
Enroute Flight Navigation

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Enroute Flight Navigation is a free flight navigation app for Android and other devices. Designed to be simple, functional and elegant, it takes the stress out of your next flight. The program has been written by flight enthusiasts, as a project of [Akaflieg Freiburg](https://akaflieg-freiburg.de/)¹, a flight club based in Freiburg, Germany.

Enroute Flight Navigation features a moving map, similar in style to the official ICAO maps. Your current position and your flight path for the next five minutes are marked, and so is your intended flight route. A double tap on the display gives you all the information about airspaces, airfields and navaids – complete with frequencies, codes, elevations and runway information.

The free aeronautical maps can be downloaded for offline use. In addition to airspaces, airfields and navaids, selected maps also show traffic circuits as well as flight procedures for control zones. The maps receive daily updates and cover large parts of the world.

Enroute Flight Navigation includes flight weather data downloaded from the [NOAA - Aviation Weather Center](https://www.aviationweather.gov/)².

While **Enroute Flight Navigation** is no substitute for full-featured flight planning software, it allows you to quickly and easily compute distances, courses and headings, and gives you an estimate for flight time and fuel consumption. If the weather turns bad, the app will show you the closest airfields for landing, complete with distances, directions, runway information and frequencies.

¹ <https://akaflieg-freiburg.de/>

² <https://www.aviationweather.gov/>

Enroute Flight Navigation

1

Program version

This manual describes program version 2.17.0.

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Table of contents

2.1 Think before you fly

Enroute Flight Navigation is a free software product that has been published in the hope that it might be useful as an aid to prudent navigation. It comes with no guarantees. It may not work as expected. Data shown to you might be wrong. Your hardware may fail.

This app is no substitute for proper flight preparation or good pilotage. Any information **must always** be validated using an official navigation and airspace data source.

Warning: Always use official flight navigation data for flight preparation and navigate by officially authorized means. The use of non-certified navigation devices and software like **Enroute Flight Navigation** as a primary source of navigation may cause accidents leading to loss of lives.

We do not believe that the use of **Enroute Flight Navigation** fulfills the requirement of the EU Regulation No 923/2012:SERA.2010³

Before beginning a flight, the pilot-in-command of an aircraft shall become familiar with all available information appropriate to the intended operation.

To put it simply: relying on **Enroute Flight Navigation** as a primary means of navigation is most likely illegal in your jurisdiction. It is most certainly stupid and potentially suicidal.

2.1.1 Software limitations

Enroute Flight Navigation is not an officially approved flight navigation software. It is not officially approved or certified in any way. The software comes with no guarantee and might contain bugs.

³ <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:281:0001:0066:EN:PDF>

2.1.2 Navigational data and aviation data

Navigational– and aviation data, including airspace and airfield information, are provided “as is” and without any guarantee, official validation, certification or warranty. The data does not come from official sources. It might be incomplete, outdated or otherwise incorrect.

2.1.3 Operating system limitations

We expect that most users will run the software on mobile phones or tablet computers running the Android operating system. Android is not officially approved or certified for aviation. While we expect that the app will run fine for the vast majority of Android users, please keep the following in mind.

- The Android operating system can decide at any time to terminate **Enroute Flight Navigation** or to slow it down to clear resources for other apps.
- Other apps might interfere with the operation of **Enroute Flight Navigation**.
- Many hardware vendors, most notably One Plus, Huawei and Samsung equip their phone with “battery saving apps” that randomly kill long-running processes. These apps cannot be uninstalled by the users, do not comply with Android standards and are often extremely buggy. At times, users can manually exempt apps from “battery saving mode”, but the settings are usually lost on system updates. Google’s own “Pixel” and “Nexus” devices do not have these problems. See the website [Don’t kill my app⁴](#) for more information.

2.1.4 Hardware limitations

Enroute Flight Navigation runs on a variety of hardware platforms, but we expect that most users will run the software on mobile phones, tablet computers and comparable consumer electronic devices that are not certified to meet aviation standards. Keep the following in mind.

- Your device might not be designed to operate continuously for extended periods of time, in particular if the display is on.
- Your device can overheat. Batteries can catch fire.
- Battery capacity is limited. Even if your device is connected to power via a USB cable, the display and/or CPU might use more energy than USB can deliver.

2.2 Installation and setup

2.2.1 App installation

Installation on Android devices

Enroute Flight Navigation is available as an Android App in the [Google Play Store⁵](#).

An unofficial version of the app is also available at [F-Droid⁶](#). While the author of **Enroute Flight Navigation** endorses publication at F-Droid, he has not tested this unofficial app for quality. The app version on F-Droid might be outdated.

Installation on Linux desktop machines

Enroute Flight Navigation is available for free download at [flathub.org⁷](#) and [snapcraft.io⁸](#). Most likely you will

⁴ <https://dontkillmyapp.com>

⁵ https://play.google.com/store/apps/details?id=de.akaflieg_freiburg.enroute

⁶ https://f-droid.org/de/packages/de.akaflieg_freiburg.enroute/

⁷ https://flathub.org/apps/details/de.akaflieg_freiburg.enroute

⁸ <https://snapcraft.io/enroute-flight-navigation>

also find the app in the software management application on your computer.

After installation, start the app. Depending on the platform, you might need to grant the necessary permissions. You will be asked to accept the terms and conditions.

2.2.2 Map download

Enroute Flight Navigation cannot be used without geographic maps. Three types of maps need to be installed for every region where you fly.

- Aeronautical maps. These contain airspaces, airfields and navaids. Some maps also contain reporting points, airfield traffic circuits and control zone entry/exit routes.
- Base maps. These contain geographic data, such as rivers, roads, railroads and land use.
- Terrain maps, which contain elevation data. At present, terrain maps are used to show a shaded terrain relief. We expect that future versions of the app will use terrain elevation also for navigational purposes.

Follow these steps to install the maps that you need.

- Open the Menu by touching the menu button in the upper right side of the screen. The button is marked with the symbol ‘≡’.
- Choose the menu item *Library*, then *Maps and Data*. The data management page will then open.
- On the map management page, click or tap on the desired maps. The maps will be downloaded and installed on your device.

Please download only those maps that you will actually need. The infrastructure and bandwidth for map downloads is kindly sponsored by the University of Freiburg, under the assumption that the cost stays within reasonable limits. You will also find that the app performs much better if it does not have to process many megabytes of map data.

Note: Do not forget that you need aeronautical maps, base maps **and** terrain maps for the desired area of flight. The base maps are large. Make sure that you have a good internet connection before you download maps. It might be inadvisable to download base maps via the mobile phone network.

Once the map download has finished, **Enroute Flight Navigation** will process the map data and update the map display after a minute or so. Tap or click on the arrow symbol ‘←’ or use the Android ‘Back’ button to leave the map page and return to the main screen.

2.2.3 Set aircraft specifics

We recommend that you tell **Enroute Flight Navigation** a little about your aircraft before you fly.

- Open the Menu by touching the menu button in the upper right side of the screen.
- Choose the menu item *Aircraft*. The aircraft page will then open.

Please fill in the relevant data. While not every data item is used in the present version of **Enroute Flight Navigation**, we expect that future versions of the app will use all the data that is requested on this page.

Tap or click on the arrow symbol ‘←’ or use the Android ‘Back’ button to leave the map page and return to the main screen.



Fig. 1: Aircraft specifics

2.2.4 Done.

You are now ready to go. There are many things that you could set up at this stage, but we recommend that you simply look around and play with the app. Continue with the next section and take it for your first flight.

2.3 Before your first flight

Now you are ready for the first use of **Enroute Flight Navigation**. General operation is very intuitive. Still, we recommend that you take a minute to make yourself familiar with the moving map display and with the basic controls before you take the app on its first flight.

2.3.1 The moving map

After startup, the app will show a moving map, similar in style to the standard ICAO maps that most pilots are used to. You can use the standard gestures to zoom and pan the map to your liking. The figures *Moving map display on the ground* and *Moving map display in flight* shows how the map will typically look.

Initially, your own position is shown as a blue circle (or gray if the system has not yet acquired a valid position). Once you are moving, your own position is shown as a blue arrow shape. The flight path vector shows the projected track for the next five minutes, sized so that each of the black and white segments corresponds to one minute.

Note: When you start the app for the first time, you will probably see a bright red aircraft symbol in the lower left corner of the map. This symbol indicates that the app is not connected to the traffic data receiver of your aircraft, so that traffic will not be shown on the moving map.



Fig. 2: Moving map display on the ground



Fig. 3: Moving map display in flight



Fig. 4: Projected flight path for the next five minutes

Once you are familiar with the app, please have a look at the Section [Sense and avoid](#) of this manual.

2.3.2 Flight Information

The bottom of the display shows a little panel with the following information.

Code	Meaning
T.TALT	True altitude (=geometric altitude) above sea level.
FL	Flight level.
GS	Ground speed.
TT	True track.
UTC	Current time.

The flight level is only available if your device is connected to a traffic receiver (such as a PowerFLARM device) that reports the pressure altitude. Flight level and current time are hidden if the display is not wide enough.

Warning: Vertical airspace boundaries are defined by pressure altitudes (with respect to QNH or standard pressure). Depending on temperature and air density, the pressure altitude will differ from the true altitude that is shown by the app. **Never use true altitude to judge vertical distances to airspaces.**

2.3.3 Interactive controls

In addition to the pan and pinch gestures, you can use the following buttons to control the app.

Symbol	Function
	Open main menu
	Switch between display modes north up and track up .
	Center map about own position.
	Zoom in
	Zoom out
	This control is shown when the app is not connected to a traffic data receiver. A click opens the traffic receiver status page.

2.3.4 Information about airspaces, airfields and other facilities

Double tap or tap-and-hold anywhere in the map to obtain information about the airspace situation at that point. If you double tap or tap-and-hold on an airfield, navaid or reporting point, detailed information about the facility will be shown. The figure *Information about EDFE airport* shows how this will typically look.



