FLIGHTZOOMER
2.0

NEW FEATURES

1 Contents

2 Disclaimer

While FlightZoomer offers fantastic features, the following operation rules must be followed:

- The system is intended for hobby usage.
- Be familiar with the operation of RC aircraft having 1kg flying weight or more.
- Use FlightZoomer only aboard a proved combination of RC equipment, airframe, flight controller, motors, propeller, battery and ESCs.
- Operate FlightZoomer strictly within the safety boundaries of any other components used aboard your model aircraft.
- Operate FlightZoomer strictly within the boundaries of applicable regulatory requirements.
- Fully respect any disclaimer and safety note which is associated with any component used on the aircraft.

3 Overview

3.1 Document scope

This document is an addendum to the complete FlightZoomer documentation which was released for version 1.5. It covers only the new version 2.0 features.

To get the full picture the existing FlightZoomer 1.5 documentation (which is still current and valid for release 2.0) and this document need to be considered in combination.

3.2 Project history

	Version	Focus
1	FlightZoomer 1.0	- Was never released - Proof of concept - Complete standalone operation, relied 100% on the phones sensors, offered only downlink, no uplink - Sensorics App - Groundstation App - Cockpit Instruments
2	FlightZoomer 1.5	- Published in September 2015 - Airborne device mated with flight controller - Highly improved sensor accuracy due to data feed from flight controller - Still primarily downlink and only minimal uplink capabilities - Navigation Database - Flight Management System - Voice Output
3	FlightZoomer 2.0	- Published in Q2 2016 - Full roundtrip connectivity - 14 new autopilot modes - Air Traffic Control simulation - Sony Camera API basic control from groundstation - Internal camera basic control from groundstation - Enhanced display mode control panel - Aircraft settings - Data of each flight is stored in an Excel file including charts - Air traffic control simulation feature

3.3 FlightZoomer in a nutshell

3.3.1 High level requirements

FlightZoomer is a smartphone based system which can be used to navigate, track, control and record the flight of remote controlled model aircraft. A special emphasis is made on the implementation of systems and procedures in a real airliner cockpit.

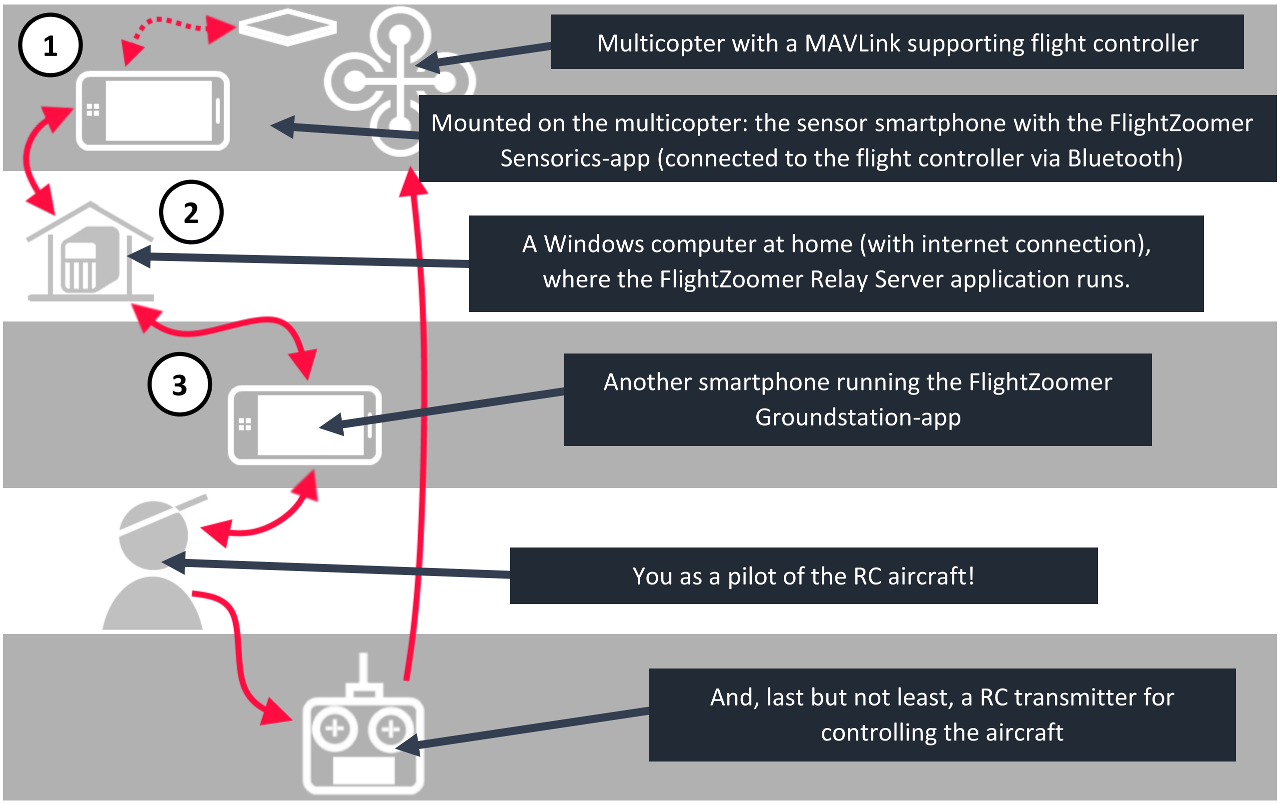
FlightZoomer is supplementary to an existing setup of an RC multicopter (experimentally also a fixed wing aircraft), a flight controller and an RC transmitter.

There are many use cases covered:

- Transmission of sensor data from an onboard smartphone to a ground-based smartphone groundstation via cellular network: so your range is virtually unlimited!
- Via MAVLink FlightZoomer supports 14 autopilot flight modes: Control the aircraft using real world autopilot modes like altitude capture and hold or ILS glideslope capture!
- In-built Air Traffic Control: be guided from cruise down to the ILS by the friendly lady from the virtual air traffic control center!
- Navigate and control the aircraft based on self-created flightplans: prepare, plan and execute routes like real pilots do (following instrument flight rules)!
- Connect with Sony cameras onboard the aircraft: start and stop video recording or continuous still shooting!
- Autopilot simulation mode: induce simulated flight movements (altitude, course, speed and vertical speed) to explore the capabilities of the groundstation in your living room!
- The source of flight and attitude sensor data preferably is the flight controller (connected via MAVLink): Get the highest available accuracy!
- The phone offers an additional “motion/location” sensor set which can be used (though by far not as accurate):
  Get a fully redundant second sensor stack!
- Provide a display to the pilot showing the position of the aircraft on a moving map: so you can navigate, guide or even track lost copters!
- Display speed, altitude and attitude to the pilot: so you get the information like in a real cockpit!
- Even scale RC aircraft are facsimiles of the originals and are flown with systems that bare no similarity with their real world counterparts: operate your RC aircraft using an avionics suite that reproduces the cockpit of a real Boeing 787 Dreamliner!
- Synthetic voice to support the pilot: experience teamwork with a simulated co-pilot!
- Enable navigation based on a radio navigation aid simulation: create your own airspace with airports and navigation aids!
- Instrument Landing System (ILS) offering the full set of real world instruments including the beeping at the outer, middle and inner markers: capture and follow the glideslope performing precision approaches with your RC aircraft!
- Let the camera of the onboard device record images or videos of the flight: make use of the stuff a smartphone brings with it!
- Provide extensive flight telemetry/logging capabilities: dig into masses of data for post flight analysis!
- Flight replay feature: show your friends at any time, how your cockpit looked during a flight!
- Testpilot feature: let the system automatically measure some of the required flight performance parameters!

3.3.2 Functional aspects

With version 2.0 the functional component diagram looks as follows:



FlightZoomer consists of three components:

1. The **FlightZoomer Sensorics device**. This is a Windows Phone device, mounted on a RC aircraft. It is connected via MAVLink to the flight controller.

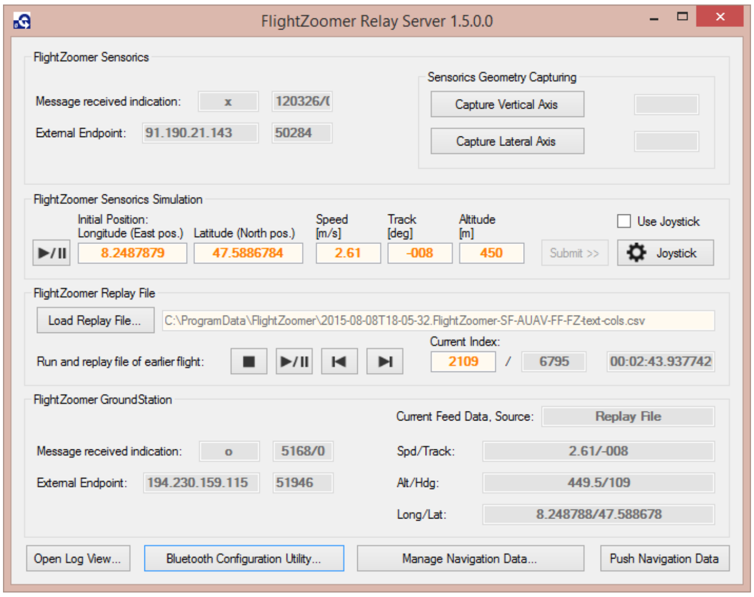
2. The relay server. This is a PC at home (or alternatively in the cloud) on which the **FlightZoomer Relay Server** application runs. The relay server connects the FlightZoomer Sensorics and the FlightZoomer Groundstation devices over the Internet.

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: Overall FlightZoomer is a pure software solution that fully relies on off-the-shelf hardware.

3.3.3 The apps

14:05
FLIGHTZOOMER SENSORICS
POWER ON/OFF
LOCK FOR FLIGHT
ON
VHF PANEL
MAVLINK
RELAY SERVER
WAN
CELLULAR WIFI
PITCH / BANK / COMPASS (ERROR)
CAL
LOCATION ERROR / D1 / D2
RAW
SPEED / COURSE / ALT



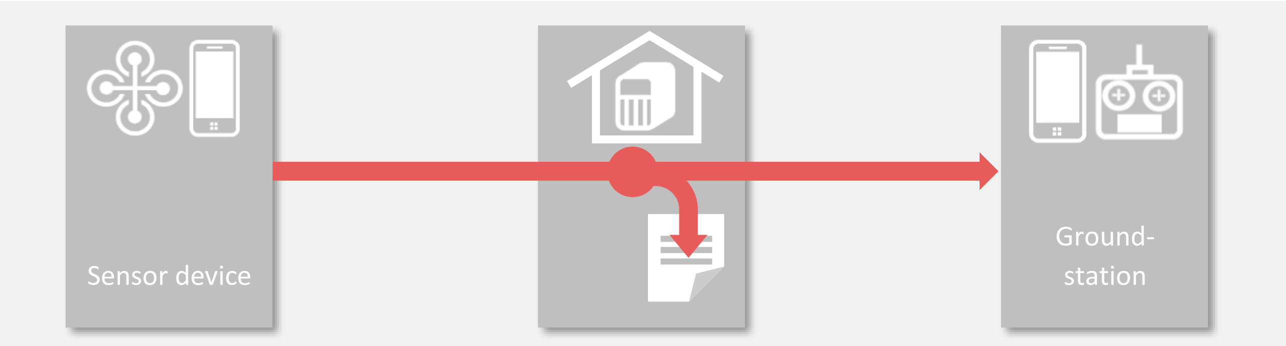
FlightZoomer Relay Server 1.5.0.0
FlightZoomer Sensorics
Message received indication:
External Endpoint:
91.190.21.143
50284
Sensorics Geometry Capturing
Capture Vertical Axis
Capture Lateral Axis
FlightZoomer Sensorics Simulation
Initial Position:
Longitude (East pos.)
Latitude (North pos.)
Speed [m/s]
Track [deg]
Altitude [m]
Use Joystick
8.2487879
47.5886784
2.61
-008
450
Submit >>
Joystick
FlightZoomer Replay File
Load Replay File...
C:\ProgramData\FlightZoomer\2015-08-08T18-05-32.FlightZoomer-SF-AUAV-FF-FZ-text-cols.csv
Run and replay file of earlier flight:
Current Index:
2109
6795
00:02:43.937742
FlightZoomer GroundStation
Current Feed Data, Source:
Replay File
Message received indication:
5168/0
Spd/Track:
2.61/-008
External Endpoint:
194.230.159.115
51946
Alt/Hdg:
449.5/109
Long/Lat:
8.248788/47.588678
Open Log View...
Bluetooth Configuration Utility...
Manage Navigation Data...
Push Navigation Data

3:57
EFIS
A/P
A/T
GS TAS
LNAV
VNAV
FLCH
HDG TRK
HOLD
BANK LIMIT
AUTO
V/S FPA
DOWN
UP
VS/FPA
ALTITUDE
AUTO
1000
HOLD
LOC
APP
ALT REF
PROP P/N
0.0W/NA
BAT V/C/CAP
00.0V/00.0A/000
FLIGHT MODE
GUIDED
VIB XY/Z
0.00/0.00
ELAPSED TIME
ST/HDOP/CNT
3D/0.0/11
HDG
307
WN1
NN1
WW1
LSHG
PR
NE1
WS1
T/D
VOR L

3.3.4 Operation scenarios

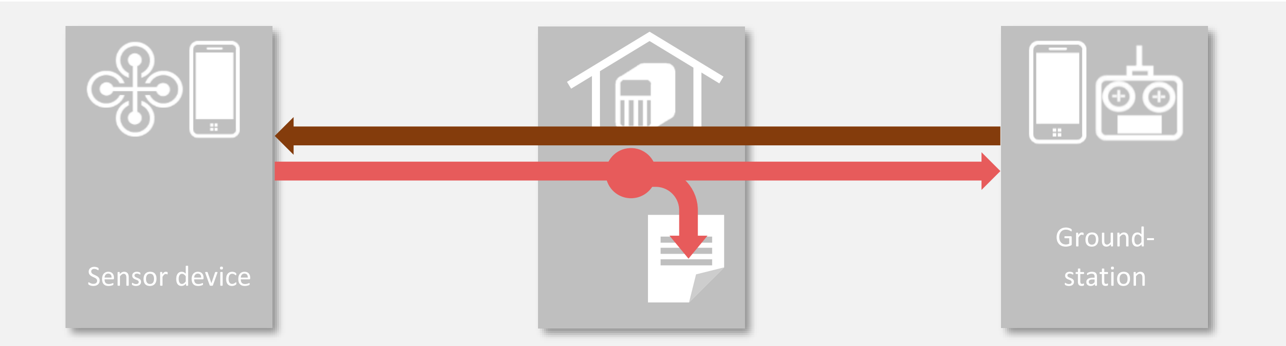
In the version 1.5 documentation six operations scenarios were introduced. In version 2.0 there is one new scenario which is so fundamentally different that it is actually a paradigm shift. The following two diagrams show the difference.

a. Normal manual operation (version 1.5)



This was the normal operation scenario prior version 2.0. The downlink data flow basically represents a solid telemetry system.

b. Normal autoflight operation



With FlightZoomer 2.0 the downlink channel has been complemented by full-fledged uplink channel which supports a precise control of the flight path using the new implemented autopilot modes.

