FLIGHTZOOMER
3.2

USER MANUAL

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2 DISCLAIMER

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

- The FlightZoomer system is intended for hobby usage only.
- Do not use FlightZoomer for manned aviation. The reliability of the app is not good enough to make human lives dependent on it.
- Be familiar with the operation of RC aircraft having 1kg flying weight or more.
- Use FlightZoomer only aboard a proven configuration of RC equipment, airframe, flight controller, motors, propeller, battery and ESCs.
- Operate FlightZoomer strictly within the safety boundaries of any other onboard components.
- Operate FlightZoomer strictly within the boundaries of any local regulatory statute.
- Fully respect any disclaimer and safety note which is associated with any other onboard or controlling component, such as RC radio and equipment, telemetry radios, autopilots.

3 DOCUMENT CHANGE LOG AND INFORMATION

Latest additions:

May 24, 2019:

- Diagram added for copters in the section about Automatic Landings / ILS ApproachesAutomatic

May 4, 2019:

- Using staged ROI's and ROI sequences

May 1, 2019:

- LNAV and VNAV mode

May 1, 2019:

- Explanations for VS-, FPA- and FLCH autopilot mode added

April 29, 2019:

- Streamlined descriptions how to install the system

April 21, 2019

- System startup for Andruav Operations

April 20, 2019

- Symbols on the Flight Management System

April 15, 2019:

- System topologies simplified

March 24, 2019:

- Automatic Landings / ILS Approaches

March 9, 2019:

- Dependency and interaction with ArduPlane parameters for autoflight

October 22, 2018:

- Checklists

The complete documentation can be downloaded as PDF with this link:

https://flightzoomer.com/FlightZoomer%203%20User%20Manual.pdf

4 FLIGHTZOOMER IN A NUTSHELL

4.1 WHAT CAN YOU DO WITH FLIGHTZOOMER?

FlightZoomer is a Ground Control Station (GCS), that allows to plan, control, navigate and manage the flight of remote controlled unmanned aircraft. The supported vehicles are ArduPilot equipped fixed wing aircraft and multicopters.

A lot of features are borrowed from manned aviation: the look&feel (based on the Boeing 787 cockpit), IFR capabilities (instruments, autopilot, Flight Management System) and the support of professional procedures.

FlightZoomer offers these use cases:

Feature	Description
Synthetic FPV Camera	The FlightZoomer cockpit app offers a synthetic outside view. Enjoy the unmatched experience when looking down on the landscape even when a traditional FPV setup would run into serious limitations (e.g. at night, in fog).
Real FPV Camera	Beside the synthetic camera, a traditional (real) video feed can be embedded seamlessly or as overlay in the FlightZoomer cockpit app.
Autopilot with more than a dozen modes	Control the aircraft using real world autopilot modes like altitude capture and hold or ILS glideslope capture! The autopilot supports basic flying, as well as following flight plans or (simulated) radio navigation aids.
Flightplan based operations	Navigate and control the aircraft based on self-created flightplans: prepare, plan and execute routes like real pilots do (following instrument flight rules)!
Flight control using speech recognition	Fly your multicopter or RC aircraft by speaking commands! A simple yet effective grammar allows flying any desired maneuver!
Navigation Database	Create and maintain your own airspace with airports and navigation aids! This enables for navigation based on simulated radio navigation aids.
Instrument Landing System (ILS)	Capture and follow the glideslope with your RC aircraft for a precision approach! The FlightZoomer Instrument Landing System (ILS) offers the full set of real world features including the beeping at the outer, middle and inner markers.
Simulation Capabilities	Get accustomed to the system using the in-built simulation capabilities! They allow to inspect, demonstrate and train most of the features just using the cockpit app in a stand-alone operation.
In-built Air Traffic Control	Be guided from cruise down to the ILS by the friendly lady from the virtual air traffic control center!
Synthetic voice feedback	Experience teamwork with a simulated co-pilot who confirms autopilot commands!

5 BASICS

5.1 SYSTEM TOPOLOGIES

Each FlightZoomer system topology offers a different solution how the Cockpit-app communicates with the flight controller.

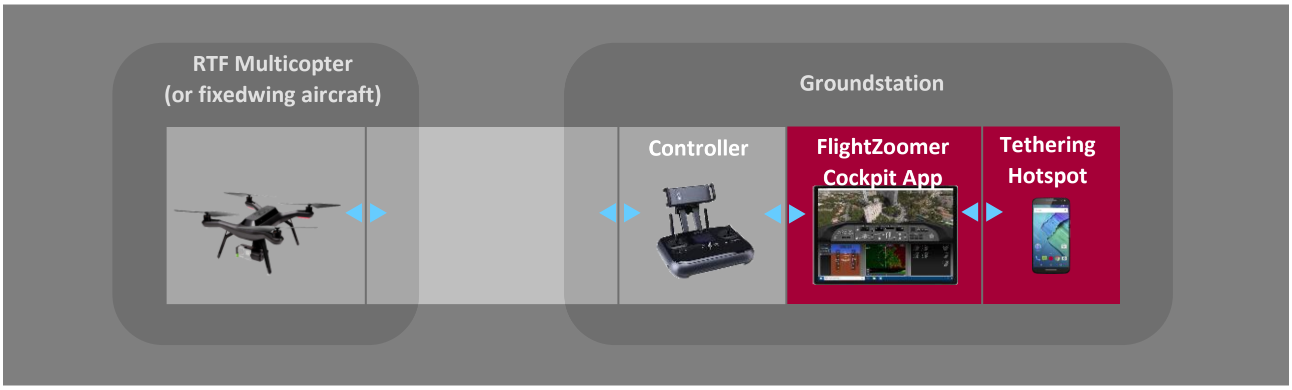
The most basic system topology makes use of a 3rd party radio telemetry solution.

Besides that, the user has the option to choose more comprehensive system topologies, which include an onboard smartphone. This offers several benefits like unlimited range.

System topologies overview:

System topology	Description	Onboard Smartphone
RTF Aircraft	The cockpit app connects to one of the existing RTF ArduPilot products (e.g. 3DR Solo or the Sky Viper multicopter).	
3rd party radio telemetry	The cockpit app connects to any kind of 3rd party telemetry solution via USB COM port. The aircraft with this topology typically is a self-built (DIY) RC plane or copter.	
Onboard smartphone connected via Andruav	Andruav is an Android based telemetry and FPV system, that provides connectivity between the aircraft and the cockpit app.	x
Standalone simulation	Standalone operation, which is offered by the Cockpit-app to simulate fully featured autopilot operations.	

5.1.1 SYSTEM TOPOLOGY WITH AN RTF AIRCRAFT



What is needed?	Specifications	Optional
RTF (Ready-To-Fly) multicopter with ArduPilot flight controller + RC controller	Verified products: • 3DR Solo multicopter • Skyrocket Sky Viper Journey	Mandatory

Computer to run the Cockpit-app	The Cockpit-app is a Windows Store app, that runs on any Windows 10 Tablet, Notebook or Desktop computer. Mid- to upper-class performance is preferred.	Mandatory
Tethering hotspot	Any mobile phone, that can provide internet access via a WiFi hotspot. Needed only if the cockpit app has no WiFi connectivity to a router.	Recommended
	If the mobile phone can’t provide the hotspot capability via USB or Bluetooth, a second WiFi link is required, which requires a USB WiFi stick.	
Microsoft Surface Dial	The FlightZoomer autopilot optionally can be controlled with the Microsoft Surface radial controller	Optional

Using a Ready-To-Fly multicopter offers the following advantages:

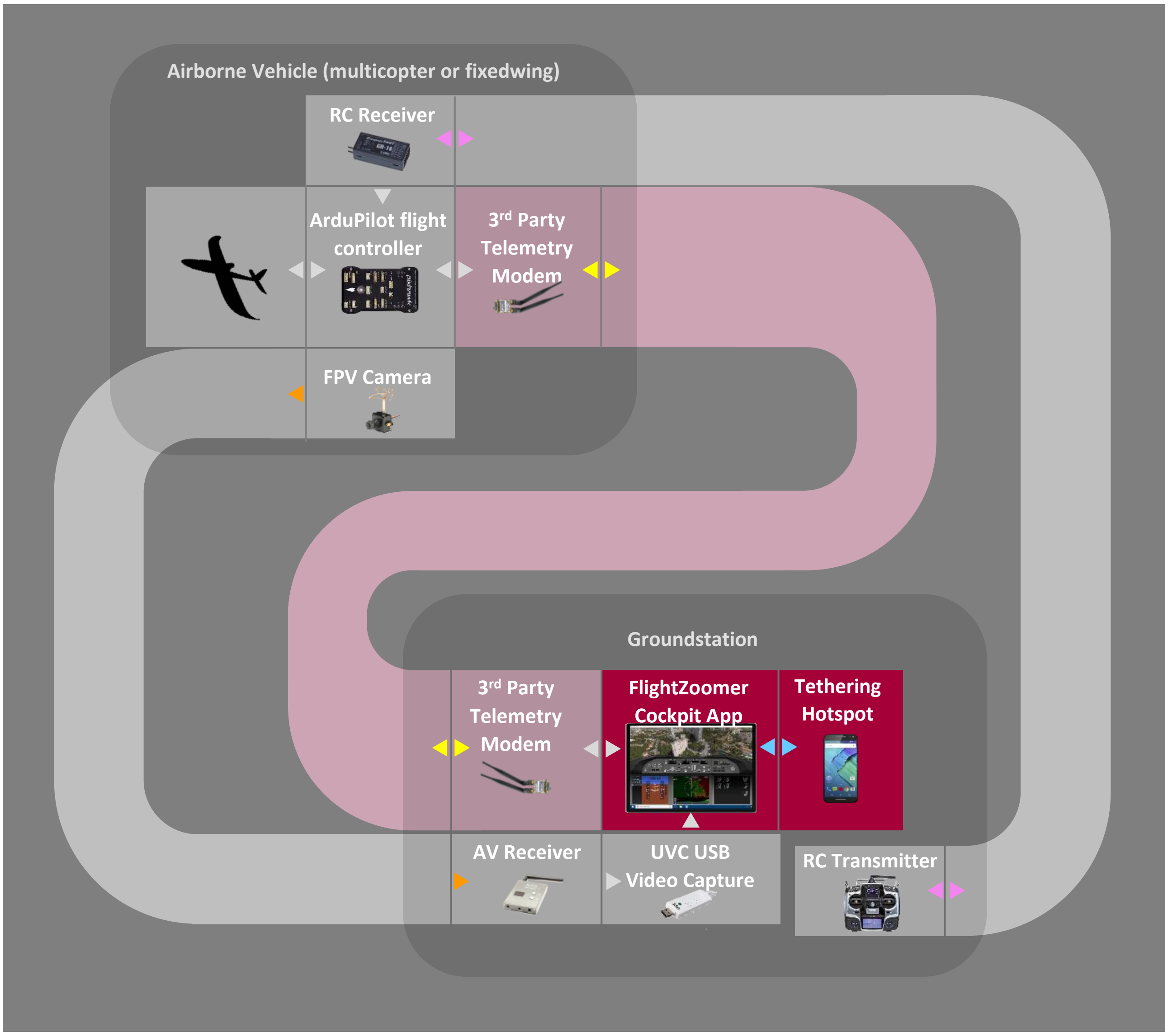
- ✓ Guaranteed performance out of the box.
- ✓ Smallest possible hardware footprint, FlightZoomer is a single device addition to an already fully functional setup.
- ✓ Lowest possible complexity.

The following restrictions apply:

- ⚠ Range limitation of the RTF product applies.
- ⚠ RTF copters tend to cost more than self-assembled vehicles.
- ⚠ Supply from factory no longer possible for 3DR Solo multicopters.

5.1.2 SYSTEM TOPOLOGY WITH A FULL DIY-SETUP USING 3RD PARTY RADIO TELEMETRY

This system topology is interesting for users, who already have a radio telemetry setup. Even though internet access is not needed for air-to-ground communication, the cockpit app preferably still has internet access (e.g. via a tethering hotspot) to support the synthetic FPV view or to fetch terrain elevation data (offline operation without these features is possible though).



What is needed?	Specifications	Restriction	Optional
Airborne Vehicle with ArduPilot flight controller + RC system	For multicopter: Configured and (auto-) tuned vehicle, capable to properly fly in Loiter mode	ArduCopter 3.3 or higher	Mandatory
	For planes: Configured and (auto-) tuned vehicle, capable to properly fly in Cruise mode. Altitudes should stay within +/- 3…5m	Arduplane 3.7 or higher	Mandatory
3rd Party Telemetry System	Any telemetry system, that is connected to the cockpit device via COM Port can	Connection only via FTDI-adapter	Mandatory

	be used, e.g. RFD 900, Ultimate LRS or Dragonlink		
Computer to run the Cockpit-app	The Cockpit-app is a Windows Store app, that runs on any Windows 10 Tablet, Notebook or Desktop computer. Mid- to upper-class performance is preferred.	Windows 10 Mobile is not supported (as the screen would be too small)	Mandatory
Tethering hotspot	Any mobile handset, that can provide internet access via a WiFi hotspot. Needed only if the cockpit app has no WiFi connectivity to a router.	-	Recommended
FPV camera + receiver + UVC video capture	Any FPV camera and FPV radio transmission product, that can feed its output via a Video-S-to-UVC capture device into the cockpit device. Alternatively, an RTSP source can be configured.	-	Optional
Microsoft Surface Dial	The FlightZoomer autopilot optionally can be controlled with the Microsoft Surface radial controller	-	Optional

Using 3rd party radio telemetry offers the following advantages:

✓ No cellular connection between aircraft and ground needed.

✓ Small hardware footprint, FlightZoomer runs only on one device.

✓ Low complexity.

The following restrictions apply:

⚠ Range limitation of the 3rd party product applies.

⚠ No possibility to use the camera of the onboard smartphone.

⚠ For the tethering hotspot still one mobile phone contract and cellular network coverage is needed. Operation of the cockpit app without internet is possible, but several features will not be available (terrain data and synthetic FPV).

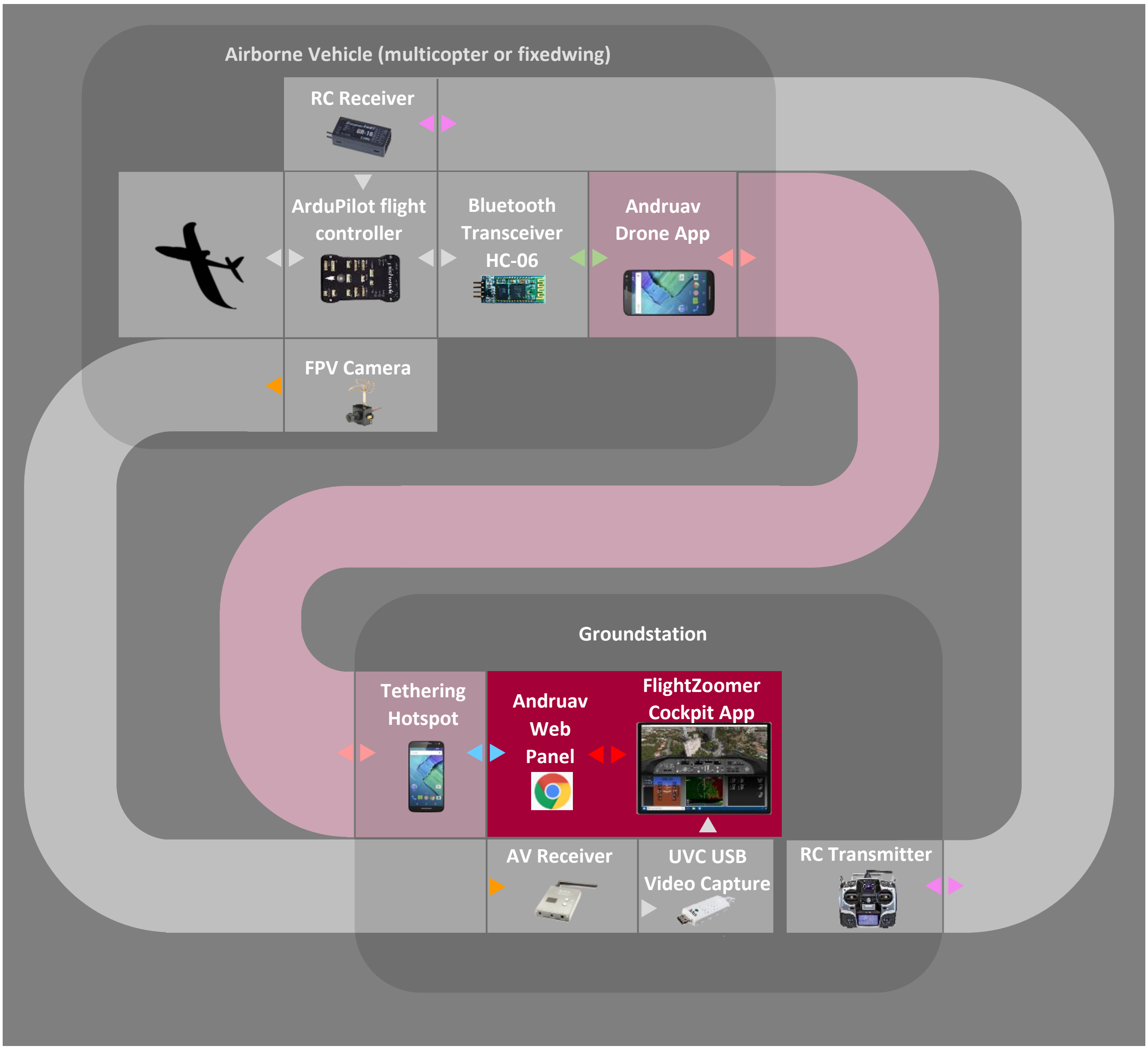
⚠ No extended onboard fail-safe capabilities. A dropping communication bus means immediate fallback to ArduPilot failsafe mechanisms (recommended is RTL due to telemetry loss).

5.1.3 SYSTEM TOPOLOGY WITH CELLULAR CONNECTIVITY USING ANDRUAV

This system topology has an onboard smartphone, that connects with the Cockpit-app via cellular networks using the 3rd party software solution Andruav.

Andruav is an Android based software, which can run as 3G endpoint on a smartphone. The smartphone is attached to the aircraft and provides a telemetry link via 3G and the internet.

System topology using Andruav:



What is needed?	Specifications	Restriction	Optional
Airborne Vehicle with ArduPilot flight controller + RC system	For multicopter: Configured and (auto-) tuned vehicle, capable to properly fly in Loiter mode	ArduCopter 3.3 or higher	Mandatory
	For planes: Configured and (auto-) tuned vehicle, capable to properly fly	Arduplane 3.7 or higher	Mandatory

	in Cruise mode. Altitudes should stay within +/- 3...5m		
Bluetooth transceiver	Bluetooth to serial transceiver, e.g. HC-06	-	Mandatory
Device to run the Andruav-app	Android handset to run the Andruav Drone-app		Mandatory
Tethering hotspot	Any mobile handset, that can provide internet access via a WiFi hotspot.	-	Mandatory
Computer to run the Cockpit-app	The Cockpit-app is a Windows Store app, that runs on any Windows 10 Tablet, Notebook or Desktop computer. Mid- to upper-class performance is preferred.	Windows 10 Mobile is not supported (as the screen would be too small)	Mandatory
FPV camera + receiver + UVC video capture	Any FPV camera and FPV radio transmission product, that can feed its output via a Video-S-to-UVC capture device into the cockpit device. Alternatively, an RTSP source can be configured.	-	Optional
Microsoft Surface Dial	The FlightZoomer autopilot optionally can be controlled with the Microsoft Surface radial controller	-	Optional

Using Direct Link offers the following advantages:

- ✓ Unlimited range due to cellular network connectivity.
- ✓ Slightly lower latency of the communication bus.

The following restrictions apply:

- ⚠ Cellular network coverage is needed at the location where the aircraft is flying, and an internet connection is needed where the Cockpit-app runs (which in a typical setup on the field requires a tethering hotspot which in turn means that cellular coverage is required also at the location of the groundstation).
- ⚠ The cellular endpoints need mobile phone contracts (typically 2 are required).
- ⚠ The nature of cellular networks means, that short time communication disruptions can happen at any time and that fail-safe considerations are crucial.

5.1.4 STANDALONE SIMULATION

The standalone simulation runs with the simplest possible system topology: one app running on a computer:

What is needed?	Specifications	Restriction	Optional
Computer to run the Cockpit-app	Stationary Windows 10 tablet, notebook or desktop PC with Internet access.	Windows 10	Mandatory
Microsoft Surface Dial	The FlightZoomer autopilot optionally can be controlled with the Microsoft Surface radial controller	-	Optional

Standalone simulation offers these advantages:

- ✓ Explore the capabilities FlightZoomer.
- ✓ Simulation covers full autopilot functionality.
- ✓ Perfect for training and education purposes.
- ✓ Supports 100% realistic dry-runs for planned flights.

5.1.5 MAVLINK REQUIREMENTS

FlightZoomer is using a number of MAVLink packets to extract relevant sensor data. These can be broadcasted from the flight controller to the onboard smartphone via Bluetooth using preconfigured streams.

The following table shows the required streams, the relevant packets and the recommended rate to transmit them (per second):

Stream	Recommended rate per second	Contained packets/ used packets	Used by FlightZoomer
RAW_SENS	10x	- RAW_IMU - SCALED_IMU2 - SCALED_PRESSURE - SENSOR_OFFSETS	X
EXT_STAT	1x	- SYS_STATUS - MEMINFO - MISSION_CURRENT - GPS_RAW_INT - NAV_CONTROLLER_OUTPUT - POWER_STATUS	X X
RC_CHAN	2x	- SERVO_OUTPUT_RAW - RC_CHANNELS_RAW	X X
POSITION	5x	- GLOBAL_POSITION_INT	X
EXTRA1	5x	- ATTITUDE - SIMSTATE (SITL)	X

Using a baud rate of 57600 easily supports the recommended packet rate. Using the default baud rate of 9600 of an out-of-the-box HC-06 Bluetooth device however would not support the previously mentioned frequencies.

5.2 NAVIGATION DATA

FlightZoomer emulates the structure and elements of a real air space. There is a navigation database, consisting of waypoints, navigation aids (radio beacons), airports and runways, which can freely be defined wherever you like.

Navigation data is used to fly the aircraft in a controlled manner. There are several possibilities: create and fly routes that follow waypoints, capture simulated radials of radio beacons or follow the glideslopes of a simulated ILS (Instrument Landing System).

The system does not need real radio equipment to implement radio beacons or ILS-approaches. A radio navigation aid is nothing but a data record, which consists typically of an ID, a location and a frequency. If the simulated navigation receiver in the Cockpit-app (on the NAV RAD page of the FMS) is tuned to the frequency of a navigation aid, the cockpit displays will simulate the appearance of the real instruments based on the aircraft location, the navigation aid location and some other parameters.

The navigation database is maintained with the Cockpit-app. The application has convenient features to create or modify navigation elements.

Creating navigation aids and airports is one of the preparation steps. With the present version it is not possible to change the airspace structure (e.g. the number and the location of navigation aids) during the flight. This reflects full scale operations, where the air space configuration and definition are also done mostly somewhere in an office and not in the cockpit while flying. What pilots later in the cockpit do before performing a flight, is entering the planned route dynamically (using the predefined navigation aids) or load a predefined company route (both methods are supported by FlightZoomer). Only in rare cases routes would be modified during the flight by defining waypoints on the fly (this not supported by FlightZoomer).

The navigation database consists of text files (ending with *.txt) which are stored in the following two folders:

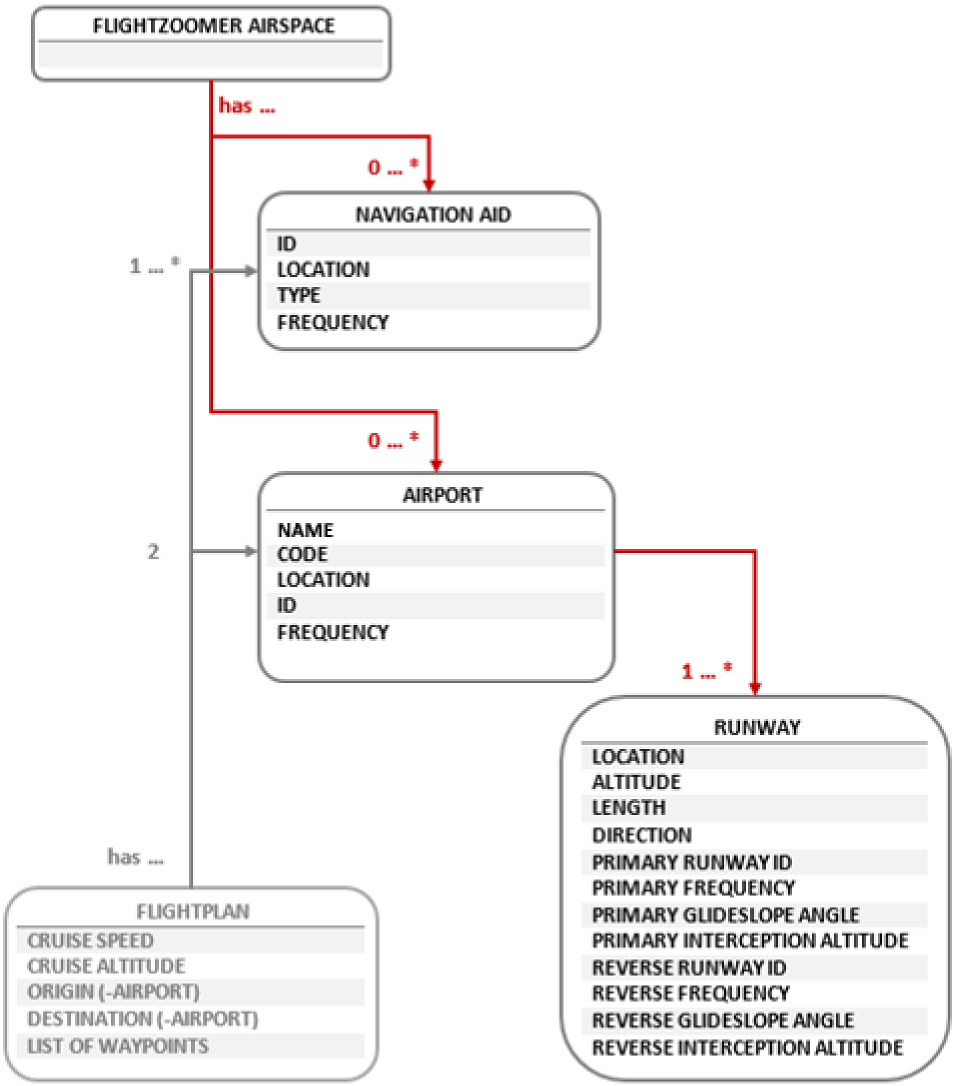
	What	Folder
1	Navigation aids	%LOCALAPPDATA%\Packages\ 63417ModelInstruments.FlightZoomerCockpit3_<code>\ RoamingState\Navigation.Navaids\NavaidsStorage.txt
2	Airports (and runways)	%LOCALAPPDATA%\Packages\ 63417ModelInstruments.FlightZoomerCockpit3_<code>\ RoamingState\Navigation.Airports\AirportsStorage.txt

Navigation data is stored in the two text files named NavaidsStorage.txt and AirportsStorage.txt. Records can be imported or exported by manually copying records to or from these text files.