Fig. 5: Information about EDFE airport

2.3.5 Go flying!

Enroute Flight Navigation is designed to be simple. We think that you are now ready to take the app on its first flight. There are of course many more things that you can do. Play with the app and have a look at the next section *Further Steps*.

2.4 Sense and avoid

Midair collisions are a major reason for loss of lives in general aviation. Collisions often happen near airfields or in the traffic circuit. In order to enhance security, **Enroute Flight Navigation** can connect to your aircraft's traffic receiver (typically a FLARM device) and display nearby traffic on the moving map.

The figure *Approaching EDTF with traffic* shows what to expect. The figure shows two traffic factors.

- There is one aircraft in the downwind section of the traffic circuit. The traffic has approximately the same altitude as the own aircraft and is sinking. The green color indicates “no alarm”.
- There is one aircraft nearby whose precise position is unknown to the traffic receiver; this is often the case with traffic that has only a Mode-S transponder. The traffic is most likely found within the yellow circle. The yellow color indicates that the traffic might be close enough to be dangerous.



Fig. 6: Approaching EDTF with traffic

Note: To show only relevant traffic, **Enroute Flight Navigation** will display traffic factors only if the vertical distance is less than 1.500m and the horizontal distance less than 20nm.

Warning: **Enroute Flight Navigation** shows traffic on the moving map, but does not issue traffic warnings. The app contains no collision avoidance algorithms. Color coding of traffic according to relevance works best with FLARM devices.

2.4.1 Compatibility

Enroute Flight Navigation should work with all modern, standard-compliant traffic receivers. The author has tested the app with the following receivers.

- AT-1 AIR Traffic⁹ by Air Avionics¹⁰.
- PowerFLARM Core¹¹ by FLARM Technology Ltd¹², and AIR Connect¹³ WiFi Adaptor by Air Avionics¹⁴.

Users reported success with the following traffic receivers.

- PilotAware Rosetta¹⁵

⁹ http://www.air-avionics.com/?page_id=253

¹⁰ <http://www.air-avionics.com/>

¹¹ <https://flarm.com/flarm-product/powerfarm-core-pure/>

¹² <https://flarm.com/>

¹³ https://www.air-avionics.com/?page_id=401

¹⁴ <http://www.air-avionics.com/>

¹⁵ <https://www.pilotaware.com/rosetta/>

- SkyEcho2¹⁶ – but see the Section *Known issues with SkyEcho devices*
- Stratux devices¹⁷
- TTGO T-Beam devices¹⁸

Note: Most traffic data receivers can only handle one concurrent connection. If more devices connect, this might lead to frequent loss of connection or loss of data. To be on the safe side, it might be useful to ask your passengers to disable Wi-Fi on their phone before boarding.

Note: For best results, use FLARM compatible devices. If your traffic receiver supports FLARM/NMEA as well as GDL90 output, always use FLARM/NMEA. The GDL90 protocol has a number of shortcomings that **Enroute Flight Navigation** cannot always work around. See the Section *Known issues with GDL90* for more details.

2.4.2 Before you connect

Before you try to connect this app to your traffic receiver, make sure that the following conditions are met.

- Your traffic receiver has an integrated Wi-Fi interface that acts as a wireless access point. Bluetooth devices are currently not supported.
- You know the network name (=SSID) of the Wi-Fi network deployed by your traffic receiver. If the network is encrypted, you also need to know the Wi-Fi password.
- Some devices require an additional password in order to access traffic data. If this is the case, you will need to know this password.

2.4.3 Connect to the traffic receiver

It takes two steps to connect **Enroute Flight Navigation** to the traffic receiver for the first time. Once things are set up properly, your device should automatically detect the traffic receiver's Wi-Fi network, enter the network and connect to the traffic data stream whenever you go flying.

Step 1: Enter the traffic receiver's Wi-Fi network

- Make sure that the traffic receiver has power and is switched on. In a typical aircraft installation, the traffic receiver is connected to the 'Avionics' switch and will automatically switch on. You may need to wait a minute before the Wi-Fi comes online and is visible to your device.
- Enter the Wi-Fi network deployed by your traffic receiver. This is usually done in the "Wi-Fi Settings" of your device. Enter the Wi-Fi password if required. Some devices will issue a warning that the Wi-Fi is not connected to the internet. In this case, you might need to confirm that you wish to enter the Wi-Fi network.

Most operating systems will offer to remember the connection, so that your device will automatically connect to this Wi-Fi in the future. We recommend using this option.

¹⁶ <https://uavionix.com/products/skyecho/>

¹⁷ <http://stratux.me/>

¹⁸ <https://www.amazon.de/TTGO-T-Beam-915Mhz-Wireless-Bluetooth/dp/B07SFVQ3Z8>

Step 2: Connect to the traffic data stream

Open the main menu and navigate to the “Information” menu.

- If the entry “Traffic Receiver” is highlighted in green, then **Enroute Flight Navigation** has already found the traffic receiver in the network and has connected to it. Congratulations, you are done!
- If the entry “Traffic Receiver” is not highlighted in green, then select the entry. The “Traffic Receiver Status” page will open. The page explains the connection status in detail, and explains how to establish a connection manually.

2.4.4 Flarmnet data

Enroute Flight Navigation is able to use the database from [Flarmnet.org](https://www.flarmnet.org)¹⁹ to identify aircraft and to show the aircraft registration in the moving map display. The process does not require user interaction: once the app connects to a FLARM device and receives traffic information, the Flarmnet database will automatically be downloaded and updated with every map update. If desired, the database can also be downloaded manually on the page “Maps and Data” (open the main menu and go to “Library/Maps and Data”).

2.4.5 Troubleshooting

The app cannot connect to the traffic data stream.

- Check that your device is connected to the Wi-Fi network deployed by your traffic receiver.

The connection breaks down after a few seconds.

Most traffic receivers cannot serve more than one client and abort connections at random if more than one device tries to access.

- Make sure that there no second device connected to the traffic receiver’s Wi-Fi network. The other device might well be in your friend’s pocket!
- Make sure that there is no other app trying to connect to the traffic receiver’s data stream.
- Many traffic receivers offer “configuration panels” that can be accessed via a web browser. Close all web browsers.

2.5 Find nearby waypoints

If the weather turns bad, **Enroute Flight Navigation** can help you find the best place to land. Open the main menu and choose the item “Nearby waypoints”. You will be presented with a list of the closest aerodromes, together with distances and directions. Click on any item to open a dialog with detailed information, including lists of runways and communications frequencies. The dialog has a button “Direct” that replaces the current route with a route that brings you directly to the aerodrome.

Apart from aerodromes, there are additional tabs that list nearby navaids and reporting points.

¹⁹ <https://www.flarmnet.org/flarmnet/>



Fig. 7: List of airfields close to the current position

2.6 Check Weather

Enroute Flight Navigation can show METAR reports and TAF forecasts from nearby airfields along your route. The data is updated frequently, provided that an internet connection is available. To check weather, open the main menu and choose the item “Weather”. The weather information comes from the “Aviation Weather Center”, a website of the US government. When you open the page for the first time, **Enroute Flight Navigation** asks for your permission to access that site.

Warning: The weather information shown by **Enroute Flight Navigation** might be outdated or otherwise wrong. Assessment of meteorological flight conditions has to be done via an officially approved source of flight weather.

As soon as weather information has been downloaded, the page will look like this.

The page body displays a list of stations that are within 85nm around your current position or your intended flight route. As you can see in the picture, the following information is shown.

- ICAO identifier for Station and Airport name
- Distance and QJJ
- METAR summary

The entries are classified and colored according to the “aviation flight categories” typically used in the United States. The coding scheme is explained in the table below. Note that this color coding might be different from the scheme typically used in your country. Green color does certainly **not** imply that it is advisable (or legal) to fly.



Fig. 8: Weather information

Category	Color	Ceiling		Visibility
low IFR	Red	<500 feet AGL	or	<1 mile
IFR	Red	500 – 1,000 feet AGL	or	1 – 3 miles
marginal VFR	Yellow	1,000 – 3,000 feet AGL	or	3 – 5 miles
VFR	Green	>3,000 feet AGL	and	> 5 miles
no data	White	–	–	–

Touch any item in the list to open dialog window with more details. The dialog window will look like this.

As you can see in the picture, the weather dialog shows the following information.

1. Station data including bearing and distance
2. METAR text (if available)
3. Decoded and translated METAR text
4. TAF text (if available)
5. Decoded and translated TAF text

Depending on screen size, you might have to scroll down in order to read the full weather forecast.



Fig. 9: Detailed Weather Dialog

2.6.1 Page footer

The footer of the page shows the following data.

- QNH of the closest airfield, as well as location and time of the report
- Time of next sunset or sunrise at current location
- Remaining time until sunset

2.6.2 Three-dot menu

The three-dot menu at the top right of the page allows to do the following.

- Check for updates of METAR and TAF data
- Disallow the internet connection to the “Aviation Weather Center” in case of privacy concerns

2.7 Plan a Flight

2.7.1 What to expect

Enroute Flight Navigation offers essential flight planning functionality: you can display the route on the moving map and compute travel time and fuel consumption estimates. The following image shows the Flight Route Window in a typical situation.

As soon as you are flying and following the route, the moving map will show additional items that help you navigate.



Fig. 10: Flight route window, route set

- The moving map shows the intended flight as a magenta line.
- The map shows the path from the current position to the next waypoint as a thin red line.
- An infobox shows distance, ETE, and ETA for the flight to the next and the final waypoint.

The following image shows a typical situation.

Note: **Enroute Flight Navigation** shows the infobox only when airborne, closer than three nautical miles to the intended route and further than three nautical miles from your destination.

2.7.2 Set up and use a route

This chapter will take you through the necessary steps to set up and use a route.

