

Mission Planner: An Open-Source Alternative to Commercial Flight Planning Software for Unmanned Aerial Systems¹

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Abstract

The use of unmanned aerial systems (UASs) for agricultural management has increased exponentially over the past decade. Applications of UASs include mapping and inventorying farmland and forested properties, scouting for nutritional deficiencies and disease incidence, and in the event of natural disasters such as hurricanes, performing damage assessments to assist insurance claims. Laws established by the Federal Aviation Administration regulate any use and operation of UASs and require operators to always be in possession of a valid Remote Pilot Certificate. For UF/IFAS Extension personnel, and likely many other universities and federally or state-funded institutions, recommendations for operating UASs may be adjusted per guidance from federal and state authorities. Recent guidelines from UF restrict the purchase of UASs from certain manufacturers due to changes in federal recommendations.

All UASs need periodic maintenance and repair. These changes have raised questions among Extension agents regarding which UASs to purchase and use, and how these changes affect their operations going forward. Free

and open-source (FOSS) options may be a very useful alternative to commercial-off-the-shelf (COTS) UASs in the following ways.

- UASs using open-source guidance and control software are more flexible than COTS counterparts in terms of the number of supported sensors and flexibility in flight mission capabilities.
- FOSS UASs can be much cheaper to own, operate, and maintain.
- FOSS UASs have an extensive backing of developers that are generally helpful in solving a range of issues (e.g., flight planning, customizing airframes or sensors, and even post-mission data processing).
- While open-source systems have a somewhat steeper learning curve than most COTS systems, they encourage technical capacity building in teams that can add to human capital and enhance critical technical skills that are useful in almost all facets of agricultural technology management.

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This publication provides guidance to help Extension agents and other UAS users get started with the ArduPilot Mission Planner (MP) software. MP is the most widely used, best supported, and stable open-source flight planning software deployed in tandem with open-source flight controllers such as the PX4 (<https://px4.io/>) and PixHawk (<https://pixhawk.org/>). The focus of this publication is to familiarize users with the features of MP and to provide a step-by-step guide to setting up and operating UASs using FOSS software.

Terminology

MP—Mission Planner.

UAS—Unmanned aerial system (also UAV, drone).

FPV—First-person view, usually a camera on the UAS that transmits video back to the operator.

Multicopter—Also multicopter, a UAS whose motion is controlled by speeding and slowing downward-thrusting motor/propellers.

MavLink—An open-source communication protocol that allows data to be exchanged among the UAS, the ground station, and all accessories and sensors on the UAS.

Accelerometer—Instrument that measures acceleration in three dimensions, used to sense orientation and change in position.

Gyroscope—Also known as gyro, measures orientation and angular velocity. Used to stabilize the drone in combination with data from the accelerometer.

Barometer—Instrument that measures air pressure to approximate flight elevation.

GPS—Global Positioning System, an instrument that triangulates satellite signals to geographically locate the UAS. Used in combination with the accelerometer and gyro to locate and guide the UAS.

Flight Controller—Main circuit board that controls the speed of motors to move the drone. Contains the gyro, accelerometer, barometer, and compass. The FC communicates with the operator via radio. The GPS is attached as an accessory.

Ground Station—The unit used by the operator to communicate with the UAS and to receive and send information,

commands, and/or telemetry data. Usually communicates with the FC using a 915 MHz radio.

HUD—Heads-up display.

Transmitter—The unit used by the operator to physically fly the UAS when it is not flying a preplanned mission. Usually communicates with the FC using a 2.5 GHz radio.

VTOL—Vertical takeoff and landing.

Baud Rate—Commonly used when discussing electronics that use serial communication; represents data transfer rates in bits per second. The standard baud rate for drones is generally 57600.

For a larger discussion on UAS and sensor types, see <https://edis.ifas.ufl.edu/publication/AE552>.

