Enroute Flight Navigation

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Getting started

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[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 near-weekly updates and cover large parts of the world.

Enroute Flight Navigation includes flight weather data downloaded from the NOAA - Aviation Weather Center[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/

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.2010[3]

> 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.

[3] 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 excempt 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[4] 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.

[4] https://dontkillmyapp.com

2 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[5].

An unofficial version of the app is also available at F-Droid[6]. 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[7] and snapcraft.io[8]. 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 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.

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.

[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

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 **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.

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.

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.

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.

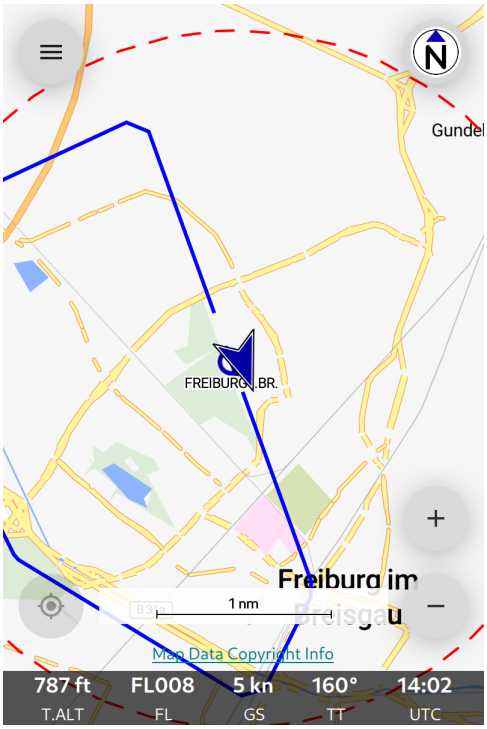

Fig. 1: Moving map display on the ground

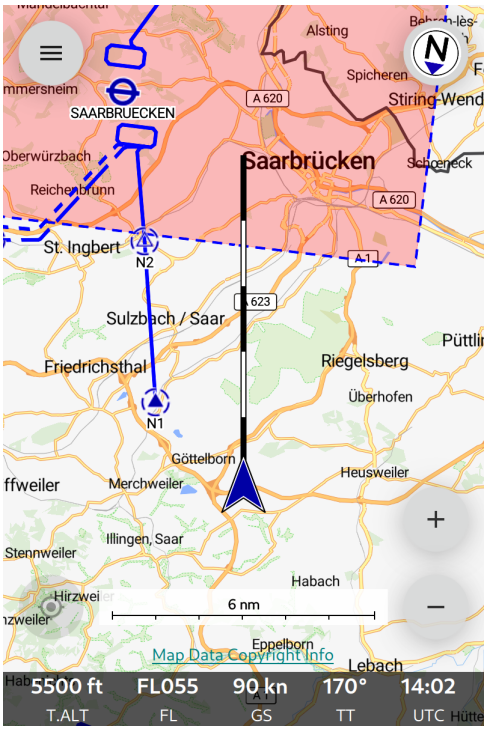

Fig. 2: Moving map display in flight

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 airspaces.**

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 **north up** and **track up**.
	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.

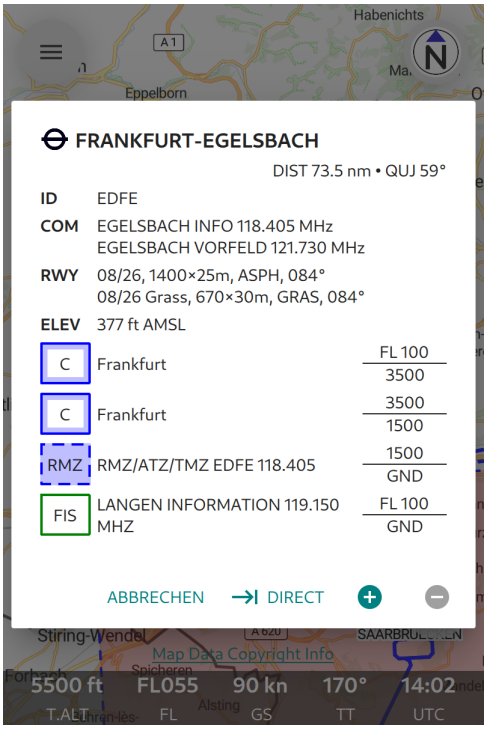

Fig. 3: Information about EDFE airport

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*.