Step 1: Set aircraft characteristics

To compute travel time, **Enroute Flight Navigation** needs to know the cruise speed of your aircraft. If you have followed this manual, you have entered this piece of data after you downloaded the aviation map. If not, then please check the section *Set aircraft specifics* again.



Fig. 11: Moving map when following a flight route

Step 2: Specify wind

Enroute Flight Navigation also needs to know about the wind. If you are not on the page “Route and Wind,” open the main menu and choose the item “Route and Wind.” Select the tab “Wind” and enter an estimate for wind direction and speed that you expect to encounter during your flight.

Step 3: Specify waypoints

Enroute Flight Navigation needs to know where you want to go. There are several ways to specify the waypoints in your route.

- Enter waypoints by name
- Select waypoints in the moving map
- Import a route from the route library
- Import a GPX file from another program

Most users will enter the waypoints manually. Still, we explain all four methods in some detail.

Option 1: Enter waypoints by name

If you are not on the “Route and Wind” page, open the main menu and choose the item “Route and Wind.” On the page, select the “Route” tab. The page will initially look like this:

A tap on the field “Add Waypoint” at the bottom of the page will open a dialog window showing a long list with all waypoints from all aviation maps you have installed. Enter a few letters of the waypoint name (“Freiburg”) or ICAO code (“EDTF”) to narrow the list down. Once the desired waypoint becomes visible, a click will add it to the route.

Click on the field “Add Waypoint” again to enter more waypoints.



Fig. 12: Flight route window, no route set



Fig. 13: Enter waypoints by name

Option 2: Select waypoints in the moving map

It is possible to add waypoints directly from the moving map. Double-tap or tap-and-hold on any point of the moving map. The waypoint description dialog will open.

- Tap on the “Plus” sign to append the waypoint to the current route.
- Tap on “Direct to” to discard the current route and to add the current position and the given waypoint to your path.
- If the waypoint is already present in your route, you can tap on the “Minus” sign to remove it.

Option 3: Import a route from the library

Section [Step 5: Save Route for Future Use](#) will show how to save a route to the library for future use. If you have already saved a route to the library, go to the open the main menu and choose the item “Library/Routes.” The route library page will open. Choose a route by tapping on the respective item in the list.

Option 4: Import a GPX file from another program

To prepare your flight, you might want to use full-featured flight preparation software or online services, such as [FL95²⁰](#). Most (if not all) programs allow exporting the route in GPX format. Transfer the GPX file to your device (using Bluetooth file transfer, Google Drive, sending yourself an e-mail, or any other communication channel).

- On Android devices, it suffices to open the file. Depending on the transfer mode, you can open the file after the Bluetooth transfer, in the Google Drive App, or perhaps in the e-mail client. **Enroute Flight Navigation** will automatically open and import the route. If more than one program on your device can handle GPX files, the system will ask you which program to use.
- On the Linux desktop, drag-and-drop the GPX file to the **Enroute Flight Navigation** window.

2.7.3 Step 4: Edit the route if necessary

It might be necessary to edit the route. If you are not on the “Route and Wind” page, open the main menu and choose the item “Route and Wind.” On the page, select the “Route” tab.

Global functions

The three-dot-menu in the upper right corner of the screen allows reversing the route or deleting it entirely.

Waypoint-specific functions

The three-dot-menu to the right of each waypoint allows one to delete a specific waypoint or move it up and down in the list. You can edit waypoints that do not refer to pre-set airfields, navaids, or reporting points. Tap on the pencil symbol to open a dialog that allows you to set a name and edit the coordinates.

²⁰ <https://fl95.de>

2.7.4 Step 5: Save route for future use

Once you are happy with the route, you might want to save it for future use. If you are not on the “Route and Wind” page, open the main menu and choose the item “Route and Wind.” On the page, select the “Route” tab. The three-dot-menu in the upper right corner of the screen allows saving the route to the library.

2.8 Manage a waypoint library

2.8.1 What to expect

Enroute Flight Navigation allows you to build a small library of waypoints that can be used in flight routes and shared with others. For the typical user, the library might contain a list of touristic landmarks (“Hohenzollern Castle”), or perhaps a list of emergency landing fields. The waypoints from the library are shown in the moving map.

Note: The waypoint library has been designed with small libraries in mind. If you import files containing thousands of waypoints, you might find that the moving map of **Enroute Flight Navigation** slows down considerably.

2.8.2 Add waypoints to the library

To add a waypoint to the library, tap-and-hold onto the moving map, so that the waypoint description dialog opens. In that dialog, click on “Library/Add...” Before saving, it is possible to assign a name and to edit the coordinates of the waypoint.

Note: To avoid data duplication, it is not possible to add airfields, navaids or reporting points to the waypoint library. If you tap-and-hold onto an airfield, you will find that the Item “Library” is disabled in the waypoint description dialog.

2.8.3 View the waypoint library

To open the waypoint library, go to the main menu and choose the item “Library/Waypoints.”

2.8.4 Import waypoints

Enroute Flight Navigation is able to import waypoints from files in CUP, GeoJSON or GPX format.

- On Android devices, transfer the file to your device and open it there. Depending on the transfer mode, you can open the file after the Bluetooth transfer, in the Google Drive App, or perhaps in the e-mail client.
- On the Linux desktop, drag-and-drop the file to the **Enroute Flight Navigation** window. Alternatively, open the waypoint library by choosing “Library/Waypoints” from the main menu, and choose the item “Import” from the three-dot menu at the top right of the screen.

2.8.5 Export and share the waypoint library

Enroute Flight Navigation is can write the waypoint library to a file, which can then be transferred to other devices, or opened with other apps. **Enroute Flight Navigation** is able to write files in GeoJSON and GPX format. While GPX is understood by most programs, GeoJSON is the preferred format for sharing data between several instances of **Enroute Flight Navigation**.

To start, open the waypoint library by choosing “Library/Waypoints” from the main menu.

- On Android devices, choose the item “Share...” from the three-dot menu at the top right of the screen, and choose the appropriate file type from the submenu.
- On the Linux desktop, choose the item “Export...” from the three-dot menu at the top right of the screen, and choose the appropriate file type from the submenu.

2.8.6 Open the waypoint library in another app

It is possible to open the waypoint library in another app. To start, open the waypoint library by choosing “Library/Waypoints” from the main menu. Once the main library page is open, choose the item “Open in other app...” from the three-dot menu at the top right of the screen, and choose the appropriate file type from the submenu.

2.9 Connect your flight simulator

Enroute Flight Navigation can connect to flight simulator software. When setup correctly, position and traffic information is sent from the flight simulator via WiFi to the device that runs **Enroute Flight Navigation**.

The author has tested **Enroute Flight Navigation** with the following flight simulator programs.

- *X-Plane 11*

Users have reported success with the following programs.

- *FlightGear*
- *MS Flight Simulator*
- *X-Plane 10*

Please contact us if you are aware of other programs that also work.

Note: **Enroute Flight Navigation** treats flight simulators as traffic receivers. To see the connection status, open the main menu and navigate to the “Information” menu.

2.9.1 Before you connect

This manual assumes a typical home setup, where both the computer that runs the flight simulator and the device that runs **Enroute Flight Navigation** are connected to a Wi-Fi network deployed by a home router. Make sure that the following conditions are met.

- Open the “Settings” page in the main menu and tap on the entry “Primary position data source” and select the “Traffic data receiver” as the main source. **As long as the built-in satnav receiver is selected, all position information provided by your flight simulator is ignored.**
- The computer that runs the flight simulator and the device that runs **Enroute Flight Navigation** are connected to the same Wi-Fi network. Some routers deploy two networks, often called “main network” and a “guest network”.

- Make sure that the router allows data transfer between the devices in the Wi-Fi network. Some routers have “security settings” that disallow data transfer between the devices in the “guest network”

2.9.2 Set up your flight simulator

Your flight simulation software needs to broadcast position and traffic information over the Wi-Fi network. Once this is done, there is no further setup required. As soon as the flight simulator starts to broadcast information over the Wi-Fi network, the moving map of **Enroute Flight Navigation** will adjust accordingly. To end the connection to the flight simulator, simply leave the flight simulator’s Wi-Fi network.

FlightGear

FlightGear works well, even though position information is only broadcast when the simulated aircraft is moving. The following two parameters in the text field of the settings dialog need to be set:

```
--generic=socket,out,1,255.255.255.255,49002,udp,foreflight-xgps  
--httpd=8080
```

The figure *FlightGear settings* shows settings window.

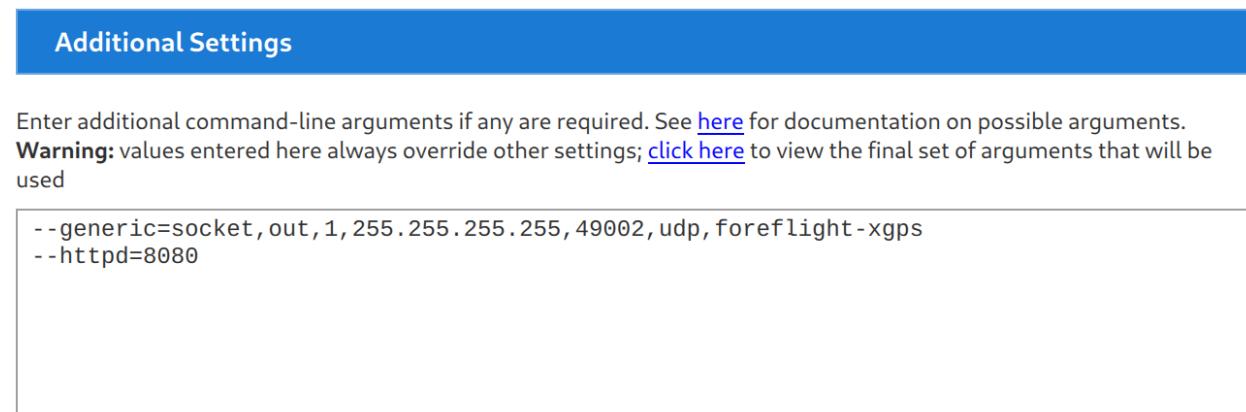


Fig. 14: FlightGear settings

MS Flight Simulator

In order to communicate with other programs, the MS Flight Simulator requires additional software. Users reported that **Enroute Flight Navigation** works well with the following EFB-connector programs.

