FLIGHTZOOMER

MANUAL

1 Contents

2 Functional aspects

2.1 Overview

FlightZoomer consists of three components:

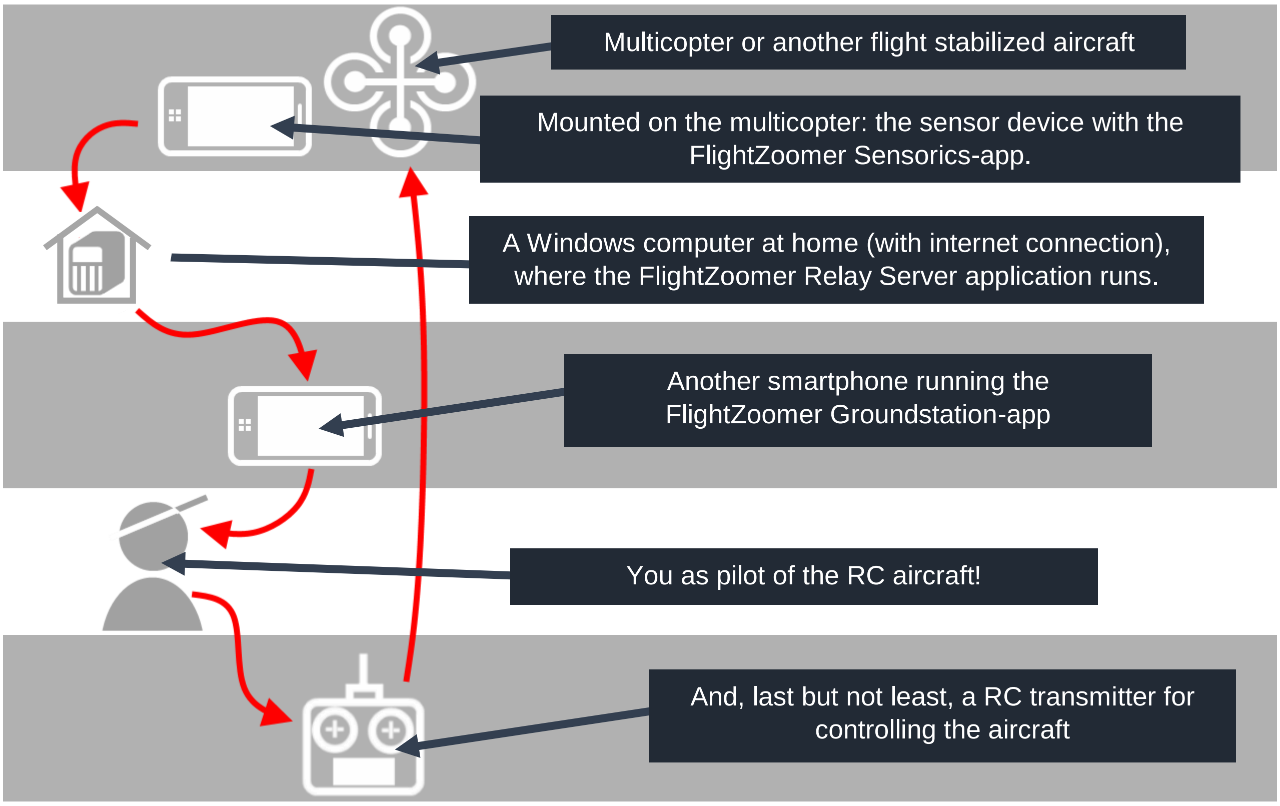
1. The **FlightZoomer Sensorics device**. This is a Windows Phone device, mounted on a RC aircraft.

2. The relay server. This is a PC at home (or alternatively in the cloud) on which the **FlightZoomer Relay Server** application runs. The relay server connects the FlightZoomer Sensorics and the FlightZoomer Groundstation devices over the Internet.

3. The **FlightZoomer Groundstation device**. This is also a Windows Phone device, which is used as display and touchscreen interface for the pilot.

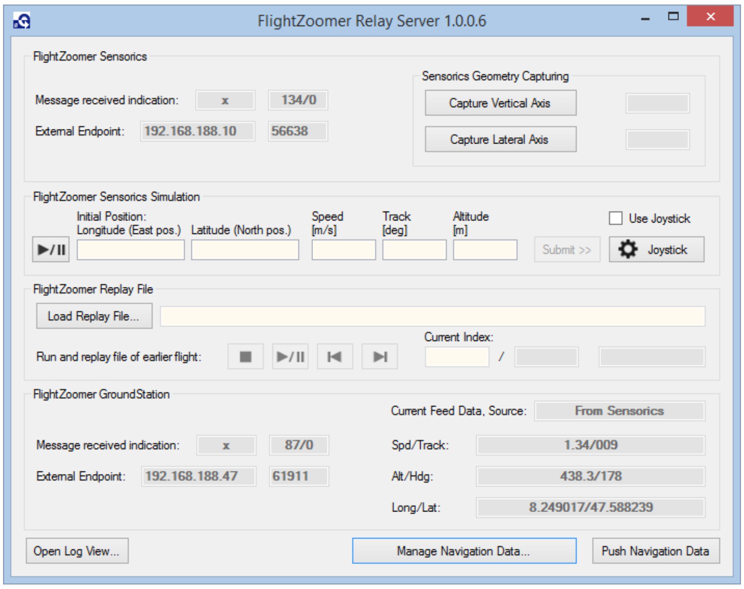
The principle is very simple: a modern smartphone is packed with sensors, which allow measuring the flight parameters with quite high accuracy. Overall FlightZoomer is a software solution that consists of the FlightZoomer Sensorics app. This app runs on a smartphone device, which is mounted on an RC aircraft. The app collects all flight parameters in real time and transmits them via cellular network to a Relay server, which then forwards the data in near real time to a second smartphone device, which runs the FlightZoomer Groundstation app and acts as a groundstation.

