).

Distance Travelled / Velocity: This is the entire distance travelled since measurement began (measured by the odometer, if available) and the current velocity.

Inverse Radius of Curvature: The inverse radius of curvature is derived as a quotient from the vertical rotation rate and the longitudinal velocity measured by the odometer. (Note: for v = 0, this value is not defined and cannot be computed! Output is NaN – not a number).



Inertial Data Checkbox: Using the checkbox “Inertial Data”, the angular rates and accelerations of the IMS in body frame (after correction of the earth’s angular rate of 15.04 deg/hr and the earth’s gravity of 9.81 m/s²) can be visualised. Using the “Command IMS” button while the inertial data is displayed, the main window can be activated so that the IMS can be commanded via keyboard (see below for keyboard shortcuts for commanding).

2 If you like to use local coordinate determination, adjust roll and pitch to be zero on a leveled plane so the pitch of the vehicle is similar to the tilt of the road

3.2.2 IMS Status

In the pane “IMS State", (Main Screen) the state of the measurement system is signalled:

“Aid” signals whether the aiding of the inertial measurement system via the odometer is active or not.

“TMOD” shows synchronisation of IMS time with GPS time (since software version 3.41).

red:	not synchronized
yellow:	synchronization in process
green:	synchronized.

“Mea” signals whether measurement is active (and thereby data storage, if activated).

“Align” gives information as to whether the system is correctly aligned. The LED shows the status as follows:

red:	no alignment
yellow:	static alignment active
blue:	coarse alignment active (only with north-seeking systems)
black:	fine alignment active (only with north-seeking systems)
green:	alignment carried out successfully.

“KNav” provides information as to whether the system is in the dead reckoning navigation mode [iDRPOS-algorithm, only optionally available] (red: Kalman filter not active; yellow: Kalman filter on standby; green: Kalman filter of the iDRPOS navigation with estimation of odometer slippage, position and heading active).

"CAN" indicates whether CAN data transmission is activated by NavCommand or not.

GPS State

POS indicates whether the data from the GPS receiver is valid:

yellow:	Standard position (*no* DGPS)
green:	Precision position (DGPS)

Track: indicates whether, before the alignment, the heading was able to be tracked via GPS on a straight course ("Track"). If the system wants to determine the track (only for IMS which do not contain a true north finding gyro system and which are mounted on a surface vehicle!), the LED is flashing to signalise that the vehicle shall drive straight forward to support the track determination until the LED changes to green.

To perform an initial alignment with heading (in reality it is the course over ground [COG] which is measured by the GPS; this COG is assumed to be a good estimation for the heading if the side-slip anble of the vehicle is neglectible) derived from the GPS, it is required to drive a certain distance with a minimum value of velocity straight forward (e.g. minimum velocity is 3 m/s, see value in pan “GPSTrack“).

TheTrack-LED is red, if...
... the track modul is not available or the track aiding is deactivated and the dead-reckoning algorithm KNav is switched off or the heading-aiding using GPS is deactivated.

TheTrack-LED flashes red-black, if...
... the track angle had not been able to be determined yet or if in Track-Search-Mode the thresholds for angular rate/velocity are active or KNav is not yet stable

TheTrack-LED flashes red-green, if...
... in the trackangle-search-mode the track angle is set (i.e. v > threshold and omega < threshold)

TheTrack-LED is green, if...
... the system is in trackangle-aiding-mode and no thresholds are active (i.e. v > threshold and omega < threshold) or KNav is stable and the trackangle aiding is active

TheTrack-LED flashes green-black, if...
...during trackangle-aiding-mode the thresholds are active (v < threshold or omega > threshold) or KNav is not yet stable

TheTrack-LED flashes green-black, if...
... the trackangle-search-mode is finished successfully, but the trackangle-aiding-mode has not been activated afterwards.

At the beginning, if the system wants to proceed a track angle determination, the Track-LED therefore flashes red-black. The Track-LED then flashes red-green after the minimum speed has been exceeded during driving straight forward and when the track angle has been determined successfully the Track-LED has green color. Then the vehicle can be stopped and an alignment can be performed to estimate roll/pitch with highest accuracy.

Only for land based vehicles with a not north seeking IMU (car, truck, rail vehicle):

In order to perform an alignment with a GPS-tracked heading, establish GPS reception and move the vehicle straight ahead at a minimum speed of 3 or 5 meters per second (values according to the configuration file). The LED turns yellow when this speed is reached and drive forward until the "Track" LED lights up green. Then stop the vehicle and perform the alignment in a stationary position. For all subsequent alignments, the current heading can then be adopted from the IMS. To track a new course with GPS, it is then necessary to restart the IMS using the button “GPS Track / IMS Reset,” otherwise the current heading will be used.

Note: In determining the initial heading with GPS prior to alignment, the vehicle should move as exactly straight as possible. Course deviations can only be recognised by GPS with a certain delay and could therefore lead to significant alignment errors! Proceed straight ahead at least until the status “Track good” is displayed. The system performs an internal validity test of the driving manoeuvre (no course deviation for a minimum duration) and may request a new alignment.

These constraints are not given using the optional iDRPOS algorithm (Dead Reckoning).

Only for vehicles with a north seeking IMU:

In order to perform an alignment only initial latitude/longitude is required from GPS or from user input. Then heading and attitude will be determined during course and fine alignment.

3.2.4 NavCommand Messages

Notes on operation and other important information (e.g. the name of the file in which measurement data is currently being saved) are shown in the lower pane “Messages from IMS”.

3.2.5 IMS Messages

In the pan “IMS Messages” all messages sent from the IMS are displayed. This pan is only of interest for advanced users and allows to get information about the internal operation of the IMS. Which messages are displayed can be configured in the configuration file of NavCommand with the parameter “ShowIMSMsg” in the section [NavCommand GUISettings].

3.2.6 Commands of Operation

All following commands can be selected by using the mouse or using the function keys (see help menu for function key description).

IMS Service:

The iNAV program on the measurement system’s processor is closed and, depending on the features of the measurement system, one of the following file access mechanisms will be started:
- an TCP/IP file server is made available to have access to the IMS file system via the Windows Explorer (for all 32bit kernel

systems)
- a DOS file server (measurement systems with 16bit Kernel and Ethernet interface via IPX) is started
- or a batch file with InterLnk/InterSvr (measurement systems with 16 bit Kernel but withRS232 interface) is started on the IMS. If the button is pressed while holding down the "Shift" key, the InterLnk/InterSvr batch file will always start.

GPS Track / IMS Reset:
Restart of the software on the processor of the measurement system. If this button is pressed while holding down the "Shift" key (should only be done after being advised by iMAR staff), a log file is created on the measurement system computer. To save this log file, see the "IMS Service" button.

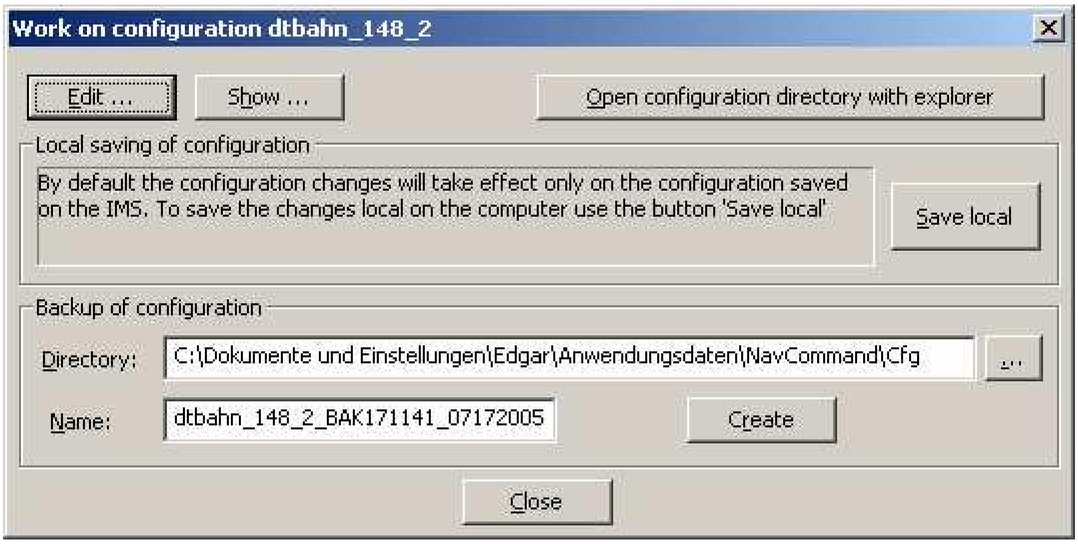
Alignment:
Alignment is started. The procedure of alignment depends on the IMS type (north-seeking or non-north-seeking)
Non-north-seeking systems: absolute immobility is required over alignment duration (20...60 seconds). During this time roll and pitch are estimated.
North-seeking systems: The duration of determine true north depends on vehicle dynamics and Kalman filter settings. It takes between 600 seconds and 30 minutes (on high seas or in-flight alignment).

Start/End Measurement:
Start/end of measurement on the IMS and data output via CAN and analog interface (and thereby of data storage as well). Location of data storage depends on the IMS and NavCommand configuration (can be done on the users computer or as an option on the IMS)

Set Marker:
This button is only active during the measurement is active. If pressed, a marker in the form of a sequential counter is written into the next data record to be stored on the user's computer via NavCommand (the value of the *next* marker is displayed underneath the button).

3.2.7 Configuration Change

Here the actual configuration can be displayed, changed, stored and a configuration backup can be created.



Change and **Show** show the same settings of the configuration, but with **Show** all changes will be discarded. **Save Locally** saves the actual IMS configuration (as it just is) into the local selected configuration stored on the local NavCommand computer (otherwise all changes of the configuration are only saved on the IMS). .

With **Configuration Backup** a backup of the actual local seaved configuration will be created under a new name. **Directory** defines the folder, in which the backup is stored (default is the configuration folder, so NavCommand will be able to find the backup again after a re-start) and **Name** defines the name of the sub-directory (a backup of the configuration consists of several files, which are stored together), where the backup is stored and which is at the same time the name of the configuration under which the backup is displayed in the NavCommand configuration selection list (default is the name of the actual selected configuration with a postfix, superposed by „_BAK“ and the actual PC time and the actual PC date). With the button **Generate** the backup will be created.

To make a backup configuration available which is not sored in the default directory, simply copy the folder into the NavCommand configuration directory. With the next start of NavCommand the configuration then is available. The folder can be reached via the button **Open Configuration Folder via Explorer**.

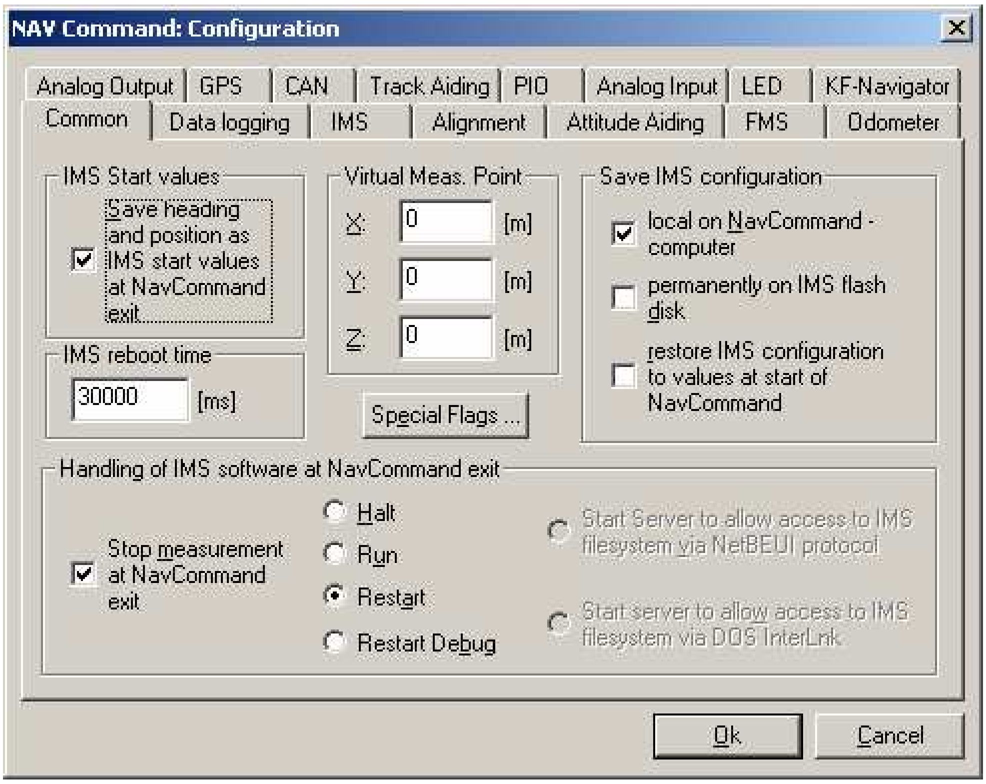
Depending on the hardware and software configuration of the IMS, some of the following described modules / dialogs may not appear or some values may not be allowed to be changed or some user specific modules are available being not described in this genaral manual. After changing some parameters a re-boot of the IMS is necessary which is automatically forced by the NavCommand software (e.g. changing the data sampling frequency). This is done after pressing the “ok” button inside of the configuration menu.

With the “Configuration Change...” pane of the main screen (keyboard shortcut F1), the menus shown in the following chapter appears after the menu described above has been displayed.

Be carefully: During storing configuration data on the IMS permanently, no power interruption is allowed for 10 seconds after storing. Otherwise the internal configuration may be corrupted temporarily or even permanently. DO NOT SWITCH POWER OFF UP TO 10 SECONDS AFTER STORING THE CONFIGURATION WITH PROGRAM EXIT!! The system will give you a warning before entering this configuration saving mode.

3.2.7.1 Common

On the tab of the configuration dialog with the title “Common”, you can indicate some general settings of the IMS like the coordinates of the virtual measurement point for data transformation, the stored-heading feature or the start-up and continuous-running behaviour.



Starting Values: It can be selected whether heading and position shall be stored if NavCommand is shut-down or not. In this case the IMS starts up at the next power-on with the stored values.

Virtual Measuring Point: The virtual measurement point is coordinated in the coordinates of the IMS and allows to transform acceleration and velocity from the IMS measuring point to the virtual measuring point. If the desired output of the IMS positions do not refer to the point defined by the mounting position of the IMS, you can use the “Virtual Meas. Point” field to indicate the vectorial distance of an alternative measuring point from the origin of the IMS coordinate system and coordinated therein. If, for example, the virtual measuring point lies in the x direction in front of the IMS origin, the x coordinate should be given as positive. The virtual measuring point refers to the IMS coordinate systemIf any angular misalignment (mounting misalignment angles) has been defined, the lever arm of the virtual measuring point must be definedin the rotated IMS coordinate system.

Recovering of Configuration:

It can be selected whether the configuration is stored permanently on the IMS or whether the initial configuration which had been found after power-on shall be recovered during NavCommand will be finished.

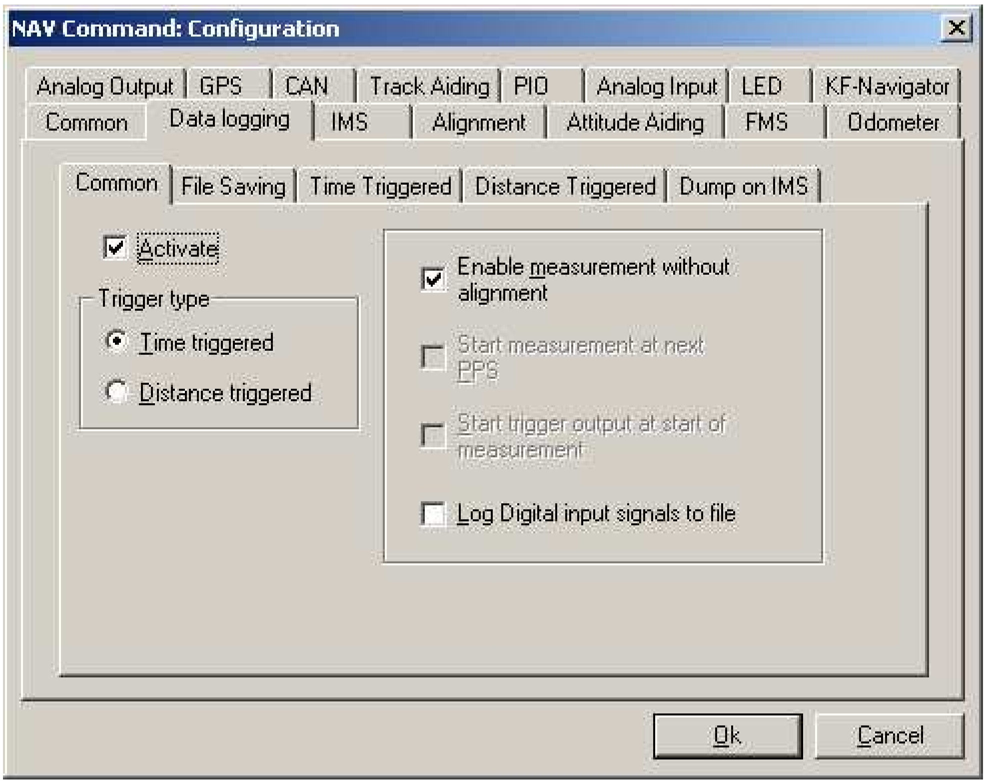
Behaviour of the IMS at leaving NavCommand:

Here is is selected what the IMS shall do when NavCommand is tuned off. Possibilities are to stop the IMS data processing or to continue the operation. This allows to start up the IMS using NavCommand and then to separate the user's computer from the IMS while the IMS continues its operation.

Furthermore some useful information is given about the used IMS: System number, software release version and recommended date for re-calibration (recommended if the system is operated as a measuring device in ISO 9000 environment).

3.2.7.2 Data Logging

Here you can define the settings for the data logging of the data which are computed on the measurement system. The data can be stored on the user's computer or (if available) on the internal flash disk of the IMS.

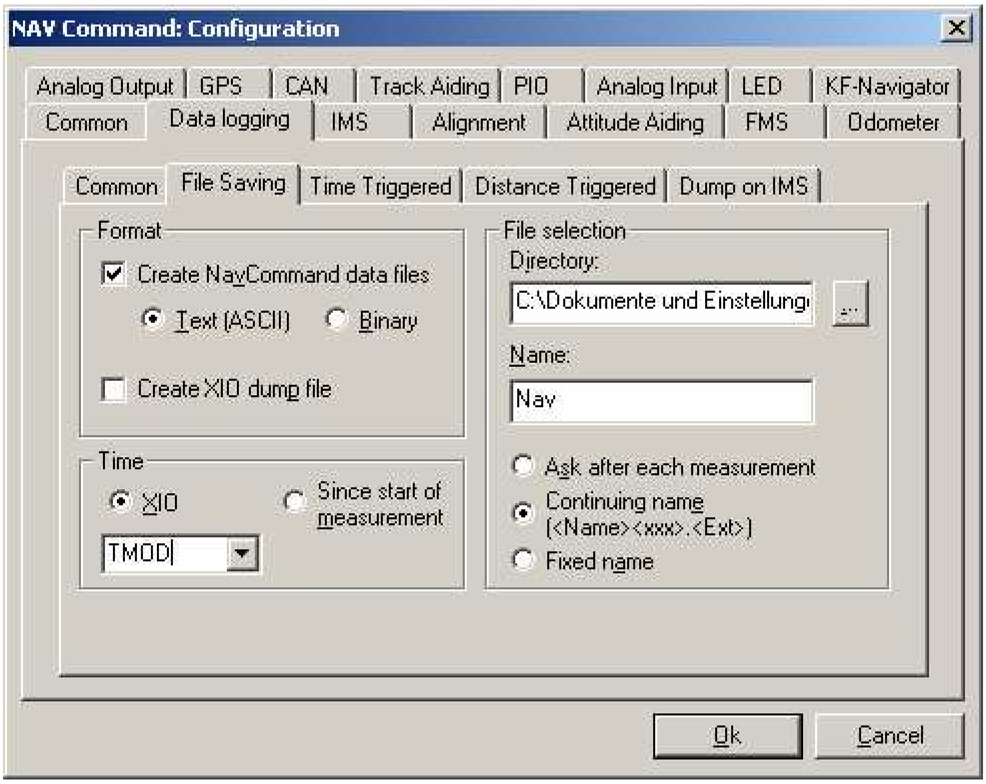


Activate Data Storing: First, the logging of measurement data on the local hard disk of the user's computer can be turned on or off using the "Activate data logging" checkbox. If this option is not choosen, the data will not be stored during the measurement.

Kind of Triggering: The triggering of data storing can be done time related or distance related.

Measurement without Alignment: If an alignment is not required after power on (e.g. systems of series iDIS-FMS, where an automatic alignment is performed without any requirement of an user interaction) here it can be choosen whether a start of the measurement is allowed without user alignment or not.

Format and Location of Data Storing:



Format: Select text file format (ASCII, all data of the same sample are stored in one line; every data sample is seperated by CR or CRNL [depends on the setting in the NavCommand configuration file]) or binary format (Little Endian-Format). The header of the file is in text for both text and binary files and describes the file structure and (in binary files) the definition of sync-bytes and header separator character. The header is terminated by the ASCII character Ctrl-Z (0x1A).

The bnary file may contain a sequence of sync bytes all n data sets to be able to re-construct a demaged file. The extended sync sequence are 4 bytes of value 0x81. The configuration of sync bytes can be set by the parameter “SyncStep“ in the section “[NavCommand DataSaving]“ in the configuration file.

Create a XIO Dump File: For a postprocessing all commanded XIO data logs can be stored in a Dump File on the user’s computer. The format is binary according to iMAR’s XIO definition.

Time: The time stored in the data file can be the GPS/ IMS -time (TMOD = UTC, i.e. seconds of day) or the time since starting the measurement (in seconds).

File Selection: Here you can specify the directory and name of the file in which the data transmitted by the measurement system are saved. The default directory is a folder named “NavCommand” in the Windows default directory “My Documents.” The file name is set up according to the following scheme:

<Name>_<DataSrc>[<xxx>].<Ext>,

where the individual components have the following meaning:

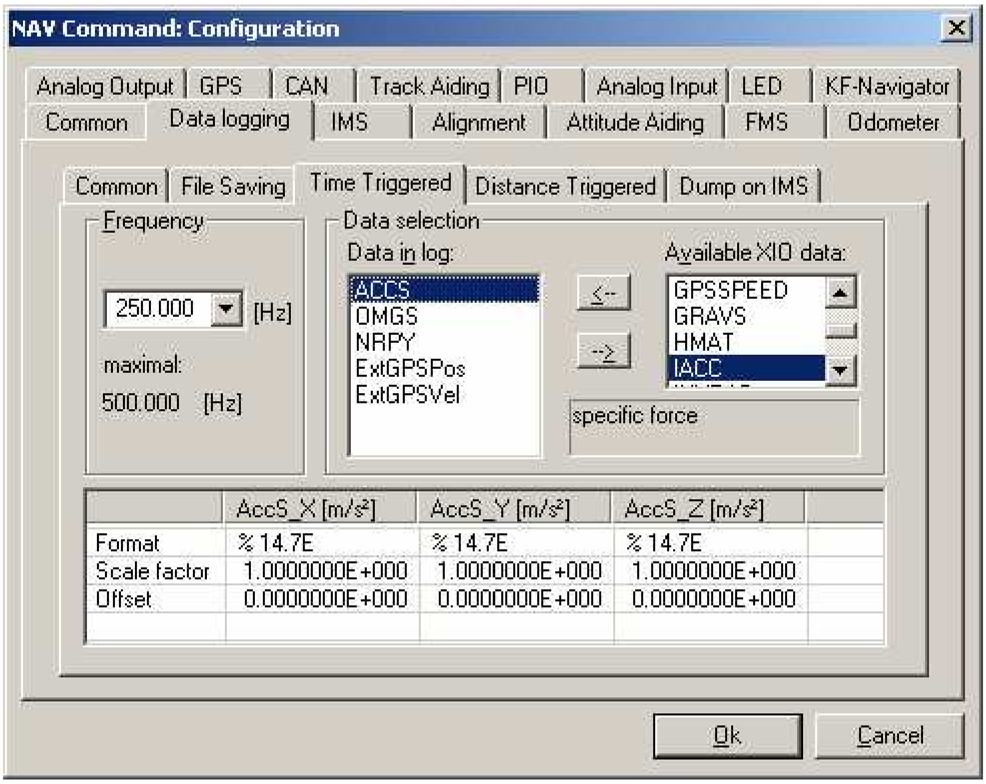
- Name: The file name entered under "Name."
- DataSrc: The data source: "IMS," "GPSPos" or "SPSVel" for inertial data, GPS position and GPS velocity.
- xxx: sequential numbering
- Ext: file extension: "Asc" for text files, "Dat" for binary files.

Three alternatives are implemented for the selection of the file name:

1. You will be explicitly asked to enter the file name after each measurement
2. The file name is generated automatically with ascending numbers
3. Data are always saved under the same fixed file name

Time related / Distance Related Data Storing:

Here the data storing frequency can be choosen (smaller or equal to IMS sampling frequency). The data toring frequency is also limited by the transmission rate of the connection between IMS and user's computer (please note that the RS232 connection only allows to transmit at maximm 11.520 bytes per second as a theoretical value; therefore it is recommended to use the Ethernet interface for data transmission). The data storing frequency must be a fraction of the sampling frequency, otherwise the system adjusts automatically to the best fit close to your settings.



