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# **Enroute Flight Navigation**

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## Getting started

<b>1</b>	<b>Think before you fly</b>	<b>3</b>
<b>2</b>	<b>Installation and setup</b>	<b>5</b>
<b>3</b>	<b>Before your first flight</b>	<b>7</b>
<b>4</b>	<b>Connect your traffic receiver</b>	<b>11</b>
<b>5</b>	<b>Connect your flight simulator</b>	<b>15</b>
<b>6</b>	<b>Make a donation</b>	<b>21</b>
<b>7</b>	<b>Map Data</b>	<b>23</b>
<b>8</b>	<b>Platform notes</b>	<b>27</b>
<b>I</b>	<b>Appendix</b>	<b>29</b>
<b>9</b>	<b>Software license</b>	<b>31</b>
<b>10</b>	<b>Third party software and data</b>	<b>43</b>
<b>11</b>	<b>Technical Notes</b>	<b>49</b>





**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/)<sup>1</sup>, 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 near-weekly 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/)<sup>2</sup>.

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.

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<sup>1</sup> <https://akaflieg-freiburg.de/>

<sup>2</sup> <https://www.aviationweather.gov/>



## 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:SER.A.2010<sup>3</sup>

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.

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

### 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.

### 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.

### 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 app](https://dontkillmyapp.com)<sup>4</sup> for more information.

### 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.

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<sup>4</sup> <https://dontkillmyapp.com>



## Installation and setup

### 2.1 App installation

**Installation on Android devices** **Enroute Flight Navigation** is available as an Android App in the [Google Play Store](#)<sup>5</sup>.

An unofficial version of the app is also available at [F-Droid](#)<sup>6</sup>. While the author of **Enroute Flight Navigation** endorses publication at F-Droid, he has not tested this unofficial app for quality.

**Installation on Linux desktop machines** **Enroute Flight Navigation** is available for free download at [flathub.org](#)<sup>7</sup> and [snapcraft.io](#)<sup>8</sup>. Most likely you will 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 Map download

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

- Aeronautical maps. These contain airspaces, airfields and nav aids. 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.

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*. The map 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.

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<sup>5</sup> [https://play.google.com/store/apps/details?id=de.akaflieg\\_freiburg.enroute](https://play.google.com/store/apps/details?id=de.akaflieg_freiburg.enroute)

<sup>6</sup> [https://f-droid.org/de/packages/de.akaflieg\\_freiburg.enroute/](https://f-droid.org/de/packages/de.akaflieg_freiburg.enroute/)

<sup>7</sup> [https://flathub.org/apps/details/de.akaflieg\\_freiburg.enroute](https://flathub.org/apps/details/de.akaflieg_freiburg.enroute)

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

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.

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**Note:** Do not forget that you need aeronautical maps **and** base 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.

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## 2.3 Done.

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.

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 any play with the app. Continue with the next section and take it for your first flight.

## 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.

### 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.



Fig. 1: Moving map display on the ground



Fig. 2: Moving map display in flight

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.

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 airspace.**

## 3.2 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 <b>north up</b> and <b>track up</b> .
📍	Center map about own position.
+	Zoom in
-	Zoom out

## 3.3 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. 3: Information about EDFE airport

### 3.4 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*.

## Connect your traffic receiver

In order to display nearby traffic on the moving map, **Enroute Flight Navigation** can connect to your aircraft's traffic receiver (typically a FLARM device).



Fig. 1: Approaching EDTF with traffic

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.

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**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.

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**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.

## 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 Traffic<sup>9</sup>](#) by [Air Avionics<sup>10</sup>](#) with software version 5.

Users reported success with the following traffic receivers.

- [PilotAware Rosetta<sup>11</sup>](#)
- [SkyEcho2<sup>12</sup>](#)
- [Stratux devices<sup>13</sup>](#)
- [TTGO T-Beam devices<sup>14</sup>](#)

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**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 “Technincal Notes” in the appendix for more details.

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## 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. This is currently **not** supported. Set up your device so that no additional password is required.