4 New Features

4.1 Overview over version 2.0

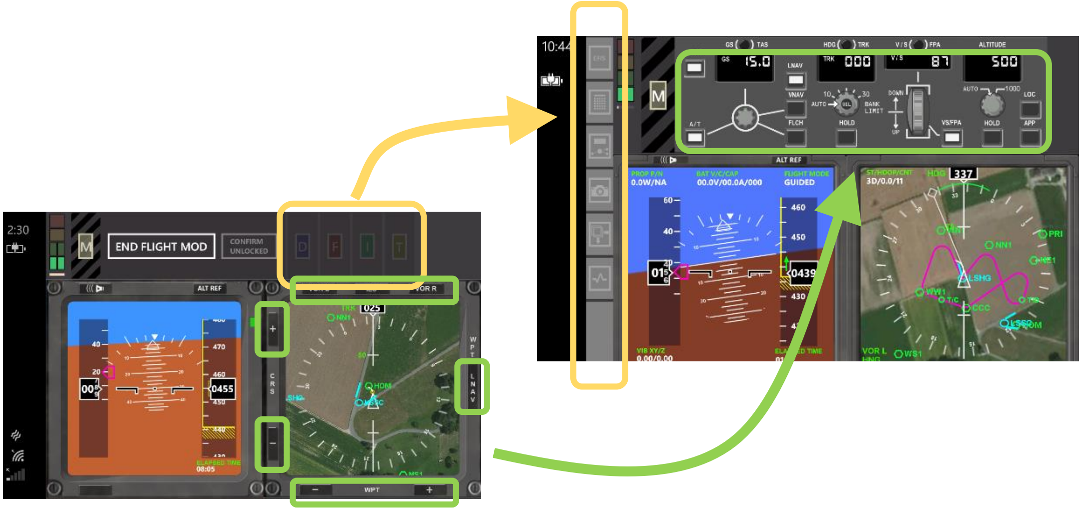
4.1.1 Paradigm changes compared with version 1.5

- The main feature of version 2.0 is the autopilot. Before (up until version 1.5) FlightZoomer only provided the instruments to the pilot, but no possibility to control the flight. Even following flight plans or capturing an ILS or VOR localizer had to be done manually using the RC transmitter. As a result, the accuracy left a lot to desire.
  With version 2.0 the focus has completely shifted to automatic flight. The capabilities of the 787 autopilot have largely been implemented. As following planned routes manually is not required/preferred anymore, a number of features became obsolete and some are not even supported anymore (see version 1.5 documentation to get the details):
    - Features that support to follow flight plans by manual flight (flight director)
    - Features that support a constant turn rate (test flight, RC transmitter configuration…)Distinction between planned and actual route on the Navigation Display
- Usage of the phones internal sensors and GPS is not recommended anymore because the data received from the flight controller is so much more accurate. As a result, the system setup is simplified significantly and a number of mainly Sensorics features become obsolete (they are still there in case somebody wants to use the version 1.5 approach):
    - The attitude of the sensor device on the aircraft is no longer relevant, thus geometry capturing is no longer needed.
    - The same applies to the compass calibration as well.
    - The GPS of the phone is also no longer needed.

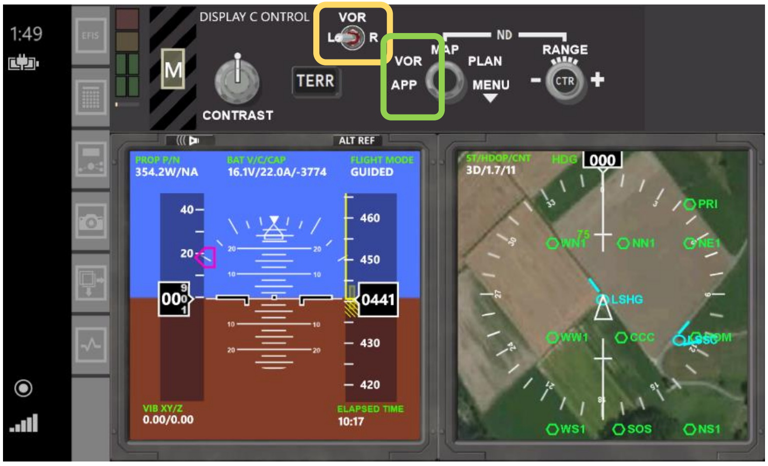
4.1.2 Functional changes compared with version 1.5

- Beside the internal camera now also the Sony camera API is supported, which enables to control a wide variety of Sony cameras via WLAN.
- The camera is now controlled from the groundstation.
- Two modes can be controlled: start/stop shooting an image series and start/stop recording a video (supported both for the internal as for a Sony camera).
- Offline video download capabilities have been removed from FlightZoomer, because the recorded videos are now stored in the official picture library of the phone (version 1.5 was targeting an OS version, which did not support that yet, hence the in-built download feature).
- New GUI layout on the groundstation:
    - The selectable panel bar buttons have been replaced by static buttons on the left side of the screen.
    - Thinner instruments frames for the Primary Flight Display and the Navigation Display give more space for content.

- The buttons on the frame of the Navigation Display have become obsolete, or have been moved to the autopilot Mode Control Panel (MCP).



- In version 1.5 a somewhat limited logic automatically determined whether the Navigation Display showed the planned route or the localizer of a tuned ILS/VOR. In version 2.0 the pilot has to manually select these options on the *DISPLAY CONTROL*-panel. That way the pilot has the possibility (and responsibility) to select the desired information at any time by himself:



    - The VOR L / R Selector allows to switch the localizer indications between the left and the right VORs (if both are tuned).
    - The left ND rotary switch has two new positions: VOR and APP. Beside MAP or PLAN, which always show the flightplan route, VOR allows to display the localizer indications for a tuned VOR, while APP allows to show the localizer indications for a tuned ILS receiver.

4.2 Autopilot

4.2.1 Functional aspects

4.2.1.1 Overview over the autopilot modes

The following table shows the 14 new autopilot modes grouped into three channels vertically and horizontally by three types of automatic flying modes:

Channel	BASIC modes		RADIO NAVIGATION modes		FLIGHT PLAN modes	
LATERAL	**Track Over Ground**	select/hold	**VOR Localizer**	arm/capture/hold	**LNAV**	activate
	Heading	select/hold	**ILS Localizer**	arm/capture/hold		
	Turn Rate	select/hold				
VERTICAL	**Altitude**	arm/capture/hold	**ILS Glideslope**	arm/capture/hold	**VNAV**	activate
	Vertical Speed	select/hold				
	Flight Path Angle	select/hold				
	FLCH Flight Level Change	activate				
SPEED	**Speed**	select/hold			**Flight Plan Speed**	select/hold

Autopilot modes types

There are three autopilot modes types:

- The BASIC modes cover the basic flight trajectory in the three degrees of freedom.
- The RADIO NAVIGATION modes enable capture and follow of simulated radio navigation aids from the navigation database.
- The FLIGHT PLAN modes control the flight based on the defined or loaded flight plan.

Autopilot mode states

For each autopilot mode one or more states are applicable. The following states exist:

States	Description
select/hold	Autopilot modes that offer these two states allow setting a target value which immediately becomes effective. Any previously active mode of the same channel is immediately deactivated.
arm/capture/hold	Autopilot modes that have these three states offer to set a target which first needs to be approached using another mode of the same channel. During that time the mode is in an armed state. The target is then automatically captured (with a soft transition), the previous mode becomes deactivated and the previously armed mode is put in the hold state.
activate	These modes have no target value and are just activated. Any previously active mode of the same channel is immediately deactivated.

Autopilot channels

The three channels LATERAL, VERTICAL and SPEED are the degrees of freedom which are covered by similar autopilot modes.

As long as the autopilot is engaged, one mode needs to be active for each channel. This means that this particular mode is in the state hold or activated. Additionally, for the two channels LATERAL and VERTICAL, a second mode can be in the state armed.

As a result, the two channels LATERAL and VERTICAL basically are composite states which at any time can have two modes: One which is in the hold or activated state, and one which is in the armed state. The following tables shows all the possible combinations.

The notation is <mode in hold or activated state> + <mode in armed state>

These are all valid LATERAL composite states:

With no armed mode	Combinations with modes in armed state	
Track Over Ground + none	Track Over Ground + VOR Localizer	Track Over Ground + ILS Localizer
Heading + none	Heading + VOR Localizer	Heading + ILS Localizer
VOR Localizer + none		
ILS Localizer + none		
LNAV + none		

A special case is the *Turn Rate*-mode. Whenever the *Track Over Ground*- or the *Heading*-mode are active, the selected turn rate is applied too during the turns.

These are all valid VERTICAL composite states:

With no armed mode	Combinations with modes in armed state	
Altitude + none	Altitude + Altitude	Altitude + ILS Glideslope
Vertical Speed + none	Vertical Speed + Altitude	Vertical Speed + ILS Glideslope
Flight Path Angle + none	Flight Path Angle + Altitude	Flight Path Angle + ILS Glideslope
FLCH + none	FLCH + Altitude	
ILS Glideslope + none		
VNAV + none		

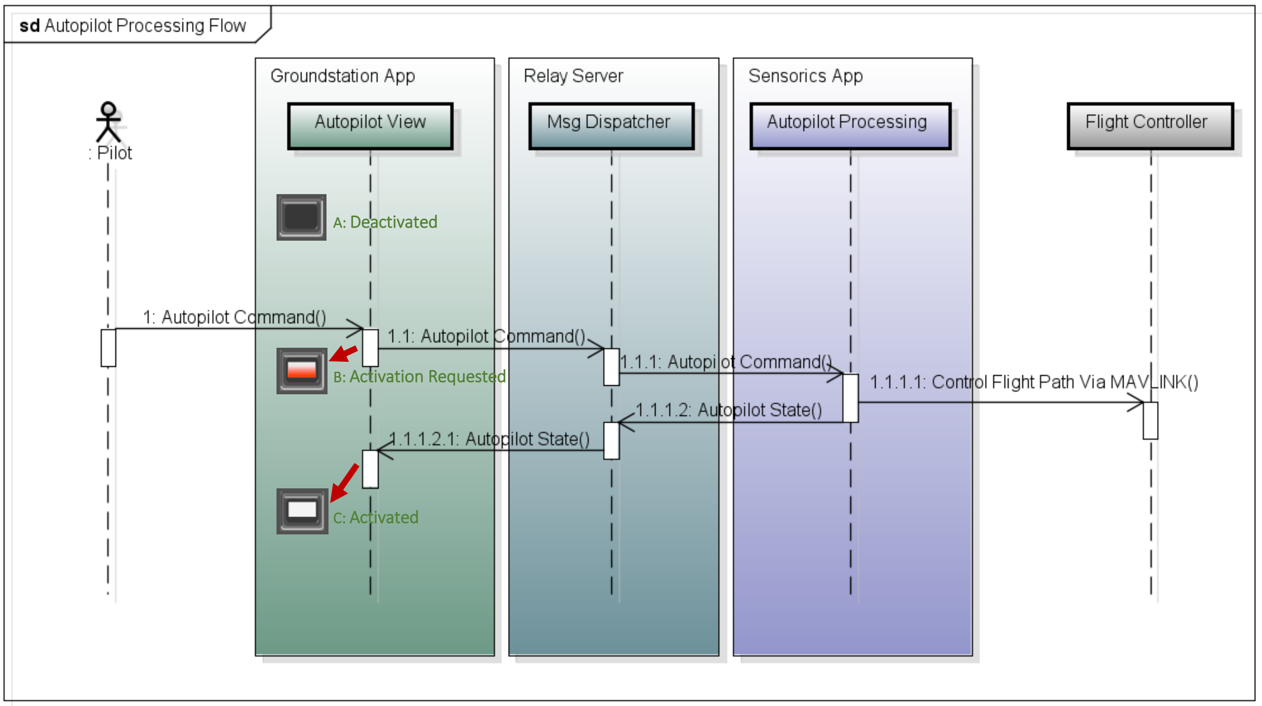
Compatibility

The FlightZoomer autopilot up to now is only supported and tested for multicopters (FlightZoomer Sensorics mated with Arducopter). Minimal version for Arducopter is 3.3.

The integration for fixed wing operations is not yet completed (mating FlightZoomer Sensorics with Arduplane).

4.2.1.2 Processing of autopilot commands

The following sequence diagram shows the processing of an autopilot command:



The processing flow works as follows:

1.	[A:]	The autopilot view component in the Groundstation-app displays the activation state of each mode by lighting the button accordingly. Unlighted means deactivated.
2.	[1:]	The pilot modifies a parameter of the autopilot via the Mode Control Panel (e.g. a requests new mode).
3.	[B:]	The respective mode button turns white (= on) but the lower half of the button still has a red shade.
4.	[1.1:], [1.1.1:]	The command is sent to the Sensorics-app and stored in the autopilot processing component.
5.	[1.1.1.1:]	The autopilot considers the new parameter to control the flight path via MAVLINK.
6.	[1.1.1.2:], [1.1.1.2.1:]	The updated autopilot state is reported to the Groundstation-app.
7.	[C:]	The respective mode button turns fully white now and the red shade disappears.

4.2.2 Groundstation-app

While the implementation of the autopilot features is spread over both the Sensorics and the Groundstation, the interaction between the pilot and the system only happens at the groundstation.

In this chapter the autopilot MCP (Mode Control Panel) is explained.

Generally, it is recommended to train the autopilot features intensively with the simulation mode before actually using it with the aircraft.

4.2.2.1 Activation of the autopilot

The activation of the autopilot is done by the autopilot master switch on the MCP. At any time, the autopilot can be activated or deactivated. Activating the autopilot will change the flight controller mode to GUIDED so that FlightZoomer can begin controlling the flight path. When the autopilot is being switched off, the flight mode will be set to POS_HOLD to overtake manual control again.

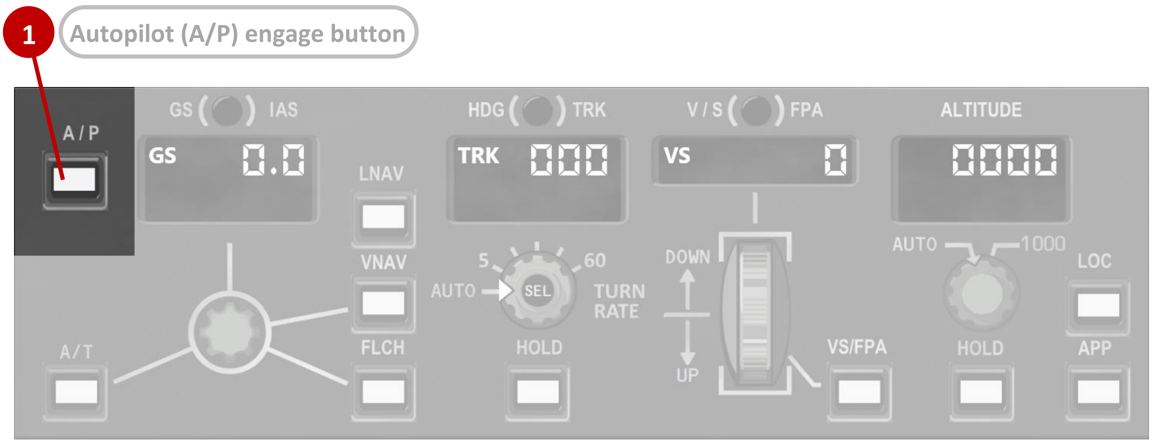
If a different APM mode than GUIDED is set manually (e.g. using the RC transmitter) the FlightZoomer autopilot will be deactivated.

Along with the activation of the autopilot goes the activation of the following default autopilot modes for each channel:

- LATERAL: Track Over Ground hold
- VERTICAL: Altitude hold
- SPEED: Speed hold

In each of the channels the momentary value is taken as the target value.