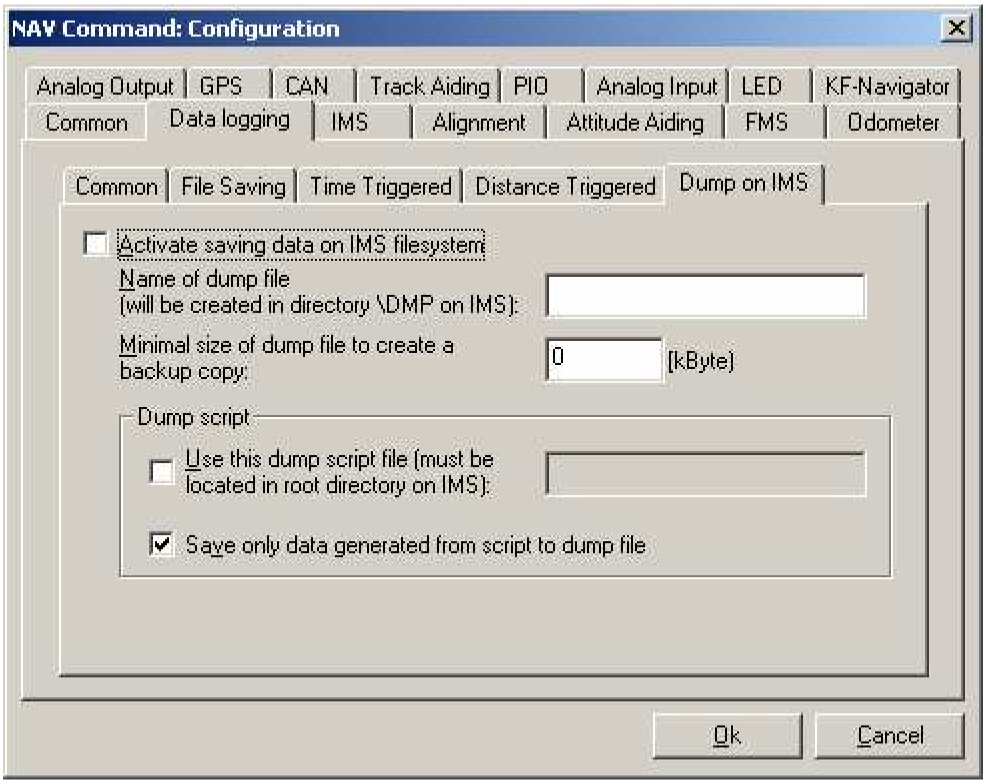
Furthermore you have to select which data shall be stored. For storing in text mode you can also adjust the number of characters which shall be used (definition is the same as used in "C" language format definitions, i.e. number of total characters and number of decimals).

GPS position (ExtValGPSPos) and GPS velocity (ExtValGPSVel) are stored in separate files, because they are only available from the GPS receiver with lower data rate than the IMS data from the inertial measurement system.

In the pan of “distance related data storing” the data can be selected which shall be stored in this mode and additional a “pulse per distance” can be activated (PPD) which indicates an output pulse (TTL) every x meters (this mode requires that an odometer is connected, so this mode is only useful for surface vehicles). ThePPD output is available as an option only. The user has to make sure that the maximum utput frequency of the PPD will not be faster as the sampling frequency.

Example: If the sampling frequency is 100 Hz and the PPD resolution is set to 0.1 m/s, it is not allowed to drive faster than 10 m/s. Otherwise the signal processing is not able to generate correct PPD and the data performance may be distorted.

Data Storing on the IMS File System:



If there is installed a flash drive with large capacity (> 1 GByte) inside of the IMS option), there is a possibility to store log data inside of the IMS. Which data shall be stored can be defined in a Dump Script File which has to be placed on the IMS file system in the main folder. It can be selected whether only the data logs defined in the script or all logs (also those which are initialised by NavCommand during the measuring session) shall be stored in the dump file on the IMS. The data storing starts after power-on of the IMS. The data will be stored in the named file. Files, which have a size smaller than specified will be deleted automatically after next power-on.

This feature of IMS internal data storing should only be used if a large flash drive is installed (e.g. 4 GByte).

The system generates automatically up to 10 backup files with enumerated extension (000...009). The eldest file is always the file with extension 009. This procedures assures that always the 10 latest dump files are available (if dump file writing is enabled).

The dump script file (e.g. XIO.INP) is a script which defines the commands sent to the navigator after power-on. The “language” of the script file is line oriented commands; semicolon separates a comment from a command.

```
*Delay 10000                        ; delay in ms
*Delay 10000
*Delay 10000
LGACT 0 0 0.0
NMEARAW 1234                        ;
GETPAR FA                           ; reading of sample frequency
GETPAR FEXT                         ; reading of ext. trigger frequency
LOG 0 500.0 IACC IOMG               ; log data definition
LOG 0  10.0 NRPY
LOG 0   1.0 TIME TMOD
AUTOX 0  1              ; store EXTVAL_GPSPOS in dump file
AUTOX 1  1              ; store EXTVAL_GPSVEL in dump file
AUTOX 3  1              ; store EXTVAL_DVLSPEED in dump file
AUTOX 5  1              ; store EXTVAL_GPSUTC in dump file
AUTOX 7  1              ; store EXTVAL_DEPTH/PRESSURE in dump file
*PPT
*Delay 10000
*Close
```

Some additional control commands are available:

LOG <N> <f> <ID$_0$> <ID$_1$> ... <ID$_{n-1}$> = initialises a data log output
where <N> Number of repetitions of the log output (0 --> ∞)
<f> Frequency of data output [Hz]
<ID$_x$> logical name of data to be sent

NMEARAW <ID> = To identify NMEA raw data in the dump file, an identifier (WORD) has to be choosen (arbitrary value). The NMEA data will then stored under this ID (see data structure of XIO packets)

AUTOX = see XIO headers XIOEXTV.H (storage of external values if they have changed)

LGACT bOR bAND Fc = activates the logs automatically which are commanded with a lower frequency than fc
rule: activate logs, if bOR || (bAND && F_log <= Fc)
If the condition is false, an external start of the logs is required (e.g. first *PPT – pulse-per-time)

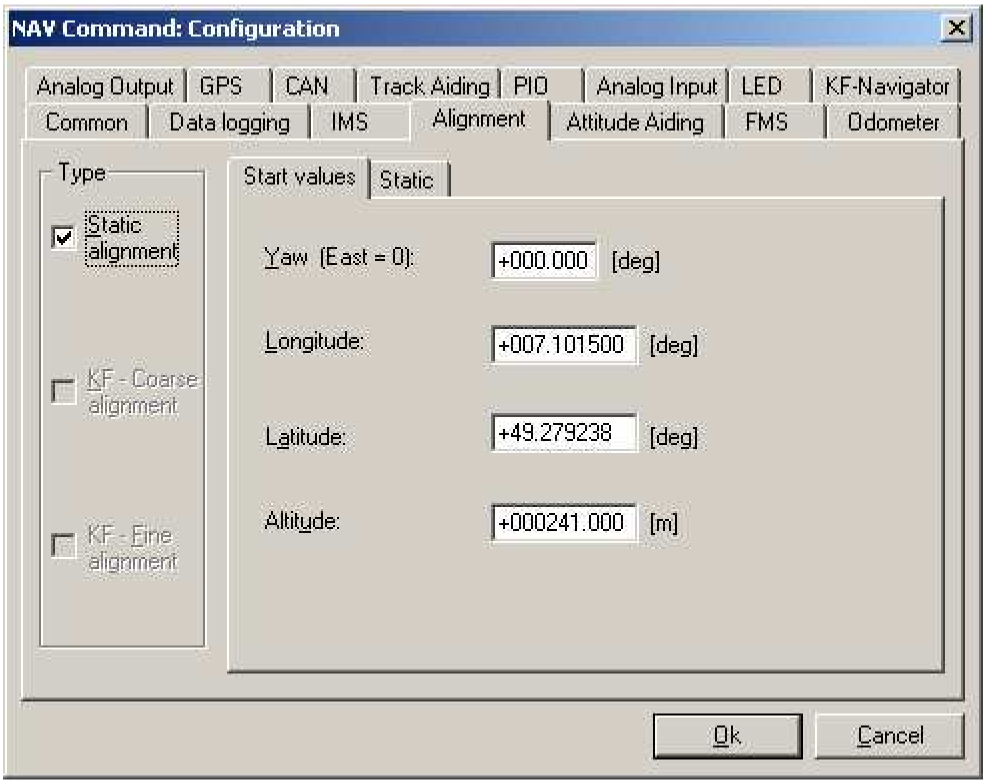
Meta Commands:

*DELAY	= Delay after start of Navigator in ms
*PPT	= performs data logging synchronous to pulse-per-time signal
*SYNC	= performs data logging synchronous to pulse-per-second signal
*TRIGGER	= starts all defined logs at the same time.
*CLOSE	= Closes this script file (data logging continued)

To stop data saving on file the XIO-command "exit 255" will be sent automatically if NavCommand is left. All files are closed and the navigator is stopped. Do not power-off the navigation system during data are stored on the internal disk!

3.2.7.3 Alignment

On this tab the alignment can be configured. The alignment is necessary for correct compensation of earth rate as well as gravity and initiates the roll, pitch nad (in north seeking systems) the heading (yaw).

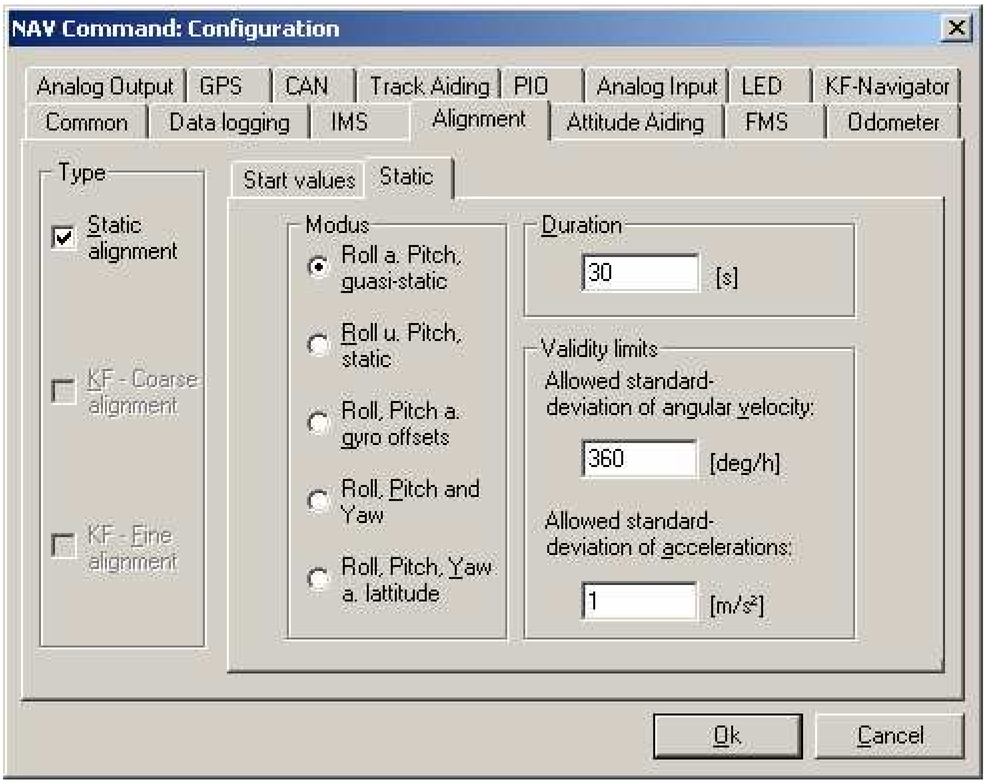


Start values: If GPS is available, longitude and latitude and altitude (height) will be taken from GPS, otherwise these values can be set manually.

Static Alignment: With the attitude alignment the initial values of roll and pitch will be determined (standstill of the vehicle is required). To do this, the knowledge of heading is required, which can be taken from GPS (two antenna GPS or driving a certain distance to achieve the track angle) or which can be set manually (this mode is used if the IMS has no gyro based true north seeking capability).

If an absolute standstill of the IMS can be guaranteed and an IMS with lower performance gyros (> 10 deg/hr) is uused, also the gyro offset can be estimated. The duration of alignment depends on environment: For systems with gyro performance 0.5...10 deg/hr the duration should be 30...100 seconds. The result of alignment is displayed in the main screen with the calculated standard deviation of measured rotation rate. The value should be less than 30...50 deg/hr. The longer the alignment duration the smaller the standard deviation. If small attitude changes during alignment may occur or if the gyro drift is not more than 1 deg/hr, the quasi-static alignment method shall be chosen and no gyro offset determination shall be activated.

If the IMS has a drift of less than 0.1 deg/hr, also a static alignment with estimation of true heading can be performed (absolute standstil is required in this case!)

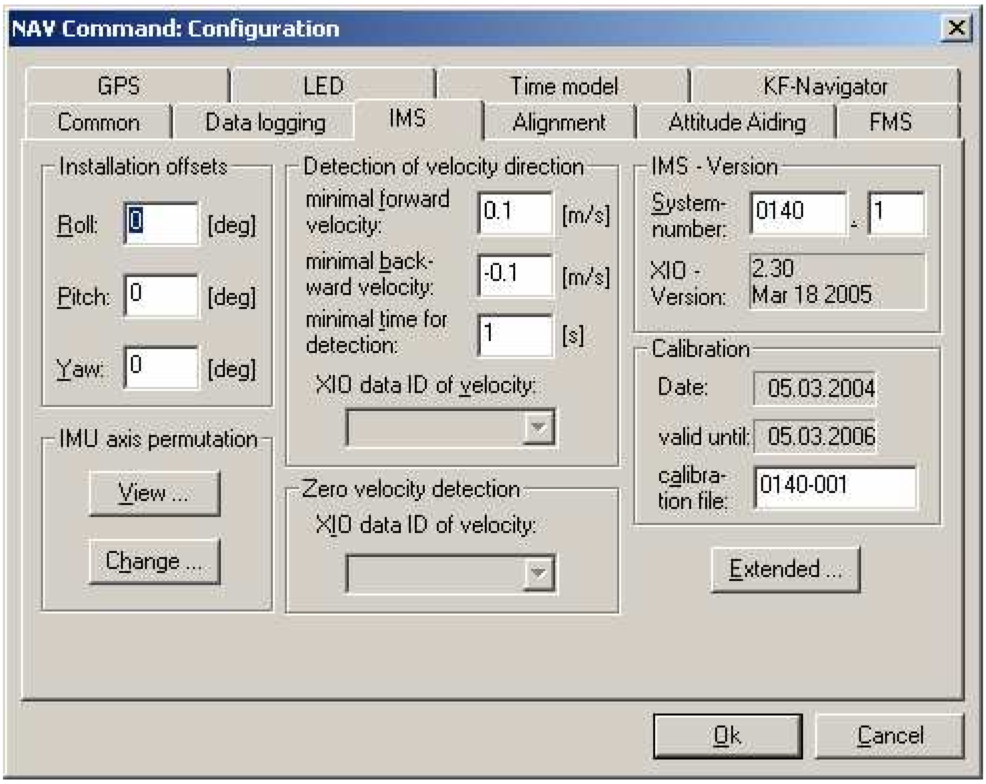


Kalman filter Alignment: Using high performance gyros the north seeking will be performed using the course/fine alignment Kalman filter. In this alignment mode the vehicle is allowed to undertake low motion.

For laser gyro or high performance fiber optic gyro based systems (north seeking and true heading capability) the alignment duration should be 5...30 minutes.

3.2.7.4 IMS

The IMS tab shows general settings of the IMS. These are mainly the mounting angular displacement corrections, the driving direction detection and information about software, hardware and calibration issues. If no hardware is connected some entries may leave empty.



Mounting angular displacement correction: Three angles delta_roll, delta_pitch, delta_yaw, which can be set to align the IMS inside of a vehicle.

A mathematical horizon levelling of the IMS can be carried out as follows: Place the vehicle on a flat surface (if it is a road vehicle), activate attitude aiding, perform an alignment (including correct heading!), note roll and pitch angles and enter them as installation position offsets under "Roll" and "Pitch". Now check the result carrying out another alignment. The angles in "Roll" and "Pitch" should now be in the area of the system accuracy. This installation angle error correction is required, for example, if the IMS is to be used for topological surveying using the local coordinate frame, where the height is determined by the distance travelled and the pitch. If no levelled surface is available, you can perform two measurements while rotating the vehicle with 180 deg change of heading and calculating the displacement angles of roll and pitch from the difference of both measurements.

Driving Direction Detection: GPS is only used as an aiding sensor, but is is not possible to detect the „heading" of the vehicle from a single antenna GPS engine because GPS only determines the motion over ground (GPS cannot detect if driving forward or backward, i.e. where is the nose of the vehicle pointing to; it only shows the track angle). Therefore the algorithm for heading estimation needs some information about the driving direction which can come from the odometer (if the odometer is able to distinguish forward/backward driving) or it must be defined that the vehicles heading cannot switch immediately of 180 degrees. If the vehicles velocity goes below of a certain velocity GPS will not be used for driving direction determination.

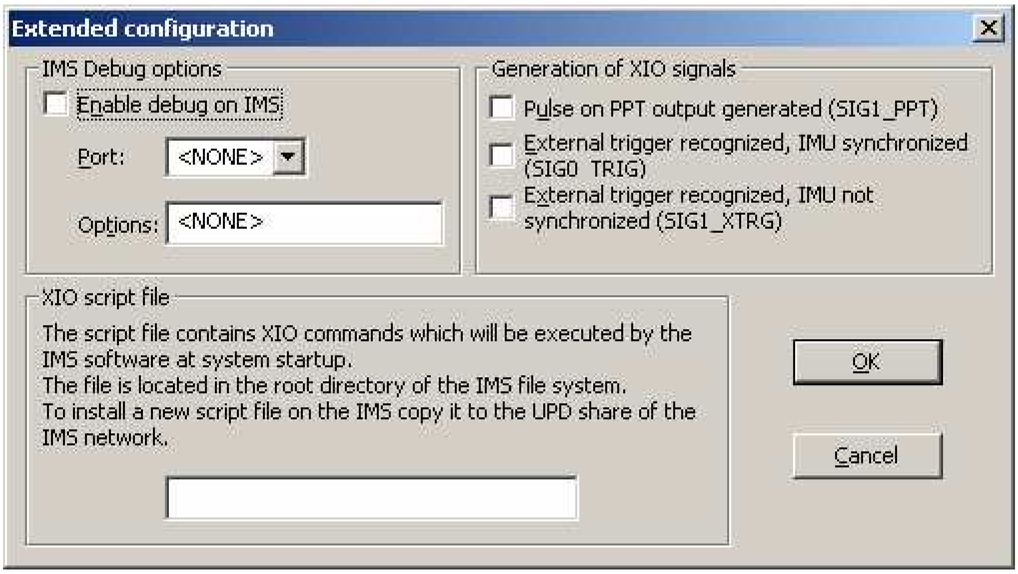
INS Version: Here you see the system number of the connected IMS and the interface software (XIO) revision number.

Calibration: Gives the date of last calibration and the recommended date of the next check of calibration performance.

Axis Permutation: Shows the logical transformation between the physical sensor axes and the system output axes. Changing these values requires a new system calibration.

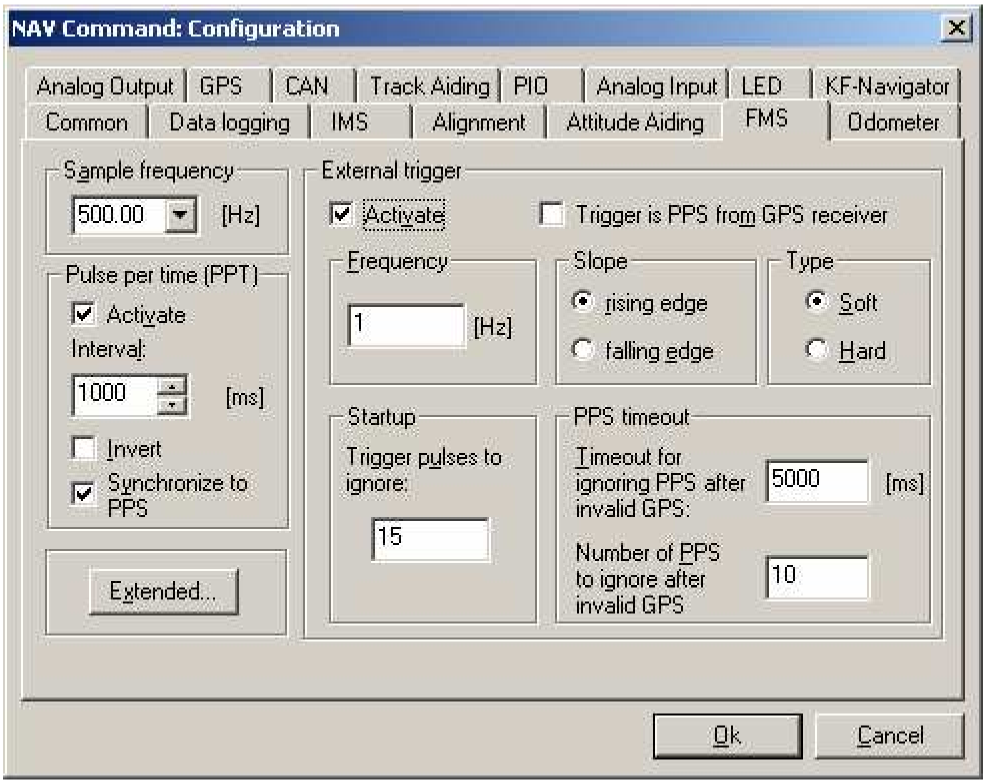
Velocity Aiding Source: It can be selected which infomation source (odometer,DVL or GPS) shall be used for velocity aiding.

The **extended** information is for internal use only.



3.2.7.5 FMS

The FMS tab is a sensor specific configuration and supports the settings being possible in conjunction with iMAR's fiber optical sensor head (FMS) and the supporting signal processing hardware. In this section also the time synchronisation and the sampling rate are defined.



If a laser gyro is integrated the name of this pan is e.g. RLG32.

Sampling Rate: Changing the sampling rate of the IMS requires a re-boot of the IMS. Do not choose a sampling rate higher than specified to guarantee stable operation.

PPT: The IMS can generate an output trigger which can be used to synchronised some external devices like a camera (PPT, pulse per Time).

External Triggering[3]: The IMS is synchronised to an external trigger source like PPS (pulse-per-second signal of the GPS) where the synchronisation may be **hard triggered** (the IMS data sampling does not start until a trigger is available after power on. This allows to force the IMS time to be synchronous to the full GPS second, i.e. there is no time phase between GPS time and IMS time) or **soft triggered** (internally the IMS clock continuously triggers the data acquisition of the inertial sensors even when the PPS trigger is not available after power-on. When PPS becomes available, a constant time phase exists between the internal trigger and the PPS which is output so the user receives time-stammed data in GPS time). In both trigger procedures the time difference between following PPS will be checked and used for synchronisation. If a trigger is missing, the IMS continuous with an internal generated trigger

Due to the fact that most GPS receivers need a certain time to produce stable PPS output (pulse per second) the IMS allows to ignore the first m PPS trigger output edges from the GPS receiver.

Because some GPS receivers have difficulties with their own PPS output if a GPS outage occurs, a timeout can be defined after which PPS is ignored when no valid GPS solution is delivered from the receiver to the IMS.

Some GPS receivers further more generate a wrong PPS after having lost the satellites and then coming back with a GPS solution. Therefore also here it can be configured to ignore m seconds of PPS after GPS signals became valid after a certain time of GPS outage.

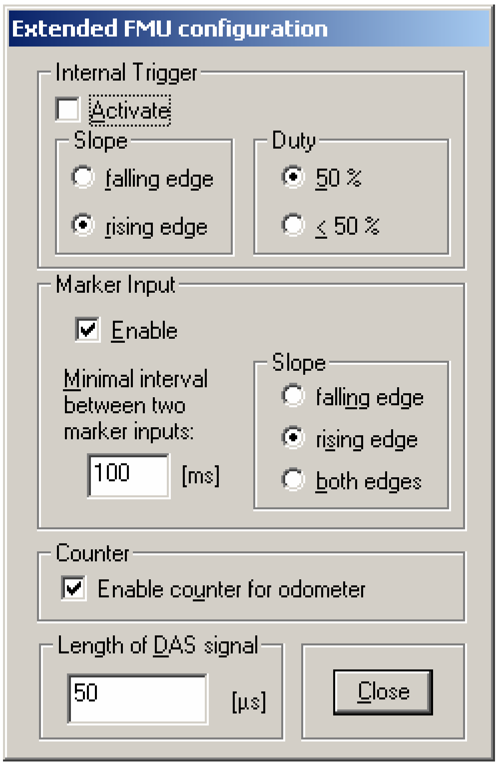
The settings in the extended FMS configuration must not be changed without consulting iMAR.

---

3 **Important information for IMS internal time modelling:** The IMS is designed to work with an external synchronisation information (PPS or marker). In this case the corresponding time information must be arrive after the trigger and before the next trigger arrives. To check the consistency of the trigger information, thresholds are set within the information must arrive after the trigger event.