4 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).

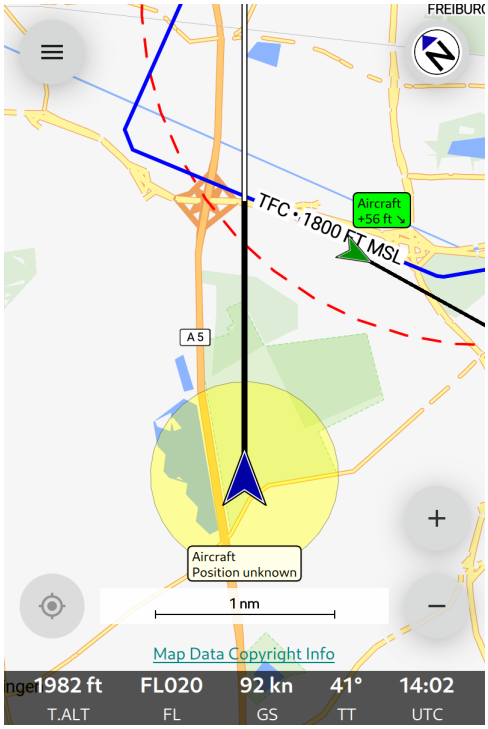

Fig. 1: Approaching EDTF with traffic

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.

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

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[9] by Air Avionics[10].
- PowerFLARM Core[11] by FLARM Technology Ltd[12], and AIR Connect[13] WiFi Adaptor by Air Avionics[14].

Users reported success with the following traffic receivers.

- PilotAware Rosetta[15]
- SkyEcho2[16] – but see the Section *Known issues with SkyEcho devices*
- Stratux devices[17]
- TTGO T-Beam devices[18]

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.

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.

[9] http://www.air-avionics.com/?page_id=253
[10] http://www.air-avionics.com/
[11] https://flarm.com/flarm-product/powerflarm-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/
[16] https://uavionix.com/products/skyecho/
[17] http://stratux.me/
[18] 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.

5 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.

- *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.

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"

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 following EFB-connector programs.

- fs2ff[19] (free, open source)
- XMapsy Essential[20] (commercial, inexpensive, does not provide barometric altitude data).
- XMapsy V3[21] (commercial, more expensive, provides barometric altitude data).

The web site of the commerical EFB program ForeFlight[22] lists additional EFB-connector programs that might also work.

Note: In MSFS2020 cold and dark mode, traffic in the air will not been 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.

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fs2ff The program fs2ff[23] does not require any complicated installation or setup, just download and run. The latest release of fs2ff can be downloaded here[24]. Detailed instruction are found here[25]. The figure *fs2ff settings* shows extremely simple settings window.

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.

XMapsy V3 If you use XMapsy V3, set the "Message-Format" to "ADS-B/GDL90" and the "Preferred Technology" to SIMCONNECT. 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.

[19] https://github.com/astenlund/fs2ff
[20] http://xmapsy.com/
[21] http://xmapsy.com/
[22] https://foreflight.com/support/support-center/category/about-foreflight-mobile/204115275
[23] https://github.com/astenlund/fs2ff
[24] https://github.com/astenlund/fs2ff/releases/latest
[25] https://github.com/astenlund/fs2ff#fs2ff-flight-simulator-to-foreflight