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<sup>9</sup> [http://www.air-avionics.com/?page\\_id=253](http://www.air-avionics.com/?page_id=253)

<sup>10</sup> <http://www.air-avionics.com/>

<sup>11</sup> <https://www.pilotaware.com/rosetta/>

<sup>12</sup> <https://uavionix.com/products/skyecho/>

<sup>13</sup> <http://stratux.me/>

<sup>14</sup> <https://www.amazon.de/TTGO-T-Beam-915Mhz-Wireless-Bluetooth/dp/B07SFVQ3Z8>



## 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.

### 4.3.1 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.

### 4.3.2 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.

## 4.4 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.



## Connect your flight simulator

**Enroute Flight Navigation** can connect to flight simulator software. The app has been tested with the following programs.

- X-Plane 11<sup>15</sup>

Users have reported success with the following programs.

- Microsoft Flight Simulator (2020)<sup>16</sup>
- X-Plane 10<sup>17</sup>

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

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**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.

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### 5.1 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.

- 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”

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<sup>15</sup> <https://www.x-plane.com/>

<sup>16</sup> <https://www.flightsimulator.com/>

<sup>17</sup> <https://www.x-plane.com/>

## 5.2 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.

### 5.2.1 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 inexpensive EFB-Connector program [XMapsy](http://xmapsy.com/)<sup>18</sup>. Other programs might also work. The following information has kindly been provided by the XMapsy developer.

**Enroute Flight Navigation** works both with the less expensive programm version **XMapsy Essential** and with the full-featured version **XMapsy V3**. Barometric altitude data is however only provided by **XMapsy V3**.

If you use **XMapsy Essential**, then set the “Message-Format” to “XPlane/simulator”. The format is called “XGPS” in this document. The figure *XMapsy settings for the “XPlane/simulator” message format* shows the XMapsy settings dialog.

Fig. 1: XMapsy settings for the “XPlane/simulator” message format

If you use **XMapsy V3**, then set the “Message-Format” to “ADS-B/GDL90”. To receive the correct altitude, be sure

<sup>18</sup> <http://xmapsy.com/>

to check the box “GDL90 ownship geometric altitudes based on MSL”. The figure *XMapsy settings for the “ADS-B/GDL90” message format* shows the XMapsy settings dialog.