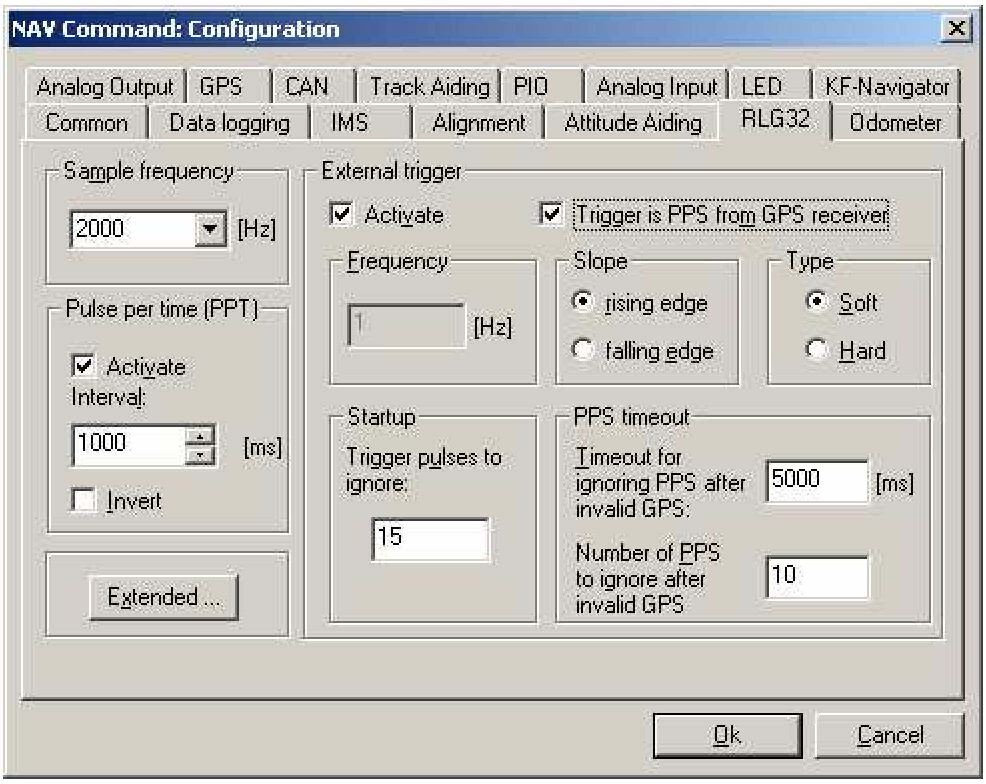
Nevertheless there is sometimes the requirement that an time synchronisation must be possible even if never a trigger edge is available. In this case the best to do in this worse condition is to determine the time when the external aiding information arrives. This time is measured and it is checked whether the following information are coming in a fixed period (if an external aiding is arriving without a constant period, it cannot be checked whether the aiding is correct and no time modeling can be performed.

The Coding inside of the IMS is as follows: Aiding information (e.g. via NMEA) is expected to be received periodically and it is checked, whether the time between following messages is constant. If the repetition rates varies more than the set thresholds, a warning is generated and the message is discarded. This is also done when a PPS (or some other external hardware trigger is available (in this case the thresholds should be enlarged because there is no physical requirement that the message arrives in a small time window)


Extended FMU configuration
Internal Trigger
Activate
Slope
falling edge
rising edge
Duty
50 %
≤ 50 %
Marker Input
Enable
Minimal interval between two marker inputs:
100
[ms]
Slope
falling edge
rising edge
both edges
Counter
Enable counter for odometer
Length of DAS signal
50
[µs]
Close

3.2.4.6 „RLG32“ Pan

This is the configuration of iMAR’s high performance laser gyro IMS of clas 0.0025 °/h. The configuration allows to change the internal sampling rate and the synchronisation settings. Changes should only be done with consultance of iMAR staff.



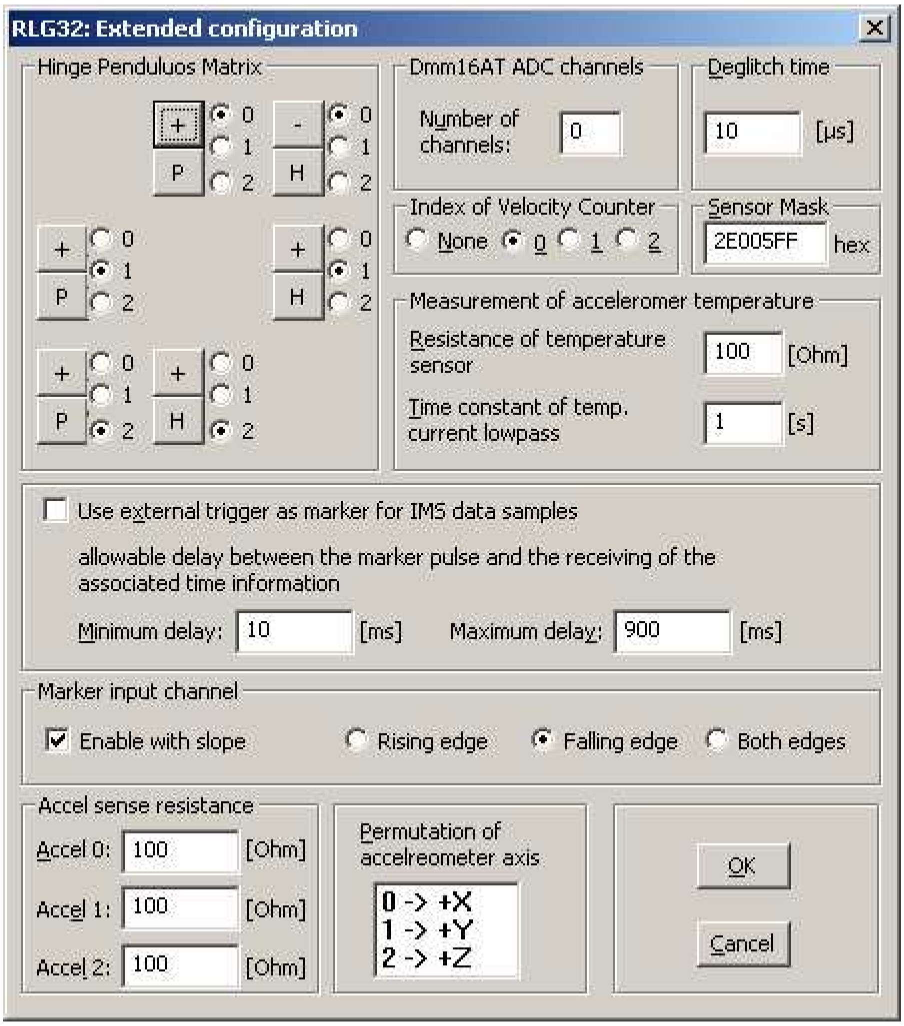
Triggering: The data acquisition can be triggered on PPS, where **hard triggering** and **soft triggering** are supported (see also description of the FMS configuration). Furthermore as a third method of synchronisation the IMS can be triggered internally (free running mode), where the trigger input is used like a marker input for time synchronisation between external time (e.g. GPS time) and internal time (IMS time).

Extended Configuration:

Some parameters like temperature dependent sensor misalignment, scaling resistors, axes permutation or the number of additional A/D channels cannot be changed by the user.

Digital Marker Input: Definition, whether a marker input is available and on which edge it shall be active.

Exernal Trigger to be used as Marker: The third possibility to synchronise the IMS (beside of hard trigger and soft trigger) is to use the external trigger input (signed as PS input) as a marker input. I.e. the internal data acquisition is driven (triggered) by the internal clock (and not by an externalö trigger) and so the IMS is in a free-running mode based on the internal time base. The incomming trigger signal is analysed and a time stamp is generated which is based on the IMS time. Together with the trigger input the user has to provide a time message via one port of the IMS to tell the IMS the external time. From this time stamp the relation between the IMS time and the external time can be derived (i.e. it is known which IMS time and which external time was valid when the trigger has been detected). The time message containing the external time shall arrive within a tolerance window after (e.g. within 10...900 ms) after the trigger.

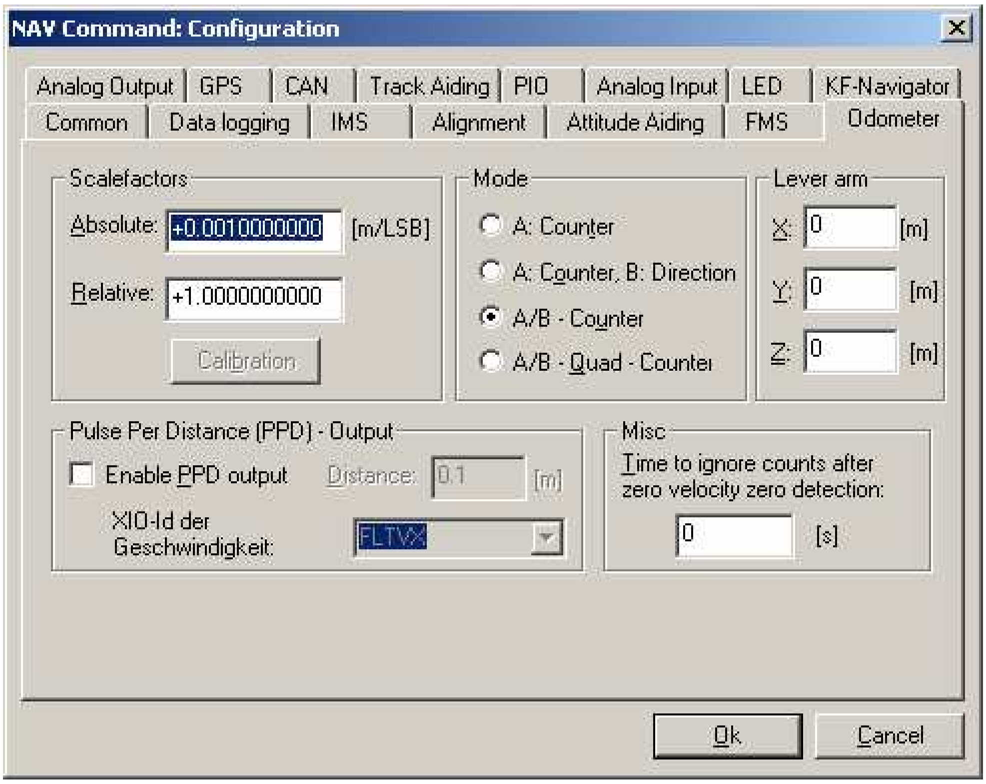


As a special constellation the PPS-Signal of the GPS can be connected: via RS232 the NMEA sequence GPGGA has to be sent after sending the PPS. Now the IMS is free running, but every second the relation between IMS time and GPS time is reported. The <u>advantage of this solution</u> is that a wrong or missing PPS has no influence on the IMS inernal data sampling or system performance.

Odometer Selection: The hardware provides up to 3 odometer inputs. Here it is selected which channel shall be used for velocity aiding.

3.2.7.7 Odometer

If the measurement system is equipped for connecting an odometer, its parameters can be set on the this tab.



Scale Factor: The absolute odometer scale factor can be set, which may be the vaalue from the odometer calibration sheet (if any). It has to be entered in the unit meter/pulse (m/lsb). The relative scale factor is linked multiplicatively with the absolute factor. This factor can be determined via the “Calibration” button by means of a calibration drive. For this, measurement is automatically started on the IMS and a distance of known length can then be driven. At the end of the course, the length of this course should be specified; the relative scale factor will then be computed automatically using the distance calculated by the measurement system. The end of the measurement can be determined by a key stroke or by using the hardware marker.

Counter Mode: Here you can indicate the mode of the counter to be used by the IMS to evaluate the odometer pulses. With iDRPOS option inside the odometer scale factor will be estimated automatically using GPS.

a) "A: Counter": Only one transmission line with pulses is available (e.g. Correvit sensor)

b) "A: Counter, B: Direction": Pulse on line A and digital directional signal for forward/backward (e.g. from the reversing light).

c) "A/B-Counter": Two lines with signals shifted by 90° are evaluated (typical output of an incremental encoder).

d) "A/B - Quad- Counter": Like c), additional both rising *and* falling edges are evaluated.

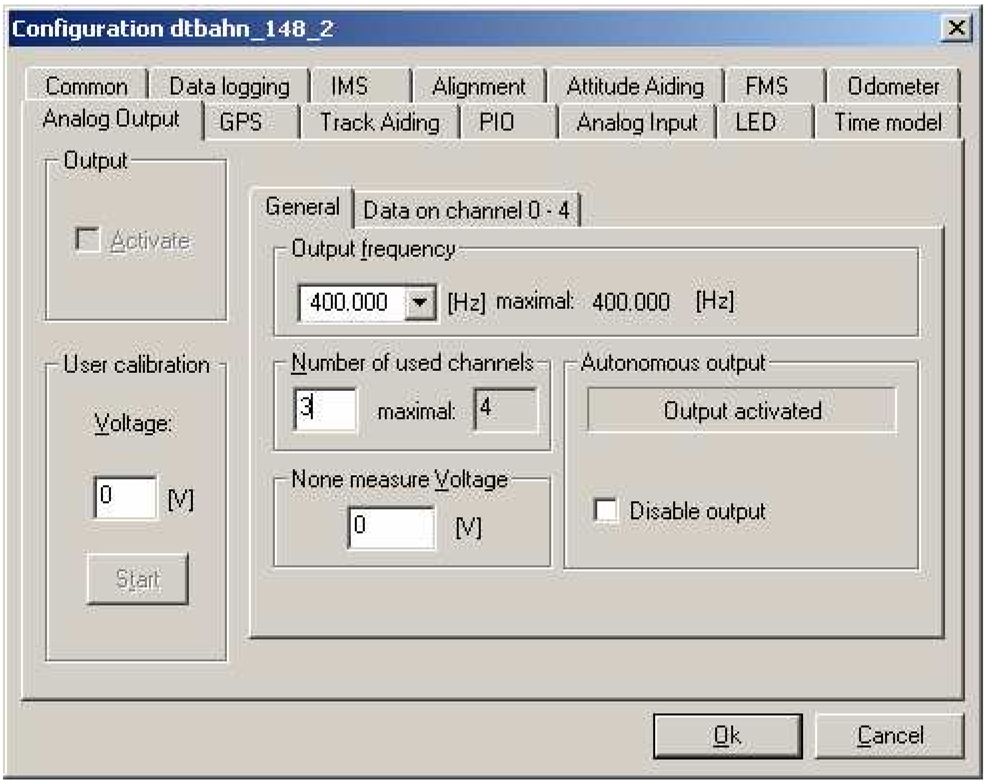
Some velocity sensors generate bad digital signals when speeding up from standstill. Therefore the possibility is given to ignore data from speed sensor for the first x seconds after leaving the standstill condition.

PPD: Under "Pulse per Distance (PPD) – Output" you can set whether, after a specified distance, a TTL pulse should be generated on the measurement system's digital output designated as PPD (not in all versions available). Additionally, data output can also be triggered on this pulse (see also description of data storage, above). Finally, it is possible to specify the distance of the odometer from the reference point of the IMS in the coordinate system of the IMS. In this way, the velocity can be transformed into the coordinate system of the IMS in order to correct the lever influence on the velocity for curved courses. The PPD is only available during a measurement is active.

Lever arm: With the lever arm, which is coordinated in the IMS coordinate system, the odometer data will be transformed into the IMS coordinate system to correct effects do to the mounting position of the odometer.

3.2.7.8 Analog Output

This configuration is used to setup the analog output interface of the system. First, the output can be activated or deactivated.



Calibration: The user can select a certain calibration voltage and this voltage can be applied immedeately to all output channels to calibrate or check all analog interfaces.

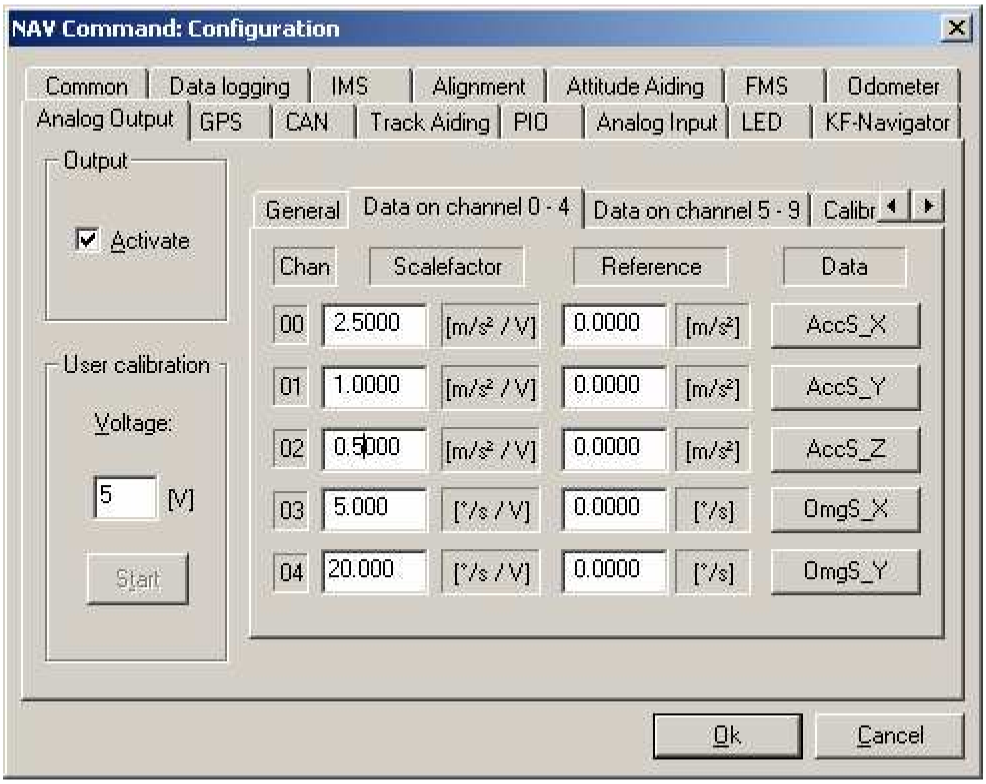
Output Frequency: The frequency of the analog output can be set, the maximum frequency is being defined by the sampling frequency of the IMS. Note, that no reconstruction filtersare integrated inside the IMS due to variable output frequency which is selectable by the user.

Voltage output, if no measurement is active: If the system is not in measurement mode, no data is output via the analog channels; instead, a fixed voltage is output whose value is set in the field “Outside measurements” In order to enable the user to calibrate the total measuring chain for the recording of the analog data, a defined voltage can be turned on to the outputs. Enter the value in the “Calibration” field and click on the adjacent button.

Data on Channel xxx: The scale factors for the analog channels are entered for acceleration, rotation rates, attitude and heading in such a way that each respective output voltage value in volts is the result of the respective measured value divided by the entered scale factor.

For example to achieve 5° pitch angle at 10 V output voltage the scalefactor has to be set to 2 deg/V.

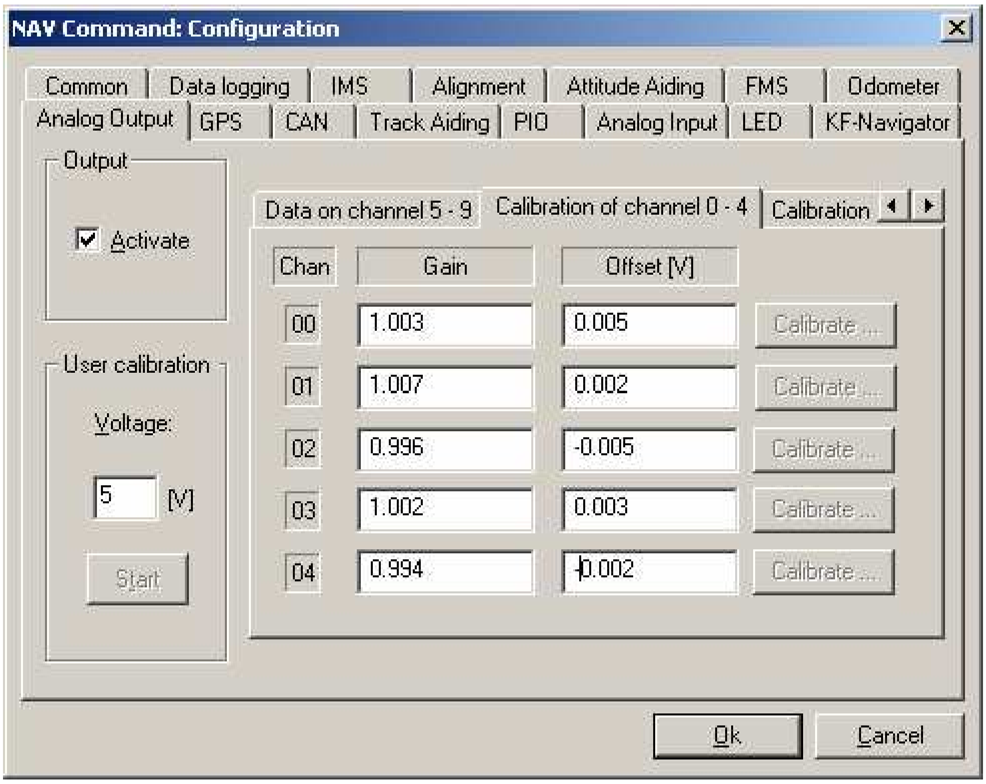
Autonomous Output: If this is set to "activated", the IMS will output data via the analog channels even if no laptop with NavCommand is connected.



The sum yaw differs from the heading in that it is not output modulo 180°.

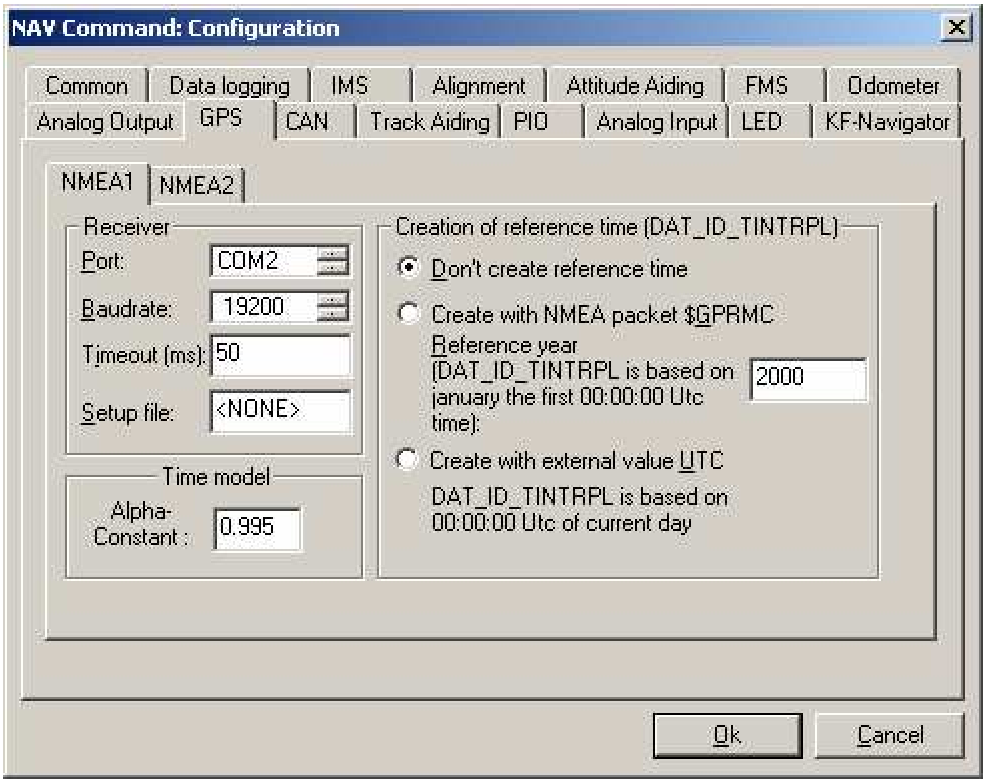
An optinal definable reference value will be substracted from all measurements of the specific channel.

Calibration Values: Here the factory set calibration values are displayed.


NAV Command: Configuration
Common
Data logging
IMS
Alignment
Attitude Aiding
FMS
Odometer
Analog Output
GPS
CAN
Track Aiding
PIO
Analog Input
LED
KF-Navigator
Output
Activate
User calibration
Voltage:
5
[V]
Start
Data on channel 5 - 9
Calibration of channel 0 - 4
Calibration
Chan
Gain
Offset [V]
00
1.003
0.005
Calibrate ...
01
1.007
0.002
Calibrate ...
02
0.996
-0.005
Calibrate ...
03
1.002
0.003
Calibrate ...
04
0.994
0.002
Calibrate ...
Ok
Cancel

3.2.7.9 GPS

Usually the IMS is equipped with an internal GPS receiver. But it can also be possible to connect an external GPS receiver and for this case the GPS configuration screen is



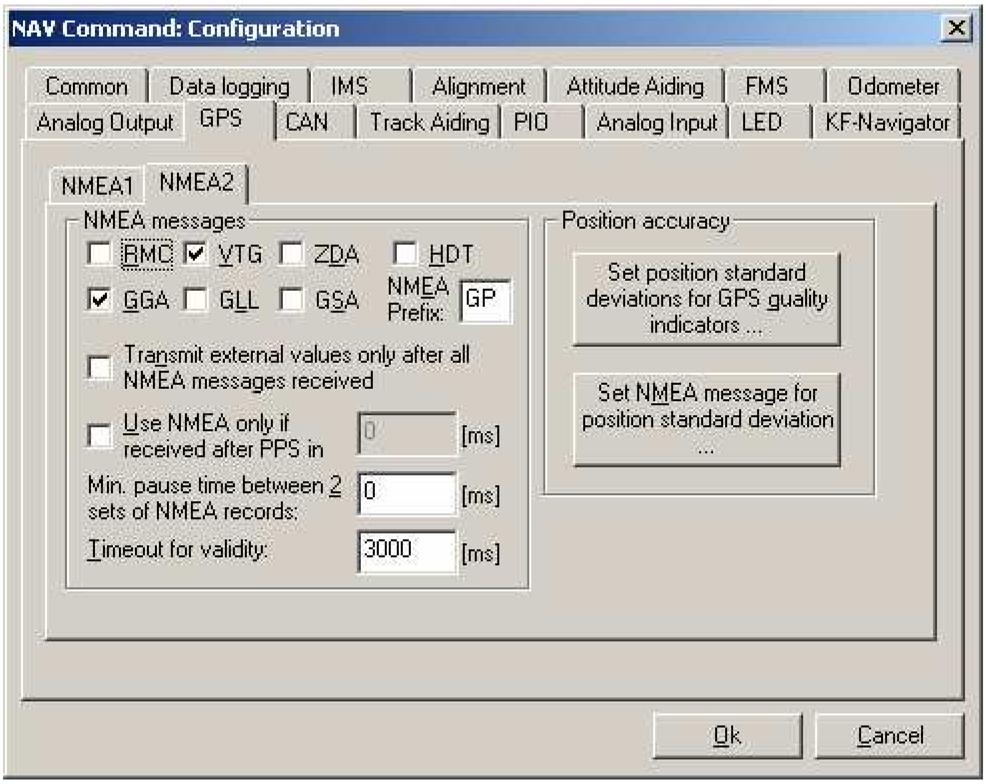
available. The settings should only be changed after consultance of iMAR staff.