Introduction

ArduPilot is a full-featured, open-source autopilot software with support for fully autonomous UAVs, ranging from FPV racing, aerial photography, rovers, and even submarines. ArduPilot has many features and users, and is a well-supported FOSS platform. ArduPilot enables the remote control of multiple autonomous systems with compatible ground station software (ArduPilot Dev Team 2021a). In particular, the ArduCopter platform, a part of the ArduPilot software ecosystem, fully supports multi-rotor platforms (e.g., quad-, hexa-, and octocopters) as well as VTOL aerial platforms. Note that in common parlance, ArduPilot is the umbrella term for the firmware installed on flight controllers to allow autonomous control, but is often also spoken of in combination with Mission Planner (MP), which is the ground control counterpart. MP was created by Michael Osborne (ArduPilot Dev Team 2021b) to help create autonomous missions with simple point-and-click entries on Google Maps™ (or other third-party)-supported maps. MP is also capable of simulating missions to predict the behavior of a running vehicle without risking a physical drone.

Installation

Mission Planner requires a computer running Windows or Linux with Mono, but this guide will assume a user is running Windows. To install Mission Planner, download the installer file from <https://ardupilot.org/planner/docs/mission-planner-installation.html>. If the link does not work, the installer can be found at <https://ardupilot.org>. Upon installation, you may be asked to enable Altitude Angel airspace management data—this can be safely ignored.

At this point, the program and all the necessary files should be present and ready to explore. For the purposes of this guide, the visuals and processes are gathered from version 1.3.75 build 1.3.7883.26333 of Mission Planner.

Graphical User Interface (GUI)

The Mission Planner GUI exposes the entire functionality of the platform, and as such, can come across as complicated at first glance. For the purposes of simple mission planning, however, the tools are easy to find. The program presents five main pages (Figure 1) that can be accessed from the navigation bar in the top-left corner, starting with “Data” and ending with “Help.” All relevant information is presented under the metric system.

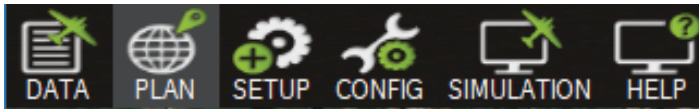


Figure 1. Navigation bar of the software.

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DATA PAGE

The landing page is the “Data” page (Figure 2) where a live stream of the telemetry and location from the UAS can be found. The dropdown menu at the top-right corner allows the user to establish a connection with the UAS. The HUD in the top-left region visualizes the current status of the UAV as a typical airplane. A quick access toolbar under the HUD allows the setting of quick actions (e.g., start mission, return to launch, etc.), data log viewing, gauge inspection, sensor readouts and statuses, servo controls (for manually triggering sensors and cameras if configured), and extra telemetry (additional information reported from the drone).



Figure 2. The Data page of the software houses the important tools to interface with the drone and view relevant data.

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PLAN PAGE

The “Plan” page (Figure 3) contains the core mission planning tools. Tools on this page allow the creation of missions of any complexity. Users generally spend the most time on this page for mission planning purposes.



Figure 3. The Plan page is where a flight path can be created.

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SETUP PAGE

The “Setup” page (Figure 4) enables the setting of key features such as firmware, configurations for radios, gimbals, and other optional add-on hardware such as landing gear and laser altimeters for the UAV. Once set, these settings are not likely to be revisited.

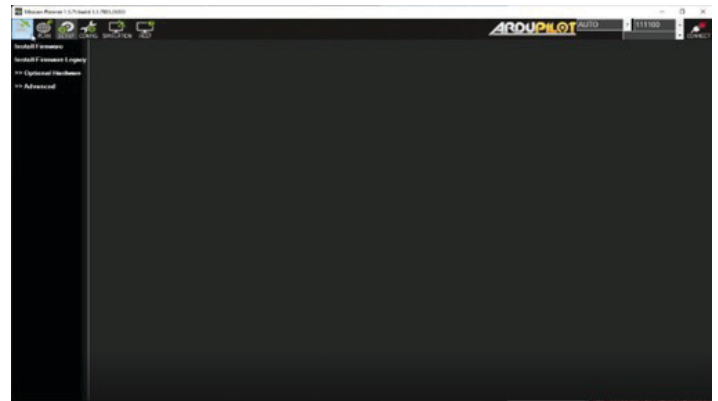


Figure 4. The Setup page where software settings can be fine-tuned.