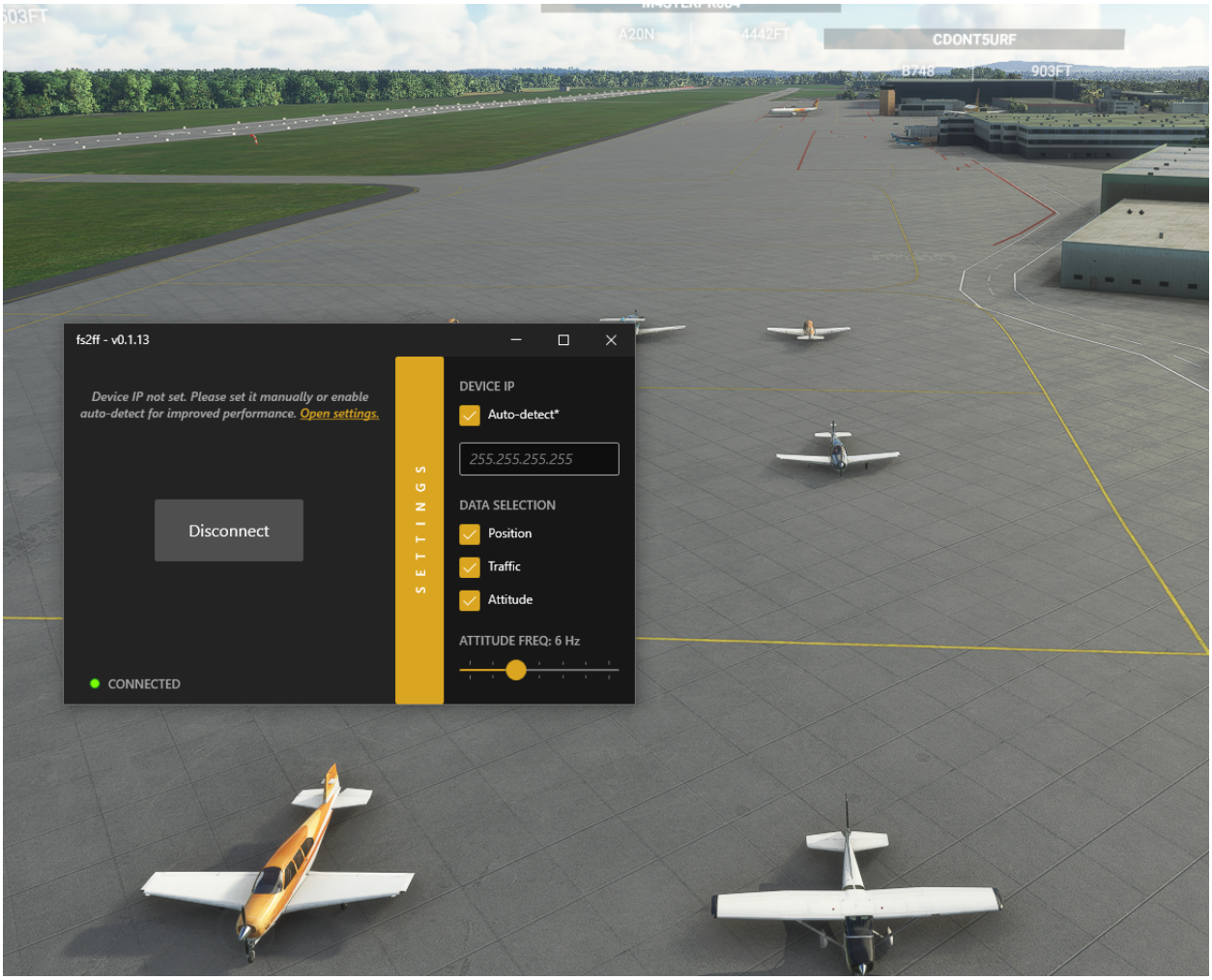


Fig. 1: fs2ff settings