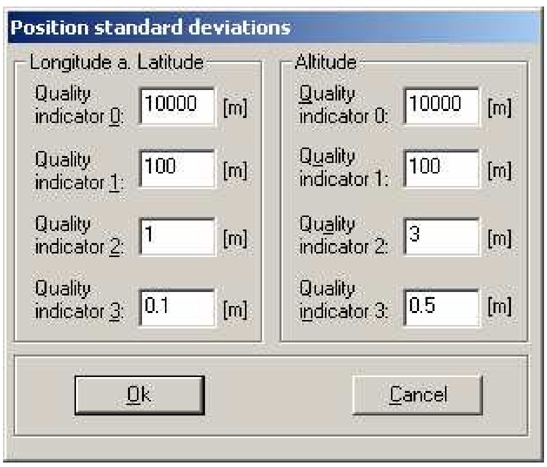
Receiver. Settings are the COM port of the IMS where the GPS is connected, the baud rate of the GPS recever and the setup file selection (the content of this file, which is located on the IMS, will be sent to the GPS receiver after power-on of the IMS for initialisation of the GPS engine).

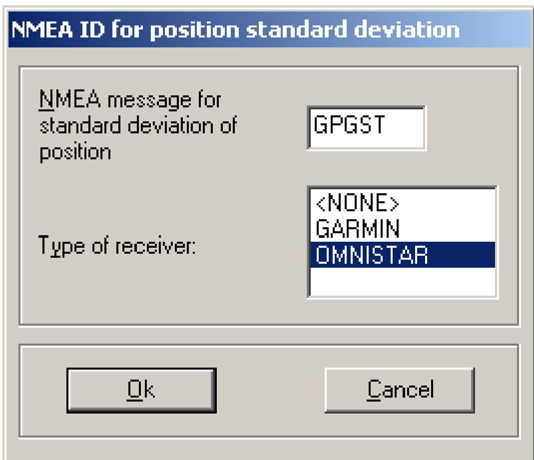
Position Accuracy: These settings classify the accuracy information of the GPS receiver. The Accuracy which is linked to the GPS quality factor is only required if no other information (e.g. NMEA message GPGST or PGRME which contains the GPS position standard deviation) is available.Otherwise the NMEA sentence has to be defined (preferred solution) which contains the standard deviation information.

NMEA Sentences: Here the NMEA messages have to be selected which shall be analysed by the IMS. All other messages will be ignored by the IMS.

Antenna Lever Arm: It defines the distance betwen the IMS and the GPS antenna, (in meters) coordinated in the IMS coordinate system.

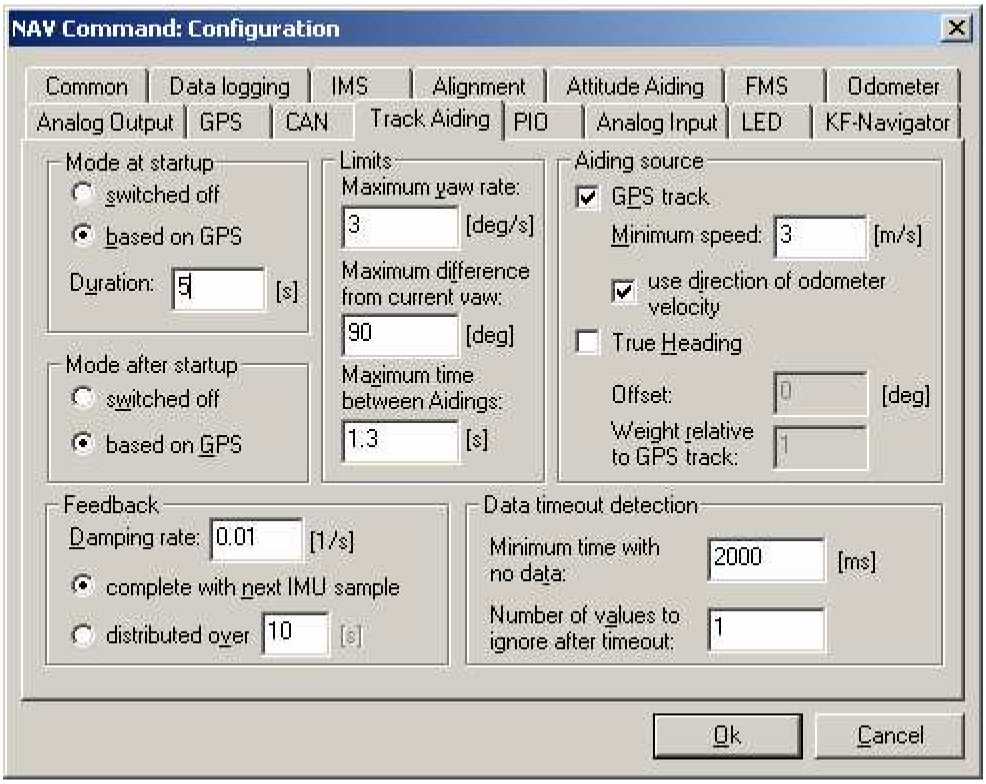






3.2.7.10 Track Aiding

The next figure shows the track aiding configuration. GPS can be used to compensate the remaining drift of the heading gyro in a special control loop (if the IMS has no gyro based north seeking capabilities). Three methods of aiding are possible:



a) using GPS velocity information (with single antenna systems and approximation of heading with track)

b) using a two antenna system providing heading information

c) using the dead-reckoning algorithm to aid the heading from the position derived from GPS, IMS and odometer information (iDRPOS).

Mode at Start-up: If the heading is not known, the heading has to be determined by using the GPS while moving a certain distance (if the system has no true-heading capability). If the determination of heading via GPS is activated, the GPS COG (course over ground / track angle) is observed under the condition that the motion dynamics is lower than the specified thresholds and the velocity is high enough (i.e. speed > min-speed and angular rate < rate threshold) over at least the specified duration. In this mode the GPS track angle has a strong influence on the IMS heading to adjust the IMS heading as fast as possible. Afterwards the algorithm switches to the mode after startup.

Mode after Start-up: The algorithm switches into this mode after at least x GPS aidings (if GPS is available with 1 Hz, this means after x seconds). In this mode the GPS track angle is weightened very low to aid the IMS heading, so distortions on the GPS track angle have no significant influence on the IMS heading performance. Nevertheless the feedback rate is high enough to compensate the gyro drift. The color of the track LED is also changed to indicate this track mode. On request the track aiding can be deactivated.

Thresholds: Thresholds can be set to use only accurate values from GPS. As GPS is only a positioning system, the track angle accuracy increases with the vehicle's velocity. Also the track angle is most accurate if the vehicle goes straight forward (no angular rates / change of heading).

Aiding Feedback: The feedback from the heading / track determined by GPS data to the IMS calculation can be defined as a time constant. A damping rate of 0.01 1/s means that an angular deviation between IMS and GPS will be corrected then with 1 % per second. To avoid so-called "feedback steps" the feedback value can be distributed over a certain time window.

Source of Aiding: Using a single antenna GPS, the COG (course over ground / track angle) is determined. If a two antenna GPS is available, directly the heading can be measured. To use this feature, the HEHDT message must be read in theGPS section.

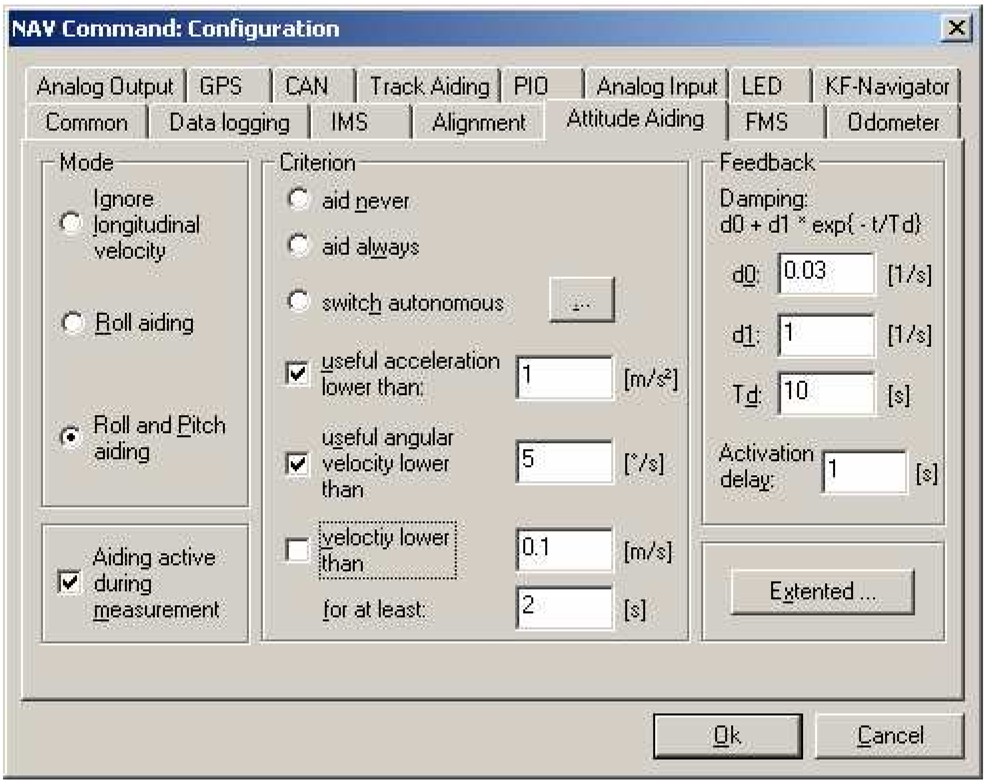
General Information: GPS track aiding can be activated only one time after start-up (only initial track alignment) or also continuously. If the direction is taken into account, the odometer velocity is used to decide the forward/backward direction of the vehicle (GPS measures always track angle over ground and not the heading!).

If no odometer is used the "use direction of velocity" must not be selected (no velocity from odometer available to detect the direction of speed for track determination).

3.2.4.11 Attitude Aiding

This section describes the attitude aiding of the IMS. Every gyro has a certain angular drift, i.e. the angular error increases over time if the system is not aided. The attitude aiding can be performed using the measured acceleration and the odometer velocity (for details see special documents). The attitude aiding is the better the lower the vehicle's dynamics is. Therefore the system allows a very wide range of threshold configuration, e.g. to disable the aiding if high rotation rate or acceleration is detected.

Mode: Typically the compensation of longitudinal and lateral acceleration (corre-



sponding to pitch and roll angle error compensation) is done.

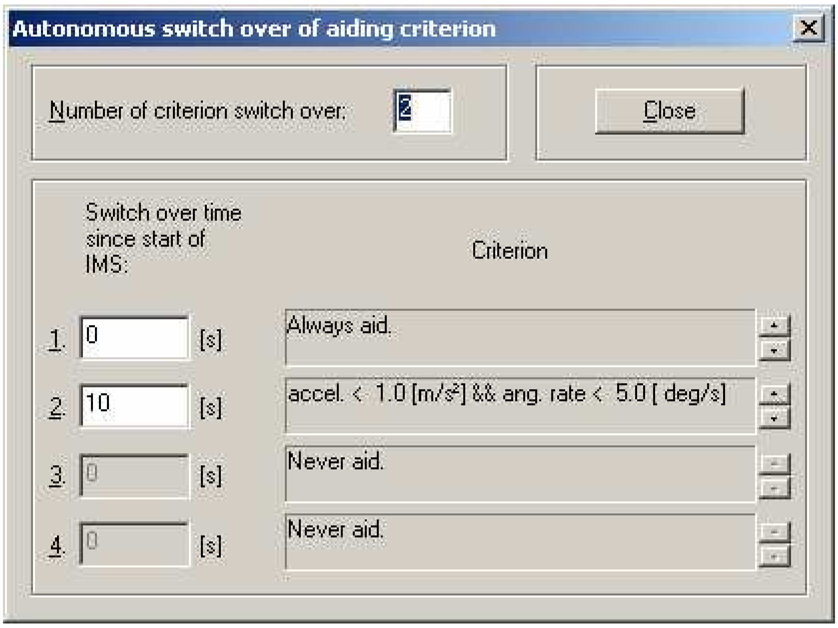
Criterion: If the motion dynamics exceeds certain limits, the aiding using the velocity information can be switched off temporary. This makes sure that the attitude aiding is only active if the dynamic acceleration is low. Criterions can be defined via acceleration, angular rate of via the velocity.

Feedback / Damping: After power-on of the IMS the attitude aiding is done (if activated) with a strong feedback from the accelerometers to the roll and pitch. This assures a fast settling of the attitude within a few seconds (the accelerometers are used during this time like level sensors). This is done by an exponential weighted feedback, which changes over the time constant to the operational constant feedback. Changing the parameters of the feedback should be done only by experienced users.

Extended: This dialog allows to adjust special filter parameters. The smoothing of the inertial data which are used to supervise the defined thresholds can be defined as well as the feedback constant and the time delay which must be passed until the aiding will be activated again after all criterions are out off "aiding off" again. Furthermore the velocity data source is defined which shall be used for aiding (odometer, DVL, GPS...). These values should only be changed under consultancy of iMAR staff.

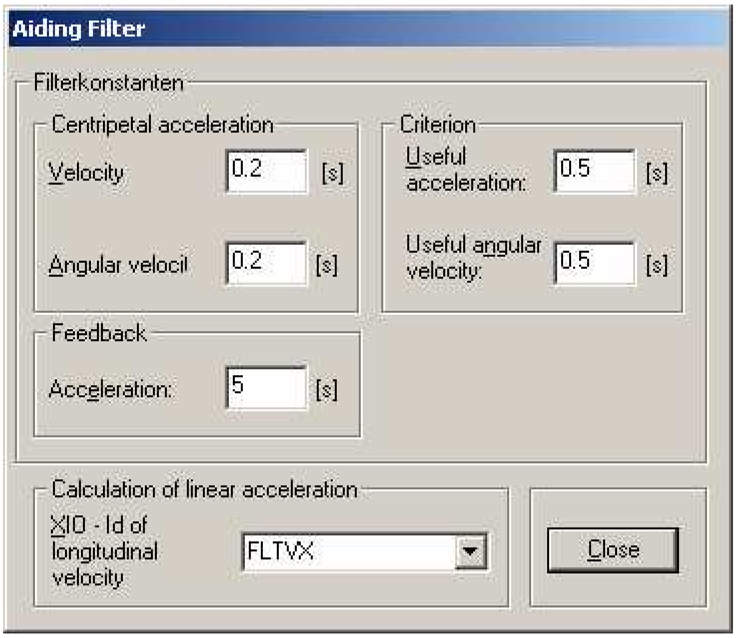
The aiding performance depends on the odometer resolution:

- Odometers with a righ resolution of 1...5 mm/pulse allow a high aiding accuracy, because the acceleration can be determined from the odometer output with sufficient accuracy. The parameter for the velocity filtering shall be set to 0.2 s, the aiding is allowed to be active also at higher accelerations.
- Odometers with a resolution of 10...100 mm/Puls are only conditionally siutable for aiding, the parameter of velocity filtering should be set to 0.5 s and the aiding shall only be active during acceleration < 0.5 m/s². Best aiding results are obtained if the aiding is active only for velocity < 0.1 m/s or if accel < 0.2 m/s² *and* angular rate < 0.2 deg/s (i.e. during standstill). Using an odometer with low resolution for attitude aiding may lead to significant wrong data in roll, pitch and gravity compensated acceleration.



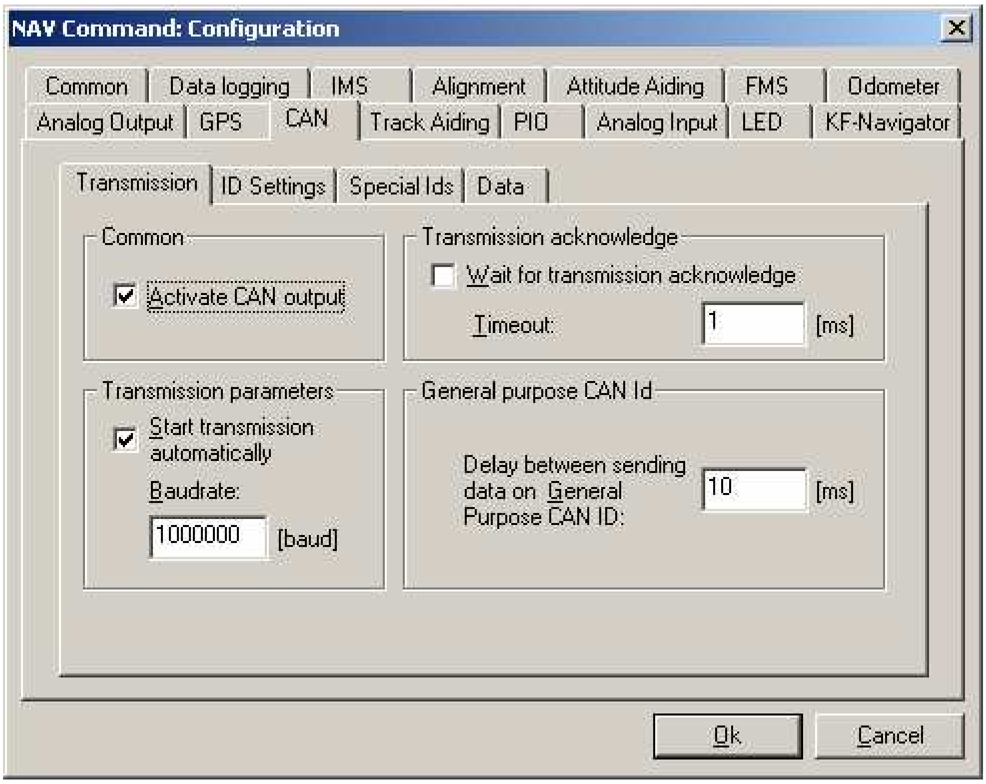
Typically settings for automotive and railway applications are:

- Aiding roll and pitch with correction of centripetal and longitudinal acceleration using odometer and rotation rate
- *For short-time measurements*: aid, if velocity lower than 0.1 m/s for at least 1 second (e.g. elk test)
- *For long time measurements:* aid, if angular velocity < 5 °/s and accel. < 1 m/s² As an option the aiding can be disabled if the measurement (F3) is activated.


Aiding Filter
Filterkonstanten
Centripetal acceleration
Velocity
0.2
[s]
Angular velocit
0.2
[s]
Criterion
Useful acceleration:
0.5
[s]
Useful angular velocity:
0.5
[s]
Feedback
Acceleration:
5
[s]
Calculation of linear acceleration
XIO - Id of longitudinal velocity
FLTVX
Close

3.2.7.12 CAN Interface

This tab shows the CAN interface configuration. The CAN data output description (definition of data identifiers and the transmission mode, i.e. continuous sending or remote frame operation) can be set in the configuration file, which can be selected at the beginning of NavCommand. Up to 16 messages can be defined and transmitted. Each CAN message consists of 8 byte information. Each message can have a separate data rate. Beside of the data transmission a command channel can be defined to send commands via CAN to the IMS. Furthermore special messages for error handling and status output can be used.



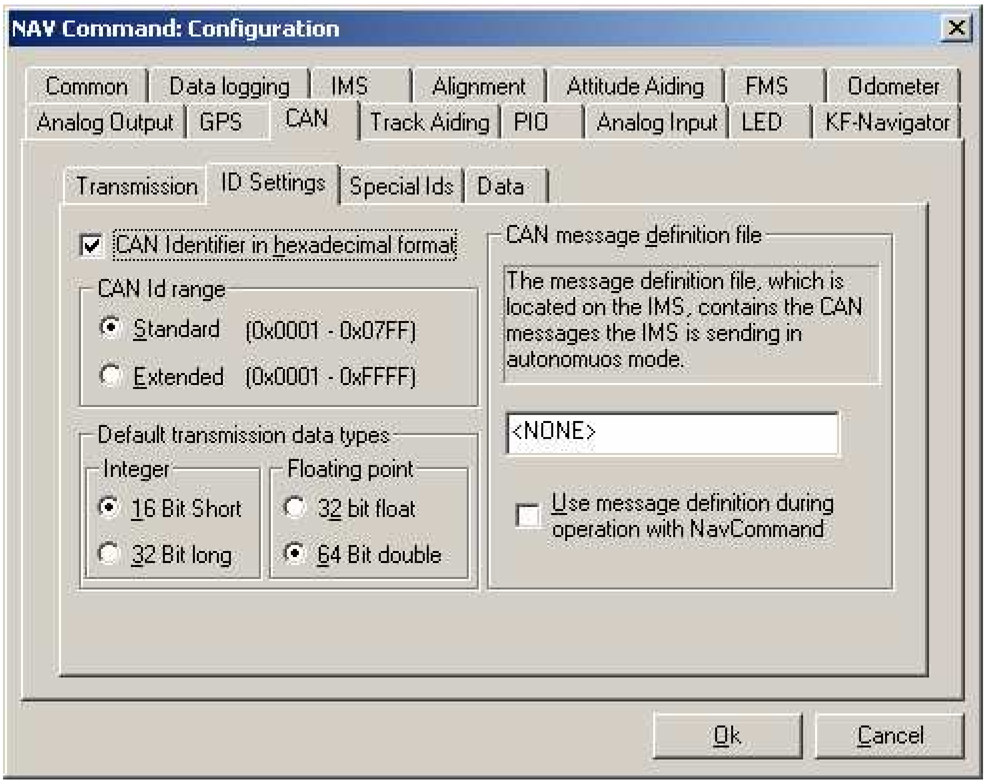
The CAN can be activated or disabled by the first check box in this pan.

Transmission Parameters: The data transmission can be started automatically after power-on of the IMS or via NavCommand interaction. The baudrate can be selected to values up to 1 MBit/s.

Transmission Acknowledge: The CAN transceiver of the IMS can be forced to wait for an acknowledge for every message it has sent out. If it receives no acknoledge for several times, the bus is going to bus-off status and can only be stated again by rebooting the IMS (fail-save-feature: the IMS disconnects from the CAN bus if several errors have been detected to avaoid that the IMS may distorte the bus).

ID Settings: The CAN ID area can be selected (standard or extended IDs), where in most applications standard IDs are used.

Default Data Type: The data transmission can made as16bit integer (short) or 32bit integer (long) or 32bit float or 64bit double. Here the default setting is selected. Beside of the default setting each ID can be defined separately in the next pan.



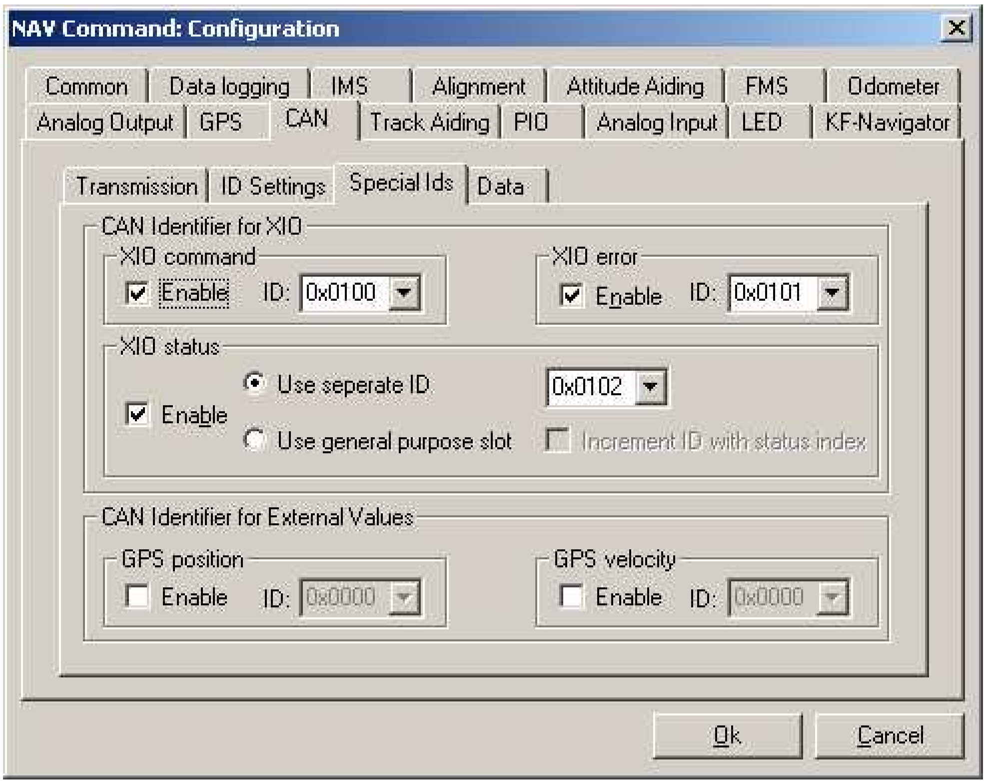
Data Output Definition File: For an autonomous operation of the IMS it is useful to be able to install the CAN messages directly after power-on of the IMS without the requirement of any intercommunication with an external software like NavCommand. To support this feature a CAN Definition Script can be installed on the IMS which is executed automatically. The structure of the script can be found in the CAN Interface document. Furthermore it can be defined whether the script shall also be used during the operation with NavCommand – in this case the script overrules the settings of data logs inNavCommand. The extension of the CAN file must be ***.CAN**!

XIO Command: Here you can choose whether a XIO Command Channel shall be provided or not. Furthermore a XIO error channel can be installed. Remeber that by hardware definition the CAN provides in totaly 16 IDs for all data and additional information. Also the XIO status can be transmitted.

GPS Data: it can be defined whether GPS position and GPS velocity shall be transmitted via CAN output (each on 8byte double format).

Therefore the checking for CAN transmission acknowledge should only be activated if the receiver of the CAN messages, which are sent by the IMS, is able to process the CAN messages immediately.

The output definition can be directly set in a further menu within NavCommand. .