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CONFIG PAGE

The “Config” (configuration) page (Figure 5) allows the specification of extra settings for MavLink configuration and UAV tuning parameters. Most of these settings can be modified using presets that can be imported or loaded in from the provided list.

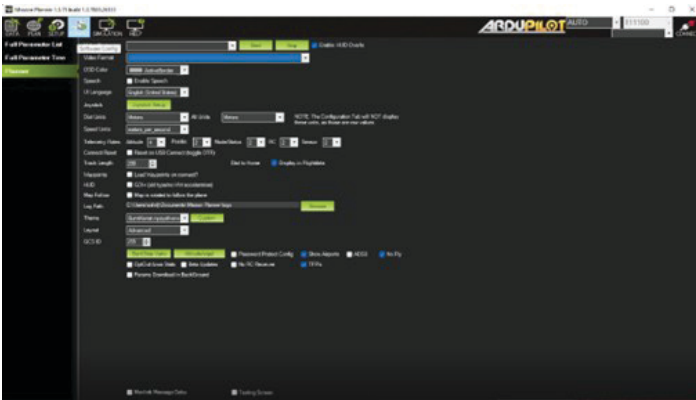


Figure 5. The Config page where UAV settings can be accessed.
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SIMULATION PAGE

The “Simulation” page (Figure 6) contains the tools to simulate the flight plan in order to validate and adjust the flight plan as needed. This page allows the selection of the type of UAV (most commonly fixed-wing UAVs or multi-rotors) and shows a simulation of what the flight would look like in approximately real-life conditions.

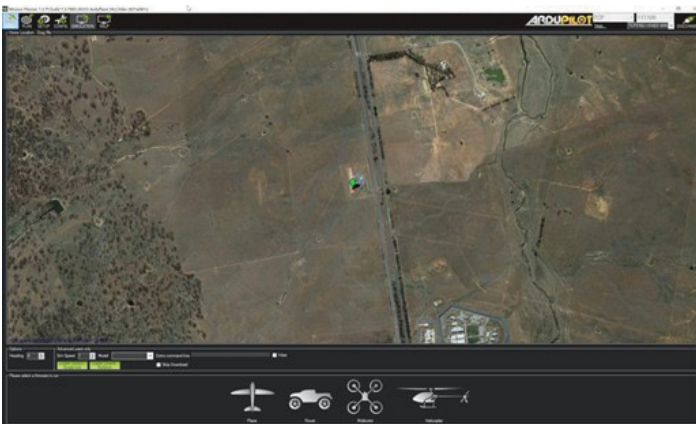


Figure 6. The Simulation page allows the user to select vehicle types in order to visualize the active flight plan.
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HELP PAGE

The “Help” page (Figure 7) contains links for support documentation for the software and firmware, as well as efficient shortcuts to navigate MP. This page also includes buttons to check for software updates.



Figure 7. The Help page shows general software information.
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Setting a Flight Plan for a Simple Survey

This section serves as a guide to set up a simple UAS flight plan with the most commonly used flight plan: a grid. Note that there are many other features, but the focus of this publication is to get a typical user started with planning a simple gridded survey using the “Survey (Grid)” tool. We assume the user is equipped with a laptop computer running Windows 8, 10, or 11, or Linux to minimize equipment needed (e.g., tablets, etc.).

1. Switch on the UAS and wait until the initializing tune finishes beeping. Once done, plug the telemetry radio in any USB port on the computer being used as the ground station.
2. Connect to your UAS with MP by clicking on the “Connect” button at the top right of the Data page. If this is the first time, MP might take some time to find the correct port to listen to the telemetry radio. One quick workaround is to open the device manager on the computer and look for any new USB connections when plugging in the telemetry radio. The baud rate is generally set at 57600.
3. Once the telemetry radio is connected, the landing page (“Data”) will start showing the current status of the UAS. Click on the “Plan” page to move to the mission planning data entry page.
4. On the “Plan” page, you will see the GPS location of your drone. Right-click on the drone and click “Takeoff” in order to set the takeoff location. Then, click and drag the map to navigate to the geographical region where you intend to set the flight path.