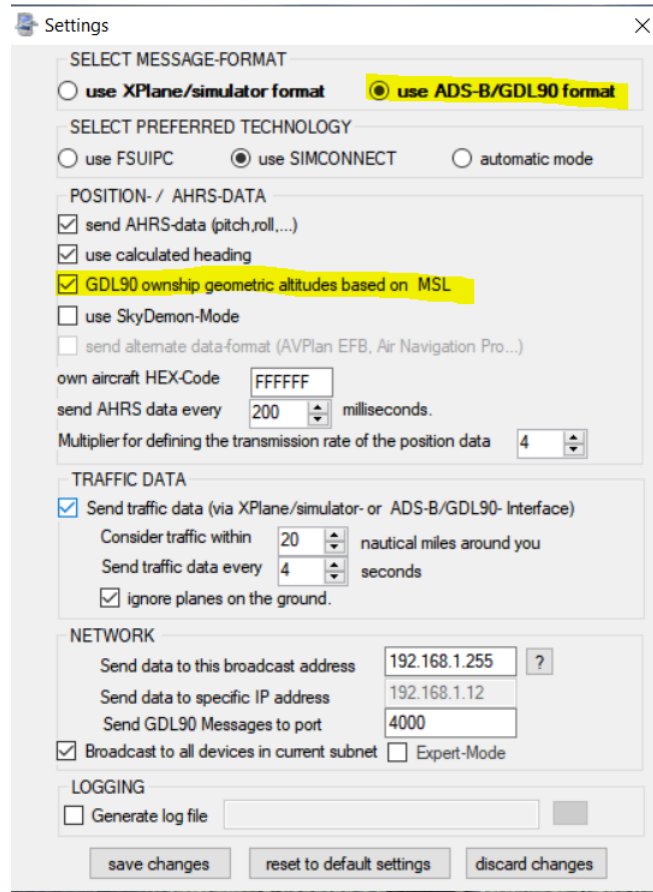
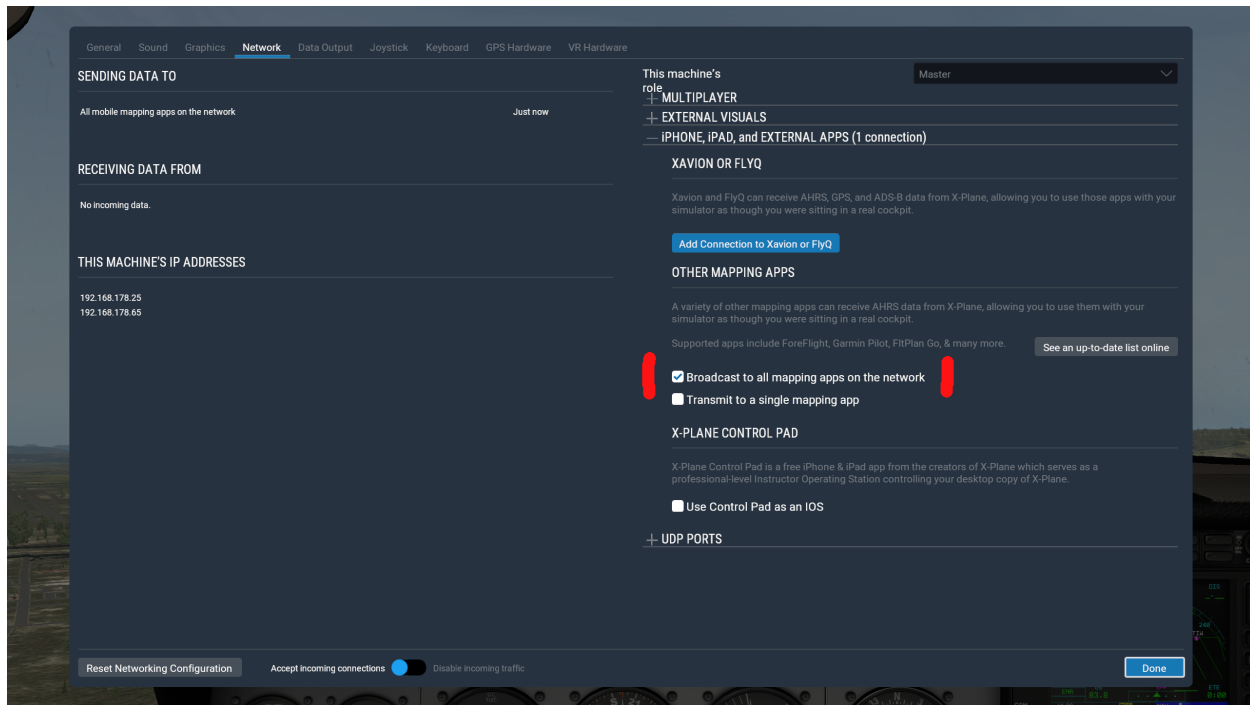