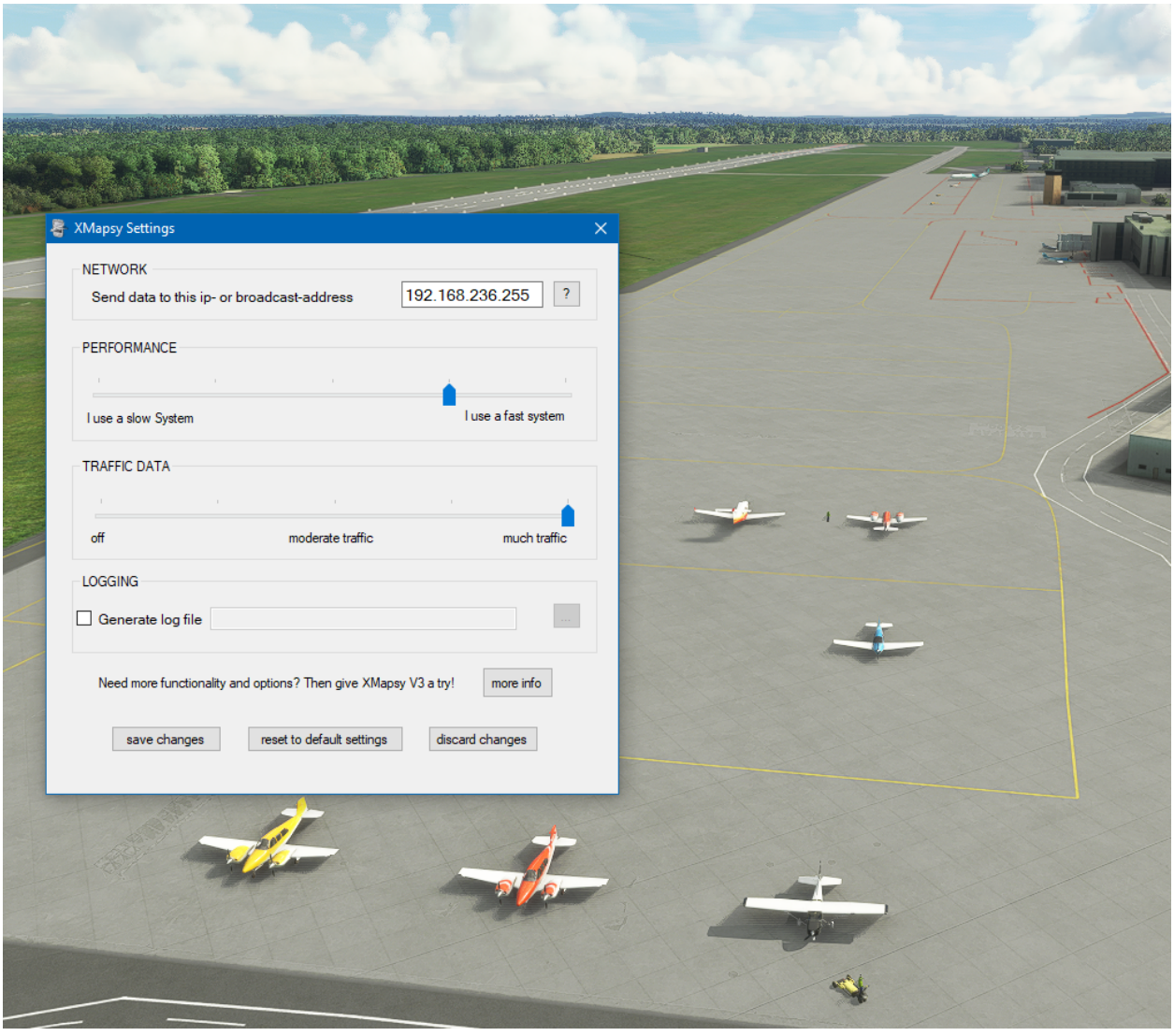


Fig. 2: XMapsy Essential settings