5. Next, create a polygon of the area you wish to survey.
To create a polygon, right-click on the map and select “Polygon | Draw a Polygon” in the context menu (Figure 8). Add “waypoints” by clicking on the screen (Figure 9). Double-clicking on the map finishes the current polygon.

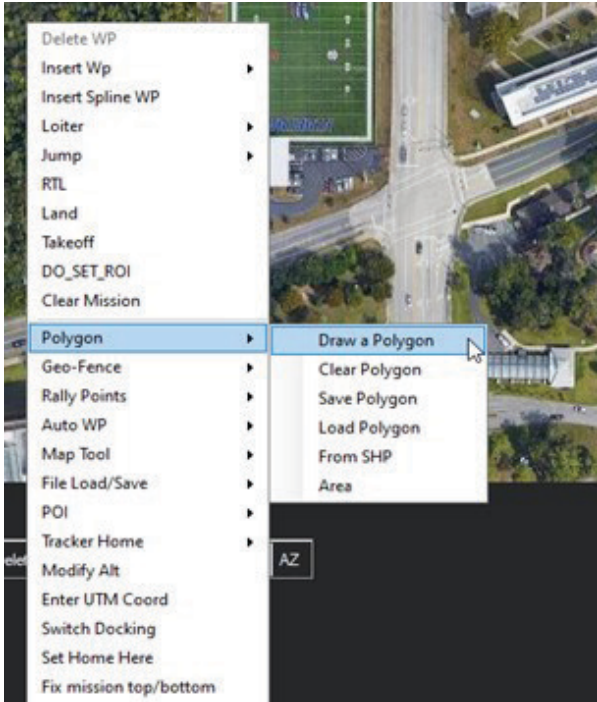


Figure 8. Menu selection to draw a polygon.
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Figure 9. Example polygon.
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6. Once the flight polygon has been set, select “Auto WP | Survey (Grid)” (Figure 10). Note that there might be multiple Survey modes. The first one is the simplest and supports creating an area from a polygon and specification of the sensor configuration, if required. Survey (Gridv2) enables more granularity in the flight path generation process, but many of these features are not necessary for the purposes of remote sensing. Other

survey features such as Wp Circle create a flight path on the perimeter of the boundary polygon. Additional information about the distinct Auto WP features can be found on the Mission Planner knowledge base.

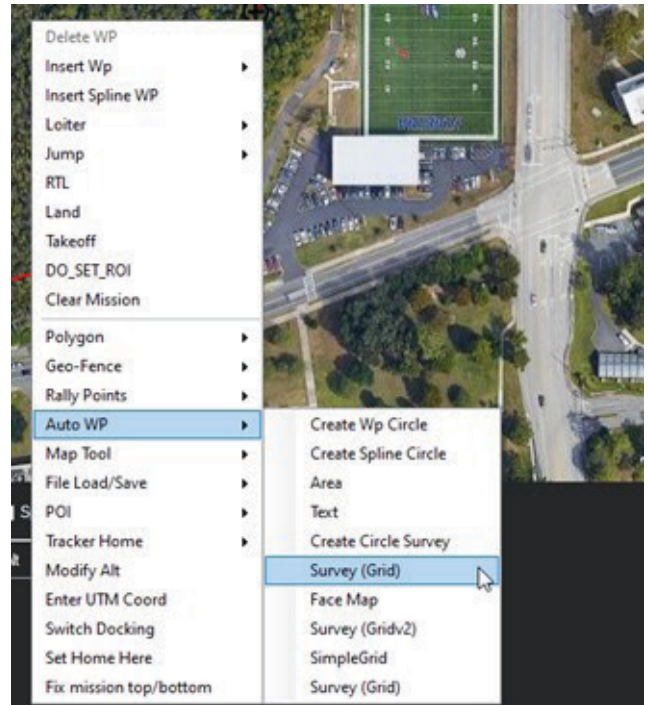


Figure 10. Creating a Grid Survey from the polygon.
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7. MP will provide a default mission layout across the grid. Select your sensor and specify the flight altitude and flight speed to see changes in the mission grid. If your camera or sensor is not already available in the dropdown menu, select “Advanced Options” in the Display box. Two tabs will appear: “Grid Options” and “Camera Config” (Figure 11).



