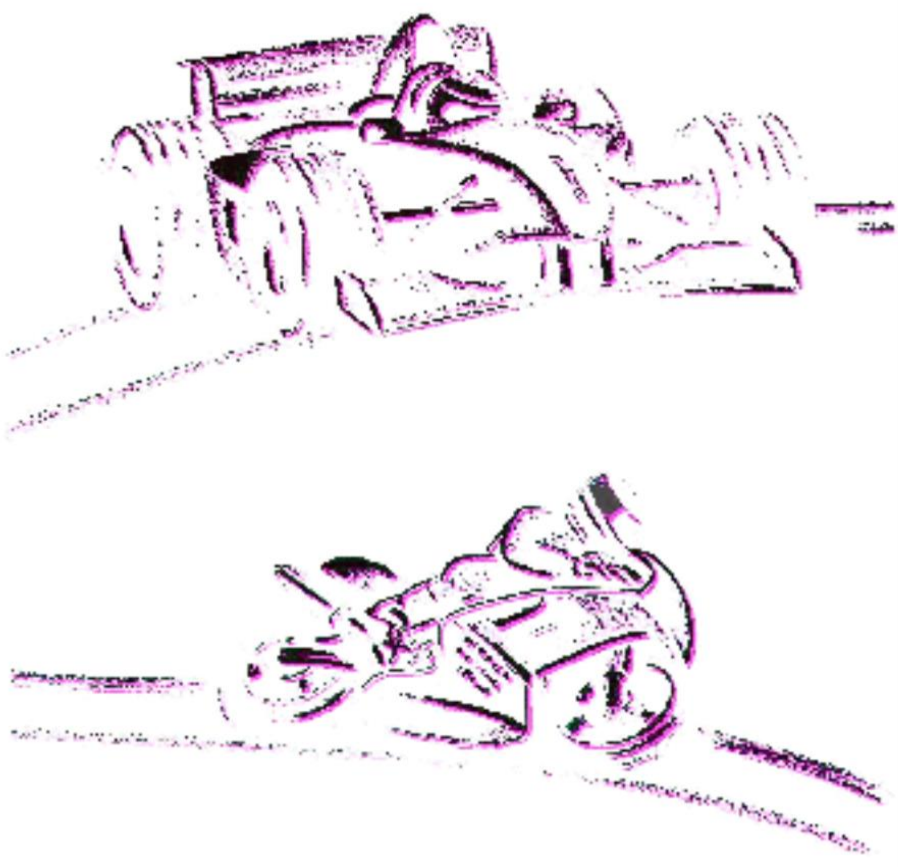
- English -



GPS/GNSS

General description

1 Revision History

Revision	Description	Release Date	Author
0	Initial Release	2021-07-29	FS
1	Link to GPS/GNSS modules overview 5.1	2022-02-15	FS
2	Improvement required modules selection	2022-07-27	FS
3	Real Time Kinematic (RTK)	2023-03-30	FS

Revision 0:
Initial release

Revision 1:
More detailed information on the different modules available (**Link to overview**)

Revision 2:
Further improvement of chapter Available modules (5) with information to GPS/GNSS module requirements (5.2 (5.1.1), firmware and intended use of different GPS/GNSS modules (5.3). Extended description of GPS Modes/Dynamical models of GPS/GNSS antennas (12.2.3).

Revision 3:

Adding chapter **Real Time Kinematic (RTK)** to where is described how to enhance positional accuracy of 2D GPS/GNSS RTK modules of **±1cm!**

2 Content

3 Notes and symbols used in this Manual

Further Information
In the paragraphs highlighted with this symbol, you will find tips and practical advice to work with the 2D-Software.

Documentation reference
Documentation reference to another manual or handout

Important information
It is very important to follow the instructions given

4 Introduction GPS/GNSS

Global Navigation Satellite Systems (GNSS) are used to determine a position on earth and to receive a globally valid time signal.

The general term for satellite navigation is GNSS but the term GPS (Global Positioning System) has become a synonym for this technology, but GPS is only one of the four GNSS.

Besides GPS, GNSS also includes GLONASS (Russian Federation), Galileo (Europe) and BeiDou (China).

The more satellites are used to determine the position, the more accurate and stable the determination of the position and thus the determination of the speed.

Documentation reference
For more information on the theory and exact functionality of GNSS positioning, we recommend the u-blox GPS-Compendium_Book

Via positioning capabilities of GNSS, all 2D GPS/GNSS modules can be used for lap time and GAP time calculations!

Documentation reference
For more information about **laptiming via GPS/GNSS** or **GAP function** (Event manual) please see manuals on our website:
http://2d-datarecording.com/downloads/manuals/

5 Available Modules

5.1 Overview

A detailed overview over the existing modules can be found on the products area on our website or the overview can be downloaded by clicking here!

2D GNSS receivers are available as **serial** receivers (Mouse/antenna) as well as GPS/GNSS**2CAN** receivers.

Serial	can be only connected to 2D loggers' **serial** connection (SIO)
CAN	can be connected to any point of 2D **CAN bus** system.

From a GNSS technical point of view, serial and GPS/GNSS CAN modules do not differ, which is why only GPS/GNSS modules will be referred to in the following chapter 5.

In chapter 6 the advantages and disadvantages of serial and CAN GPS/GNSS modules will be discussed.

5.1.1 Firmware

If new firmware is required, please contact 2D via contact form.

5.1.1.1 GPS/GNSS Serial modules

At GPS/GNSS **serial** modules always the firmware of the connected recording device is important.

25 Hz serial antenna	Firmware > 100 required to use 25 Hz antenna
10 HZ RTK serial antenna	Firmware > 100 required to use RTK functionality

5.1.1.2 GPS/GNSS CAN modules

At GPS/GNSS **CAN** modules always the firmware of the module itself is important.

GPS2CAN module	Via firmware update of GPS2CAN modules from 2019+ can receive signals from all GNSS instead of just GPS, which improves positional accuracy. Update reduces the rate from 12.5 to 10 Hz.
GPS2CAN/GNSS2CAN module _3A3G(IMU)	The update to GPS/GNSS2CAN modules with/without IMU is done via firmware update and can therefore be carried out at any time!

5.2 Requirements to GNSS receivers

Due to the wide variety of applications for GNSS modules (racing, vehicle development, outdoor sports tracking, ...), the following four main requirements for GPS/GNSS modules arise:

Dynamical capabilities
Generally, the higher the GNSS sampling rate of a module, the higher the possible dynamic range of motion that can be detected. Dynamic means the ability to detect motion, with fast movements and changes in direction (outdoor sports such as skiing or mountain biking) requiring a GNSS module with high dynamic range to detect every detailed movement. For vehicle brake tests, it is also important to work with high dynamics in order to be able to accurately detect speed changes during braking or acceleration using the GNSS speed signal.

Positional accuracy
The original requirement for GNSS modules is the most accurate possible position detection. However, this position detection is strongly influenced by many parameters such as external influences like ionospheric errors, satellite orbit errors, operational disturbances of individual satellites, signal reflections from buildings or shielding of GNSS signals by trees or buildings. Also, engine vibrations, road surface or a wobbly mounting are playing a role at positional accuracy. The accuracy of the position also depends on the GNSS module's ability to process correction data.

Susceptibility to external influences
This point relates very much on the previous point, as there are also differences in how GNSS modules deal with the disturbance caused by the external influences mentioned. By accessing much more GNSS satellites, the reliability and thus the accuracy of all 2D GNSS modules is highly increased, because with more satellites received it is normally not a big problem if some satellite connections are lost due to external influences.

Size, robustness and mounting
Finally, the small size, in the case of many modules even with a built-in IMU, and robustness are decisive requirements for GPS/GNSS receivers, as they are usually mounted in a decentralised and exposed position with a clear view of the sky and are thus exposed to external influences. Especially in two-wheel racing and outdoor sports, the available mounting space with good GPS/GNSS conditions are often severely limited. The variable mounting options (adhesive tape, magnets, screws) also contribute significantly to the wide range of applications for 2D GPS/GNSS antennas. Based on 2D's many years of experience in racing, the above-mentioned points play a major role in addition to the technical implementation!

Documentation reference
For more information about **the 2D GPS/GNSS modules behaviours** in regard to the requirements, 2D execute test to visualize the different performances**,** please see the document **Revision of GNSS modules** on our website:
http://2d-datarecording.com/downloads/manuals/

5.3 *Intended use of GPS/GNSS modules*

A detailed overview over the existing modules can be found on the products area on our website or the overview can be downloaded by clicking here!

The modules in the boxes shown are based on different chip sets. Setting a 25 Hz chip to sample rate 10 Hz is possible but does not change the receivable GNSS constellation to that of a 10 Hz chip!

10 Hz KIT antenna & 12.5 Hz GPS2CAN with **12.5 Hz firmware**

With 10 Hz or 12.5 Hz sampling rate the modules are suitable for racing applications with **less demands on dynamics**.

Both modules are able to receive only GPS satellites, what results in a **high susceptibility to external influences.**

Hence, these modules are appropriate to be used on racetracks for **laptiming via GPS position** with permanently free visibility to sky (no trees nearby circuit, e.g., at motocross tracks, no bridges, signboards,…).

GPS2CAN modules are also **available with built-in IMU**.

10 Hz modules (12.5 Hz GPS2CAN with **10 Hz firmware update**)

The main difference between these 10 Hz modules and the former mentioned 10 Hz KIT and 12.5 Hz GPS2CAN with **12.5 Hz firmware** is, that here two satellite systems can be received concurrently, what results in a **better positional accuracy** and **lower susceptibility to external influences** by receiving GPS + GLONASS or GPS + BeiDou.

GPS2CAN modules with 10 Hz firmware are suitable for racing applications with **less demands on dynamics**.

Hence, these 10 Hz modules are very appropriate for **laptiming via GNSS position**.

GPS2CAN modules are also **available with built-in IMU**.

25 Hz modules:

This module is very suitable for all kinds of fast outdoor sports such as skiing, mountain biking or vehicles on racetracks, where a combination of **high dynamic capabilities** and **good positional accuracy** is required.

In addition, 25 Hz modules can receive all four GNSS, i.e., up to 32 satellites, at the same time, but only uses the strongest 16 satellites for calculating the current position and keeps all other signals ready in order to be able to use a new satellite directly in the event of a failure of one of the strongest 16 satellites.

This results in a **very low susceptibility to external influences**, what is very important at outdoor sports in or nearby forest, race track uses with big importance of reliability of GPS/GNSS data or any other applications in urban areas with buildings.

All the mentioned points are valid for racing and industrial applications. For acceleration and braking tests with vehicles we strongly recommend using a **25 Hz** module.

Of course, **laptiming via GNSS position** is possible.

25 Hz CAN modules (GNSS2CAN) are also **available with built-in IMU**.

50 Hz modules:

Important information
50 Hz GPS modules are not availablable any more!

10 Hz **RTK** modules (**with** RTK correction data):

However, as soon as **highest positioning accuracy** is necessary, it is recommended to use the 10 Hz RTK module with RCTM correction data (RTK **enabled**) to achieve a positioning accuracy of up to one centimetre, as is necessary, for example, for tests of Advanced Driver Assistance Systems (ADAS).

Without applying RTK correction data to the antenna, the 10 Hz RTK antenna can be used as normal 10 Hz serial antenna!