As these files are stored in the roaming folder of the Cockpit app's dedicated storage area, the navigation database is automatically replicated between any device, on which the Cockpit app is installed and operated.

5.2.1 NAVIGATION DATA MODEL

The following diagram shows the navigation data model (with the relationship to a flightplan):



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5.2.2 NAVIGATION AID

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

In controlled airspace (manned) 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 enables unambiguous determination of the current position.
   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 most 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 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 and can be left empty. In that case the navigation aid emulates a GPS FIX and would not be useable for radio navigation.

5.2.3 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 including common properties in their data model as well as a list of runways, which are described in the next section.

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 simulated UAS flight area!). In manned aviation, 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).

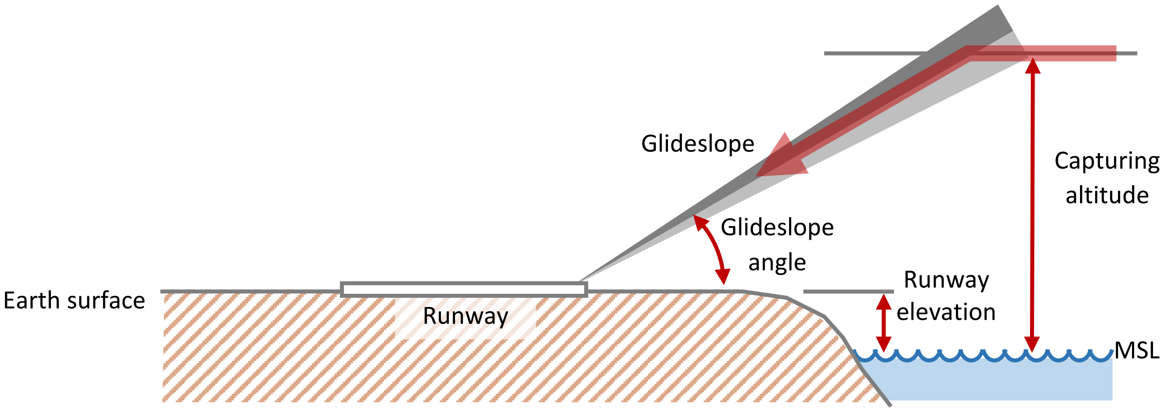
An airport has the following properties:

	Element	Purpose
1	NAME	Name of the airport
2	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 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.
3	LOCATION	The location is also mandatory and defines the geographic coordinates of the airport navigation aid. It consists of longitude and latitude.
4	ID	The ID identifies the radio navigation aid which is located on the airport. The description for ID in the chapter before does apply here as well.
5	FREQUENCY	This property defines the frequency of the navigation aid which is located on the airport. The description for FREQUENCY in the chapter before does apply here as well.

5.2.4 RUNWAY

Runways can also be placed freely on the landscape, but they need to be assigned to an airport. Runways support flying ILS approaches.

The vertical geometry of 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.
3	LENGTH	Length of the runway in meters.
4	DIRECTION	Direction (primary) between 0° and 360°. The reverse direction does not exist as an 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 Flight Display and on the Navigation Display. 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 the glideslope and the horizontal earth surface. While real ILS typically have 3° glideslope angles, for multicopters 20° is recommended and for fixed wing planes maybe 10°. This property is only required if a frequency has been specified.
8	PRIMARY INTERCEPTION ALTITUDE	The interception altitude in meters 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 Flight Display and on the Navigation Display. 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.

5.3 DISPLAY UNITS

While FlightZoomer internally strictly works with SI units (e.g. meter and kilogram), the presentation layer in the Cockpit-app supports several units for the most relevant physical values. These are called display units.

The following table shows display units:

App	Parameters	Default unit (supported display units)			
FlightZoomer Cockpit	Speeds	km/h	(m/s	nm/h	Mph)
	Altitudes, distances	m	(ft)		
	Vertical speeds (m or ft is the same as the selected display unit for altitudes and distances, a minute is always the divider)	m/min	(ft/min)		

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

6 HOW TO INSTALL

The instructions to install FlightZoomer strongly depend on the actual setup. If you use an RTF Copter as the 3DR Solo, you can skip nearly all steps below.

The following table shows, which installation steps apply in which case:

Step	System topology		
	RTF Aircraft	3rd party telemetry	3G using Andruav
Install the FlightZoomer Cockpit-app	x	x	x
Connect with the 3rd party telemetry modem		x	
ArduPilot configurations		x	x
MAVLink connection		x	x
Specific configurations for multicopter operations		x	x
Specific configurations for fixed wing aircraft		x	x
Prepare navigation database	x	x	x
Attach the mobile handset to the aircraft			x
Install the Andruav app on onboard smartphone			x
Establish the connection to the flight controller			x

6.1 COMMON INSTALLATION STEPS

6.1.1 INSTALL THE FLIGHTZOOMER COCKPIT-APP

The FlightZoomer 3 Cockpit app can easily be installed from the Microsoft Store. Just enter "flightzoomer cockpit" in the search textbox, select the app in the result list (choose *FlightZoomer Cockpit 3* and not *FlightZoomer Cockpit 3 – Simulation Edition*) and press Install.

⚠ Additionally, it is strongly recommended, that you download maps for offline usage in the areas, where you want to fly (this applies also to all areas, where you want to fly in the simulator). Without having offline maps, some users have reported stability problems.

6.1.2 CONNECT WITH THE 3RD PARTY TELEMETRY MODEM

The 3rd party telemetry solution needs to be set up and configured as described by the vendor. Search for instructions how to set up a telemetry link for a COM-port based GCS (like e.g. Mission Planer).

Test the telemetry connection with Mission Planer and note the required baud rate. It is later needed, when connecting the Cockpit-app with the ground side telemetry modem.

6.1.3 ARDUPILOT CONFIGURATIONS

6.1.3.1 MAVLINK CONNECTION

Telemetry channel baud rate:

Parameter	Value	Description
SERIALx_BAUD	57	Use 57600 (value = 57) as default, set lower if 3rd party radio requires less to work flawlessly.
SERIAL1_PROTOCOL	1	MAVLink1

MAVLink packet flow rates:

Parameter	Value		Description
SRx_ADSB	0	Hz	ADSB stream rate to ground station
SRx_EXT_STAT	5	Hz	Extended status stream rate to ground station
SRx_EXTRA1	5	Hz	Extra data type 1 stream rate to ground station
SRx_EXTRA2	5	Hz	Extra data type 2 stream rate to ground station
SRx_EXTRA3	1	Hz	Extra data type 3 stream rate to ground station
SRx_PARAMS	0	Hz	Parameter stream rate to ground station
SRx_POSITION	10	Hz	Position stream rate to ground station
SRx_RAW_CTRL	0	Hz	Raw Control stream rate to ground station
SRx_RAW_SENS	5	Hz	Raw sensor stream rate to ground station
SRx_RC_CHAN	5	Hz	RC Channel stream rate to ground station

These flow rates are suitable if the baud rate of the MAVLink connection between the flight controller is configured as 57600. If a lower baud rate is required, the packet rates can be reduced likewise to match the available bandwidth. The data processing in the FlightZoomer Cockpit-app is capable to handle any thinkable data rate.

6.1.3.2 SPECIFIC CONFIGURATIONS FOR MULTICOPTER OPERATIONS

For failsafe FlightZoomer relies on the ArduCopter GCS failsafe mechanism:

Parameter	Value	Description
FS_GCS_ENABLE	1	Possible values: 0 = Disabled; 1 = Enabled always RTL; 2 = Enabled Continue with Mission in Auto Mode; 3 = Enabled always SmartRTL or RTL; 4 = Enabled always SmartRTL or Land Failsafe action, will be triggered after 5 seconds of no MAVLink heartbeat messages. Choose the preferred action, which the copter shall perform after the flight controller stops receiving heartbeat messages from the Cockpit-app.

6.1.3.3 SPECIFIC CONFIGURATIONS FOR FIXED WING AIRCRAFT

As the FlightZoomer autopilot for fixed wing operations relies on the Auto mode, the following settings are required:

Parameter	Value	Description
MIS_RESTART	0	0 means that missions are resumed after activating Auto mode and not restarted.

For failsafe FlightZoomer relies on the ArduPlane GCS failsafe mechanism:

Parameter	Value		Description
FS_GCS_ENABL	3		Possible values: 0 = Disabled; 1 = Heartbeat; 2 = HeartbeatAndREMRSSI; 3 = HeartbeatAndAUTO Failsafe condition, needs to be effective for FS_LONG_TIMEOUT seconds to trigger GCS failsafe. Using the value 3 (= HeartbeatAndAUTO) means, that RTL is only triggered, while the FlightZoomer autopilot has control.
FS_LONG_ACTN	1		Possible values: 0 = Continue; 1 = ReturnToLaunch; 2 = Glide; 3 = Deploy Parachute The action to take on a long (FS_LONG_TIMEOUT seconds) failsafe event. Using value 1 (= ReturnToLaunch) the RTL mode is activated, if the MAVLink heartbeat is interrupted for more than FS_LONG_TIMEOUT seconds.
FS_LONG_TIMEOUT	10	s	10 seconds after the flight controller would stop receiving heartbeat messages (from the Cockpit-app via the telemetry system) the flight controller shall switch to RTL. The user can choose other values for the best tradeoff between the expected length of communication drops and the duration which can be risked flying unattended.

6.1.4 PREPARE NAVIGATION DATABASE

One important step for preparing FlightZoomer is the creation of a suitable navigation database. This task is done with the Cockpit-app. The basics for the navigation database are described in section 5.2.

Some tips how to create the navigation database:

- A mini tutorial how to create a navigation database is available on YouTube in this video.
- Creating the navigation database means that you already have a clear vision what kind of flights you want to do.
- The task to create the navigation database needs to be clearly separated from performing a flight. For this reason, the Navigation Data Management screen is only accessible directly after starting the Cockpit-app and not anymore after entering the cockpit.
- Wherever you wish to have waypoints for your routes place a VOR or a GPS FIX. You can cover the whole landscape with as many navigation aids as you want.
- Landing strips, which shall be used by multicopters, can be placed virtually anywhere (Because the last segment is a straight descend without any horizontal speed components).
- For plane operations, the location of the touchdown point is affected by a considerable error of about +/- 20m in runway direction and +/- 5m to the side (determined by the accuracy of the ArduPlane LAND mode), so the chosen landing strips ideally are a sufficiently large grass area.

6.2 EXTRA PREPARATION FOR ANDRUAV OPERATIONS

6.2.1 ATTACH THE MOBILE HANDSET TO THE AIRCRAFT

This section explains how the mobile handset can be mounted on an RC aircraft or copter and what needs to be considered:

- The mobile handset should be mounted detachable.
- Provide lightweight, yet sturdy installation.
- The screen should be accessibly when mounted.
- Provide as much physical clearance as possible between the mobile handset and any other RF emitting device (e.g. the Bluetooth transceiver, in case there is an FPV transmitter, a bi-directional RC receiver or even the power transmission cables, ESC…)
- The position of the mobile handset impacts the aerodynamics of the aircraft/copter. This is especially important when flying with high speeds. Positions in front of the center of gravity can have a negative impact on the stabilization especially for multicopters. While all the examples in the following *best practices*-section have worked at fairly high speeds (~ 20 m/s), the ideal position would be like a trailing horizontal stabilizer, which is tilted to become aerodynamically neutral at the max forward pitch angle (of the copter).

Consider optionally:

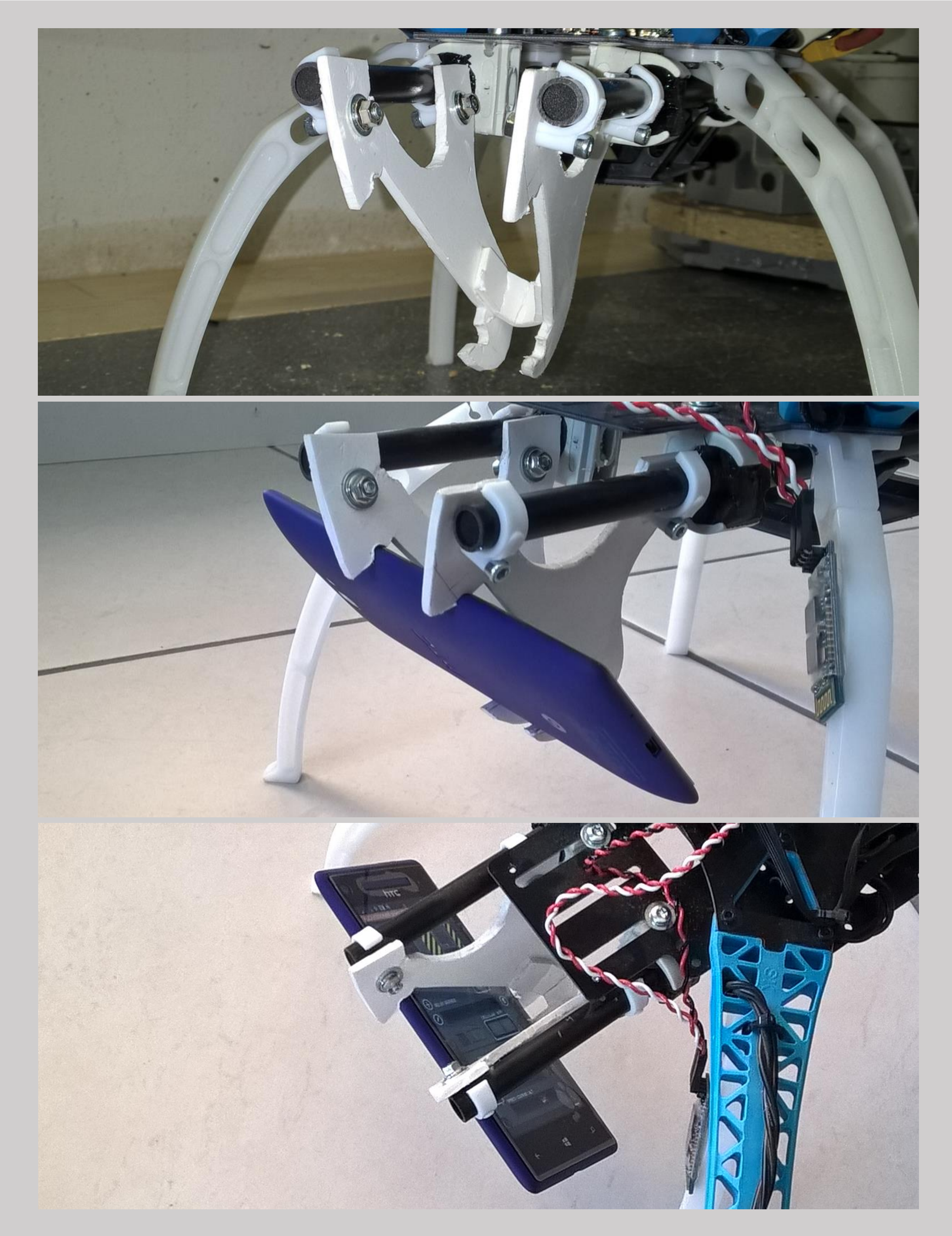
- If you intend to use the camera of the phone stick to these guidelines:
  - The mobile handset needs to be fitted with unobstructed camera vision.
  - Keep vibrations away from the mobile handset. Google "copter" and "vibrations".

BEST PRACTICES:

The following images show some solutions for attaching smartphones successfully to multicopters.

A very successful approach was to fix only the back cover of the phone, so the phone itself could easily be detached from the copter. Note also that the phone becomes aerodynamically neutral when the copter pitches forward:

THE FOLLOWING EXAMPLE ALLOWS USING THE CAMERA:



6.2.2 INSTALL THE ANDRUAV APP ON ONBOARD SMARTPHONE

Install Andruav on the onboard smartphone from the Google Play store.

6.2.3 ESTABLISH THE CONNECTION TO THE FLIGHT CONTROLLER

Follow the steps outlined in the Andruav documentation to connect the mobile phone with the flight controller.

If you are going to use a Bluetooth connection, the following wiki page provides helpful guidance: http://ardupilot.org/copter/docs/common-mission-planner-bluetooth-connectivity.html

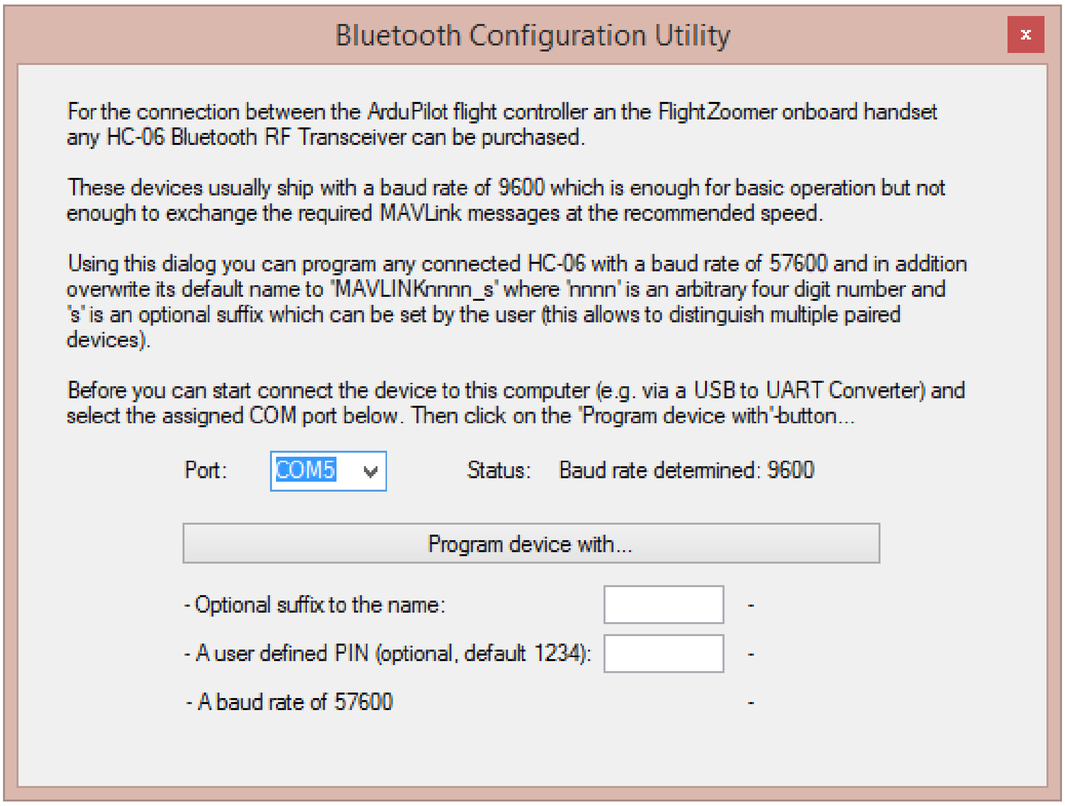
If you are going to use a HC-06 device for the Bluetooth connection, you can consider using the configuration utility as described in the next section.

6.2.4 CONFIGURE THE BAUD RATE OF THE BLUETOOTH TRANSCEIVER

This section only applies, if you connect the onboard smartphone with the flight controller through a HC-06 Bluetooth transceiver.

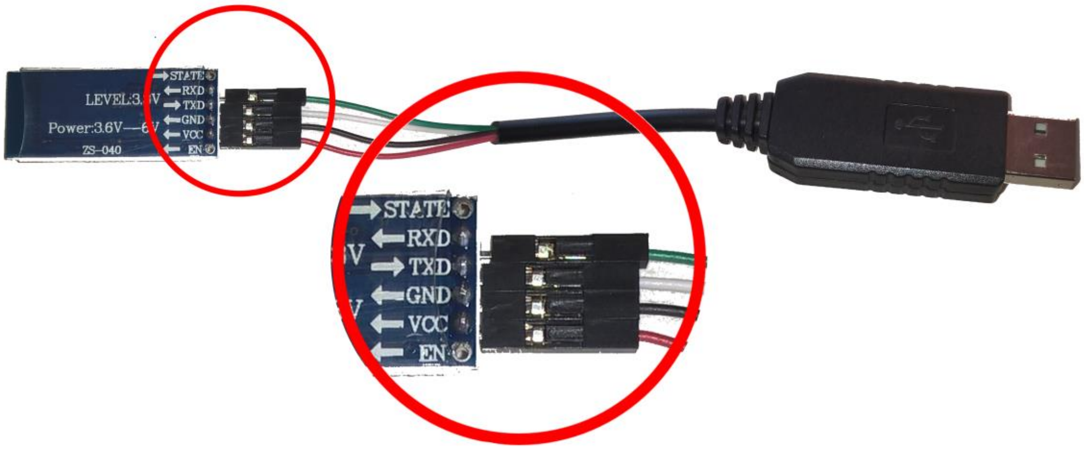
Factory fresh HC-06 devices typically have the default baud rate of 9600. It is recommended to change the configuration of the transceiver to a higher value.

For this purpose, the Relay Server application has a special utility to automatically overwrite the configuration parameters of a HC-06 Bluetooth transceiver with the correct values:

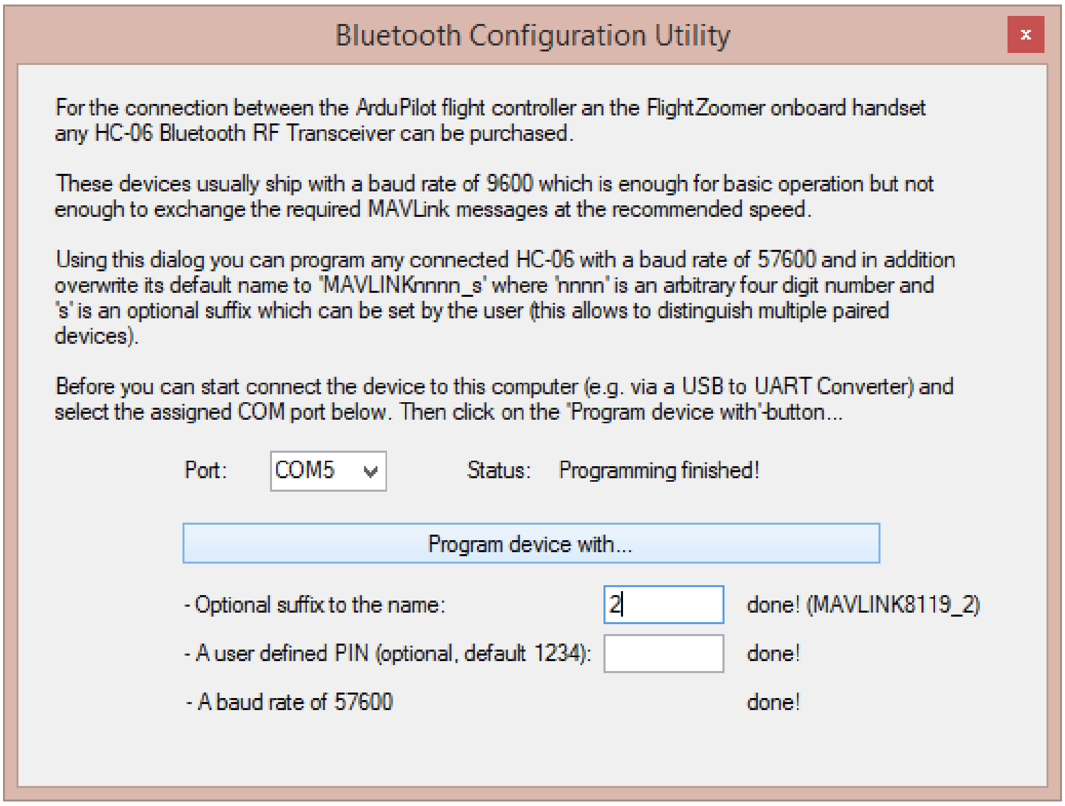


Perform the following actions to re-program the HC-06 device:

- Connect the HC-06 with the computer using a typical USB to RS 232/UART Adapter (as offered for Arduino) like shown on this image:



- Download and install the application FlightZoomer relay server.
- Open the Bluetooth programming utility from the Relay Server main window by clicking the button *Bluetooth Configuration Utility….*
- Confirm that the correct COM port is shown in the *Port* dropdown box (or select it otherwise).
- The current baud rate will automatically be determined!
- Choose whether you want to add a one-character-suffix to the name and choose a PIN code (or leave it at 1234).
- Click on the button *Program device with…*
- Once all steps are completed the utility looks like this:



7 HOW TO OPERATE

7.1 INTRODUCTION VIDEOS

The following videos allow to get a brief impression, how some of the FlightZoomer features are working and how they are operated:

<table>
<tr><th>Video</th><th>Covered topics</th></tr>
<tr><td></td><td>

Synthetic & Classic FPV combined - FlightZoomer 3 Feature Preview

- Feature demonstration: synthetic FPV camera
- Video shows of the synthetic FPV camera and its features
- Starting at 2:04, the synthetic FPV camera control buttons at the top are demonstrated
- Starting at 4:15, the embedding of the classic FPV camera feed and the following options are shown:
  - Classic FPV off
  - Classic FPV in an overlay window
  - Classic FPV as screen wide main view (replacing the synthetic view)
- The first sequence shows the synthetic FPV view in an area, that belongs to the Bing Maps 3D Cities. The following

</td></tr>
</table>

sequences are shot at places, that are covered by standard 3D terrain (without 3D objects).