- [fs2ff²¹](#) (free, open source)
- [XMapsy Essential²²](#) (commercial, inexpensive, does not provide barometric altitude data).
- [XMapsy V3²³](#) (commercial, more expensive, provides barometric altitude data).

The web site of the commercial EFB program ForeFlight²⁴ lists additional EFB-connector programs that might also work.

²¹ <https://github.com/astenlund/fs2ff>

²² <http://xmapsy.com/>

²³ <http://xmapsy.com/>

²⁴ <https://foreflight.com/support/support-center/category/about-foreflight-mobile/204115275>

Note: In MSFS2020 cold and dark mode, traffic in the air will not be shown. You have to power on the avionics!

Note: At the time of writing (04Aug21), the MS Flight Simulator reports only traffic that has a tail number. This is likely due to a bug in the MS Flight Simulator software.

fs2ff

The program [fs2ff²⁵](#) does not require any complicated installation or setup, just download and run. The latest release of fs2ff can be downloaded [here²⁶](#). Detailed instruction are found [here²⁷](#). The figure *fs2ff settings* shows extremely simple settings window.



Fig. 15: fs2ff settings

XMapsy Essential

If you use XMapsy Essential, you need not to setup anything. Just start XMapsy Essential and start MSFS2020. The broadcast address will be setup automatically. The figure *XMapsy Essential settings* shows the settings.

²⁵ <https://github.com/astenlund/fs2ff>

²⁶ <https://github.com/astenlund/fs2ff/releases/latest>

²⁷ <https://github.com/astenlund/fs2ff#fs2ff-flight-simulator-to-foreflight>

Enroute Flight Navigation



Fig. 16: XMapsy Essential settings

XMapsy V3

If you use XMapsy V3, set the “Message-Format” to “ADS-B/GDL90” and the “Preferred Technology” to SIM-CONNECT. To receive the correct altitude, be sure to check the box “GDL90 ownship geometric altitudes based on MSL”. The figure *XMapsy V3 settings* shows verified XMapsy V3 settings for proper work with MSFS2020. The Broadcast address will be determined by Xmapsy and should not be touched except you have extended network configuration experience.

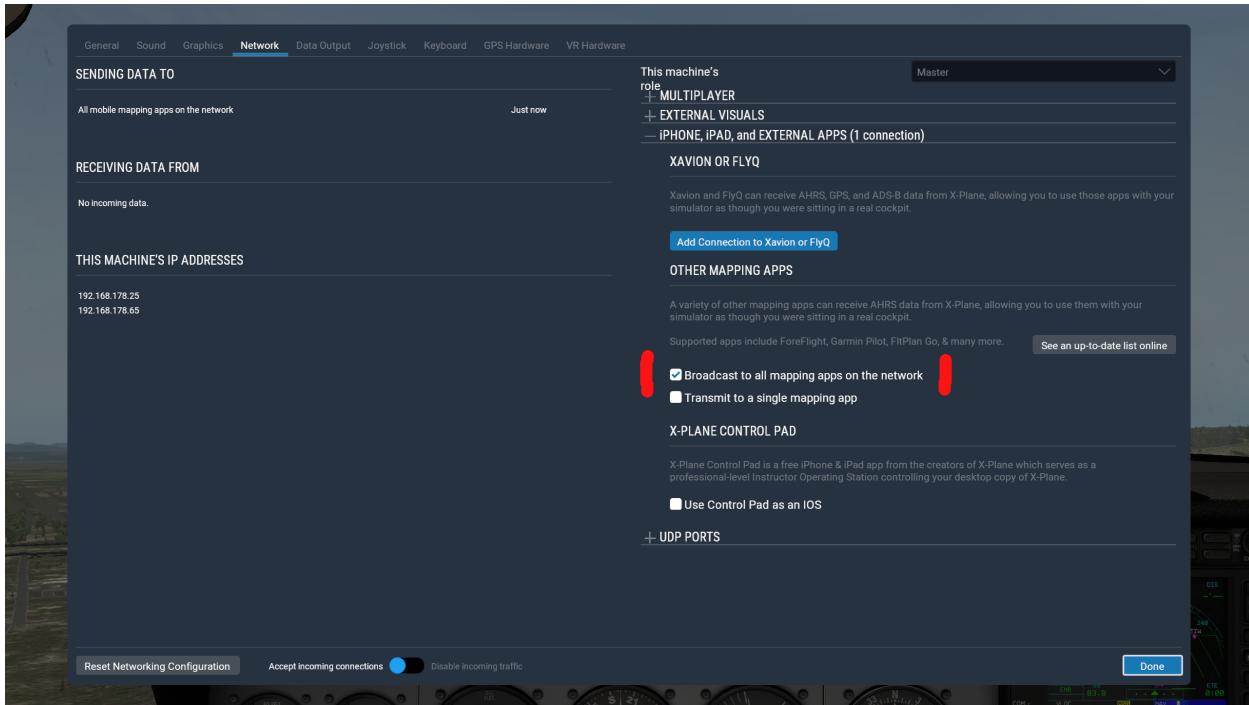


Fig. 17: XMapsy V3 settings

Enroute Flight Navigation

X-Plane 11

Open the “Settings” window and choose the “Network” tab. Locate the settings group “This machine’s role” on the right-hand side of the tab. Open the section “iPHONE, iPAD, and EXTERNAL APPS” and select the item “Broadcast to all mapping apps on the network” under the headline “OTHER MAPPING APPS”.



X-Plane 10

Follow the explanation on [this page²⁸](#), which explains how to connect X-Plane 10 to the commercial app ForeFlight. In short: Open the “Settings” window and click “Internet Options”. There, go to the “iPhone/iPod” tab and turn on the “ForeFlight” option. Please be sure to disable output of data on tab “Data”.

²⁸ <https://www.x-plane.com/2012/08/foreflight-charts-supported-in-x-plane-10-10-beta-9/>



Other programs

The flight simulator needs to be set up to send UDP datagrams in one of the standard formats “GDL90” or “XGPS” to ports 4000 or 49002. Given the choice, GDL90 is generally the preferred format.

2.9.3 Troubleshooting

Enroute Flight Navigation treats flight simulators as traffic receivers. To see the connection status, open the main menu and navigate to the “Information” menu. If the entry “Traffic Receiver” is highlighted in green, then **Enroute Flight Navigation** has already found the program in the network and has connected to it. If not, then select the entry. The “Traffic Receiver Status” page will open, which explains the connection status in more detail.

2.10 Make a donation

Enroute Flight Navigation is a non-commercial project of [Akaflieg Freiburg](#)²⁹ and the [University of Freiburg](#)³⁰. The app has been written by flight enthusiasts in their spare time, as a service to the community. The developers do not take donations.

If you appreciate the app, please consider a donation to Akaflieg Freiburg, a tax-privileged, not-for-profit flight club of public utility in Freiburg, Germany.

IBAN:	DE35 6809 0000 0027 6409 07
BIC:	GENODE61FR1
Bank:	Volksbank Freiburg
Message:	Enroute Flight Navigation

2.11 Use your own maps

Enroute Flight Navigation comes with a set of base maps that cover large parts of the world and are updated frequently. Still, there might be situations where a user would like to use their own base maps.

- Where available, some users might prefer to use official ICAO charts of their countries.
- Some users might prefer raster maps that follow a different style.
- Some users might prefer to install high-detail vector maps for particular regions of interest.

Enroute Flight Navigation is able to import MBTILES file containing raster or vector data. Vector data must follow the standard [OpenMapTiles](#)³¹ schema. Vector maps are rendered in the same style that **Enroute Flight Navigation** uses for its own maps. It is possible to install vector maps along with the maps provided by **Enroute Flight Navigation**, in order to provide higher detail for particular regions of interest.

2.11.1 Import Maps

Import Maps on Android devices

If you are using an Android device, you need to transfer the MBTILES file to the device, and open it there. There are many ways to transfer files, but most users will likely do one of the following.

- Download the MBTILES file on the Android device with a web browser. The browser will then offer to open the file in **Enroute Flight Navigation**.
- Download the MBTILES file to a desktop computer, connect the device to the desktop computer via USB and then copy the file to the device. Afterwards, the file can be opened by a file management app on the Android device.

²⁹ <https://akaflieg-freiburg.de/>

³⁰ <https://uni-freiburg.de/en/>

³¹ <https://github.com/openmaptiles/openmaptiles>

Import Maps on Linux Desktop

If you are running **Enroute Flight Navigation** on a Linux Desktop machine, use the file manager to drag-and-drop the file into the main window of the app.

Note: MBTILES files are often extremely large. It is possible that your device becomes unresponsive for a few seconds while copying the file. Also, note that **Enroute Flight Navigation** will copy the file to its internal data directory. In order to save space, we recommend deleting the MBTILES file once it has been imported.

2.11.2 MBTILES Map Data Sources

We are aware of a few websites that offer vector or raster maps that can be used with **Enroute Flight Navigation**. Please let us know if you know of other map data sources!

- The website [maptiler data³²](https://data.maptiler.com/downloads/planet/) provides excellent vector maps that can be installed alongside the base maps provided by **Enroute Flight Navigation**, in order to provide high-detail maps for specific regions of interest.
- The website [open flightmaps³³](https://www.openflightmaps.org/) provides excellent aviation maps in raster format for a variety of European countries, as well as South Africa and Namibia.