It must also be mentioned that **when applying RTK correction data**, that the **susceptibility to external influences** is highly increased because by having external influences not only the reception of the GPS/GNSS module itself is disturbed but also the quality of the for RTK required carrier phase measurement is reduced**!**

For RTK use a good antenna mounting is necessary as RTK operation require higher signal quality.

Important information
Trying to achieve highest positional accuracy of ±1cm in forest, or urban areas with high buildings, can practically become problematic! Achieving hightest postion accuracy of 1 cm in deep forest and urban canyons with high buildings can be problematic!

Documentation reference
For more information about **RTK functionality** please see chapter Real Time Kinematic (RTK) for more information!

10 Hz **RTK** modules (**without** RTK correction data)

This module should only be used for RTK applications!

6 Serial GPS/GNSS & GPS/GNSS2CAN

2D serial GPS/GNSS receiver (Mouse) can be connected to 2D loggers supplying **serial** connection (SIO).

The GPS/GNSS**2CAN** receivers can be connected to all 2D system via **CAN** bus.

For serial data transmission, the GPS/GNSS serial antenna must be connected directly to the 2D recording device at the appropriate **serial port** using a four-pin connector, whereas a GPS/GNSS2CAN module can be connected at any point in the 2D **CAN** bus system.

Important information
For receiving GPS/GNSS via serial antenna, the corresponding port must be available on the 2D recording device because not all 2D recording devices provide a serial port!

Further Information
2D recording device can be a logger as well as the latest generation of Dashboards called DashTFT.

6.1 Advantages of GPS/GNSS2CAN modules

Depending on the firmware used in module, the GPS/GNSS**2CAN** modules are able to provide channels of an integrated **6(9) DoF IMU.**

Thereby the GPS/GNSS2CAN modules can also work as simple GPS/GNSS modules which are transferring their data **via CAN**!

6.1.1 Connectivity

Through CAN-bus connection, the GPS/GNSS2CAN modules can be plugged in on every position on CAN-bus system.

6.1.2 Built-in IMU

With firmware where the IMU is activated, the IMU channels can be send with a sampling rate up to 1000Hz.

Also, a first order IIR filter for individual filtering for all axes or built-in coordinate transformation can be applied to the IMU channels.

Important information
With GPS/GNSS2CAN firmware the IMU channels can be enabled or disabled!

Documentation reference
For more information about IMU please see the manual XXX on 2D-website
http://2d-datarecording.com/downloads/manuals/

6.1.3 Online Calculation channels

Additionally, GPS/GNSS2CAN modules also provide *Online Calculation channels*.

Documentation reference
For more information about CALC channels please see manual **Online Calculation Channels** on 2D-website:
http://2d-datarecording.com/downloads/manuals/

6.1.4 Further channels

Furthermore, the GPS/GNSS2CAN modules has the Event channels *Laptime* and *Sectime* which can be used for online GPS/GNSS laptiming tasks.

The advantage is that the Lap- and Sectime Event channels can be sent via CAN to other CAN modules (e.g., displays).

GPS/GNSS2CAN modules are also able to create laptime signals (not laptimes itself!) via GPS coordinates and sends the laptime signals in TransponderX2 format on CAN Bus to a logger (see chapter 12.2.5.3).

Documentation reference
For more information about Event channels please see manual **Event Channels** on 2D-website:
http://2d-datarecording.com/downloads/manuals/

Beside Event channels and TransponderX2 simulation, also more channels like Online Roll angle calculation are available at GPS/GNSS2CAN modules (see chapter 11.1).

6.2 Advantages of serial GPS/GNSS modules

6.2.1 Connectivity

Serial GPS/GNSS antennas does not need a CAN bus system and thus can be run standalone with a suitable Logger only.

Thereby, a compact measurement system with GPS/GNSS data can be set up.

6.3 Conclusion GPS/GNSS2CAN & serial GPS/GNSS modules

Many of the functions provided directly by GPS/GNSS2CAN (Online Calc Channels, Laptiming) can also be used in conjunction with a 2D logger with serial GPS.

Both ways have their raison d'être, and their usefulness always depends on the respective areas of application!

If there are any specific application, please contact 2D via contact form.

7 Samplingrates

Until summer 2021 2D offers single GNSS modules based on GPS only with maximum 12 concurrent satellites with sampling rates 10, 12.5 and 50 Hz.

From 2021 new 10 and 25 Hz GPS/GNSS modules are additionally available as serial and CAN modules, which using up to 32 GNSS satellites what significantly improves positional accuracy!

Generally, the higher the GNSS sampling rate of a receiver, the higher the possible dynamic range of motion that can be detected.

Fast movements and changes in direction in outdoor sports such as skiing, or mountain biking require a GNSS receiver with high dynamics. For vehicle brake tests, it is also important to work with high dynamics in order to be able to accurately detect speed changes during braking or acceleration using the GNSS speed signal.

Documentation reference
For more information about all new GPS/GNSS modules please see descriptions
New 2D GPS/GNSS CAN Modules 2021 and **Revision of GNSS modules**
http://2d-datarecording.com/downloads/manuals/

Documentation reference
For more information about all available 2D GPS/GNSS modules please see **Product overview** on our website:
http://2d-datarecording.com/en/products/hardware/

7.1 Serial GPS/GNSS modules

With Sticklogger-Firmware > 100 the 12.5 Hz Mouse can also be set via **Logger setting** to 10 Hz to receive signals from all GNSS instead of just GPS, which improves positional accuracy.

To switch from 12.5 Hz- to 10 Hz-Mode, just the sampling rate of all channels in loggers GPS group must be set to 10 Hz.

Further Information
The switch is done easily via **Logger setting**!
By accessing much more satellites, the reliability and thus the positional accuracy is highly increased!
The reduction in dynamic range due to the reduction of the rate from 12.5 to 10 Hz is justified by the improvement in the reliability and accuracy of the signal.

If new Logger-firmware is required, please contact 2D via contact form.

7.2 CAN GPS/GNSS modules

Via **firmware update** of GPS2CAN modules from 2019**+** can receive signals from all GNSS instead of just GPS, which improves positional accuracy. Update reduces the rate from 12.5 to 10 Hz.

Further Information

The switch is done via **firmware update**!

By accessing much more satellites, the reliability and thus the positional accuracy is highly increased!

The reduction in dynamic range due to the reduction of the rate from 12.5 to 10 Hz is justified by the improvement in the reliability and accuracy of the signal.

If new GPS/GNSS firmware is required, please contact 2D via contact form.

8 Real Time Kinematic (RTK)

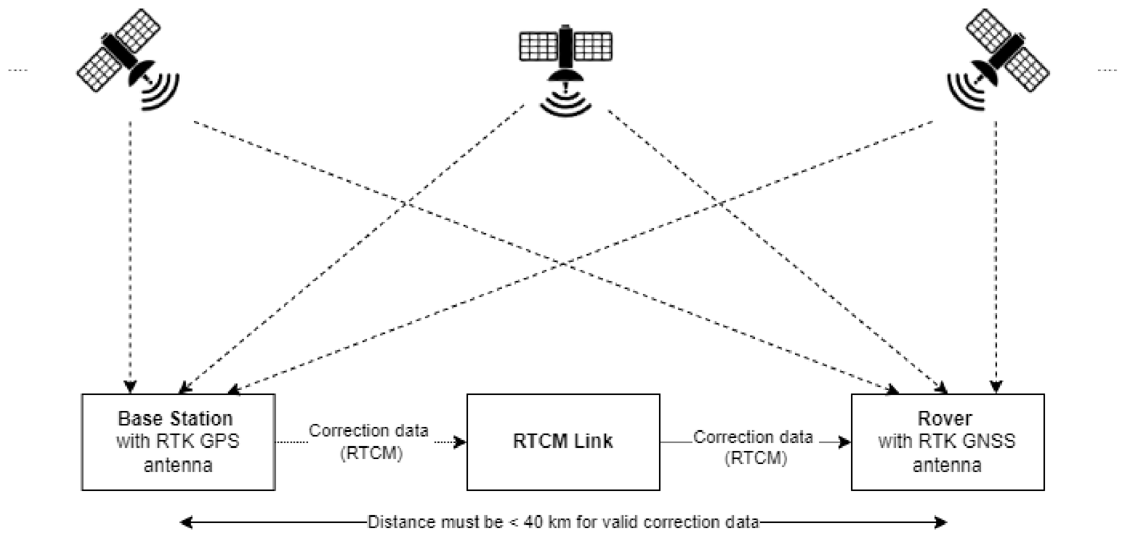
Real Time Kinematic (RTK) is a technique used to enhance the precision of position data derived from Global Navigation Satellite Systems (GNSS), such as GPS, GLONASS, BeiDou or Galileo.

In order to achieve a positional accuracy of **±1cm** so-called correction data is used which is generated by a (usually locally fixed) Base Station. The correction data fundamentally is the difference between an exactly known and currently detected GPS/GNSS position of Base Station and is caused by ionospheric errors and thus are responsible for the GPS/GNSS position deviations between actual position and detected position of GPS/GNSS receivers. The errors affect all GPS/GNSS signals in a given area equally (~ radius 20 km around Base Station).

Via the RTCM Link the RTCM (Radio Technical Commission for Maritime services) correction data is transferred from Base Station to the moving GPS/GNSS receivers called Rovers. By internally applying it in Rovers to the received GPS/GNSS positions, the Rovers positional accuracy is reduced to **±1cm.**

A GPS/GNSS RTK system consists of the following components:

Glossary	
Base Station	A GPS/GNSS receiver for acquiring correction data
RTCM Link	A medium to transport the correction data stream from the **Base Station** to the **Rover**
Rover	Moving GPS/GNSS receiver which uses correction data to increase the accuracy of position data up to (**±1cm**)!



Similar to the normal reception of GNSS satellite signals, the transmission time and thus the distance between satellite and GNSS antenna is also determined, but with RTK the sinusoidal signal transmitted by the satellite is evaluated for the current carrier phase of this signal. Therefore, the accuracy of transmission time is highly increased, what results in high accurate distance between satellite and module! If the now more precise distance between satellite and GNSS antenna is received by several satellites, the position of the GNSS antenna can be determined via triangulation, as with the usual GPS/GNSS, with RTK to a positional accuracy of **±1cm**.

When using RTK, the external conditions (shielding of the satellite signal by houses, trees, ...) as well as the weather conditions (sunny, cloudy, ...) play an even greater role than with normal GNSS antennas, since these external influences degrade the received sinusoidal signal and thus make carrier phase detection more difficult.

8.1 RTK applications

As soon as **highest positioning accuracy in dynamic situations** is necessary, it is recommended to use the 10 Hz RTK module with correction data to achieve a positioning accuracy of up to one centimetre. However, precision is not only the most important point when using GNSS, especially at brake/acceleration tests, racing and other sports it is also important for also having good dynamical capabilities of GNSS.

The 2D RTK Rovers are suitable for applications **with normal dynamic requirements** and **laptiming via GNSS**, like the normal 10 Hz modules.
For RTK use a good antenna mounting is necessary as RTK operation require higher signal quality.

Due to their very small and robust design and the antennas connected via cables, the 2D RTK modules (2D mobile RTK Base Station & 2D RTK Rover) can also be used very well in applications with very limited installation space. The use of up to two antennas on one rover or the use of several individual rovers in conjunction with the 2D analysis software allows a wide range of applications to be realized!