The following user interface element is used to activate and deactivate the autopilot:

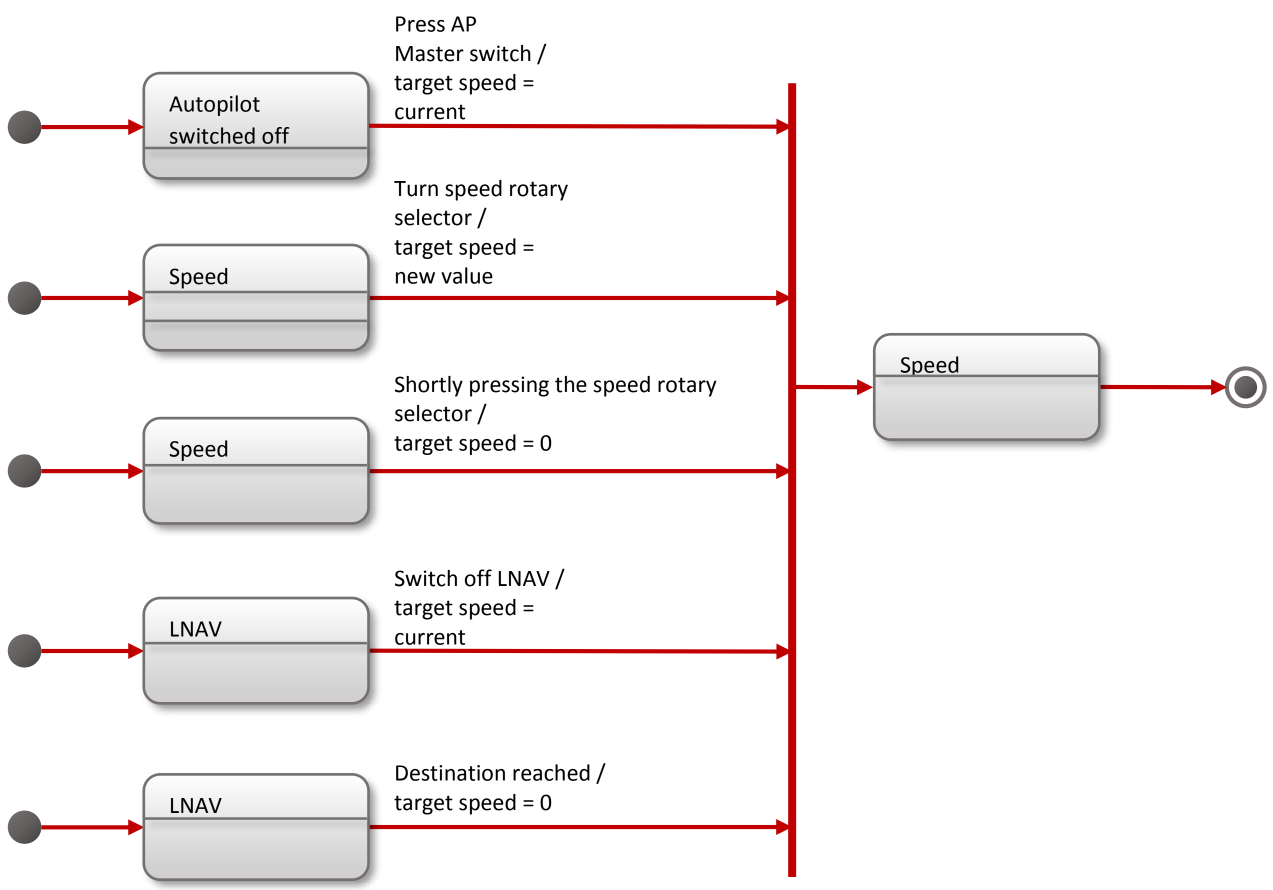


	Element	Purpose
1	Autopilot (A/P) engage button	This button is the master switch for the autopilot. The switch is shaded red in the lower half as long as the last request has not been acknowledged from the onboard device.

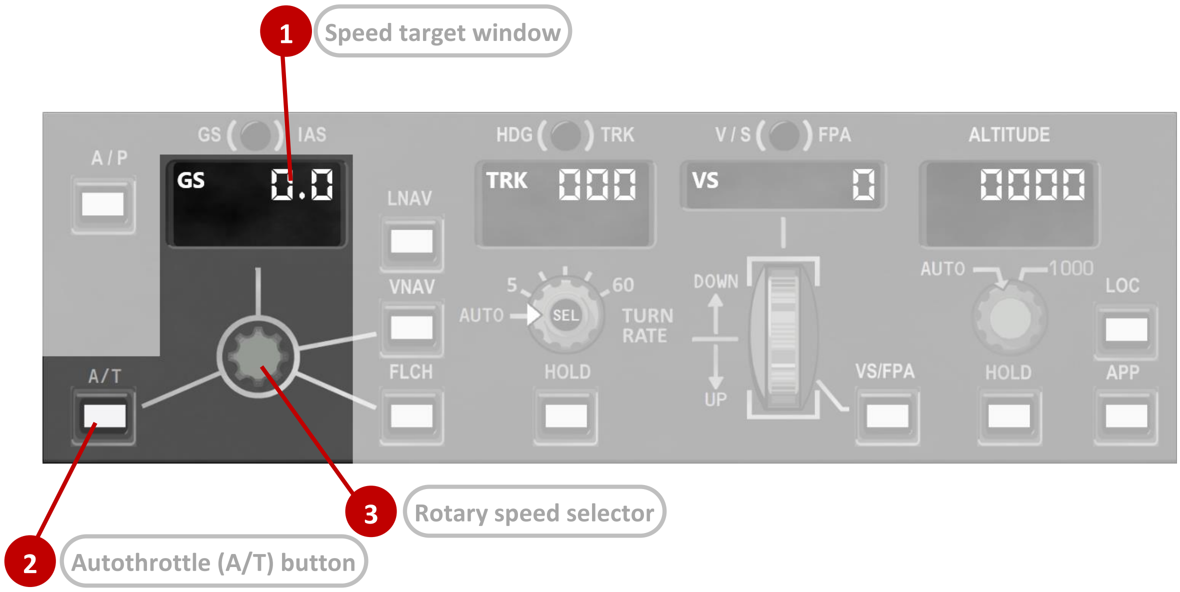
4.2.2.2 *Speed*-mode

Mode type	BASIC
Channel	SPEED
Supported phases	Select / Hold
Overview	The *Speed*-mode controls the forward speed of the aircraft. It is the most basic autopilot mode because any other autopilot mode depends on it. Without having set a forward speed, no other mode will be effective except the two basic direction modes *Heading* and *Track over ground*. The *Speed*-mode is also called autothrottle because for fixed wing aircraft the throttle controls the speed.
Unit	The target speed value is set and shown in display units. The display unit for speed can be defined either as m/s, knots, km/h or mph on the IDENT page of the FMS.
Target value range	Any positive value including 0.0 can be selected as target speed.
Supported combinations	The *Speed*-mode is only applicable if the autopilot operates in any of the BASIC- or RADIO NAVIGATION-modes. Using the *LNAV*-mode will select the target speed from the flight plan (see *Flight Plan Speed*-mode).

The following transitions are possible to reach the *Speed*- mode:



The following user interface elements are used to control the *Speed*-mode on the MCP:

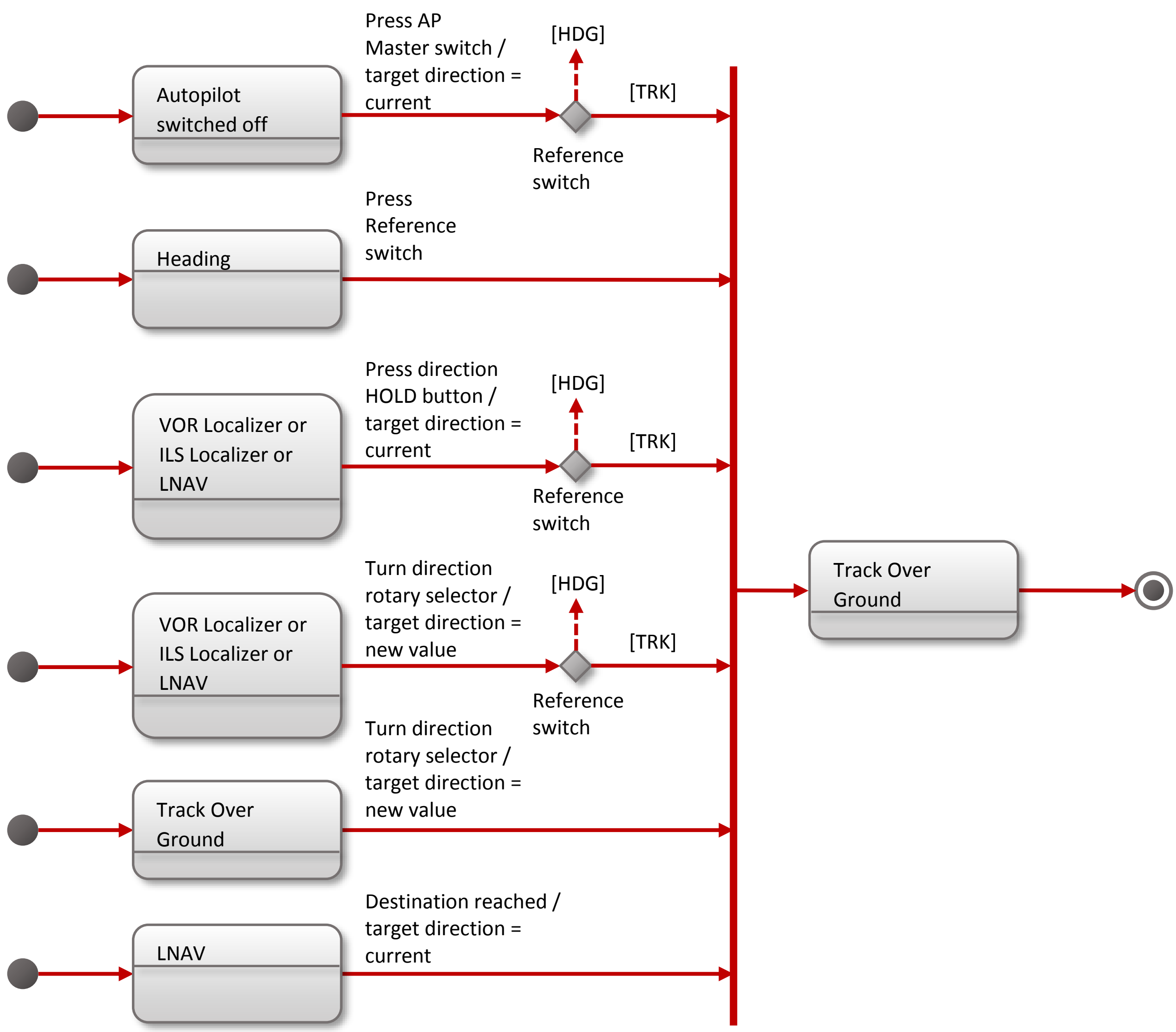


	Element	Purpose
1	Speed target window	The speed target window shows the currently set target speed. The value is set using the rotary speed selector beneath it.
2	Autothrottle (A/T) button	The autothrottle controls the forward speed. As the autothrottle currently is not supported independently of the autopilot, the state of this button at any time correlates with the A/P button state.
3	Rotary speed selector	This selector defines the target speed in display unit. The following user interaction is supported: - **Shortly pressing the knob** Reset the target speed immediately to zero (emergency stop). - **Pressing and holding the selector** Pressing and holding the knob opens a zoomed version of the rotary selector, which allows selecting the target value by sliding with the finger around the center: 

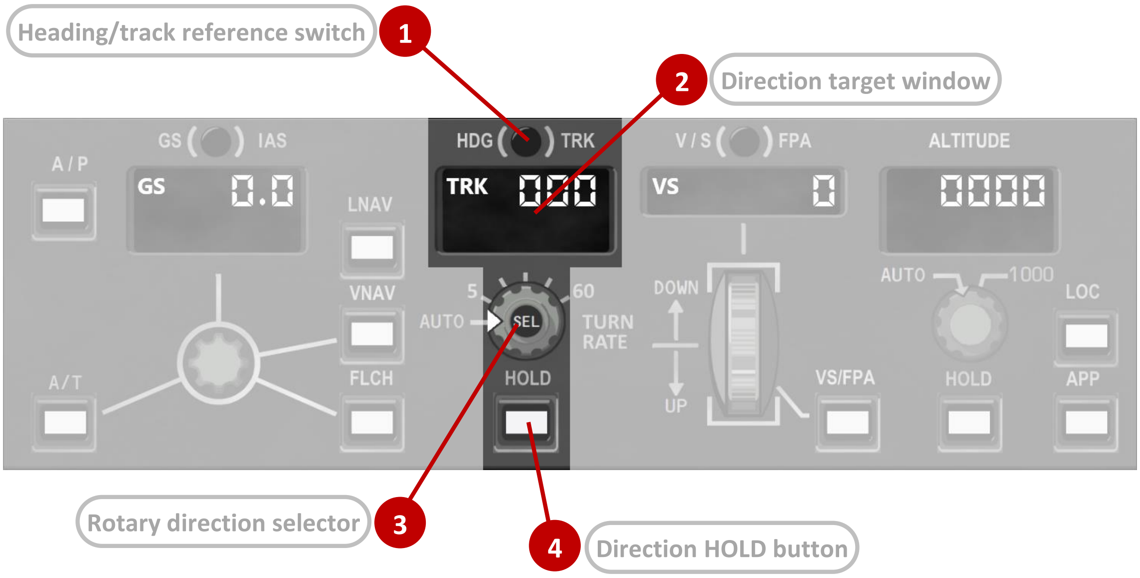
4.2.2.3 Track Over Ground-mode

Mode type	BASIC
Channel	LATERAL
Supported phases	Select / Hold
Overview	The *Track Over Ground*-mode is the default lateral mode. It controls the direction of the flight path over ground. This means that a bank angle is applied to counter the effect of any crosswind component.
Unit	The target direction is set and shown in degrees.
Target value range	The number range for the target direction is 0°...360°.
Supported combinations	n/a

The following transitions are possible to reach the *Track Over Ground*- mode:



The following user interface elements control the *Track Over Ground*-mode on the MCP:

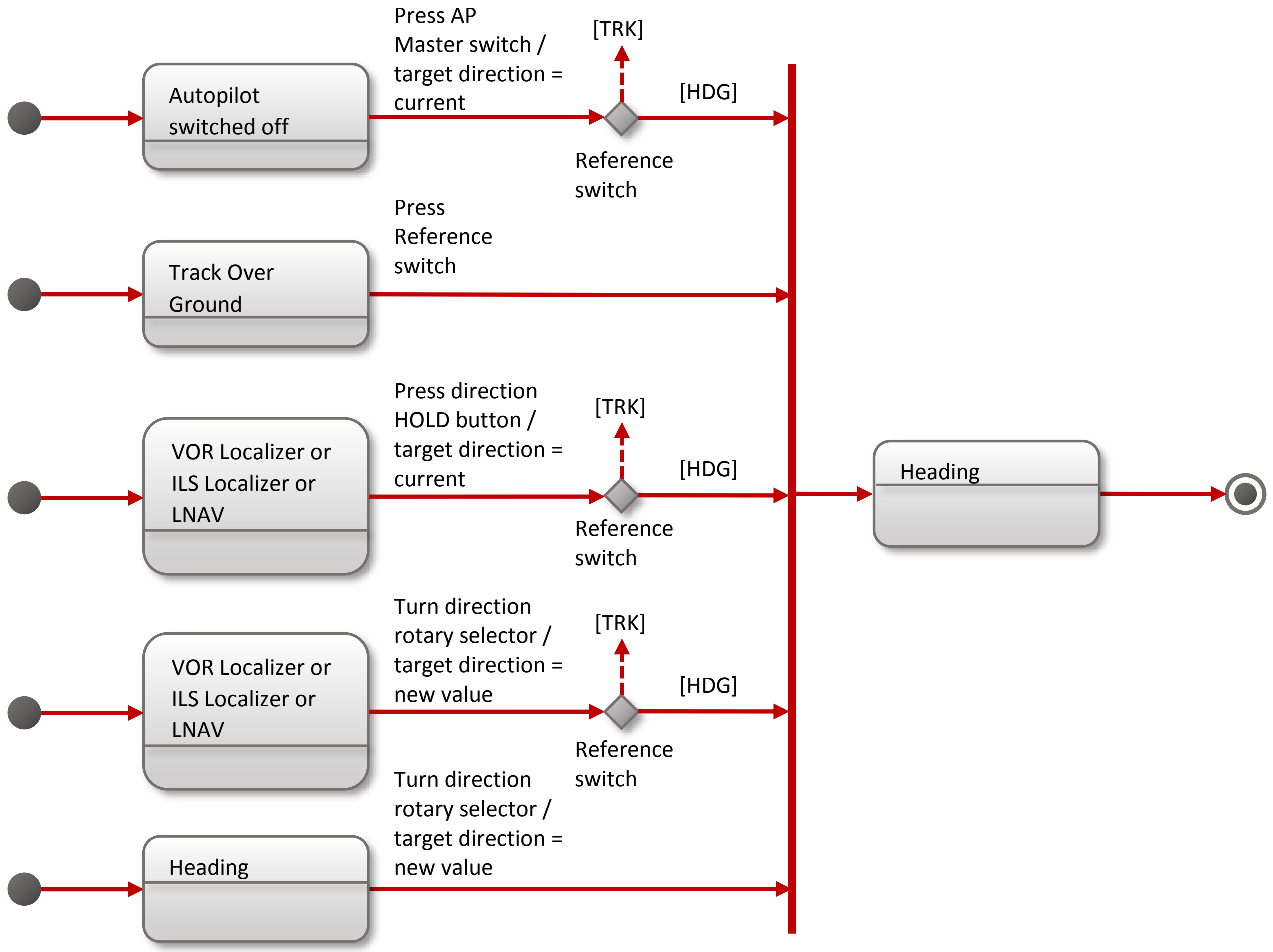


	Element	Purpose
1	Heading/track reference switch	This button toggles between the *Track over ground*-mode and the *Heading*-mode.
2	Direction target window	The direction target window shows the currently selected target direction. In addition, a text label indicates the variation of the direction mode (TRK for *Track over ground*, HDG for *Heading*).
3	Rotary direction selector	This selector defines the target direction. The following user interaction is supported: - Pressing and holding the selector opens a zoomed version of the rotary selector:  - On the zoomed selector the target value can be chosen by sliding with the finger around the center. - Sliding along the outer track (red arrows) will set the target direction directly according to the compass rose. This means that the position of the finger directly matches the resulting target direction (up = 0°, right = 90°, down = 180°, left = 270°). - Sliding along the inner track (yellow arrows) will continuously increase or reduce the target value, allowing a fine tuning to the desired target direction.
4	Direction HOLD button	This button enables an immediate hold of the current direction (either *Track Over Ground* or *Heading*, depending on the selected variation). This is possible at any time and coming from any other lateral mode. Whenever one of the two basic direction hold modes is active, this button becomes illuminated.