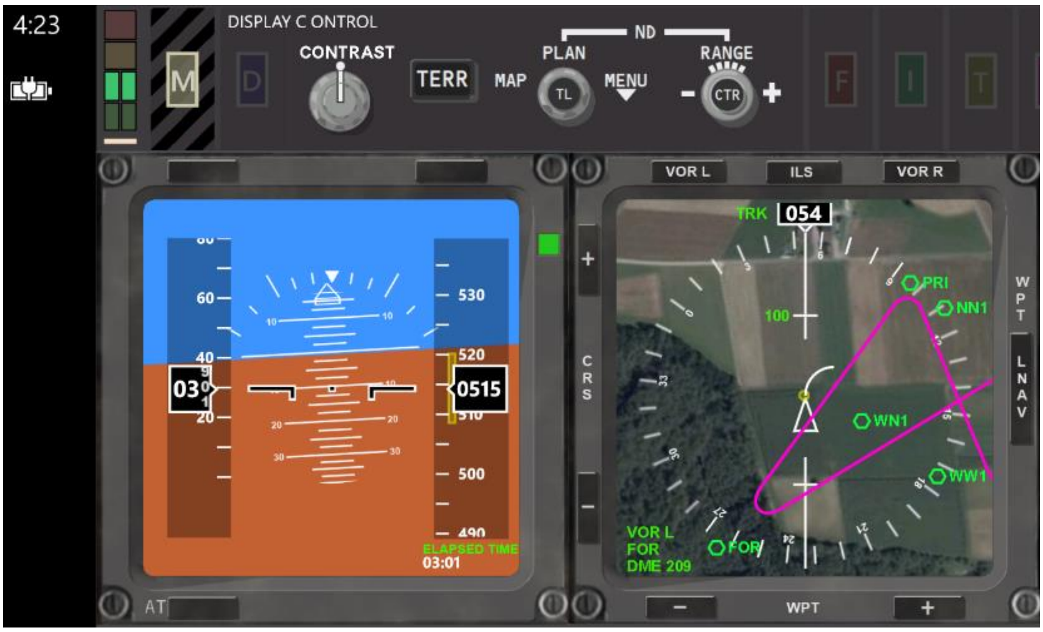
The following diagram shows the control loop over all involved elements:



2.2 The apps


FLIGHTZOOMER SENSORICS
POWER ON/OFF
LOCK FOR FLIGHT
on
ON
VHF EARTH-CONNECTOR
RELAY SERVER
CELLULAR WIFI
PITCH / BANK / COMPASS (ERROR)
CAL
LOCATION ERROR / D1 / D2
RAW
0005/000.0/000.0
SPEED / COURSE / ALT
NaN/NaN/NaN


FlightZoomer Relay Server 1.0.0.6
FlightZoomer Sensorics
Message received indication:
x
134/0
External Endpoint:
192.168.188.10
56638
Sensorics Geometry Capturing
Capture Vertical Axis
Capture Lateral Axis
FlightZoomer Sensorics Simulation
Initial Position:
Longitude (East pos.)
Latitude (North pos.)
Speed [m/s]
Track [deg]
Altitude [m]
Use Joystick
Submit >>
Joystick
FlightZoomer Replay File
Load Replay File...
Current Index:
Run and replay file of earlier flight:
FlightZoomer GroundStation
Current Feed Data, Source:
From Sensorics
Message received indication:
x
87/0
Spd/Track:
1.34/009
External Endpoint:
192.168.188.47
61911
Alt/Hdg:
438.3/178
Long/Lat:
8.249017/47.588239
Open Log View...
Manage Navigation Data...
Push Navigation Data


4:23
DISPLAY C ONTROL
CONTRAST
TERR
MAP
PLAN
ND
MENU
RANGE
TL
CTR
VOR L
ILS
VOR R
TRK 054
PRI
NN1
WN1
WW1
FOR
VOR L
FOR
DME 209
CRS
WPT
LNAV
WPT
60
40
20
030
530
520
0515
500
490
ELAPSED TIME
03:01
AT

2.3 How does it work

A detailed functional description would exceed the reasonable scope of this document. Therefore the following diagram shall just show a bunch of ingredients (technologies/algorithms/formulas), which have been used or have been under consideration for FlightZoomer:

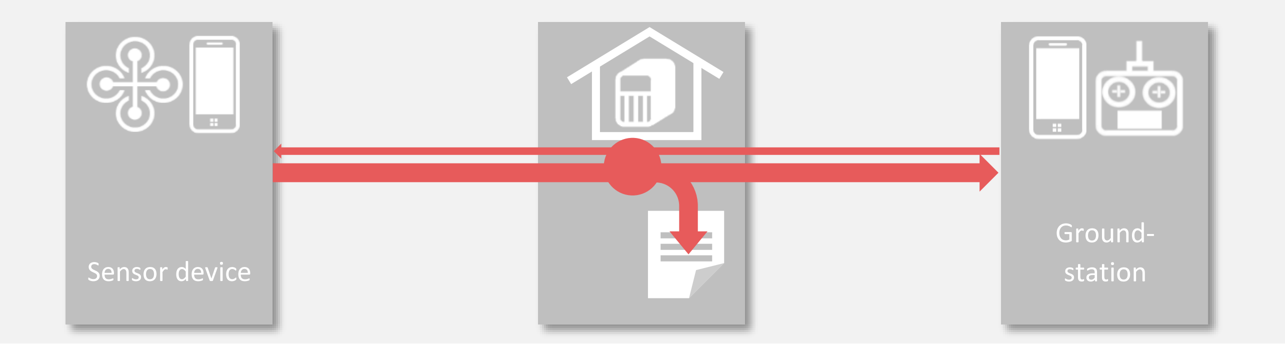
2.4 System requirements

- FlightZoomer is a sole software solution.
- The devices, on which the software runs, are off-the-shelf devices.
- The typical latency of FlightZoomer is not bad (0.03 to 0.13 seconds, on average about 0.08 seconds) but occasional spikes do not allow controlling the RC aircraft without additional stabilization. Thus the RC aircraft must be equipped with a flight controller (like XAircraft SuperX or DJI NAZA for multicopters). The flight controller must offer predictable flight characteristics.
- As the onboard device can be mounted on the aircraft in any attitude (a geometry capturing sequence is needed to measure the actual attitude).

2.5 Operation scenarios

There are many operation scenarios, which serve different purposes and use cases.