Automotive

- Tests and validation of Advanced Driver Assistance Systems (ADAS)

With two individual 2D-RTK-Rovers (**two antennas** on **two vehicles**) the directional vector between them can be calculated with 1 cm accuracy up to 250 km/h, due to 2D's proprietary GPS/GNSS position correction algorithm, e.g., for active cruise control validation.

- Slide slip angle

With Rover with two 2D-RTK-antennas (**two antennas** on **one vehicle**) the directional vector between them can be calculated with 1 cm accuracy up to 250 km/h, due to 2D's proprietary GPS/GNSS position correction algorithm, e.g., for slide slip angle calculations

- Vehicles inclination/tilting while driving

With Rover with two 2D-RTK-antennas (**two antennas** on **one vehicle**)

- Full three-dimensional trace of driving line

Racing

- High accuracy driving line analysis
- Distance to Apex calculation
- Track limit calculations
- Jump height detection (Motocross)

Industrial

- Bending of crane booms under load
- Load positioning (ships, forklifts, cranes, …)
- Ship loadings
- Autonomous vehicles/objects

8.2 RTK components

8.2.1 Base Station

Base stations generally consist of a RTK GPS/GNSS receiver that detects the current GPS/GNSS position and compares it to the actually known position of the base station to create what is called correction data. Simply, the correction data is the difference between the known position and the detected position, which is caused by various types of errors in the GPS/GNSS signals and affects all GPS/GNSS signals in a given area, and thus also the signals received by Rovers. The errors are responsible for the GPS/GNSS position deviations.

Through an interface, this correction data is transmitted in a standardized data transfer format called *RTCM* (Radio Technical Commission for Maritime services) to the Rover(s) to improve their positional accuracy.

2D offers its own mobile base stations (Datasheet), which are very easy to set up, can be easily transported and be used as stationary as well as moving Base Station!

Normally 2D mobile (transportable) Base Stations are used at serval testing grounds and thus are not mounted fix on one point. Therefore, it can work in Survey Mode to use the connected GPS/GNSS antenna to detect its own position from this GPS/GNSS data and use it as “known position” for creating correction data.

Glossary	
Correction data	Created by Base Stations to correct errors applied to GPS/GNSS signals due to ionospheric errors. Correction data is only valid around 40 km around respective Base Station and transferred via RTK Link to Rover(s) in a standardized data transfer format called *RTCM* (Radio Technical Commission for Maritime services).
Public Base Station	Public institutions such as universities or other research facilities often provide correction data from their own surveyed base stations for a fee.
2D mobile Base Station	2D offers its own mobile base station with its own power supply due to its robust, waterproof and compact design. Can be used as stationary but easily transportable Base Station when RTK should also be available far away from other (public) Base Stations. By Survey Mode own position is detected as “known position”.
Survey Mode	Detecting static GPS/GNSS position of Base Station over longer time period (e.g., 5 minutes) to use the position as “known position”.

8.3 RTCM Link

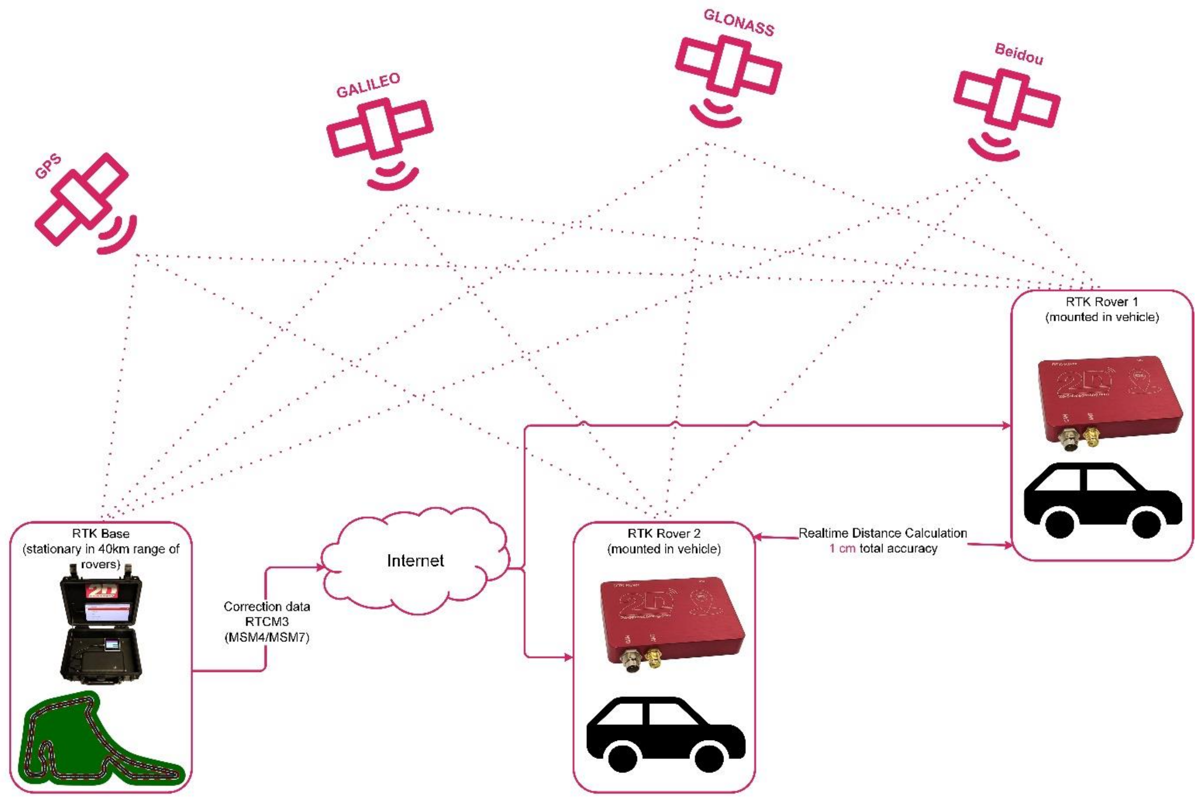
RTCM link is a medium to transport the correction data stream from the **Base Station** to the **Rover(s)**.

At 2D Base Stations basically three options are available to transfer correction data:

- Transfer via **Internet**
- Transfer via **Radio Frequency (RF)** (1-20 km, depends on local restrictions)
- Transfer via **direct Wi-Fi link** (< 250 m)

8.3.1 Via Internet

Both the 2D Base Station and 2D RTK Rover modules have built-in Wi-Fi that can be set via a user interface to connect each module to a local Wi-Fi or mobile hotspot (multiple Wi-Fi connections configurable) to upload (Base Station) or download (2D RTK Rover) correction data to a 2D-hosted Internet server to establish the RTCM link via internet between Base Station and Rover(s).



8.3.2 Via Radio Frequency (RF)

Also, 2D Base Station and 2D RTK Rover both have the option to use 433/866/2400 MHz radio frequency transmission for transferring correction data from Base Station to Rover(s) for local operation up to 20 km operation radius, without requiring any internet connection at all. Use of RF depends on local restrictions.

8.3.3 Via direct Wi-Fi link

Instead of transferring correction data via RF in local operation without any internet connection, also the Wi-Fi interfaces of the 2D modules can be used in combination with external antennas to set up the RTCM Link via Wi-Fi point-to-point connection (< 250 m) via 2D Base Station and 2D RTK Rover(s).

8.4 Rover

GPS/GNSS receiver which uses the received correction data to increase the accuracy of their position data up to **±1cm**! The 2D-RTK-Rover(s) must be connected to RTK Link to receive correction data which is applied online in module to the received GPS/GNSS signals to achieve the high accuracy.

Also, **without** suppling correction data the RTK GPS/GNSS module they can be used as normal GPS/GNSS receivers with general positional GPS/GNSS accuracy.

The outstanding small and very robust design of the 2D-RTK-Rover (Datasheet) also makes it suitable for projects with very limited installation space like motorcycles or mountain bikes. The actual RTK GPS/GNSS antenna can also be mounted very well outside the vehicle or at exposed locations of the test vehicle via the cable connection to the actual rover module (up to 5 m cable possible).

2D Rovers also accept correction data provided by publicly operated base stations (e.g., RTK2GO) can also be used.

8.4.1 2D-RTK-Rover-Types

2D-RTK-Rover via CAN (Datasheet)	
RTCM Link	To receive correction data the module can be connected to internet via the built-in Wi-Fi to receive the correction data from server hosted by 2D or using a RF antenna.
Processing	The correction data is applied online in Rover to the received GPS/GNSS signals to achieve the high accuracy.
Output	2D-RTK-Rover outputs the already corrected GPS/GNSS data as normal as CAN messages on CAN-bus to log them in any 2D Logger. 2D-RTK-Rover with CAN-output can be connected to any point of CAN-bus system.
GNSS-Rate	10 Hz (GPS, Glonass, Galileo, Beidou)
Comment	2D-RTK-Rover offers the possibility to connect 2 antennas, so with **two antennas** on **one vehicle** the directional vector can be calculated, e.g., for slide slip angle measurement.

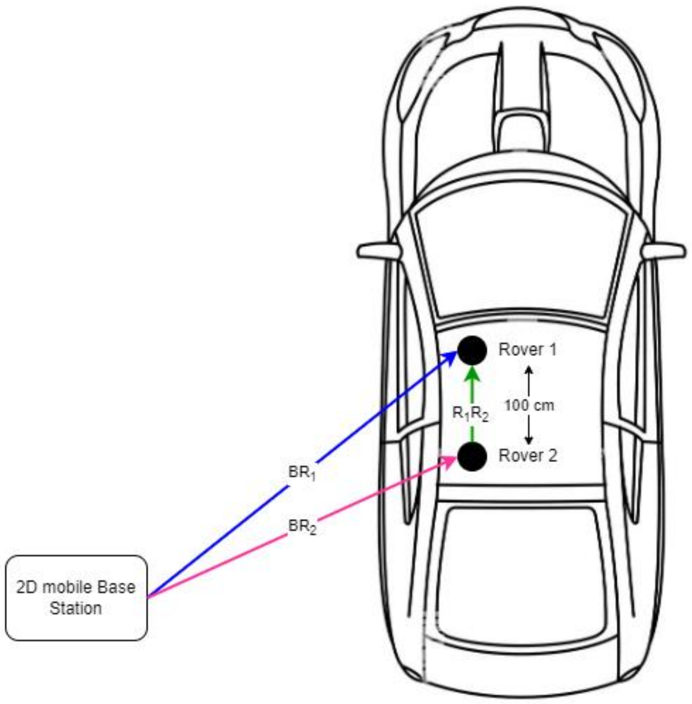
2D-RTK-Rover via serial Port (e.g. Sticklogger V4w RTK)	
RTCM Link	As interface to RTCM Link a Sticklogger with internal Wi-Fi interface (e.g., SLV4w RTK) can be used which hotspot is connected to internet to receive correction data and directly apply it to on serial port incoming GPS/GNSS data.
Processing	The correction data is applied online in Sticklogger to the received GPS/GNSS signals to achieve the high accuracy.
Output	Sticklogger V4w RTK directly stored corrected GPS/GNSS data.
GNSS-Rate	10 Hz (GPS, Glonass, Galileo, Beidou)
Comment	All in one logging and RTK module with all known Sticklogger functionalities

Further Information
Please contact 2D via email mail@2d-datarecording.com for customized advice on the 2D RTK Rover module that is right for your application!