Fig. 2: XMapsy settings for the “ADS-B/GDL90” message format

### 5.2.2 X-Plane 11

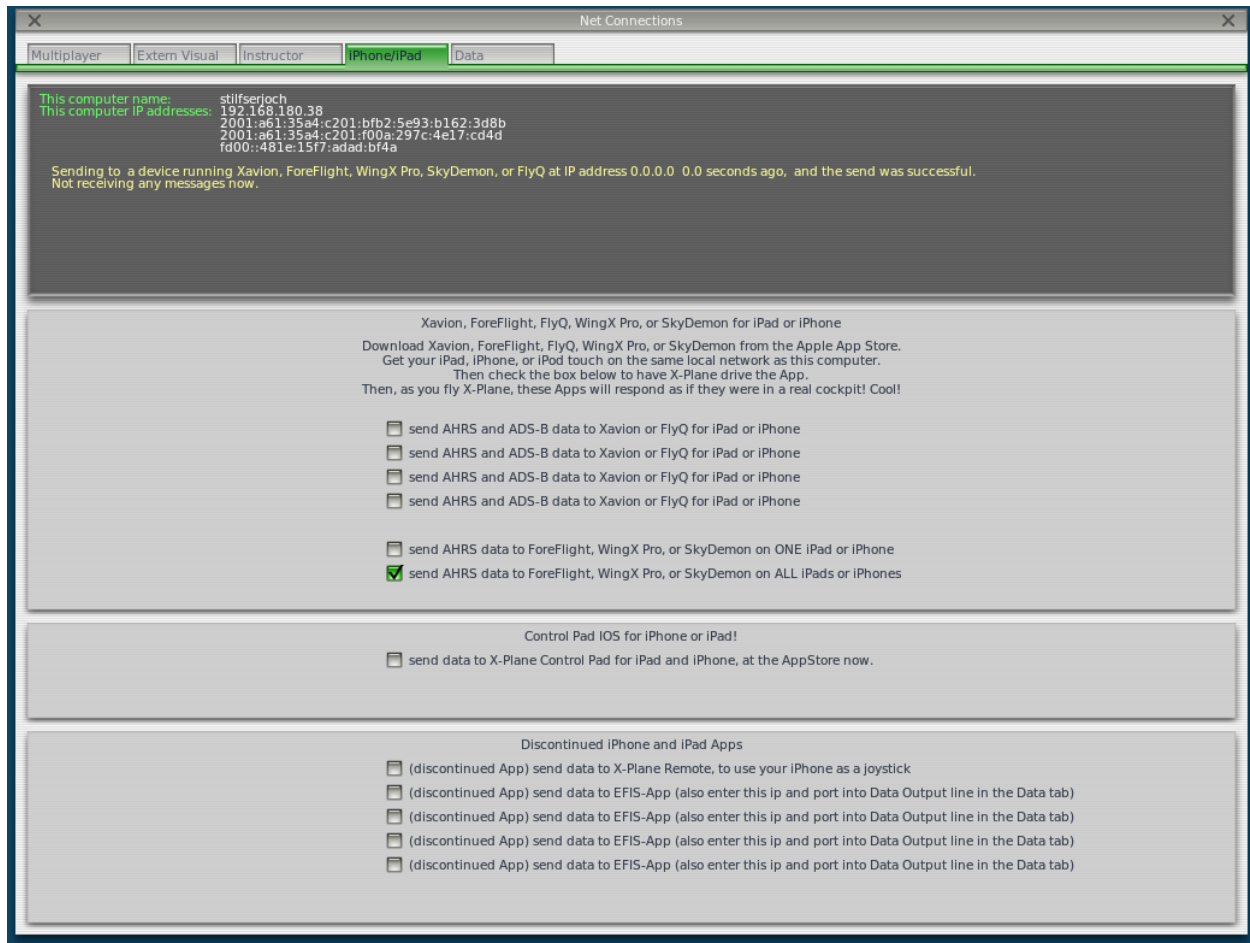
Open the “Settings” window and choose the “Network” tab. Locate the settings group “This machine’s role” on the right-hand side of the tab. Open the section “iPHONE, iPad, and EXTERNAL APPS” and select the item “Broadcast to all mapping apps on the network” under the headline “OTHER MAPPING APPS”.



### 5.2.3 X-Plane 10

Follow the explanation on [this page](https://www.x-plane.com/2012/08/foreflight-charts-supported-in-x-plane-10-10-beta-9/)<sup>19</sup>, 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”.

<sup>19</sup> <https://www.x-plane.com/2012/08/foreflight-charts-supported-in-x-plane-10-10-beta-9/>



## 5.2.4 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.

## 5.3 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.





## Make a donation

**Enroute Flight Navigation** is a non-commercial project of [Akaflieg Freiburg](https://akaflieg-freiburg.de/)<sup>20</sup> and the [University of Freiburg](https://uni-freiburg.de/en/)<sup>21</sup>. 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

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<sup>20</sup> <https://akaflieg-freiburg.de/>

<sup>21</sup> <https://uni-freiburg.de/en/>



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

## 7.1 Base maps

Our base maps are edited versions of maps kindly provided by [Klokan Technologies](https://www.klokantech.com/)<sup>22</sup> through the [OpenMapTiles](https://openmaptiles.org)<sup>23</sup> project.

## 7.2 Aeronautical maps

### 7.2.1 Update policy

Our aeronautical maps are updated once a week.

### 7.2.2 Data origin

The aeronautical maps are compiled from databases provided by the [openAIP](http://openaip.net)<sup>24</sup> and the [open flightmaps](https://www.openflightmaps.org/)<sup>25</sup> 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
Nav aids	openAIP
Procedures (Traffic Circuits, ...)	open flightmaps
Reporting Points	open flightmaps

<sup>22</sup> <https://www.klokantech.com/>

<sup>23</sup> <https://openmaptiles.org>

<sup>24</sup> <http://openaip.net>

<sup>25</sup> <https://www.openflightmaps.org/>

## 7.2.3 List of maps

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

- Class 1 maps are compiled from [openAIP](http://openaip.net)<sup>26</sup> and [open flightmaps](https://www.openflightmaps.org/)<sup>27</sup> data. These maps contain complete information about airspaces, airfields and nav aids. 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 [openAIP](http://openaip.net)<sup>28</sup> data only. They contain complete information about airspaces, airfields and nav aids.