2.5.1 Normal operation

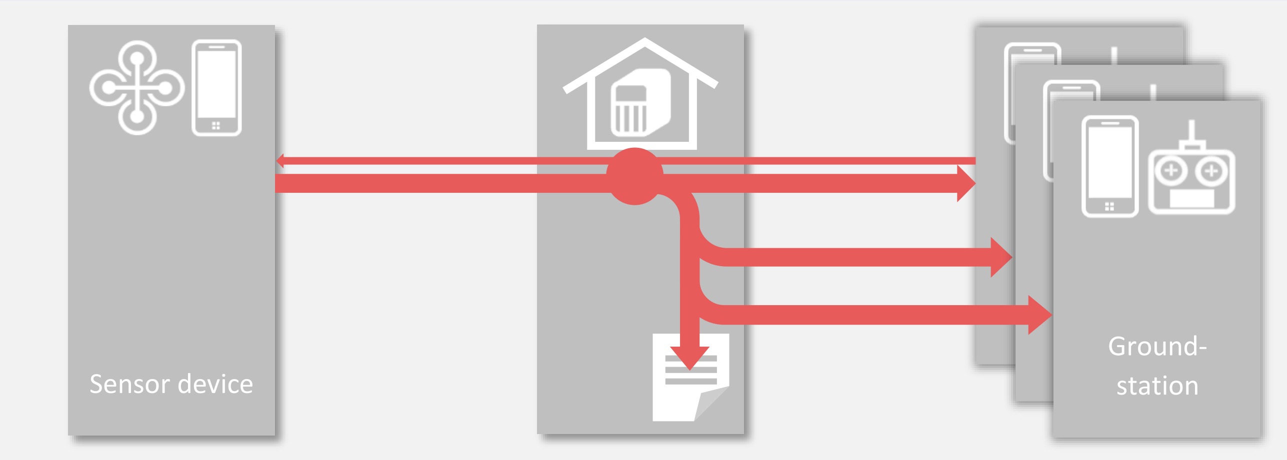


During normal operation the sensor device transmits sensor and location data to the relay server. The data is then fed forward to the groundstation.

In the opposite direction certain commands can be sent from the groundstation to the sensor device.

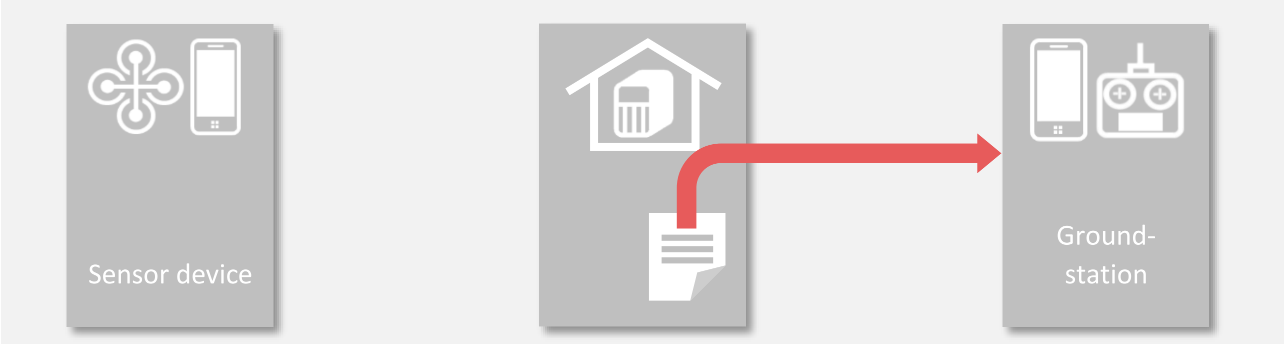
The sensor and location data are automatically written into a flight-logfile on the relay server as soon as the system switches to flight locked mode.

2.5.2 Normal operation, multiple groundstations



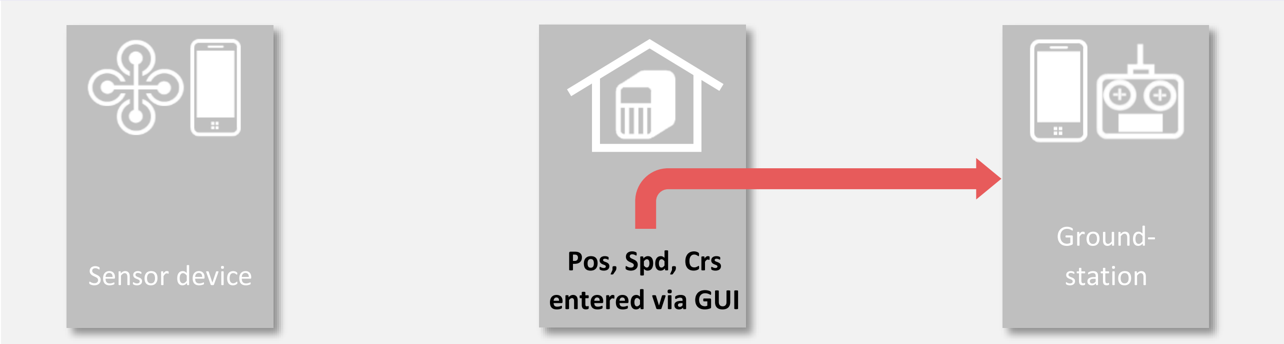
Supplementary to the normal operation scenario, additional groundstations can connect to the relay server. This allows observing flights from multiple devices. So you can you onboard your wife or your friends when taking off with your RC aircraft! Regardless where they are on the world!

2.5.3 Replay file operation



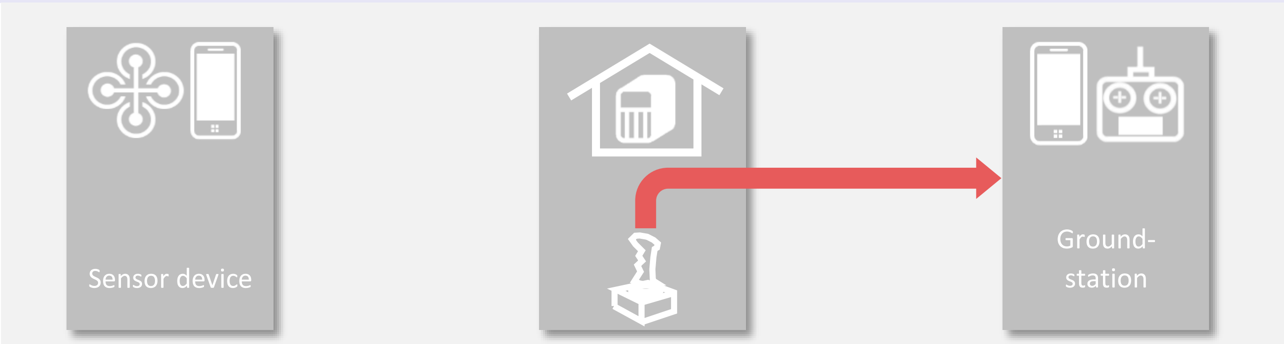
The flight logfiles, which have been created while flying, can be used later to replay the flight in real time. This allows repeating earlier flights for analysis, training or demonstration purposes.