The ultimate terrain view for drone pilots! - FlightZoomer 3 Feature Preview

- Feature demonstration: terrain view
- Video shows the FlightZoomer 3 terrain map and the vertical situation display.
- From 0:30 the elements of the Vertical Situation Display are explained.
- At 1:40 various zoom levels of the terrain map are demonstrated, you can see whole Europe vertically cut in two parts: red is higher terrain, green is lower terrain.
- From 2:00 on the aircraft descends into a valley using the Vertical Situation Display to keep sufficient clearance.
- Beginning at 3:20, the implementation details are explained.
- At 3:47 the Vertical Situation Display shows the terrain profile along a route with several waypoints.
- All the video sequences have been done using the inbuilt simulation mode.

Fly with a single Rotary Controller - FlightZoomer 3 Feature Preview

- Feature demonstration: fly with the Surface Dial rotary controller
- Starting at 0:30, the embedded classic FPV feed is used to show, how the Surface Dial is manipulated.
- At 0:41 the basic manipulations are explained, how the feature works.
- From 1:20 the dial is used to fly a copter over a mountain pass
- At 3:18 starts the last sequence, that shows dynamic flight maneuvers of a copter in a densely populated area (Zurich downtown).
- All the video sequences have been shot using the inbuilt simulation mode.
- Other demonstrated features: copter operations, autopilot modes SPD, TRK, ALT, FPA, automatic landing.

Flight Control by Speech Recognition - FlightZoomer 3 Feature Preview

- Feature demonstration: flying the aircraft just using voice commands.
- The video shows the sequence how the pilots speaks an instruction, listens to the readback from the software and confirms it, if it was correct.
- At 2:22 the video shows the handling of wrongly understood instructions.

- Video shows a real flight, not simulator exercises.
- Other demonstrated features: fixed-wing operation, autopilot modes TRK, ALT, FLCH, APP (= ILS approach), automatic landing.

"FlightZoomer Version 3 - Simulation Edition" Walkthrough

- Feature demonstration: simulation mode.
- In this short video all steps are shown, that are needed, to perform a flight in simulation mode after the Cockpit-app has been installed:
    - 0:25: Create a minimal, but suitable navigation database (consisting of an airport, a runway and two waypoints).
    - 1:08: Pick the position, where the simulate copter shall begin its flight.
    - 1:20: Enter the cockpit.
    - 1:28: Enter the battery parameters on the PERF FMS page
    - 1:39: Create a minimal flightplan using the created airport, runway, and waypoints.
    - 2:49: Activate the autopilot, the LNAV and VNAV autopilot modes to follow the planned route and vertical profile.
    - 4:06: Switch to basic autopilot modes (TRK and ALT hold) by pressing the TRK HOLD button.
    - 4:11: Activate the virtual Air Traffic-controller, who guides the flight by synthetic voice instructions to the final approach. Simulating the manned aviation ATC Uplink capabilities, the instructions are also displayed in written form on the left of the Primary Flight Display.
    - 4:20: Use the ACPT button to load the instructed target values automatically into the autopilot.
    - 4:33: Activate the APP display mode to show the deviation indications for the ILS approach.
    - 4:41: Accept the clearance to capture the localizer and the glideslope. From that point on, the copter first captures the localizer (extended runway center line) and then while flying at level the glideslope from below. After that, a fully automatic descend to the runway is performed.

FlightZoomer Version 2.0 in a nutshell - 14 new autopilot modes

- In this video the 14 autopilot modes are explained and demonstrated.
- The video shows the Version 2 groundstation, but the explained principles, procedures and capabilities are mostly applicable for version 3 as well.

- The flight is simulated.
- The simulated vehicle is a copter.
- The covered topics are these:
    - At 0:34: Version 2 system topology
    - From 4:40: walkthrough through all 14 autopilot modes

FlightZoomer - 1st automatic ILS approach with Air Traffic Control guidance

In this older video, the first successful automatic ILS approach is shown. The vehicle was a copter. The video shows this memorable real flight, not simulator exercises.

FlightZoomer 3 flown from overseas, fully automatic landing (ILS)

In this very recent video, the multi Cockpit feature is shown:

- Using the DirectLink topology, more than one cockpit-app can connect to an aircraft.
- Using this capability, the co-pilot was at the place where the aircraft was flying, while the pilot in command was located 6280km away.
- Using the autopilot and based on instructions via a Skype connection, the pilot in command was overtaking control shortly after takeoff and performing the entire rest of the flight, including an automatic ILS approach to full stop.
- The video shows a real flight, not simulator exercises.
- Other demonstrated features: fixed-wing operation, autopilot modes TRK, ALT, FLCH, APP (= ILS approach), automatic landing.

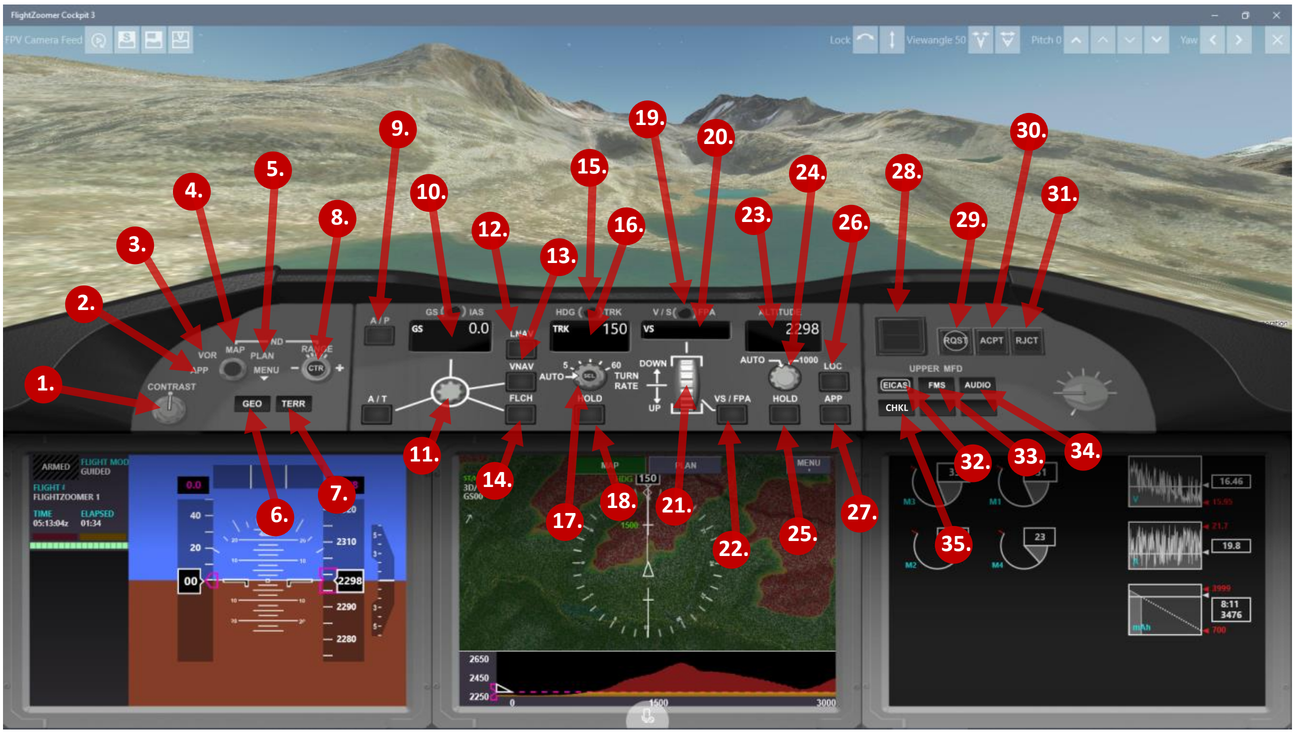
7.2 FLIGHTZOOMER COCKPIT-APP OVERVIEW

7.2.1 FPV VIEW

	Feature :: Command	Remarks
1	Real FPV Camera :: (Re-)Initialize camera	Allows to restart the video device. Used to restart video display if it has been interrupted. The video input device itself needs to be selected on the settings screen.
2	Real FPV Camera :: Switch off	
3	Real FPV Camera :: Show as overlay	Overlay window can be dragged anywhere on the screen and can also been resized.
4	Real FPV Camera :: Show screen wide	The screen wide real FPV camera replaces the synthetic FPV camera. It can be moved up and down.
5	Real FPV Camera :: Show full screen	The real FPV camera is shown across the full screen.
6	Real FPV Camera :: Real FPV camera view	In this screenshot the real FPV camera is shown as the overlay window.
7	Synthetic FPV Camera :: Synthetic FPV camera view	The synthetic FPV camera is always shown screen wide. The viewing direction can be dragged around by sweeping the finger over the screen or by clicking with the mouse and moving while the left button is pressed.

8	Synthetic FPV Camera :: Lock bank angle	Gimbal feature on the bank angle: the bank angle of the synthetic FPV camera stays fixed.
9	Synthetic FPV Camera :: Lock pitch angle	Gimbal feature on the pitch angle: the pitch angle of the synthetic FPV camera stays fixed.
10	Synthetic FPV Camera :: Zoom in	Reduces the field of view.
11	Synthetic FPV Camera :: Zoom out	Increases the field of view.
12	Synthetic FPV Camera :: Increase pitch angle by 15 degrees	Increases the constantly applied offset to the pitch angle by 15 degrees. Command can be repeated but only as long as the resulting pitch angle does not exceed 0 degrees (limitation of the MapControl)
13	Synthetic FPV Camera :: Increase pitch angle by 5 degrees	Increases the constantly applied offset to the pitch angle by 5 degrees. Command can be repeated but only as long as the resulting pitch angle does not exceed 0 degrees (limitation of the MapControl)
14	Synthetic FPV Camera :: Decrease pitch angle by 5 degrees	Decreases the constantly applied offset to the pitch angle by 5 degrees. Command can be repeated but only as long as the resulting pitch angle does not exceed -90 degrees (limitation of the MapControl)
15	Synthetic FPV Camera :: Decrease pitch angle by 15 degrees	Decreases the constantly applied offset to the pitch angle by 15 degrees. Command can be repeated but only as long as the resulting pitch angle does not exceed -90 degrees (limitation of the MapControl)
16	Synthetic FPV Camera :: Decrease yaw angle by 45 degrees	Increases the constantly applied offset to the yaw angle by 45 degrees.
17	Synthetic FPV Camera :: Increase yaw angle by 45 degrees	Increases the constantly applied offset to the yaw angle by -45 degrees.
18	Synthetic FPV Camera :: Reset to default	Resets the constantly applied offsets for the pitch and bank angle.

7.2.2 GLARESHIELD

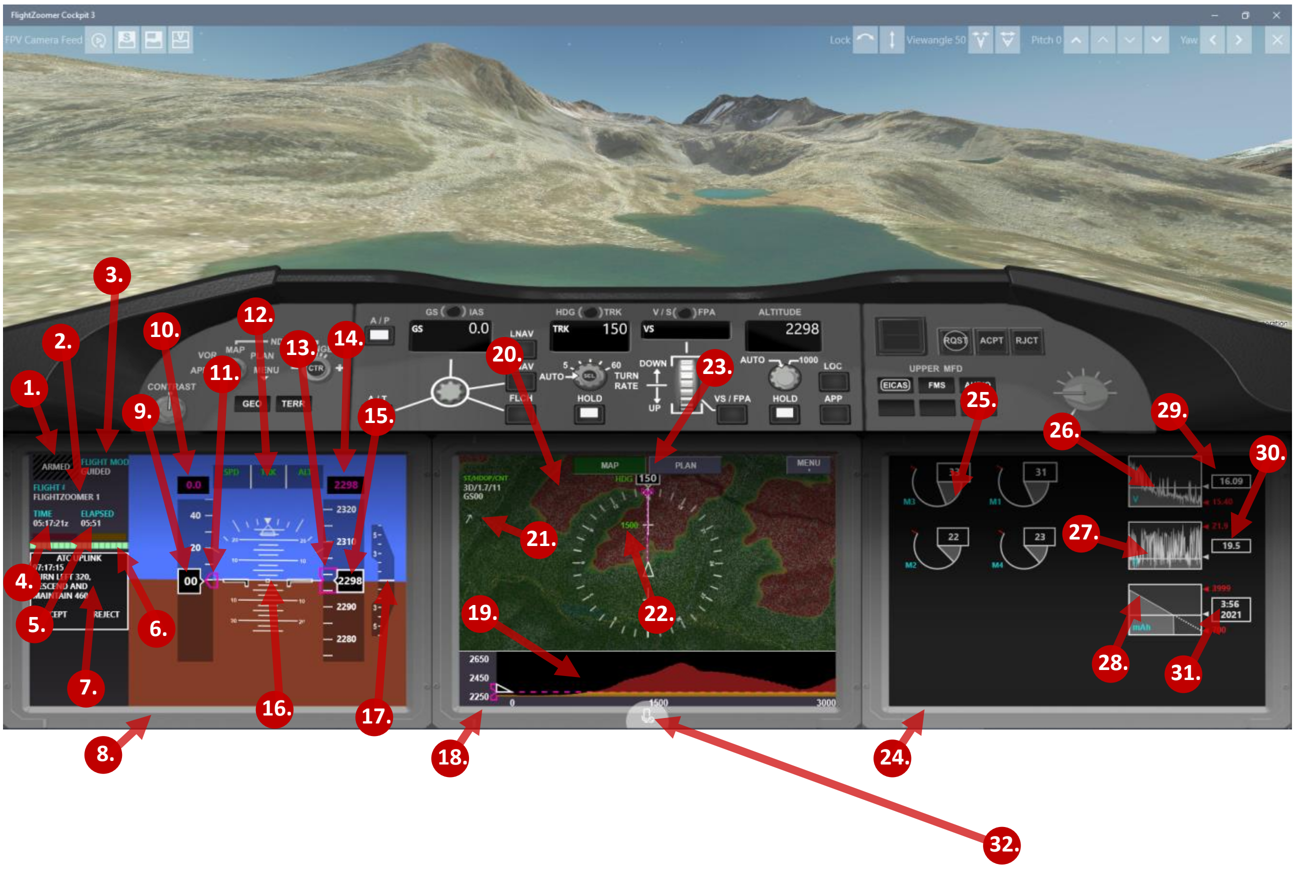


	Feature :: Command	Remarks
1	Display Control Panel :: CONTRAST	Navigation Display brightness. Less by pressing on the left of the dial, more by pressing on the right of the dial.
2	Display Control Panel :: APP selection	Activates the approach display mode, which shows lateral and vertical deviation indications on the Navigation Display and the Primary Flight Display.
3	Display Control Panel :: VOR selection	Activates the VOR display mode, which shows lateral deviation indications on the Navigation Display.
4	Display Control Panel :: MAP selection	Activates the default display mode, which shows the planned route on the Navigation Display.
5	Display Control Panel :: PLAN selection	Activates the alternative display mode, where north is always up on the Navigation Display.
6	Display Control Panel :: GEO button	Activates and deactivates the normal map on the Navigation Display.
7	Display Control Panel :: TERR button	Activates and deactivates the terrain map and the Vertical Situation Display on the Navigation Display. Switching this option off reduces system load remarkably.
8	Display Control Panel :: RANGE control	Increases or decreases the zoom level of the Navigation Display. Less zoom by pressing on the left of the dial, more by pressing on the right of the dial. The RANGE control also modifies the horizontal extension of the Vertical Situation Display.

9	Autopilot :: A/P	Activates and deactivates the autopilot. Activating the autopilot means for ArduCopter the activation of the Guided-mode and for ArduPlane the activation of the Auto-mode. Deactivating the autopilot (so the pilot can continue flying manually) means for ArduCopter the activation of the PosHold-mode and for ArduPlane the activation of the Cruise-mode.
10	Autopilot :: Speed target value	SPD mode is always on. The selected speed target determines the forward speed of the vehicle.
11	Autopilot :: Speed target value selector	Press to get a circle of speed target values on the right to pick the desired target speed.
12	Autopilot :: LNAV button	Activates and deactivates the LNAV mode, which follows a planned route laterally.
13	Autopilot :: VNAV button	Activates and deactivates the VNAV mode, which follows a planned route vertically.
14	Autopilot :: FLCH button	Activates and deactivates the FLCH mode, which automatically performs a climb or a descend in order to reach a changed altitude target value.
15	Autopilot :: HDG / TRK selector	Toggle between HDG and TRK as basic direction mode. After the autopilot is first switched on, the initial basic direction mode is always TRK. Operating 3DR Solo, HDG is not supported.
16	Autopilot :: Direction target value	Target value for HDG or TRK mode
17	Autopilot :: Direction target value selector	Press and keep pressed to get a circle of direction target values on the right to pick the desired target direction. Press and release immediately on either side of the rotary controller to iterate through the turn rate limitation settings.
18	Autopilot :: Current direction hold button	Press to activate HDG or TRK mode and pick the current heading or track over ground as target value.
19	Autopilot :: V/S / FPA selector	Toggle between V/S (Vertical Speed) or FPA (Flight Path Angle) as basic vertical mode
20	Autopilot :: Climb/descend target value	Target value for V/S or FPA mode. Unit for V/S is the defined display unit for length per minute (e.g. 100m per minute). The unit for FPA is °.
21	Autopilot :: Climb/descend target value selector	Press and move up or down in order to select the desired climb or descend target.
22	Autopilot :: Current climb/descend hold button	Press to activate V/S or FPA mode (depending on the V/S / FPA selector) and pick the current climb or descend rate as target value.
23	Autopilot :: Altitude target value	Target value for the altitude. Whenever the vehicle passes at this altitude while flying in V/S, FPA or FLCH the climb or descend is terminated and flight continues at this level.

24	Autopilot :: Altitude target value selector	Press to get a circle of altitude target values on the right to pick the desired target altitude.
25	Autopilot :: Current altitude hold button	Press to activate the ALT hold mode and terminate any other vertical mode, that was active before.
26	Autopilot :: LOC button	Press to capture a configured VOR radial (on the NAV RAD page of the FMS)
27	Autopilot :: APP button	Press to capture the localizer and glideslope of the selected ILS approach (on the NAV RAD page of the FMS)
28	Master Warning :: Reset button and light	Light turns yellow or red whenever a warning or error occurs. The related message is printed on the Primary Flight Display. Using the Master Warning button, the event can be acknowledged.
29	Air Traffic Control :: RQST	If an ILS approach is selected on the NAV RAD page of the FMS, this button can be used at any time during the flight, to request the inbuilt Air Traffic Controller (ATC) to provide guidance. By written and voice instructions, virtual ATC directs the flight into a suitable downwind and base, followed by the final approach. The button needs only to be pressed once. After that the complete sequence of instructions, that set the stage for the final approach, is generated by the FlightZoomer AI logic and issued, instruction by instruction, at the correct time.
30	Air Traffic Control :: ACPT	Using this button, instructions can be accepted, which were requested by the RQST button. Accepting any instruction automatically loads the required mode- and target value-changes into the autopilot for execution.
31	Air Traffic Control :: RJCT	Using this button, instructions can be rejected
32	3rd Display Control :: EICAS	Activates the engine and power management to be displayed on the rightmost cockpit screen.
33	3rd Display Control :: FMS	Activates the Flight Management System (FMS) to be displayed instead of the rightmost cockpit screen.
34	3rd Display Control :: AUDIO	Activates the Audio Control Panel to be displayed instead of the rightmost cockpit screen.
35	3rd Display Control :: Checklist	Puts the interactive checklist on the rightmost screen. Organized in a hierarchical structure the checklists are ordered after vehicle, flight phase or other criteria.

7.2.3 INSTRUMENTS



	Feature :: Command	Remarks
1	Flight Data Block :: ARMED Indication	-
2	Flight Data Block :: Flight ID	As defined on the start screen.
3	Flight Data Block :: Ardupilot Mode	Current mode of the Ardupilot flight controller.
4	Flight Data Block :: Zulu time	Zulu (UTC) time.
5	Flight Data Block :: Elapsed time	Time since cockpit entry.
6	Flight Data Block :: Communication bus activity	Green ticks show messages with updated position data. White ticks indicate incoming messages, that don’t contain new position data.
7	Flight Data Block :: ATC instructions	Indication of issued Air Traffic Control (ATC) instructions. Acknowledged or rejected using either the ACPT or the RJCT button.
8	PFD :: Primary Flight Display	-
9	PFD :: Speed	Indication of current speed (in display unit).
10	PFD :: Target speed	Indication of current target speed.
11	PFD :: Target speed mark	Mark that indicates the current target speed on the speed bar.
12	PFD :: Autopilot Mode Annunciator	Shows the currently active and or armed autopilot modes.
13	PFD :: Target altitude mark	Mark that indicates the current target altitude on the altitude bar.
14	PFD :: Target altitude	Indication of current target altitude.

15	PFD :: Altitude	Indication of current altitude (in display unit).
16	PFD :: Attitude indication	Artificial horizon
17	PFD :: Vertical Speed	Indication of vertical speed (in display unit for length per minute).
18	ND :: Navigation Display	-
19	ND :: Vertical Situation Display (VSI)	Vertical cut through the terrain in current flight direction. If a flightplan is loaded, the terrain is shown along the planned route. The range setting of the Navigation Display also controls the scale of the VSI.
20	ND :: Terrain and geographical map	To be displayed on the Navigation Display as additional map layers. Controlled by the TERR- and GEO-buttons.
21	ND :: Wind indication	Shows wind direction and speed both as value pair and a direction arrow. Wind speed is shown in display unit.
22	ND :: Scale mark	The displayed value equates to the distance between the scale mark and the center (in meter).
23	ND :: MAP/PLAN toggle buttons	Use the buttons to switch from MAP to PLAN mode and back.
24	EICAS :: Engine Indication System	The EICAS shares the 3rd display with the FMS or the audio panel. Switching between theses displays/panels is done on the glareshield with the EICAS-, FMS- and AUDIO-buttons.
25	EICAS :: Motor power setting(s)	For each motor: current power setting in %
26	EICAS :: Voltage Indication Graph	Shows how the battery voltage developed
27	EICAS :: Current Indication Graph	Shows how the battery current developed
28	EICAS :: Consumption Indication Graph	Shows how the battery depleted
29	EICAS :: Voltage value	Indication of actual and minimum voltage
30	EICAS :: Current value	Indication of actual and maximum current
31	EICAS :: Consumption value and rest time	Indication of consumed battery capacity and the remaining flight time at the current discharging rate.
32	Voice Recognition :: Activate / deactivate	Activates the microphone to enable voice recognition. More details can be found in the section Fly with voice recognition.

7.2.4 FLIGHT MANAGEMENT SYSTEM

The Flight Management System (usually abbreviated as FMS) is a flexible input/output system, that allows to manage the flight by defining various parameter (e.g. the route of a flightplan).

The FMS has different pages as INIT (for initialization), NAV RAD (to tune radios for e.g. the ILS), RTE (to define the flightplan), FIX (to browse through the navigation database), CAM (to control the camera) or ROI (to control regions of interest).

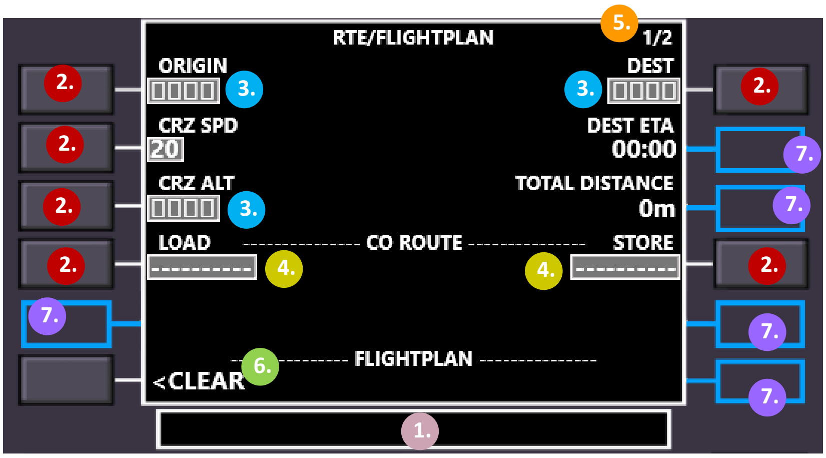
Some FMS Pages are multi screen pages, which have multiple related subpages. On the RTE page for example, on the first page the common parameter like the origin and the destination airport are defined. On the next page(s), any number of waypoints can be defined.

	Feature :: Command	Remarks
1	FMS :: Open / close button	Opens or hides the FMS panel.
2	FMS :: Flight Management System	Display and keyboard to enter and maintain flight related data.
3	FMS :: Page selection keys	These buttons directly open the related FMS page.
4	FMS :: Scratchpad	Line to enter input into the system
5	FMS :: Left Line Select Keys LSK L1-L6	Six buttons to load input from the scratchpad to the respective line on the left side. Buttons become a cyan box if the line is read only. If the line beside the LSK starts with a "<"-character, the LSK navigates to the FMS page, which is mentioned on the line.
6	FMS :: FMS page title	Title of the FMS page.