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

Continent	Country	Class
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
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

continues on next page

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<sup>26</sup> <http://openaip.net>

<sup>27</sup> <https://www.openflightmaps.org/>

<sup>28</sup> <http://openaip.net>

Table 1 – continued from previous page

Continent	Country	Class
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



## 8.1 Android

### 8.1.1 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.

### 8.1.2 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.

### 8.1.3 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.

## 8.2 Linux desktop

### 8.2.1 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

### 8.2.2 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 followin 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



## **Part I**

# **Appendix**



## Software license

The program **Enroute Flight Navigation** is licensed under the [GNU General Public License V3<sup>29</sup>](https://www.gnu.org/licenses/gpl-3.0-standalone.html) or, at your choice, any later version of this license.

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Version 3, 29 June 2007

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## Third party software and data

**Enroute Flight Navigation** builds on a large number of open-source software components and on open-source data.

### 10.1 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 [OpenMapTiles](#)<sup>30</sup>, published under a [CC-BY 4.0 design license](#)<sup>31</sup>.
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<sup>30</sup> <https://github.com/openmaptiles/openmaptiles>

<sup>31</sup> <https://github.com/openmaptiles/openmaptiles/blob/master/LICENSE.md>

<sup>32</sup> <http://www.openaip.net>

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<sup>34</sup> <https://www.openflightmaps.org/>

<sup>35</sup> <https://www.openflightmaps.org/live/downloads/20150306-LCN.pdf>

<sup>36</sup> <https://github.com/adobe-type-tools/agl-aglfn>

<sup>37</sup> <http://angleproject.org/>

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<sup>38</sup> <http://www.freetype.org>

<sup>39</sup> <https://www.gnome.org/fonts/>

<sup>40</sup> <http://www.boost.org>

<sup>41</sup> <https://github.com/raptor/clip2tri>

<sup>42</sup> <http://www.angusj.com/delphi/clipper.php>

<sup>43</sup> <https://github.com/kkaefer/css-color-parser-cpp>

<sup>44</sup> <https://curl.haxx.se>

<sup>45</sup> <http://zlib.net/>

<sup>46</sup> <https://dejavu-fonts.github.io/>

<sup>47</sup> <https://github.com/mapbox/earcut.hpp>

<sup>48</sup> <https://github.com/mapbox/earcut.hpp>

<sup>49</sup> <https://earth-info.nga.mil>

<sup>50</sup> <http://robertpenner.com/easing/>

<sup>51</sup> <https://github.com/google/double-conversion>

<sup>52</sup> <https://github.com/FortAwesome/Font-Awesome>

<sup>53</sup> <https://github.com/freebsd/freebsd/>

<sup>54</sup> <http://www.freetype.org>

<sup>55</sup> <http://www.freetype.org>

<sup>56</sup> <http://www.freetype.org>

<sup>57</sup> <http://www.freetype.org>

<sup>58</sup> <https://github.com/mapbox/geojson-cpp>



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<sup>59</sup> <https://github.com/mapbox/geojson-vt-cpp>