2.5.4 Simulated operation



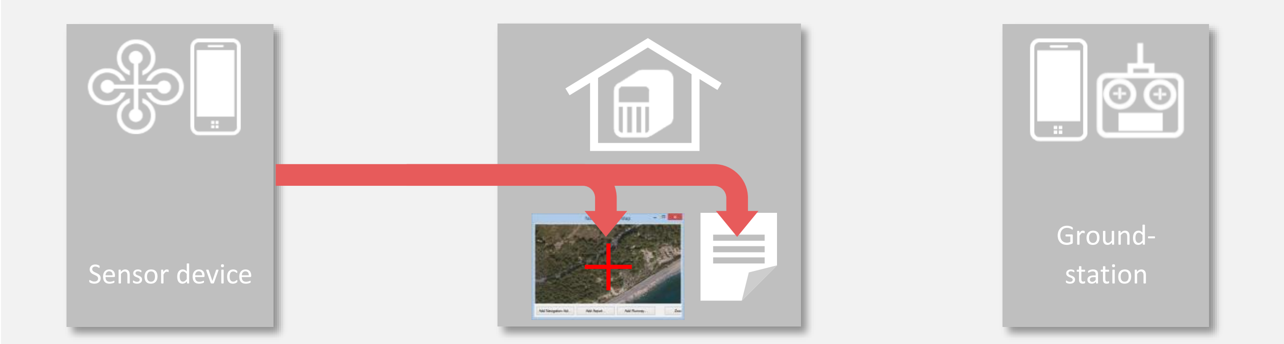
Beside the option to replay logfiles from earlier flights, the flight parameters (location, speed, course and altitude) can also be generated directly by providing these parameters on the relay server GUI. This allows to simulate very precise flight movements again for training purposes and system acquainting.

2.5.5 Simulated operation, with joystick



The input for the flight simulation can also come from standard joystick, which is connected to the relay server. This allows to train and inspect the features of the groundstation nearly as realistic as flying with the real model.

2.5.6 Live position



The last operation scenario allows to observe and track the position of the sensor device directly on the relay server. Again a feature to impress those, who stayed at home. This capability is also available during normal operation.

2.6 Network connectivity

2.6.1 FlightZoomer Sensorics app

The FlightZoomer Sensorics app allows to define whether the preferred connectivity would be via cellular or WIFI network interfaces (switching on the connection either with the CELULAR or the WIFI button).

Setting the network preference just means that the operating system will pick the preferred network interface type if more than one are available. Without preference the operating system would pick the best available network in that case. And if only one network is available, the device will establish connectivity using that network interface in all cases. Independent of the selected network interface, the FlightZoomer Sensorics app will display which network interface type is being used.

While flying, cellular network connectivity should be selected as preference. The WIFI option on the other hand allows setting up local communication between the sensor device and the relay server at home without burdening the mobile data plan. This can be used for testing purposes and to download videos from the device (if FlightZoomer Sensorics is used to record videos, the only way to download them is the built-in download functionality).

2.6.2 FlightZoomer Groundstation app

The FlightZoomer Groundstation app will always automatically connect to the relay server with cellular network preference. There is no option to choose the network type preference.

2.7 State Model

The whole system has three end-to-end modes:

- Idle
- Connected
- Locked for flight

Idle mode:
The app on either smartphone has been started but not yet connected to the relay server.

Connected mode:
The connection from either of the smartphones to the relay server has been established. In this state all the sensor data is already passed from the sensor device to the groundstation device. The whole flight preparations can take place in this mode.

Locked for flight mode:
Immediately before taking off, the devices need to be switched into flight locked mode. This prevents further user input on the touchscreen of the FlightZoomer Sensorics device and starts recording the flight data on the relay server. In addition the camera starts recording a video or taking images (if any of the two options is activated).

2.8 Navigation data

FlightZoomer allows to simulate the structure and elements of a real air space. There is a navigation database, consisting of navigation aids (radio beacons), airports and runways, which can freely be defined in the area of your flying field. Navigation data is used to fly the RC model in a controlled manner. There are a number of possibilities: capture simulated radials of radio beacons, follow glideslopes of a simulated ILS (Instrument Landing System) or create flightplans and fly any predefined route at will.

The system does not need real radio equipment to implement these features. A navigation aid is nothing but a data record, which consists typically of an ID, a location and a frequency. If the also simulated navigation receiver on the groundstation is tuned to the frequency of a navigation aid, the groundstation cockpit displays will simulate the appearance of the real instruments based on the aircrafts location, the navigation aid location and some other parameter.

FlightZoomer stores the navigation data in a database that is located on the relay server. Any groundstation which connects to the relay server will automatically download and import a copy of the navigation data.

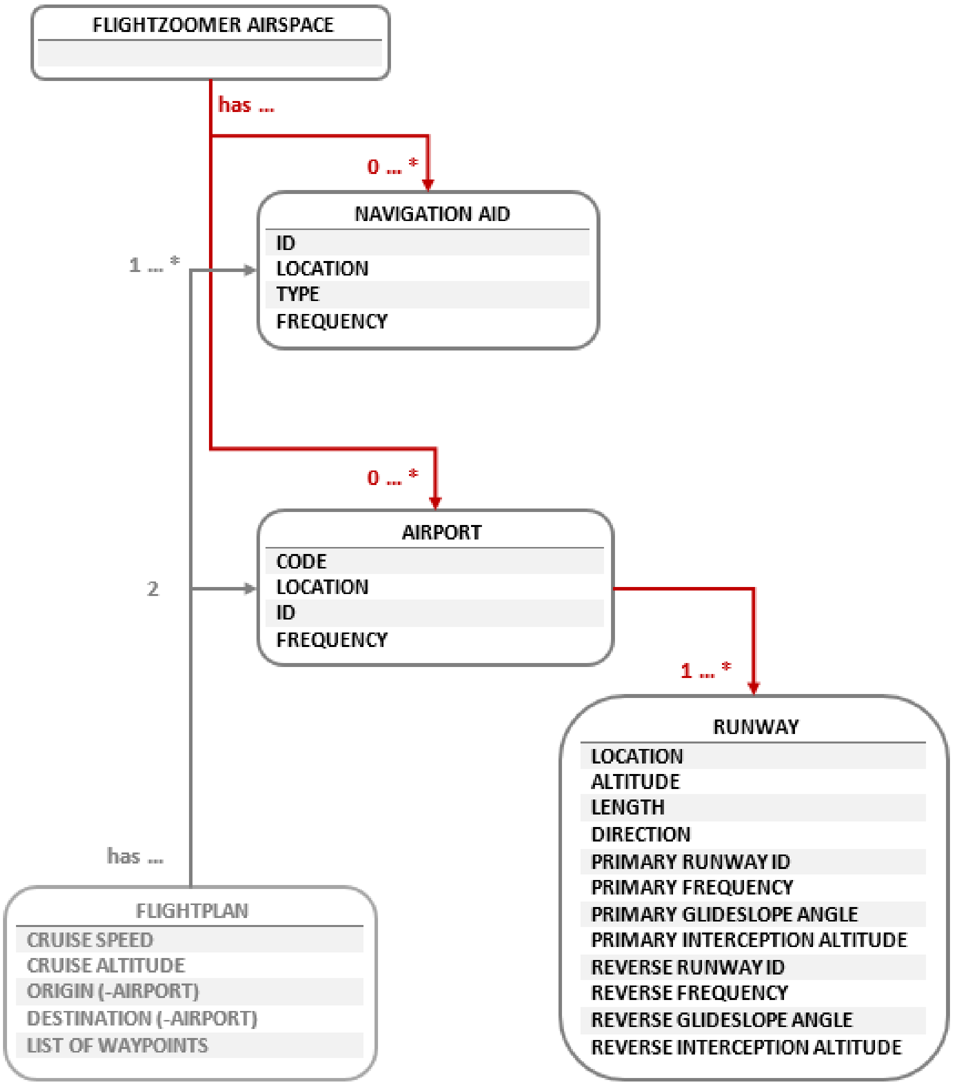
Also the creation and modification of navigation data is done with the FlightZoomer Relay Server application. The application has convenient features for that purpose. Creating navigation aids and airports is one of the preparation steps.