2.11.3 Raster Maps in GeoTIFF format

We are aware of websites that offer raster maps in GeoTIFF format. At present, **Enroute Flight Navigation** cannot handle GeoTIFF files, but there are tools that convert GeoTIFF to MBTILES.

- Official ICAO maps for Denmark are available from the danish [AIM Naviair³⁴](https://aim.naviair.dk/en/charts/)
- Official ICAO maps for Spain are available from the spanish [Insignia Servicio de Información Aeronáutica³⁵](https://aip.enaire.es/AIP/CartasInsigniaImpresas-es.html)
- Official ICAO maps for Switzerland are available from the swiss [Federal Office of Topography swisstopo³⁶](https://www.swisstopo.admin.ch/en/geodata/aero/icao.html)
- Official VFR raster charts are available from the [United States Federal Aviation Administration³⁷](https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/)

Users have successfully used the free tool [QGIS³⁸](https://qgis.org/en/site) to convert GeoTIFF files to MBTILES, which can then be used with **Enroute Flight Navigation**.

Since QGIS is a powerful tool that is not always easy to use, one user has kindly provided the following short tutorial.

- Install QGIS on your desktop computer. On Fedora Linux, we found that the packages provided by the default software repository were outdated and lacked the necessary functionality. We followed the installations instructions on the [QGIS website³⁹](https://qgis.org/en/site) to install a current and full-featured version of the program.
- Open QGIS. Create a new project and open the GeoTIFF file in QGIS by dragging-and-dropping the GeoTIFF file into the QGIS window. The content of the GeoTIFF file should become visible.
- Choose the menu item “Project/Properties...” to open the dialog window “Project Properties”. There, set the coordinate reference system to EPSG:3857. To locate the reference system, use the text field “Filter” and search for EPSG:3857.

³² <https://data.maptiler.com/downloads/planet/>

³³ <https://www.openflightmaps.org/>

³⁴ <https://aim.naviair.dk/en/charts/>

³⁵ <https://aip.enaire.es/AIP/CartasInsigniaImpresas-es.html>

³⁶ <https://www.swisstopo.admin.ch/en/geodata/aero/icao.html>

³⁷ https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/

³⁸ <https://qgis.org/en/site>

³⁹ <https://qgis.org/en/site/forusers/download.html>



Fig. 18: QGIS Main Window

- Use the menu items under “View/Panels/...” to ensure that the panels “Layer” and “Layer Styling” are visible. Select the layer of your GeoTIFF file and in the “Layer” panel. Then, go to the “Layer Styling” panel and set “Resampling” to “Bilinear” for better image render quality.
- Use the menu items under “View/Panels/...” to ensure that the panel “Processing Toolbox” is visible. Inside the “Processing Toolbox”, double click on “Raster Tools->Generate XYZ Tiles (MBTiles)”. The dialog “Generate XYZ Tiles (MBTiles)” will open. Fill the necessary parameters, as seen in the image below. We found the function “Draw on Map Canvas” useful to specify the map extent. Pay attention to the maximum zoom level, as the time and file size increase significantly after zoom level 12. Depending on the size of your GeoTIFF and on the number of zoom levels you use, it may take a while to generate the MBTILES file.

2.12 Settings

Enroute Flight Navigation is designed to be simple. The number of user settings is deliberately small. To access the user settings, open the main menu and choose “Settings.”



Fig. 19: QGIS Generate Tiles Dialog

2.12.1 Moving Map

The settings grouped under “Moving Map” change the appearance of the map display.

Airspace Altitude Limit

If you never fly higher than 5,000ft, you will probably not be interested in airspaces that begin above FL100. **Enroute Flight Navigation** allows you to set an altitude limit to improve the readability of the moving map. Once set, the app will show only airspaces below that limit. Tap on the entry “Airspace Altitude Limit” to set or unset the altitude limit.

Once you set an altitude limit, the moving map will display a little warning (“Airspaces up to 9,500 ft”) to remind you that the moving map does not show all airspaces. The app will automatically increase the limit when your aircraft approaches the altitude limit from below.

Warning: Airspace boundaries are often flight levels. The true altitude of a flight level depends on meteorological conditions (such as the temperature gradient) and is not known to **Enroute Flight Navigation**. When deciding which airspace to show, the app will use an approximation. The approximation might be off by 1,000ft or more in extreme weather. **Always leave an ample safety margin when setting an airspace altitude limit.**

Hide Gliding Sectors

In regions with high glider traffic, local regulations often allow gliders to fly in airspaces that are otherwise difficult to access, such as control zones. The moving map displays these “Gliding Sectors” in bright yellow. If you are not flying a glider, the gliding sectors are probably not relevant. Hiding the gliding sectors might improve the readability of the moving map.

2.12.2 Navigation

Show altitude AGL

If set, then the navigation bar at the bottom of the moving map screen will show the aircraft elevation above ground level, instead of sea level. This feature works only if terrain maps for your region are installed. If terrain data is not available, the altimeter field of the navigation bar will display “–“.

If you are unsure if terrain data is available, open the main menu and go to “Library/Maps and Data” to check which maps are installed in your device.

2.12.3 System

Primary position data source

Enroute Flight Navigation can either use the built-in satnav receiver of your device or a connected traffic receiver as a primary position data source. This setting is essential if your device has reception problems or if you use **Enroute Flight Navigation** together with a flight simulator.

- You will most likely prefer the built-in satnav receiver for actual flight. The built-in receiver provides one position update per second on a typical Android system, while traffic receivers do not always provide timely position updates.
- If you use **Enroute Flight Navigation** together with a flight simulator, you **must** choose the traffic receiver as a primary position data source. As long as the built-in satnav receiver is selected, all position information provided by your flight simulator is ignored.

Note: Setting a traffic receiver as a primary position data source is safe even when the app is not connected to a traffic receiver. When no traffic receiver is connected, **Enroute Flight Navigation** will automatically fall back using the built-in satnav receiver of your device.

Night mode

The “Night Mode” of Enroute Flight Navigation is similar to the “Dark Mode” found in many other apps. We designed the night mode for pilots performing VFR flights by night, whose eyes have adapted to the darkness. Compared with other apps, you will find that the display is quite dark indeed.

Ignore network security errors

This entry is visible if you have asked the app to download data via insecure internet connections after a secure connection attempt failed. Uncheck this item to revert to the standard policy, which enforces secure connections.

Clear password storage

This entry is visible if you have connected to a traffic data receiver that requires a password in addition to the Wi-Fi password and if you have asked the app to remember the password. Tap on this entry to clear the password storage.

2.12.4 Help

The items grouped under “Help” refer the user to this manual.

2.13 Map Data

Our maps available for offline use, so that the app does not require any internet connection in flight.

2.13.1 Base maps

Our base maps are edited versions of maps kindly provided by Klokan Technologies⁴⁰ through the OpenMapTiles⁴¹ project.

2.13.2 Terrain maps

Our terrain maps are derived from the Terrain Tiles Open Dataset on Amazon AWS⁴². The underlying data sources are a mix of:

- 3DEP (formerly NED and NED Topobathy) in the United States, 10 meters outside of Alaska, 3 meter in select land and territorial water areas
- ArcticDEM strips of 5 meter mosaics across all of the land north of 60° latitude, including Alaska, Canada, Greenland, Iceland, Norway, Russia, and Sweden
- CDEM (Canadian Digital Elevation Model) in Canada, with variable spatial resolution (from 20-400 meters) depending on the latitude.
- data.gov.uk, 2 meters over most of the United Kingdom
- data.gv.at, 10 meters over Austria
- ETOPO1 for ocean bathymetry, 1 arc-minute resolution globally
- EUDEM in most of Europe at 30 meter resolution, including Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, and United Kingdom

⁴⁰ <https://www.klokantech.com/>

⁴¹ <https://openmaptiles.org>

⁴² <https://registry.opendata.aws/terrain-tiles/>

- Geoscience Australia's DEM of Australia, 5 meters around coastal regions in South Australia, Victoria, and Northern Territory
- GMTED globally, coarser resolutions at 7.5", 15", and 30" in land areas
- INEGI's continental relief in Mexico
- Kartverket's Digital Terrain Model, 10 meters over Norway
- LINZ, 8 meters over New Zealand
- SRTM globally except high latitudes, 30 meters (90 meters nominal quality) in land areas

Attributions

- ArcticDEM terrain data DEM(s) were created from DigitalGlobe, Inc., imagery and funded under National Science Foundation awards 1043681, 1559691, and 1542736;
- Australia terrain data © Commonwealth of Australia (Geoscience Australia) 2017;
- Austria terrain data © offene Daten Österreichs – Digitales Geländemodell (DGM) Österreich;
- Canada terrain data contains information licensed under the Open Government Licence – Canada;
- Europe terrain data produced using Copernicus data and information funded by the European Union - EU-DEM layers;
- Global ETOPO1 terrain data U.S. National Oceanic and Atmospheric Administration
- Mexico terrain data source: INEGI, Continental relief, 2016;
- New Zealand terrain data Copyright 2011 Crown copyright (c) Land Information New Zealand and the New Zealand Government (All rights reserved);
- Norway terrain data © Kartverket;
- United Kingdom terrain data © Environment Agency copyright and/or database right 2015. All rights reserved;
- United States 3DEP (formerly NED) and global GMTED2010 and SRTM terrain data courtesy of the U.S. Geological Survey.

2.13.3 Base maps

Our base maps are edited versions of maps kindly provided by Klokan Technologies⁴³ through the OpenMapTiles⁴⁴ project.

Our base maps are edited versions of maps kindly provided by Klokan Technologies⁴⁵ through the OpenMapTiles⁴⁶ project.