7	FMS :: FMS page	Content of the FMS page, consisting of six parameter, values, settings or indications on either side of the display.
8	FMS :: Right Line Select Keys LSK R1-R6	For these buttons, the same applies as described above for the LSK L1-L6.
9	FMS :: Page scrolling keys	The BACK key allows jumping back to the last displayed page (this is only supported, where meaningful, e.g. on the FIX page or when lists are shown). The two buttons PREV PAGE and NEXT PAGE allow scrolling through multi screen pages.
10	FMS :: Alphabetical keyboard	Text input on the keyboard is always written into the scratchpad. Entering a value for a parameter therefore requires two steps: 1. Enter the value into the scratchpad using the keyboard. 2. Pressing the LSK beside the parameter, which shall be set.
11	FMS :: Numerical keyboard	
12	FMS :: EXEC button	Used to finalize an entered route.

The various FMS pages and their content is described in the Procedures section.

Some commonly used symbols and methods are described here:



	Symbol / method	Remarks
1	Enter a value into the scratchpad	Enter a value by typing on the keyboard. Each character appears in the scratchpad. Alternatively, the scratchpad can be filled using this method: • If a parameter has already been defined and the respective LSK (2) is pressed again, a copy of its value is written again into the scratchpad. This is e.g. useful to define the ORIGIN (-airport) and then copy the same airport also to the DEST-parameter. Note: This feature is only supported where copying makes sense (e.g. not for numbers).

2	By pressing one of the LSKs, define the respective parameter with the value from the scratchpad	Whatever value appears in the scratchpad can be loaded into a parameter using the LSK (line select key) beside the parameter. All parameter which can be defined by the user, have a grey background and are surrounded by a white rectangle. Many times, parameter which need to be picked from a selection (e.g. ORIGIN, which accepts all configured airport codes) can also be selected following these steps: 1. Precondition: the parameter is still empty (if it is defined already, delete it as described below). 2. Press the respective LSK. 3. The full list of all available options is shown. 4. Select the desired value from the list. To delete a value, press the DEL key from the keyboard (which fills DELETE into the scratchpad) and then the respective LSK.
3	Mandatory parameter	Little squares are placeholders for mandatory parameter.
4	Optional parameter	Dashes are placeholders for optional parameter.
5	Multi screen FMS page	The multi screen indications inform the user, how many related subpages this FMS page has and which one currently is displayed.
6	Prompts	Caret characters indicate functions (CLEAR the flightplan in this case) or prompts to jump to another page of the Flight Management System
7	Read-only lines	Read-only lines have no LSK, they are used to display information.

7.3 PROCEDURES

These step-by-step guidelines illustrate the recommended usage of FlightZoomer 3.

Were suitable, each step has a small checkbox, so you can open the guidelines in a browser on a mobile device while going through the procedure and tick off the completed steps.

Legend for the used devices:

AC = aircraft
FC = flight controller
AV = Andruav device
3PR = 3rd party radio telemetry system
SY = Sony camera
CP = groundstation (FlightZoomer Cockpit-app)
RC = RC transmitter

7.3.1 CHANGE DISPLAY UNITS

As [described before](#), most data in the Cockpit app can be displayed in different units.

To change the displayed units, proceed as follows:

Step	Action	Device
☐1	Open the FMS	CP
☐2	Navigate to the IDENT page by pressing INIT, followed by pressing IDENT (LSK L1)	CP
☐3	Press LSK R2 repeatedly to cycle through the supported units for horizontal speeds  	CP
☐4	Press LSK R3 repeatedly to cycle through the supported units for distances or altitudes (the same setting applies to both).  	CP

7.3.2 SYSTEM START UP

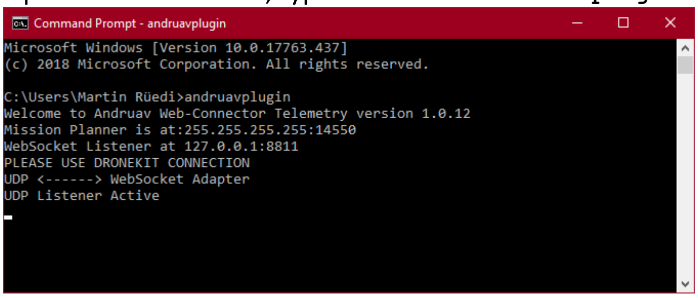
7.3.2.1 FOR 3RD PARTY RADIO TELEMETRY OPERATIONS

Step	Action	Device
☐ 1	Power up the aircraft and the flight controller.	AC
☐ 2	Establish the connection with the 3rd party radio telemetry.	3PR
☐ 3	Start the FlightZoomer Cockpit-app	CP
☐ 4	In the Cockpit-app, on the welcome screen, select the 3rd Party Telemetry-tab; enter the COM port and the bitrate.	CP
☐ 5	Press the button *Enter Cockpit...*; The air-to-ground connection is established	CP
☐ 6	Basic instrument end-to-end check	AC -> FC -> 3PR -> CP

7.3.2.2 FOR ANDRUAV OPERATIONS

Some of the steps are described in greater details also in this video:
https://www.youtube.com/watch?v=mUCbhzvmVcI

Step	Action	Device
☐ 1	Power up the aircraft and the flight controller.	AC
☐ 2	Start the Andruav-app	AV
☐ 3	Connect the Andruav-app with the flight controller	FC<->AV
☐ 4	Connect the Andruav-app with the Andruav backend	AV
☐ 5	Launch Google Chrome (after internet connectivity has been established via a hotspot), load the Andruav WEB panel and press Connect	CP
☐ 6	Open a command line, type and execute **`andruavplugin:`**	CP

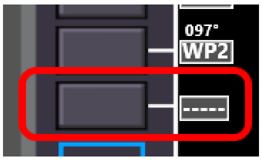


Step	Action	Device
☐ 7	On the Andruav WEB Panel, change Tele Off to Tele On	CP
☐ 8	Start the FlightZoomer Cockpit-app	CP
☐ 9	Select the 3rd Party Telemetry-tab; choose UDP and set port 14550 before your press Enter Cockpit…	CP
☐ 10	Basic instrument end-to-end check	AC -> FC -> CP -> CP

7.3.3 FLIGHT PREPARATIONS

Step	Action	Device
☐ 1	Optional: enter flight route. This is needed to use the LNAV and VNAV autopilot modes.	CP
☐ 1.1	Alternative 1: Enter flight route manually	CP
☐ 1.2	Alternative 2: Load stored route from database	CP
☐ 2	Optional: Tune the ILS receiver	CP
☐ 2.1	Enter the ILS frequency on the FMS NAV RAD page	CP
☐ 3	Configure the ND appropriately on display control panel: Recommended is MAP mode, TERR on (TERR off if the system performance is marginal)	CP
☐ 4	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 -> PERF FMS page	CP
☐ 5	On the same FMS page, enter the battery capacity, which shall be considered as reserve into the RES BAT CAP attribute.	

7.3.3.1 ENTER THE FLIGHT ROUTE MANUALLY IN THE FMS

Step	Action	Device
☐ 1	Open the RTE page of the FMS, using the RTE button	CP
☐ 2	Enter origin of the route. Use one of these methods: a. Write the airport CODE (as defined in the navigation database) into the scratchpad and press the LSK 1L key. b. Keep the scratchpad empty and press the LSK 1L key, to get a list of all available airports, so you can pick the one you want.	CP
☐ 3	Enter destination of the route using the LSK 1R key. Beside the two methods mentioned before, you can use a third one if the destination is the same as the origin (which is typically the case when flying with FlightZoomer): c. Press LSK 1L to copy the entered CODE (from step 2) into the scratchpad. Then press LSK 1R to load the CODE into the destination field.	CP
☐ 4	Go to the second RTE page using the NEXT PAGE key. On the second RTE page waypoints 1 to 6 can be entered (and waypoints 7 to 12 on the third, and so on). If origin and destination have not been defined, no waypoint can be entered. Enter each waypoint using one of these methods: a. Write the waypoint ID (as defined in the navigation database) into the scratchpad and press the LSK 1L-6L key, which is beside the empty box with the dashes (which is always one position below the already defined waypoints):  b. Keep the scratchpad empty and press the LSK 1L-6L key, which is beside the empty box with the dashes, to get a list of all available navigation aids, so you can pick the one you want. As soon as the waypoints form a flyable route (the distance between each waypoint leaves enough space to fly the speed dependent turns), the resulting route is immediately shown on the Navigation Display and also updated as more waypoints are added. The route can be modified at a later point (but not while the LNAV mode is performing the route) using one of these methods: a. To overwrite a waypoint: Enter the waypoint ID into the scratchpad and press the LSK 1L-6L key, which is beside the waypoint that you want to replace b. To delete a waypoint: Press the DEL key in the keyboard, the scratchpad is filled with DELETE, then press the LSK 1L-6L, which is beside the waypoint, which shall be deleted.	CP
☐ 5	Scroll back to the first RTE page using PREV PAGE key. Enter the cruise speed in the scratchpad and press LSK 2L. As the turn radius for planned routes is proportional to the cruise speed, the route on the Navigation Display is updated any time, when the cruise speed is changed.	CP

	If the target cruise speed is set so high, that the resulting turn radius no longer can be flown with the given waypoints, the route is erased from the Navigation Display and using the LNAV mode will not be possible. If that happens, you either need to plan a route with longer distances between the waypoints or use a lower cruise speed.	
☐ 6	Enter the cruise altitude in the scratchpad and press LSK 3L. This defines the vertical flight profile for the VNAV autopilot mode and is displayed on the Vertical Situation Display. On line 2R and 3R on the first RTE page, the calculated flight duration and the route length are shown. Note: to follow flight routes with the LNAV autopilot mode, the VNAV mode is not mandatory. You can also at any time use any of the other vertical autopilot modes and just follow the route laterally. So, if the route requires a more complex vertical flight profile than the single cruise altitude, the climbs and descends can be performed (manually) during the flight with the ALT, FLCH, VS and FPA modes.	
☐ 7	Press EXEC button on the FMS to activate the route.	CP
☐ 8	Optional: store route for later reuse to the database:	CP
☐ 8.1	Enter the route name in the scratchpad and press the LSK 4R key on the first RTE page.	CP

7.3.3.2 LOAD A STORED FLIGHT ROUTE FROM DATABASE

Step	Action	Device
☐ 1	Enter route name in the scratchpad and press LSK 4L key on the first RTE page.	CP
☐ 2	Press EXEC button on the FMS to activate the route.	CP

7.3.4 BASIC FLYING WITH FLIGHTZOOMER

7.3.4.1 TAKE OFF

As it is not possible, to perform the take off with the FlightZoomer autopilot, you need to take off with one of the ArduPilot modes. Also, in manned aviation, the autopilot is activated earliest shortly after being airborne.

Take off check list:

Step	Action
1	Arm ArduPilot using the RC transmitter
2	Set the desired ArduPilot mode for manual flight (for plane either Manual, Stabilize or FBWA and for copter e.g. PosHold)
3	Check RC transmission (for plane)
4	Check the FlightZoomer displays
5	Take off!

7.3.4.2 LANDING

Step	Action
1	Land the aircraft manually or using the FlightZoomer ILS (APP mode)
2	Disarm ArduPilot
3	Deactivate the airborne part of the telemetry system
4	Shutdown the FlightZoomer Cockpit app (by closing it)

7.3.5 FLYING WITH THE FLIGHTZOOMER AUTOPILOT

7.3.5.1 COMMON GUIDELINES

Operating the FlightZoomer autopilot, the following points need to be considered:

COMMON CONSIDERATIONS:

- Activating the autopilot, FlightZoomer changes the mode of the flight controller (to *Guided* for copters and *Auto* for planes).
- Deactivating the autopilot can be done in two ways:
  - Either by pressing the A/P button on the Mode Control Panel:

  - Or by manually switching the flight controller into another mode using the transmitter. FlightZoomer will detect the changed mode and switch off immediately the FlightZoomer autopilot. Typically, this method is used by switching to *RTL* manually as soon as something unexpected happens.
- The recommended emergency procedure is switching ArduPilot manually into *RTL* mode by a switch on the RC transmitter.

CONSIDERATIONS FOR COPTER:

Use a well-tuned multicopter:

- The starting point for FlightZoomer autopilot operations is having a well-tuned multicopter. Optimize ArduCopter until you are satisfied with the handling in *RTL* or *Loiter* mode.

ArduPilot mode for autoflight:

- For FlightZoomer autopilot operations, ArduCopter is put into *Guided* mode.

CONSIDERATIONS FOR PLANE:

Use a well-tuned aircraft:

- The starting point for FlightZoomer autopilot operations is having a well-tuned aircraft. Optimize ArduPlane until you are satisfied with the plane handling in *RTL* or *Cruise* mode.

Airspeed sensor usage:

- The aircraft can be equipped with or without airspeed sensor.

Autoflight accuracy:

- Be aware that the accuracy of the autopilot modes will not be as good as in the simulator. The accuracy of the altitude hold mode is at best as good as with ArduPlane's own *Cruise* mode. Also, speed may swing more than expected around the target value (especially when flying without airspeed sensor, the speed target can only be considered as a rough indication of how much power will be set on average).

Ardupilot flight protections:

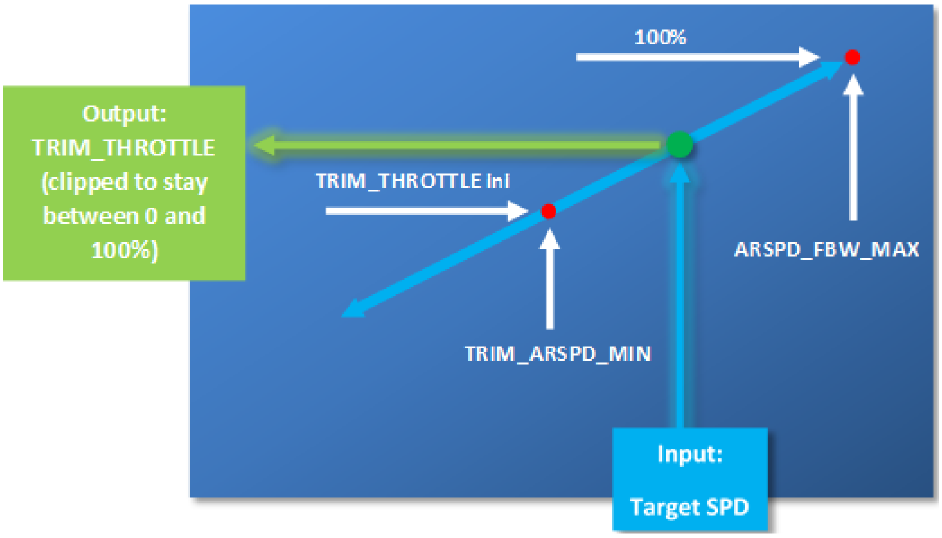
- For speed, throttle and altitude ArduPlane's internal mechanisms as TECS and Throttle Nudging remain effective during FlightZoomer autopilot operations (the same way how they work in Auto mode).

Interactions with ArduPilot for autoflight:

- For FlightZoomer autopilot operations, ArduPlane is put into *Auto* mode.
- To process any of the FlightZoomer autopilot modes, a dynamically updated waypoint is automatically injected into the ArduPlane mission at the second position (so the home waypoint is not affected).
- When the FlightZoomer autopilot is switched off, the previously loaded mission is loaded into ArduPlane again. If the autopilot was deactivated by the A/P button, FlightZoomer also activates the ArduPlane *Cruise* mode, so you can easily continue flying manually.

Dependency and interaction with ArduPlane parameters for autoflight:

- FlightZoomer adopts to the connected aircraft in a flexible way by using ArduPlane parameters for calculations.
- The valid speed range for autopilot operations is simply derived from the ArduPlane Parameters ARSPD_FBW_MIN and ARSPD_FBW_MAX. If you wish to change the speed range, use Mission Planer to adjust these two values.
- Likewise, FBWB_CLIMB_RATE is used to limit the possible vertical speeds and flight path angle.
- The ARSPD_USE parameter is used to determine, whether an airspeed sensor is in use.
- If an airspeed sensor is in use, the target airspeed is commanded by overwriting the value of the TRIM_ARSPD_CM-parameter with the target speed.
- If no airspeed sensor is in use, the target airspeed is commanded by overwriting the TRIM_THROTTLE-parameter according to this algorithm:



- The parameter LIM_ROLL_CD is overwritten to control the commanded turn rate. The parameter is only overwritten while a turn is ongoing in HDG or TRK mode and is reset to the default value immediately after the turn is completed.
- The roll limits are defined as follows:
  - Turnrate Position => Value
  - AUTO => LIM_ROLL_CD is reset to original value as read from memory initially
  - Position 1 (5 on UI) => LIM_ROLL_CD = 10°
  - Position 2 => LIM_ROLL_CD = 15°

- Position 3 => LIM_ROLL_CD = 20°
- Position 4 => LIM_ROLL_CD = 35°
- Position 5 (60 on UI) => LIM_ROLL_CD = 45°

Flight tactics:

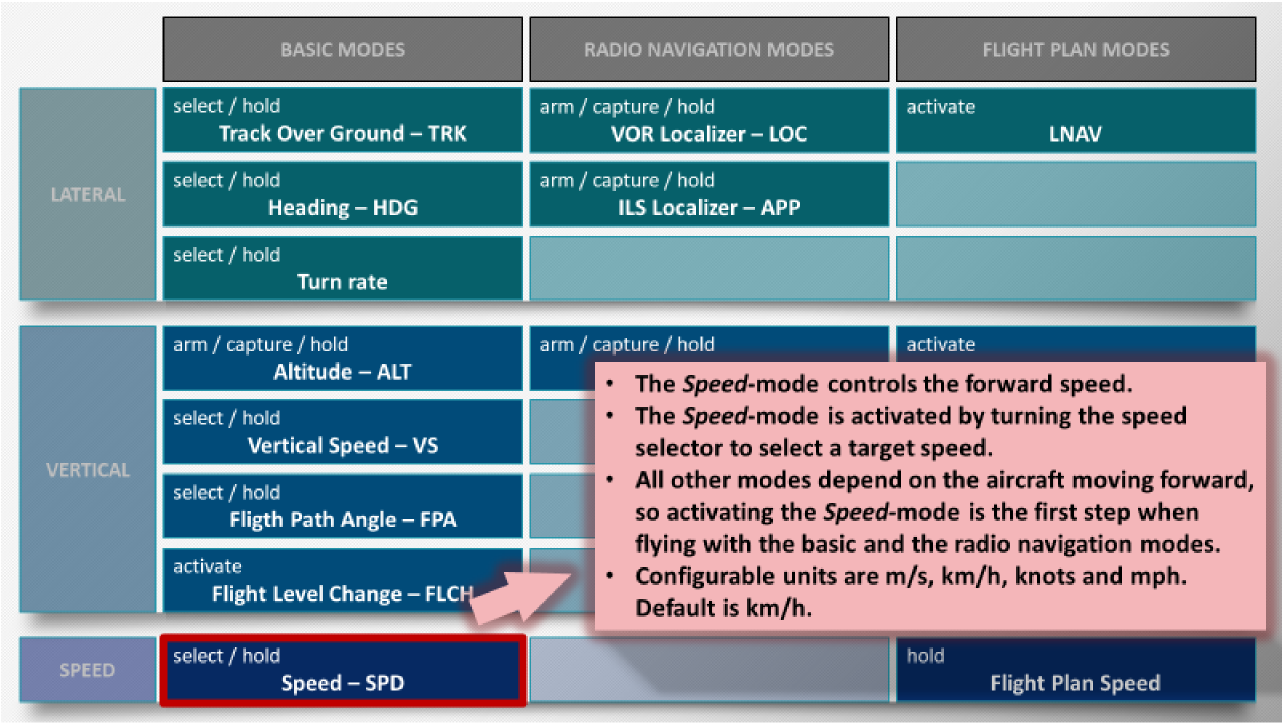
- As fixed wing aircraft never stop, you need to anticipate the flight maneuvers ahead.
- If you command a turn, consider already the location and the flying direction the plane will end up after the turn. Avoid ending up in situations, where no escape is possible.
- For these reasons fly at places where you have enough space.
- Whenever possible fly higher than obstacles like mountains, trees or power lines.

7.3.5.2 AUTOPILOT MODES

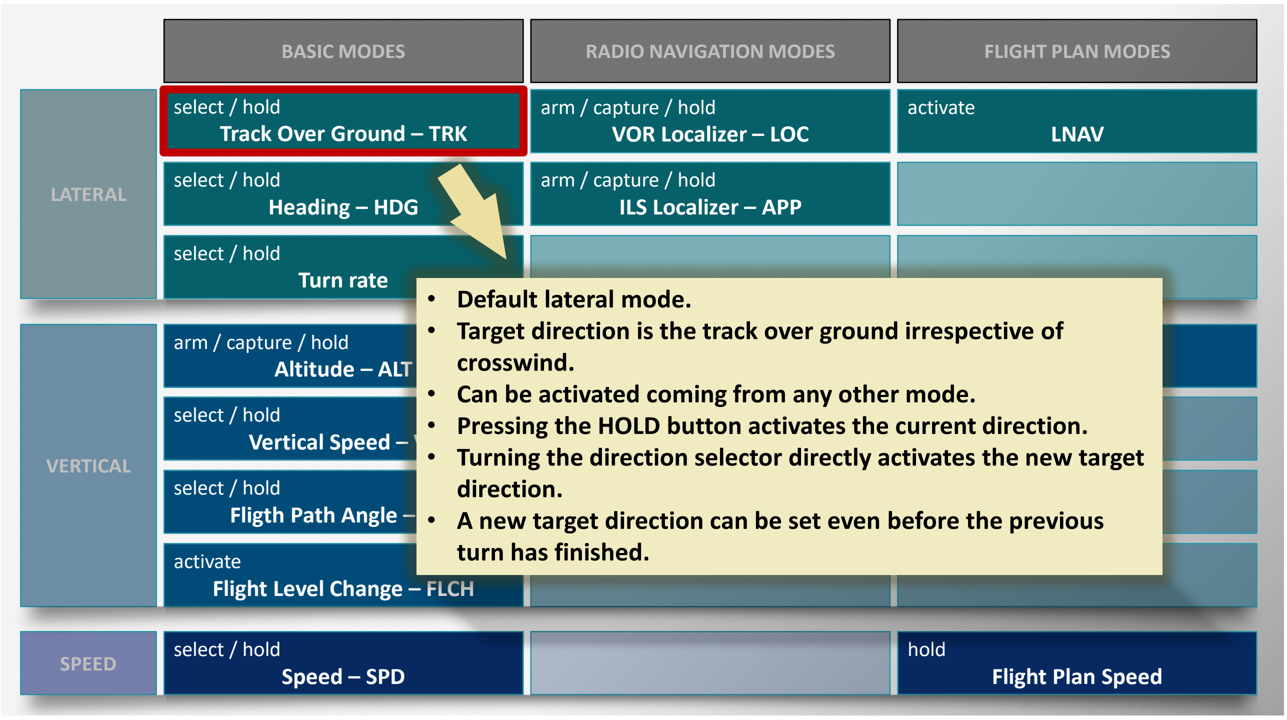
The following table shows the 14 FlightZoomer autopilot modes. The columns of the table show the three types of automatic flying modes (BASIC, RADIO NAVIGATION and FLIGHTPLAN) and the rows are arranged in groups for the three autopilot channels (LATERAL, VERTICAL and SPEED):

	BASIC MODES	RADIO NAVIGATION MODES	FLIGHT PLAN MODES
LATERAL	select+hold **Track Over Ground – TRK**	arm+capture+hold **VOR Localizer – LOC**	activate **LNAV**
	select+hold **Heading – HDG**	arm+capture+hold **ILS Localizer – APP**	
	select+hold **Turn rate**		
VERTICAL	arm+capture+hold **Altitude – ALT**	arm+capture+hold **ILS Glideslope – APP**	activate **VNAV**
	select+hold **Vertical Speed – VS**		
	select+hold **Fligth Path Angle – FPA**		
	activate **Flight Level Change – FLCH**		
SPEED	select+hold **Speed – SPD**		hold **Flight Plan Speed**