The navigation database consists of text files (ending *.txt) which are located in the following folder:

	What	Folder
1	Navigation aids	C:\ProgramData\FlightZoomer\Navigation.Navaids
2	Airports (and runways)	C:\ProgramData\FlightZoomer\Navigation.Airports

Navigation data which is generated within the Relay Server application is stored automatically in two files named navaids.base.txt and airports.base.txt. Other *.txt files can be added manually in the two folder and will be included automatically into the navigation database. Due to technical limitations for downloading the files to the groundstation the total size of all the *.txt-files must not exceed 10kB.

The following diagram shows the navigation data model (+ the relations to a flightplan):



2.8.1 Navigation aid

Navigation aids are points on the landscape, which allow to determine the position of the aircraft and are also used as waypoints for flight routes.

In real aviation there are three basic types of navigation aids:

1. Non-directional beacon (NDB): The ID for NDBs has three letters. This type of radio beacons is mostly obsolete nowadays. They operate at low frequencies and don´t provide inherent and precise directional information. FlightZoomer does not model NDBs.
   More information can be found here:
   http://en.wikipedia.org/wiki/Non-directional_beacon
2. VHF omnidirectional range (VOR): The ID for VORs has three letters. VORs are still in use in aviation today. They offer exact measurements of the radial on which the aircraft is located. A subtype are VORDMEs which additionally offer a distance measurement. Tuning to a single VORDME allows to determine the current position unambiguously.

More information can be found here:
http://en.wikipedia.org/wiki/VHF_omnidirectional_range

3. Fixed geographic coordinates (GPS FIX): The ID for GPS FIXs has five letters. These are fixed positions which were defined to support airways and flight paths without the need to install ground based radio beacons. They far outnumber VORs in real airspaces. As they don't emit any radio signals they can only be used for aircrafts which can determine their location autonomously. Due to GPS and other advanced systems this is almost always the case today.

FlightZoomer implements the VOR, VORDME and GPS FIX navigation aid types.

A navigation aid has the following properties:

	Element	Purpose
1	ID	The ID identifies a certain navigation aid and needs to be distinct within the whole navigation database. It consists typically of 3 to 5 uppercase letters (3 letters for VORs and VORDMEs and 5 letters for GPS FIXs). FlightZoomer does not restrict the character count however so any desirable ID can be assigned to navigation aids (and thus be displayed on the navigation display). The ID is mandatory.
2	LOCATION	The location is also mandatory and defines the geographic coordinates. It consists of longitude and latitude.
3	TYPE	The possible types are VORDME, VOR and GPS FIX. The first would offer distance measurement and radial capturing, the second only radial capturing and the third could not be used for radio navigation but only for flightplans. However there is currently no different behavior implemented for each of these, so each type would represent a VORDME (with the small exception, that leaving away the frequency would emulate a GPS FIX).
4	FREQUENCY	The frequency is used to tune to a certain navigation aid. It also needs to be distinct within the whole navigation database. The frequency property is not mandatory but can be left away. In that case the navigation aid emulates a GPS FIX and would not be useable for radio navigation. But it can still be used for flightplans.

2.8.2 Airport

Airports can be placed freely on the landscape. They are needed as origin or destination for flightplans and can also be used to fly ILS approaches.

Airports are a composite data structure because beside the common properties their data model also contains a list of runways, which are described in the next chapter.

An airport typically also has a radio navigation aid. The data model thus has properties for the airport navigation aid ID and frequency.

In FlightZoomer the code of airports follows the guidelines from the ICAO (although the airport codes you define will never be visible outside your mini world!). In real world the ICAO defines the airport codes for any airport worldwide. ICAO codes have four letters as opposed to the IATA codes having three letters. The first or the first and the second letter stand for the country and are defined statically (see this map ICAO countries prefix map).

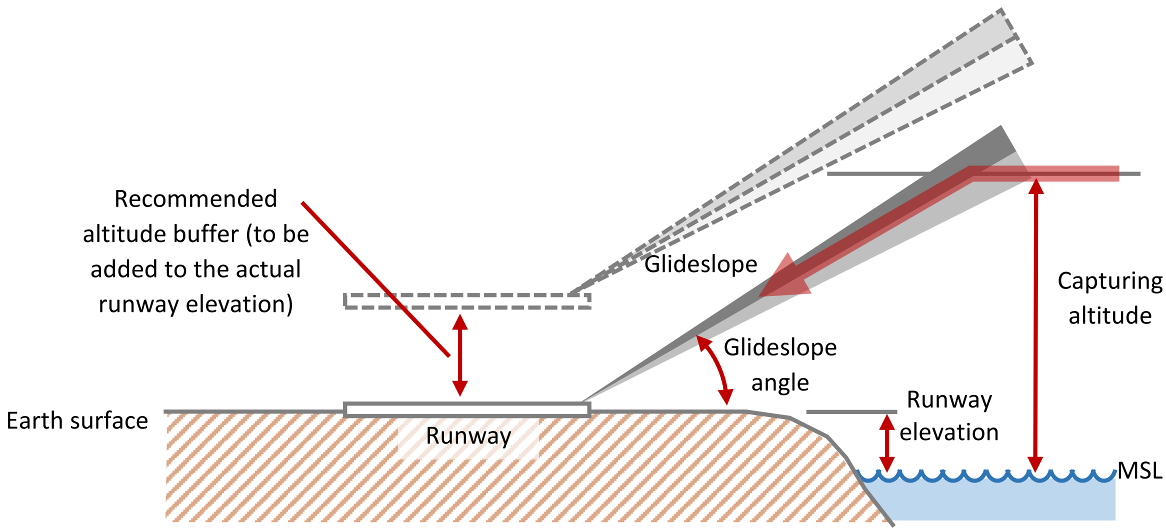
An airport has the following properties:

	Element	Purpose
1	CODE	The CODE identifies a certain airport according to the ICAO scheme and needs to be distinct within the whole navigation database. It consists of 4 uppercase letters. FlightZoomer does not restrict however the character count so any desirable name can be assigned as CODE to an airport (and thus be displayed on the navigation display). The CODE is mandatory.
2	LOCATION	The location is also mandatory and defines the geographic coordinates of the airport navigation aid. It consists of longitude and latitude.
3	ID	The ID identifies the radio navigation aid which is located on the airport. The description for ID in chapter 2.8.1 does apply here as well.
4	FREQUENCY	This property defines the frequency of the navigation aid which is located on the airport. The description for FREQUENCY in chapter 2.8.1 does apply here as well.

2.8.3 Runway

Runways can also be placed freely on the landscape but they need to be assigned to an airport. They serve the purpose to fly ILS approaches.

An ILS approach is defined by the following parameters (in red):



A runway has the following properties:

	Element	Purpose
1	LOCATION	The location is mandatory and defines the geographic coordinates of the center of the runway. It consists of longitude and latitude.
2	ALTITUDE	Altitude of the runway in meter above sea level. It is one possibility to define the actual altitude of the runway. Due to the somewhat limited vertical accuracy of the system, it is recommended however, to define the runway altitude 5…10 m

		higher. This would give some safety buffer to complete also suboptimal approaches.
3	LENGTH	Length of the runway in meter.
4	DIRECTION	Direction (primary) between 0° and 360°. The reverse direction does not exist as attribute but is derived from this property.
5	PRIMARY RUNWAY ID	The ID of a runway is formed by the first two digits of the direction (e.g. direction = 73° -> ID = 07, direction = 157° -> ID = 16) Parallel runways are suffixed with L, R or C: L for left, R for right and C for center (e.g. 28L and 28R).
6	PRIMARY FREQUENCY	The next three properties are optional and describe the ILS approach to the primary runway direction. If the navigation receiver on the groundstation is tuned to this frequency, deviations from the ILS glideslope will be indicated on the primary and navigation displays. Like the frequency of any navigation aid, each ILS frequency needs to be distinct within the whole navigation database.
7	PRIMARY GLIDESLOPE ANGLE	The primary glideslope angle is the vertical angle between glideslope and the earth surface. While real ILS typically have 3° glideslope angles, for multicopters 20° is recommended and for fixed wing planes maybe 5°..10°. This property is only required if a frequency has been specified.
8	PRIMARY INTERCEPTION ALTITUDE	The interception altitude in meter is the altitude, at which the final approach ideally begins. In reality this altitude is 2000´ to 3000´ above the runway. For FlightZoomer the interception altitude typically would be defined 50m to 70m above the runway.
9	REVERSE RUNWAY ID	The ID of the reverse runway is formed by the first two digits of the opposite direction (e.g. direction = 73° -> opposite direction = 253° -> ID = 25, direction = 157° -> opposite direction = 337° -> ID = 34). Parallel runways are differentiated as described under PRIMARY RUNWAY ID.
10	REVERSE FREQUENCY	The next three properties are also optional and describe the ILS approach to the reverse runway direction. If the navigation receiver on the groundstation is tuned to this frequency, deviations from the ILS glideslope will be indicated on the primary and navigation displays. The frequency of the reverse runway ILS must not only be different than the frequency for the primary direction but also distinct from any other ILS or navigation aid frequency.
11	REVERSE GLIDESLOPE ANGLE	The reverse glideslope angle is the vertical angle between the reverse glideslope and the earth surface. For details see PRIMARY GLIDESLOPE ANGLE.
12	REVERSE INTERCEPTION ALTITUDE	The interception altitude in meter is the altitude, at which the final approach ideally begins. For details see PRIMARY INTERCEPTION ALTITUDE.

2.9 System accuracy

As with any technical system, there is a gap between the ideal, perfect accuracy and what can be achieved with the actual implementation. FlightZoomer is not different in that regard. There are several areas, which need to be looked at separately in the following chapters.

2.9.1 Time accuracy

Due to the system architecture of FlightZoomer the transmission and display of sensor data is not possible in absolute real-time. Obviously mobile network coverage can be impaired temporarily or even be marginal for a longer period of time. The design of the communication channels from the sensor device to the groundstation is focused especially on recovering from any kind of failure modes. So whenever the connection is lost, connectivity will be reestablished as soon as the network will allow it.

During normal operation the time lag between measuring and displaying the data varies between about 40ms and 120ms. At times the connectivity between the sensor device and the groundstation will be interrupted and the time lag can grow to several seconds.

Factors which contribute to the actual time lag for transmitted data packages:

Factor 1: The currently available network speed

While a stable 3G connection does easily support the figures above (min 40ms, max 120ms, average 80ms) a 2.5G connection will degrade the average lag time by several 100ms.

Factor 2: Time during which the network type switches

During the phases while the device is switching between different network types (2.5G, 3G or 4G), the lag time temporarily can worsen. In order to avoid connectivity drops while the device switches between network modes, it is recommended to configure the sensor device to stick to a lower connection speed (than the highest). FlightZoomer does not need 4G, so restricting the network on the sensor device to 3G is sufficient.

Factor 3: Distance between sensor device and groundstation

A very small impact also comes from the actual distance between the sensor device and the groundstation (via the relay server). Switching from a closely located relay server (e.g. home based) to a cloud based can add some dozens of milliseconds to the total lag time.