⁴³ <https://www.klokantech.com/>

⁴⁴ <https://openmaptiles.org>

⁴⁵ <https://www.klokantech.com/>

⁴⁶ <https://openmaptiles.org>

2.13.4 Aeronautical maps

Update policy

Our aeronautical maps are updated once per day, provided that new data is available. Note, however, that we do not guarantee regular updates.

Data origin

The aeronautical maps are compiled from databases provided by the [openAIP⁴⁷](#) and the [open flightmaps⁴⁸](#) projects. While openAIP covers most of the world, the open flightmaps cover fewer countries but contain more detailed information.

Map Feature	Data Origin
Airfields	openAIP
Airspace: Nature Preserve Areas	open flightmaps
Airspace: all other	openAIP
Navaids	openAIP
Procedures (Traffic Circuits, ...)	open flightmaps
Reporting Points	open flightmaps

List of maps

For simplicity, our maps are divided in “Class 1” and “Class 2”.

- Class 1 maps are compiled from [openAIP⁴⁹](#) and [open flightmaps⁵⁰](#) data. These maps contain complete information about airspaces, airfields and navaids. In addition, the maps contain (mandatory) reporting points. Some of our tier 1 maps also show traffic circuits and flight procedures for control zones.
- Class 2 maps are compiled from [openAIP⁵¹](#) data only. They contain complete information about airspaces, airfields and navaids.

Below is a complete list of the maps that we offer.

Continent	Country	Class
Africa	Madagascar	Class 2
Africa	Namibia	Class 1
Africa	South Africa	Class 1
Asia	Japan	Class 2
Australia Oceanica	Australia	Class 2
Australia Oceanica	New Zealand	Class 2
Europe	Austria	Class 1
Europe	Belgium	Class 1
Europe	Bulgaria	Class 1
Europe	Croatia	Class 1
Europe	Cyprus	Class 2
Europe	Czech Republic	Class 1

continues on next page

⁴⁷ <http://openaip.net>

⁴⁸ <https://www.openflightmaps.org/>

⁴⁹ <http://openaip.net>

⁵⁰ <https://www.openflightmaps.org/>

⁵¹ <http://openaip.net>

Table 1 – continued from previous page

Continent	Country	Class
Europe	Denmark	Class 1
Europe	Estonia	Class 2
Europe	Finland	Class 1
Europe	France	Class 2
Europe	Germany	Class 1
Europe	Greece	Class 1
Europe	Hungary	Class 1
Europe	Iceland	Class 2
Europe	Ireland	Class 2
Europe	Italy	Class 1
Europe	Latvia	Class 2
Europe	Liechtenstein	Class 2
Europe	Lithuania	Class 2
Europe	Luxembourg	Class 2
Europe	Malta	Class 2
Europe	Netherlands	Class 1
Europe	Norway	Class 2
Europe	Poland	Class 1
Europe	Portugal	Class 2
Europe	Romania	Class 1
Europe	Serbia	Class 2
Europe	Slovakia	Class 1
Europe	Slowenia	Class 1
Europe	Spain	Class 2
Europe	Sweden	Class 1
Europe	Switzerland	Class 1
Europe	United Kingdom	Class 2
North America	Canada	Class 2
North America	United States	Class 2
South America	Argentina	Class 2
South America	Brazil	Class 2, NavAids missing

2.14 Platform notes

2.14.1 Android

Network security problems

Like most other programs, **Enroute Flight Navigation** uses Transport Layer Security (TLS)⁵² for secure communication with servers on the internet. The technology relies on digital certificates⁵³ that are built into the Android operating system and can only be updated by the device manufacturer through system security updates. Regrettably, manufacturers of Android devices are often not interested in after-sales support and provide updates only for a very short period of time, if at all.

If a device does not receive regular system updates, the certificates will expire after a while, and secure network connections are no longer possible. As covered in the media⁵⁴, many users of systems running Android 7.1 (or below)

⁵² https://en.wikipedia.org/wiki/Transport_Layer_Security

⁵³ https://en.wikipedia.org/wiki/Transport_Layer_Security#Digital_certificates

⁵⁴ <https://techcrunch.com/2021/09/21/lets-encrypt-root-expiry>

started to experience problems on 30. September 2021, when an important certificate expired.

When certificates expire, some apps will stop working. Other app authors prefer to hide the complexity of secure communication from their users and write apps that will silently revert to insecure communication. These apps appear to run as normal, but leave communication (and eventually the system) open to tampering and manipulation.

The author of **Enroute Flight Navigation** believes that pilots should be able to make an informed decision about the security of their systems. **Enroute Flight Navigation** will tell the user of any network security errors. Users can then decide to do one of the following.

- Replace the device by a more recent model, preferably from one of the few manufacturers who offer long-time support for their products.
- Accept the risk of insecure communication and ignore network security errors in the future.

Note: The author, who is concerned about short-lived digital products, uses a Fairphone⁵⁵ personally. Fairphones are long-lasting, can be repaired easily and receive many years of security updates. Other brands might have similar offers.

Screen backlighting

Enroute Flight Navigation overrides the system settings of your device and ensures that the screen backlighting is always on. To save battery power, the screen can be switched off manually with the hardware “power button” of your device.

Screen locking

Enroute Flight Navigation stays on top of the lock screen of your device. It will therefore be shown immediately as soon as the screen is switched on. You can therefore use **Enroute Flight Navigation** without unlocking your device.

Wi-Fi locking

When running on Android, **Enroute Flight Navigation** acquires a Wi-Fi lock as soon as the app receives heartbeat messages from one of the channels where it listens for traffic receivers. The lock is released when the messages no longer arrive.

2.14.2 Linux desktop

File import by drag-and-drop

It is possible to import files by dragging and dropping them anywhere in the main window of **Enroute Flight Navigation**. The following file types are accepted.

Content	Format	File name
FLARM Test Data	Text	*.txt
Flight Route	GeoJSON	*.geojson
Flight Route	GPX	*.gpx

⁵⁵ <https://www.fairphone.com>

Command line

Rather than importing file by drag-and-drop, file names can also be given when starting **Enroute Flight Navigation** via the Unix command line. The following command line options are supported.

Option	Description
-h, --help	Displays help on commandline options.
--help-all	Displays help including Qt specific options.
-v, --version	Displays version information.
-s	Run simulator and generate screenshots for manual

2.15 Airspace Display

The display of airspace will generally follow the common ICAO symbology.

Note: The Airspace structure at an arbitrary point may be seen by double touching the point on the screen. This will select the point as a waypoint. The waypoint pop-up window shows the information on the waypoint including airspace structure. This technique is also helpful to view the data and vertical limits of special use airspace.

2.15.1 Restricted Airspace

Restricted airspace are surrounded by an intense red dashed line and a thick transparent red line inside the restricted area boundaries. When selecting a point inside the restricted area by double touching the screen the information to the related area is given with the waypoint pop-up window:

- Area Name
- Area altitude limits
- Area activation time

2.15.2 Controlled Airspace

All boundaries of controlled airspace are indicated by a solid blue line and a thick transparent blue line inside the airspace. When selecting a point inside the controlled airspace by double touching the screen the information to the related area is given with the waypoint pop-up window:

- Airspace designation
- Vertical Limits
- Other airspace at location

Note: Communication frequencies are shown in the pop-up window related to the station or aerodrome.

All controlled airspace (Class A – Class D) are shown in the same way even if different restrictions or ATC clearance requirements may be present.

2.15.3 Control Zone

The Control Zone of an airport is indicated by a dashed blue line filled in transparent red color. When selecting a point inside the Control Zone (CTR) by double touching the screen the CTR designation and vertical limit is given within the waypoint pop-up window.

Note: Communication frequencies are shown in the pop-up window related to the station or aerodrome.

2.15.4 Transponder Mandatory Zones

Transponder Mandatory Zones (TMZ) are indicated by a black dashed outline. When selecting a point inside the Transponder Mandatory Zone (TMZ) by double touching the screen the information to the related areas is given with the waypoint pop-up window:

- Area Name
- Area altitude limits
- Monitoring Frequency
- Mode 3 Squawk

2.15.5 Radio Mandatory Zone

Radio Mandatory Zones (RMZ) are indicated by a solid blue dashed outline and filled in transparent blue. When selecting a point inside the Radio Mandatory Zone (RMZ) by double touching the screen the information to the related area is given with the waypoint pop-up window:

- Area Name
- Area altitude limits
- Radio Frequency

2.15.6 Parachute Jumping Areas

Parachute Jumping Exercise areas (PJE) are indicated with a solid red dashed outline. When selecting a point inside the PJE by double touching the screen the information to the related area is given with the waypoint pop-up window:

- Area Name
- Area altitude limits
- Radio Frequency

2.15.7 Nature Reserve Areas

Nature Reserve Areas (NRA) are indicated with a solid green outline. When selecting a point inside the NRA by double touching the screen the information to the related area is given with the waypoint pop-up window:

- Area Name
- Area altitude limits

Caution: Check restrictions applicable for flying inside NRA when planning your flight. For example in Austria high fines are applicable when flying inside NRA.

2.15.8 Airfields

The symbology used to display airfields follows the ICAO rules. When selecting an airfield by double touching the screen the related Airfield Information is given in a pop-up window:

- Airfield Name and Identifier
- Radio Frequency including COM and Information frequencies
- Navaid frequencies
- Runway orientation, dimensions and surface
- Field elevation
- Data for associated airspace
- Approach and Departure Routes

Approach routes to airfields are shown as solid blue lines. The designation of the route is written along the paths. The associated reporting points are shown as blue triangles with a dashed circle and the reporting point designation. Approach Routes will be shown by a solid line and Departure Routes will be shown as dashed lines.

Note: Approach Routes will only be displayed when zooming into the area.

2.15.9 Traffic Pattern

Traffic pattern for motorized aircraft are shown as blue lines. Traffic circuits for gliders or Ultralight aircraft are shown as red lines. Entry and exit routes to traffic pattern are indicated by open ends of the pattern. The traffic circuit will show the traffic circuit altitude when the information is available.