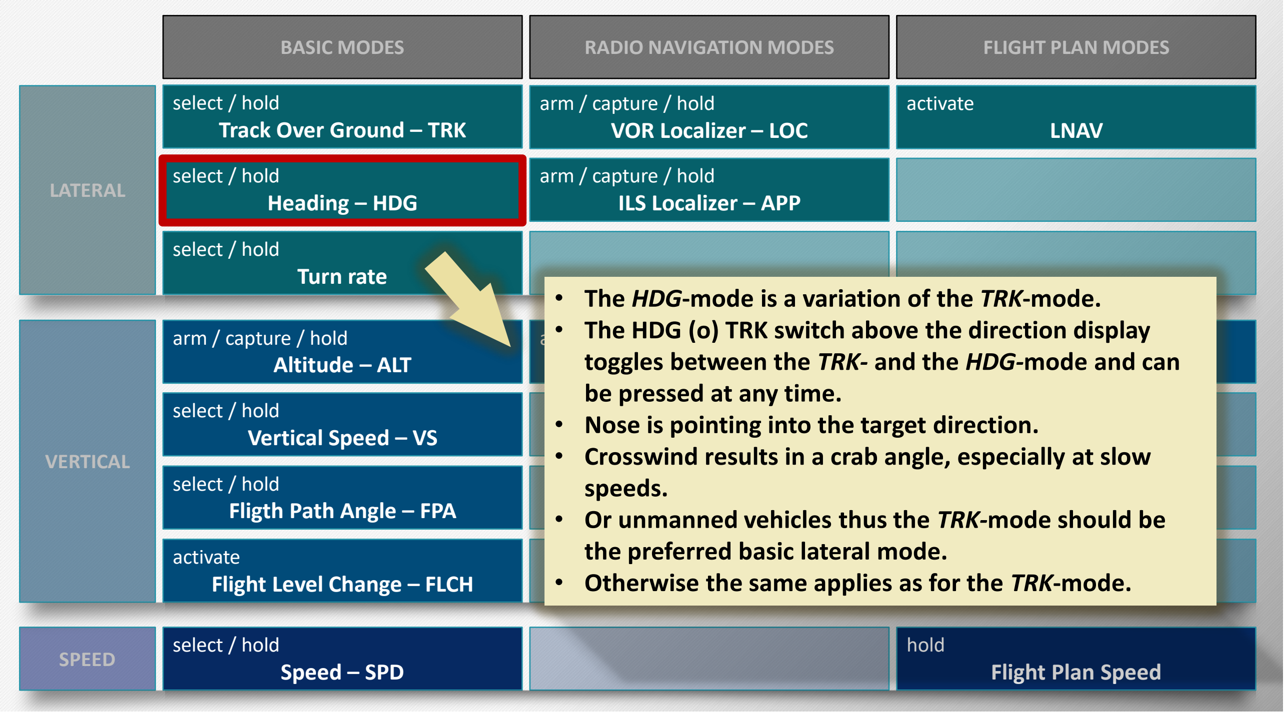
SPEED - SPD MODE



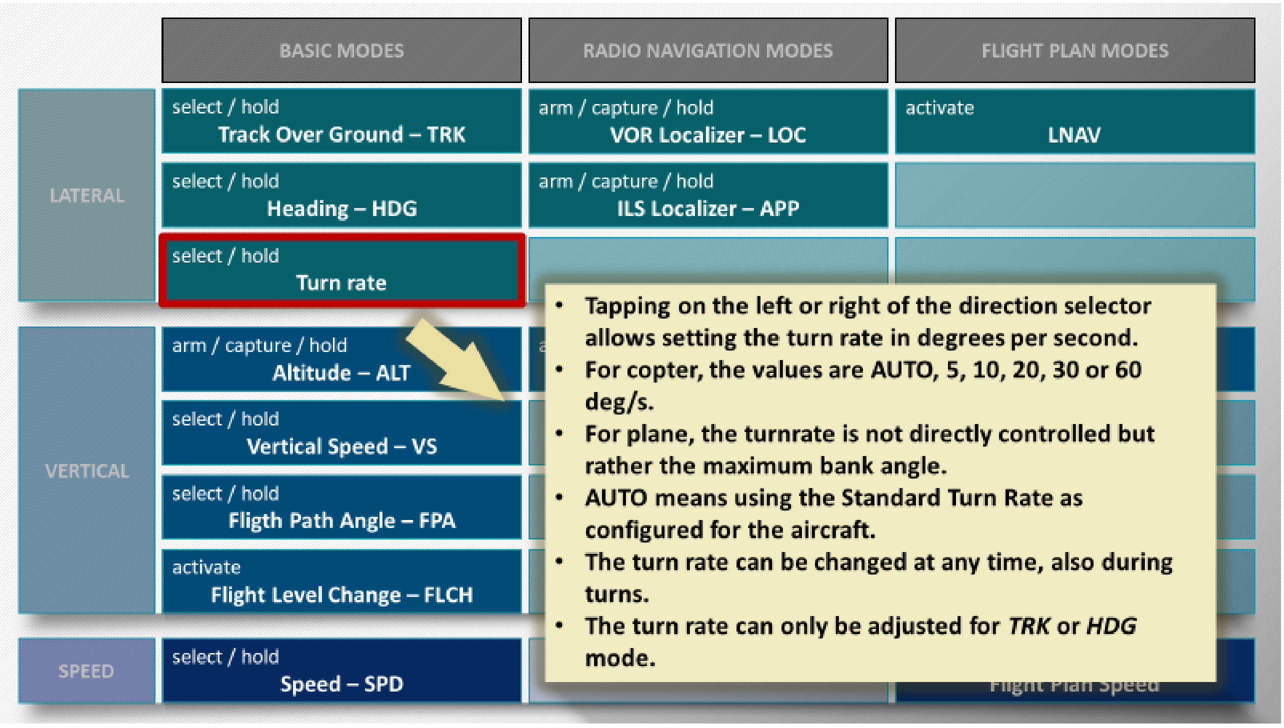
TRACK OVER GROUND - TRK MODE



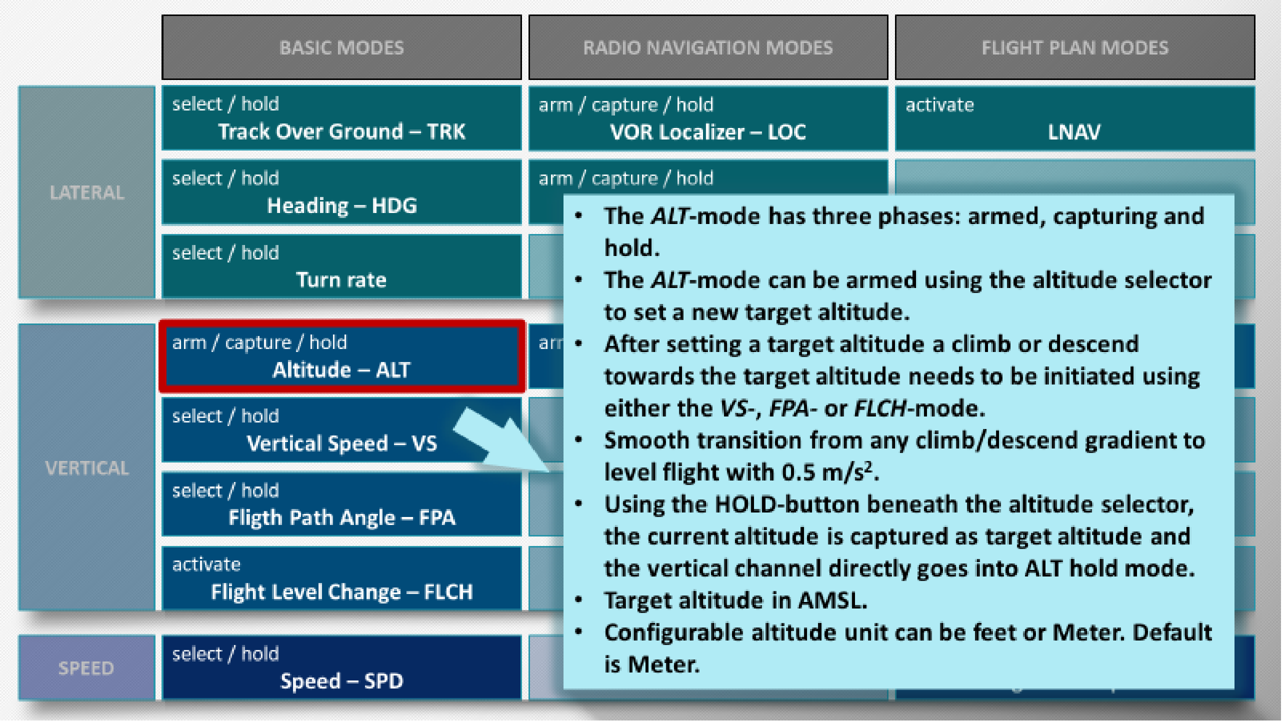
HEADING - HDG MODE



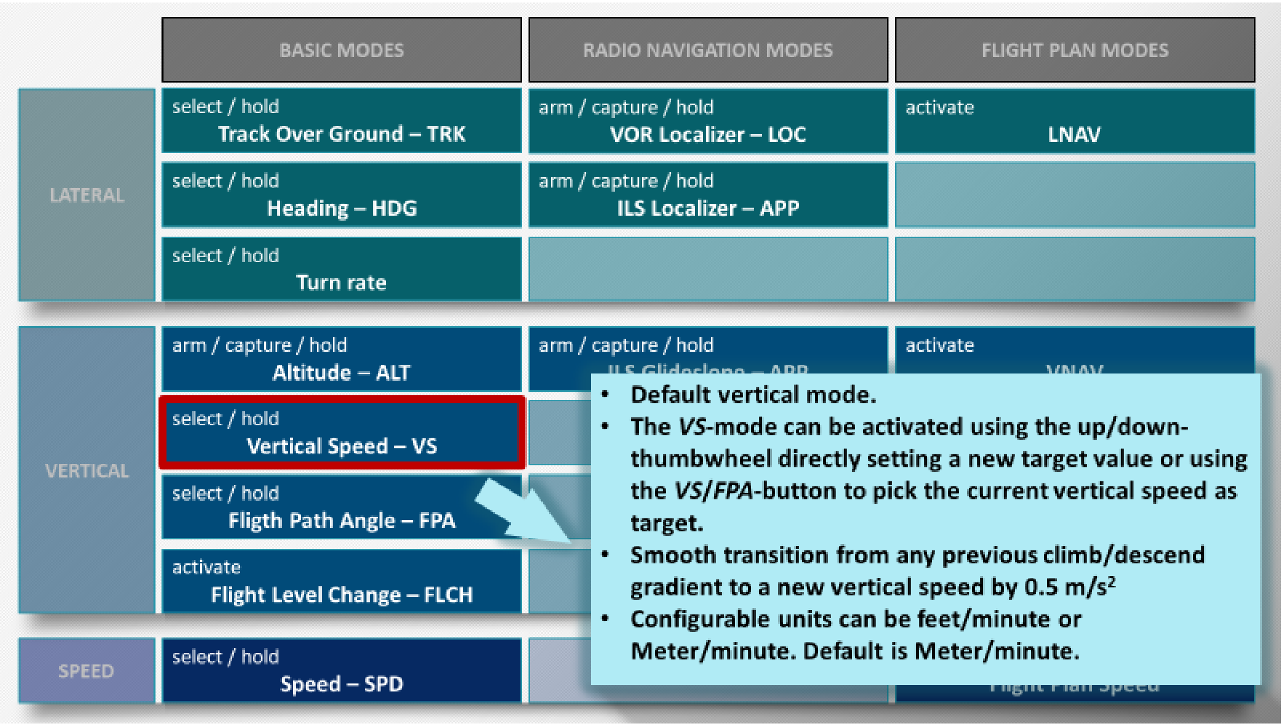
TURNRATE – MODE



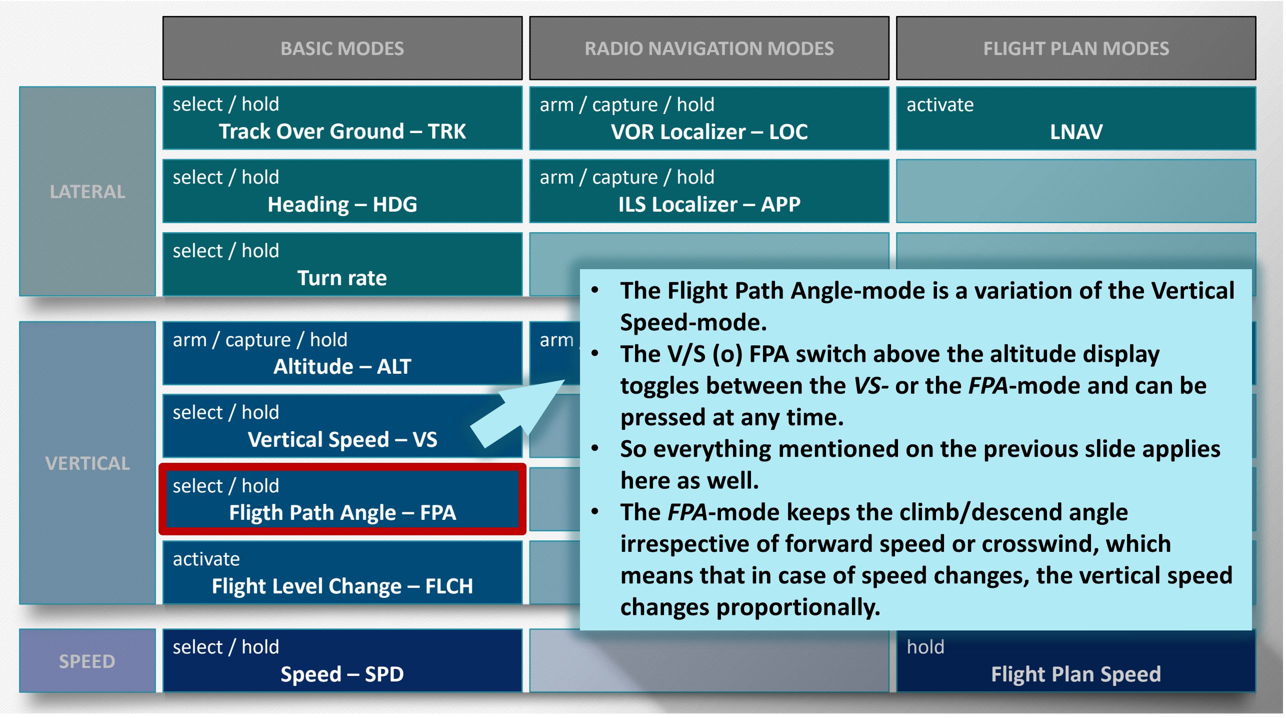
ALTITUDE - ALT MODE



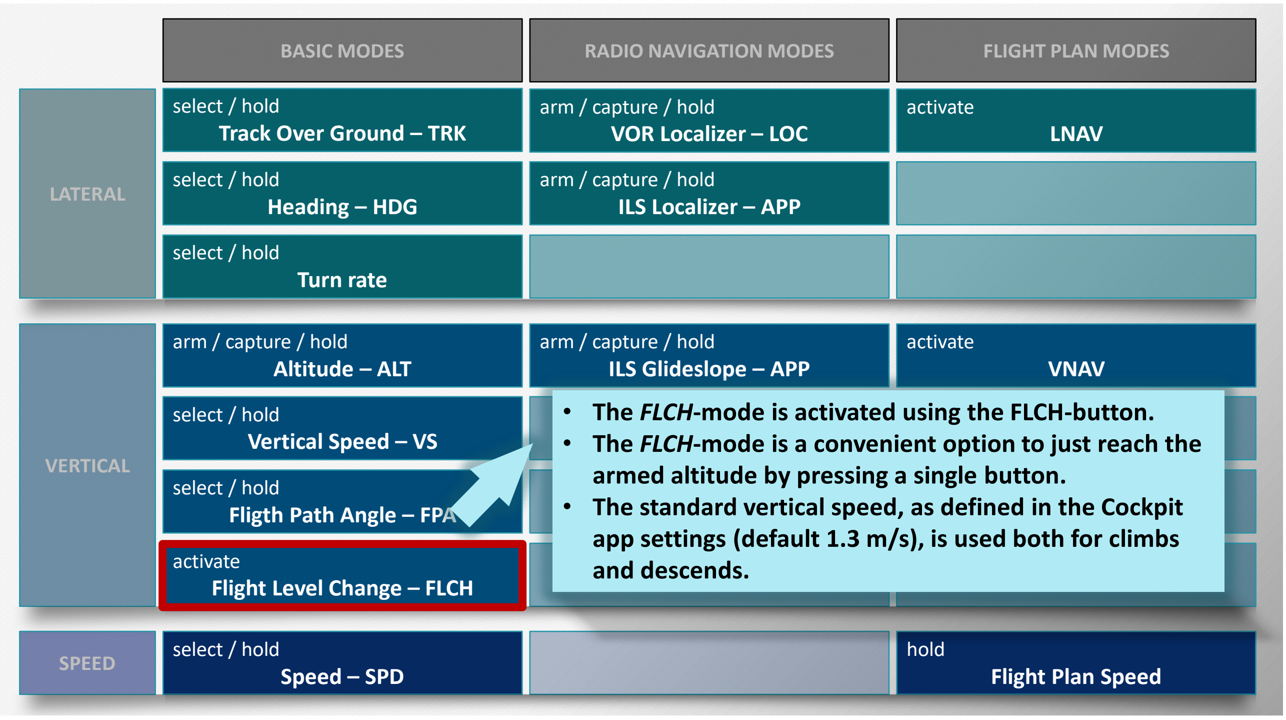
VERTICAL SPEED - VS MODE



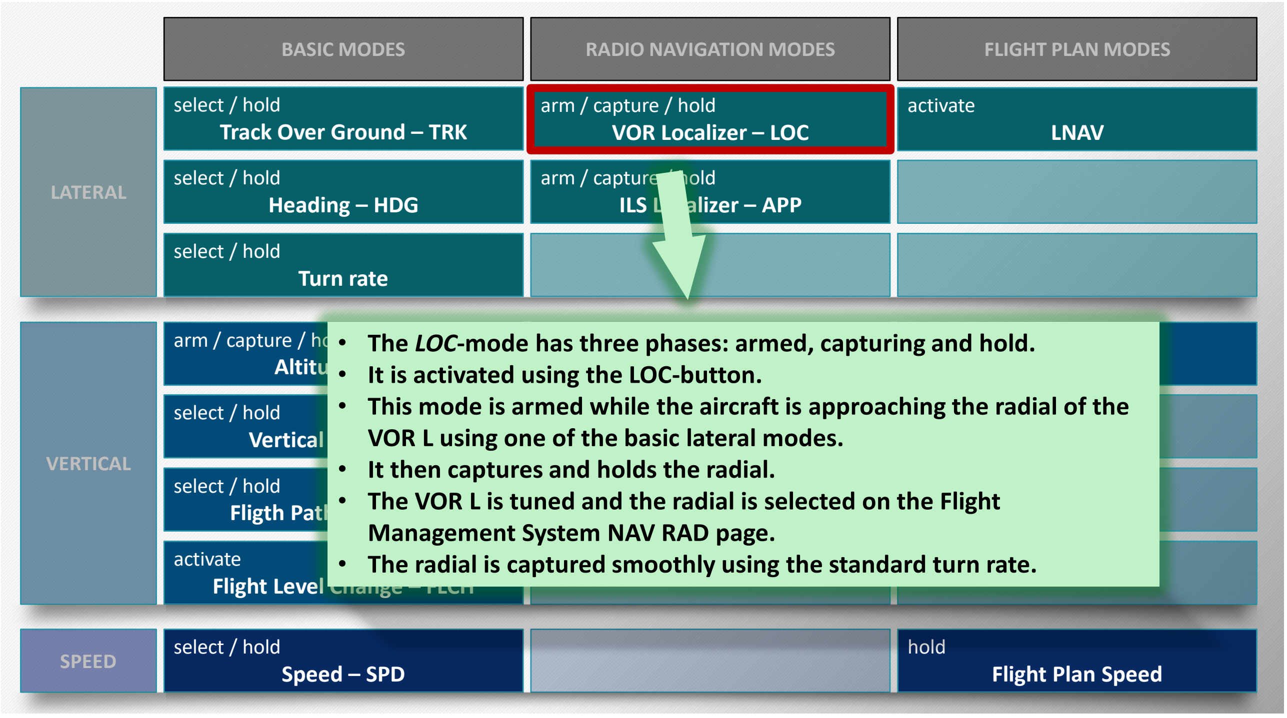
FLIGHT PATH ANGLE - FPA MODE



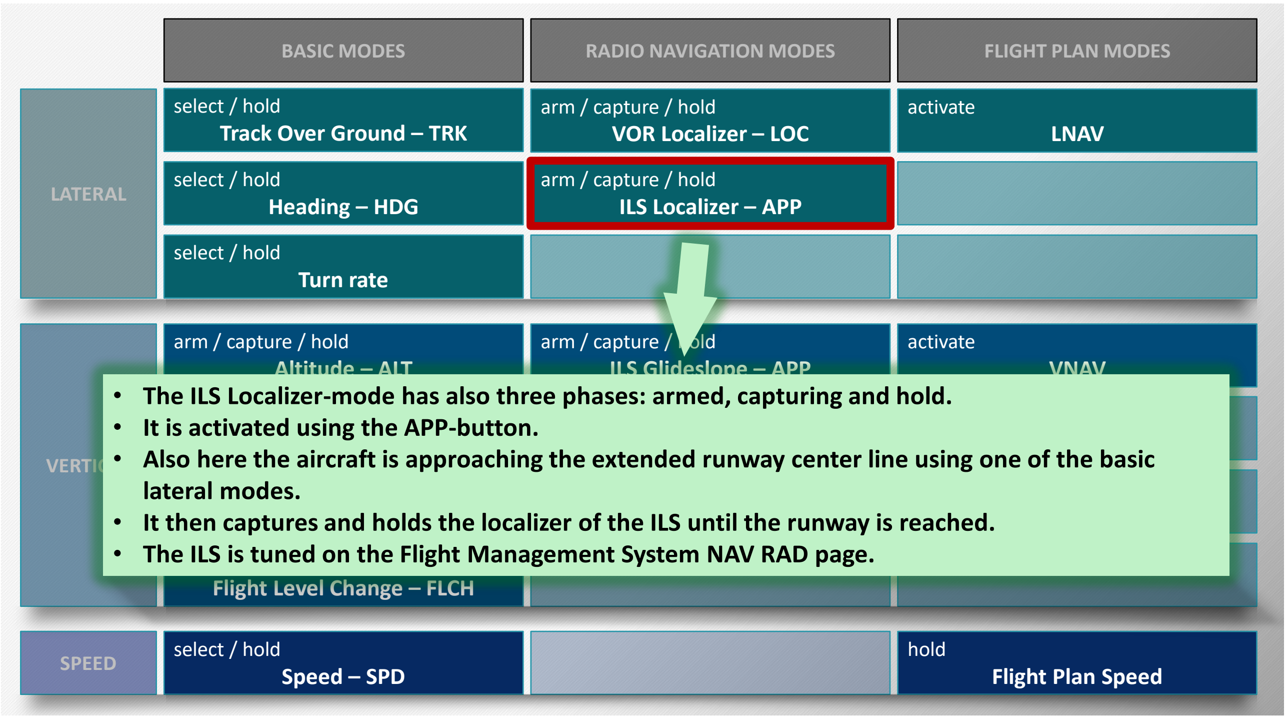
FLIGHT LEVEL CHANGE - FLCH MODE



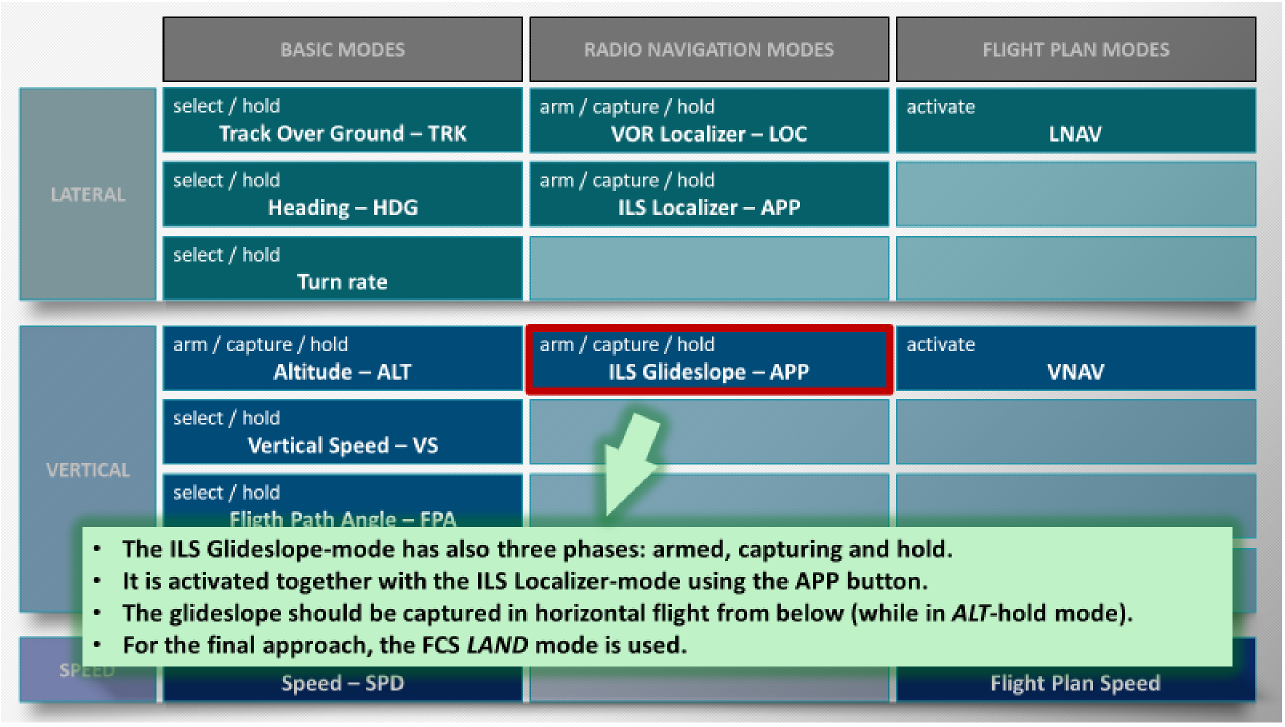
VOR LOCALIZER - LOC MODE



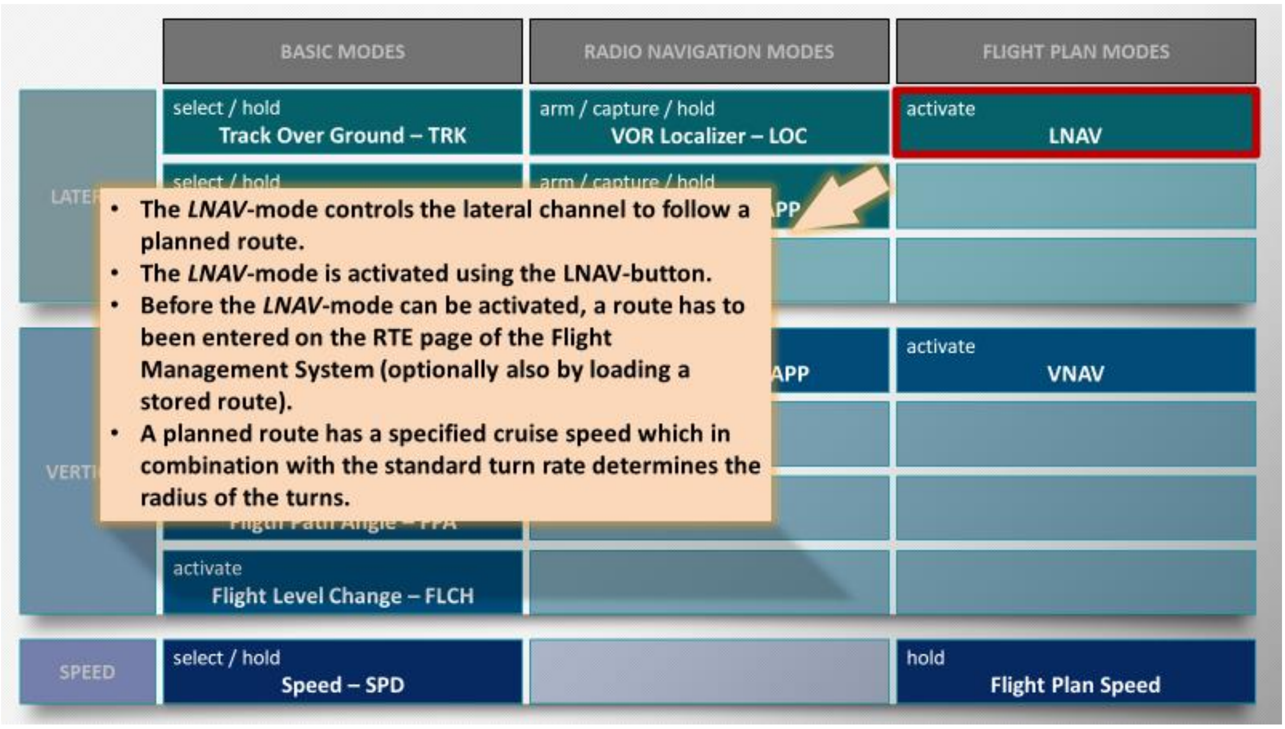
ILS LOCALIZER - APP MODE (LATERAL CHANNEL)