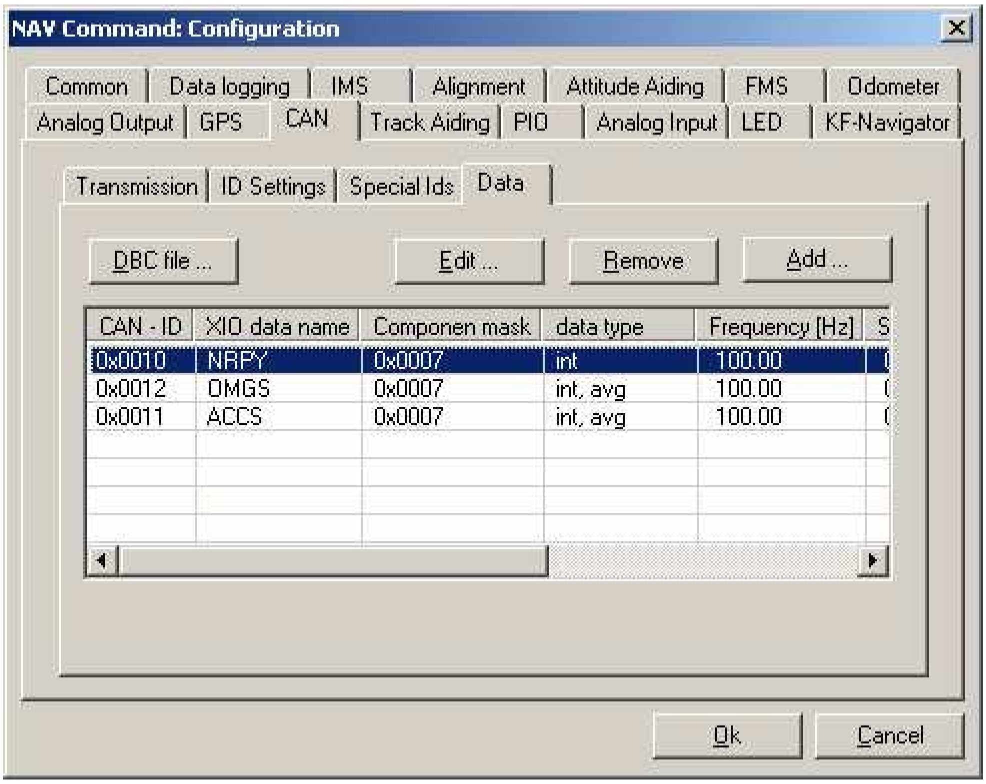
Important: If the IMS transmits data autonomously via CAN to a receiver, it should be ensured that this receiver also accepts the data. Otherwise, continual CAN transmission errors will result and the inertial measurement system will shut itself down. It is also possible to switch off the transmission acknowledge supervision of course.

If the CAN data is output as remote frames, an acceptance of the data is of course not required (see CAN specification).

Data: In the CAN data pan it is defined which data dshall be transmitted via CAN on which ID and what is the data format. With “Add Data” new logs can be added and with “Edit Data” existing logs can be modified. The scale factors can be entered. The scalefactor is defined by “output per LSB”, i.e. if 16 bit integer output is choosen, then 1 LSB = 1/32,768 of output range. Example: If the yaw angle output range shall be +/- 180°, then the scale factor is 180/32,768 °/LSB = 0.0055 °/LSB.

Furthermore it can be selected whether the output data shall be averaged or not. If the sampling rate is e.g. 500 Hz and the data output rate is 100 Hz, the averaging would lead to the output of the mean value of the last fife data samples.

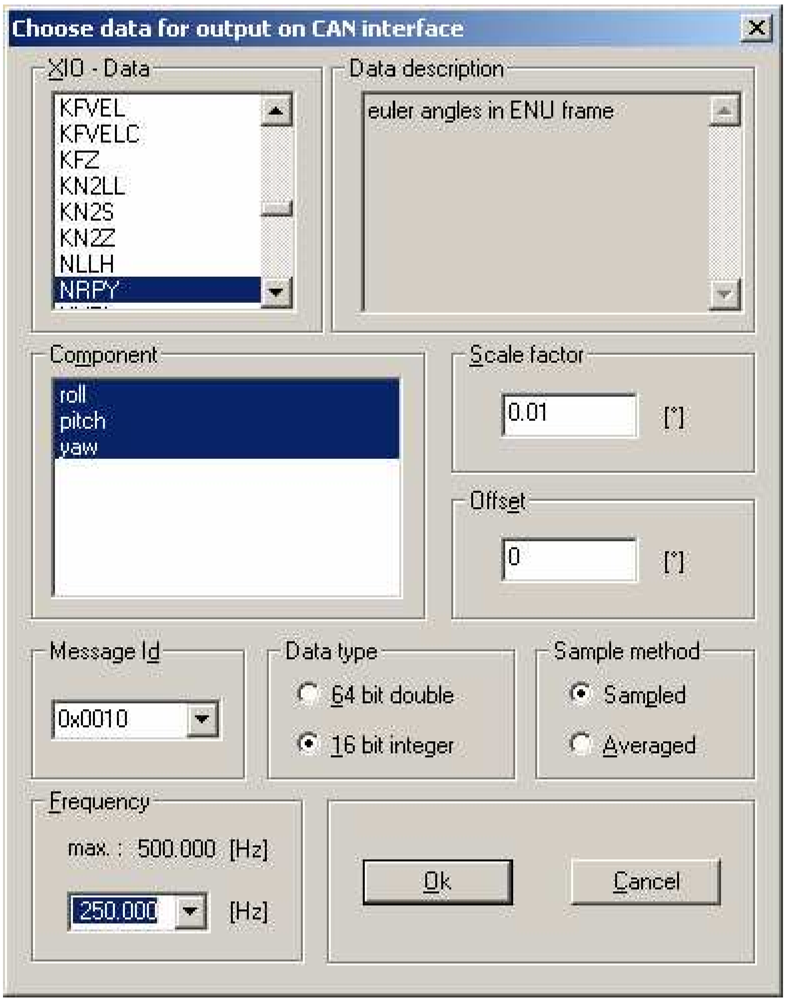
If a data set, which contains 3 components (e.g. angular rate, x/y/z) shall be output in double format, so 3 identifiers are required (each ID provides 8 byte). The system then automatically reserves the choosen ID and the following 2 IDs.



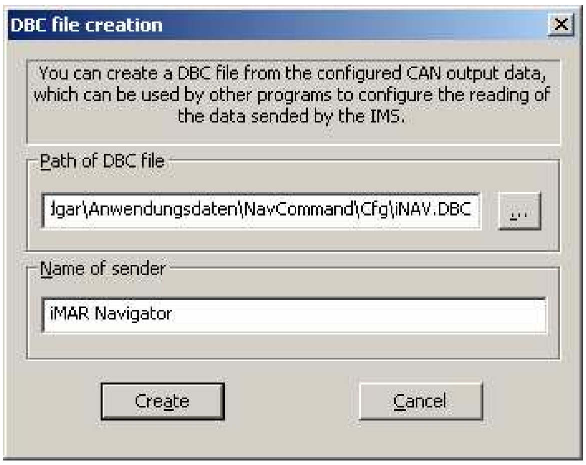
Edit: Allows to edit the selected ID in the list

Delete: Allows to delete the selected ID from the list

Add: Allows to add a further ID to the list. Remember that at maximum 16 IDs are available according to the CAN specificatiion (including all special IDs).

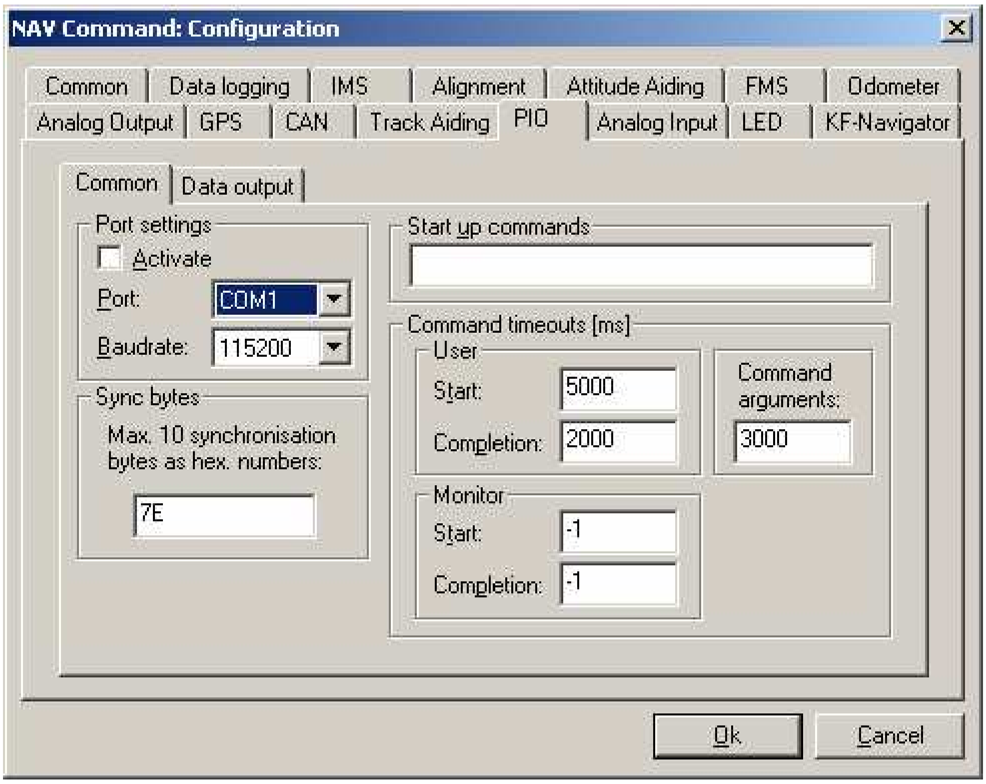


DBC File: Here the generation of a so-called DBC file is supported. The DBC file has the extension *.dbc and is supported from many third party CAN recording programs to configure the receiving hardware. As the required sender name you may use "iMAR Navigator". The file structure is according to the Vector-DBC-Standard.



3.2.7.13 PIO

The PIO interface provides a very simple communication (PIO = primitive input/output). All chosen data are transmitted with the same frequency. The data can be sent in text or binary format. Also XIO commands can be sent via PIO. The definition of data to be sent must be done in an file stored on the IMS. A detailled description can be found in the PIO documentation.



Interface: Definition of the used COM interface on the IMS, which shall be used for the PIO protocol, and the Baud rate. With selecting a COM port it has to be taken care that no other application (e.g. GPS or XIO) uses the same COM port on the IMS.

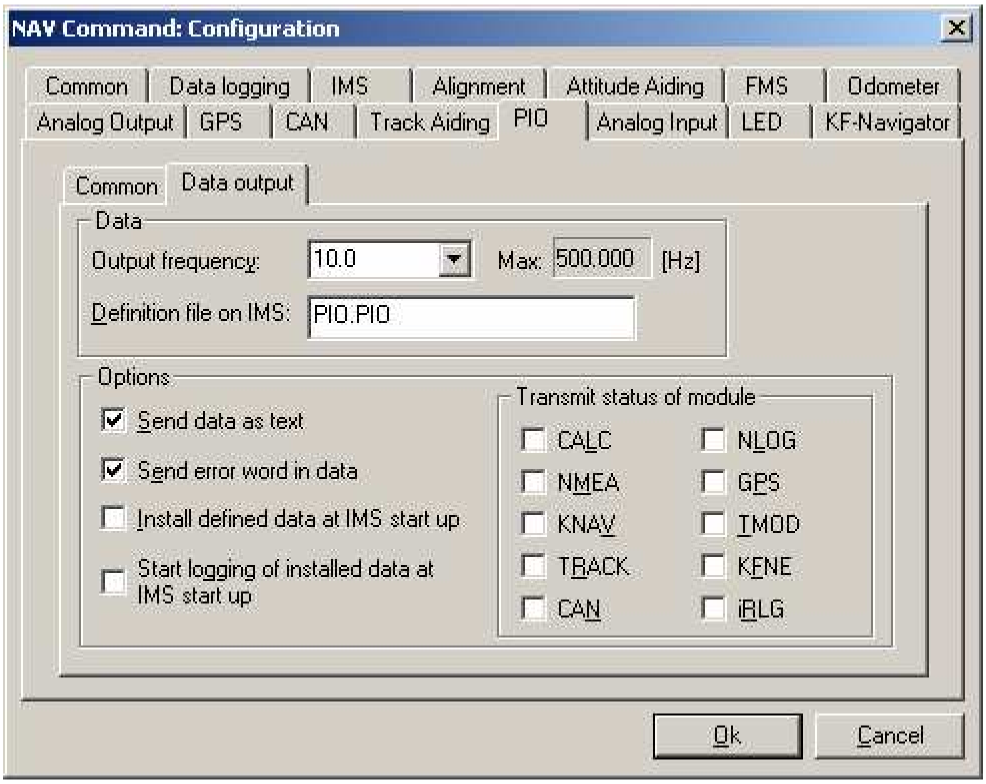
Synchronisation: A data transmission in binary format via RS232 requires a synchrinisation so the receiver will be able to decode the data properly. It can be defined how many sync bytes shall be used with each transmitted data set and what is the content of the sync stream (up to 10 sync bytes are allowed).

Timeout: To avoid a dead-lock of the IMS due to receiving incomplete commands via RS232, a time-out is defined. The receive buffer of the PIO will be deleted if no full command has been recived inside the timeout duration. A value of -1 defines an unfinete timeout.

Transmission: Here the **Data Definition File** is set which contains the information which data shall be sent and furthermore the **Data Rate** is defined. The data rate must be selected in a way that it is made sure that the channel capacity of the RS232 can carry the whole data. Remember that at 115.2 kBd at maximum 11.250 bytes can be transmitted per second (theoretical value).

Special hints: To start the data transmission of the defined data automatically at IMS start up, one must insert the '+' command in the 'start up commands' list (at the end of the list) and select 'Install defined data at start up' and 'Create log for installed data at start up'. Special command description is found in the PIO manual.

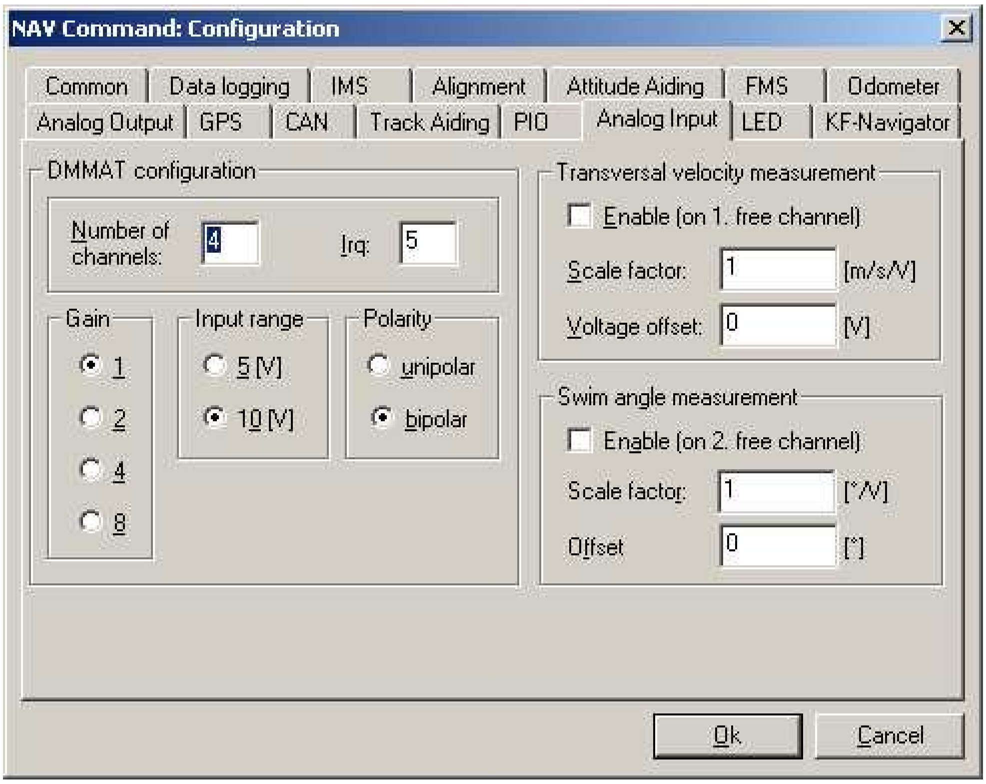
Options: It is selected whether the data transmission is done in text format or in binary format. Furthermore it is defined whether the data logs are installed automatically and whether the data transmission starts automatically after power on or after receiving a command via PIO from the user's application. Also an error channel can be installed. If 'Send error word in data' is checked then after each data packed the error code of the last error on the IMS software is send (or zero, if no error happened so far). 'Install defined data at start up' installs the data defined in the definition file automatically on system start up; otherwise the user has to send the PIO command '*' via RS232 to install the data. If 'Create log for installed data at start up' is not checked, the user must send the PIO command 's0' to create the log, before the log data can be transmitted after the PIO command '+' is send.



Data Rate / Data Format: It can be choosen with which data rate the log data shall be transmitted via the PIO interface (this can also be selected with a PIO command – please refer to the PIO documentation) and whether the transmission shall be in text mode or in binary format. Furthermore the **Status** of the internal modules can be transmitted (each as a 32bit word). If no file shall be used the name has to be set to <none>.

3.2.7.14 Analog Inputs

The IMS optionally can be equipped with additional analog inputs, which can be used to acquire exernal analog data synchronous to the IMS data.



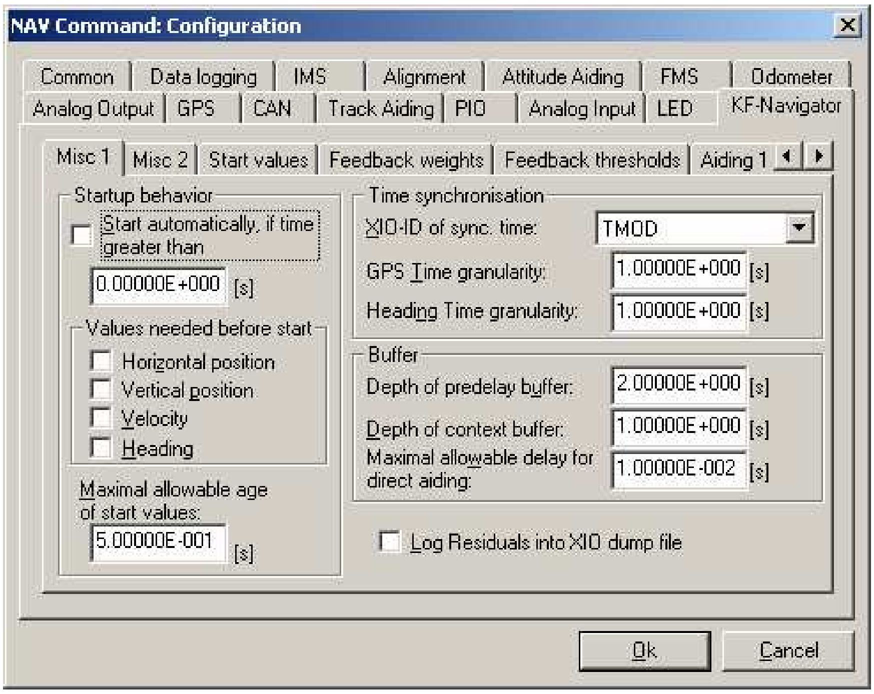
Parameters: The number of available channels is defined by hardware. Gan, range and polarity can be choosen.

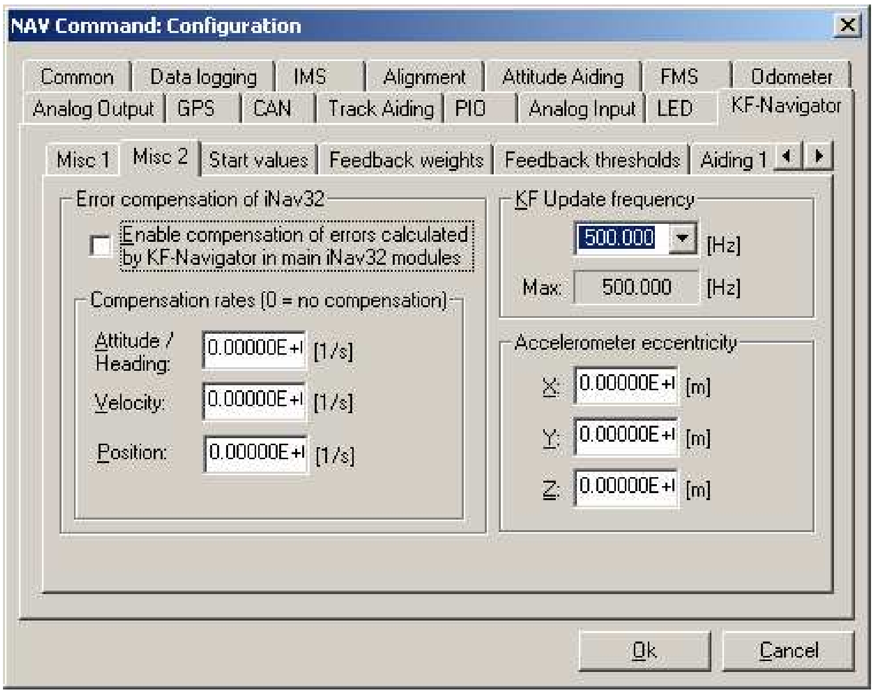
Special Channels: For special applications (e.g. vehicle motion analysis of cars or trucks) the first analog input channel can be used to connect a transversal speed sensor. The second input channel may be used to acquire the slip angle from an external analog sensor.

3.2.7.15 Kalman-Filter - Navigator

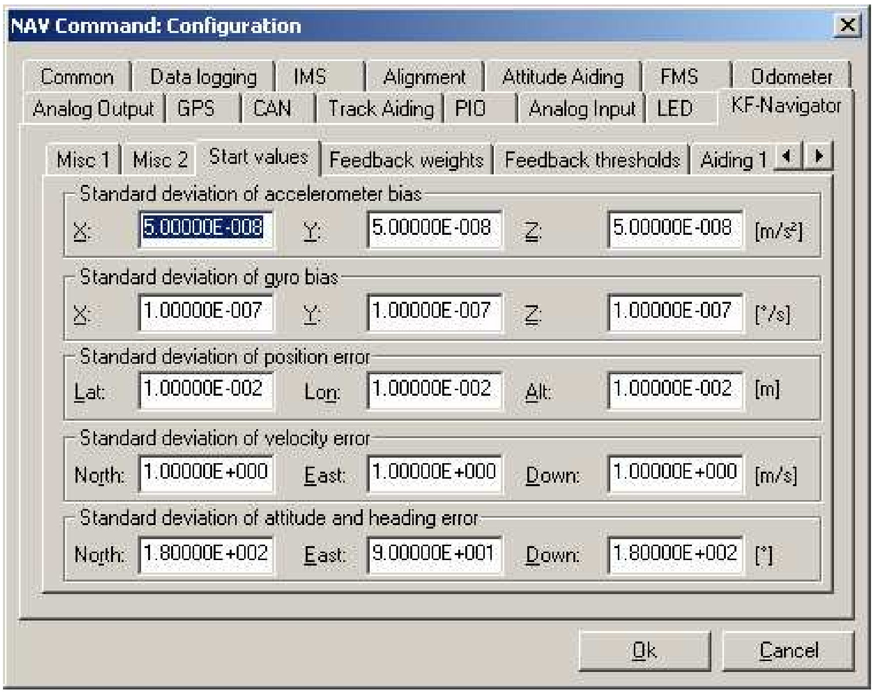
The IMS can be equipped with a navigational Kalman filter, which can estimate the IMS sensor bias as well as position, velocity and attitude/heading deviations if appropriate external aiding information is available. On this way the total system performance can be improved for long time navigation tasks.