8.4.2 Base line vector between two Rovers (Proof of Concept)

In 2D-Rover-Systems various channels are available as well as distance channels which are providing the current distance (as vector **BR_1** & **BR_2**) between Rover and Base Station. By having all distances of Rovers to Base Station (no matter if moving or stationary) also the vector **R_1R_2** between the Rovers and thus the distance can be calculated with a +/- 1 cm accuracy.

For testing two individual 2D RTK Rover systems were placed on a car´s roof with a distance of 100 cm (base line) between the Rover antennas:

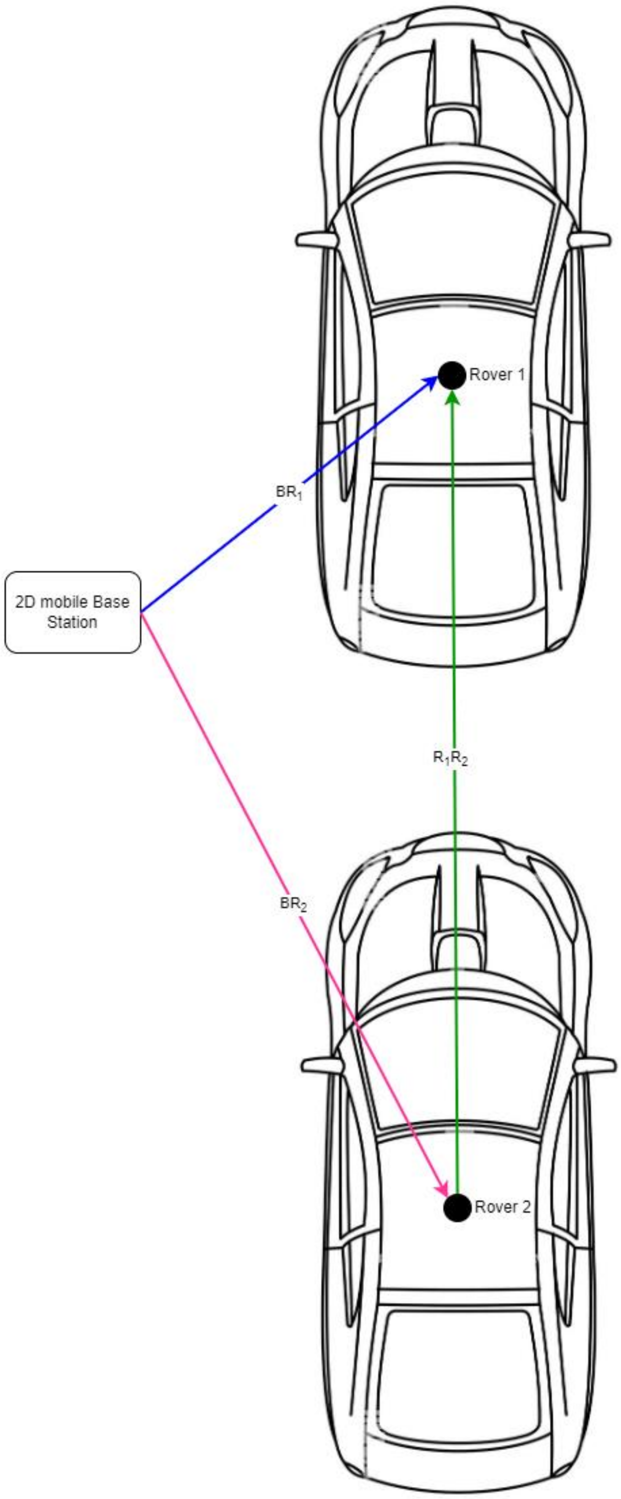


Under real urban driving conditions without houses, trees and bridges 2D RTK system is able to determine the distance between two GNSS modules (rovers) with an accuracy of base line of almost +/- 1 cm up to a speed of 300 km/h.

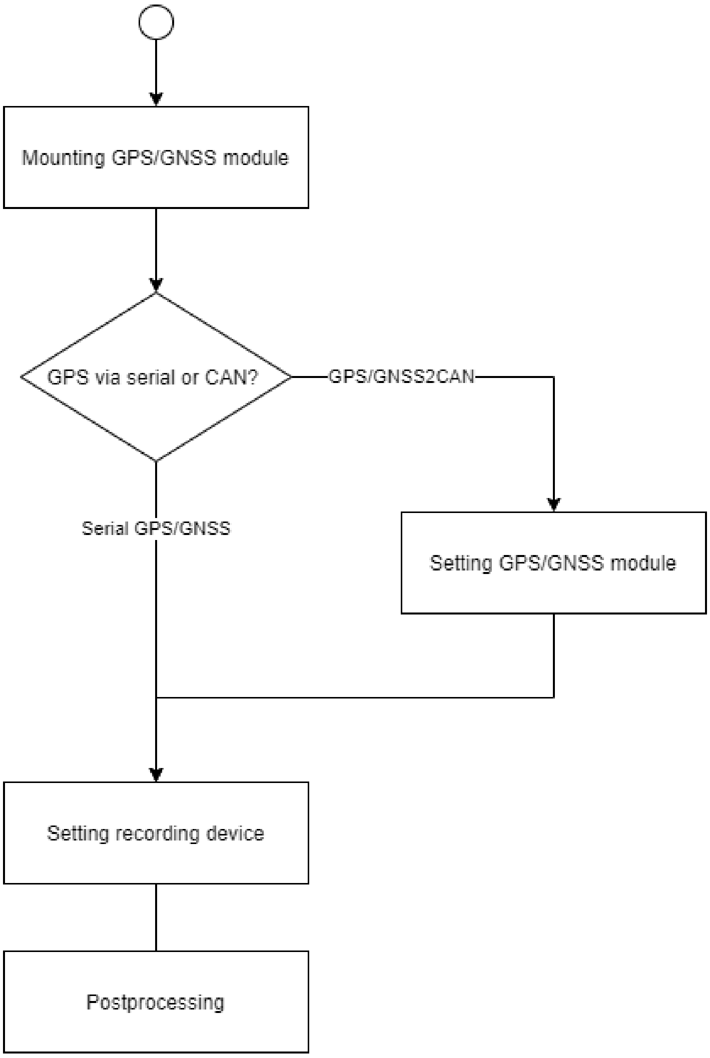
8.4.3 ADAS setup

This proof of concept is transferrable to the application when the two Rovers are **not** placed on same vehicle like in ADAS tests.

By knowing the position of Rovers on vehicle all distances between different points of cars chassis can be calculated:



9 Checklist



Mounting instructions

Available Modules

SETTING instructions GPS/GNSS modules

RECORDING instructions

GPS post-processing

10 MOUNTING instructions

In general, the correct mounting of GNSS modules must be observed in order to obtain a usable measurement result.

Further Information
External influences such as engine vibrations, road surface, a wobbly mounting or signal reflections from buildings or trees have a particularly strong effect on the quality of the measurement result!

Basically, the output, raw speed of the GPS/GNSS module is a result of the current vehicle speed, the speed of movement of the vehicle due to e.g., pitching movements when braking and the speed caused by inherent movements of the GPS/GNSS module due to poor installation.

The latter can be caused by vibrations of the poorly mounted module or incorrect values caused by the speed of the GNSS module's own movement e.g., due to the tilting movement of the module during heavy braking.

Important information
Due to the high dynamics of the 2D GPS/GNSS modules, the movements of an incorrectly mounted module can already superimpose the actual movements of the vehicle!

In general, it is important to know, that the higher the dynamic range of a receiver, the more an modules movement becomes visible as noise. But a slow module will be equally disturbed!

It is very important that the GPS/GNSS module must have clear view to the sky to get the best possible GPS/GNSS satellite reception!

It is recommended that the module be mounted **evenly** on a **solid metal plate** using high quality **double-sided tape** at a location on the vehicle that is not shielded from other parts of the vehicle.

Thereby three advantages are gained:

1. A metal plate or carbon fibre parts are acting as an "amplifier" and strongly improves the GPS/GNSS signal reception.

   Further Information
   If no metal plate or carbon fibre is used as mounting base, a self-adhesive ground plane for GPS modules (AC-GPS_ground_plane-000) must be used.

2. Much better mounting possibilities are achieved when using a metal plate because the antenna can be mounted even and fix on the plate with double-sided adhesive tape to reduce movements of the antenna itself
3. By fixed mounting on plate the mass of the antenna is increased and thereby the impact of external vibrations on GPS-chip is greatly decreased

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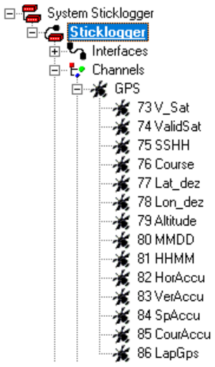
11 Channels

11.1 Online GPS/GNSS channels

As it will be obvious from the following overviews, the GPS/GNSS2CAN and serial GPS/GNSS modules have different numbers of GPS channels available for online use.



After being read into *WinIt*, each 2D module is displayed in the system tree according to the same scheme, with the *Channels* group divided into the respective available groups.

There is also a prepared group for the GPS channels on each 2D module, which can process a certain selection of GPS channels.

This GPS group was created so that the GPS channels are always recorded in the same way, regardless of whether they are received via a GPS/GNSS2CAN or serial GPS/GNSS module.

Important information
The switch between CAN and serial recording must be changed at only one point in the setting of the **recording** device and is explained in chapter 13.

Important information
Regarding the GPS/GNSS-postprocessing channels, there is no difference between GPS/GNSS2CAN or serial GPS/GNSS! For more information, please see

Documentation reference
For more information about **GPS/GNSS postprocessing** please see the respective manual on 2D website:
http://2d-datarecording.com/downloads/manuals/

Since there are fewer channels recorded in the GPS group than in the GPS/GNSS2can module, for example, both GPS/GNSS2CAN and the serial GPS/GNSS modules are available to record the remaining channels as well:

GPS/GNSS2CAN modules:
Each GPS/GNSS channels from GPS/GNSS2CAN module can be recorded as CAN-IN channels and can be send to the **recording** device via right-click and option *Send to*.

Documentation reference
For more information about sending and receiving CAN-channels please see the manual **XXX** on 2D website:
http://2d-datarecording.com/downloads/manuals/

Serial GPS/GNSS modules:
For some GPS channels of the serial modules, there are separate CALC commands via which the respective GPS channels are available online via the CALC channels.