4.2.2.4 Heading-mode

Mode type	BASIC
Channel	LATERAL
Supported phases	Select / Hold
Overview	The *Heading*-mode is an alternative to the *Track Over Ground*-mode. It controls only the direction of the nose of the aircraft. This means that the target direction will differ from the actually flown flight path over ground if there is a crosswind component. In manned aviation the *Heading*-mode is more often used than the *Track Over Ground*-mode. Typically, whenever Air Traffic Control provides vectors for an approach, they will request an aircraft to hold a particular heading. For RC aircraft on the other hand the *Track Over Ground* is considered as the default mode because even with moderate crosswind the sideward drift becomes notable using the *Heading*-mode.
Unit	The target direction is set and shown in degrees.
Target value range	The number range for the target direction is 0°…360°.
Supported combinations	n/a

The following transitions are possible to reach the *Heading*-mode:

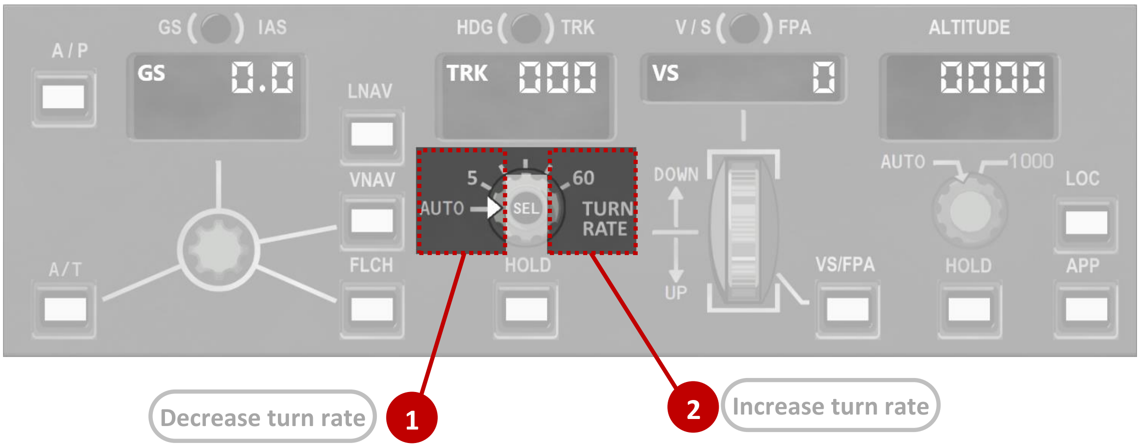


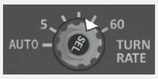
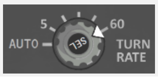
For the description of the user interface elements please refer to the previous chapter about the *Track Over Ground*-mode.

4.2.2.5 Turn Rate-mode

Mode type	BASIC
Channel	LATERAL
Supported phases	Select / Hold
Overview	The turn rate determines how quickly the aircraft turns to the right or to the left. For a given forward speed, it also directly determines the turn radius.
Unit	FlightZoomer supports setting the target turn rate to either AUTO or one of five distinct target values: AUTO: The turn rate is taken from the standard turn rate, which is configured in the aircraft settings 5°/s: A turn rate of 5 degrees per second; results in very wide and gentle turns 10°/s: A turn rate of 10 degrees per second; results in a moderate turn 20°/s: A turn rate of 20 degrees per second; typical default turn rate 30°/s: A turn rate of 30 degrees per second; turns a bit more aggressive 60°/s: A turn rate of 60 degrees per second; definitely would spill the passengers' coffee if there were any.
Target value range	n/a
Supported combinations	The selected turn rate becomes immediately effective as soon, as one of the basic direction modes becomes active (*Track Over Ground* or *Heading*). The selected turn rate is not applied to any other of the lateral modes. The radio navigation modes and the flight plan modes calculate turns based on the standard turn rate, which has been configured in the aircraft settings (Sensorics app).

The following user interface elements are used to control the *Turn Rate*-mode on the MCP:

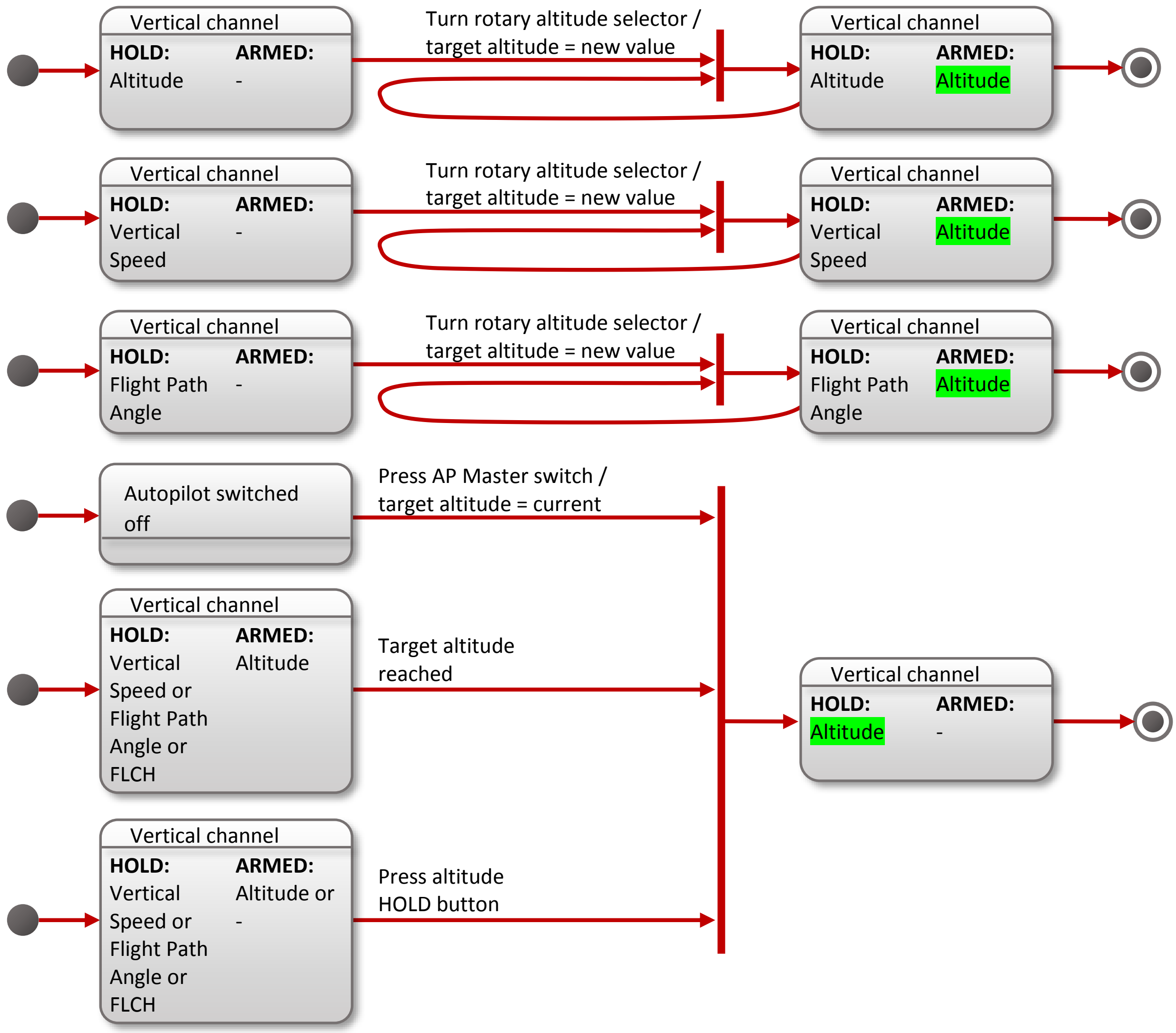


	Element	Purpose
1	Decrease turn rate	Tapping on the area to the left of the direction rotary selector, selects the next lower turn rate setting. The resulting setting is indicated by the selector as follows: AUTO  5 °/s  10 °/s  20 °/s  30 °/s  60 °/s 
2	Increase turn rate	Tapping on the area to the right of the direction rotary selector, selects the next higher turn rate setting. See above how the various settings are indicated.

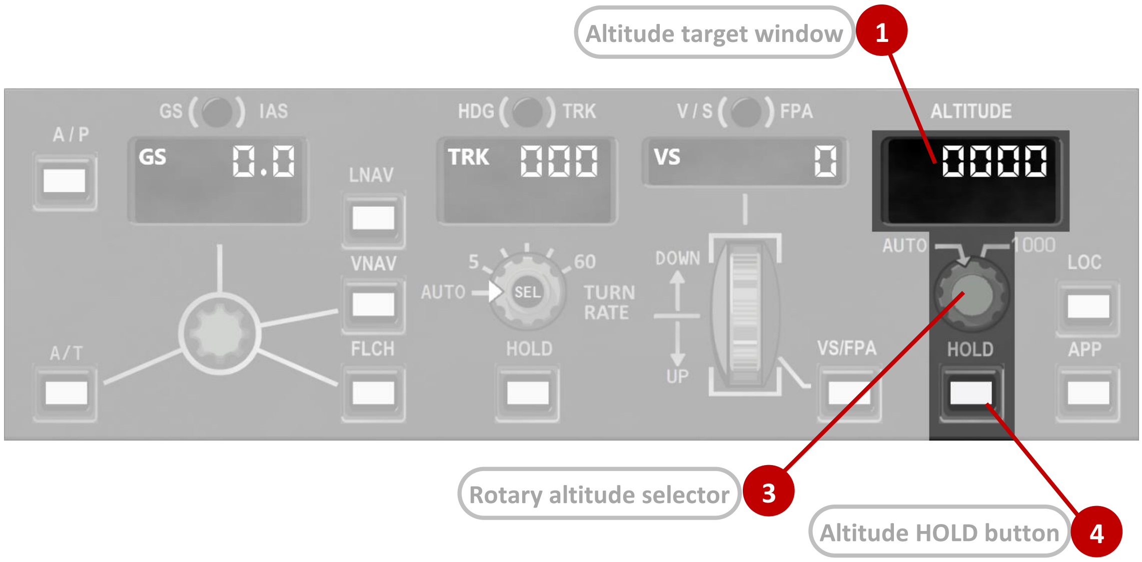
4.2.2.6 Altitude-mode

Mode type	BASIC
Channel	VERTICAL
Supported phases	Arm / Capture / Hold
Overview	The *Altitude*-mode can be armed independently of the current vertical mode and climb rate by setting a target altitude. After setting a target altitude one of the other basic vertical modes needs to be used to capture the armed altitude. The transition to level flight (while capturing the target altitude) is done by applying a steady deceleration of 0.5 m/s^2
Unit	Display unit for altitudes (can be ft or m), the target altitude is defined in AMSL
Target value range	Unlimited
Supported combinations	See diagram below

The following transitions are possible to reach the *Altitude*-mode. The diagram shows composite states for the vertical channel, highlighting both the active (HOLD) and the armed (ARMED) mode:



The following user interface elements are used to control the *Altitude*-mode on the MCP:

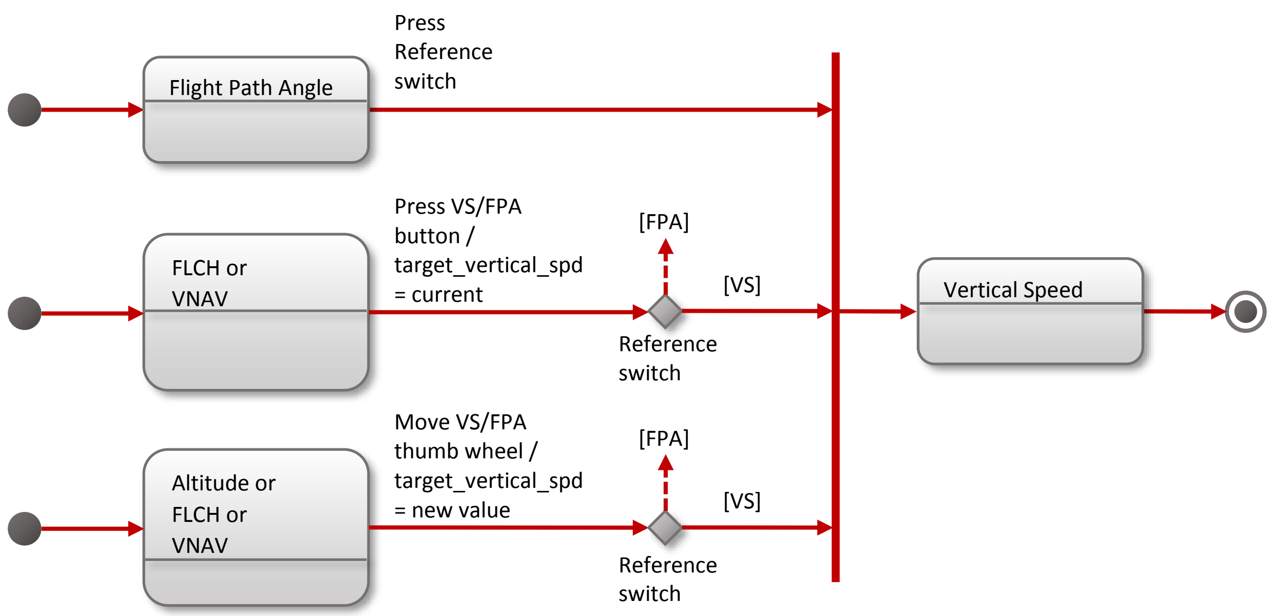


	Element	Purpose
1	Altitude target window	The altitude target window shows the currently selected target altitude. The target value is set using the rotary selector beneath it. The displayed value represents at any time the autopilot target altitude, or, while the *VNAV*-mode is active, the flight plan cruise altitude.
2	Rotary altitude selector	With this selector a target altitude can be defined in display unit. The following user interaction is supported: - **Pressing and holding the selector** Pressing and holding the knob opens a zoomed version of the rotary selector, which allows selecting the target value by sliding with the finger around the center: 
3	Altitude HOLD button	The altitude HOLD button enables an immediate hold at the current altitude. This is possible at any time and coming from any other vertical mode. This button is not yet illuminated while the *Altitude*-mode is in armed state. Only after the *Altitude*-mode is in hold state, the button becomes illuminated.