<sup>60</sup> <https://github.com/mapbox/geometry.hpp>

<sup>61</sup> <https://github.com/mapbox/geosimplify-js>

<sup>62</sup> <https://github.com/google/fonts>

<sup>63</sup> <https://fonts.google.com/icons>

<sup>64</sup> <https://gradle.org>

<sup>65</sup> <https://github.com/microsoft/GSL>

<sup>66</sup> <http://harfbuzz.org>

<sup>67</sup> <https://wiki.linuxfoundation.org/accessibility/iaccessible2/>

<sup>68</sup> <https://trac.webkit.org/wiki/JavaScriptCore>

<sup>69</sup> <https://github.com/jquery/jquery>

<sup>70</sup> <https://github.com/KDAB/KDSingleApplication>

<sup>71</sup> <https://github.com/mourner/kdbush.hpp>

<sup>72</sup> <https://www.freedesktop.org/wiki/Software/dbus/>

<sup>73</sup> <http://libjpeg-turbo.virtualgl.org/>

<sup>74</sup> <http://www.libpng.org/pub/png/libpng.html>

<sup>75</sup> <https://www.kernel.org>

<sup>76</sup> <https://github.com/olivernn/lunr.js>

<sup>77</sup> <https://github.com/mapbox/mapbox-gl-native>

<sup>78</sup> <https://github.com/google/material-design-icons>

<sup>79</sup> <https://github.com/bashtage/sphinx-material/>

<sup>80</sup> <https://github.com/mity/md4c>

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<sup>81</sup> <https://github.com/nnaumenko/metaf>

<sup>82</sup> <https://bitbucket.org/alekseyt/nunicode.git>

<sup>83</sup> <https://www.khronos.org/>

<sup>84</sup> <https://www.khronos.org/>

<sup>85</sup> <https://www.openssl.org>

<sup>86</sup> <https://github.com/akrzemi1/Optional>

<sup>87</sup> <https://github.com/maputnik/osm-liberty>

<sup>88</sup> <http://www.pcre.org/>

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<sup>90</sup> <http://www.pixman.org/>

<sup>91</sup> <http://code.google.com/p/poly2tri/>

<sup>92</sup> <https://github.com/mapbox/polylabel>

<sup>93</sup> <https://github.com/mapbox/protozero>

<sup>94</sup> <https://github.com/nitroshare/qhttpengine>

<sup>95</sup> <https://qt.io>

<sup>96</sup> <http://rapidjson.org>

<sup>97</sup> <http://www.dominik-reichl.de/projects/csha1/>

<sup>98</sup> <https://angularjs.org/>

<sup>99</sup> <https://github.com/mapbox/shelf-pack-cpp>

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<sup>100</sup> <https://www.sqlite.org/>

<sup>101</sup> <http://www.color.org/>

<sup>102</sup> <https://github.com/buelowp/sunset>

<sup>103</sup> <https://github.com/mapbox/supercluster.hpp>

<sup>104</sup> [http://tango.freedesktop.org/Tango\\_Desktop\\_Project](http://tango.freedesktop.org/Tango_Desktop_Project)

<sup>105</sup> <https://www.deviantart.com/darkobra/art/Tango-Weather-Icon-Pack-98024429>

<sup>106</sup> <https://github.com/taocpp/>

<sup>107</sup> <http://publicsuffix.org/>

<sup>108</sup> <https://github.com/intel/tinycbor>

<sup>109</sup> <https://github.com/jashkenas/underscore>

<sup>110</sup> <https://www.unicode.org/ucd/>

<sup>111</sup> <http://cldr.unicode.org/>

<sup>112</sup> [https://github.com/okdshin/unique\\_resource](https://github.com/okdshin/unique_resource)

<sup>113</sup> <http://valgrind.org/>

<sup>114</sup> <https://github.com/mapbox/variant>

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<sup>117</sup> <https://github.com/GPUOpen-LibrariesAndSDKs/VulkanMemoryAllocator>

<sup>118</sup> <https://github.com/mapbox/wagyu>

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<sup>120</sup> <https://www.x.org/>

<sup>121</sup> <https://xcb.freedesktop.org/>

## 11.1 Traffic Receiver

### 11.1.1 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.

**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 \(ICD\)](#)<sup>122</sup>, Version 7.13, as published by [FLARM Technology Ltd.](#)<sup>123</sup>.
- Datagrams in GDL90 format must conform to the [GDL 90 Data Interface Specification](#)<sup>124</sup>.
- Datagrams in XGPS format must conform to the format specified on the [ForeFlight Web site](#)<sup>125</sup>.

---

<sup>122</sup> <https://flarm.com/support/manuals-documents/>

<sup>123</sup> <https://flarm.com/>

<sup>124</sup> [https://www.faa.gov/nextgen/programs/adsb/archival/media/gdl90\\_public\\_icd\\_reva.pdf](https://www.faa.gov/nextgen/programs/adsb/archival/media/gdl90_public_icd_reva.pdf)

<sup>125</sup> <https://www.foreflight.com/support/network-gps/>

### 11.1.2 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 as 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.

### 11.1.3 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.