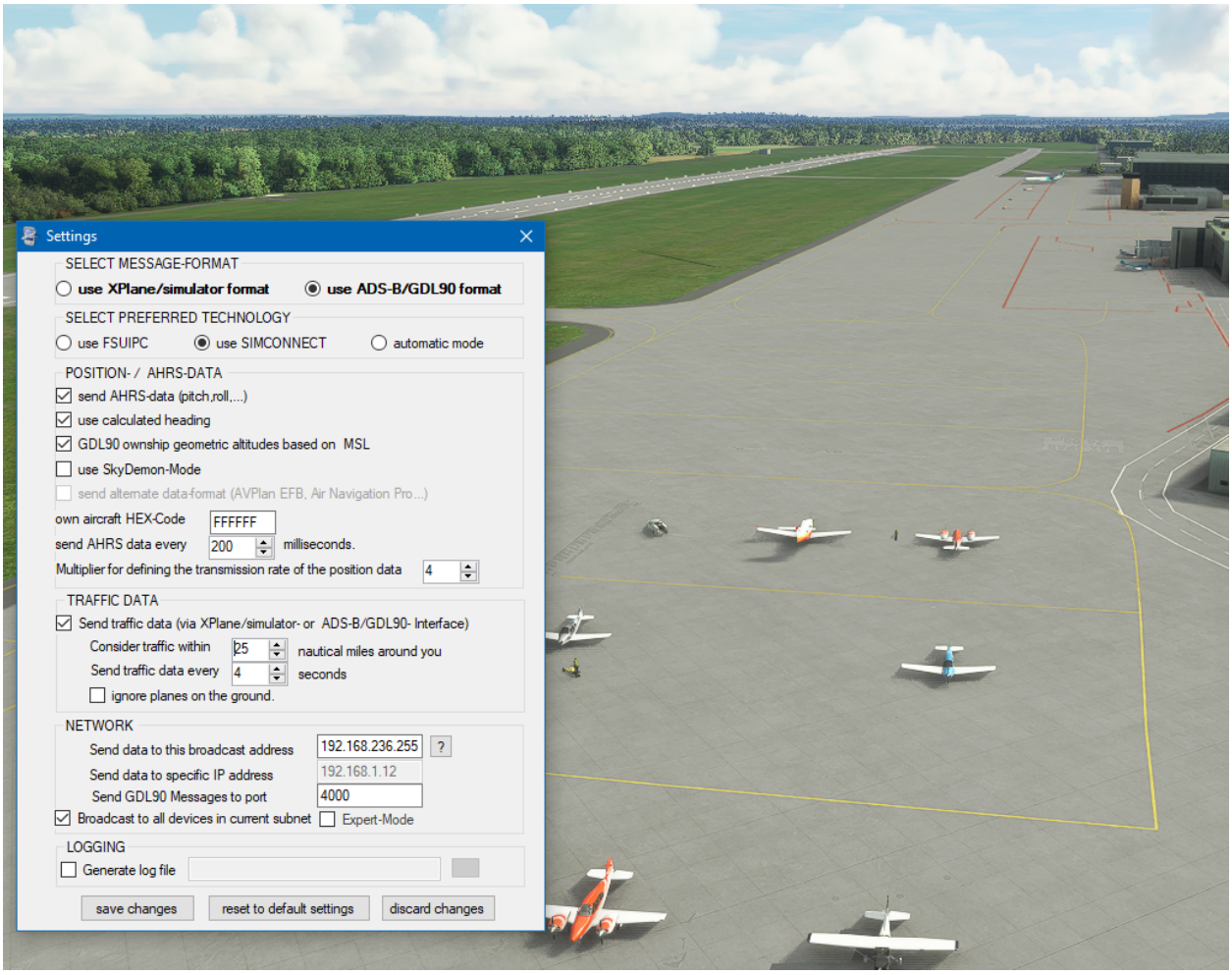
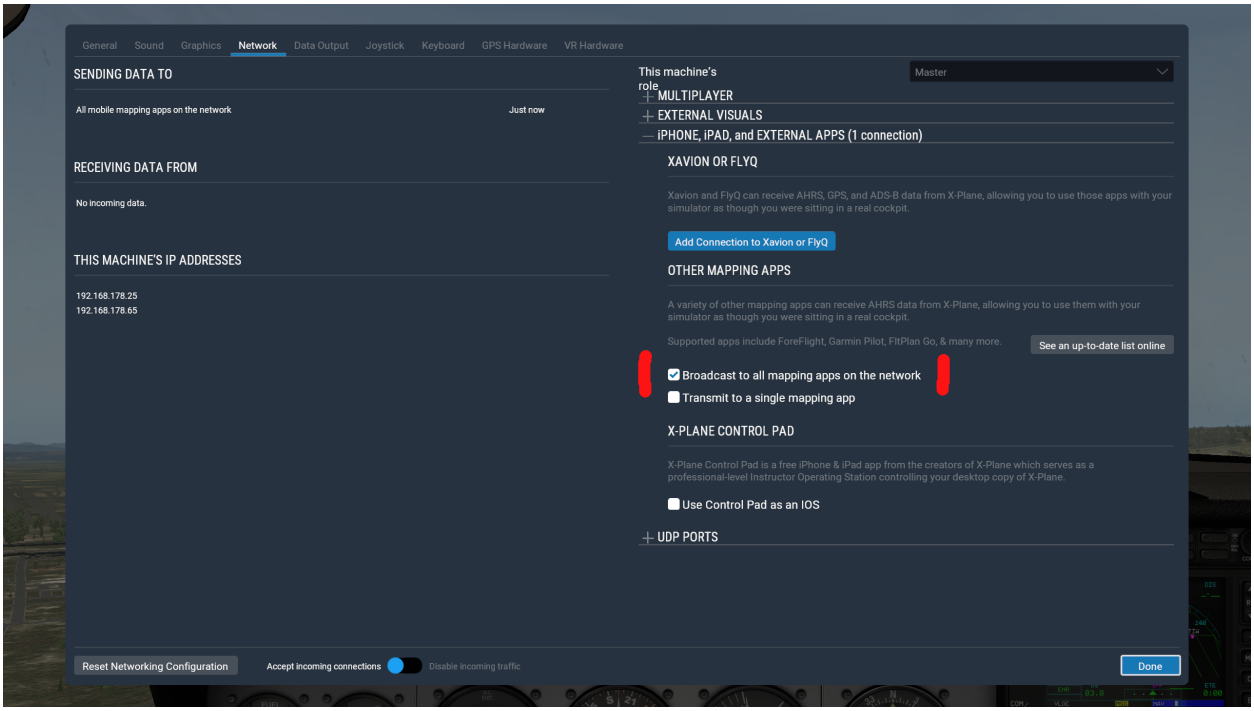