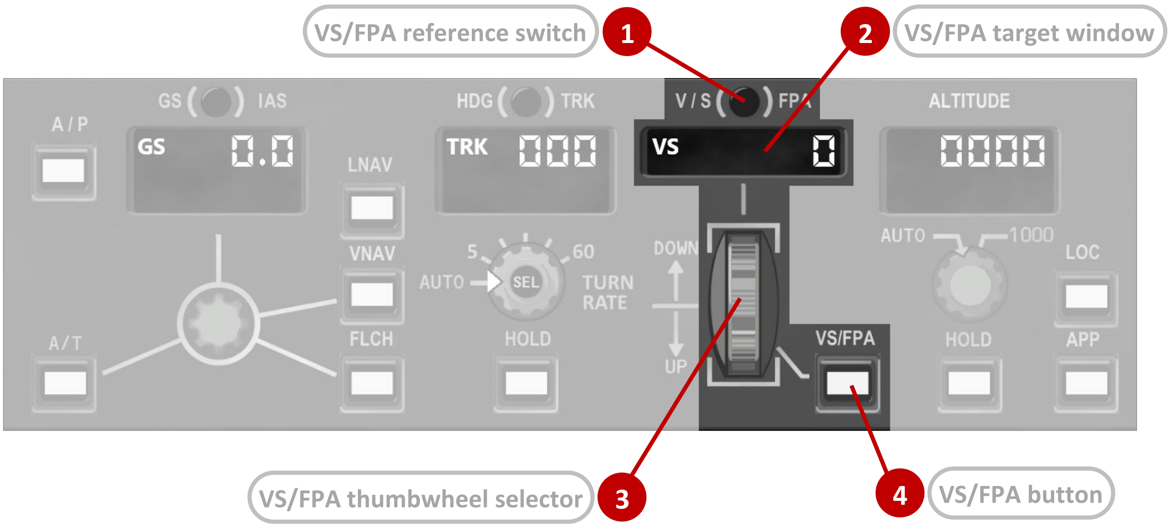
4.2.2.7 Vertical Speed-mode

Mode type	BASIC
Channel	VERTICAL
Supported phases	Select / Hold
Overview	The *Vertical Speed*-mode applies a constant climb or descend speed. This means that the resulting climb or descend angle varies with the forward speed.
Unit	The target vertical speed is entered in display unit per minute (thus can be ft/min or m/min). The divider is borrowed from real aviation, where the altitude change per minute allows for easy vertical flight profile estimations.
Target value range	Unlimited
Supported combinations	n/a

The following transitions are possible to reach the *Vertical Speed*-mode:



The following user interface elements are used to control the *Vertical Speed*-mode on the MCP:

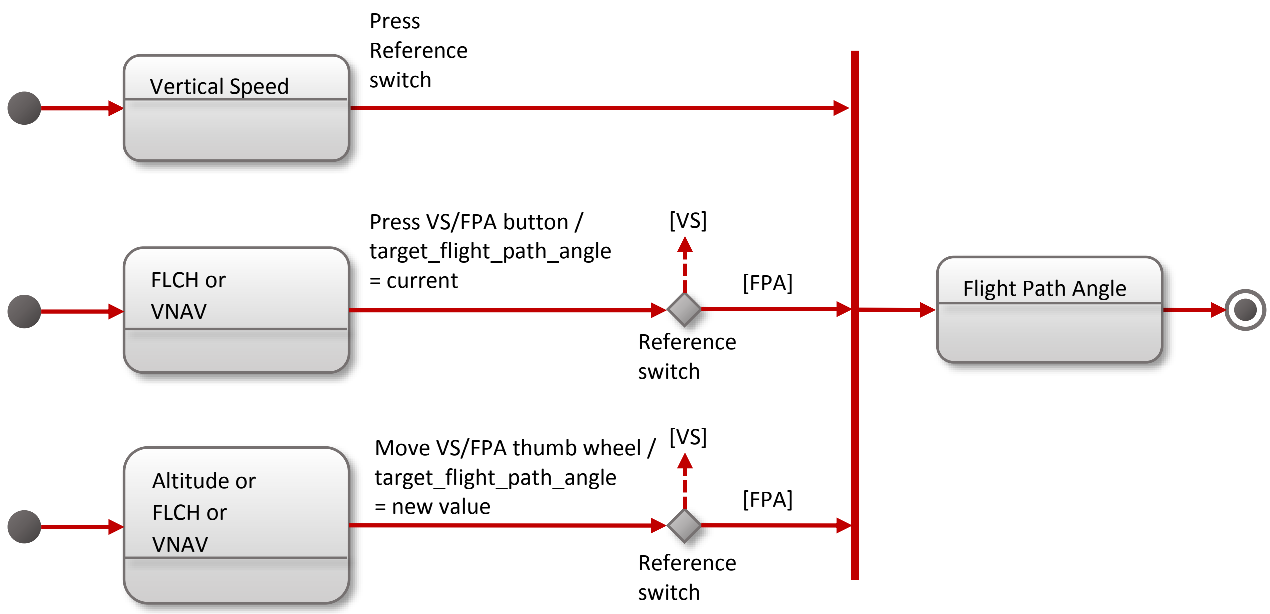


	Element	Purpose
1	VS/FPA reference switch	This button toggles between the *Vertical Speed*-mode and the *Flight Path Angle*-mode.
2	VS/FPA target window	The VS/FPA target window shows the currently selected target value for either the *Vertical Speed*-mode or the *Flight Path Angle*-mode. In addition, a text label indicates the variation (VS for *Vertical Speed*, FPA for *Flight Path Angle*).
3	VS/FPA thumbwheel selector	This selector defines the target vertical speed or flight path angle. The following user interaction is supported: - Tap on the thumbwheel and slide upwards or downwards to set a new target. The whole vertical space of the touchscreen can be used to slide.
4	VS/FPA button	Pressing this button holds the current climb or descend gradient (either *Vertical Speed* or *Flight Path Angle*, depending on the selected variation). Whenever one of the two modes is active, this button becomes illuminated.

4.2.2.8 Flight Path Angle-mode

Mode type	BASIC
Channel	VERTICAL
Supported phases	Select / Hold
Overview	The *Flight Path Angle*-mode applies a constant climb or descend angle. This means that the resulting climb or descend speed varies with the forward speed.
Unit	The flight path angle is defined in degrees.
Target value range	The number range for the target flight path angle is -45°...45°.
Supported combinations	n/a

The following transitions are possible to reach the *Vertical Speed*-mode:



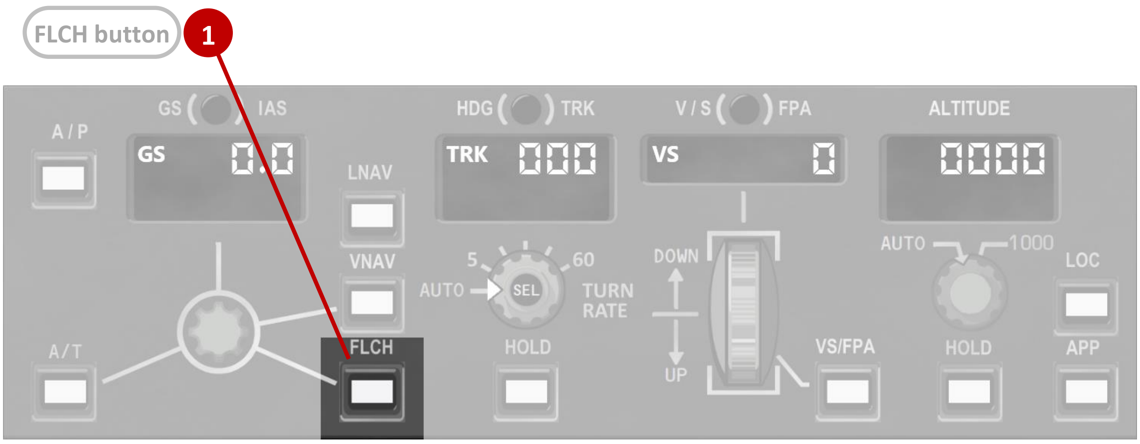
For the description of the user interface elements please refer to the previous chapter about the *Vertical Speed*-mode.

4.2.2.9 FLCH-mode

Mode type	BASIC
Channel	VERTICAL
Supported phases	Activate
Overview	The *FLCH*-mode immediately initiates a climb or descend to an armed target altitude (FLCH means flightlevel change). This is the most convenient way to initiate climbs or descends. In full scale aviation, this mode uses energy management to calculate the most economic climb or descend speed (by setting either the throttle either to idle for descending or CLIMB THRUST for climbing). FlightZoomer however does not calculate the climb/descend gradient based on energy calculations. Instead a constant climb/descend rate is applied, which can be configured in the aircraft settings.
Unit	The regular vertical speed (defined in the aircraft settings), which is used for the *FLCH*-mode, is specified in m/s.
Target value range	Unlimited
Supported combinations	It is a precondition for the *FLCH*-mode, that an altitude has been armed.

The following transition is possible to reach the *FLCH*-mode:

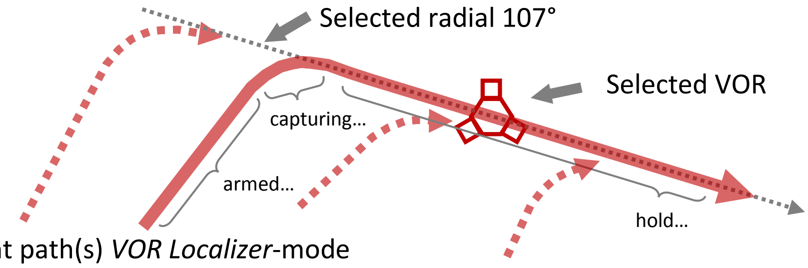
The following user interface elements are used to control the *FLCH*-mode on the MCP:



	Element	Purpose
1	FLCH button	Pressing this button triggers the *FLCH*-mode. Whenever the *FLCH*-mode is active, this button becomes illuminated.

4.2.2.10 VOR Localizer-mode

Mode type	RADIO NAVIGATION modes
Channel	LATERAL
Supported phases	Arm / Capture / Hold
Overview	The *VOR Localizer*-mode allows to arm, capture and hold a VOR radial:



Flight path(s) *VOR Localizer*-mode

As a precondition, the VOR must have been defined in the navigation database. The VOR can be tuned (red box below) and the radial can be selected (yellow box below) on the NAV RAD page of the FMS. The *VOR Localizer*-mode only supports the left receiver (VOR L):

The turn rate for capturing the radial is the standard turn rate from the aircraft settings.

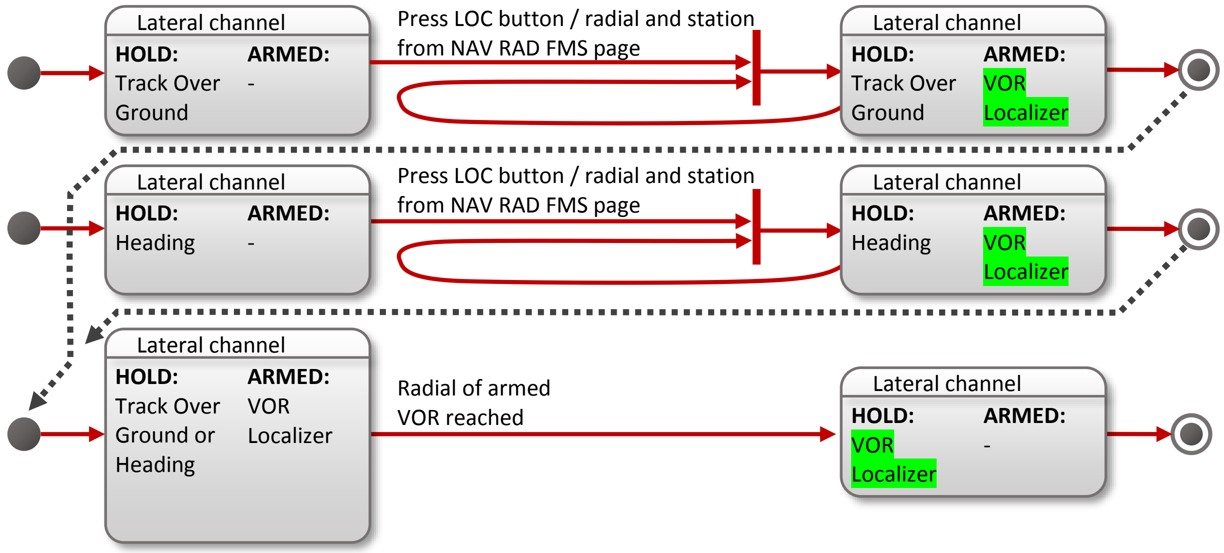
The *VOR Localizer*-mode allows to fly on a radial towards a VOR and past a VOR. The mode stays in the armed state while approaching the radial. Once a radial is captured and as long as the lateral autopilot mode is not changed, the aircraft holds the radial until the end of the earth…

If the selected radial is behind the current position, the *VOR Localizer*-mode will stay in armed state forever (to be precise after a straight flight one time around the globe, the radial will be found ahead of the aircraft and be captured ;-).

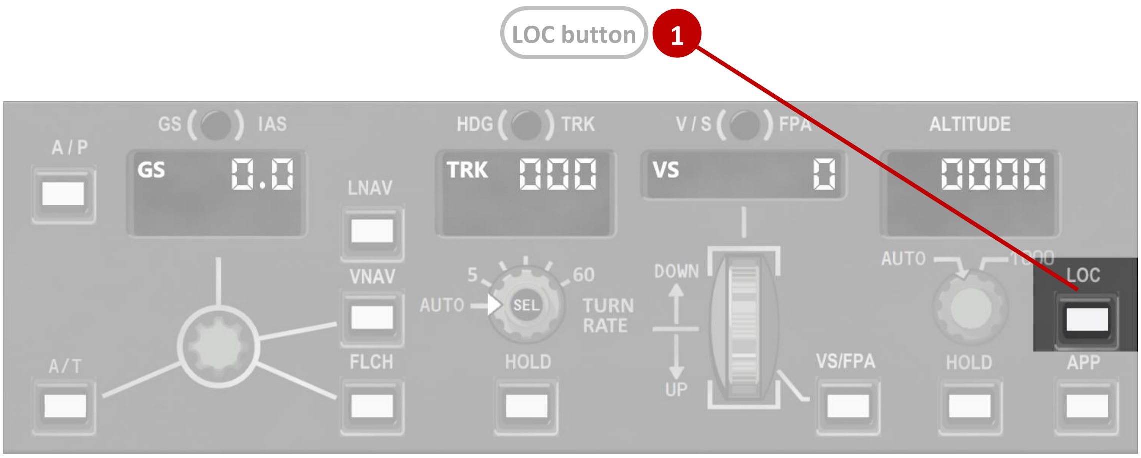
Note: In manned aviation, VOR based navigation was heavily used in the early days of IFR flying. Today RNAV has replaced the classic VOR-to-VOR way of flying. RNAV waypoints can not only be VORs but freely placed navigation fixes without radio station. The FlightZoomer autopilot mode which represents RNAV flying is the *LNAV*-mode. And to be really precise, the LOC-button on the real 787 does not support following VOR radials as implemented by FlightZoomer at all. In modern jets, like the 787, the VOR Localizer mode is restricted to VOR approaches, where the VOR, like an ILS, has a directed beam (called localizer) to allow high precision lateral guidance towards a runway. Therefore, the implementation in FlightZoomer

	actually recreates the functionality of the VOR/LOC button, which is present in older jets, like the 737.
Unit	The radial can be defined in ° on the NAV RAD FMS page.
Target value range	n/a
Supported combinations	The *VOR Localizer*-mode allows capturing a radial only coming from one of the two basic lateral modes, *Track Over Ground* or *Heading*.