Note: Traffic pattern will only be displayed when zooming into the area.

2.16 Route Planning

2.16.1 Waypoints

Waypoints are the central element of aeronautical navigation. A waypoint is selected by touching the moving map at the location of the waypoint display. When a waypoint is selected a pop up window will show detailed information of the waypoint. Waypoints may also be directly added to a route by list selection or search. A waypoint may be directly added from the waypoint pop-up window to the end of the current route by touching the “+” selection at the lower end. The selection of “→ Direct” will overwrite the current route by a route from current location to the selected point. Overwriting the current route has to be confirmed if a route is present.

The following types of Waypoints are available:

- Aerodromes
- Reporting points
- Navaids
- Arbitrary points on the map.

For Aerodromes the full set of information will be displayed:

- Aerodrome symbol indicating type of airport
- Aerodrome designation
- Distance and Bearing to Aerodrome
- Meteorological information if available
- Aerodrome communication information
- Runway direction and length
- Field elevation
- Airspace data

For Reporting Points the following information will be displayed:

- Reporting Point designation
- Distance and bearing to Reporting Point
- Reporting Point communication information
- Airspace data

For Navaids the following information will be displayed:

- Navaid symbol, designation and type
- Distance and bearing to Navaid
- Navaid ID, frequency and elevation
- Airspace data

For Arbitrary Points the following information will be displayed:

- Point designation if manually entered
- Distance and bearing to Point
- Airspace data

2.16.2 Flight Routes

Enroute Flight Navigation provides direct planning of one flight Route. A Route will remain present until it is cleared. Route planning is entered via the Menu point Route. The Menu is entered via the Menu symbol in the upper left corner of the map area. Then the Route symbol has to be touched to go to the Route area.

A Route may be planned in the following ways:

- “Add Waypoint” in the Route window will open a selection window for a waypoint and add the selected waypoint to the route.
- “+” symbol in the waypoint details pop-up window will add the waypoint to the last position of the Route.
- “Direct” in the waypoint details pop-up window will provide a Route between current position and desired waypoint

Note: The designation of a Waypoint may be changed after touching the pencil symbol in waypoint line of the Route screen.

The Route Display will show the following information:

- Symbol of the waypoint
- Designation of the waypoint
- Route Point Menu
- **Navigation Data**
 - Distance between way points
 - Time calculated between way points using the cruise speed set in the “Aircraft and Wind” page
 - True Course between way points
 - True Heading between way points

Note: A Route may also be imported from a GPX file from another PC. After sending the GPX file as Email attachment Enroute Flight Navigation will offer to open the GPX file.

The Route Point Menu provides the option to:

- Move a waypoint up in the Route
- Move a waypoint down in the Route
- Remove a waypoint from the Route

The Route Menu is entered by touching the Route Menu Symbol on the Route page. For Arbitrary Points the standard designation “Waypoint” may be changed by touching the pencil symbol and entering a designation.

The following options are available from the Route Menu:

- Open a previously stored route from the library
- Save the current route to the library
- View the route library
- Share the Route in JSON or GPX format
- Open the Route in another APP using the JSON or GPX format

Enroute Flight Navigation

- Clear Route
- Reverse Route

The previously created and stored routes will be kept in a data base within Enroute Flight Navigation. Routes consist of the data for the selected way points. The Route data may be exported for use in other applications.

The Route display has 3 Sub windows:

- Route
- Wind
- ACFT

At the lower end of the route window the calculated data of the total route will be displayed:

- Total Distance
- Total flight time
- Fuel consumed

Warning: Make sure wind and aircraft speed are correct. Failure to enter correct data will result in wrong route time and fuel consumed calculation. The route time and fuel consumed are calculated using the aircraft speed and wind entered at previously.

2.16.3 Route – Aircraft and Wind

The Aircraft and Wind sub-pages of the Route page allows to enter aircraft performance and wind data required for navigational calculations. The aircraft data will be used to determine the distance of the flight and the true course. The Wind data will be used to calculate the true heading and duration of the flight. The duration of the flight will determine the fuel used. Enroute Flight Navigation only offers a very superficial flight planning and cannot replace a full flight planning, but is only intended to provide quick reference.

Note: Aircraft and wind data will be automatically kept in memory. For any calculation the aircraft and wind data entered at last occasion will be used.

Warning: Always perform a full flight preparation in accordance with the flight manual of the aircraft used. The use of Enroute Flight Navigation as primary flight planning may cause accidents leading to loss of lives.

The Wind sub-page of the Route page offers the following input fields:

- Direction in degrees
- Speed in knots

Only one speed, fuel consumption and wind may be entered for the whole route.

The Aircraft sub-page of the Route page offers the following input fields:

- **Aircraft**
 - Cruise Speed: Average Speed for Route
 - Descent Speed: Allows to enter a different speed for the descent phase (Currently not used)
 - Fuel Consumption: Average Fuel consumption per hour

Part I

Appendix

2.17 Software license

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Version 3, 29 June 2007

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2.18 Third party software and data

Enroute Flight Navigation builds on numerous open-source software components and on open-source data.

2.18.1 Geographic maps

As a flight navigation program, Enroute Flight Navigation heavily relies on geographic map data. The geographic maps are not included in the program, but are downloaded at runtime. They are compiled from the following sources.

- The base maps are modified data from OpenMapTiles⁵⁷, published under a CC-BY 4.0 design license⁵⁸.
- The aviation maps contain data from openAIP⁵⁹, licensed under a CC BY-NC-SA license⁶⁰.
- The aviation maps contain data from open flightmaps⁶¹, licensed under the OFMA General Users' License⁶².

⁵⁷ <https://github.com/openmaptiles/openmaptiles>

⁵⁸ <https://github.com/openmaptiles/openmaptiles/blob/master/LICENSE.md>

⁵⁹ <http://www.openaip.net>

⁶⁰ <https://creativecommons.org/licenses/by-nc-sa/3.0/>

⁶¹ <https://www.openflightmaps.org/>

⁶² <https://www.openflightmaps.org/live/downloads/20150306-LCN.pdf>

2.18.2 Software and data included in the program

Depending on platform and configuration, the following components might be included in the installation of **Enroute Flight Navigation**.

- Adobe Glyph List For New Fonts⁶³. BSD 3-Clause “New” or “Revised” License.
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- Easing Equations by Robert Penner⁷⁷. BSD 3-clause “New” or “Revised” License.
- Efficient Binary-Decimal and Decimal-Binary Conversion Routines for IEEE Doubles⁷⁸. BSD 3-clause “New” or “Revised” License.

⁶³ <https://github.com/adobe-type-tools/agl-aglf>

⁶⁴ <http://angleproject.org/>

⁶⁵ <http://www.freetype.org>

⁶⁶ <https://www.gnome.org/fonts/>

⁶⁷ <http://www.boost.org>

⁶⁸ <https://github.com/raptor/clip2tri>

⁶⁹ <http://www.angusj.com/delphi/clipper.php>

⁷⁰ <https://github.com/kkaefer/css-color-parser-cpp>

⁷¹ <https://curl.haxx.se>

⁷² <http://zlib.net/>

⁷³ <https://dejavu-fonts.github.io/>

⁷⁴ <https://github.com/mapbox/earcut.hpp>

⁷⁵ <https://github.com/mapbox/earcut.hpp>

⁷⁶ <https://earth-info.nga.mil>

⁷⁷ <http://robertpenner.com/easing/>

⁷⁸ <https://github.com/google/double-conversion>

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- forkfd. MIT License.
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- kdbush.hpp⁹⁸. ISC License.
- libdbus-1 headers⁹⁹. Academic Free License v2.1, or GNU General Public License v2.0 or later.
- LibJPEG-turbo¹⁰⁰. Independent JPEG Group License.

⁷⁹ <https://github.com/FortAwesome/Font-Awesome>

⁸⁰ <https://github.com/freebsd/freebsd/>

⁸¹ <http://www.freetype.org>

⁸² <http://www.freetype.org>

⁸³ <http://www.freetype.org>

⁸⁴ <http://www.freetype.org>

⁸⁵ <https://github.com/mapbox/geojson-cpp>

⁸⁶ <https://github.com/mapbox/geojson-vt-cpp>

⁸⁷ <https://github.com/mapbox/geometry.hpp>

⁸⁸ <https://github.com/mapbox/geosimplify-js>

⁸⁹ <https://github.com/google/fonts>

⁹⁰ <https://fonts.google.com/icons>

⁹¹ <https://gradle.org>

⁹² <https://github.com/microsoft/GSL>

⁹³ <http://harfbuzz.org>

⁹⁴ <https://wiki.linuxfoundation.org/accessibility/iaccessible2/>

⁹⁵ <https://trac.webkit.org/wiki/JavaScriptCore>

⁹⁶ <https://github.com/jquery/jquery>

⁹⁷ <https://github.com/KDAB/KDSingleApplication>

⁹⁸ <https://github.com/mourner/kdbush.hpp>

⁹⁹ <https://www.freedesktop.org/wiki/Software/dbus/>

¹⁰⁰ <http://libjpeg-turbo.virtualgl.org/>

- LibPNG¹⁰¹. libpng License and PNG Reference Library version 2.
- Linux Performance Events¹⁰². GNU General Public License v2.0 only with Linux Syscall Note.
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- protozero¹²⁰. BSD 2-clause “Simplified” License.
- QEventDispatcher on macOS. BSD 3-clause “New” or “Revised” License.