Fig. 3: XMapsy V3 settings

5.2.2 X-Plane 11

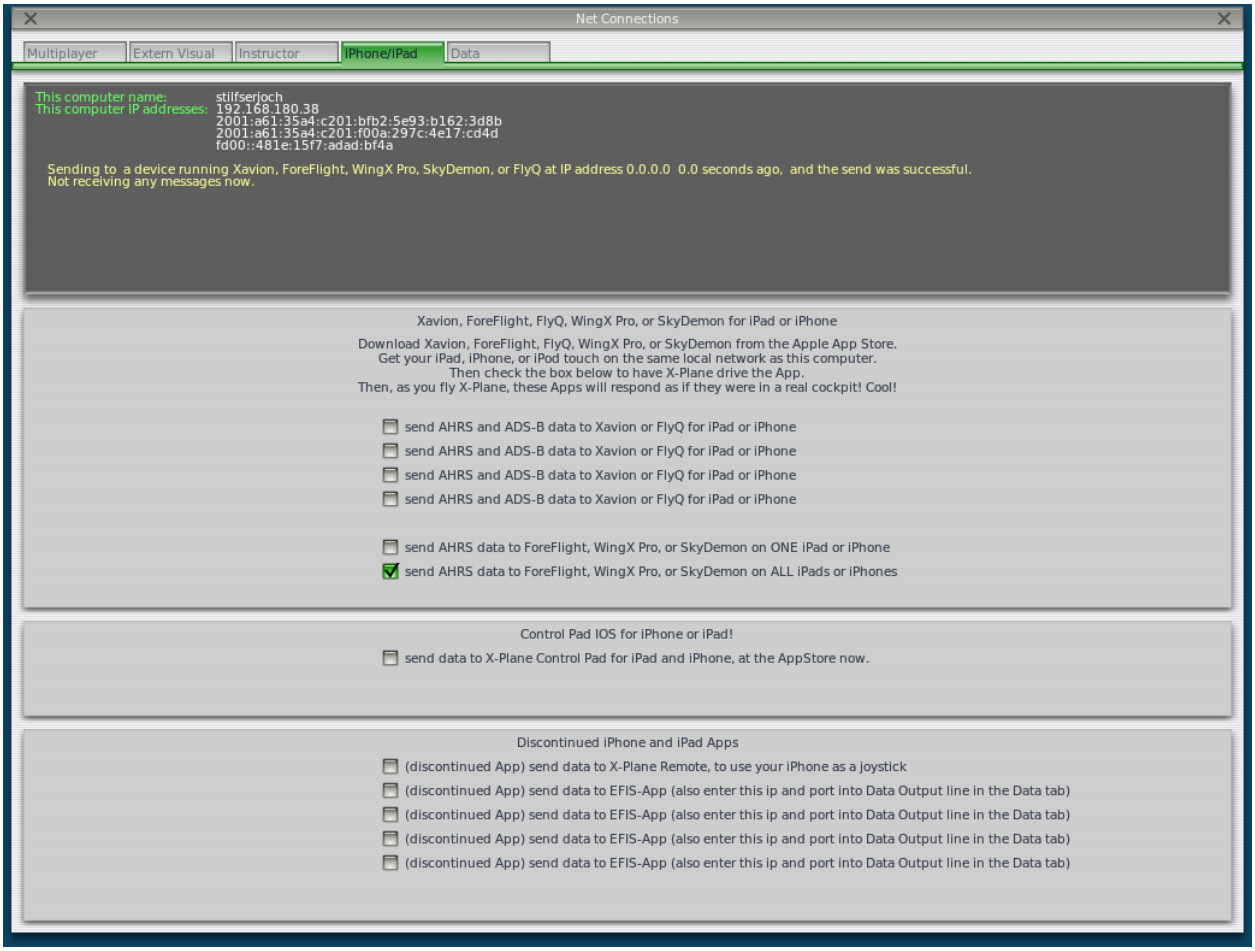
Open the “Settings” window and choose the “Network” tab. Locate the settings group “This machine’s role” on the right-hand side of the tab. Open the section “iPHONE, iPAD, and EXTERNAL APPS” and select the item “Broadcast to all mapping apps on the network” under the headline “OTHER MAPPING APPS”.