Documentation reference
For more information about CALC channels and GPS-CALC-commands please see the manual **Online Calculation Channels** on 2D website:
http://2d-datarecording.com/downloads/manuals/

11.1.1 GPS/GNSS2CAN

Name	Dimension	Sensor Info	GPS group	CALC
V_Sat	km/h	GPS speed over ground		
ValidSat	-	Visible satellites		
SSHH	s	Seconds:Hundredth		
Course	deg	Moving direction		
Lat_dez	deg	Position in dezimal degree		
Lon_dez	deg	Position in dezimal degree		
Altitude	m	m above sea level		
MMDD	-	Month:Day		
HHMM	-	Hour:Minute		
HorAccu	m	Accuracy horizontal position		
VerAccu	m	Accuracy vertical position		
SpAccu	km/h	Accuracy of speed		
CourAccu	deg	Accuracy of course		
Speed_N	km/h	Speed N/S		
Speed_E	km/h	Speed E/W		
Speed_D	km/h	Speed up/down		
Speed_3d	km/h	Speed 3D		
HDOP		DOP horizontal		
GDOP		DOP geometrical		
PDOP		DOP position		
VDOP		DOP vertical		
Year	-	Date year		
Month	-	Date month		
Day	-	Date day		
Hour	h	Date hour		
Minute	min	Date minute		
Second	s	Date second		
hSec	hs	Date hsec		
n.u.		Position in minutes of degree		
Lat_deg	deg	Position in minutes of degree		
Lon_deg	deg	Position in dezimal degree - signed		
Lat_dezs	deg	Position in dezimal degree - signed		
Lon_dezs	deg	Calculated lateral acceleration		
A_Lat	m/s²	Calculated longitudinal acceleration		
A_Lon	m/s²	Calculated lean angle		
Banking	deg	Calculated yaw speed		
LapGps	-	GPS-Laptrigger information		
iToW	s	Integer Time of Week		
fToW	ns	Fraction Time of Week		
GPSweek		GPS week		
GPSLeapSecond		GPS LeapSecond (Difference to UTC)		

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11.1.2 Serial GPS/GNSS

Name	Dimension	Sensor Info	GPS group	CALC
V_Sat	km/h	GPS speed over ground		
ValidSat	-	Visible satellites		
SSHH	s	Seconds:Hundredth		
Course	deg	Moving direction		
Lat_dez	deg	Position in dezimal degree		
Lon_dez	deg	Position in dezimal degree		
Altitude	m	m above sea level		
MMDD	-	Month:Day		
HHMM	-	Hour:Minute		
HorAccu	m	Accuracy horizontal position		
VerAccu	m	Accuracy vertical position		
SpAccu	km/h	Accuracy of speed		
CourAccu	deg	Accuracy of course		
Speed_N	km/h	Speed N/S		
Speed_E	km/h	Speed E/W		
Speed_D	km/h	Speed up/down		
Speed_3d	km/h	Speed 3D		
LapGps	-	GPS-Laptrigger information		
iToW	s	Integer Time of Week		
fToW	ns	Fraction Time of Week		
GPSweek		GPS week		
GPSLeapSecond		GPS LeapSecond (Difference to UTC)		

11.1.3 Post-processing

Name	Dimension	Sensor Info
V_Sat	km/h	GPS speed over ground
ValidSat	-	Visible satellites
SSHH	s	Seconds:Hundredth
Course	deg	Moving direction
Longitude	deg	Position in dezimal degree
Latitude	deg	Position in dezimal degree
Altitude	m	m above sea level
MMDD	-	Month:Day
HHMM	-	Hour:Minute
HorAccu	m	Accuracy horizontal position
VerAccu	m	Accuracy vertical position
SpAccu	km/h	Accuracy of speed
CourAccu	deg	Accuracy of course
Speed_N	km/h	Speed N/S
Speed_E	km/h	Speed E/W
Speed_D	km/h	Speed up/down
Speed_3d	km/h	Speed 3D
HDOP		DOP horizontal
GDOP		DOP geometrical
PDOP		DOP position
VDOP		DOP vertical
Year	-	Date year
Month	-	Date month
Day	-	Date day
Hour	h	Date hour
Minute	min	Date minute
Second	s	Date second
hSec	hs	Date hsec
n.u.		Position in minutes of degree
Lat_deg	deg	Position in minutes of degree
Lon_deg	deg	Position in dezimal degree - signed
Lat_dezs	deg	Position in dezimal degree - signed
Lon_dezs	deg	Calculated lateral acceleration
A_Lat	m/s²	Calculated longitudinal acceleration
A_Lon	m/s²	Calculated lean angle
Banking	deg	Calculated yaw speed
LapGps	-	GPS-Laptrigger information
iToW	s	Integer Time of Week
fToW	ns	Fraction Time of Week
GPSweek		GPS week
GPSLeapSecond		GPS LeapSecond (Difference to UTC)
V_GPS	km/h	GPS speed over ground
GPSValid	-	GPS valid information
GPS_Yaw	deg/s	Yaw-rate via GPS
Radius	m	Radius of corner
Curvature	1/m	Curvature of corner
A_Lon_GPS	m/s²	Longitudunal acceleration via GPS
A_Lat_GPS	m/s²	Lateral acceleration via GPS
Banking_GPS	deg	Banking via GPS
SOD	s	Seconds of Day

11.1.4 Channel descriptions

11.1.4.1 GPS/GNSS positioning channels

Lat_dez & Lon_dez are the positions in decimal degrees. Together with Altitude, a position on earth can be determined.

11.1.4.2 ValidSat

Outputs the number of currently received GPS/GNSS as combined information:

Integer number: Indicates valid GPS/GNSS reception with value > 0.

Decimal number: Indicates the number of currently visible GPS/GNSS satellites

$$Currently\ received\ satellites = (\#ValidSat - 1) * 10$$

ValidSat	Currently received satellites
0.05	0
1.5	5
1.7	7
2.0	10
2.8	18

Click here to check how many GNSS satellites are visible at your current location! Also use the filters on the left side of the *Charts* tab to see the improvement by using all GNSS satellites compared to only GPS satellites.

11.1.4.3 Time channels

The time channels MMDD, HHMM and SSHH are very important for adding time information to your measurement. The channels HHMM and SSHH are combined to a channel SOD (SecondOfDay) in post-processing.

Time information is required for *GoPro AutoSync* feature or synchronizing measurements.

Documentation reference
For more information about **GoPro AutoSync and GPS/GNSS post-processing** please see respective manuals on 2D website:
http://2d-datarecording.com/downloads/manuals/

11.1.4.4 GPS/GNSS laptrigger channel

Basically, GPS laptimes are created from a trigger channel *#LapGPS*, which reduces its value from 65535 the closer it gets to a defined position.

Documentation reference
For more information about **Laptimes via GPS coordinates** please see the respective manual on 2D website:
http://2d-datarecording.com/downloads/manuals/

11.1.4.5 Accuracy channels

When using 10 and 25 Hz GNSS modules, the GNSS chips are providing accuracy channels which can be used to identify the current signal quality of GPS/GNSS channels.

Difference to DOP (Dilution of Precision):

At the 2D module DOP precision analysis should no longer used because the 2D GPS/GNSS modules already provide GPS/GNSS accuracy channels for horizontal and vertical position, speed and course.

The big advantage is that 2D accuracy channels really describe the accuracy of the module itself, while the DOP describe only the positional accuracy of the currently available satellite constellation! So, DOP is a very general precision, whereby our accuracy channels are showing the individuality precisions of the antennas.

These two precision types can differ a lot!

Therefore, it is better to rely on our 2D accuracy channels, which are directly provided by the chip.

2D accuracy channels:

Name	CH-name	Unit	Description
Horizontal accuracy	HorAccu	[m]	Accuracy of horizontal position (Latitude & Longitude)
Vertical accuracy	VerAccu	[m]	Accuracy of vertical position (Altitude)
Speed accuracy	SpAccu	[km/h]	Accuracy of GPS/GNSS speed (V_Sat/V_GPS)
Course accuracy	CourAccu	[m]	Accuracy of GPS/GNSS course (Course)

Important information
All four accuracy channels only provide the values as absolute values! Therefore, their signals are only suitable for validating GPS/GNSS conditions during current situation, e.g., during brake tests.

Further Information
The four channels are updated with the respective rate of the GPS/GNSS module used.

When evaluating the accuracy of GPS/GNSS channels, it is always important to take into account the currently number of visible satellites (ValidSat → 11.1.4.2).

A major point of the changes to the GPS/GNSS modules in 2021 was that the number of satellites to be received was increased by new modules (25 Hz) or firmware updates (GPS2CAN: 12.5 Hz → 10 Hz).

Further Information

Number of visible satellites used for positional detection under perfect conditions at 2D GPS/GNSS modules:

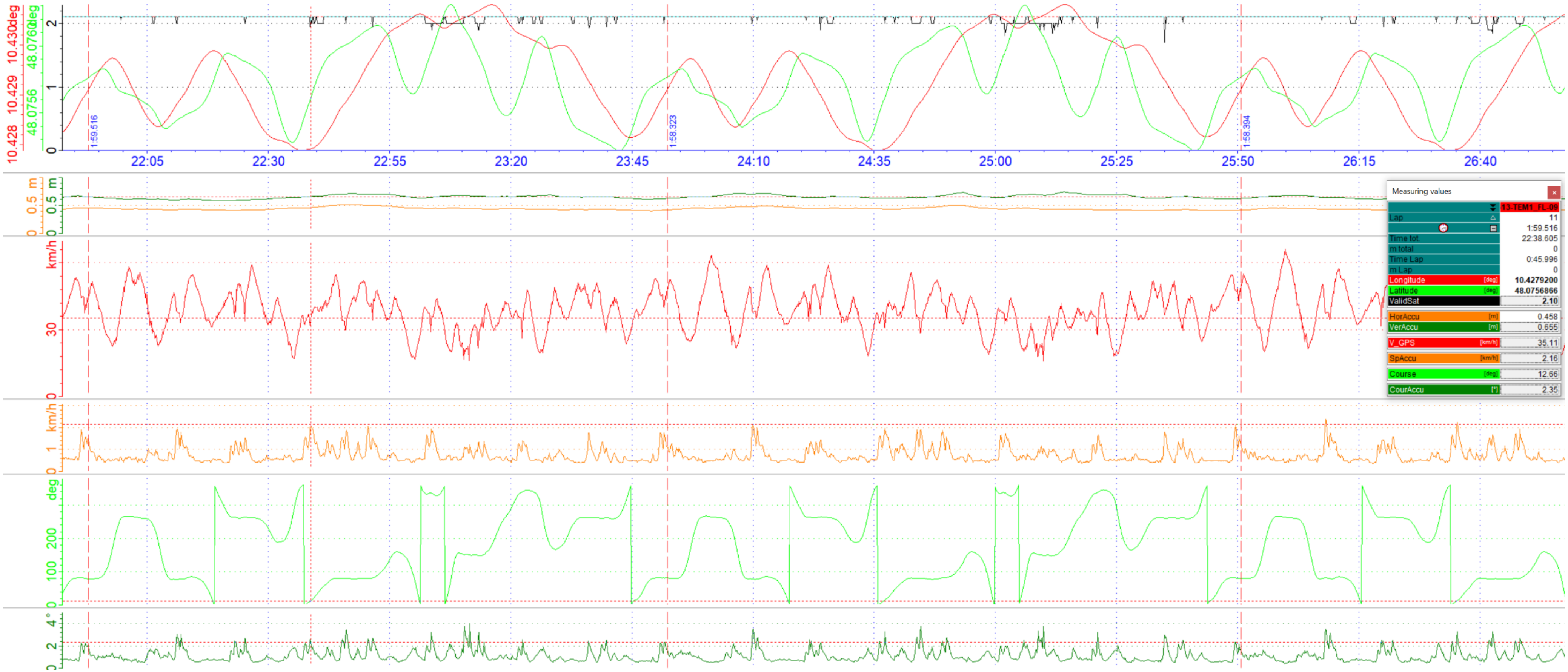
Old 12.5 Hz Firmware	(GPS only):	10 – 12 satellites	(max. ValidSat= 2.2)
10 Hz	(multiple GNSS):	32 satellites	(max. ValidSat= 3.2)
25 Hz	(multiple GNSS):	16 strongest satellites	(max. ValidSat= 2.6)

⇨ This information is valid for serial and CAN GPS/GNSS modules!