¹⁰¹ <http://www.libpng.org/pub/png/libpng.html>

¹⁰² <https://www.kernel.org>

¹⁰³ <https://github.com/olivermn/lunr.js>

¹⁰⁴ <https://github.com/mapbox/mapbox-gl-native>

¹⁰⁵ <https://github.com/google/material-design-icons>

¹⁰⁶ <https://github.com/bashtage/sphinx-material/>

¹⁰⁷ <https://github.com/mity/md4c>

¹⁰⁸ <https://github.com/nnaumenko/metaf>

¹⁰⁹ <https://bitbucket.org/alekseyt/nunicode.git>

¹¹⁰ <https://www.khronos.org/>

¹¹¹ <https://www.khronos.org/>

¹¹² <https://www.openssl.org>

¹¹³ <https://github.com/akrzemil/Optional>

¹¹⁴ <https://github.com/maputnik/osm-liberty>

¹¹⁵ <http://www.pcre.org/>

¹¹⁶ <http://www.pcre.org/>

¹¹⁷ <http://www.pixman.org/>

¹¹⁸ <http://code.google.com/p/poly2tri/>

¹¹⁹ <https://github.com/mapbox/polylabel>

¹²⁰ <https://github.com/mapbox/protozero>

- [QHttpEngine](#)¹²¹. MIT License.
- [Qt Toolkit, Libraries and Modules](#)¹²². GNU General Public License v3.0.
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- [tao_tuple](#)¹³³. MIT License.
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- Text Codec: EUC-KR. BSD 2-clause “Simplified” License.
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- [underscore](#)¹³⁶. MIT License.

¹²¹ <https://github.com/nitroshare/qhttpengine>

¹²² <https://qt.io>

¹²³ <http://rapidjson.org>

¹²⁴ <http://www.dominik-reichl.de/projects/csha1/>

¹²⁵ <https://angularjs.org/>

¹²⁶ <https://github.com/mapbox/shelf-pack-cpp>

¹²⁷ <https://www.sqlite.org/>

¹²⁸ <http://www.color.org/>

¹²⁹ <https://github.com/buelowp/sunset>

¹³⁰ <https://github.com/mapbox/supercluster.hpp>

¹³¹ http://tango.freedesktop.org/Tango_Desktop_Project

¹³² <https://www.deviantart.com/darkobra/art/Tango-Weather-Icon-Pack-98024429>

¹³³ <https://github.com/taocpp/>

¹³⁴ <http://publicsuffix.org/>

¹³⁵ <https://github.com/intel/tinycbor>

¹³⁶ <https://github.com/jashkenas/underscore>

- Unicode Character Database (UCD)¹³⁷. Unicode License Agreement - Data Files and Software (2016).
- Unicode Common Locale Data Repository (CLDR)¹³⁸. Unicode License Agreement - Data Files and Software (2016).
- unique_resource¹³⁹. Boost Software License 1.0.
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- XCB-XInput¹⁴⁸. MIT License.
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2.19 Technical Notes

2.19.1 Traffic Data Receiver support

Communication

Enroute Flight Navigation expects that the traffic receiver deploys a WLAN network via Wi-Fi and publishes traffic data via that network. In order to support a wide range of devices, including flight simulators, the app listens to several network addresses simultaneously and understands a variety of protocols.

Enroute Flight Navigation watches the following data channels, in order of preference.

- A TCP connection to port 2000 at the IP addresses 192.168.1.1, where the app expects a stream of FLARM/NMEA sentences.
- A TCP connection to port 2000 at the IP addresses 192.168.10.1, where the app expects a stream of FLARM/NMEA sentences.
- A UDP connection to port 4000, where the app expects datagrams in GDL90 or XGPS format.
- A UDP connection to port 49002, where the app expects datagrams in GDL90 or XGPS format.

¹³⁷ <https://www.unicode.org/ucd/>

¹³⁸ <http://cldr.unicode.org/>

¹³⁹ https://github.com/okdshin/unique_resource

¹⁴⁰ <http://valgrind.org/>

¹⁴¹ <https://github.com/mapbox/variant>

¹⁴² <https://github.com/mapbox/vector-tile>

¹⁴³ <https://www.khronos.org/>

¹⁴⁴ <https://github.com/GPUOpen-LibrariesAndSDKs/VulkanMemoryAllocator>

¹⁴⁵ <https://github.com/mapbox/wagyu>

¹⁴⁶ <https://webgradients.com/>

¹⁴⁷ <https://www.x.org/>

¹⁴⁸ <https://xcb.freedesktop.org/>

Enroute Flight Navigation

Enroute Flight Navigation expects traffic data in the following formats.

- FLARM/NMEA sentences must conform to the specification outlined in the document FTD-012 Data Port Interface Control Document (ICD)¹⁴⁹, Version 7.13, as published by FLARM Technology Ltd.¹⁵⁰.
- Datagrams in GDL90 format must conform to the GDL 90 Data Interface Specification¹⁵¹.
- Datagrams in XGPS format must conform to the format specified on the ForeFlight Web site¹⁵².

Known issues with GDL90

The GDL90 protocol has a number of shortcomings, and we recommend to use FLARM/NMEA whenever possible. We are aware of the following issues.

Altitude measurements

According to the GDL90 Specification, the ownship geometric height is reported as height above WGS-84 ellipsoid. There are however many devices on the market that wrongly report height above main sea level. Different apps have different strategies to deal with these shortcomings.

- **Enroute Flight Navigation** as well as the app Skydemon expect that traffic receivers comply with the GDL90 Specification.
- ForeFlight has extended the GDL90 Specification so that traffic receivers can indicate if they comply with the specification or not.
- Many other apps expect wrong GDL90 implementations and interpret the geometric height has height above main sea level.

MODE-S traffic

Most traffic receivers see traffic equipped with MODE-S transponders and can give an estimate for the distance to the traffic. They are, however, unable to obtain the precise traffic position. Unlike FLARM/NMEA, the GDL90 Specification does not support traffic factors whose position is unknown. Different devices implement different workarounds.

- Stratux devices generate a ring of eight virtual targets around the own position. These targets are named “Mode S”.
- Air Avionics devices do the same, but only with one target.
- Other devices create a virtual target, either at the ownship position or at the north pole and abuse the field “Navigation Accuracy Category for Position” to give the approximate position to the target.

Enroute Flight Navigation has special provisions for handling targets called “Mode S”, but users should expect that this workaround is not perfect.

¹⁴⁹ <https://flarm.com/support/manuals-documents/>

¹⁵⁰ <https://flarm.com/>

¹⁵¹ https://www.faa.gov/nextgen/programs/adsb/archival/media/gdl90_public_icd_reva.pdf

¹⁵² <https://www.foreflight.com/support/network-gps/>

ForeFlight Broadcast

Following the standards established by the app ForeFlight, **Enroute Flight Navigation** broadcasts a UDP message on port 63093 every 5 seconds while the app is running in the foreground. This message allows devices to discover Enroute's IP address, which can be used as the target of UDP unicast messages. This broadcast will be a JSON message, with at least these fields:

```
{
  "App": "Enroute Flight Navigation",
  "GDL90": {
    "port": 4000
  }
}
```

The GDL90 “port” field is currently 4000, but might change in the future.

Known issues with SkyEcho devices

Enroute Flight Navigation works fine with SkyEcho devices. There are, however, several shortcomings that users should be aware of.

Unidirectional FLARM

The SkyEcho can receive FLARM signals, but cannot send them. The SkyEcho device cannot be seen by other FLARM users. The author of **Enroute Flight Navigation** is not convinced that unidirectional FLARM is a good idea.

FLARM Output

uAvionix follows an unusual business model. The FLARM/NMEA output of the SkyEcho is encrypted. To read the FLARM data, all apps need to include commercial, closed-source decryption libraries that must be purchased by the app users. The author of **Enroute Flight Navigation** feels that this is incompatible with the idea of free, open source software.

To communicate with SkyEcho devices, **Enroute Flight Navigation** will switch to the GDL90 protocol.

Altimeter readings

SkyEcho includes an integrated barometric altimeter, but does not have any access to static pressure. To estimate the barometric altitude, the SkyEcho correlates cabin pressure altitude to altitudes of nearby traffic. The author of **Enroute Flight Navigation** is not convinced that this method gives altimeter readings that are sufficiently reliable for aviation purposes.

2.20 Privacy policies

The app **Enroute Flight Navigation** has been designed to not send any data to us. We do not track our users. We do not collect data. However, note the following.

- The app contains third-party software components, including map rendering software from MapBox, Inc. While we have checked that no data is collected by these components, there is a chance that we overlooked something.

2.20.1 Internet access

The app accesses internet sites that may not be under our control. These sites may keep access logs or track their users.

- The app downloads maps and data from the server cplx.vm.uni-freiburg.de at the University of Freiburg. The app will also connect to this server to check for updates.
- The app downloads METAR/TAF weather data from the Aviation Weather Center¹⁵³, a website of the United States government. In order to provide relevant data, the app sends your location and your current route to the Aviation Weather Center at regular intervals.

2.20.2 Privileges of the Android app

The Android app requires the following privileges.

- ACCESS_COARSE_LOCATION and ACCESS_FINE_LOCATION – Accessing the device's location is clearly necessary for a navigation app.
- ACCESS_NETWORK_STATE and ACCESS_WIFI_STATE – Required to automatically connect to traffic receivers.
- CHANGE_WIFI_MULTICAST_STATE – The app receives traffic and position information from traffic data receivers and flight simulators via UDP network broadcasts. This privilege is required to receive the relevant data packages.
- INTERNET – This privilege is required to download and update map, data and METAR/TAF reports.
- VIBRATE – The app vibrates your device, for instance to give haptic feedback for key presses.
- WAKE_LOCK – Required to maintain WiFi connections to traffic data receivers even when the device display is off.
- WRITE_EXTERNAL_STORAGE and READ_EXTERNAL_STORAGE – This privilege is required to store the flight map library in a globally accessible directory. This ensures that the library persists when the app is uninstalled or reinstalled. It also ensures that other apps, such as file managers or file synchronization software, can access the data.

¹⁵³ <https://www.aviationweather.gov>