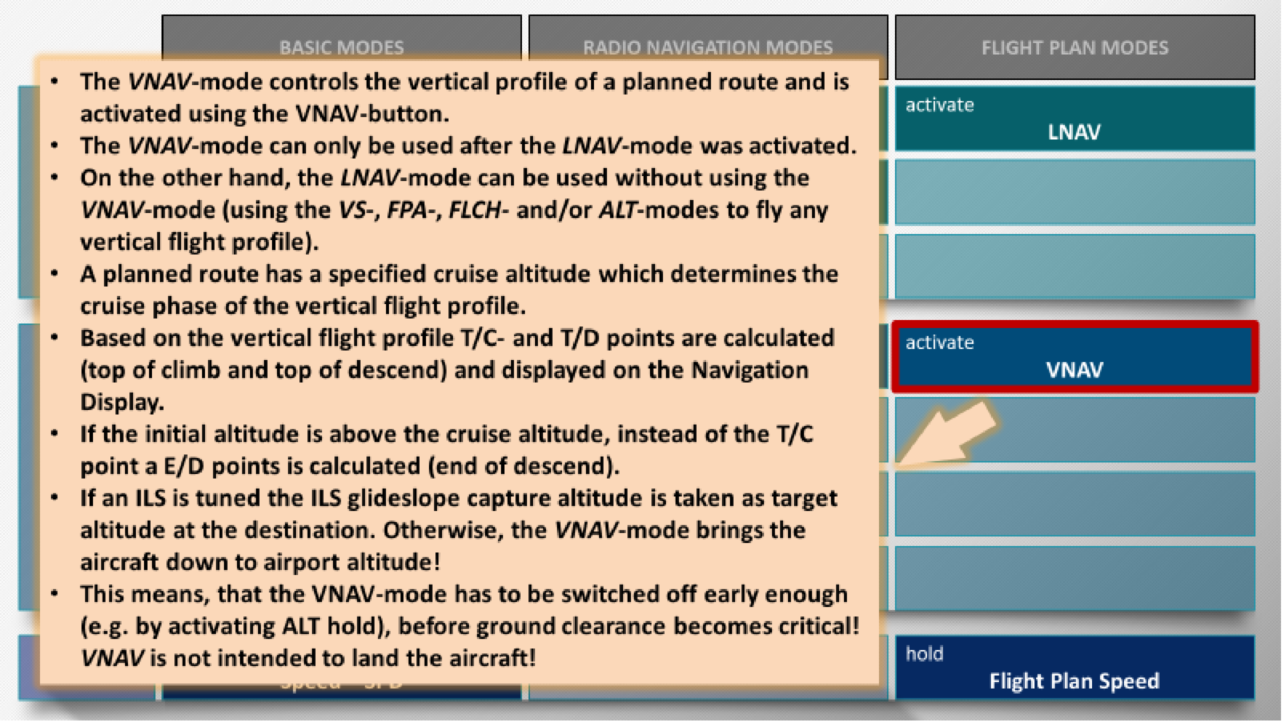
ILS GLIDESLOPE - APP MODE (VERTICAL CHANNEL)



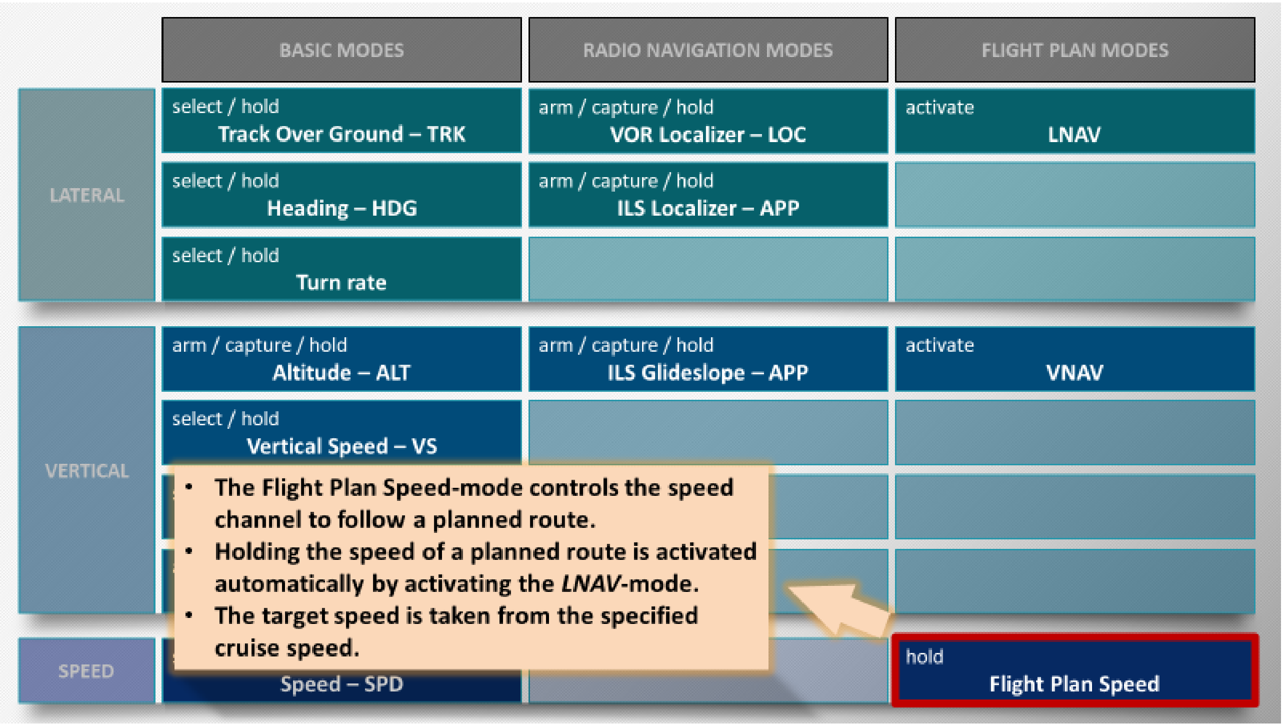
LATERAL NAVIGATION - LNAV MODE



VERTICAL NAVIGATION - VNAV MODE



FLIGHT PLAN SPEED MODE



7.3.5.3 AUTOPILOT BASIC FUNCTIONALITY

TYPES OF AUTOMATIC FLYING:

There are three autopilot modes types:

- The BASIC modes allow basic flight maneuvers in all dimensions.
- The RADIO NAVIGATION modes enable to capture and follow 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 require the selection of a target first, which needs to be approached using another mode of the same channel. Initially these modes are in 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. The mode, which was active before for the same channel is immediately deactivated.

AUTOPILOT CHANNELS:

The FlightZoomer autopilot modes all belong to one of the three processing channels LATERAL, VERTICAL and SPEED. These channels are processed largely independently, so you can e.g. follow a planned route laterally with the LNAV mode but fly any vertical profile using the four basic vertical modes ALT, VS, FPA or FLCH.

AUTOPILOT MODE COMPOSITIONS:

If the autopilot is engaged, one mode needs to be active for each channel. Additionally, for the two channels LATERAL and VERTICAL, a second mode can be in the armed state.

As a result, the two channels LATERAL and VERTICAL basically are composite channels which at any time can have one or two modes: At least one which is in the hold or activate state, and optionally a second one which is in the armed state. Some typical cases are explained int the tables below.

The notation is <active mode> + <armed mode>

These are some typical LATERAL composite combinations:

Possible combinations with both active and armed modes	
TRK + LOC	**Fly Track Over Ground and capture a VOR radial:**

	Using the TRK mode, the radial of an armed radio navigation aid (VOR) can be approached. The moment, it is reached, the LOC mode becomes active.
TRK + APP	**Fly Track Over Ground and capture the ILS:** Using the TRK mode, the localizer of an armed ILS approach can be approached. The moment, the current track intersects the localizer, the APP mode becomes active. Note: the lateral and the vertical channel of the APP mode also work independently: the localizer and the glideslope don't need to be captured in the same moment. Instead, each is captured as soon as it is reached.

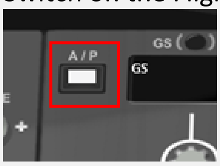
These are some typical VERTICAL composite combinations:

Possible combinations with both active and armed modes	
VS + ALT	**Fly in Vertical Speed mode and capture the armed altitude** While climbing or descending with the VS mode, an altitude can be armed, which will be captured the moment it is reached. The automatic transition to ALT after reaching the target altitude is not only possible coming from VS, but also coming from FPA or FLCH.
ALT + APP	**Fly in Altitude hold mode and capture the ILS glideslope** While flying in active ALT hold mode, the ILS can be armed, so the glideslope will be captured the moment it is intersected. The automatic transition to APP while capturing the glideslope is not only possible coming from ALT, but also coming from VS or FPA.

See in the following sections, how all this dry theory supports intuitive and easy flight operations!

7.3.5.4 ACTIVATING THE AUTOPILOT

There is no possibility to activate the autopilot before taking off.

Step	Action
1	Take off manually
2	Fly level and straight ahead. Make sure, that you have sufficient space ahead. Have the flight maneuvers already in mind, that you intend to fly after activating the autopilot.
3	Switch on the FlightZoomer autopilot by pressing the A/P button on the Mode Control Panel 
4	The FlightZoomer autopilot will activate the basic modes TRK, SPD and ALT. The current track over ground, speed and altitude will be taken as initial target values for these modes.

7.3.5.5 USING THE BASIC AUTOPILOT MODES (SPD, TRK, HDG, ALT, VS, FPA AND FLCH)

INITIATE A TURN TO A NEW TARGET DIRECTION USING THE TRK OR HDG MODE:

Step	Action	
1	Press and keep pressed the direction target value selector as marked on the screenshot. You need to continuously keep the finger on the touchscreen or the mouse button pressed for step 1, 2 and 3.	
2	The target directions open as a circle on the right side. Slide your finger over the touchscreen or move the mouse pointer (while keeping pressed the left mouse button) to the circle and either directly select one of the magenta quick target directions or start circling around the center to dial in any direction in between. The chevron pointer indicates the currently flown direction. The value in the display indicates the selected target direction.	
3	Lift your finger from the touchscreen or release the mouse button to lock in the new target direction. The aircraft will immediately start turning to the new target direction.	

Alternative input methods:

- Use the Surface Dial.
- Hold the mouse pointer over the target value selector and use the mouse wheel to select a new target direction.
- Use voice recognition to command a new target direction.

TOGGLE BETWEEN HDG OR TRK AS DIRECTIONAL MODE:

Step	Action
1	Press the HDG / TRK selector: 
2	Each time the HDG / TRK selector is pressed, the directional mode toggles between HDG and TRK (as indicated on the Direction display beneath).

Note: for small and slow aircraft like UAS, drones or RC aircraft, it is recommended to use the TRK mode. As the speed of the aircraft often is not much higher than the speed of the wind, the flown course will deviate strongly from the direction into which the nose is pointing. Using the TRK mode you will get the course over ground, that matches the target value.

CLIMB OR DESCEND TO A NEW TARGET ALTITUDE:

Step	Action	
1	Press and keep pressed the altitude target value selector as marked on the screenshot. You need to continuously keep the finger on the touchscreen or the mouse button pressed for step 1, 2 and 3.	
2	The target altitudes open as a circle on the right side. Slide your finger over the touchscreen or move the mouse pointer (while keeping pressed the left mouse button) to the circle and either directly select one of the magenta quick target altitudes or start circling around the center to dial in any altitude in between. The value in the display indicates the target altitude, which would be selected if the finger would be taken from the touchscreen or the mouse button would be released.	
3	Lift your finger from the touchscreen or release the mouse button to lock in the new target altitude. The new altitude is only armed now, so the vertical mode, which was active before starting the user interaction, will remain effective (until the target altitude is crossed).	
4	Initiate the climb or descend using either the VS, FPA or FLCH mode. Use one of the following procedures: a. Press the FLCH button to activate the FLCH mode. The aircraft will immediately initiate a climb or descend to reach and capture the new target altitude. b. To initiate climbs or descends using the VS or the FPA mode, see next paragraph	

Alternative input methods:

- Use the Surface Dial.
- Hold the mouse pointer over the target value selector and use the mouse wheel to select a new target altitude.
- Use voice recognition to command a new target altitude.

Note: the target altitudes are entered in the display unit for altitudes and distances, which can be Meter or feet (see section 7.3.1 how to change display units)

To initiate the actual climb or descend to the armed altitude requires using one of the following two possibilities:

1. Use the FLCH mode
   – or –
2. Use the VS or FPA mode

INITIATE A CLIMB OR DESCEND USING THE FLCH MODE:

The easiest method, to initiate a climb or descend to a new target altitude (which has been armed as described just above) is using the FLCH (flight level change) mode.

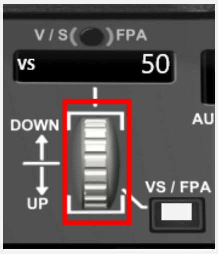
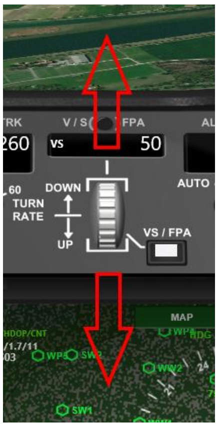
As prerequisite to activate the FLCH mode, a new target altitude must have been armed before.

Step	Action
1	Press the FLCH button: 
2	The aircraft will start climbing or descending towards the armed target altitude.

INITIATE A CLIMB OR DESCEND USING THE VS OR FPA MODE:

Typical cases, when the VS or FPA mode would be used:

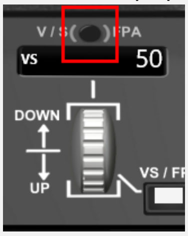
1. In order to start climbing/descending to a new target altitude, which has been armed before.
   – or –
2. The VS or FPA can also be used to climb or descend if no target altitude has been set. Be aware, that in this case the climb or descend would not be guarded and never stop (until the vehicle bumps into something hard!). It is required to press the ALT HOLD button to end unguarded climbs or descends (setting the target VS to 0 is not recommended but would have the same effect).

Step	Action	
1	Press and keep pressed the VS / FPA thumbwheel. You need to continuously keep the finger on the touchscreen or the mouse button pressed for step 1, 2 and 3. Note: the default unit is Meter/minute. Specifying the climb rate per minute is common in manned aviation.	
2	Slide your finger or move the mouse pointer (while keeping pressed the left mouse button) either upwards to set a negative climb rate or downwards to establish a positive climb rate. This emulates the turn direction of thumbwheel. The value in the display indicates the target value for vertical speed or flight path angle.	
3	Lift your finger from the touchscreen or release the mouse button to lock in the new target value.	

Alternative input methods:

- Use the Surface Dial.
- Hold the mouse pointer over the target value selector and use the mouse wheel to select a new target altitude.

TOGGLE BETWEEN VS OR FPA MODE:

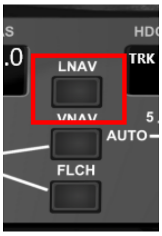
Step	Action
1	Press the V/S / FPA selector: 
2	Each time the V/S / FPA selector is pressed, the climb/descend mode toggles between VS and FPA (as indicated on the display beneath).

7.3.5.6 USING THE LNAV AND VNAV MODES

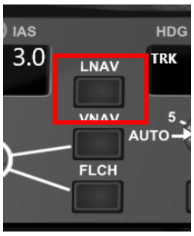
Prerequisite
Following the steps as described in the section about flight preparations, a flight route has been defined on the RTE page of the FMS.

The autopilot modes to execute the flightplan are LNAV and VNAV.

ACTIVATE THE LNAV MODE:

Step	Action
1	The aircraft is flying with activated autopilot.
2	Press the LNAV button: 
3	The aircraft will immediately start turning towards the first waypoint. At the same time, the cruise speed from the flightplan will be set as target speed.
4	 The LNAV mode can be terminated at any time by pressing the HDG / TRK HOLD button, which will activate the basic modes TRK, SPD and ALT. The current track over ground, speed and altitude will be taken as target values for these modes.

ACTIVATE THE VNAV MODE:

Step	Action
1	The aircraft is flying with activated autopilot and the LNAV mode has already been activated.
2	Press the VNAV button: 
3	The aircraft will immediately start climbing (or descending) in order to reach and capture the defined cruise altitude.

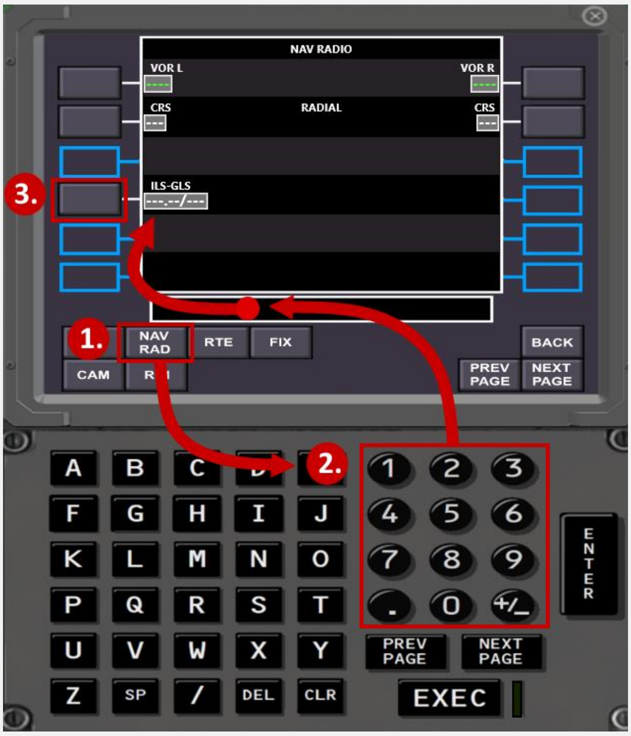
7.3.5.7 AUTOMATIC LANDINGS / ILS APPROACHES

LANDING PREPARATIONS

Prerequisite

The airport and the runway, which is going to be approached, has been added to the navigation database.

These steps are done either preflight or during the flight before entering the landing pattern.

Step	Action
1	Tune the ILS on the NAV RAD page of the FMS. Enter the frequency of the ILS as shown the following screenshot:  Hint: If you don't know the ILS frequency from memory, you can browse through the navigation database using the FIX page on the FMS.
2	After the ILS frequency has been tuned, the Navigation Display mode changes to APP display mode, which has the following elements:

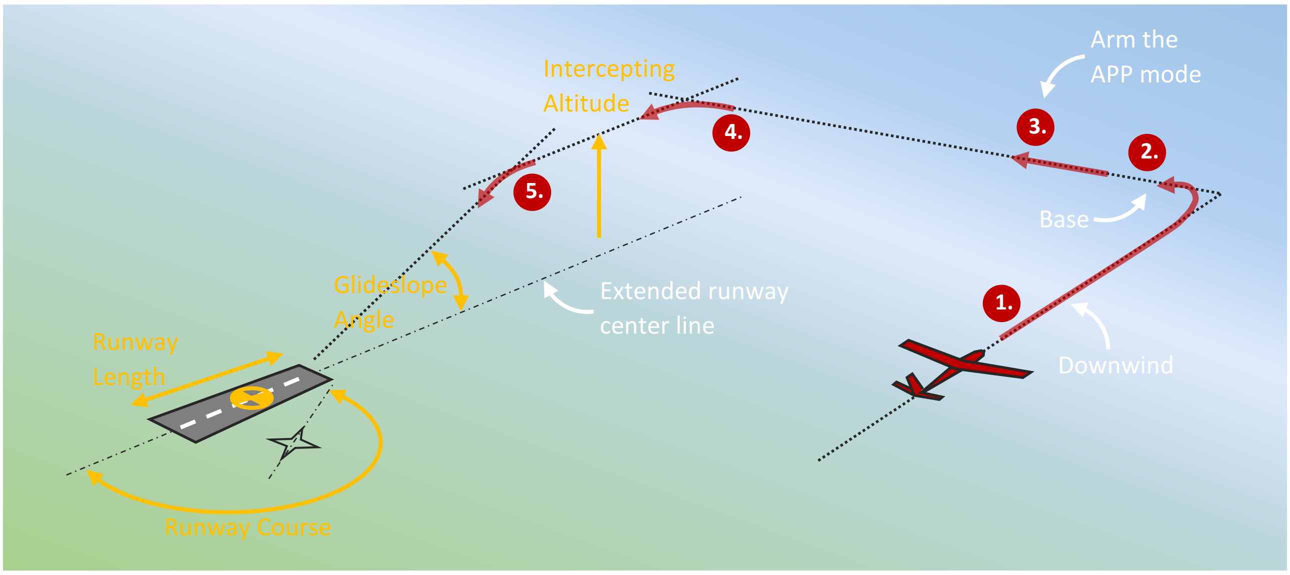
1. In this example, this runway is going to be approached. It has a course of 142°. The extended runway center line is reached after flying course 225° for a while.
2. The runway course pointer shows the direction of the runway.
3. The deviation indicator is a bar, that shows by deflection in both directions how far the aircraft currently is from the extended runway center line. In this example, as the aircraft would approach the extended runway center line on course 225°, this bar would slowly creep to the center and the moment, when the aircraft reaches the extended center line, the deviation bar and the runway course pointer would fall in one line.

Alternatively, the APP display mode can also be activated manually at any time using the APP Selector (not to be mistaken from the APP button on the autopilot Mode Control Panel!):

Other display modes are MAP (to show the planned flight route) or VOR (similar like APP but to follow VOR radials without controlling the vertical channel).

LANDING PROCEDURE

The following diagram shows the approach pattern and the automatic ILS approach as it is flown with both copter and plane. The parameter in yellow are defined in the navigation database:



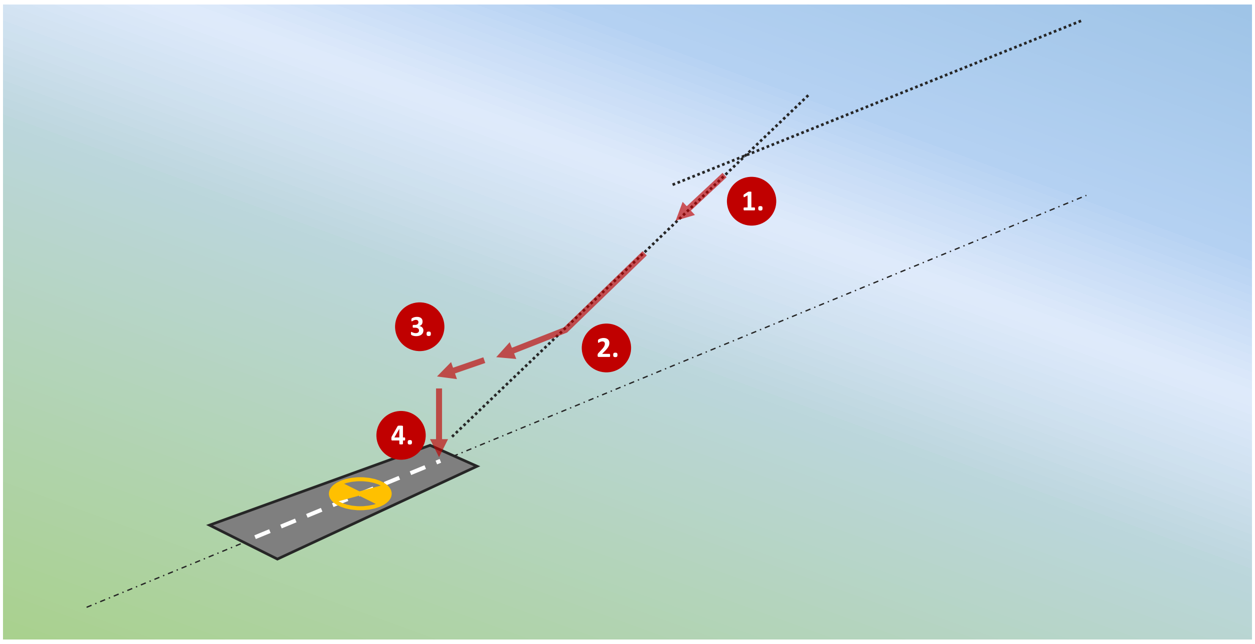
Step	Action
1	Use the autopilot and its BASIC modes (SPD, TRK, ALT, VS, FPA or FLCH) to fly the first part of the landing pattern. This means, that you first fly the downwind (1), at the end of the downwind turn into base (2) in order to fly a course, that intersects the extended runway center line.
3	Reduce SPD a bit coming from cruise. The SPD mode remains active until the Ardupilot LAND mode gets automatically activated.
4	While approaching the extended runway center line, arm the Approach-mode on the Mode Control Panel using the APP button (3):  Once the APP mode is armed, both the glideslope and the localizer will be captured and followed automatically whenever either of them is intersected. So, pressing the APP button, while the aircraft is on a suitable course to capture the ILS (and also has a suitable altitude), is the last manual action done by the pilot. From that point on the flight will continue fully automated and end with a full stop landing.
5	The autopilot is capable to capture the ILS localizer (4) coming from any inbound course (even if e.g. a 170° turn is required). Regardless of the intersecting course, the moment, when the turn to the runway needs to begin, is exactly calculated to end up on the runway center line once the turn is completed. Nevertheless, in order to fly a realistic and smooth ILS approach, aim to intersect the runway center line with an angle between 30° to 90° (in manned aviation 30° is common).
6	Ideally (and realistically) the aircraft is still flying level after the localizer has been captured and the glideslope is approached from below. As the APP mode is active, the aircraft will automatically capture the glideslope and begin the final descend as soon as the glideslope is intersected (5).