5.2.3 X-Plane 10

Follow the explanation on this page[26], 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”.

[26] 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.

6 Make a donation

Enroute Flight Navigation is a non-commercial project of Akaflieg Freiburg[27] and the University of Freiburg[28]. 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.

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

[27] https://akaflieg-freiburg.de/
[28] https://uni-freiburg.de/en/

7 Map Data

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[29] through the OpenMapTiles[30] 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[31] and the open flightmaps[32] 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

[29] https://www.klokantech.com/
[30] https://openmaptiles.org
[31] http://openaip.net
[32] 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[33] and open flightmaps[34] 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 openAIP[35] 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	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

[33] http://openaip.net
[34] https://www.openflightmaps.org/
[35] 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 Platform notes

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 then 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

9 Software license

The program **Enroute Flight Navigation** is licensed under the GNU General Public License V3[36] or, at your choice, any later version of this license.

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Version 3, 29 June 2007

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Preamble

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[36] https://www.gnu.org/licenses/gpl-3.0-standalone.html

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  For example, if you distribute copies of such a program, whether gratis or
  for a fee, you must pass on to the recipients the same freedoms that you
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  there is no warranty for this free software. For both users' and authors'
  sake, the GPL requires that modified versions be marked as changed, so that
  their problems will not be attributed erroneously to authors of previous
  versions.

  Some devices are designed to deny users access to install or run modified
  versions of the software inside them, although the manufacturer can do
  so. This is fundamentally incompatible with the aim of protecting users'
  freedom to change the software. The systematic pattern of such abuse occurs
  in the area of products for individuals to use, which is precisely where it
  is most unacceptable. Therefore, we have designed this version of the GPL to
  prohibit the practice for those products. If such problems arise
  substantially in other domains, we stand ready to extend this provision to
  those domains in future versions of the GPL, as needed to protect the
  freedom of users.

  Finally, every program is threatened constantly by software patents. States
  should not allow patents to restrict development and use of software on
  general-purpose computers, but in those that do, we wish to avoid the
  special danger that patents applied to a free program could make it
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  The precise terms and conditions for copying, distribution and modification
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  “The Program” refers to any copyrightable work licensed under this
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  may be individuals or organizations.

  To “modify” a work means to copy from or adapt all or part of the work in a
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  fashion requiring copyright permission, other than the making of an exact
  copy. The resulting work is called a "modified version" of the earlier work
  or a work "based on" the earlier work.

  A "covered work" means either the unmodified Program or a work based on the
  Program.

  To "propagate" a work means to do anything with it that, without permission,
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  private copy. Propagation includes copying, distribution (with or without
  modification), making available to the public, and in some countries other
  activities as well.

  To "convey" a work means any kind of propagation that enables other parties
  to make or receive copies. Mere interaction with a user through a computer
  network, with no transfer of a copy, is not conveying.