Documentation reference

For more information about all new GPS/GNSS modules please see descriptions
New 2D GPS/GNSS CAN Modules 2021 and **Revision of GNSS modules**
http://2d-datarecording.com/downloads/manuals/

Losing some satellites at a higher number of visible satellites (around 15 visible satellites) has a smaller impact on GPS/GNSS accuracy then losing some satellites on low number of visible satellites (normal conditions with GPS only: 6-9 visible satellites)!



The shown screenshot shows a GPS/GNSS measurement with 25 Hz antenna with normal GPS/GNSS conditions (approx. 12 visible satellites) on Motocross racing track with lap by lap repetition of "accuracy" events by trees or buildings. All accuracies are within the usual limits!

Used scaling of accuracy channels:

HorAccu & VerAccu: 0-1 m

SpAccu 0-3 km/h

CourAccu: 0-5 degrees

12 SETTING instructions GPS/GNSS modules

12.1 *SIO (via serial)*

Important information

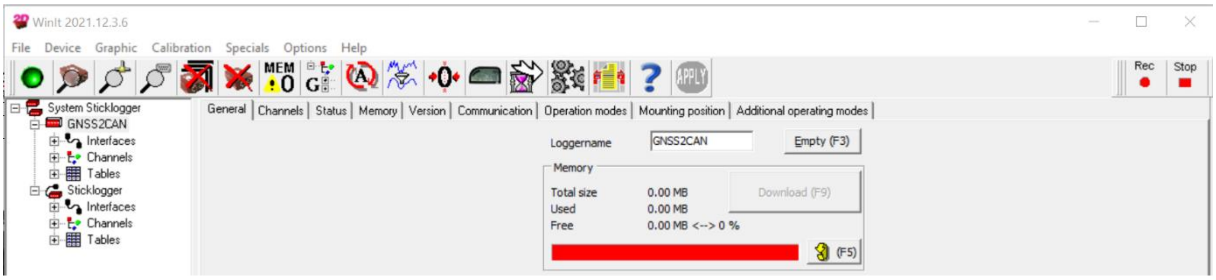
Operation mode of the serial GPS/GNSS module is managed via setting of **recording** device (chapter 13)!

12.2 *Setting GPS/GNSS2CAN module (via CAN)*

For setting the GPS/GNSS2CAN modules a logger, e.g. Sticklogger, for communication.

Important information

The following steps can only be executed in GPS/GNSS2CAN modules!



12.2.1 General

Select name of GPS/GNSS module.

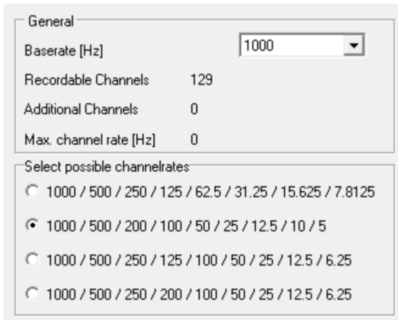
12.2.2 Channels

The <u>Baserate</u> and different *possible channelrates* can be set here.

Both parameters depend on the later use.

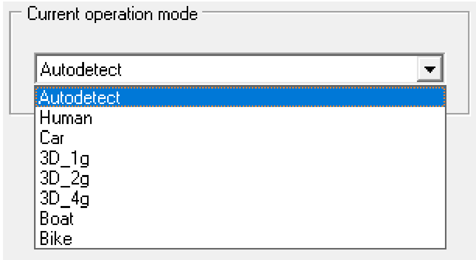
<u>*Example:*</u>

With 10 Hz antenna a graduation with a possible rate of 10 Hz must be chosen.



12.2.3 Operation modes/GPS Mode

In this menu, the dynamic model of the vehicle used at respective test can be chosen via the operation modes.



The different available modes also have an influence on the performance of the GNSS module and thus on the accuracy of the position detection. Therefore, the selection of the correct mode is very important for the later use of the module!

2D suggestion
Not all modes are available at all GPS/GNSS modules and antennas.

Furthermore, at the different modes the filtering the non-relevant axes (*Car* and *Boat*) are filtered more strongly, with *3D_...* the same filtering is available for all three axes.

Important information
For the different modes there are certain limits for the range of use, which depend on speed & altitude or altitude only. The module should therefore always be operated within the respective limits to ensure correct position detection.

2D suggestions:

GPS Mode	Areas of application
Human	Walking
Car	Car/Automotive testing in urban environment, street and race bikes with lower dynamics
Boat	Maritime watercrafts
Bike (if available)	Race bike on track, Street bikes, Scooters, Mountain biking, Skiing
3D_1g (if Bike not available)	Professional Race cars and race bikes on track with higher dynamics, Scooters, Mountain biking, Skiing (all with good GPS/GNSS conditions)
3D_2g	Propeller-driven airplanes
3D_4g	Jet planes
10 Hz KIT antennas should always be used on Mode *AutoDetect*	

2D suggestion
For all other special applications please contact 2D via **contact form**.

Human:
Applications with low acceleration and speed, e.g., how a pedestrian would move.
Low acceleration assumed.

Max. horizontal speed:	30 m/s
Max. vertical speed:	20 m/s
Max. altitude:	9000 m

Car:
Used for application with equivalent dynamics to those of a passenger car.
Low vertical acceleration assumed.

Max. horizontal speed:	100 m/s
Max. vertical speed:	15 m/s
Max. altitude:	6000 m

Boat:
Recommended for applications at sea, with zero vertical acceleration.

Max. horizontal speed:	25 m/s
Max. vertical speed:	5 m/s
Max. altitude:	500m

Bike: (not available at every GPS/GNSS antenna)
Used for applications with equivalent dynamics to those of a motor bike. Low vertical acceleration assumed.

Max. horizontal speed:	100 m/s
Max. vertical speed:	15 m/s
Max. altitude:	6000 m

3D_1g:
Used for application with a higher dynamic range and greater vertical acceleration than a passenger car.

Max. altitude:	50000 m

3D_2g:
Recommended for typical airborne environments.

Max. altitude:	50000 m

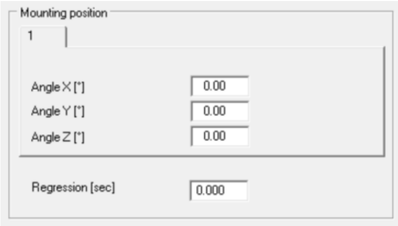
3D_4g:
Only recommend for extremely dynamic environments.

Max. altitude:	50000 m

12.2.4 Mounting position correction for IMU orientation system

For changing of orientation of 6(9)DoF-IMU the mounting position can be adjusted online via three angles entered at the modules *Mounting position* tab in *WinIt*.

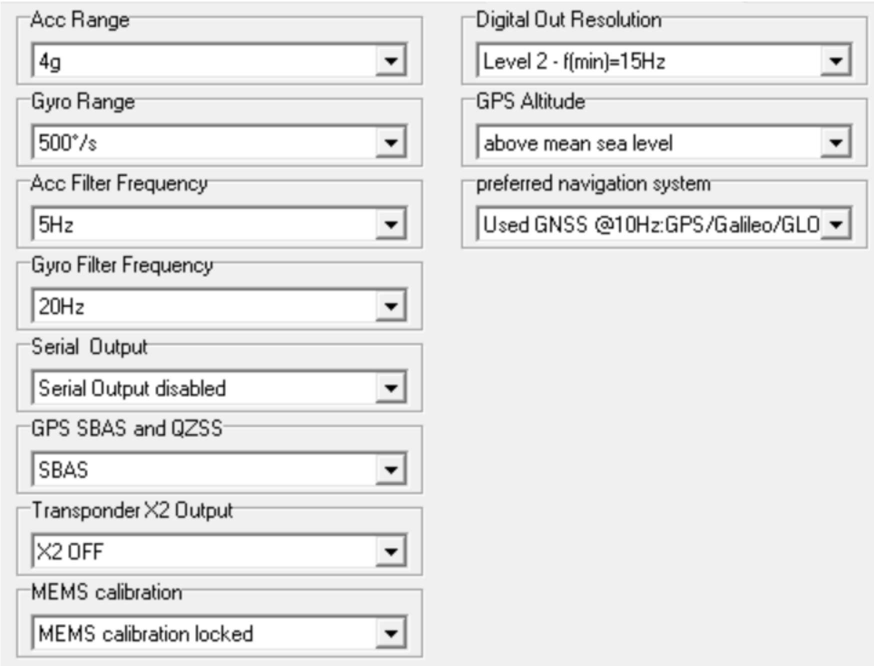
With this function, not only can the IMU alignment be leveled at non-levelled mounting positions, but the alignment can be changed online to any desired orientation during use.



Important information
If required, it is better to adjust orientation of IMU channels in post-processing via *CALC Tool*!
2D also offers a toolchain called *2D_FilterAndRotate* for special IMU-based projects, which includes freely configurable rotation corrections and/or filtering in post-processing.
For special IMU based projects please contact 2D via **contact form** for more information.

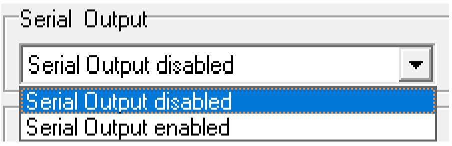
Documentation reference
For more information about ***2D_FilterAndRotate*** toolchain please see respective manual on 2D website: http://2d-datarecording.com/downloads/manuals/

12.2.5 Additional operating modes



12.2.5.1 Serial Output

The *Serial Output* function should always be set to **disabled** as it is no longer used!



12.2.5.2 Augmentation systems – GPS SBAS and GZSS

In order to improve the accuracy of GNSS reception, additional systems (SBAS – Satellite Based Augmentation Systems) have been set up, which are mainly intended to eliminate ionospheric errors in GNSS reception.

For this purpose, several geostationary satellites permanently transmit the correction values for the ionospheric error measured by reference stations.

The following errors can be compensated for with SBAS systems:

- Errors of the satellite clocks
- Satellite orbit errors
- Ionospheric errors
- Errors due to operational disturbances of individual satellites

Further Information
Selection *SBAS* covers augmentation systems WAAS (North America) and EGNOS (Europe)

12.2.5.3 Transponder X2 Output

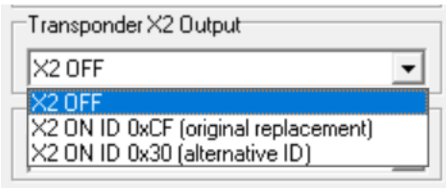
The TransponderX2 system is used in many racing classes for lap and section timing and for further communication between race control and the drivers.

For this purpose, the transmit and receive loops are embedded in the asphalt on many tracks.

The interaction of the transponder with the embedded loops can then be used to create lap or section times in 2D system via the TransponderX2.

For teams using **TransponderX2** and Laptiming **via GPS** alternately, the GPS/GNSS2CAN module is able to create **laptrigger signals as normally via GPS coordinates** but sends laptrigger signal on TransponderX2-CAN-Identifier to simulate the TransponderX2 module.

Thereby, the GPS/GNSS2CAN imitates a TransponderX2 module on CAN-bus but still generating laptrigger signals via GPS coordinates!



With this feature when switching between the two laptiming generation options only the modules must be connected or disconnected respectively!

Please see chapter 15.1 how to setup the modules for the previously describe functionality.

Important information
This function is called Transponder X2 Output and has been implemented in the GPS/GNSS2CAN module only!
It must be ensured that TranponderX2 setting is correct!

Further Information
For easy switching between the two laptime generation options, an adapter cable can be purchased from 2D to connect the GPS/GNSS2CAN module to the system's designated TransponderX2 connector.