IMPLEMENTATION OF THE FINAL APPROACH

After step 6 in the procedure above has been completed, the fully automated final approach has started.

The implementation of the final approach differs between plane and copter.

Final approach with multicopters (ArduCopter):



❶ At first, Copters will stay in GUIDED mode and will descend on the glideslope towards the runway.
❷ The moment, when an altitude of 7m above ground will be reached, the descend will stop and the copter will continue in level flight until the begin of the runway is reached.
❸ At that point, forward speed will be cut to zero, and the FlightZoomer auto flight controller will put the copter automatically in LAND mode.
❹ The ArduCopter LAND mode will then simply perform a straight down descend.

ILS approaches for copter are explained in this YouTube video:
https://www.youtube.com/watch?v=LIytO4afRMw

Final approach with planes (ArduPlane):

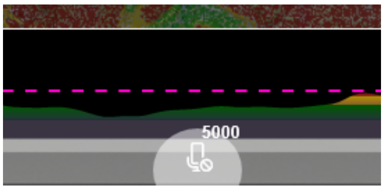
For plane, the FlightZoomer auto flight controller will put the aircraft in LAND mode right after the final approach has started (at point ❺ in the description above). All through the final approach, ArduPlane's LAND mode will be in charge of controlling the flight.

The precision, which can be expected therefore directly depends on the accuracy of ArduPlane's LAND mode. Consult the respective ArduPlane documentation, to get the best possible automatic landings.

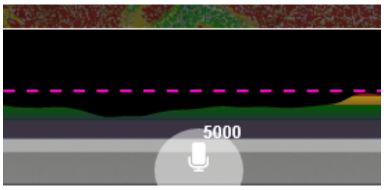
7.3.5.8 FLY WITH VOICE RECOGNITION

User interaction with the autopilot is not only possible using the screen elements or the Surface Dial. There is a third option, which is voice recognition.

The feature is activated by pressing the following button in the middle at the bottom:



After confirming the usage of microphone and camera the button becomes:



After that you can speak commands using the following grammar:

digit = "zero" | "one" | "two" | "three" | "four" | "five" | "six" | "seven" | "eight" | "nine";
activateAutopilot = ("activate autopilot" | "switch autpilot on");
deactivateAutopilot = ("deactivate autopilot" | "switch autpilot off");
turnRight = "turn right", digit, [digit], [digit];
turnLeft = "turn left", digit, [digit], [digit];
setSpeed = ["set"], "speed", ["to"], digit, [digit], [digit], [digit];
startDescend = "descend", ["to"], ["altitude"], digit, [digit], [digit], [digit], [digit];
startClimb = "climb", ["to"], ["altitude"], digit, [digit], [digit], [digit], [digit];
tuneILS = ("tune" | "set"), "I L S", ["receiver" | "frequency" | "to"], digit, digit, digit, "dot", digit, digit;
activateAPPmode = ("activate" | "arm"), ["the"], ("approach" | "I L S"), ["mode"];
readBackAccepted = ("affirmative" | "accepted" | "positive");
readBackRejected = "negative";
correction = "correction";

Meaning of the notation:

rule = chain of text portions (a portion can be another rule or a terminal string), portions are separated by commas
["some text"]: can be spoken or left away
("text a" | "text b"): one-of text portion
"text": terminal string

See how this works in this video:

7.3.6 USING CHECKLISTS

The FlightZoomer Cockpit app offers an interactive checklist, which closely recreates the integrated checklists of the Boeing 787. The following features are provided:

Where are checklists displayed?:

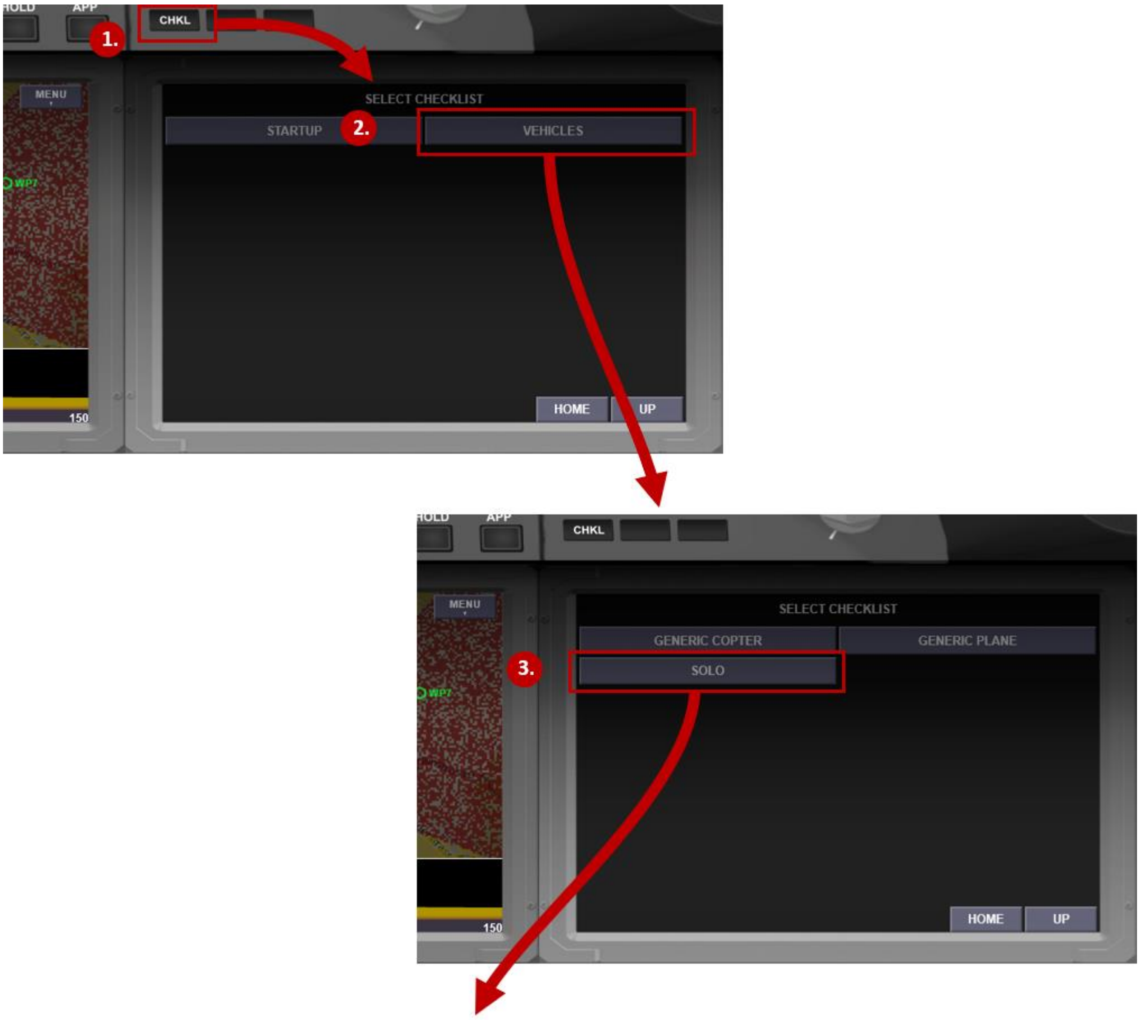
- Inside the cockpit, the checklists are displayed on the rightmost multifunction display (MFD).
- To change the display into the checklist mode, press the button CHKL.

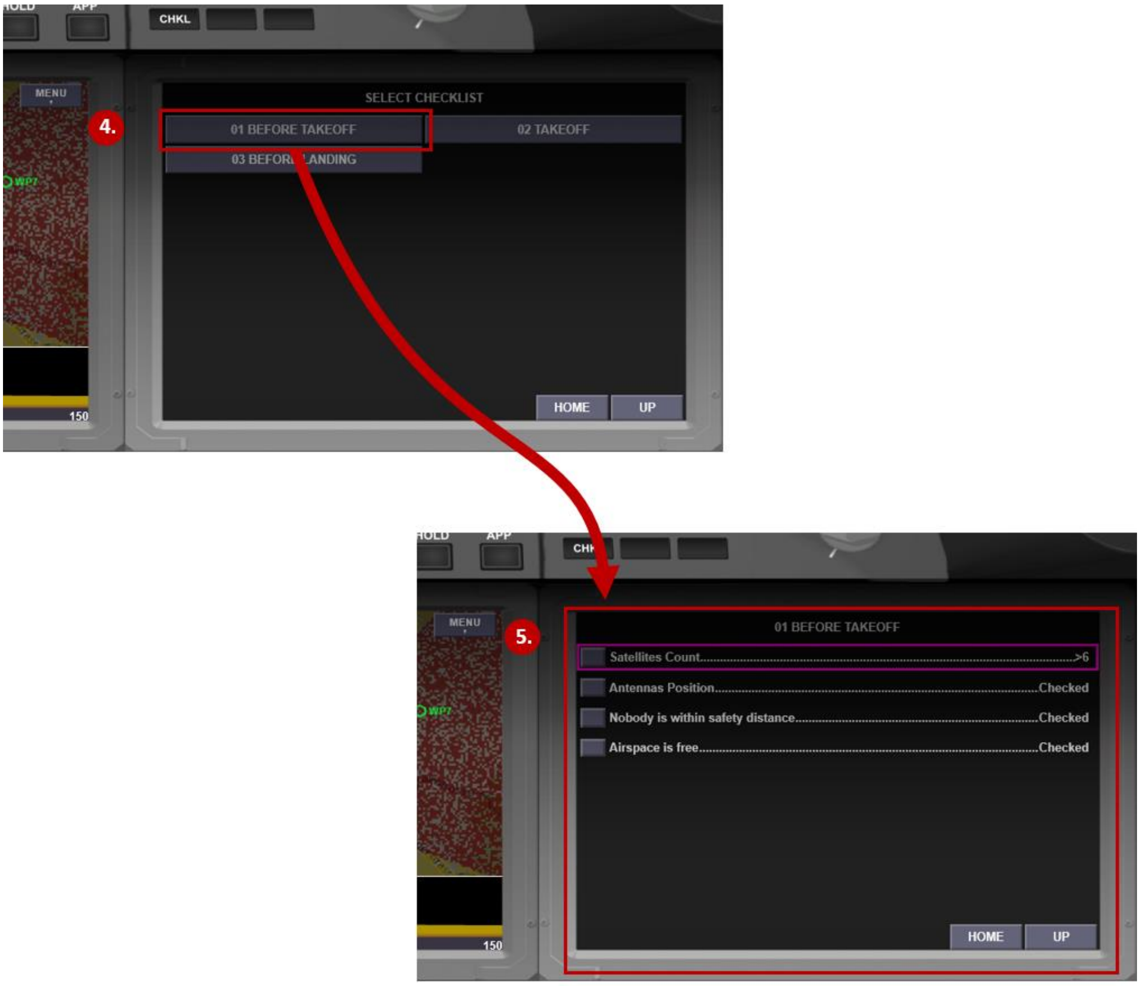
Checklists structure:

- Checklists are organized in a hierarchical structure, which allows to navigate easily through a large number of checklists for different cases, flight states, aircraft types or even hardware configurations.

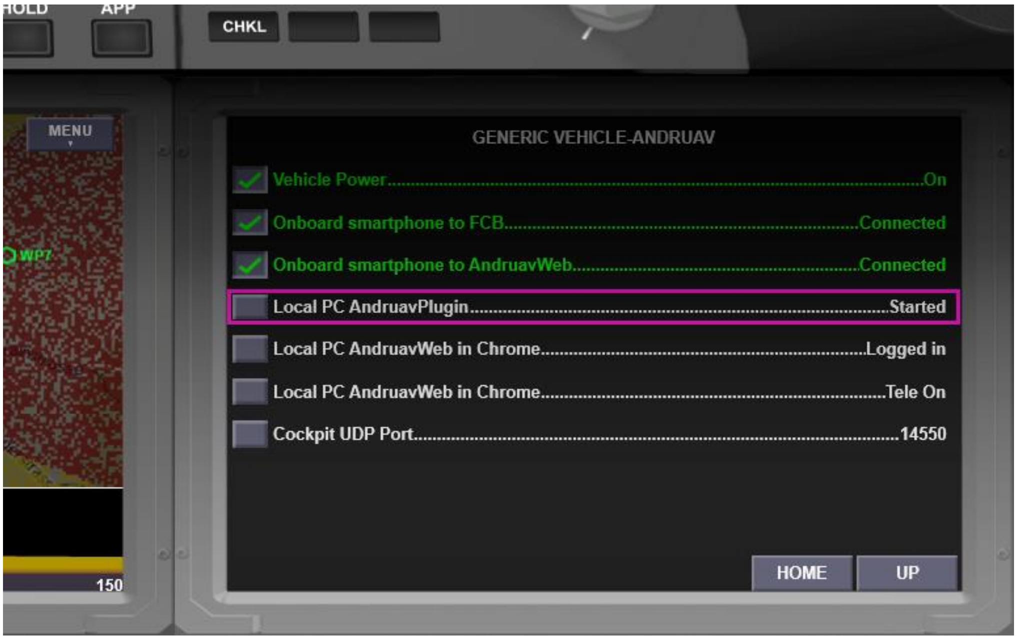
USING CHECKLISTS:

See in the following sequence (based on the stock checklists), how the checklist for the 3DR Solo take off preparations is selected:





- If the checklist is worked through manually, the various checklist positions can be ticked off by pressing the little square buttons at the beginning of each line. The following screenshot shows a checklist which is half worked through:



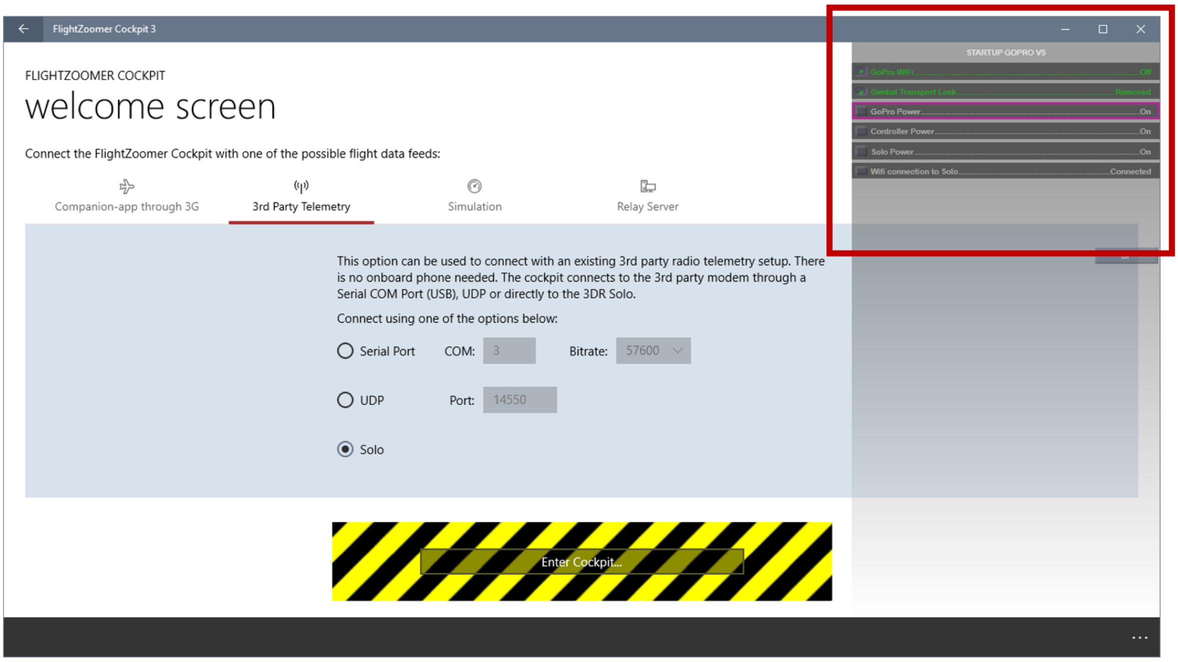
HAND-FREE VOICE INTERACTION:

- Alternatively, if voice recognition has been enabled with the microphone button at the bottom of the Navigation Display, checklists can be worked through interactively:
  - After opening a checklist, the virtual co-pilot starts reading through the checklist positions.
  - After the synthetic voice spoke the first line, the voice recognition expects the user to speak the confirmation term, as printed at the end of the line (in the example above, the user would say "started" to confirm the selected checklist position).
  - The voice recognition engine will recognize the spoken conformation by the user, automatically select the next line and repeat the sequence of speaking the checklist position and listening for the confirmation.
  - This way, you can go through the whole checklist without any manual interaction. Even working through checklists during the flight becomes an enjoyable experience!
  - After the last position is worked through, the synthetic voice confirms the whole checklist to be completed.

CHECKLIST ON WELCOME SCREEN:

- Besides the checklists inside the cockpit, special startup checklists are also shown on the welcome screen of the Cockpit-app. These can be used as guidance through the system startup process:

  Important note: on the welcome screen the voice recognition is not available, so the checklist items need to be ticked off manually!



STOCK SET OF CHECKLISTS:

- There is a set of stock checklists, which are installed together with the Cockpit-app.

- The physical location of checklists on the filesystem is under this path:
  <Windows downloads-folder>\FlightZoomerCockpit3\Checklists

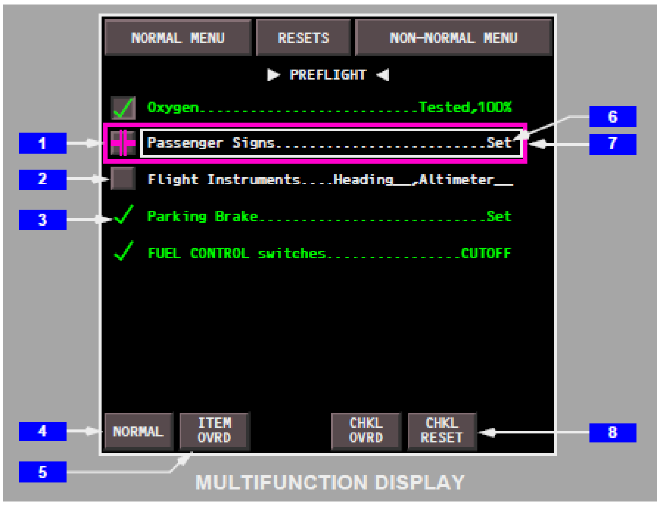
CUSTOMIZE CHECKLISTS:

- As checklists are text-files and the hierarchical structure is simply derived from folders, the content can be customized and modified by the user in any aspect: modify existing or create new checklists, add new vehicles or other topics, create dedicated checklists for different configurations, organize the checklists differently, always supporting the voice interaction feature… the list of possibilities is endless.
- To change the hierarchical structure, simply modify, create or move the folder structure under the mentioned folder. Do not change the structure under the Startup folder, as it is used to display the checklists on the welcome screen.
- To create or modify the content of checklists simply edit the text-files in the folders. The convention about the format of a checklist row is as follows:
  - Each checklist item is defined in a row.
  - Each row is split in four parts, which need to be separated by a semicolon (";").
  - The first part is the text, that is printed at the beginning of a line in the checklist
  - The second part is the confirmation text, that is printed at the end of a line in the checklist
  - The third part is the text, that is spoken by the synthetic co-pilot. The spoken text often would be the same as the printed text, though more verbose variations are thinkable. Also adding a hint about the expected confirmation might be useful. Besides that, sometimes the voice synthetization pronounces words wrongly, so in the third portion words might need to be "misspelled" for the voice engine to speak it correctly (e.g. gimbal needs to be written as ghimbal to prevent the voice synthesizer to say "jimbal "!)
  - The fourth part is the text, that is expected by voice recognition as spoken confirmation by the user.
  - See the listing of the Solo Startup GoPro V5-checklist as an example:

```
// Item text on display;target-value;spoken item;recognized voice acknowledgment
GoPro WiFi;Off;gopro wifi connection;off
Gimbal Transport Lock;Removed;ghimbal transport lock;removed
GoPro Power;On;gopro power state;on
Controller Power;On;controller power;on
Solo Power;On;solo power;on
Wifi connection to Solo;Connected;wifi connected;connected
```

CHECKLISTS IN THE BOEING 787 IN COMPARISON:

- To give you an impression, how closely the checklist feature is modeled after the real Boeing 787, the following extract from the (1500 pages long) Flight Crew Operation Manual shows the checklist, how it is used in manned aviation:


NORMAL MENU
RESETS
NON-NORMAL MENU
▶ PREFLIGHT ◀
Oxygen...........................Tested,100%
Passenger Signs..........................Set
Flight Instruments....Heading__,Altimeter__
Parking Brake............................Set
FUEL CONTROL switches................CUTOFF
NORMAL
ITEM OVRD
CHKL OVRD
CHKL RESET
1
2
3
4
5
6
7
8
MULTIFUNCTION DISPLAY

7.3.7 USING STAGED ROI'S AND ROI SEQUENCES

An ROI (region of interest) is a spot, to which the onboard camera keeps pointing while the aircraft is flying. ROI's are a feature of ArduPilot, which is using the Gimbal (and the vertical Axis of the vehicle in case of copters) to control the camera view direction in all axis (ArduPlane requires a three axis gimbal to accomplish the same).

7.3.7.1 CAPABILITIES

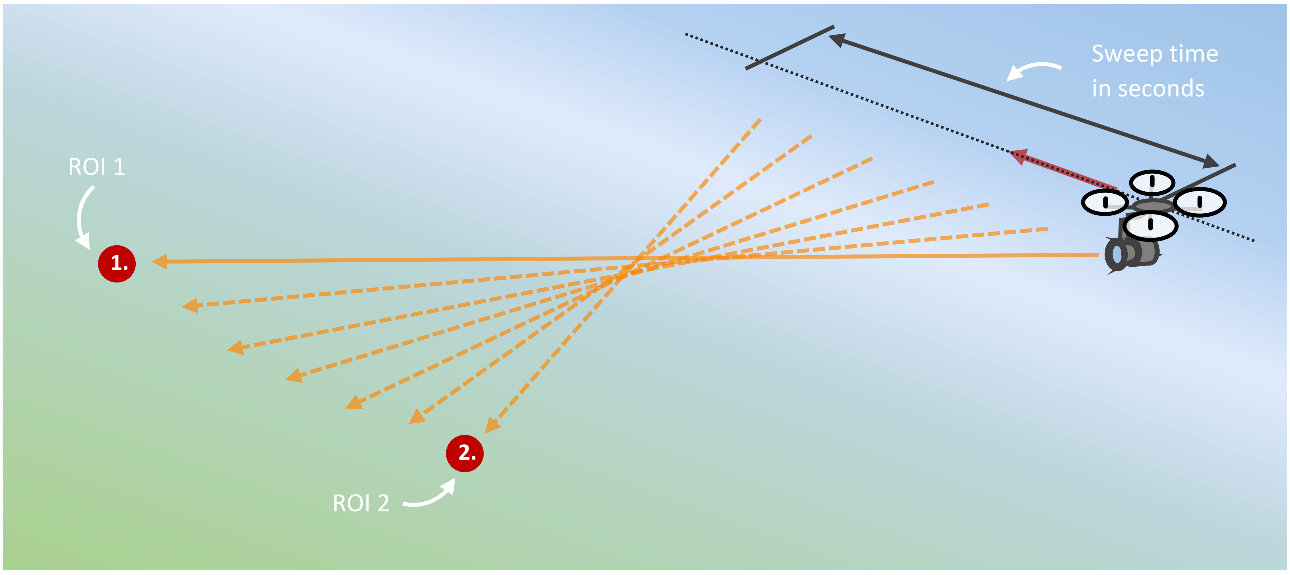
FlightZoomer expands the capabilities of ArduPilot ROI's as described below.