The following transitions are possible to reach the *VOR Localizer*-mode (armed or hold):



The following user interface elements are used to control the *VOR Localizer*-mode on the MCP:



	Element	Purpose
1	LOC button	Pressing this button triggers the *VOR Localizer*-mode. Whenever the *VOR Localizer*-mode is active, this button becomes illuminated.

4.2.2.11 ILS Localizer-mode

Mode type	RADIO NAVIGATION modes
Channel	LATERAL
Supported phases	Arm / Capture / Hold

Overview

The *ILS Localizer*-mode is used for automatic approaches to a runway and works very similar like the *VOR Localizer*-mode.

A difference between the *VOR Localizer*- and *ILS Localizer*-mode is, that an ILS station has both vertical and lateral radio beams, that guide an aircraft to a runway. This means that there is no radial, which freely can be selected. Instead the direction of the runway is the selected automatically as the (only possible) radial to be followed.

While there is no predetermined order in which the vertical and the horizontal beam should be captured, typically first the localizer is captured before the glideslope closes in from above.

As a precondition for an ILS approach, the ILS must have been defined in the navigation database. The ILS frequency of the runway, which is used for the landing, can be tuned on the NAV RAD page of the FMS:

The turn rate for capturing the ILS is the standard turn rate from the aircraft settings.

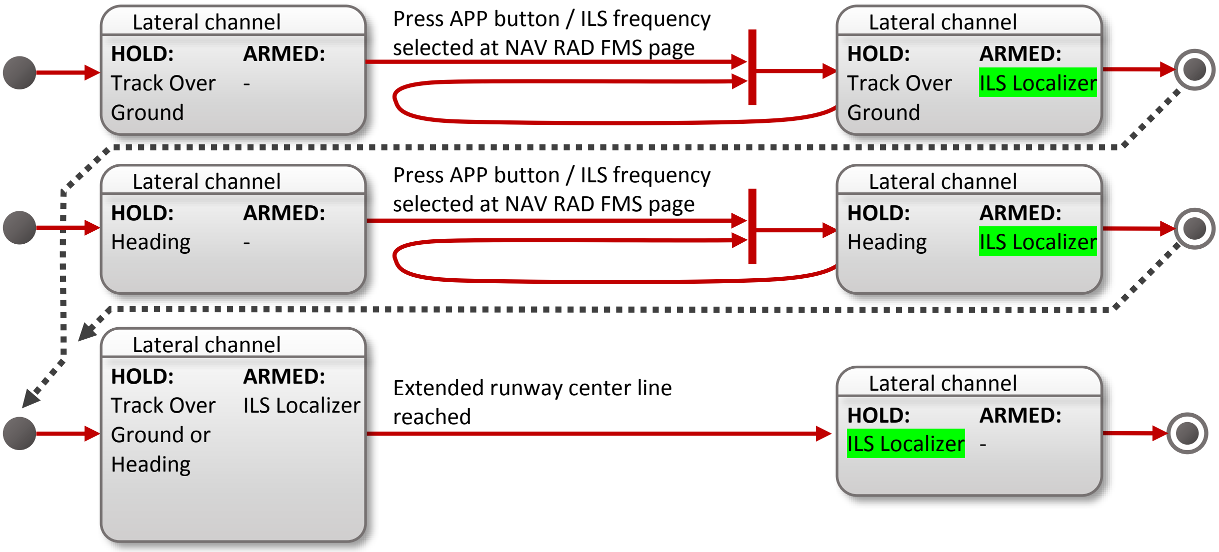
Another property, which is defined in the aircraft settings, is the behavior at the end of the approach. The available options allow to let the aircraft stop and keep the position at the runway threshold (recommended for multicopters) or to continue the descend gradient infinitely.

The latter would let land a fixed wing aircraft on a sufficiently spaced landing strip. Without a flare phase though, but it needs to be considered that landing at the standard ILS glide angle of 3° without flaring is SOP (standard operating procedure) under certain (weather-) conditions even for the largest jets. FlightZoomer approaches can be defined with any glide angle (when the navigation database is created using the relay server application). So having rather shallow glide angles of 3° or 4° at maximum is not only realistic but also perfectly feasible in order to let fixed wing aircraft land automatically.

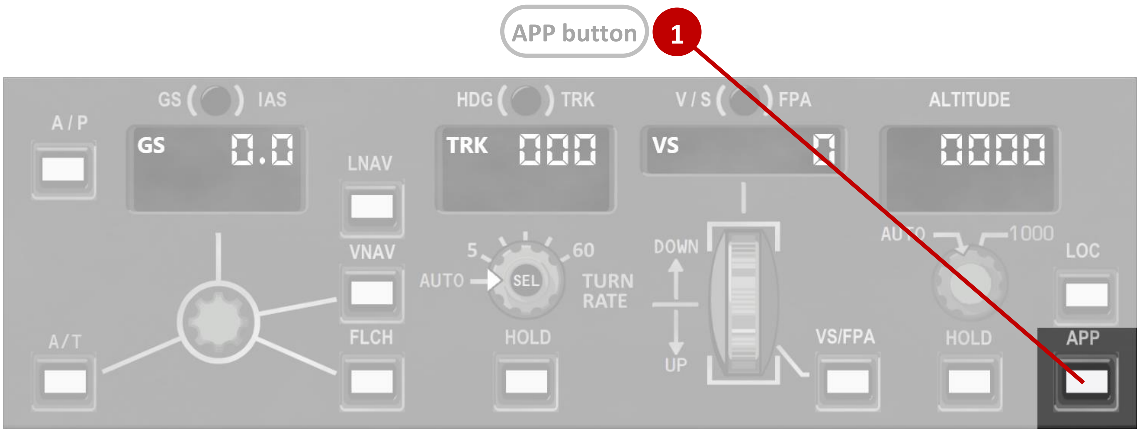
For multicopters the ILS approach works well for glide angles up to 15° or 20°.

Unit	n/a
Target value range	n/a
Supported combinations	The *ILS Localizer*-mode always goes along with the *ILS Glideslope*-mode. Tuning the radio receiver to an ILS frequency and pressing the APP button on the MCP always activates both of these modes.

The following transitions are possible to reach the *ILS Localizer*-mode (armed or hold):



The following user interface elements are used to control the *ILS Localizer*-mode on the MCP:

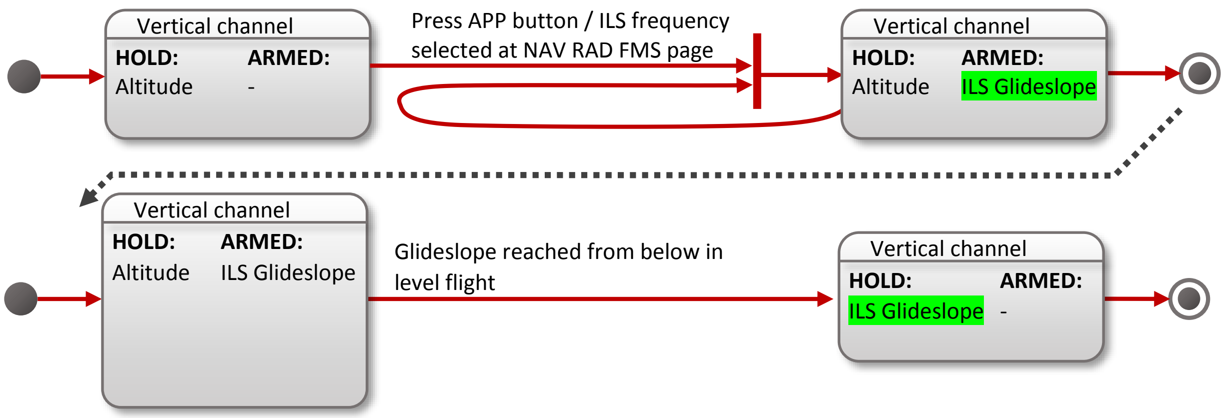


	Element	Purpose
1	APP button	Pressing this button triggers the *ILS Localizer*-mode. Whenever the *ILS Localizer*-mode is active, this button becomes illuminated.

4.2.2.12 ILS Glideslope-mode

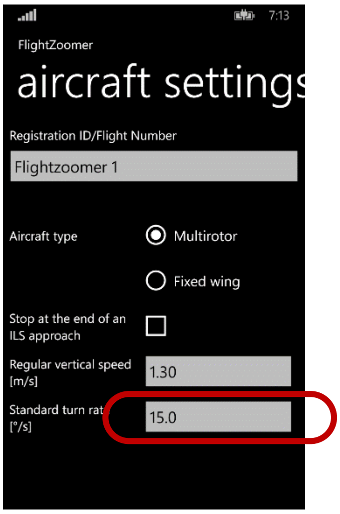
Mode type	RADIO NAVIGATION modes
Channel	VERTICAL
Supported phases	Arm / Capture / Hold
Overview	The *ILS Glideslope*-mode captures an armed ILS for the vertical channel and holds the glideslope during the descend to the runway threshold. This mode can only be activated in combination with the *ILS Localizer*-mode. Refer also to the description for the *ILS Localizer*-mode to see some common remarks about ILS approaches. The *ILS Glideslope*-mode can only be in armed state below the glideslope. If the APP button is pressed while at or above the glideslope, the mode immediately changes to the capture and later to the hold state. To safely and smoothly capture the glideslope, the aircraft should also be in level flight while approaching the glideslope. The flight segments up to the final approach should be executed in a way, that complies with the two mentioned requirements (catch the glideslope from below and catch it in level flight).
Unit	n/a
Target value range	n/a
Supported combinations	See *ILS Localizer*-mode

The following transitions are possible to reach the *ILS Glideslope*-mode. The diagram shows composite states for the vertical channel, highlighting both the active (HOLD) and the armed (ARMED) mode:



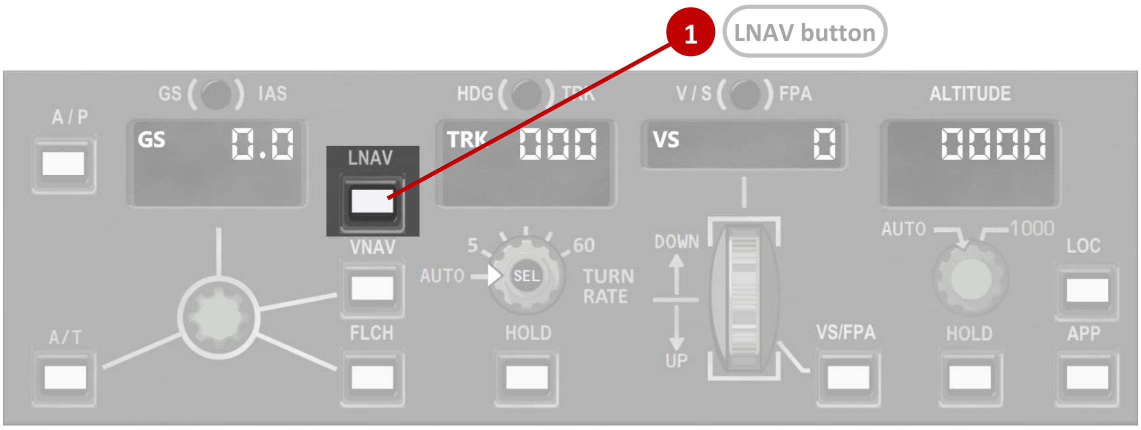
For the description of the user interface element please refer to the previous chapter about the *ILS Localizer*-mode.

4.2.2.13 LNAV-mode

Mode type	FLIGHT PLAN modes
Channel	LATERAL
Supported phases	Activate
Overview	The *LNAV*-mode controls the lateral channel to follow a planned route. Before the *LNAV*-mode can be activated, a route has to been entered on the RTE page of the Flight Management System (optionally also by loading a stored route). A planned route has a specified cruise speed and cruise altitude. The cruise speeds in combination with the standard turn rate determines the radius of each turn. The cruise altitude is used calculate the vertical flight profile (see *VNAV*-mode). The *LNAV*-mode can be activated from any location. The aircraft will turn to the first waypoint of the route and continue to follow the planned route from there on. At the end of the route the aircraft stops and holds the position. The turn rate, which is applied for right and left turns, cannot be controlled using the *Turn Rate*-mode on the fly (because the turn radius would not be predictable as a result). Instead the standard turn rate is used, which can be specified in the aircraft settings (Sensorics app): 
Unit	n/a
Target value range	n/a
Supported combinations	The *LNAV*-mode can be used in combination with any vertical mode, except the *ILS Glideslope*-mode. This means that the usage of *VNAV*-mode is not mandatory (though recommended).

The following transitions are possible to reach the *LNAV* -mode:

The following user interface elements are used to control the *LNAV*-mode on the MCP:

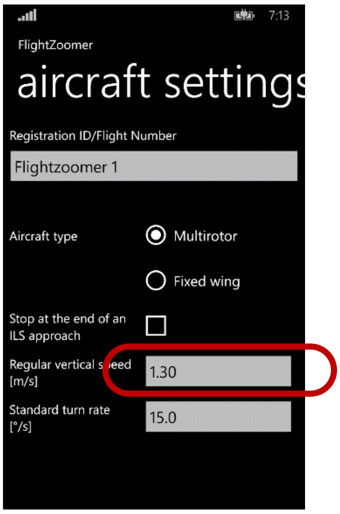


	Element	Purpose
1	LNAV button	Pressing this button triggers the *LNAV*-mode. Whenever the *LNAV*-mode is active, this button becomes illuminated.

4.2.2.14 VNAV-mode

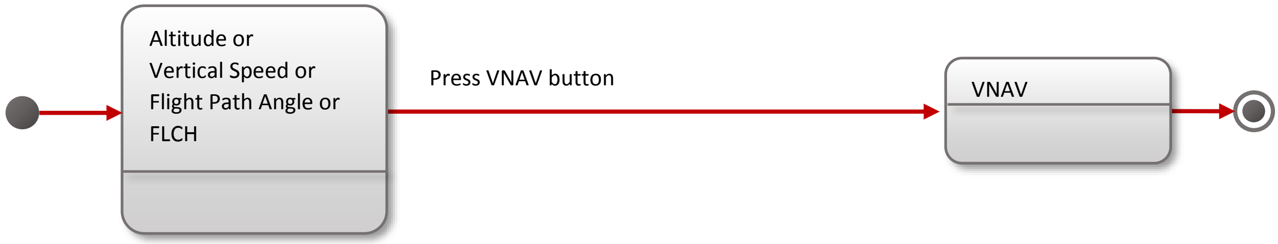
Mode type	FLIGHT PLAN modes
Channel	VERTICAL
Supported phases	Activate
Overview	The VNAV-mode controls the vertical channel to follow a planned route. The VNAV-mode can only be switched on while the LNAV-mode has already been activated. This means that the LNAV-mode can also be used without activating the VNAV-mode (using any of the basic vertical modes instead for the vertical channel). A planned route has a specified cruise altitude which determines the vertical flight profile. Based on the vertical flight profile T/C- and T/D points are calculated (top of climb and top of descend) and shown on the ND. If the initial altitude is above the cruise altitude, instead of the T/C point a E/D points is calculated (end of descend).