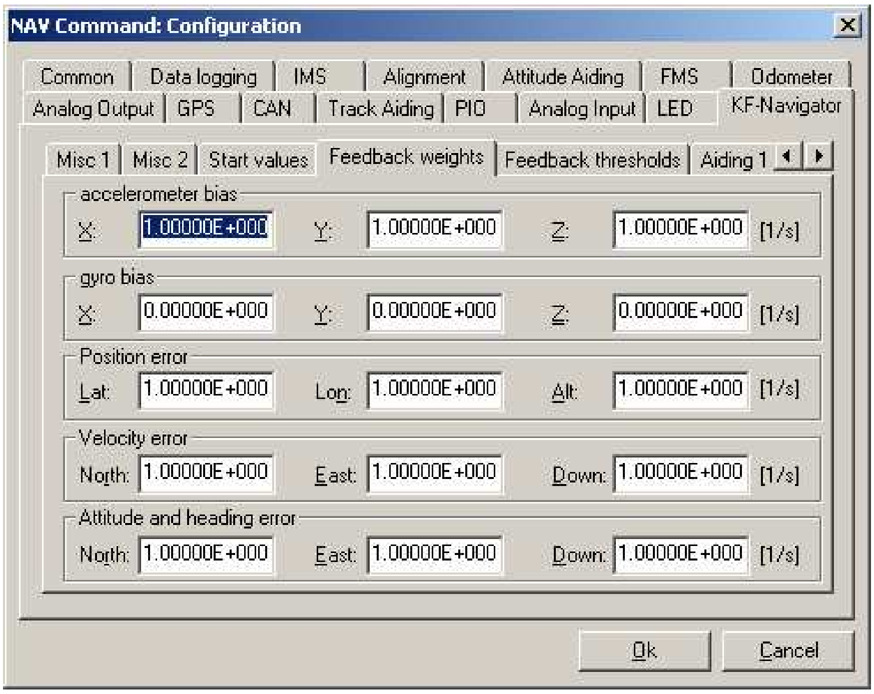
The Kalman filter is described in a separate documentation and can be parameterised

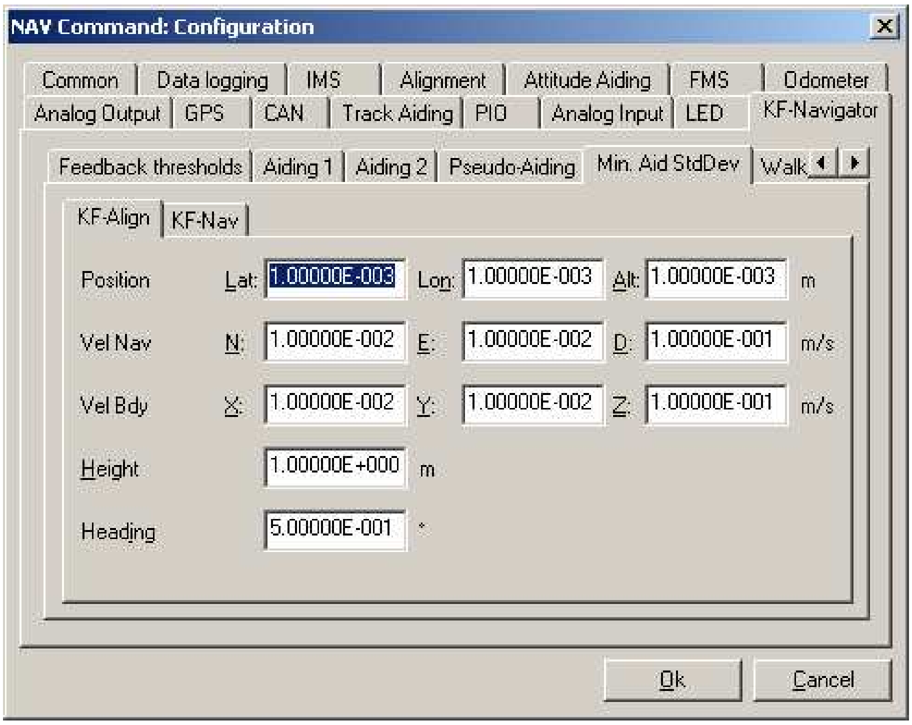


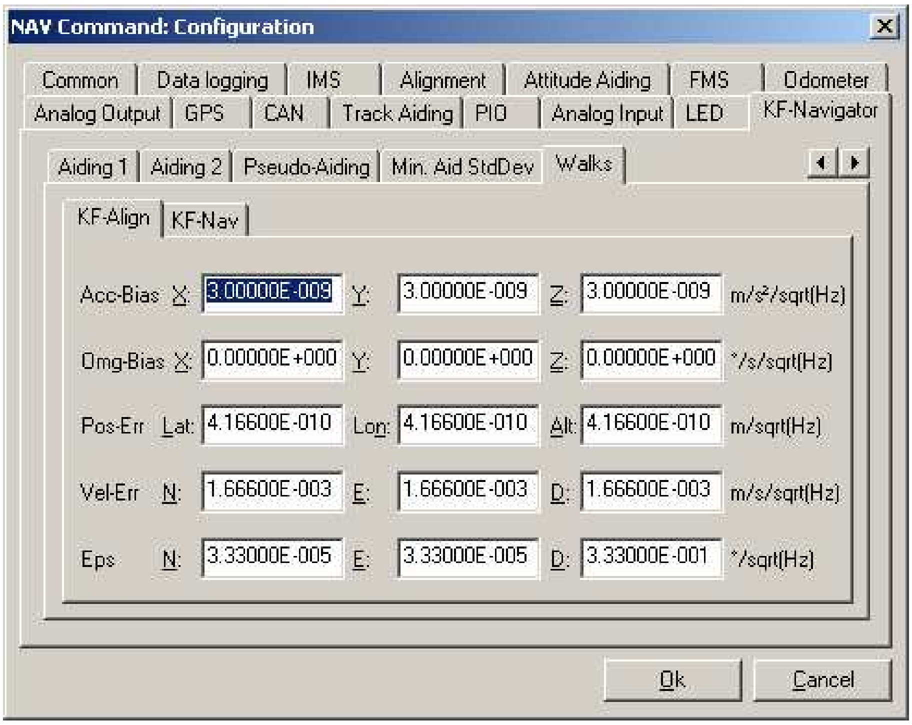


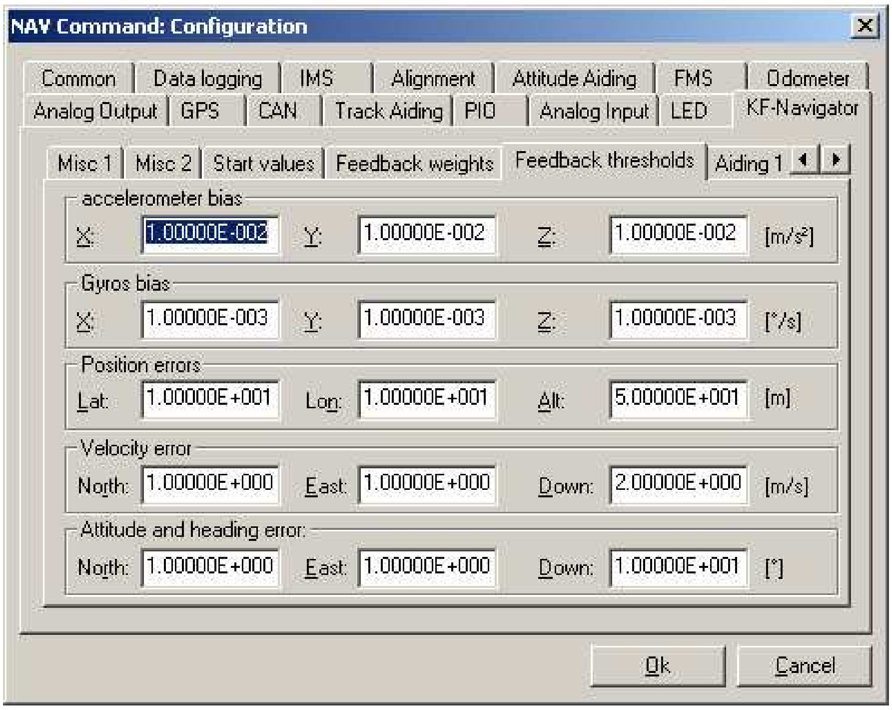
via NavCommand.

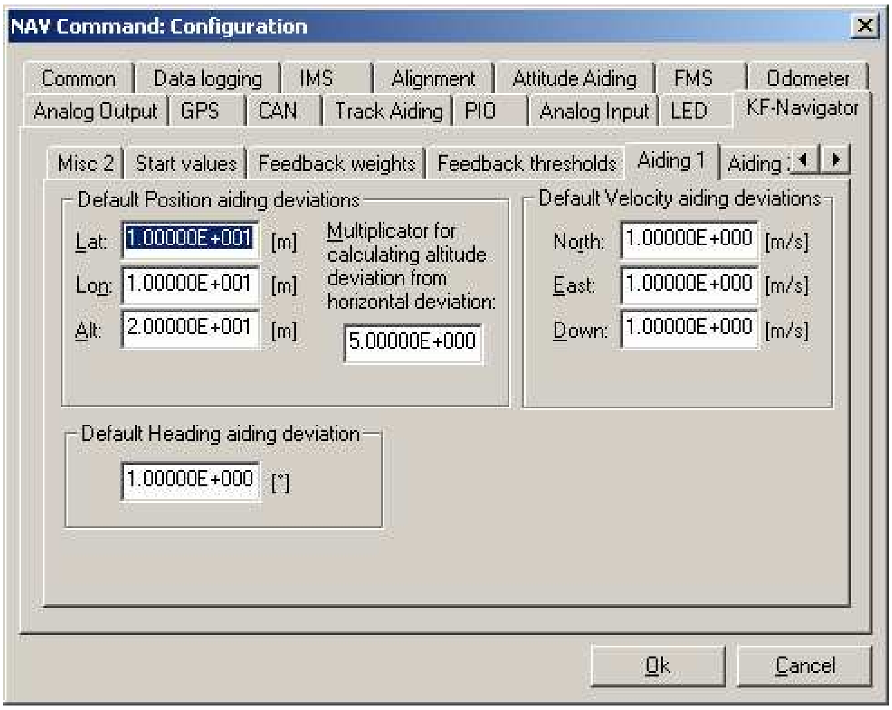


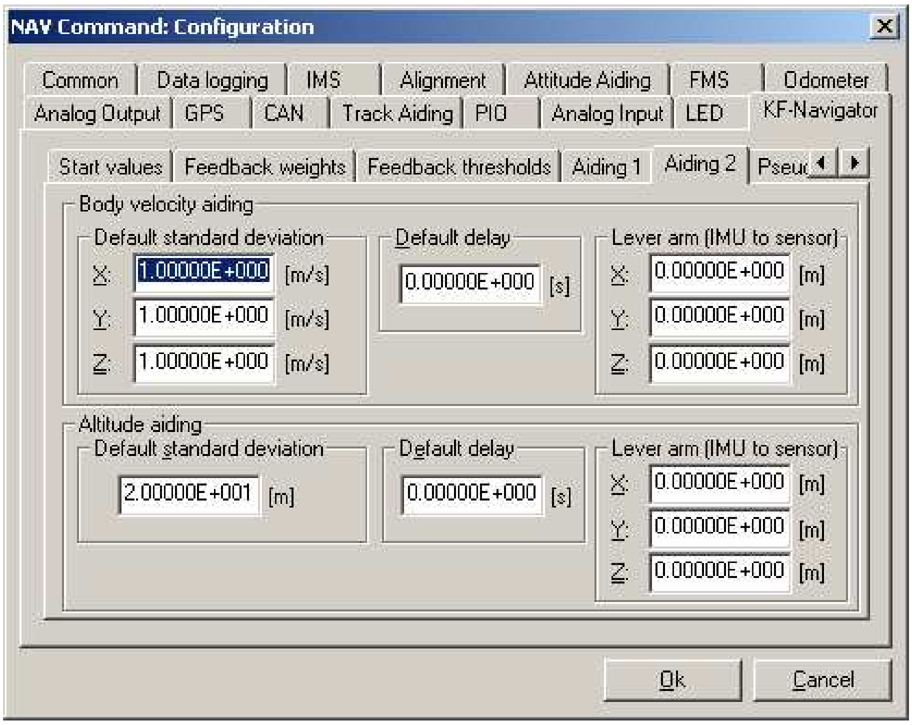


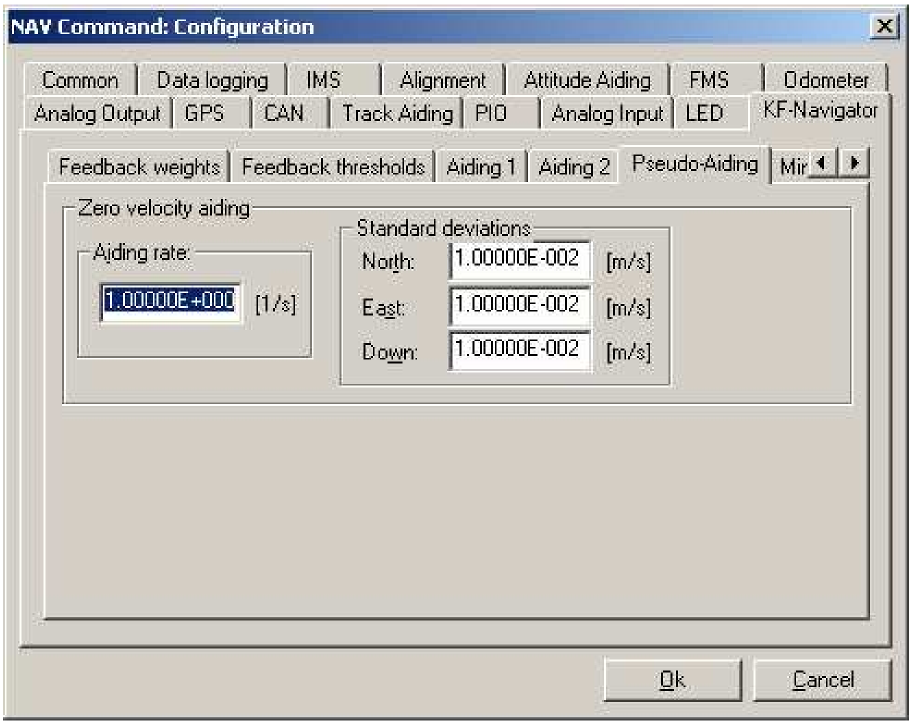

NAV Command: Configuration
Common
Data logging
IMS
Alignment
Attitude Aiding
FMS
Odometer
Analog Output
GPS
CAN
Track Aiding
PIO
Analog Input
LED
KF-Navigator
Feedback thresholds
Aiding 1
Aiding 2
Pseudo-Aiding
Min. Aid StdDev
Walk
KF-Align
KF-Nav
Position Lat: 1.00000E-003 Lon: 1.00000E-003 Alt: 1.00000E-003 m
Vel Nav N: 1.00000E-002 E: 1.00000E-002 D: 1.00000E-001 m/s
Vel Bdy X: 1.00000E-002 Y: 1.00000E-002 Z: 1.00000E-001 m/s
Height 1.00000E+000 m
Heading 5.00000E-001 °
Ok
Cancel


NAV Command: Configuration
Common
Data logging
IMS
Alignment
Attitude Aiding
FMS
Odometer
Analog Output
GPS
CAN
Track Aiding
PIO
Analog Input
LED
KF-Navigator
Aiding 1
Aiding 2
Pseudo-Aiding
Min. Aid StdDev
Walks
KF-Align
KF-Nav
Acc-Bias X: 3.00000E-009 Y: 3.00000E-009 Z: 3.00000E-009 m/s²/sqrt(Hz)
Omg-Bias X: 0.00000E+000 Y: 0.00000E+000 Z: 0.00000E+000 °/s/sqrt(Hz)
Pos-Err Lat: 4.16600E-010 Lon: 4.16600E-010 Alt: 4.16600E-010 m/sqrt(Hz)
Vel-Err N: 1.66600E-003 E: 1.66600E-003 D: 1.66600E-003 m/s/sqrt(Hz)
Eps N: 3.33000E-005 E: 3.33000E-005 D: 3.33000E-001 °/sqrt(Hz)
Ok
Cancel


NAV Command: Configuration
Common | Data logging | IMS | Alignment | Attitude Aiding | FMS | Odometer
Analog Output | GPS | CAN | Track Aiding | PIO | Analog Input | LED | KF-Navigator
Misc 1 | Misc 2 | Start values | Feedback weights | Feedback thresholds | Aiding 1
accelerometer bias
X: 1.00000E-002 Y: 1.00000E-002 Z: 1.00000E-002 [m/s²]
Gyros bias
X: 1.00000E-003 Y: 1.00000E-003 Z: 1.00000E-003 [°/s]
Position errors
Lat: 1.00000E+001 Lon: 1.00000E+001 Alt: 5.00000E+001 [m]
Velocity error
North: 1.00000E+000 East: 1.00000E+000 Down: 2.00000E+000 [m/s]
Attitude and heading error:
North: 1.00000E+000 East: 1.00000E+000 Down: 1.00000E+001 [°]
Ok
Cancel

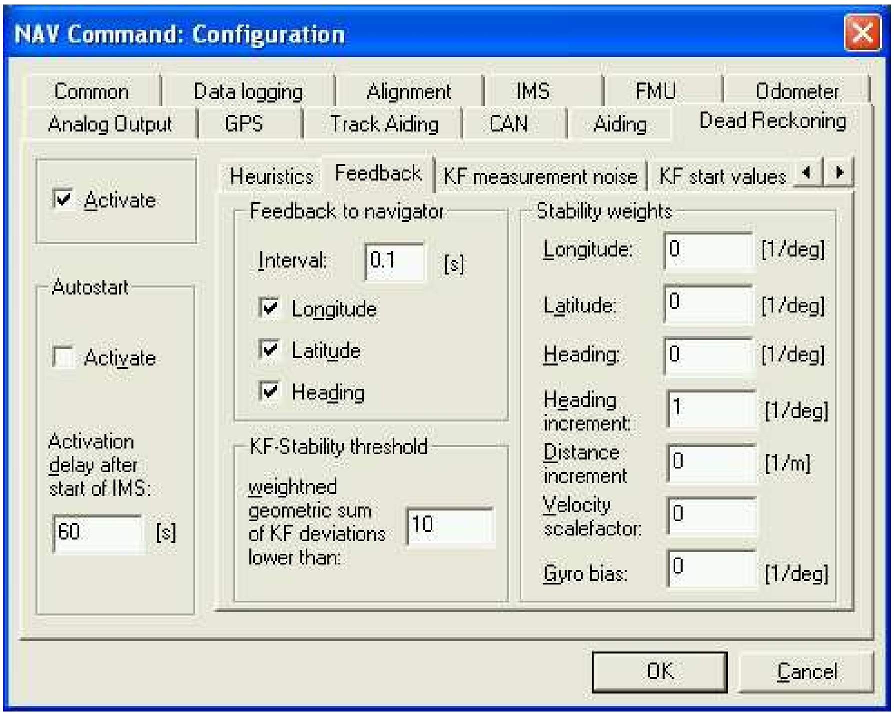

NAV Command: Configuration
Common | Data logging | IMS | Alignment | Attitude Aiding | FMS | Odometer
Analog Output | GPS | CAN | Track Aiding | PIO | Analog Input | LED | KF-Navigator
Misc 2 | Start values | Feedback weights | Feedback thresholds | Aiding 1 | Aiding
Default Position aiding deviations
Lat: 1.00000E+001 [m]
Lon: 1.00000E+001 [m]
Alt: 2.00000E+001 [m]
Multiplicator for calculating altitude deviation from horizontal deviation:
5.00000E+000
Default Velocity aiding deviations
North: 1.00000E+000 [m/s]
East: 1.00000E+000 [m/s]
Down: 1.00000E+000 [m/s]
Default Heading aiding deviation
1.00000E+000 [°]
Ok
Cancel


NAV Command: Configuration
Common
Data logging
IMS
Alignment
Attitude Aiding
FMS
Odometer
Analog Output
GPS
CAN
Track Aiding
PIO
Analog Input
LED
KF-Navigator
Start values
Feedback weights
Feedback thresholds
Aiding 1
Aiding 2
Pseu
Body velocity aiding
Default standard deviation
X: 1.00000E+000 [m/s]
Y: 1.00000E+000 [m/s]
Z: 1.00000E+000 [m/s]
Default delay
0.00000E+000 [s]
Lever arm (IMU to sensor)
X: 0.00000E+000 [m]
Y: 0.00000E+000 [m]
Z: 0.00000E+000 [m]
Altitude aiding
Default standard deviation
2.00000E+001 [m]
Default delay
0.00000E+000 [s]
Lever arm (IMU to sensor)
X: 0.00000E+000 [m]
Y: 0.00000E+000 [m]
Z: 0.00000E+000 [m]
Ok
Cancel


NAV Command: Configuration
Common
Data logging
IMS
Alignment
Attitude Aiding
FMS
Odometer
Analog Output
GPS
CAN
Track Aiding
PIO
Analog Input
LED
KF-Navigator
Feedback weights
Feedback thresholds
Aiding 1
Aiding 2
Pseudo-Aiding
Mir
Zero velocity aiding
Aiding rate:
1.00000E+000 [1/s]
Standard deviations
North: 1.00000E-002 [m/s]
East: 1.00000E-002 [m/s]
Down: 1.00000E-002 [m/s]
Ok
Cancel

3.2.7.16 KNAV Dead Reckoning

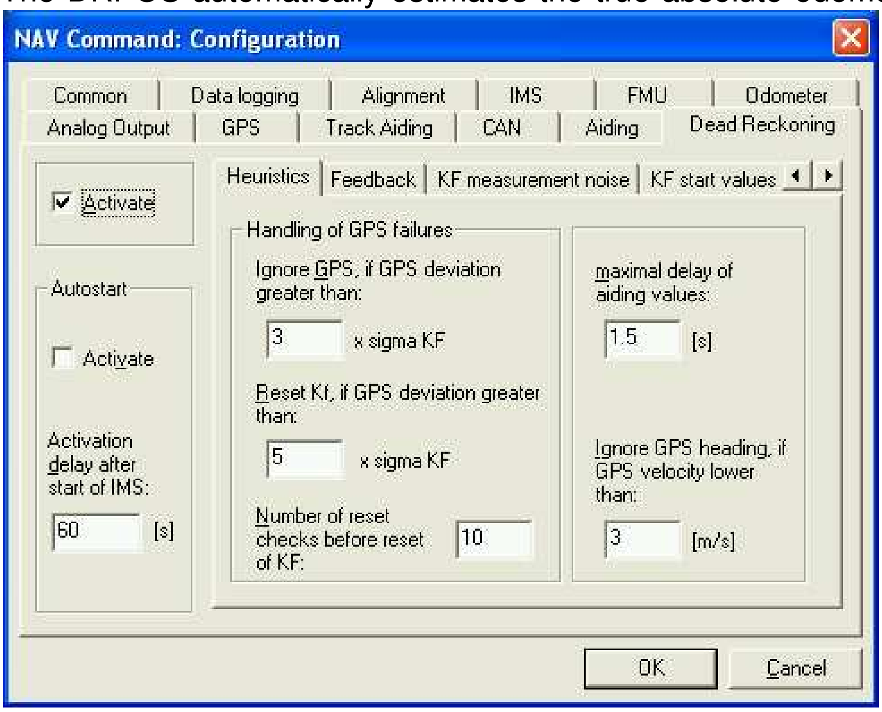
This pan allows the configuration of the Dead-Reckoning calculation (option only).



The DRPOS calculation can be activated on request (also possible via function key).

Details of parameter settings can be found in the separate DRPOS documentation.

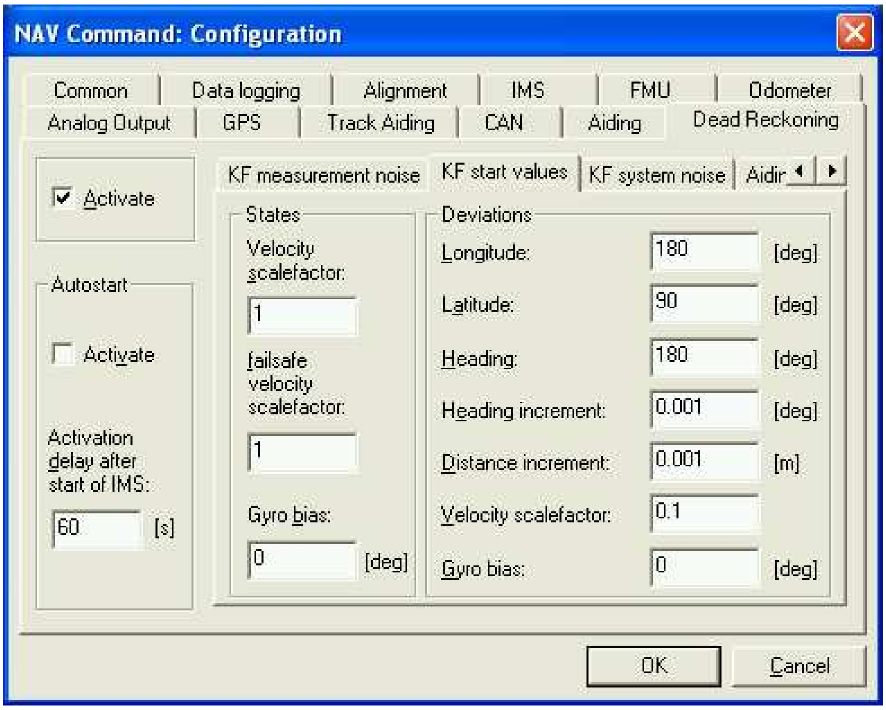
The DRPOS automatically estimates the true absolute odometer scale factor by esti-



mating a relative scale factor and multiplying both internally.

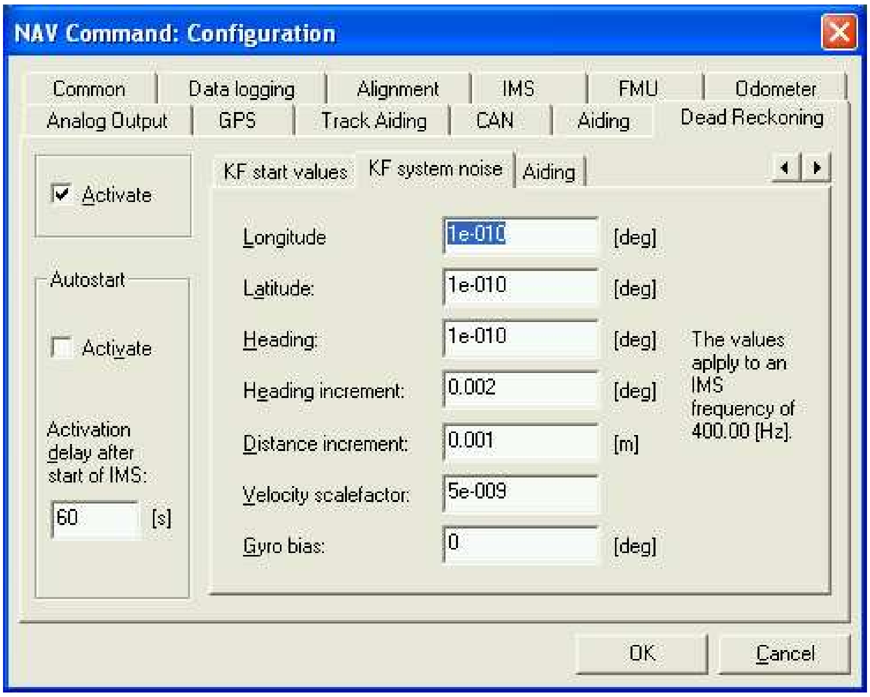
Typically therefore the start value of the relative scale factor is 1.0 (the absolute scale factor can be configured in the odometer settings). The fail safe scale factor is used if the Kalman filter estimates an internal relative scale factor which differs more than the tolerance from the fail-safe scale factor.