  An interactive user interface displays "Appropriate Legal Notices" to the
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  how to view a copy of this License. If the interface presents a list of user
  commands or options, such as a menu, a prominent item in the list meets this
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1. Source Code.

  The "source code" for a work means the preferred form of the work for making
  modifications to it. "Object code" means any non-source form of a work.

  A "Standard Interface" means an interface that either is an official
  standard defined by a recognized standards body, or, in the case of
  interfaces specified for a particular programming language, one that is
  widely used among developers working in that language.

  The "System Libraries" of an executable work include anything, other than
  the work as a whole, that (a) is included in the normal form of packaging a
  Major Component, but which is not part of that Major Component, and (b)
  serves only to enable use of the work with that Major Component, or to
  implement a Standard Interface for which an implementation is available to
  the public in source code form. A "Major Component", in this context, means
  a major essential component (kernel, window system, and so on) of the
  specific operating system (if any) on which the executable work runs, or a
  compiler used to produce the work, or an object code interpreter used to run
  it.

  The "Corresponding Source" for a work in object code form means all the
  source code needed to generate, install, and (for an executable work) run
  the object code and to modify the work, including scripts to control those
  activities. However, it does not include the work's System Libraries, or
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  general-purpose tools or generally available free programs which are used
  unmodified in performing those activities but which are not part of the
  work. For example, Corresponding Source includes interface definition files
  associated with source files for the work, and the source code for shared
  libraries and dynamically linked subprograms that the work is specifically
  designed to require, such as by intimate data communication or control flow
  between those subprograms and other parts of the work.

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  You may convey a work based on the Program, or the modifications to produce
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  sections 4 and 5, provided that you also convey the machine-readable
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a) Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.

b) Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

c) Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.

d) Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.

e) Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A “User Product” is either (1) a “consumer product”, which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, “normally used” refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless

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  of whether the product has substantial commercial, industrial or
  non-consumer uses, unless such uses represent the only significant mode of
  use of the product.

  “Installation Information” for a User Product means any methods, procedures,
  authorization keys, or other information required to install and execute
  modified versions of a covered work in that User Product from a modified
  version of its Corresponding Source. The information must suffice to ensure
  that the continued functioning of the modified object code is in no case
  prevented or interfered with solely because modification has been made.

  If you convey an object code work under this section in, or with, or
  specifically for use in, a User Product, and the conveying occurs as part of
  a transaction in which the right of possession and use of the User Product
  is transferred to the recipient in perpetuity or for a fixed term
  (regardless of how the transaction is characterized), the Corresponding
  Source conveyed under this section must be accompanied by the Installation
  Information. But this requirement does not apply if neither you nor any
  third party retains the ability to install modified object code on the User
  Product (for example, the work has been installed in ROM).

  The requirement to provide Installation Information does not include a
  requirement to continue to provide support service, warranty, or updates for
  a work that has been modified or installed by the recipient, or for the User
  Product in which it has been modified or installed. Access to a network may
  be denied when the modification itself materially and adversely affects the
  operation of the network or violates the rules and protocols for
  communication across the network.

  Corresponding Source conveyed, and Installation Information provided, in
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10 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[37], published under a CC-BY 4.0 design license[38].
- The aviation maps contain data from openAIP[39], licensed under a CC BY-NC-SA license[40].
- The aviation maps contain data from open flightmaps[41], licensed under the OFMA General Users´ License[42].

10.2 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 Fonts[43]. BSD 3-Clause “New” or “Revised” License.
- ANGLE Library[44]. BSD 3-clause “New” or “Revised” License.
- ANGLE: Array Bounds Clamper for WebKit. BSD 2-clause “Simplified” License.
- ANGLE: Khronos Headers. MIT License.
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11 Technical Notes

11.1 Traffic Data Receiver support

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)[129], Version 7.13, as published by FLARM Technology Ltd.[130].
- Datagrams in GDL90 format must conform to the GDL 90 Data Interface Specification[131].
- Datagrams in XGPS format must conform to the format specified on the ForeFlight Web site[132].

[129] https://flarm.com/support/manuals-documents/
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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 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 Avioncs 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.

11.1.4 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 unidirectionl 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.

Alitmeter 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 realiable for aviation purposes.