Figure 11. Example generated survey flight path.
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8. In the “Camera Config” tab (Figure 12), fill out your camera settings per manufacturer specifications. Alternatively, the “Load Sample Photo” button allows reading of the EXIF data (camera information embedded in the image file) from an existing photo from any sensor to automatically fill out most of the information. The Trigger Method specifies capture mode for the camera (i.e., how the controller tells the camera to take a picture). These settings are dependent on the sensor; more information can be found in the “Cameras and Gimbals” section of the ArduPilot documentation for most-used sensors. Note: Configuring the camera settings is essential to avoid blank regions. Blank spots can be caused if the spacing between flight lines is too wide. It is essential to avoid this because missing data could create added complexity in map stitching. Changes made to the sensor information will adjust the flight plan accordingly to ensure a complete data set.

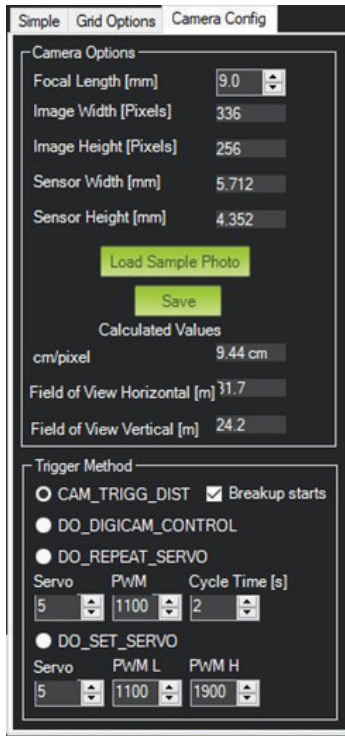


Figure 12. Camera settings.
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9. Once done, MP will ask for a home altitude, which is the altitude from which you will launch the drone. After all configurations are done, the result should appear similar to Figure 13.

10. In order to send the flight path to the drone, click on “Write” in the toolbar on the right side of the page. This will upload the flight plan to the UAS.



Figure 13. Fully generated Survey flight path generated in a polygon adjusted for camera settings.
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Auto grid has now been set up. When the drone is launched in the general area, it will now fly to the position of the second waypoint and begin capturing images. When the grid is complete, it will fly back to the launch location.

“Arming” the UAS and Starting a Mission

“Arming” the drone initializes the drone to the state where the motors can spin when the throttle is applied. Each drone manufacturer has a unique method to arm and disarm the drone using a radio transmitter; refer to the user manual for the proper procedure. Mission Planner allows an alternate process to arm and disarm the drone using only the field laptop (Figure 14).

On the Data page, locate and click on the “Actions” tab on the navigation bar below the HUD on the left side of the page (see Figure 14). Clicking on the Arm/Disarm button changes the HUD notification from “DISARMED” to “ARMED” after a few seconds.



Figure 14. Menu buttons to arm the drone and begin the mission.
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In order to start flying the flight path created earlier, you must ensure that the drone is armed, and that the HUD reports no errors. If there are any unfamiliar errors, refer to Mission Planner forums (ArduPilot n.d.) or the knowledge base (ArduPilot Dev Team 2021a). In order to start the mission, locate the dropdown menu next to the “Do Action” button and select the “Mission_Start” option. Click on the “Do Action” button and then confirm the operation on the pop-up menu to begin the mission. If any abnormalities occur with the flight hardware or the mission, you can safely return the drone to the launch point by finding and selecting the “Return_To_Launch” option from the dropdown menu next to the “Do Action” button, and then clicking the “Do Action” button. After the flight concludes or terminates, make sure to disarm the drone to avoid potential accidents and to ensure the safety of all users and observers.

Additional ResourcesThe Mission Planner knowledge base (<https://ardupilot.org/planner/index.html>) is an excellent resource if you encounter any errors. YouTube videos by Linn Aerospace that illustrate a step-by-step process are linked here https://www.youtube.com/watch?v=rui2Trps2yc&ab_channel=LinnAerospace.

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