Factor 4: The sensor data update rate

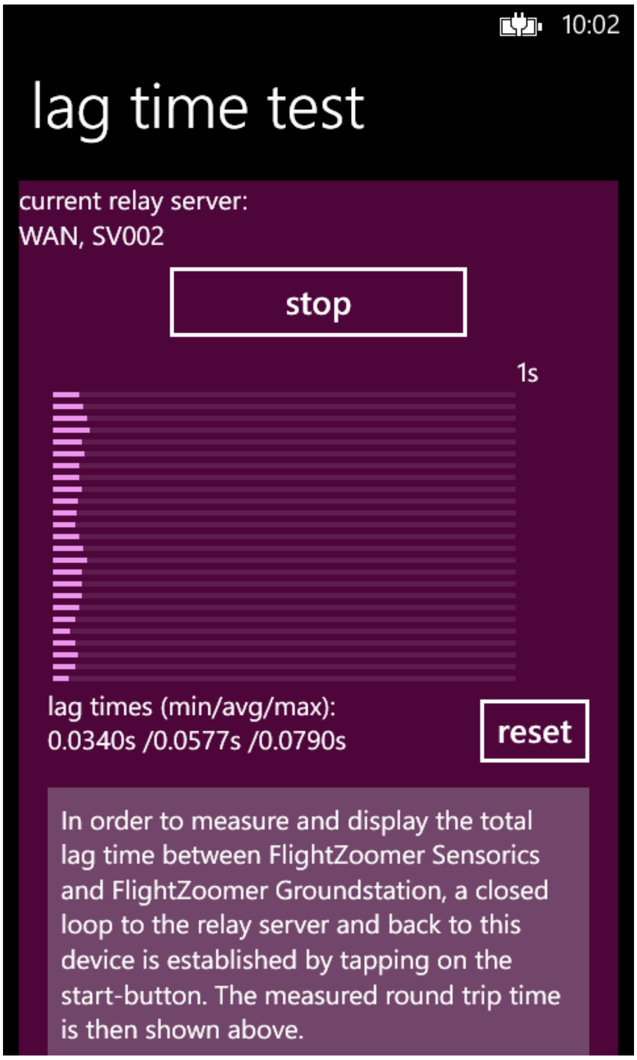
While attitude and compass are updated after 17ms or 25ms respectively, the GPS position (and the related attributes as speed, altitude and track) are updated once per second. There are smoothing algorithms however on the groundstation-side to provide steady and fluent display updates.

Lag time test feature

The FlightZoomer Sensorics app has an in-built feature to measure and display exactly how long it takes for each single transmitted package over the entire communication channel from the sensor device to the groundstation device. This test is accomplished solely by the Sensorics-app and the relay server and does not need the Groundstation-app. Once the test is started, a second connection from the sensor device to the relay server is established which is used to simulate the complete end-to-end connection.

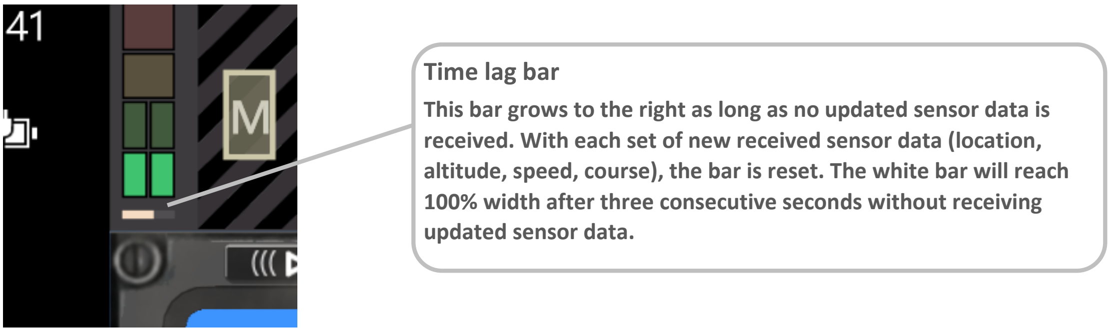
While the test cannot be performed during the flight (because the Sensorics app needs to be manipulated), the test feature is still very helpful understanding the system time response and the factors that impact it positively and negatively.

The following screenshot shows the lag time test screen. For more details refer to the chapter **Error! Reference source not found.**:



Time lag indication on the display of the groundstation

FlightZoomer does also measure and display the current time lag on the groundstation. At any time and on all screens on the top left of the display the time lag bar is indicated:



Pilot guidelines to mitigate the lag time

- The time lag bar needs to be considered while flying.
- In case of excessive lag time the displayed information quickly becomes outdated and should not be trusted anymore.
- With a multicopter: speed shall be reduced and the POSITION-hold mode should be activated.
- If connectivity does not recover before any situational awareness is lost, the flight must continue with visual guidance or the FlightZoomer independent fallback mechanism shall be triggered (e.g. the RETURN-TO-HOME feature of the flight controller).
- Especial caution is warranted whenever the current flight trajectory would intersect terrain (e.g. during descends or when flying towards higher terrain).

2.9.2 Position accuracy

The position determination is crucial for the system. It is not only the primary source for navigation but also speed and course are derived from it. Depending on various factors the position accuracy can vary from about 3 Meter to very large figures.

Factors which contribute to the overall position error:

Factor 1: GPS inaccuracy

The GPS accuracy depends on the momentary conditions (on the number of received satellites). Newer smartphones often also support GLONASS which improves the position accuracy significantly. Experience with a Lumia 925 has shown a notably improved performance of the position detection. Other than selecting a better or worse sensor device there is normally nothing that can be done to improve the GPS accuracy.

Factor 2: Capabilities of the chosen device

More than one would expect, the actual device has an impact on the position accuracy. During flight testing several devices have been used and the accuracy differences between them has been notable.

The following table summarizes device specific differences for a selected set of smartphones:

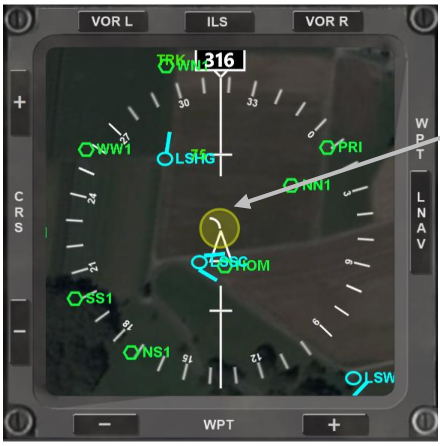
	OS	Overall position accuracy	Consistency	Remarks
Samsung OMNIA 7	Windows Phone 7	Good	Most of the time good.	This rather old device allegedly even supports GLONASS (using [this](#) app), but the used chipset in fact offers no GLONASS support. In the end the app does not improve the accuracy notably. Consider also [this](#) to fix issues that might appear after some time.
Nokia Lumia 710	Windows Phone 7	Insufficient	Frequent degradations.	This device was hardly useable for FlightZoomer. While the compass sensor worked very well, the GPS performed badly.
NOKIA Lumia 925	Windows Phone 8	Very good	Consistently good performance.	GLONASS support included for better position accuracy. The Lumia 925 proved to offer winning accuracy for GPS and compass.

Factor 3: Time lag of position feed

Any movement of the aircraft since the last received sensor data obviously adds to the location error.