All angular velocity and speed related values are given in unit / sample. Therefore a gyro bias is given in deg (at 200 Hz sampling rate the bias in deg/s is the related bias [deg] divided by 200 Hz, so the result is in [deg/s]).



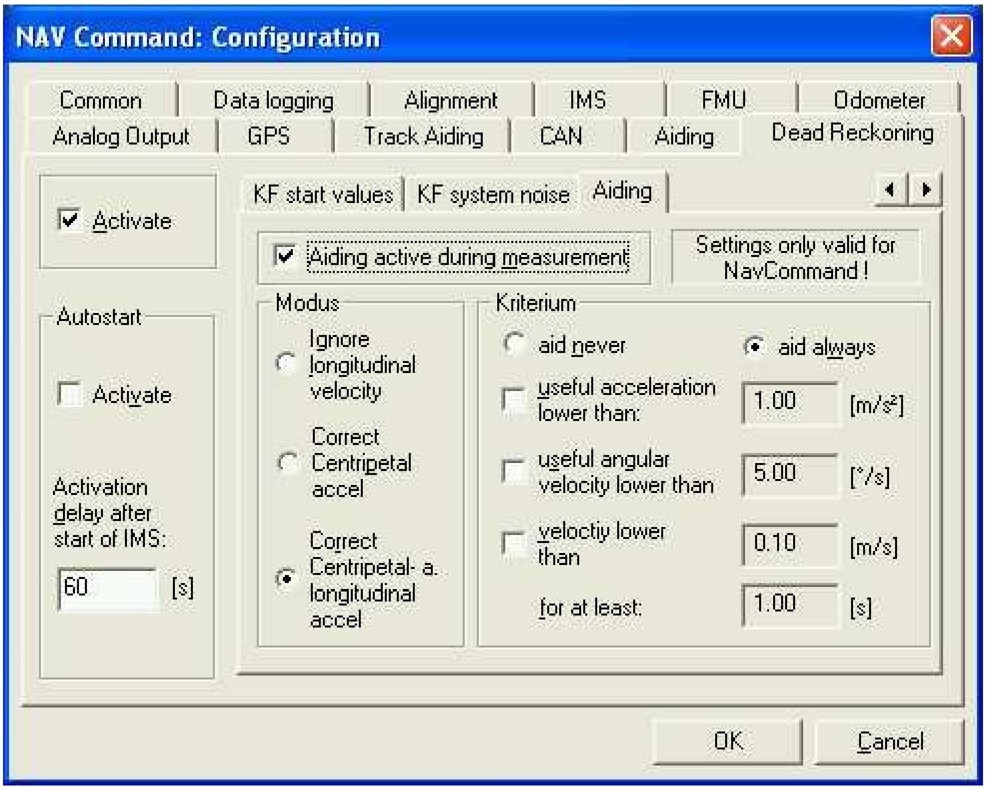
The next figures show the settings of the KF system noise and the measurement noise. Using the absolute odometer scalefactor quantisation assures that the measuring noise of the odometer will be automatically adjusted if the odometer scale factor is changed. The next figure shows the so-called feedback from the DRPOS Kalman filter to the navigator algorithm. So the DRPOS results will lead to an internal update of longitude / latitude / heading data handles every second.

Direct access to the DRPOS results is possible by direct selection of the KF state vec-



tor for data storing. If the Lon/Lat/Yaw logs are used instead, the values are updated only e.g. once per second (e.g. useful for update of internal earth rate correction algorithm).

An indicator shows whether the Kalman filter has reached a stable solution. This is analysed by observation of the elements of the covariance matrix. If the weighted sum of theses elements is lower than a certain threshold, the internal stability flag for the Kalman filter solution is set.



Finally the usage of GPS solutions to aid the Kalman filter can be controlled by heuristic conditions: The KF always estimates the position error of the IMS. If the GPS position and the IMS position do not fit, then it can be assumed that the GPS position is temporarily wrong (e.g. multipath). If the distance between IMS position and GPS position is x times the estimated position difference, then the GPS measurement update will not be performed. If the deviation is larger than y times the standard deviation for more than z GPS updates, then the KF will be reset, because than it is more reliable that the IMS is wrong than the GPS is wrong. This procedure guarantees that the Kalman filter will come back to a stable condition even if very difficult measurements have disturbed the filter significantly.

Following parameters are recommended at sampling rate 200 Hz:

```
Measuring Noise:
SIGODO=          0.002           (not 0.0001, because uncertainty
                                 of position is higher than odo
                                 resolution!!)
                                 (still stable for 0.02, but
                                 noisy; used for driven wheel
                                 mounted odo)
SIGODO=          0.02            (for odometer with 5 cm / pulse)

SIGGPSVEL=       3               Default for GPS velocity error
SIGGPSPOS=       15              Default for GPS position error
SIGFOG=          0.0001          gyro angular increment
SIGPSI=          5.0             GPS-Heading
```

```
System noise, system dynamics:
SIGLON=             1.0E-10             Longitude
SIGLAT=             1.0E-10             Latitude
SIGHDG=             1.0E-10             Heading
SIGDPHI=            0.002               angular increment
SIGDS=              0.001               distance increment
SIGVSCF=            0.00002             Odometer scale factor
SIGBIAS=            5E-09               gyro bias

Initial values:
SigVGPS=            0.5
SigGPSPos=          15
                    180                 Longitude
                    90                  latitude
                    180                 heading
                    0.001               angular increment
                    0.002               distance increment
                    0.1                 rel. Odo scale factor
                    0                   gyro bias

Heuristics:
                    Ignore:       3 x   GPS ignore
                    Reset:        5 x   KF Reset
                    Wait for:     10 x  number of tests before reset
                    Delay:        1.5   max. delay of aiding inf.
                    MINSPEED:     3.0   ignore GPS for low velocity
```

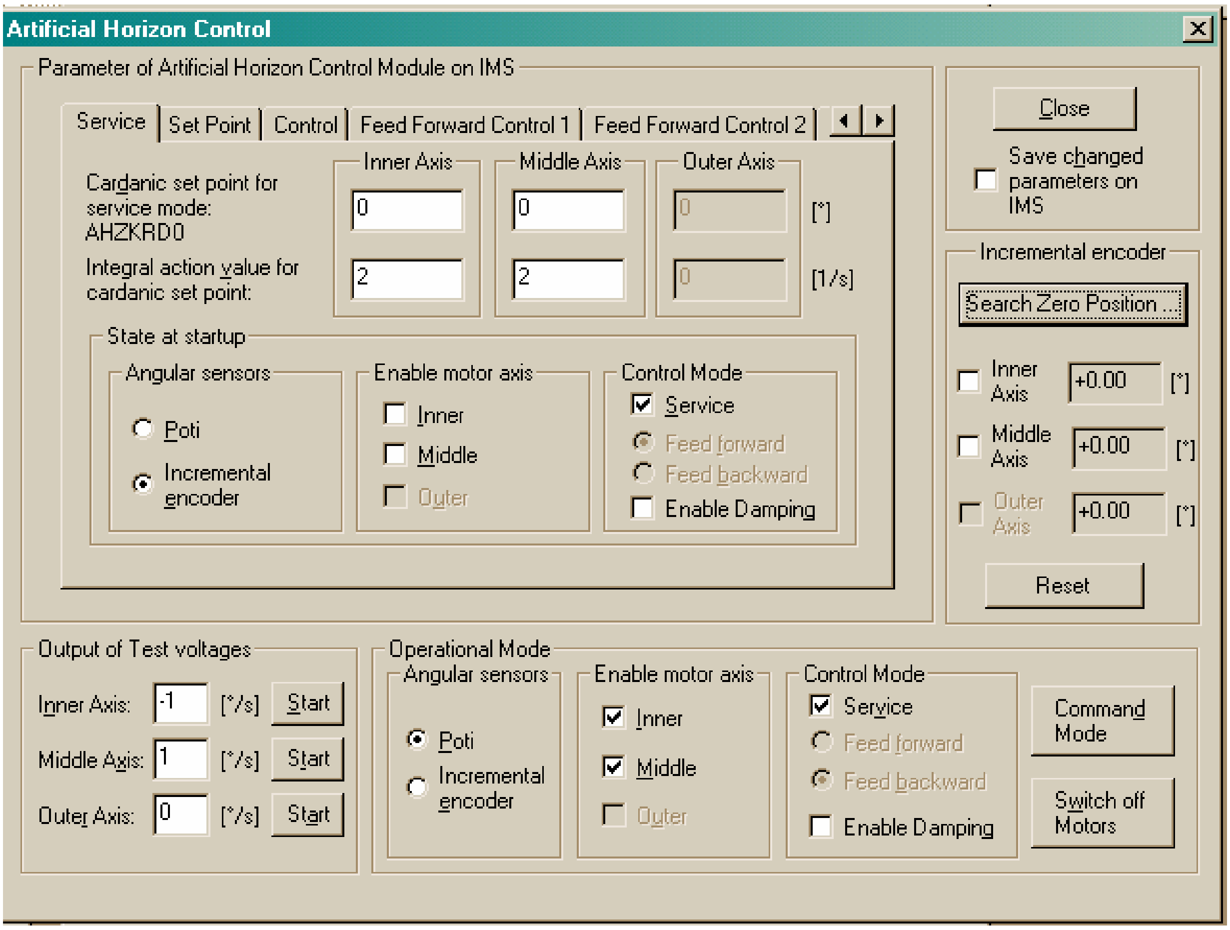
Following parameters are recommended at sampling rate 400 Hz:

```
Measuring Noise:
SIGODO=             0.002               (not 0.0001, because uncertainty
                                        of position is higher than odo
                                        resolution!!)
                                        (still stable for 0.02, but
                                        noisy; used for driven wheel
                                        mounted odo)
SIGODO=             0.02                (for odometer with 5 cm / pulse)

SIGGPSVEL=          3.0                 Default for GPS velocity error
SIGGPSPOS=          15                  Default for GPS position error
SIGFOG=             0.0001              gyro angular increment
SIGPSI=             5.0                 GPS-Heading

System noise, system dynamics:
SIGLON=             1.0E-10             Longitude
SIGLAT=             1.0E-10             Latitude
SIGHDG=             1.0E-10             Heading
SIGDPHI=            0.001               angular increment
SIGDS=              0.00025             distance increment
SIGVSCF=            0.000001            Odometer scale factor
SIGBIAS=            1.25E-09            gyro bias

Initial values:
SigVGPS=            0.5
SigGPSPos=          15
                    180                 Longitude
                    90                  latitude
                    180                 heading
                    0.001               angular increment
                    0.002               distance increment
                    0.1                 rel. Odo scale factor
                    0                   gyro bias
```

```
Heuristics:
                    Ignore:              3 x    GPS ignore
                    Reset:               5 x    KF Reset
                    Wait for:            10 x   number of tests before reset
                    Delay:       1.5     max. delay of aiding inf.
                    MINSPEED:    3.0     ignore GPS for low velocity
```

3.2.7.17 AHZCTRL Platform Stabilisation

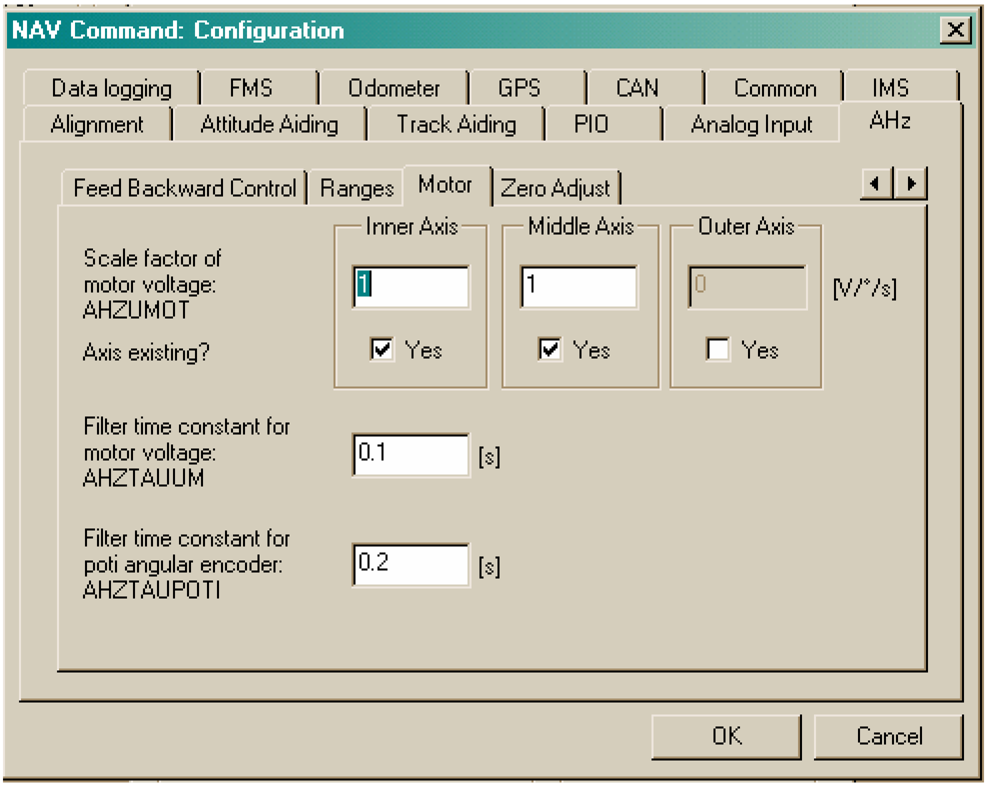
The next figure shows the configuration of the platform stabilisation module "AHZCTRL" (option only). It is used e.g. if a device (camera, laser, antenna...) shall be stabilised on a gimballed platform. The module allows the control of all settings for the stabilisation system like setting of control parameters, amplification values, limiter switch settings and a lot of other parameters. More details about the meaning of the parameters and settings can be found in the documentation "Nav Modules".



In the main AHZCTRL dialog which can be opened by a function key from the "Help" panel, all general control parameters can be set. The upper left window is used to set the parameters of the inner/middle/outer axis and to select the angular measurement system (potentiometer or angular incremental encoder), to enable/disable the motor axes (disable = motor voltage = 0.0) and to select the control mode (i.e. whether the system shall be operated in service mode, feed forward mode, feed backward mode and whether the angular rate damping shall be active to limit the inertial angular rate) at start up condition.

In the lower section of the screen test voltages can be applied on the motor drives to test the motor system (**be careful with high speed motion!! Keep your fingers away from moving parts!**) and the settings for the operational condition can be defined. Also a "SWITCH OFF" button is available (!! The "SWITCH OFF MOTORS" button only sets the motor voltage to zero! This may not lead to a standstill of the motor, if there is e.g. an offset in the motor amplifier input circuit on the side of the motor electronics !!)

If incremental encoders are implemented for angular control support (instead of potentiometers), the zero position of the encoders can be detected by performing a certain motion on all axes. The kind of search motion depends on the axis configuration (implementation of end value limit stops). With the "Search Zero Position..." button the zero position can be found automatically. The search algorithm and the required settings in the file CALIG.CFG on the filesystem on the IMS is described in the "Nav Modules" documentation. **It is highly recommended to study the information given in the separate description "Nav Modules" there before starting any procedure with the platform stabilisation module!**

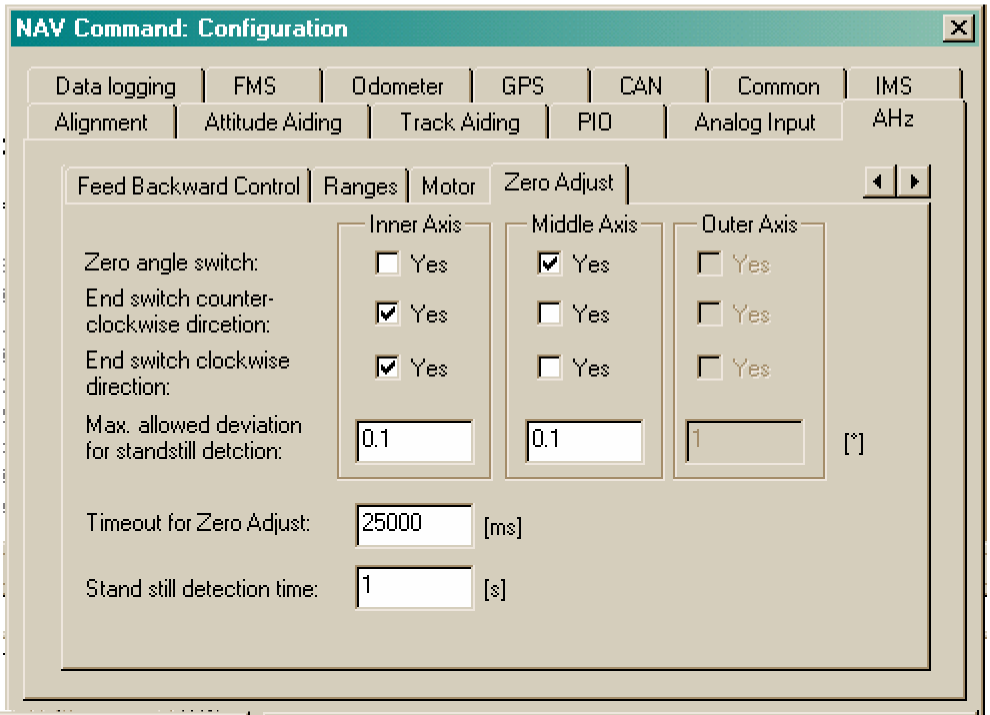


In the common configuration menus several parameters can be set like the procedure of searching the angular zero point ("zero adjust"), motor settings and motor axis configuration ("motor"), angular and angular rate ranges ("ranges") and control parameters.

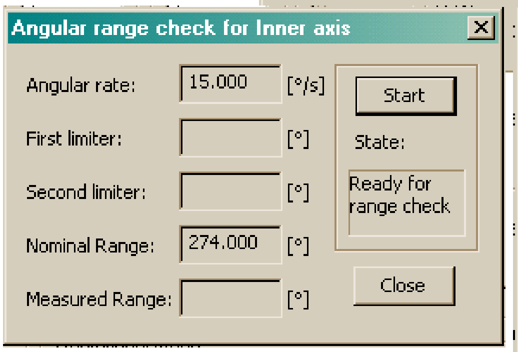
In the "motor" pan also the time constants for the motor voltage (1st order low pass) and the sampling of the potentiometer voltage (angle measurement – only required if no incremental encode is used for axis angular measurement) can be set.

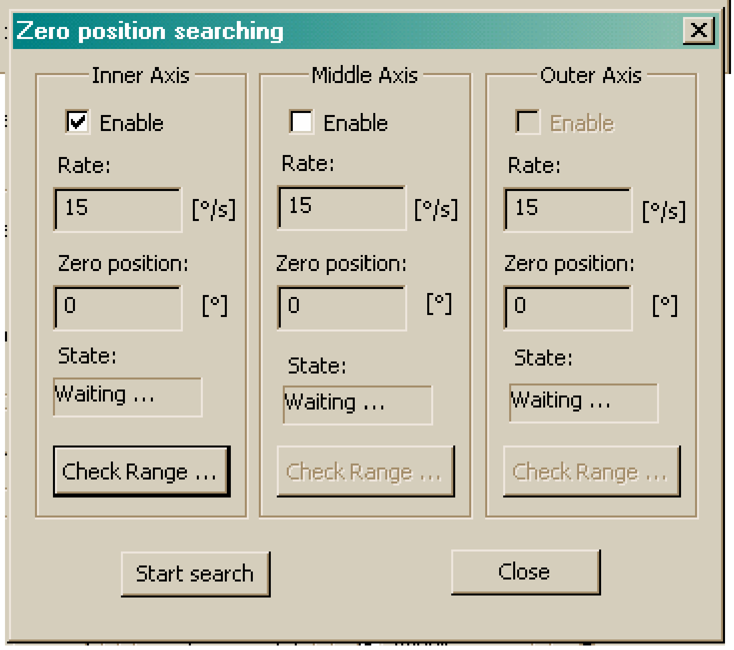
In the "zero adjust" pan the locations of the motion switches can be defined. This is necessary to perform later the right motion to detect the zero angle position of each axis. If an axis has the capability to rotate around without limitation (in such axes typically slip rings are installed), no limit switch is installed but a zero angle switch is required to detect the zero position automatically after power on of the system. To detect an end limit switch under/after motion, a certain minimum standstill is required and therefore a limit switch is identified if the angle does not change more than e.g. 0.1 degree.

The standstill duration should be longer than a certain limit (e.g. 1 second). The time-out for zero adjust search gives the duration which is given to find the limit switches; if more time is needed it is assumed that the motion of the axis cannot be performed correctly and the search is aborted.



The NavCommand program can be used to set the total stabilisation system to work. Therefore NavCommand allows to check the axes motion continuously.





If the limitations (rate) is exceeded, the NavCommand will stop the motor by sending 0 V output voltage to the motor.

Attention! A zero voltage on the motor control output may not mean that the motor is at standstill (depends e.g. on residual motor voltage offsets outside of the control of the iMAR system). Operate the stabilisation system only if you are sure that nobody can be hurt by the driving motors! Fast motor reactions can lead to dangerous squezings of fingers, arms or legs.

3.3 Data Storing

For measurement systems of the series iDIS-FMS, iDIS-FP or iNAV-FMS, you can specify in the configuration file of NavCommand which data should be transmitted and saved via Ethernet/TCP/IP (recommended) or via RS232 to the user's PC/notebook. The data shown on the main screen of NavCommand n real-time is independent of this, as it is entered hard-coded in the program and transmitted only at a low data rate for visualisation. The data to be saved can be defined independently of one another for time- and distance-related data.

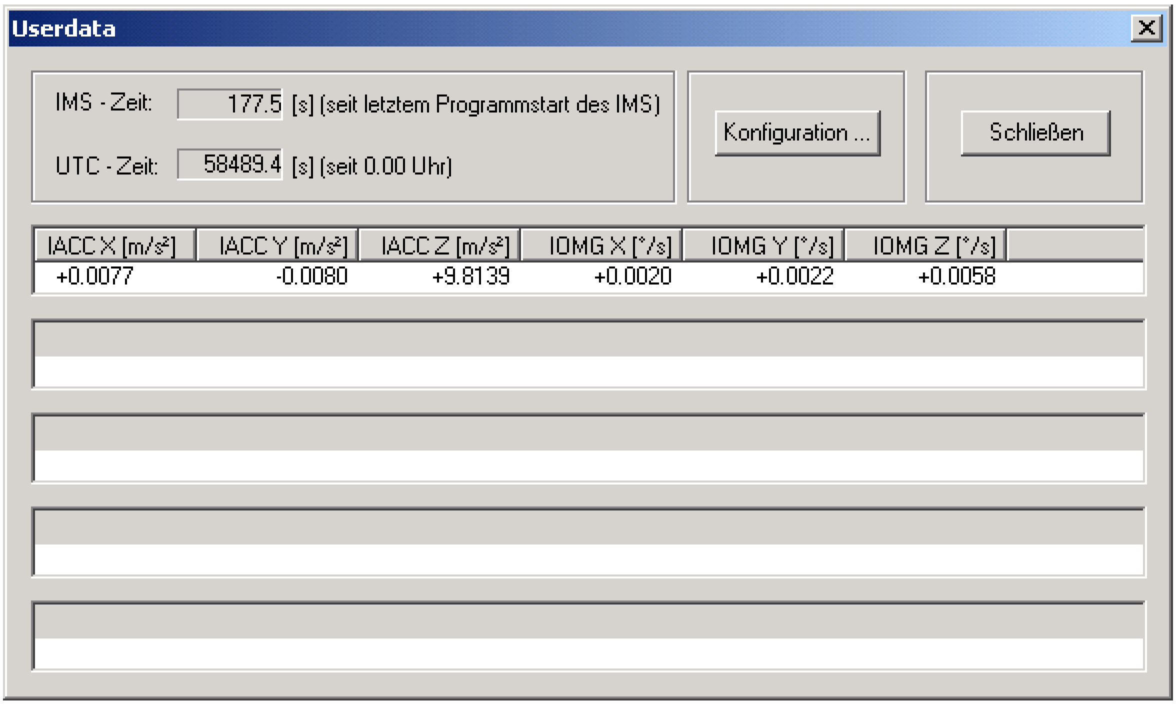
For each mode of storage (time- or distance-related), a maximum of 12 data records can be defined. Each data record is specified via the XIO identifier of the date (see Appendix B, e.g. OMGS for rotation rate vector in the sensor/body coordinate system) and optional information on the transmitted number format (4-byte float or 8-byte double per IEEE 754), on the conversion of transmitted binary format into ASCII text format (as "C" printf – format string) as well as via a scale factor by which the values of a data record are multiplied prior to saving. Angular information in textfiles is stored in deg or deg/s while those data are stored in rad or rad/s in binary files.

The external values "GPS Position" and "GPS Velocity" are stored in separate files. They can also stored together with the time tagged data, but then the following identifiers have to be used:

`ExtGPSPos`	to store GPS position and corresponding standard deviations
`ExtGPSVel`	to store GPS position and corresponding standard deviations

3.4 User Defined Display of Special Logs

NavCommand allows the user to monitor all internal values of the IMS in real-time on the laptop's additional display. For this on the Help Screen a special window can be activated (F7) where those values are displayed. What values shall be displayed can be defined in the UDD (user defined display) selection menu, where the data handling is similar to the working with the NavCommand's configuration files.



3.5 Special Notes and Troubleshooting

What you should check before you contact our support...