If the cruise altitude cannot be reached (e.g. the route has not enough length totally), a T/C/D point will be calculated, where climb directly is followed by the descend towards the destination.
If an ILS is tuned the ILS glideslope capture altitude is taken as target altitude at the destination.
The climb and descend rate for the VNAV vertical flight profile is taken from aircraft settings (Sensorics app):

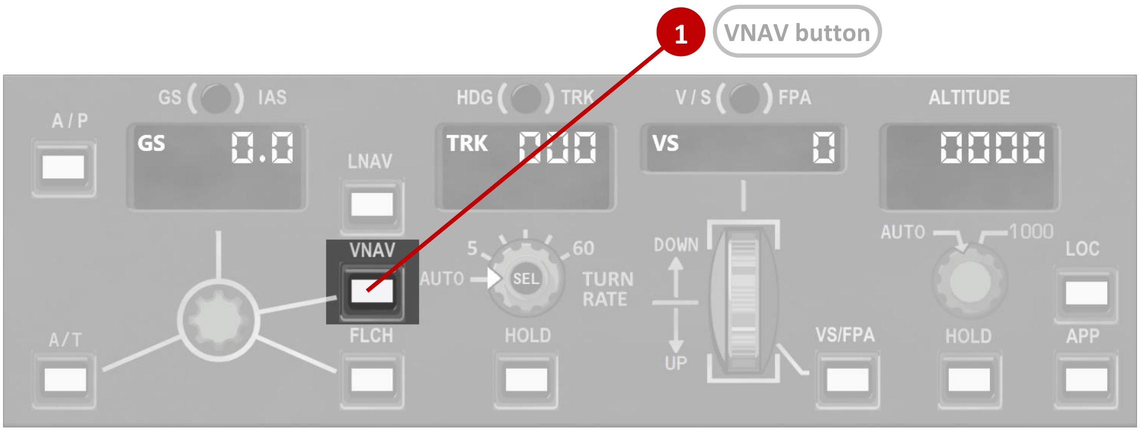


Unit	n/a
Target value range	n/a
Supported combinations	The *VNAV*-mode requires the *LNAV*-mode to be active, before it can be activated.

The following transitions are possible to reach the *VNAV*-mode:



The following user interface elements are used to control the *VNAV*-mode on the MCP:



	Element	Purpose
1	VNAV button	Pressing this button triggers the *VNAV*-mode. Whenever the *VNAV*-mode is active, this button becomes illuminated.

4.2.2.15 Flight Plan Speed-mode

Mode type	FLIGHT PLAN modes
Channel	SPEED
Supported phases	Implicate activation
Overview	For the *LNAV*-mode the speed is specified in the flightplan. This mode automatically holds the flightplan cruise speed as long as LNAV is switched on. The LNAV target speed is defined on the first RTE page in the FMS: 
Unit	The target speed value is set and shown in display units. The display unit for speed can be defined either as m/s, knots, km/h or mph on the IDENT page of the FMS.
Target value range	Any positive value including 0.0 can be selected as target speed.
Supported combinations	This mode automatically engages and disengages with the *LNAV*-mode.

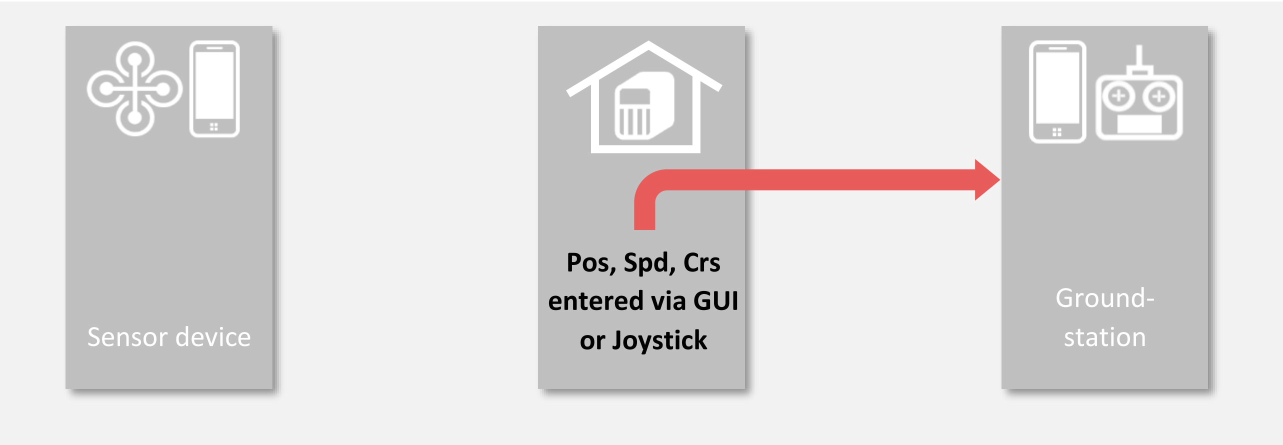
4.3 Simulation

4.3.1 Overview over the simulation features

Beside the still existing, Relay Server based simulation, two new simulation feature has been implemented in the groundstation, that allows completely autonomous usage of the autopilot. The following diagrams show the possibilities.

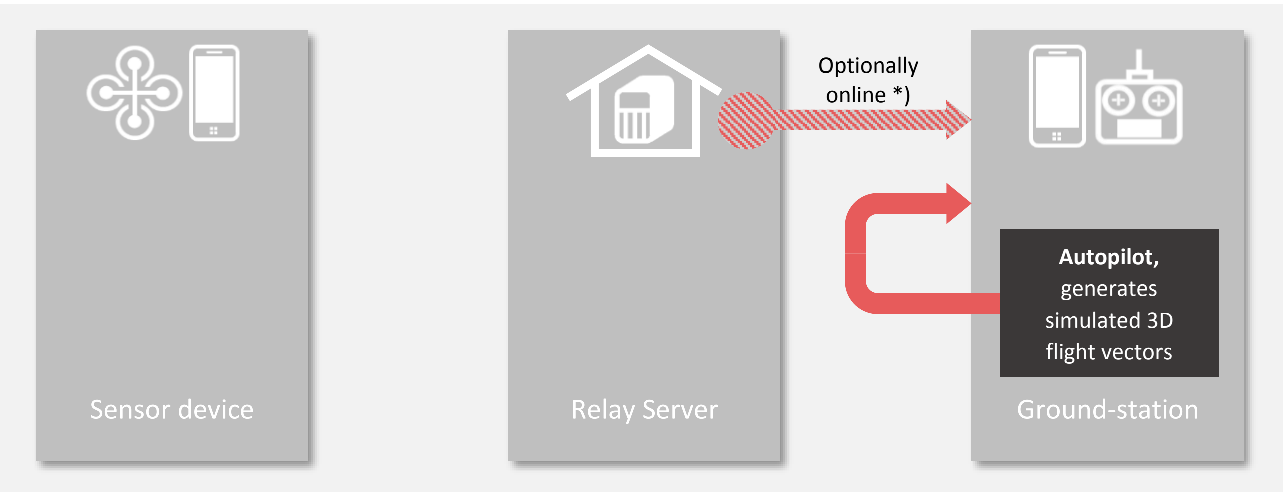
A. Relay server induced basic aircraft movements simulation

Existing, see version 1.5 documentation.



B. Autopilot simulation

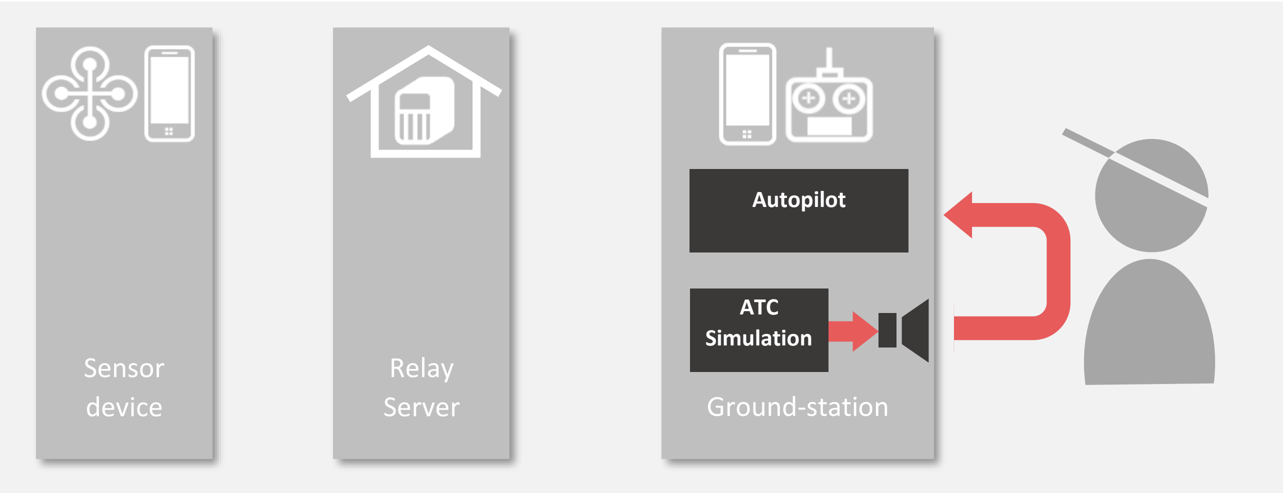
New, see chapter 4.3.2.



*) For initial load of the navigation database (only once required) and to access stored flight plans

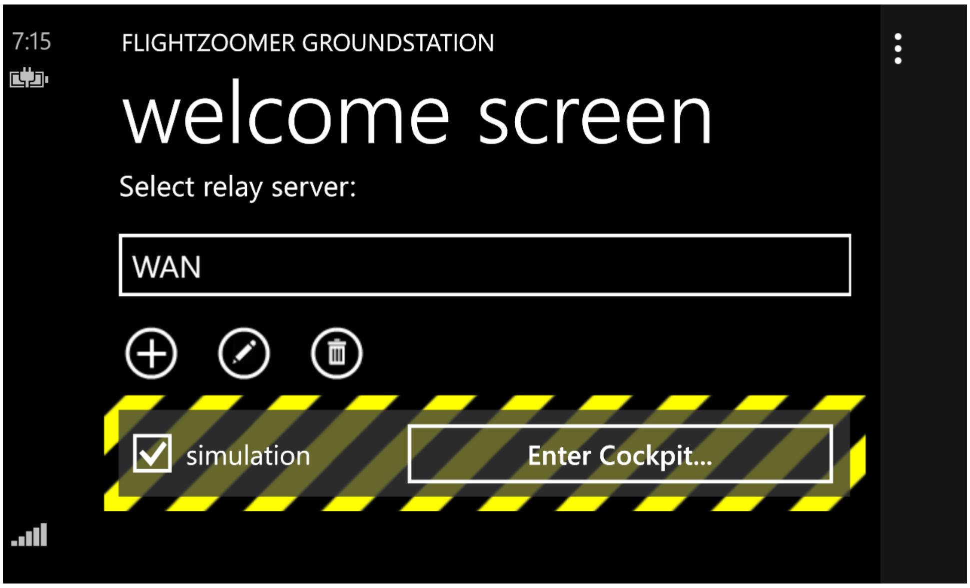
C. Air Traffic Control simulation

New, see chapter 4.3.3.



4.3.2 Autopilot simulation

On the welcome page, the checkbox “simulation” allows to start the app in simulation mode:



The simulation mode covers the complete end-to-end processing chain from the autopilot GUI, to the autopilot controlling, to the physics of a simulated multicopter and back. It is intended for training and demonstration purposes.

In simulation mode the ground station simulates the overall system reaction, when using the autopilot. Most of the autopilot features can be used without any preparation. The simulation mode works just like a backend behind the existing ground station functionality.

There are two ways, how the simulation mode can be used: either the groundstation in combination with the relay server (online) or the groundstation completely stand-alone (offline). If the connection to the relay server cannot be established after 8 seconds, the simulation switches to offline.

The following limitations for the simulation mode exist:

<table>
<tr><th>Limitation</th><th>Online operation (in combination with the relay server)</th><th>Offline operation (Entirely stand-alone)</th></tr>
<tr><td>Navigation Database</td><td>The simulation mode does not deviate from the normal behavior (the most current navigation database is just automatically loaded at app start).</td><td>After failing to connect to the relay server for 8 seconds, the entire navigation database is loaded from locally cached copy. It always reflects the state, that was current when connecting the last time to the relay server. (this means also, that no navigation database is available, if the groundstation app has not at least once been connected to the relay server).</td></tr>
<tr><td>Store and load flight plans (CO ROUTE)</td><td>The simulation mode does not deviate from the normal behavior (flight plans can be stored/loaded to/from the relay server).</td><td>Accessing the stored flight plans on the relay server is not supported.
This limitation does not make a big difference though because creating routes on the fly is possible without restrictions.</td></tr>
<tr><td>Aircraft Settings</td><td colspan="2">The source of the aircraft settings is the Sensorics-app. These settings are replicated and cached locally on the Groundstation–app. If present, the cached aircraft settings are used for the simulation mode. If not, default settings are used:
Flight-number (ATC call sign) = Flightzoomer 1
Copter = true
Stop after ISL approach = true
Standard climb speed = 1.3 m/sec
Standard turn rate = 15°/sec</td></tr>
<tr><td>Initial location</td><td colspan="2">In simulation mode the aircraft initially is positioned at the FlightZoomer flight test range in Switzerland. The position can be moved to any location by loading or creating a flightplan. If that is done the simulated location is moved to the origin of the flight plan.</td></tr>
</table>

Procedure to use the simulation mode:

1. Check the *simulation*-checkbox before entering the cockpit.
2. Confirm the warning popup.
3. If the configured relay server can be reached, the navigation database is loaded, and the simulation can begin (using the autopilot).
4. If the configured relay server cannot be reached, the navigation database is loaded from local cache.
5. Use the autopilot by activating it.
6. Use the basic/radio navigation/flight plan autopilot modes. Also the Air Traffic Control Simulation is supported.

It is recommended to deeply become acquainted with the autopilot using the simulation mode before actually taking off with the real aircraft.

4.3.3 Air Traffic Control simulation

Using the in-built speech synthesis, FlightZoomer offers the possibility to simulate instructions from a virtual air traffic control center.

The air traffic simulation feature has the following capabilities:

- The instructions of a virtual air traffic officer are simulated with a female voice
- Each instruction is read back by a male voice, simulating the pilot, who acknowledges anything spoken also in real world aviation. This gives you the chance, to hear the instruction a second time.
- The feature is only available for the approach phase of a flight at the moment.
- Air traffic control guidance can be engaged during the flight at any time and at any location.
- Depending on the current altitude and location a target altitude is instructed (which is the ILS capturing altitude) and directions are given, to fly a realistic approach pattern (downwind, base and final approach).
- The call sign can be defined in the aircraft settings (the default value is “Flightzoomer 1”).

Procedure to use the Air Traffic Control simulation:

1. Ensure, that the ILS receiver is tuned to the frequency of a runway from the navigation database
2. Engage the air traffic control feature. Tap on the indicated area on the navigation display:

3. The synthetic male voice of you (the pilot) immediately contacts approach control.
4. The air traffic controller (female) replies to the request and starts guiding you to the runway.
5. Engage and set the altitude and heading or track hold autopilot modes as instructed, to be vectored to the ILS.

The following set of clearances and instructions exist:

First contact	… by the pilot	<call sign>, contact <airport name> approach
	… reply by ATC	<call sign>, this is <airport name> approach, <lateral guidance>, <vertical guidance>, expect vectors ILS runway <selected runway ID>
Lateral guidance	… by ATC	<call sign>, Turn right/left to <new target direction> degrees
	… confirmation by the pilot	Turn right/left to <new target direction> degrees, <call sign>
Vertical guidance	… by ATC	<call sign>, Climb/descend to <new target altitude>
	… confirmation by the pilot	Climb/descend to <new target altitude>, <call sign>
ILS clearance	… by ATC	<call sign>, Cleared for ILS approach, runway <runway ID>
	… confirmation by the pilot	Cleared for ILS approach, runway <runway ID>, <call sign>
Landing clearance	… by ATC	<call sign>, Cleared to land, <runway ID>, have a good day!
	… confirmation by the pilot	Cleared to land, <call sign>, bye, bye

Note: to add realism, the ATC simulation feature is programmed to vary these instructions slightly (only the buffer words, the content is strictly reproduced).