Documentation reference
For more information about laptiming via GPS/GNSS coordinates or TransponderX2 please see the respective manuals on 2D website:
http://2d-datarecording.com/downloads/manuals/

Creating and analysing laptimes is also possible in post-processing via Analyzer.

Documentation reference
For more information about **Laptiming via Analyzer** coordinates please see the respective manual on 2D website:
http://2d-datarecording.com/downloads/manuals/

Documentation reference
The Transponder X2 can be purchased via the **Mylaps** website https://www.mylaps.com/

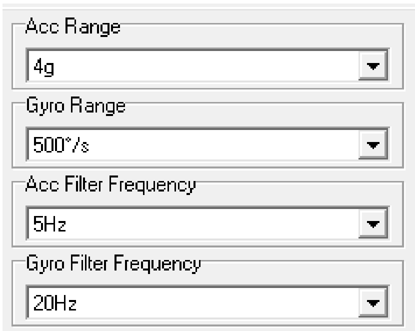
12.2.5.4 Accelerometer and Gyroscope settings

The IMU built into the GPS/GNSS2CAN is a 6(9)DoF (6 Degrees of Freedom) IMU (Inertial Measurement Unit), which means that the acceleration and rotation rates are measured each via three axes. The IMU channels are located in the *Analog* group of the respective 2D module and can be send to a 2D recording device for logging.

Beside the Accelerometer and Gyroscope, the modules also provide Magnetometer channels of all three axis.

Documentation reference
For more information about IMU please see the respective manuals
http://2d-datarecording.com/downloads/manuals/

The parameters of the accelerometer and gyroscope can be set in *Additional operating modes* menu where different ranges and Filter frequencies can be set for accelerometer as well as for gyroscope.



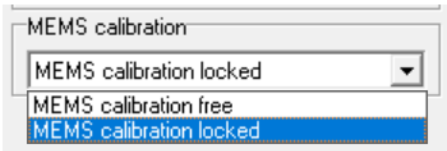
The settings of the IMU strongly depends on the application!

Important information
Not every 2D module is able to use the accerelormeter range 32g.
If not usable the module enters the maximum range automatically after pressing <***Apply***>.

2D suggestion
2D suggest for car or truck testings with good, vibration free mounting to use Acc Range 2g or 4g.
For bikes 16 or if available 32 g should be used to avoid clipping of the accelerometer channels due to high vibrations of the bike.

Important information
When Magnetometer is used, only Gyro Filter frequencies of 150 Hz and lower should be used because otherwise Magnetometer will be deactived!

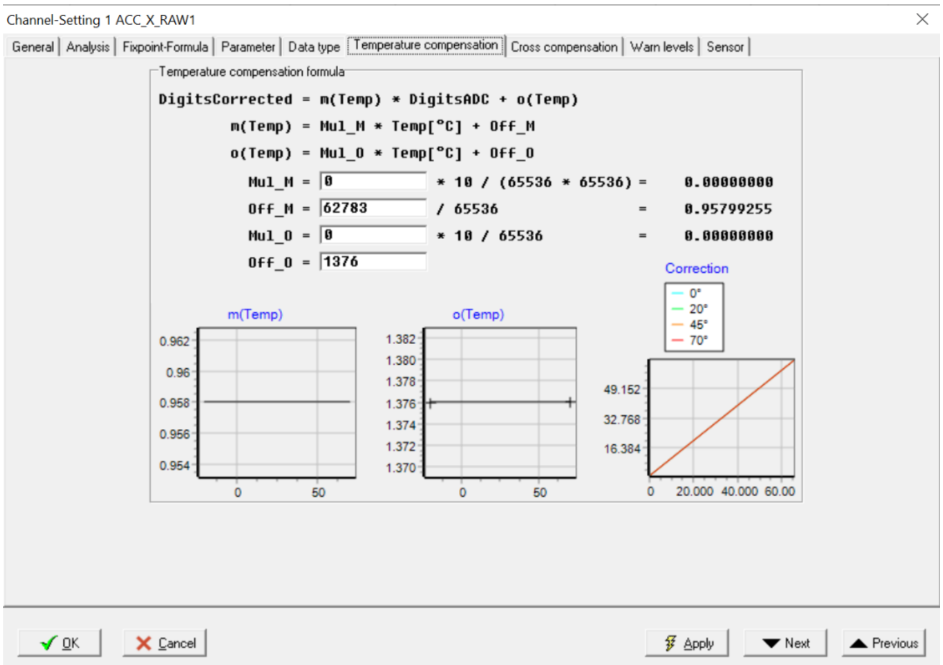
12.2.5.5 MEMS calibration



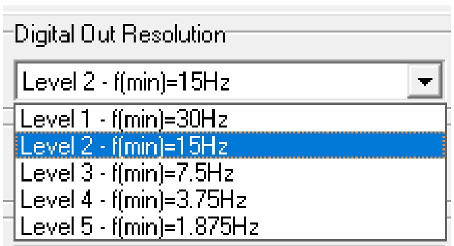
Via the Channel-settings of the Analog-IMU channels of GPS/GNSS2CAN different parameters like the Temperature compensation or Cross compensation can be freely adjusted by the user to manually calibrate the IMU.

Calibrating the IMU manually is only possible if “MEMS calibration free” is selected.

Important information
As manual calibration is a very demanding task, automatic calibration is performed automatically if the drop-down menu is set to "MEMS calibration locked".
Users should no change from locked to free MEMS calibration!



12.2.5.6 Digital Out Resolution



this function is important when the GPS/GNSS2CAN module outputs the GPS/GNSS speed via digital pulses to imitate a wheel speed sensor.

Important information
The respective frequency f(min) depends on the speed range to be covered!

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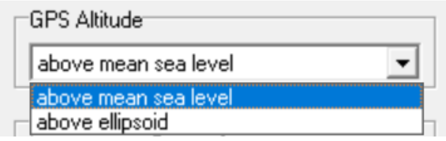
12.2.5.7 *GPS Altitude*

Two different altitude values can be outputed from GPS/GNSS modules which can be selected via the drop-down menu.



Altitude above ellipsoid

The simplest basis for two dimensional positioning and height determination is the so-called WGS84 ellipsoid, which is a simple mathematically determined ellipse of rotation that comes closest to the basic shape of the earth's sphere.

The ellipsoidal height is the height vertically above the reference ellipsoid that approximates the Earth's surface.

Altitude above sea level

To determine the *Altitude above sea level*, the geoid is used, which can be regarded as a gravity model of the earth and can thus approximate the actual elevations and depressions of the earth's surface better than the ideal model of the earth as an ellipse.

The surface of a geoid thus represents the Mean Sea Level (MSL), i.e. the presumed sea surface if there were no tides, winds and other factors influencing the movements of the sea. The only factor that influences the shape of the MSL is the Earth's gravitational field.

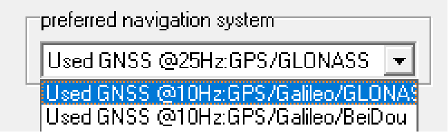
Further Information
The use of *Altitude over mean sea level* is more suitable for local Altitude determinations than *Altitude over.*

12.2.5.8 *Preferred navigation system*

***** More information will be available soon *****

This dropdown menu is only important at RTK functionaltiy!

Via dropdown menu, different combinations for the GPS/GNSS modules can be chosen:



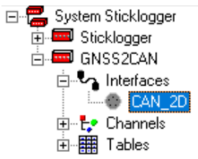
13 RECORDING instructions

13.1 GPS/GNSS2CAN module

If the factory setting of the GPS/GNSS2CAN module has not been changed, no extra setting changes must be made on this device in order to record the GPS channels in the **recording** device.

Further Information
At all 2D modules the user is able to change the CAN-Send-Identifier of each channel via the group *Interface* which can be found on *WinIt* system tree.

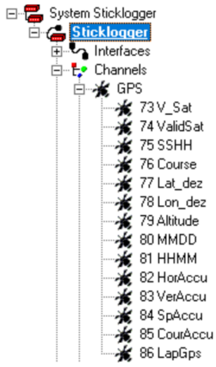
The Send-IDs of the GPS channels are from #790 onwards by default!



Base	0x790	Default	V_Sat	ValidSat	SSHH	Course
Base	0x791	Default	Lat_dez		Lon_dez	
Base	0x792	Default	Altitude		MMDD	HHMM
Base	0x793	Default	HorAccu	VerAccu	SpAccu	CourAccu
Base	0x794	Default	Speed_N	Speed_E	Speed_D	Speed_3d

13.2 Recording device

Further Information
Serial GPS/GNSS modules are not shown in the system tree because only CAN-devices are shown.
GPS/GNSS2CAN modules can only be read into *Winit* by using a communication device (Logger, Dashboard, USB2CAN, WIFI2CAN, …).



After being read into *WinIt*, each 2D module is displayed in the system tree according to the same scheme, with the *Channels* group divided into the respective available groups.

There is also a prepared group for the GPS channels on each 2D module, which can process a certain selection of GPS channels.

This GPS group was created so that the GPS channels are always recorded in the same way, regardless of whether they are received via a GPS/GNSS2CAN or serial GPS/GNSS module.

Important information
The switch between CAN and serial recording must be changed at only one point in the setting of the **recording** device and is explained in chapter 13.

Important information
Beside the in GPS group shown channels, all other GPS/GNSS channels from GPS/GNSS2CAN module can be recorded as CAN-IN channels!

Documentation reference
For more information about sending and receiving CAN-channels please see the manual **XXX** on 2D website:
http://2d-datarecording.com/downloads/manuals/

At first the settings of the **recording device**, e.g., by using a Sticklogger, is described.

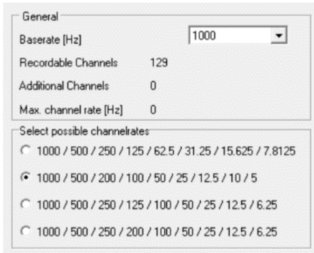
1. Read in recording device in *WinIt*

2. Select **recording** device an navigate to tab *General*

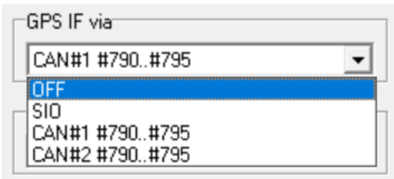
3. At possible sampling channel rates select a group with the rate of the 2D-GPS/GNSS module (chapter 5.1) used or to a multiple of it

   Example:

   With 10 Hz antenna a graduation with a possible rate of 10 Hz must be chosen.



4. Select **recording** device an navigate to tab *Additional operating modes*
5. Select how the **recording** device will receive the GPS data



Important information
When using a serial 2D-GPS/GNSS module, in the *Additional operating modes* menu of the recording device further GPS/GNSS settings can be done like GPS/GNSS2CAN settings from chapter 12.2!