Position error indication on the display of the groundstation

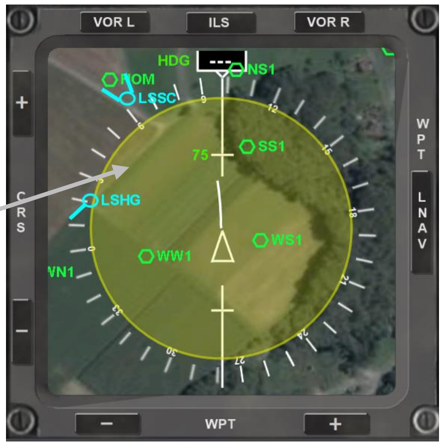
The navigation display on the groundstation shows at any time a yellow circle around the center mark, which indicates the current position error:



Position error circle

This circle indicates at any time the largest possible error between the displayed and the actual position. The actual position therefore lays somewhere within the boundaries of the yellow error circle. On this screenshot a somewhat derogated accuracy is shown.

The circle size scales up and down with the display range (zoom).



Maximum error

On this screenshot the largest displayed error is shown. In case of larger errors the error circle will still stay within the compass rose.

Pilot guidelines to mitigate the position error

- The position error circle needs to be considered while flying.
- The yellow position error circle should stay away from obstacles.
- In case of a sudden loss of position accuracy the flight should be slowed down and continued using fallback navigation mechanisms (visual guidance, RETURN-TO-HOME feature of the flight controller).
- Considerable time should be spent flying simple flight profiles and circuits to become familiar with the system response.
- This means that at any time fallback possibilities must be available.
- Better results and more safety can be achieved with spacious and extensive flight profiles.
- FlightZoomer ideally is used to cruise along routes with ample of straight legs and not too many (and too tight) turns.
- FlightZoomer does not support 3D flying.

2.9.3 Altitude accuracy

The altitude is derived from the same source like the position (GPS). Therefore the description in the previous chapter is fully applicable for the altitude as well.

Additionally it is possible that the altitude readout is not updated as frequent as the position altitude. Also in general the GPS altitude error is larger than the horizontal error.

Altitude error indication on the display of the groundstation

The current altitude error is shown on the primary display as follows:

Altitude error bar:
The vertical yellow bar indicates at any time the largest possible error between the displayed and the actual altitude. The actual altitude therefore lays somewhere within the boundaries of the error bar.

Pilot guidelines to mitigate the altitude error

- As the terrain usually is much closer vertically than horizontally (except very close to mountains), the altitude tends to be more safety relevant than the position.
- To create good altitude awareness therefore additional feedback should be considered (visual tracking, fly with activated ALTITUDE-hold mode, stick to one altitude while cruising…).
- Especially double check the plausibility of altitude readouts while descending. Even rather short altitude feed interruptions can develop to dangerous situations. The plane quickly will be actually lower than indicated.

2.9.4 Turn indication accuracy

One of the areas which is affected the most from lag time and the position error is the situational awareness during turns (both about the turn rate and the turn progress). In order to execute predictable turns FlightZoomer offers two features which help guiding the pilot:

1. When following flightplan routes, the Flight Director provides a countdown timer both audibly and visually indicating the beginning of the turn and once the turn has started for the remaining turn time (assuming a constant turn rate). The following screenshot shows the Flight Director indicating the current right turn to be continued for exactly another 7.5 seconds:

   Once the countdown timers reach zero, the stick shall be released and the aircraft is expected to fly the new course. Parallely the voice output counts down the seconds audibly.
2. During normal flight there is a feature called Course Guidance which counts up turn progress in 30° steps once a turn has been detected (only available audibly).

Pilot guidelines to fly predictable turns

- During free flight apply only rather small turn rates (this behavior is not unrealistic when thinking about real aircraft).
- Also don’t fly too long turns. In general apply rather small course corrections (also this is a realistic behavior looking at real aircraft).
- Consider a RC transmitter configuration as described in **Error! Reference source not found.**. This allows applying constant turn rates which helps getting a feeling about the turn progress even in case of a small time lag on the displays.
- Use the mentioned features above to control turns.

2.9.5 Compass accuracy

The direction of the compass rose on the primary display can be switched between two sources: the magnetometer sensor of the smartphone or - alternatively - the calculated track from GPS (called track-lock). The accuracy of the later is covered in chapter 2.9.2 Position accuracy.

The requirements for a good flight experience with the compass is a small lag time and a smooth step response. While the compass usually responds quicker to directional changes than the GPS track, the output of the magnetometer sensor proved to be a bit erratic with an older device (OMNIA 7), so choosing the GPS track instead was the better option. The GPS track will however not change at all if there is no forward speed. Also crab angles can’t be derived from the GPS track only. On the other hand the track above ground is more relevant for navigation.

Factors which impact the compass accuracy and responsiveness (and thus the usability):

Factor 1: The actual device

Upper class (and newer) devices like the Lumia 925 have performed much better regarding magnetometer accuracy. In fact while this device was really useable in compass mode the older OMNIA 7 had to be flown in GPS track-lock mode.

Factor 2: The compass calibration

After each power on (and sometimes also between) the compass needs to be calibrated.

Factor 3: How the device is mounted on the aircraft

Proximity of the sensor smartphone to other electrical (especially high power) devices.

Factor 4: The compass smoothing setting

There are four compass smoothing settings available on the groundstation (none, soft, medium or strong).

Pilot guidelines to mitigate the compass error

- Enough time should be spent testing various options (with GPS track, witch compass, compass smoothing options) to find out, which combination is the best match for the actual hardware setup and the personal preferences.
- If a reliable compass feedback can't be achieved, revert to the GPS track mode (which offers nearly the same flying experience).

2.9.6 Attitude accuracy

The accuracy of the displayed attitude largely depends on the following factors:

- Conducting the geometry capturing sequence precisely.
- The device itself.
- The current time lag of the data feed.

For all practical purposes the attitude is usually sufficiently accurate enough.

2.10 Units of measurement

FlightZoomer is strictly based on SI units except on the presentation layer of the groundstation. SI units are meter and kilogram. The following table shows how units of measurement are used:

	App	Usage	Parameters	Supported units			
1	FlightZoomer Sensorics	Various screens	Distances, lengths, altitudes	m			
			Speeds	m/s			
			Angles	degree			
2	FlightZoomer Relay Server	Screens, logfile and navigation data	Distances, lengths, altitudes	m			
			Speeds	m/s			
			Angles	degree			
3	FlightZoomer Groundstation	Various screens	Distances, lengths, altitudes	m	ft		
			Speeds	m/s	km/h	nm/h	mph
			Angles	degree			

Legend:
m = Meter; m/s = Meter per Seconds; ft = Feet; km/h = kilometer per Hours; nm/h = Nautical Miles per Hours (= knots); mph = Miles per Hours.