It is recommended to use the simulation mode to get acquainted with the ATC simulation feature.

4.4 Camera control

New camera features:

- The internal camera (either front or back) of the sensor device can be controlled from the ground station
- These features are covered:
  - start/stop recording a video
  - start/stop taking an image series
- Either the front- or the back-camera can be used
- Any orientation of the camera can be configured
- The video or images are captured with the best resolution
- Additionally, the Sensorics-app now supports the interactivity with the Sony camera API
- The Sony camera needs to be connected to the sensor device using WLAN and will automatically be detected
- With the Sony camera the same features can be used as with the internal camera
- Shooting an image series both with the internal and the Sony camera works as follows:
  - Activate the image series camera mode on the groundstation
  - The configured camera(s) (can be either of the internal cameras and/or a connected Sony camera) start(s) capturing images with the shortest possible interval
  - The interval depends only on the time the camera needs to make one shoot
  - The images of the internal camera are stored in the picture library of the phone

Discontinued version 1.5 features:

- Recording automatically an image series or a video as long as the sensor device is in LOCKED-mode
- Changing the resolution of the internal camera
- Having to download the captured videos from the sensor device to the groundstation

4.4.1 Sensorics-app

The *Sensorics*-app now supports the interactivity with a Sony camera API that just needs to be connected via WiFi with the onboard device. The camera must support the standard WiFi camera API (there is a long list of supported models on the Sony homepage).

The following screen in the Sensorics app allows to select the camera which shall be used. The usage is self-explanatory:

	Sony camera (external)	Phone camera (internal)
Supported features	• Series shutter • video recording • Controlled from the ground station	• Series shutter • video recording • Controlled from the ground station • Supports either main (=back) or front camera
Resolution	Default setting	Best available resolution
Rotation	Defined by installation	Can be chosen on the *cameras*-page. The selected setting is stored in the app settings.

4.4.2 Groundstation-app

If any camera has been selected in the Sensorics app, it can be controlled from the groundstation using the following sub panel:

<table>
<tr><th></th><th>Description</th><th>Camera control panel</th></tr>
<tr><td>1</td><td>Here the camera is deactivated</td><td>
</td></tr>
<tr><td>2</td><td>Using the SERIE SHUTTER start button, the camera starts shooting one image after another. The frequency depends on the capabilities of the camera.</td><td>
</td></tr>
<tr><td>3</td><td>Using the VIDEO start button, the camera starts recording a video.</td><td>
</td></tr>
</table>

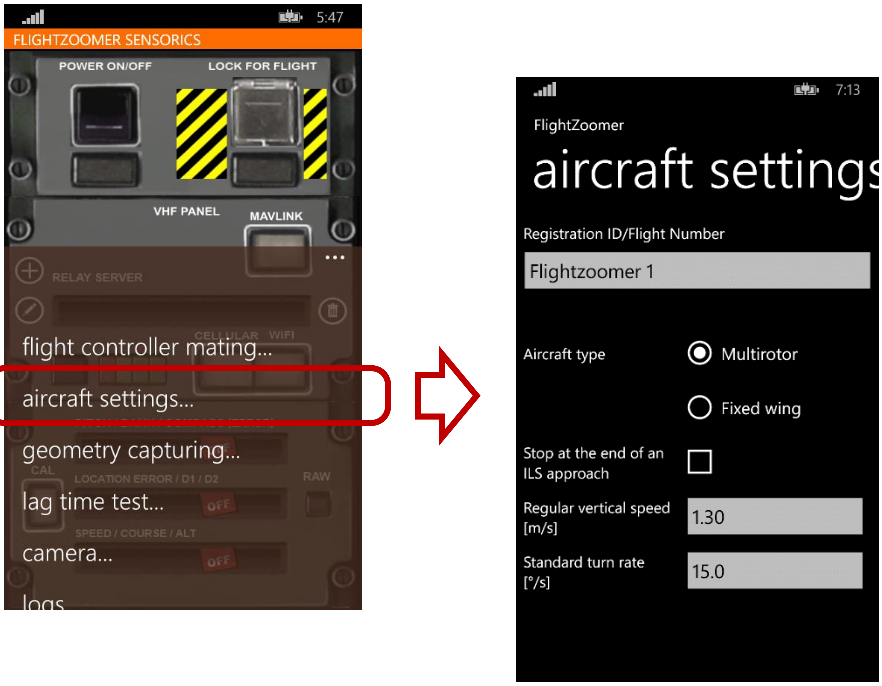
4.5 Aircraft settings

4.5.1 Sensorics-app

The aircraft settings can easily be used to tailor the system behavior to match a particular setup or according to personal preferences.

As these basically are attributes that apply to a particular aircraft, the definition happens on the *Sensorics*-app, which runs aboard the aircraft. Consequently, these settings need to be fixed on the ground, after being airborne they can't change anymore.

The settings page can be opened in the *Sensorics*-app with the respective menu:



	Settings	Purpose
1	Registration ID/Flight Number	This string defines the unique ID of a flight within a FlightZoomer network. The string is also used as call sign for the Air Traffic Controller simulation. You can either choose real airline names and flight numbers if you like (e.g. American 94, United 100, Lufthansa 1234 and so on) or just any other call sign you want. Default is <Flightzoomer 1>
2	Aircraft type	Currently only Multirotor is supported for automatic flight. Default value is Multicopter.
3	Stop at the end of an ILS approach	This option allows to let the aircraft terminate an ILS approach at the runway threshold (recommended for multicopters) or to continue the descend gradient infinitely. The latter would let land a fixed wing aircraft on a sufficiently spaced landing strip. Without a flare phase though, but it needs to be considered that landing at the standard ILS glide angle of 3° without flaring is SOP (standard operating procedure) under certain (weather-) conditions even for the largest jets. FlightZoomer approaches can be defined with any glide angle (when the navigation database is created using the relay server application). So having rather shallow glide angles of 3° or 4° at maximum is not only

		realistic but also perfectly feasible in order to let fixed wing aircraft land automatically. Default value is Checked.
4	Regular vertical speed	This is the standard climb or descend rate. This figure is used for autopilot modes, where the climb rate is not specified specifically, like the *FLCH*- or *VNAV*-mode. Default value is 1.3 m/s.
5	Standard turn rate	This is the standard turn rate. This figure is used for autopilot modes, where the turn rate is fixed, like the *VOR Localizer*-, *ILS Localizer*- or *LNAV*-modes. Default value is 1.3 m/s.

4.5.2 Groundstation-app

Any time a connection between the sensor device and the groundstation is established, the aircraft settings are replicated to the *Groundstation*-app and locally stored.

4.6 Flight logs generated as Excel files

4.6.1 Relay Server Application

Another area, that was improved for version 2.0 is the automatic log file generation. Earlier the relay server automatically generated a comma separated file during the time, the system ran in *LOCKED*-mode (= “Armed” in Ardupilot terminology).

With version 2.0 the comma separated file is still generated (to be used for the “replay file” feature). Additionally, the relay server generates a full-fledged Excel document, that contains of course the raw flight data, but also flight summary data and some charts.

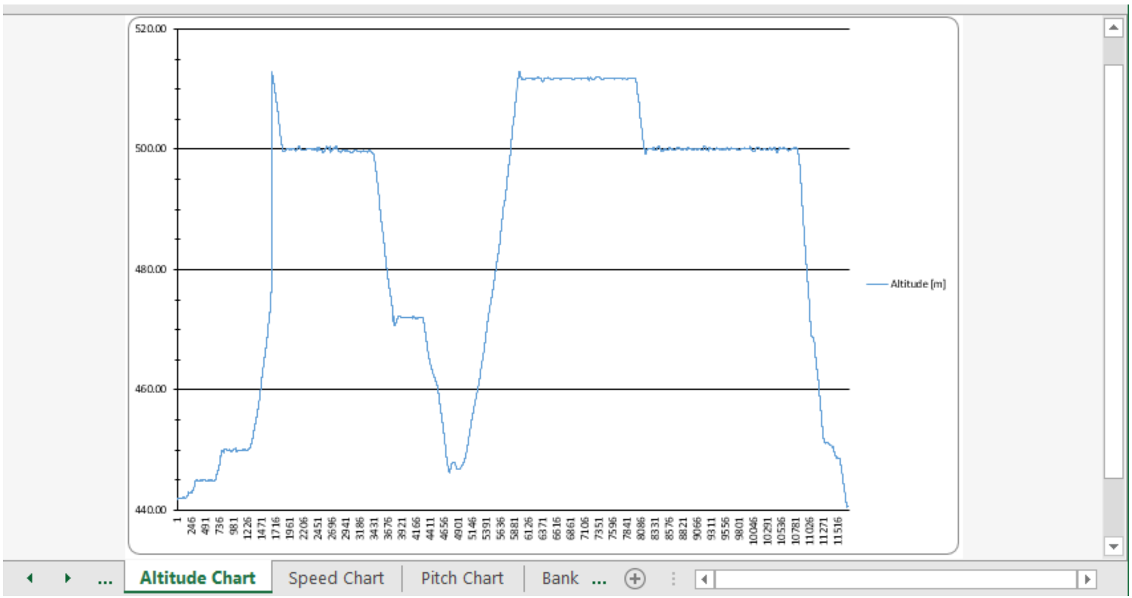
Using the Excel document and normal spreadsheet operations, any thinkable data analysis and presentation can easily be achieved.

An example of a flight summary (flight stats tab):

	Average Value	Minimum Value	Maximum Value
Total # Of Records	11714		
Arm Time	2016-05-06 19:44:28Z		
Disarm Time	2016-05-06 20:00:26Z		
Block Time	0:00:15:58.4409984		
Altitude [m]	485.942220609583	440.29	513.01
Altitude [ft]	1594.29862404081	1444.52099736955	1683.10367453395
Speed [m/s]	2.63872107914285	0.01	12.25
Speed [km/h]	9.49939588491425	0.036	44.1
Speed [kts]	5.12925158248103	0.0194384	23.81204
Speed [mph]	5.9026607307778	0.0223694	27.402515
Pitch [°]	-3.15346770373201	-19.08107	13.62776
Bank [°]	-1.70812229243646	-15.24977	13.55629
VSpd [m/s]	-0.0552164261931186	-2.42	1.12
VSpd [m/min]	-3.31298557158712	-145.2	67.2
VSpd [ft/min]	-10.8693752348224	-476.377952754	220.472440944
Voltage [V]	14.5927553146077	12.893	16.591
Current [A]	11.3017211645181	0.13	19.35

Flight Stats | Flight Data | Autopilot St ...

An example of a chart (altitude tab):



5 Step-by-step guidelines

These step-by-step guidelines illustrate the recommended usage of FlightZoomer 2.0.

Legend for the used devices:

AC = aircraft
FC = flight controller
CC = companion computer (sensor device, FlightZoomer Sensorics app)
SY = Sony camera
GS = groundstation (FlightZoomer Groundstation app)
RC = RC transmitter

5.1 Operation

The following sequence of steps covers a typical flight using a planned route and an automatic (ILS) approach to the destination.

5.1.1 Preparations at home

1. Ensure all the batteries are charged
2. Simcard charged
3. Start Relay Server Application
4. Connection test with both apps

5.1.2 System start up

1. Power up the aircraft, the flight controller and the Bluetooth transceiver (AC)
2. Start the FlightZoomer Sensorics app (CC)
3. Establish Bluetooth connectivity between flight controller and smartphone (FC<->CC)
4. Switch on the connection to the relay server (CC)
5. *<Optional: if Sony camera is used>*
   5.1 *<Connect to the Sony camera with WLAN (CC<->SY)>*
6. Start the FlightZoomer Groundstation app (GS)
7. Press Enter Cockpit...; connection to relay server is established (GS)
8. Basic instrument check (FC->CC->GS)

5.1.3 Cockpit preflight preparations

1. <Optional: use flight plan (GS)>
1.1 <Alternative: enter route manually (GS)>
1.1.1 <Enter origin on FMS RTE page (GS)>
1.1.2 <Enter destination on FMS RTE page (GS)>
1.1.3 <Enter waypoints on page 2 ff on FMS RTE page (GS)>
1.1.4 <Enter cruise altitude and cruise speed on page 1 of FMS RTE page (GS)>
1.1.5 <Press EXEC button on FMS to activate the route (GS)>
1.1.6 <Optional: store route to database>
1.1.6.1 <Enter route name and press 3R key on page 1 of FMS RTE page (GS)>

1.2 <Alternative: load existing route from database>
1.2.1 <Enter route name and press 3L key on page 1 of FMS RTE page (GS)>
1.2.2 <Press EXEC button on FMS to activate the route (GS)>
2. <Optional: tune the ILS receiver>
2.1 <Enter the ILS frequency on the FMS NAV RAD page (GS)>
3. Configure the ND appropriately on display control panel: MAP mode, TERR on (GS)
4. Press ALT REF above the PFD to reset the ground indication on the PFD (GS)
5. Enter the momentary charged battery capacity (or the full battery capacity if it is charged fully) into the TOT BAT CAP attribute on the INIT REF -> PERF FMS page (GS)

5.1.4 During flight

5.1.4.1 Take off

1. Arm the aircraft manually using the RC transmitter (AC, RC)
2. FlightZoomer will change to locked mode automatically (CC, GS)
3. Take off manually using the RC transmitter (AC, RC)

5.1.4.2 Follow planned route automatically

1. Switch on the autopilot on the MCP (GS)
2. Press LNAV on the MCP (GS)
3. Press VNAV on the MCP (GS)

5.1.4.3 Transition to a basic lateral mode, coming from *LNAV*-mode

1. <Optional: for an approach and if the ILS receiver is tuned >
1.1 <Select APP on the DISPLAY CONTROL-panel to show the localizer on the ND (GS)>
2. Select either TRK or HDG as reference with the HDG/TRK reference switch (GS)
3. Press (TRK- or HDG-) HOLD on the MCP (GS), the current direction becomes the selected target direction
4. Modify the target direction using the rotary direction selector

5.1.4.4 Transition to a basic vertical mode, coming from *VNAV or ILS-Glideslope*-mode

To *Altitude*-mode:

1. Press (ALTITUDE) HOLD on the MCP (GS), the current altitude after a smooth transition to level flight becomes the selected target altitude

To *Vertical Speed*- or *Flight Path Angle*-mode:

1. Select either V/S or FPA as reference with the VS/FPA reference switch (GS)
2. Press VS/FPA on the MCP (GS), the current vertical gradient becomes the selected target VS or FPA
3. Modify the target VS or FPA using the thumbwheel selector

To *FLCH*-mode:

Not possible, as the FLCH-mode requires a target altitude to be armed.

5.1.4.5 Fly approach vectors

1. *<Optional: let air traffic control provide the commands for the approach (GS)>*
1.1 *<touch the compass rose on the ND on the 270° position (GS)>*
2. Dial in target directions to fly appropriate segments (optionally as adviced by ATC) to catch the ILS localizer (GS)
3. Dial in target altitudes to reach the ILS capturing altitude before intersecting the glideslope. Aim to capture the ILS glideslope from below (GS)
4. Press either
   FLCH
   or
   select a VS/FPA target value
   to initiate the descend to the dialed target altitudes (GS)
5. Prior the last turn to runway direction press APP on the MCP to arm the ILS (GS)
6. Depending on the respective aircraft setting (CC) the aircraft will just stop and keep the altitude at the runway threshold or continue with the descend gradient.

6 Glossary

Abbreviation term	Description	Manned aviation term
AP	Autopilot	X
FLCH	Flight Level Change autoflight mode	X
FMS	Flight Management System	X
ILS	Instrument Landing System Navigation system based on specialized radio stations; these provide two radio beams that guide aircraft both vertically and laterally while approaching a runway	X
LNAV	Lateral Navigation Automatic flight mode where the loaded flight plan is being followed.	X
ND	Navigation Display	X
PFD	Primary Flight Display	X
VNAV	Vertical Navigation	X
VOR	VHF omnidirectional range	X