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6. Select the *GPS* group of **recording** device to display the GPS channel grid as shown below

Recording	On	Name	Samplingrate	Sensor info	Digits	Multiplicator	Value
☒	☒	V_Sat	10	GPS speed	0	0.0100	0.00
☒	☒	ValidSat	10	Visible satellites	22012	0.0001	2.20
☒	☒	SSHH	10	Seconds:Hundredth	0	0.0100	0.00
☒	☒	Course	10	Driving direction	0	0.0100	0.00
☒	☒	Lat_dez	10	Position in dezimal degree	490032479	0.000000100	49.0032479
☒	☒	Lon_dez	10	Position in dezimal degree	84613964	0.000000100	8.4613964
☒	☒	Altitude	10	m above sea level	0	0.0100	0.00
☒	☒	MMDD	10	Month:Day	0	0.0100	0.00
☒	☒	HHMM	10	Hour:Minute	0	0.0100	0.00
☒	☒	HorAccu	10	accuracy horizontal position	0	0.00100	0.000
☒	☒	VerAccu	10	accuracy vertical position	0	0.00100	0.000
☒	☒	SpAccu	10	accuracy of speed	0	0.0360	0.00
☒	☒	CourAccu	10	accuracy of course	0	0.0100	0.00
☒	☒	LapGps	10	Lap signal	0	1.0000	0.00

Further Information
Regardless of whether the GPS data was received via CAN-1, CAN-2 or serially, the GPS channels are always displayed in the *GPS* group when using the *Additional operating mode* setting menu!

7. Select all channels of *GPS* group by pressing *[CRTL]+[a]*

8. Via right-click open the submenu and select *Recording On*

9. Again, select all channels of *GPS* group by pressing *[CRTL]+[a]*

10. Via right-click open the submenu and select *Change samplingrate*

11. Set samplingrate of all channels of *GPS* group at least to the samplingrate of the 2D-GPS/GNSS module used (chapter 6.2) or to a multiple of it

12. Press <***Apply***> to send changes to the **recording** device

13. With a valid GPS/GNSS reception check if GPS/GNSS channels are received correctly

Recording	On	Name	Samplingrate	Sensor info	Digits	Multiplicator	Value
☒	☒	V_Sat	10	GPS speed	32	0.0100	0.32
☒	☒	ValidSat	10	Visible satellites	20020	0.0001	2.00
☒	☒	SSHH	10	Seconds:Hundredth	5560	0.0100	55.60
☒	☒	Course	10	Driving direction	28446	0.0100	284.46
☒	☒	Lat_dez	10	Position in dezimal degree	490031949	0.000000100	49.0031949
☒	☒	Lon_dez	10	Position in dezimal degree	84614118	0.000000100	8.4614118
☒	☒	Altitude	10	m above sea level	13306	0.0100	133.06
☒	☒	MMDD	10	Month:Day	727	0.0100	7.27
☒	☒	HHMM	10	Hour:Minute	1502	0.0100	15.02
☒	☒	HorAccu	10	accuracy horizontal position	1464	0.00100	1.464
☒	☒	VerAccu	10	accuracy vertical position	2431	0.00100	2.431
☒	☒	SpAccu	10	accuracy of speed	28	0.0360	1.01
☒	☒	CourAccu	10	accuracy of course	4362	0.0100	43.62
☒	☒	LapGps	10	Lap signal	0	1.0000	0.00

13.3 Recording conditions

If possible, recordings containing GPS/GNSS channels should always start outside with clear view to the sky to ensure best possible GPS/GNSS reception.

14 Postprocessing

After the GPS channels have been recorded, the 2D Analyzer offers further processing of the GPS channels in post-processing.

Documentation reference
For more information about ***GPS post-processing*** please see the manual on 2D website:
http://2d-datarecording.com/downloads/manuals/

This is a very big advantage of the 2D because the user can take influence on the following parameters of 2D-GPS/GNSS-postprocessing:

- Time delay correction
- Filter adjustment
- Post-processing channels

15 Appendix

15.1 *Laptiming via TransponderX2 and GPS/GNSS coordinates alternately*

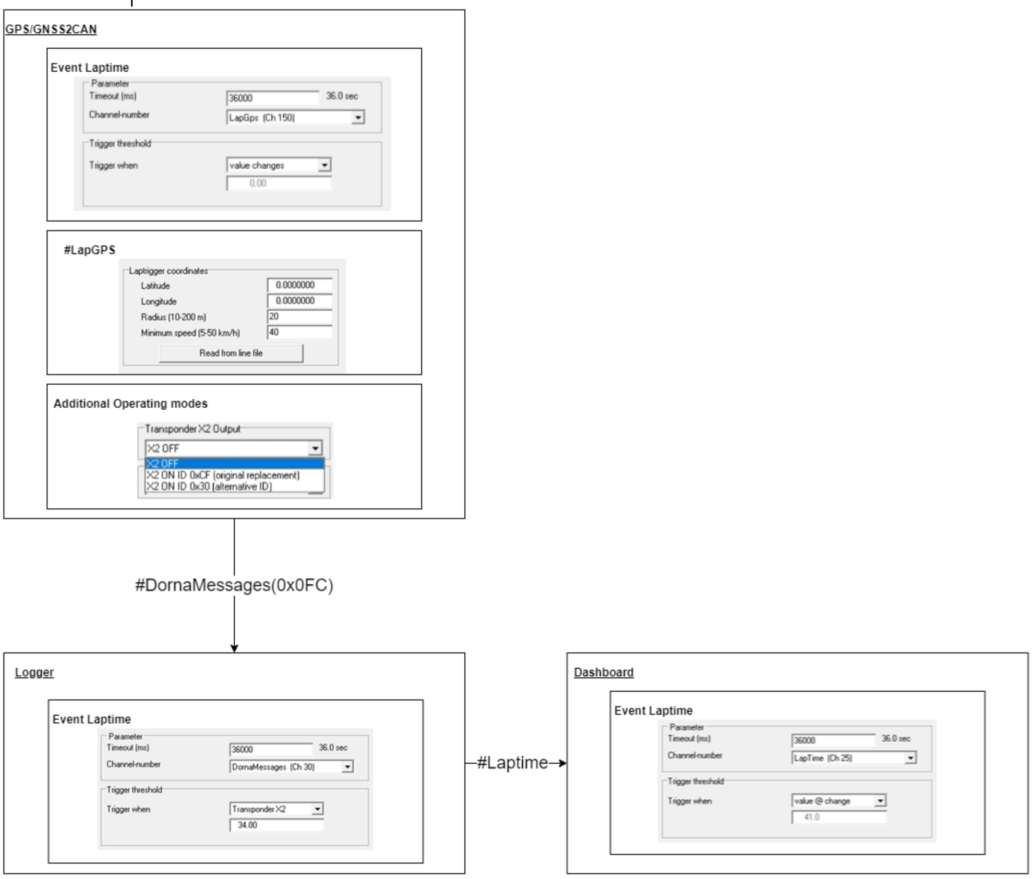
As already mentioned, various 2D modules are capable of calculating a laptime and since for most applications it is not sufficient to only calculate the laptime but also to display it, a sensible structure, i.e. where the laptime is calculated or displayed, should be set up, which strongly depends on the later use.

15.1.1 Example 1 – Creating laptimes by GPS/GNSS2CAN – GPS coordinates

The setup is explained in this example by the fact that the laptrigger signals are acquired via **Transponder X2 messages or GPS/GNSS coordinates**, the logger calculates, transmits, and records the laptime, and the dashboard only displays the laptime.

By using the *Additional Operating Modes* settings *X2 ON ID…* the GPS/GNSS2CAN module is creating laptrigger signals as normally via GPS coordinates but sends laptrigger signal on TransponderX2-CAN-Identifier to simulate the TransponderX2 module.

Further Information
The laptime is also recorded in logger.



Value @ change: Laptime is not calculated but received laptime can used for displaying or recording!
TransponderX2: Laptime is calculated via selcted TransponderX2 message

16 FAQ

1. For GPS channels, the desired sampling rate cannot be selected, only sampling rates above or below the desired rate.

   ➔ In the module settings, the selectable sampling rates must be checked to see if the desired sampling rate is among the possible sampling rates that can be selected. (12.2.2).

2. What happens if, e.g., a 25 Hz antenna is used but the sampling rate of GPS channels is not 25 Hz?

   a) Sampling rate above 25 Hz (e.g. 50 Hz)

   ⇨ 25 Hz antenna is working with 25 Hz
   ⇨ GPS channels are recorded with 50 Hz
   (every GPS sample is recorded twice → **no problem**)

   b) Sampling rate below 25 Hz (e.g. 12.5 Hz)

   ⇨ 25 Hz antenna is working with 12.5 Hz only
   ⇨ GPS channels are recorded with 12.5 Hz only
   (only every second GPS sample is recorded → basically no problem but only half of possible dynamic of 25 antenna used)

   c) Sampling rate below 25 Hz (e.g. 10 Hz)

   ⇨ 25 Hz antenna is working with 10 Hz only
   ⇨ GPS channels are recorded with 10 Hz only
   (10 is not an integer divisor of 25, the result of recording is jitter **→ no useful GPS data!)**

Further Information

Like can be seen at the examples, basically it is no problem to record GPS channels with other sampling rate than the GPS/GNSS modules sampling rate as long as the recording rate is an integer divisor of the GPS/GNSS modules sampling rate!

However, if the sampling rate is too low, the entire dynamic bandwidth of the GPS/GNSS module will not be used.

This information is valid for both CAN and serial GPS/GNSS modules!

3. How it can be found out which sampling rate an antenna works on (e.g., at antenna with no labelling on)?

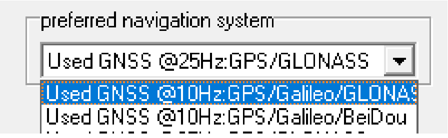
   ⇨ Read in system via WinIt and set sampling rate of GPS channels to 50 or 100 Hz (Samplingrates by which the possible GPS/GNSS modules rates 10, 12.5 and 25 Hz can be divided with integer result)
   ⇨ Ensure that channel #SSHH is recorded
   ⇨ Start measurement
   ⇨ Analyze the single steps of channel #SSHH if they are 0.1 sec (10 Hz), 0.08 sec (12.5 Hz) or 0.04 sec (25 Hz)

Further Information
This information is valid for both CAN and serial GPS/GNSS modules!

4. Analysing GPS/GNSS problems

   ⇨ Please see chapter 11.1.4.5 for a description how GPS/GNSS accuracy can be evaluated.

5. At 12.2.5.8 not the correct selection was made for used GPS/GNSS antenna



6. How it can be found out if the antenna is still working or damaged?

   a. Check #SSHH for checking valid connection from antenna to logger

⇨ Read in system via WinIt and switch on channel #SSHH
⇨ If #SSHH is repeatedly counting from 0 to 60 sec the antenna is working.
Continue with b.

Further Information
For this test no valid GPS/GNSS connection is required because even without GPS/GNSS reception #SSHH is repeatedly counting from 0 to 60 sec.

⇨ If #SSHH is not counting from 0 to 60 sec, please contact 2D via contact form

   b. Check correct GPS position

⇨ Read in system via WinIt, switch on and check channel #Lat_dez and #Lon_dez if your current position was detected correctly and if #ValidSat shows a value > 0.9 (11.1.4.2).

If no position is detected and #ValidSat remains < 0.9, place the switched-on 2D measuring system in an outdoor position with a clear view of the sky and wait about 15 minutes to allow for at least one Almanac update period (lasting approx. 12 min).

Further Information
A recording is not necessary but can help to evaluate if position was detected correctly.

⇨ Read in system via WinIt and check channel #Lat_dez, #Lon_dez and #ValidSat again.

Further Information
After an antenna has been switched off for a longer period of time or the antenna is switched on again for the first time since a large position change (country change), it may take some time until the current position is found again correctly (cold start).

After a position has been found again, the current position is stored in the antenna so that the next time the antenna is switched on at same position after a short time, it can be connected more quickly (hot start).

⇨ If still no position is found, please contact 2D via contact form