1. **No start-up:** Is the voltage of your power supply set correctly (see type plate of the IMS) ?
   Avoid long supply cables with too small diameter and use a power supply with low intrinsic resistor and fast output regulation at changes of the load!
2. **No Network Access:** Is the IP address of your computer set properly to be able to communicate with the IMS? The default address of the IMS is 192.168.1.199. Is there any firewall configured which may prohibit the access to the IMS from your computer? Please have a look to the specific manual to change the IP address of the IMS if required.
3. **No data on screen:** Is the PPS available ?
   Only for systems which are set to be hard triggered by GPS.
4. **No odometer velocity:** Is the odometer correctly configured ?
   Are voltage level and current of the odometer sufficient and is the correct odometer type selected in the odometer configuration? (A or A/B counter)
5. **Wrong odometer speed sign:** change the sign of the odometer scale factor.
6. **Drift on Roll and Pitch:** Is the aiding correctly set (parameters) ? Has the **heading determination** been done properly (otherwise a drift of up to 30 deg/hr mayoccur due to wrong earth rate compensation)?
7. **Data loss on interfaces:** Is the configured data volume on the CAN or RS232 interface higher than physically possible? Reduce the data volume typically to not more than 80 % of the channel capacity. Data volume = Number of Bytes x Data Rate, where at RS232 each byte is transmitted as 10 Bit.
8. **Error during data transmission via RS232:**
   The used latop may not be able to process the RS232 data at high data rate (Windows?). To use a RS232-to-USB-Converter probably will solve the problem. Sporadic loss of data will not affect the system operation (internal data and transmission within NavCommand).
9. **Windows-NT**
   During starting Windows-NT the IMS shall not be connected to the user's computer (or shall be switched off). Otherwise NT will try to identify the IMS as a mouse device (if connected via RS232) and may crash (blue screen). As an alternative you can insert the line "/NoSerialMice=Com1" in the "Boot.Ini" file in the root folder of the boot drive of NT, if the IMS is connected to COM1 of the computer.
10. **CAN does not work:** Is the CAN-Bus terminated with 120 Ohm at your side? The IMS has no internal termination to give the user highest flexibility in network configuration.

Before you contact the support...

... note the serial number of your IMS (SYS.......), the manufacturing date, the version number of your NavCmmand software and have the Log-, Err- and Msg-Files at your hand, which were created at your last NavCommand run.

Log Files:

If problems occur during the operation of the measurement system, the log files created by NavCommand can be useful for troubleshooting. One of these is the file "NavCommand.Err," which contains error messages generated by the NavCommand program and which can be found in the "Bin" subdirectory of the target directory specified at the time of installation. The other is the file "IMSMsg.log," which contains the error and log messages transmitted by the measurement system and which by default can also be found in the "Bin" subdirectory of the installation directory. Its path can, however, be changed with the "IMSLogDir" parameter in the "[NavCommand-GUISettings]" section of the "NavCommand.Cfg" configuration file (see Appendix A for more information on the configuration file). The files are written sequentially, a header with date and time being attached each time the program is started.

You can access to these files also via NavCommand in the communication startup screen.

Debug Version startup:

In addition, it may be necessary for problem diagnosis to create a log file on the IMS. For this, the Navigator program running on the IMS must be restarted. This can be achieved from NavCommand using the "GPS Track/IMS Reset" button by holding down the "SHIFT" key while clicking on the button. This procedure shall only be done during being in contact with iMAR staff.

1. Set the IMS sampling frequency to 100 Hz
2. Build up communication
3. Press „Ctrl" and the button "GPS Track/IMS Reset" at the same time, after the communication has been established

The IMS then generates a lot of messages, which are stored in the log file. To go back to the standard operation the IMS has to be re-booted (do not forget to change the sampling rate to obtain highest accuracy!)

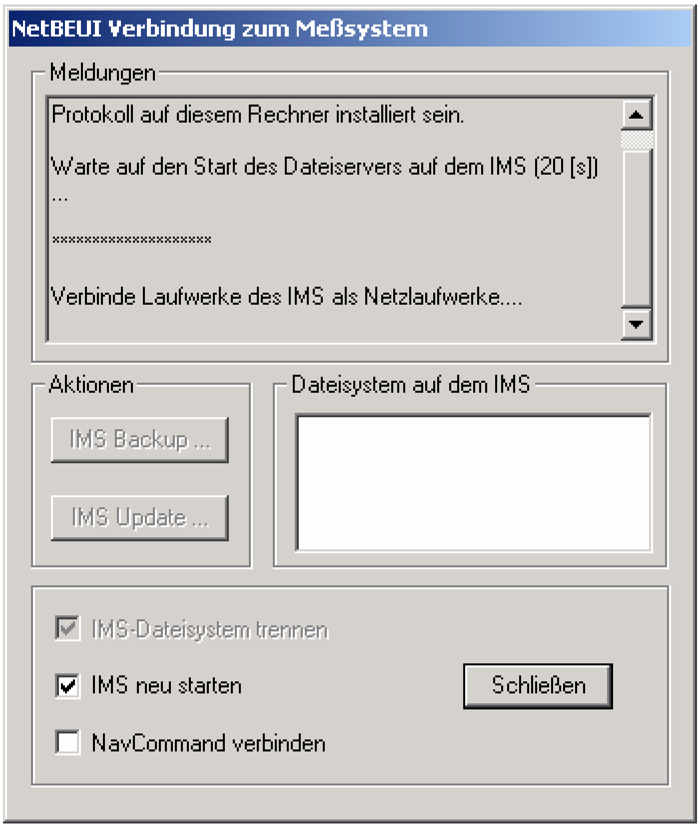
Activation of the debug version on the IMS should only be undertaken following consultation with iMAR.

4 Accessing the IMS File System

There are two ways to access the IMS file system:

a) **Ethernet connection**
If the measurement system (IMS) is equipped with an RJ45 connector, the connection can be established via a null-modem (cross-over) Ethernet cable and a 10/100MBit network card. The network protocol used is TCP/IP (on 32Bit Navigators) and Microsoft NetBEUI on elder systems (manufactured until about year 2002). To start the file server on the measurement system, activate the “IMS Service” button in the NavCommand main window. Two network drives are established through which the C: (flash disk) and D: (RAMDrive or flash_drive) drives of the measurement system can be accessed. After the required data from the IMS was saved or played onto the IMS, the network connection can be re-established and the software restarted on the IMS.

b) **InterLnk-InterSvr (only for systems build until about year 2000)**
If the measurement system or the NavCommand computer does not have a network connection, the connection to the measurement system can also be made via the serial interface. For this, activate the “IMS Service” button in NavCommand while holding down the “SHIFT” key and boot the computer with the supplied DOS



boot diskette. In the boot menu, you can then select whether the IMS drives should be mounted or the log/configuration files should be copied from the IMS to the connected computer. After a menu item has been selected, a batch file will start that gives further instructions and performs the desired actions. If the log/configuration files from the IMS are copied, the navigation software will automatically be launched on the IMS after the copying is finished. Otherwise, the IMS must be turned off and on again in order to be able to re-establish a connection via NavCommand.

The access to the IMS file system via TCP/IP is described in detail in a separate documentation.

The IMS file system has different sections (32 Bit systems, manufactured since 2002):

Drive C: (Flash):

\NAV: all system files, binary files (configuration) in folder \BIN etc.
\UPD: to install an software update or to provide a new parameter file, those files have to be copied into the „update“ folder where the IMS is checking the files with the next re-boot before installing them.

Drive D: (Flash):

Data drive for DUMP files (up to 4 GByte)

For IMS with elder 16bit OS the file system has the following structure (manufacturing date until of about 2002):

C: drive (Flash-Disk)
\Nav: Navigator software and configuration files (in particular “Config.Txt”)
\Net: Network software and configuration
\Dos: DOS system software with realtime operating kernel
\Etc: Batch files, help programs

D: drive (RAMDrive)
\: log and error files generated by the Navigator

Appendix A List of Measurement Data, User Logs

The following shows the measurement data that can be selected and saved with NavCommand in the measurement file. This list is being continually expanded as needed. The most often used logs are marked yellow.

Depending on the IMS hardware and software, not all data listed below are available on every IMS.

Note, that some data are only available on the elder 16bit systems (they are specially marked). These data are the Kalman filter logs of an elder filter solution, which are substituted in the new 32bit systems by a high sophisticated filter where all filter logs of this filter start with „KF" in the log name.

A1 General Data Logs:

Following logs (time referenced periodical data) are currently available (DAT_ID_xxx) for output (A: accumulating output):

- ACCCR ; average value of acceleration for aiding criterion 2,7
- ACCFMS ; original acceleration from FMS IMU (x,y,z) (A)
- ACCH ; Acceleration vector transformed into the horizontal plane, gravity compensated (x,y,z) (A)
- ACCR ; Acceleration vector in world coordinate system (gravity compensation applied) (A)
- ACCRG ; Acceleration vector in world coordinate system incl. gravity (ENU) (A)
- ACCS ; Acceleration vector in IMS coordinate system (A) (gravity compensation applied)
- ACCT ; temperature dependent misalignm. matrix of accels
- ADAMP ; Absolute value of damping inside the aiding algorithm
- AVAL ; RLG: A-Values of accels (0,1,2)
- CMAT ; C-matrix (DCM)
- CMATM ; C-matrix (DCM) (A)
- CPULD ; CPU load (0...1) (A)
- DELTAH ; From DELTAR calculated height since alignment
- DELTAR ; during actual sampling intervall travelled distance measured by odometer, transformed into world coordinate system
- DELTAS ; during actual sampling intervall travelled distance in body x direction measured by odometer (A)
- DELTAXY ; From DELTAR calculated horizontal position (alignment = 0,0,0)

- DMM16AT ; voltage of analog input channels [V]
- EACC ; inertial acceleration measured by external accelerometer (x,y,z) (A)
- EOMG ; angular velocity measured by external rate sensor (x,y,z) (A)
- FLTVX ; filtered longitudinal velocity (from odometer)
- GRAVS ; Gravity, co-ordinated in IMS co-ordinate system (A)
- HMAT ; horizontal transformation matrix
- IACC (ACCSG) ; Inertial acceleration vector incl. gravity (x,y,z) (A)
- INVRAD ; Inverse radius of curvature [1/m]
- ITACC ; RLG: Temperature current of 3 Accels [µA]
- ITACCF ; RLG: filtered Temperature current of 3 Accels [µA]
- ITACC ; temperature current of the accelerometers [µA]
- IOMG (OMGSE) ; Inertial rotation rate vector incl. earth rotation rate (x,y,z) (A)
- KN2LL ; Longitude and latitude from the KF state vector, (only in 16bit systems)
- KN2S ; Standard deviation vector in dead-reckoning-navigation (iDRPOS-FMS) , (only in 16bit systems)

Lon	standard deviation of estimated Longitude
Lat	standard deviation of estimated Latitude
Hdg	standard deviation of estimated Heading
DPhi	standard deviation of estimated yaw angle increment
DS	standard deviation of estimated position increment
SCF	standard deviation of estimated Odo scale factor
Bias	standard deviation of estimated gyro bias

- KN2Z ; State vector in dead-reckoning iDRPOS-FMS navigation (Lon, Lat, Hdg, DPhi, DS, SCF, BIAS) , (only in 16bit systems)

Lon	estimated Longitude
Lat	estimated Latitude
Hdg	estimated Heading
DPhi	estimated yaw angle increment
DS in	estimated position increment
SCF	estimated Odo scale factor
Bias	estimated gyro bias

- NLLH ; Calculated position (Longitude, Latitude, Altitude)
- NRPY ; Calculated Eulerian angles (roll, pitch, yaw) of navigator (ENU)
- NVEL ; Calculated velocity in world coordinate system (ENU)
- NYAW ; Calculated yaw angle (Yaw)
- OMGCR ; average value of rotation rate for aiding criterion 3
- OMGH ; Rotation rate vector transformed into the horizontal plane, earth rate compensated (x,y,z) (A)

- OMGR ; Rotation rate vector in the world coordinate system (earth rotation rate compensated) (A)
- OMGRE ; Rotation rate vector in world coordinate system incl. earth rotation rate (ENU) (A)
- OMGRF ; Filtered Rotation rate vector in the world coordinate system (earth rotation rate compensated) (A)
- OMGS ; Rotation rate vector in IMS coordinate system (earth rotation rate compensated) (A)
- OMGSEF ; Filtered inertial rotation rate vector incl. earth rotation rate (x,y,z) (A)
- OMGSF ; average value of rotation rate for virtual measurement point transformation
- PCOA ; Main elements of the covarinace matrix of Coarse-Alignment (only in 16bit systems)
- PFIA ; Main elements of the covarinace matrix of Fine-Alignment (only in 16bit systems)
- QUAT ; Quaternion components
- RACC ; Raw acceleration vector (0,1,2) (A)
- RAWVX ; Raw value of longitudinal velocity [m/s]
- RVEL3 ; Raw value of longitudinal velocity of 3 odometers ; (if any applied, e.g. for pipeline inspection) [m/s]
- RLGA ; RLG: acceleration before misalignment correction (A)
- RLGAUX ; RLG: Auxiliary ADC channels in Volt (ADC16) Number of channels is defined in Edit-Menue
- RLGB ; RLG: Accel bias B from modell [g] (0,1,2) (A)
- RLGC ; RLG: Accel scale factor C from model [mA/g] (0,1,2) (A)
- RLGH ; RLG: Axes-Misalignment ACC H/MIO [rad] (0,1,2)
- RLGISP ; Current from the accelerometer, determined from RLGISP = RLGUACC / R_s
- RLGP ; RLG: Axes-Misalignment ACC P/MIP [rad] (0,1,2)
- RLGUACC ; RLG: measured voltages at ADC24 [V] (0,1,2) (A)
- RLGVEL3 ; Odometer Velocity of RLG-IMU (3 odometers; counter increments x absolute odometer scale factor)
- ROMG ; Raw rotation rate vector (0,1,2) (A)
- RPYDOT ; Deviation of Eulerian angles (d RPY / dt) {3}
- RPYNED ; Calculated Eulerian angles of navigator (NED)
- SACC ; Acceleration vector of sensor triad (x,y,z) (A)
- SCOA ; Square-root of the main elements of the covarinace matrix of Coarse-Alignment (standard deviation), only for 16bit systems

- SFIA ; Square-root of the main elements of the covarinace matrix of Fine-Alignment (standard deviation), only for 16bit systems
- SOMG ; Rotation rate of sensor triad (x,y,z) (A)
- SUMS ; totally distance travelled measured by odometer since last alignment (derived from DELTAS)
- SUMYAW ; Summarized yaw angle (not limited to $\pm\pi$) {1}
- TACC ; Acceleration after correction of cross coupling and before global permutation (A)
- TEMP ; Temperature of the IMS [°C]
- TIME ; IMS time [s]
- TMOD ; result of internal time model in UTC [s]
- TOMG ; Rotation rate after correction of cross coupling and before global permutation (A)
- UTACC ; RLG: Temperature voltage of 3 Accels [V]
- UTADC ; RLG: Temperature voltage of 3 ADC24 [V]
- UTADCF ; RLG: filtered Temperature voltage of 3 ADC24 [V]
- VX ; Value of longitudinal velocity (odometer) [m/s]
- VXSHFT ; Transformed odometer velocity
- ZCOA ; State vektor of Coarse-Alignment ($\varepsilon_N,\varepsilon_E,\delta\omega_N,\delta\omega_E$), only in 16bit systems
- ZFIA ; State vektor of Fine-Alignment ($\varepsilon_y,\varepsilon_x,\varepsilon_z$), only in 16bit systems

A2 Special External Data:

- ExtGPSPos ; GPS Position (stored in separate file)
- ExtGPSVel ; GPS Velocity (stored in separate file)
- ExtUtcSec ; UTC second of day from GPS
- ExtHdt ; Heading reference (east = 0)
- ExtPosErr ; Position error in ENU coordinate system

Not all data is available on all systems. The NavCommand program detects the available data at the connection startup automatically.

A3 Odometer Aided data Signal Processing

Calculation equations of the distance and position data logs (if installed on the IMS):

```
DAT_ID_RAWVX = PAR_ID_AVSCF * counter_difference * PAR_ID_FA * (1.00|0.50|0.25)
```

1.0	for A-counter (single line)
0.5	for A/B counter (two lines, 90° shift)
0.25	for quadrature counting (rising and falling edges) of A/B counter

```
DAT_ID_VX = (DAT_ID_RAWVX – PAR_ID_VXOFF*) * PAR_ID_RVSCF
DAT_ID_VXSHFT = DAT_ID_VX + PAR_ID_VDRVELX x DAT_OMGSEF**
DAT_ID_FLTVX = Filter(DAT_ID_VXSHFT, PAR_ID_TAUVX)
DAT_ID_DELTAS = DAT_ID_VXSHFT / PAR_ID_FA
DAT_ID_DELTAR = DAT_ID_CMAT^T * (0, 0, DAT_ID_DELTAS)^T

DAT_ID_DELTAH(k)***  = DAT_ID_DELTAH(k-1) + DAT_ID_DELTAR_U
DAT_ID_DELTAXY(k)*** = DAT_ID_DELTAXY(k-1) + (DAT_ID_DELTAR_E, DAT_ID_DELTAR_N)^T
DAT_ID_SUMS(k)***    = DAT_ID_SUMS(k-1) + DAT_ID_DELTAS
DAT_ID_INVRAD        = DAT_ID_OMGRF_z**** / Vhor*****

E,N,U :     East, North, Up
T     :     transposed matrix
*     :     is a constant parameter, can be determined during alignment,
            elsewhere = 0
**    : can be changed by command,
        DAT_ID_OMGSEF = Filter(DAT_ID_OMGSE, PAR_ID_TAUOF)
***   : will be set to 0 by XIO_CMD_BEGAL0
****  : DAT_ID_OMGRF = Filter(DAT_ID_OMGR, PAR_ID_TAUOF)
***** : Vhor = DAT_ID_FLTVX * Sqrt(DAT_ID_CMAT_11^2 + DAT_ID_CMAT_21^2)
```

A4 Data description in XIO - NavCommand

The file XIODatDesc.txt contains the default settings for the formatted output of data logs in NavCommand. The content can be found on the NavCommand CD.

Appendix B Flash-Status of the LEDs of the IMS

If the IMS contains optical output devices (LEDs), it is possible to define the behaviour of the green LED in the configuration of the system. Flashing sequences show the state of selected status-bit in the selected status-mode. The red LED indicates system warnings or faults (like "no GPS connected").

The following settings are possible for the green LED (can be set by system programmers, please contact iMAR if required):

1.) Status-bit definitions in the syntax *K***.***N*, where *K* (0, 1, 2...) is the index-number of the status (so-called Status Mode) and *N* is the corresponding bit-number (0...31). There is only a limitation in the number of bits due to the input line, but more than 4 or 5 bit are difficult to distinguish for the user.

2.) Cycle duration Td in milliseconds

3.) Multiplier M0 for short On-duration of LED M0 * Td

4.) Multiplier M1 for long On-duration of LED M1 * Td; it should be M1 > M0

5.) Break-multiplier Mp

Hint: The multipliers should be integer.

Flash-Format:

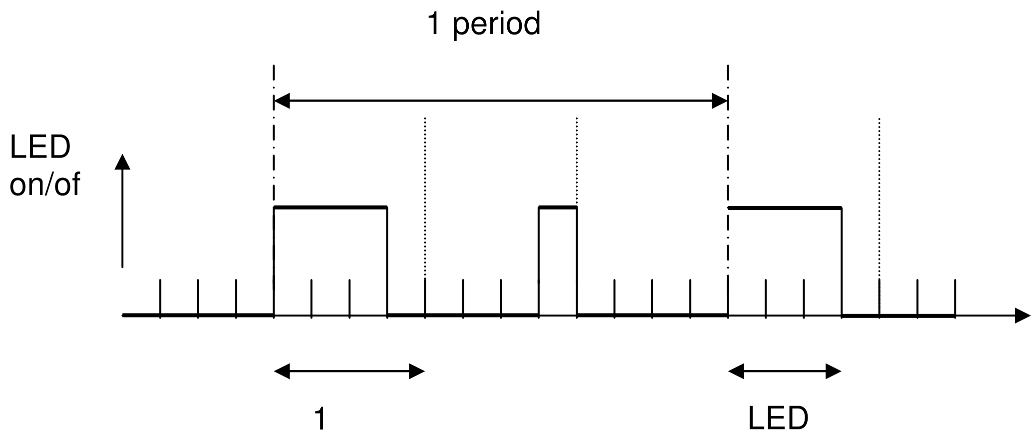
The status-bits will be displayed in the given order as short (if = 0) or long (if = 1) flash (LED on). The duration of these signals is M0 * Td resp. M1 * Td. Then it follows a break of length M1 * Td resp. M0 * Td, so the total length of one status-bit is always (M0 + M1) * Td. After all status-bits are displayed a break of length Mp * Td is performed.

Example:

Status-Bit-Definitions=0.17 0.22 5.4 6.2
Cycle duration=250 ; [ms]
Multiplier if Bit equal 0=1
Multiplier if Bit equal 1=3

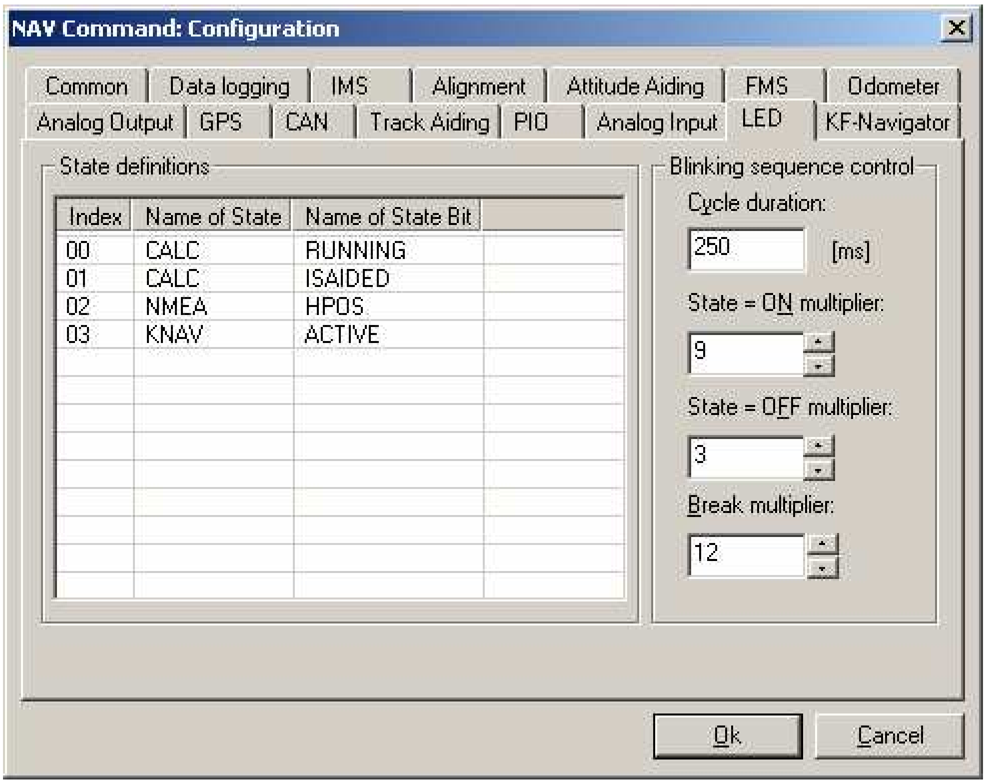
Break-Multiplier=4

In this case the codes are
0.17 Navigator initialisation finished
0.22 Attitude aiding active
5.4 GPS Lon/Lat valid
6.2 KNAV active (dead reckoning)



(the figure shows an setting with only 2 defined status bits:
break, 1st status = 1, 2nd status = 0, break, 1st status = 1, ...)

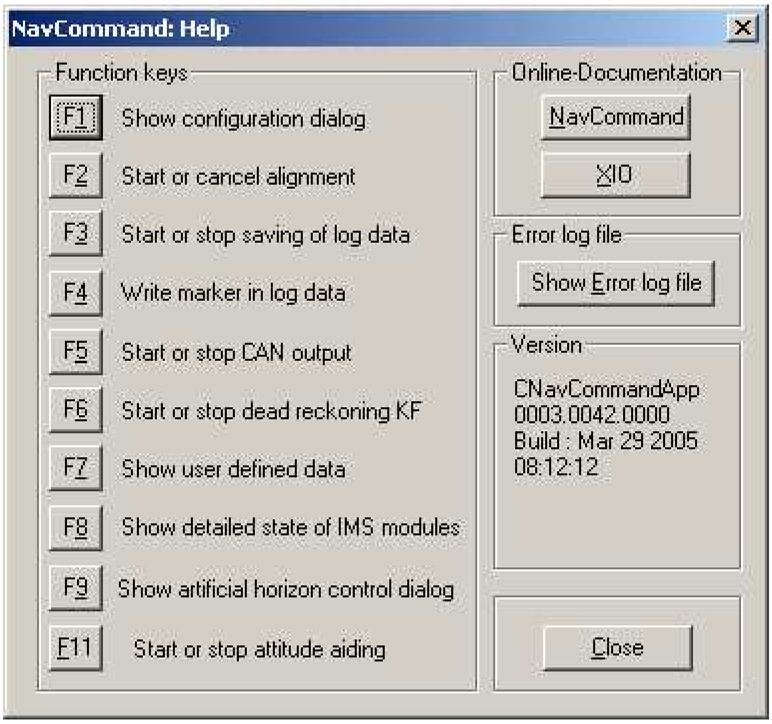
In praxi it is recommended to set the break factor to a bigger value (e.g. 12) to make it easier to detect the start of a new sequence.



The red LED indicates warning or error conditions. If the red LED is flashing, then a warning is signalised (e.g. data communication error with GPS). Continuous red LED light indicates a fatal system error or file transfer mode (navigation software on the IMS not running).

Appendix C Short-Cuts of NavCommand

Via the Help button on the NavCommand Main Screen you can display all function keys available to make operation most comfortable.



Advanced users have also access to the status monitor screens to be able to observe the internal behaviour of the IMS (function key .F8).

All special function keys are described and can also be triggered using the mouse. E.g. pressing F5 starts CAN transmission (depends on settings).

The following short-cuts are available without a button on the screen (see also the help screen):

- F5: enables/disables CAN output (if CAN interface is available)
- F6: enables/disables DRPOS calculation (dead-reckoning position determination, if DRPOS module is available)
- F7: Show user definable data (see special chapter)
- F8: Special internal status information (for system programmers)
- F9: Artificial horizon, platform and line-of-sight stabilisation