The following table summarizes the features:

	Feature	Needs to be purchased as in-app purchase
1	Smooth ROI-to-ROI sweeps	
2	Staged single ROI's	
3	ROI sequences	x

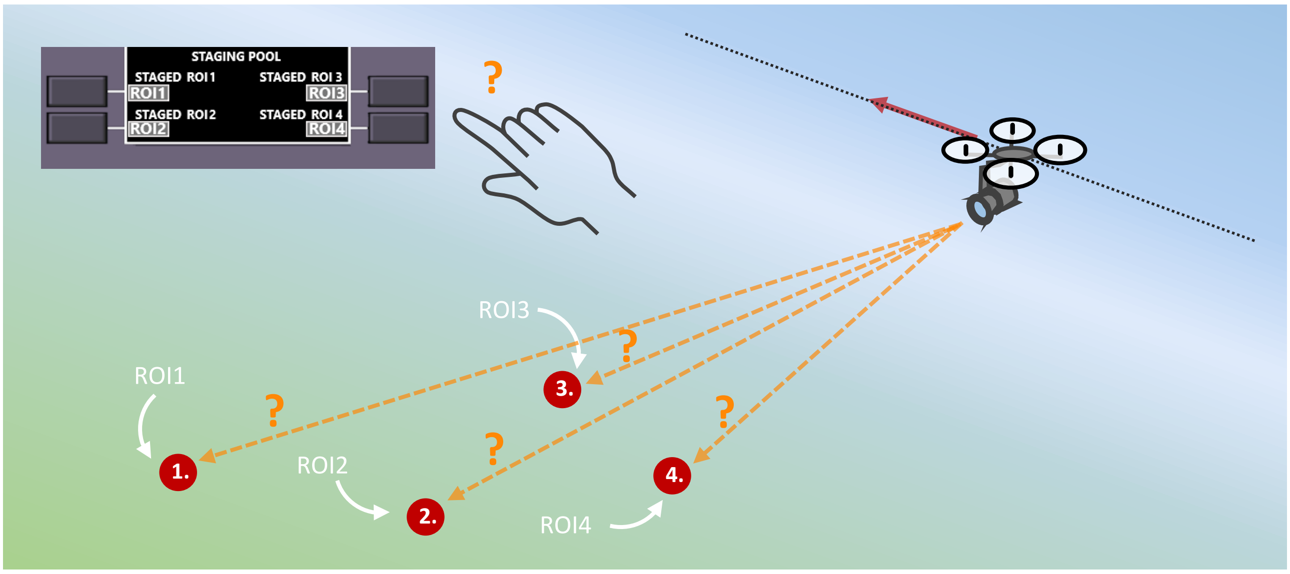
SMOOTH ROI-TO-ROI SWEEPS

For the transition from one ROI to another, FlightZoomer allows to define a sweep time in seconds. Whenever the ROI is changed, the camera gently pans from the previous to the new ROI for the duration, which is configured as the sweep time.



STAGED SINGLE ROI'S

FlightZoomer supports up to four ROI's as staged ROI's. This means, that they have been pre-defined and can be targeted by pressing a single button. By defining a sweep time, the transition from the previous ROI to the new one is performed as one smooth camera sweep. Staged ROI's can be selected at any time, even while the transition to the previous ROI is still going on.



ROI SEQUENCES

By defining a sequence of ROI's, the camera direction can be scripted to follow as complex paths, as the user wishes. The trigger to advance the camera to the next ROI can either be time based (time-based ROI sequences) or in synchronization with the waypoints of a flown route (waypoint-synchronized ROI sequences).

The later possibility allows both predetermined flight routes with synchronized camera movements. As the smooth camera sweeps are also standard for ROI sequences, arbitrarily complex video sequences become scriptable, plannable and repeatable.

The following visualization is taken from the video, that demonstrates ROI sequences:

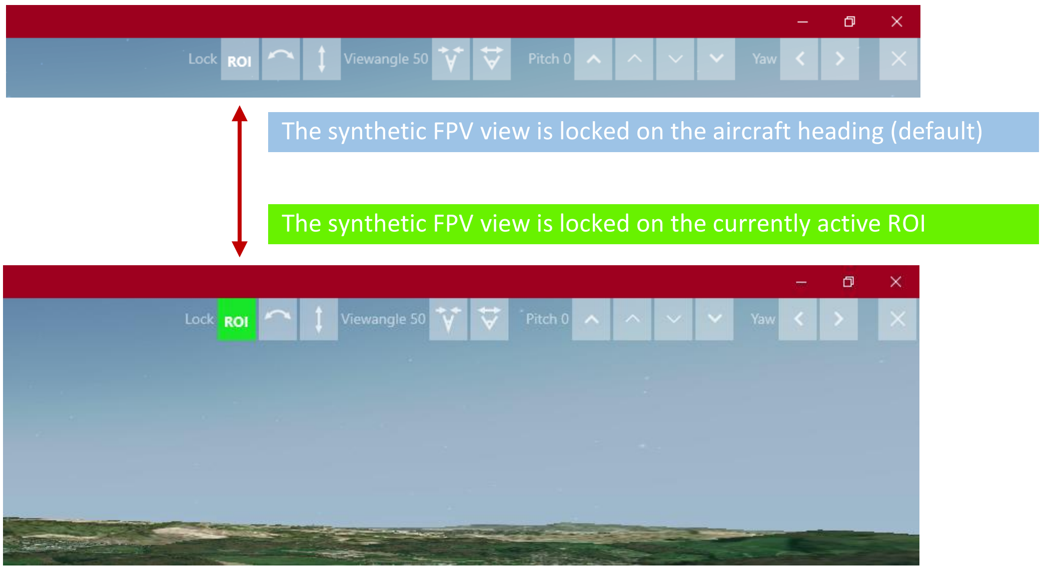
7.3.7.2 WORKING WITH ROI'S

All ROI related actions are done with the ROI page of the Flight Management System. The ROI page has minimally three subpages:

- On page 1, single ROI's can be activated from a pool of up to four staged ROI's.
- On page 2, the common properties of a ROI sequence can be configured.
- On page 3, the first six ROI's of the sequence can be defined.
- If the ROI the sequence has more than six ROI's, these can be continued on page 4 and following. There is no limitation in the total number of ROI's.

COMMON FEATURES

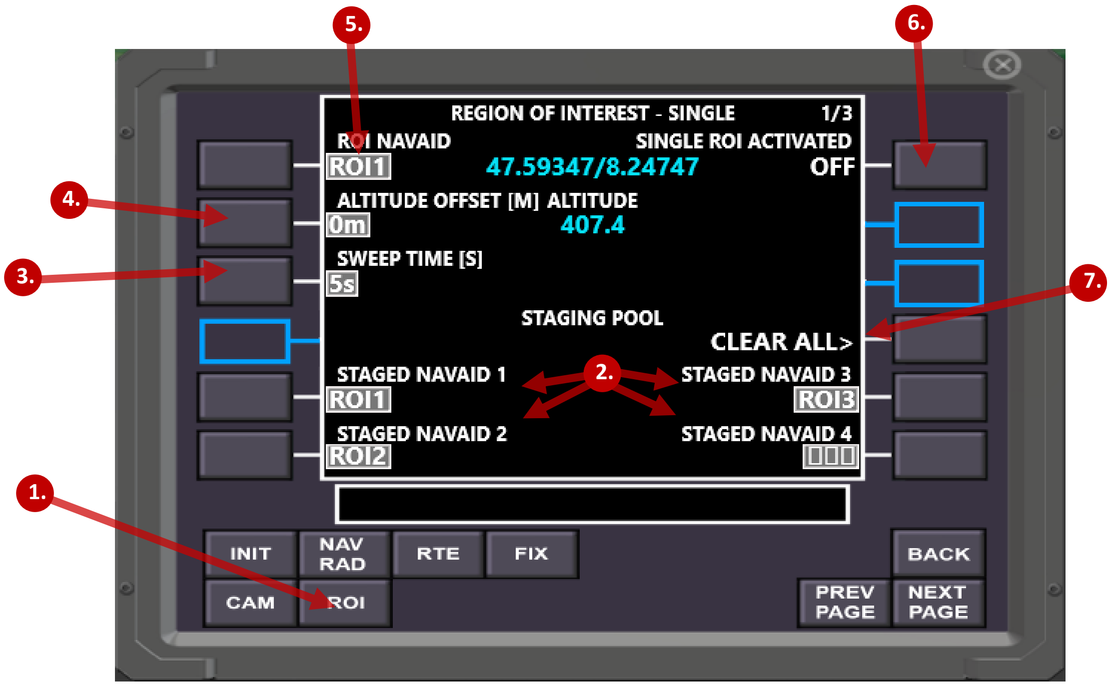
- **FPV view locked on ROI**
  The synthetic FPV view can be locked on the currently active ROI by the ROI button at the top:



- **What can be used as ROI's?**
  - Every FlightZoomer navigation aid can be used as ROI.
  - This means, that at first every ROI needs to be defined in the navigation database.
  - Selecting ROI's usually is done the same way, as waypoints are selected on the RTE page of the FMS.
- **Use the simulation mode to plan your ROI shots**
  Load the FlightZoomer cockpit in simulation mode, to try out all ROI related features.

7.3.7.3 SINGLE AND STAGED ROI'S

The elements to handle a single ROI are presented on the first page of the ROI FMS page:



	Element	Remarks
1	ROI Page Selection key	Used to open the ROI FMS page
2	Staging pool, staged ROI position 1 - 4	On these four positions, ROI's (= Navaids) can be loaded. A staged ROI can quickly be activated during the flight by pressing the respective LSK. Define a staged ROI by pressing the respective LSK, which either directly loads the ID of a navigation aid from the scratchpad or, if the scratchpad is empty, shows the list of all available Navaids, to pick the right one.
3	Sweep time [s]	Whenever a new ROI is activated, the transition from the current camera direction to the new ROI takes as long, as the sweep time is configured. Default is 5s.
4	Altitude offset [Meter]	The altitude offset is added to the elevation of the next activated ROI. This allows to bring variation in the vertical movement of the camera.
5	Currently active ROI	On the top left line, the currently active ROI is displayed. It is loaded by either pressing LSK L1 and directly load the ID of a navigation aid from the scratchpad or, if the scratchpad is empty, get the list of all available Navaids, to pick the right one. Alternatively (and preferably), one of the four LSKs of the staging pool can be used, to directly load one of the staged ROI's as the currently active ROI.
6	Master single ROI On/Off switch	Use LSK 1R to activate or deactivate ROI's. Once single ROI's are activated, the transition to the currently active ROI begins.
7	Clear all staged ROI's	Allows to easily clear all staged ROI's.

PROCEDURE TO WORK WITH SINGLE ROI'S:

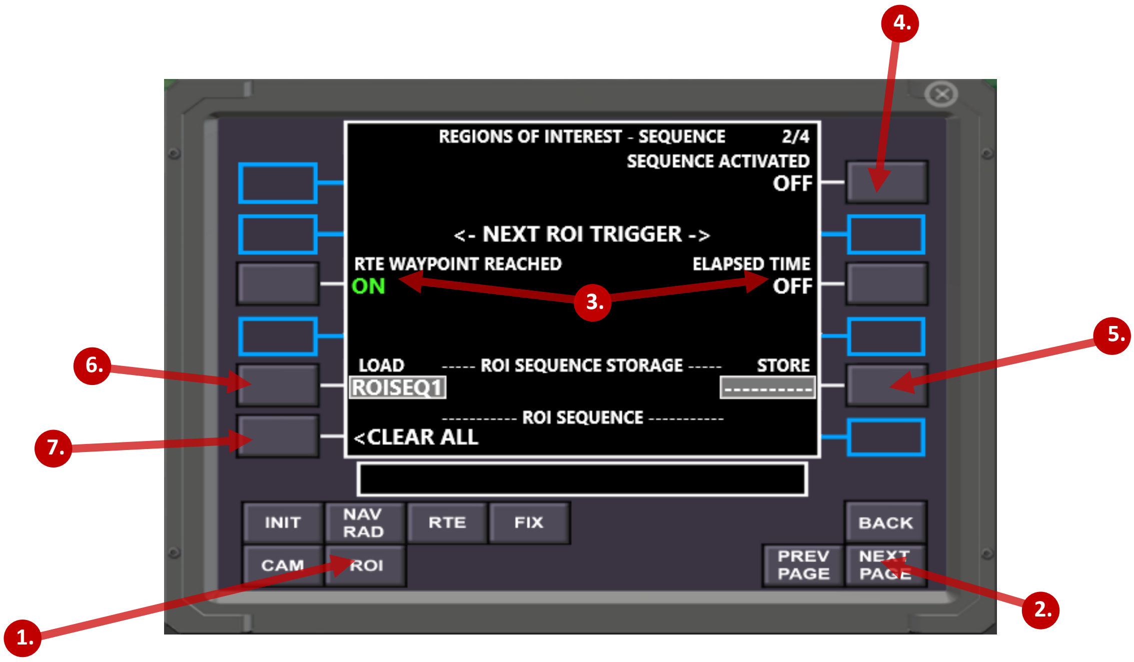
Prerequisite: the ROI's, which shall be used have been added to the navigation database as navigation aids.

Step	Action
1	Enter up to four staged ROI's. There are two possibilities, how you can do this: 1. Either enter the ID of the navigation aid in the scratchpad and press the respective LSK 2. Or press the LSK beside an empty staging position, as a result you get a list of all available navigation aids, so you can pick the right one.
2	Define the sweep time in seconds or leave it at 5 seconds. The sweep time can be changed at any time, even during the flight.
3	Load the currently active ROI either by selecting a navigation aid the usual way, or by pressing the LSK beside a staged ROI.
4	Optionally define the offset altitude in Meter, which shall be added to the ROI's elevation.
5	Press ROI at the top of the synthetic FPV view if you prefer see, how the camera is pointing to the ROI.
6	Activate single ROI's using the on/off master switch
7	While single ROI's are activated, several actions are possible: a. Change the currently active ROI by pressing the LSK beside one of the staged ROI's. b. This is even possible, while the last transition is still ongoing. c. The two parameters sweep time and altitude offset can be adjusted at any time. They become effective with the next ROI change. d. If only the altitude offset has been changed, LSK 2R becomes enabled (called **SEND>** update), which allows to start a transition to the new target altitude even without changing the current ROI.

7.3.7.4 ROI SEQUENCES

COMMON ROI SEQUENCE PROPERTIES

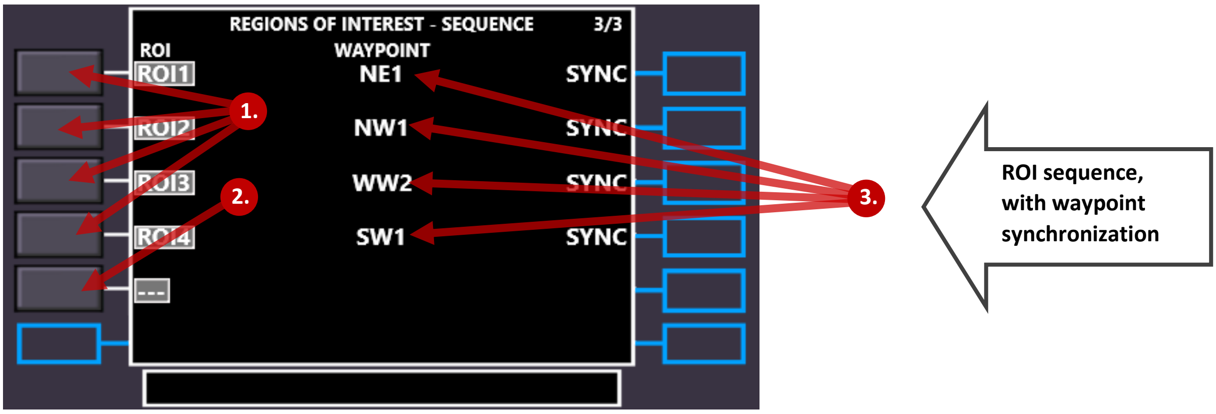
The common elements to handle a ROI sequence are presented on the second page of the ROI FMS page:

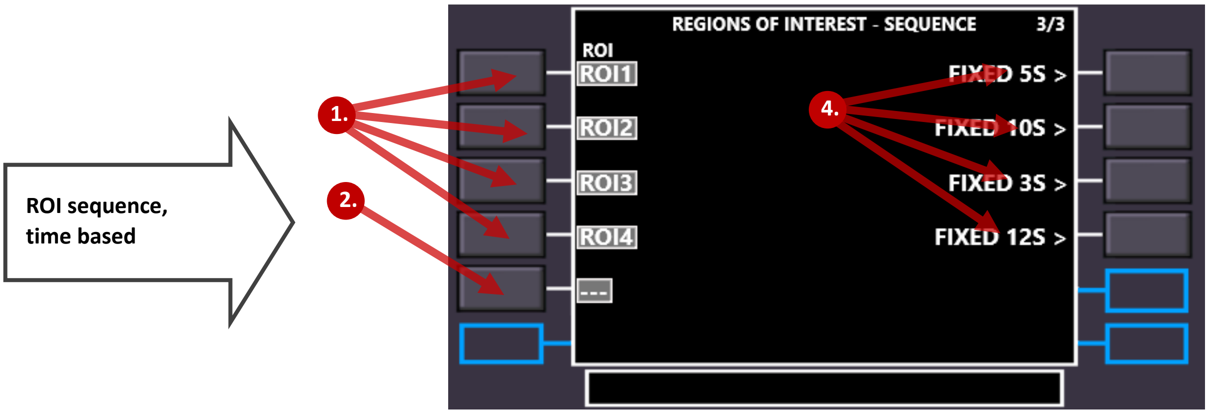


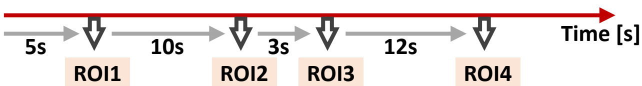
	Element	Remarks
1	ROI Page Selection key	Used to open the ROI FMS page
2	NEXT PAGE key	Press once to load the second page to manipulate Roi sequences. This key is also used to load the third and following subpages to define the actual ROI's of the sequence.
3	NEXT ROI TRIGGER selection	Trigger type to begin the transition to the next ROI: • Pressing LSK 3L activates triggering based on passed waypoints of a flightplan. • Pressing LSK 3R activates time-based triggering (for each ROI can be specified, how long the sweep to the next ROI will take).
4	Master ROI sequence On/Off switch	Use LSK 1R to activate or deactivate the defined ROI sequence. If the ROI sequence is time based, the execution will immediately start. If the ROI sequence is synchronized with the planned route, the execution will immediately start if the autopilot is already in LNAV mode or wait in an armed state until the autopilot mode is changed to LNAV.
5	STORE current ROI sequence	All settings of the current ROI sequence can be stored under a given name in the scratchpad by pressing LSK 5R.
6	LOAD stored ROI sequences	By providing the right name in the scratchpad and pressing LSK 5L, all settings for a ROI sequence can be loaded from an earlier stored one. Alternatively, if line 5L is empty, pressing LSK 5L opens a list of all stored ROI sequences, so you can pick the one you want.
7	CLEAR ALL	Reset all settings of the ROI sequence to their default values.

SEQUENCE OF ROI'S

The actual sequence of ROI's is defined on the third (and following) page(s) of the ROI FMS page:





	Element	Remarks
1	Sequence of ROI's	In this example a ROI sequence consisting of four ROI's has been defined.
2	Empty position to define the next ROI in the sequence	At the fifth position, the next ROI can be appended to the sequence in this example. To do this press the respective LSK, which either directly loads the ID of a navigation aid from the scratchpad or, if the scratchpad is empty, shows the list of all available navigation aids, which allows you to pick the right one.
3	Related waypoints per ROI	If the ROI sequence is synchronized with the waypoints of the current flightplan, the related waypoint IDs are printed in the center column per ROI. In this example, the camera sweep towards ROI1 will end exactly when the aircraft reaches waypoint NE1. At this point immediately a sweep to ROI2 begins, which will take exactly as long, as it will take the aircraft to reach waypoint NW1.
4	Time to next ROI	For time-based ROI sequences, each ROI is not tied to a waypoint, but freely put on the time axis by fixed sweep times (per ROI). The ROI sequence of the given example would be executed as shown in following diagram:  Define the sweep time per ROI with LSK R1-6.

PROCEDURE TO WORK WITH ROI SEQUENCES:

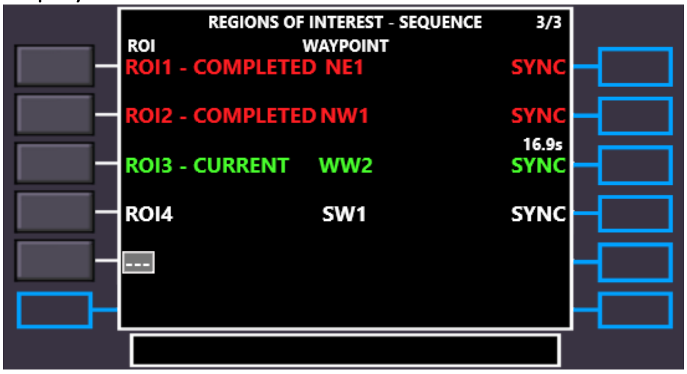
Prerequisite: the ROI's, which shall be used for the ROI sequence must have been added to the navigation database as navigation aids.

As the procedures differ quite a bit, the steps for waypoint-synchronized and time-based ROI sequences are separately described.

Steps for waypoint-synchronized ROI sequences

Step	Action	Flight preparation	Optional
1	On the RTE page of the FMS: define the flightplan (route) to be flown. Define as many waypoints as you like. The number of waypoints does not need to match the number of ROI's of the ROI sequence, which is going to be defined later.	X	
2	Change to the ROI pages of the FMS.	X	
3	Define the ROI sequence. This can be accomplished in two ways:	X	
3.a.	**Option 1: Load a ROI sequence** • If the ROI sequence has been stored earlier, simply provide the name in the scratchpad and press LSK L5 (LOAD)	X	
3.b	**Option 2: Create a ROI Sequence** • On the second subpage of the ROI FMS page, select the trigger type for waypoint-synchronization by pressing LSK L3 (RTE WAYPOINT REACHED). • Start entering the ROI's of the ROI sequence on page 3 of the ROI FMS page. Do this by pressing the respective LSK L1-6, which either directly loads the ID of a navigation aid from the scratchpad or, if the scratchpad is empty, shows the list of all available navigation aids, which allows you to pick the right one. Always after six ROI's continue on the next page (4, 5, and so on).	X	
4	If you wish, you can return to page 2 of the ROI FMS page, provide a name in the scratchpad and press LSK R5 to store the ROI sequence for future usage.	X	X
5	Take off, activate the autopilot and as suitable the LNAV mode (VNAV is optional for ROI sequences)		
6	If wished, lock the synthetic FPV view on the currently active ROI using the ROI button at the upper window boundary.		X
7	On the second ROI FMS page activate ROI sequences by pressing LSK 1R (the ROI sequence master On/Off switch). Note: the actual relations between ROI's and waypoints are dynamic and depend on the moment, when the ROI sequence is activated. The number of already passed waypoints does not matter. At the time of activation, the first ROI will simply fall together with the next waypoint, which is going to be reached. Only if the ROI sequence is activated before the first waypoint is reached (- or – before		

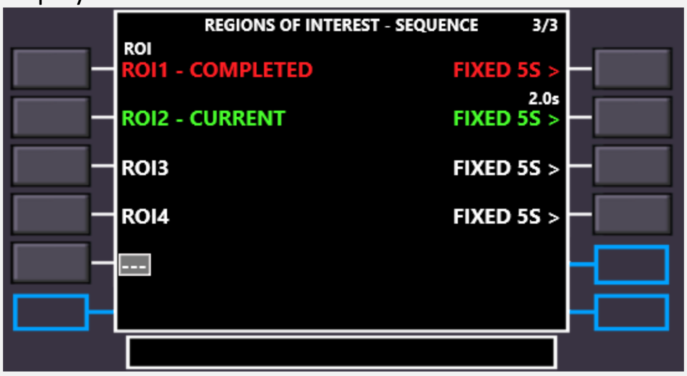
	the LNAV mode has been activated), the indexes of waypoints and ROI's will match.		
8	While the ROI sequence is executed, the progress is displayed on the FMS as follows:		



	Already passed ROI's are shown in red, the one which is targeted by the current sweep in green and the remaining duration of the sweep in seconds above the green SYNC.		
9	The ROI sequence ends in one of three ways: a. Either the last ROI of the defined sequence has been reached. b. Or the pilot deactivates the ROI sequence with LSK R1 on the second ROI FMS subpage. c. Or the pilot deactivates the LNAV mode of the autopilot.		

Steps for time-based ROI sequences

Step	Action	Flight preparation	Optional
1	Change to the ROI pages of the FMS.	X	
2	Define the time-based ROI sequence. This can be accomplished in two ways:	X	
3.a.	**Option 1: Load a ROI sequence** • If the ROI sequence has been stored earlier, simply provide the name in the scratchpad and press LSK L5 (LOAD)	X	
3.b	**Option 2: Create a ROI Sequence** • On the second subpage of the ROI FMS page, select the trigger type for waypoint-synchronization by pressing LSK R3 (ELAPSED TIME). • Start entering the ROI's of the ROI sequence on page 3 of the ROI FMS page. Do this by pressing the respective LSK L1-6, which either directly loads the ID of a navigation aid from the scratchpad or, if the scratchpad is empty, shows the list of all available navigation aids, which allows you to pick the right one. Always after six ROI's continue on the next page (4, 5, and so on).	X	

	• For each time-based ROI, define the sweep time by putting the value in seconds into the scratchpad and pressing LSK R1-6.		
4	If you wish, you can return to page 2 of the ROI FMS page, provide a name in the scratchpad and press LSK 5R to store the ROI sequence for future usage.	X	X
5	Take off, activate the autopilot and fly a suitable flightpath. All autopilot modes can be used.		
6	If wished, lock the synthetic FPV view on the currently active ROI using the ROI button at the upper window boundary.		X
7	On the second ROI FMS page activate ROI sequences by pressing LSK 1R (the ROI sequence master On/Off switch).		
8	While the ROI sequence is executed, the progress is displayed on the FMS as follows:  Already passed ROI's are shown in red, the one which is targeted by the current sweep in green and the remaining duration of the sweep in seconds above the green FIXED nS.		
9	The ROI sequence ends in one of two ways: d. Either the last ROI of the defined sequence has been reached. e. Or the pilot deactivates the ROI sequence with LSK 1R on the second ROI FMS subpage.		