FIXAR

WHITE PAPER

AERIAL PHOTOGRAPHY PERFORMANCE IMPROVEMENT GUIDE FOR FIXAR 007

Introduction

3 years of hard and dedicated work of top-class engineers and developers with surveying background allowed FIXAR team to build a safe and easy-to-use complete drone solution that offers highest performance and ensures trustworthy autonomous flight for aerial photography.

FIXAR products improve operational efficiency, reduce downtime, and improve safety for surveyors and their equipment.

With a wide spectrum of swappable downward-facing sensors, such as RGB or multispectral camera payloads in combination with PPK capability you can achieve highly accurate images (down to 1 cm/px or 1.18 in/px) even at hard-to-reach areas.

All-in-one autonomous drone solution that save your resources and reduce downtime

FIXAR UNMANNED AERIAL SYSTEM

FIXAR 007
UAV

FIXAR Autopilot
Autopilot

FIXAR xGroundControl
GCS to create a flight route

PAYLOAD VARIATIONS

Onboard TRIMBLE, TOPCON or EMLID GNSS receiver
Guarantee the exact coordinates of images using PPK or RTK

Advanced digital camera Sony A6000 / Sony RX1 RM2
Exceptionally high-quality images for orthophoto maps and terrain models.

Multispectral photographic camera MicaSense RedEdge MX
Multispectral images and subsequent processing in photogrammetric tools (NDVI index calculation, crop germination, etc.).

Hyperspectral cameras
Spectral resolution from 350 nm to 1,700 nm, opearting ranges, infrared and ultraviolet.

Thermal imaging cameras
Highly detailed thermal images.

Every item included in the FIXAR 007 package has its own function in the aerial photography process chain and was designed to offer the highest performance in aerial photography.

The FIXAR 007 Aerial Photography Performance Improvement Guide was developed to assist you to reach the optimal image quality and aerial photography results when operating our UAV.

Deep Tech by FIXAR

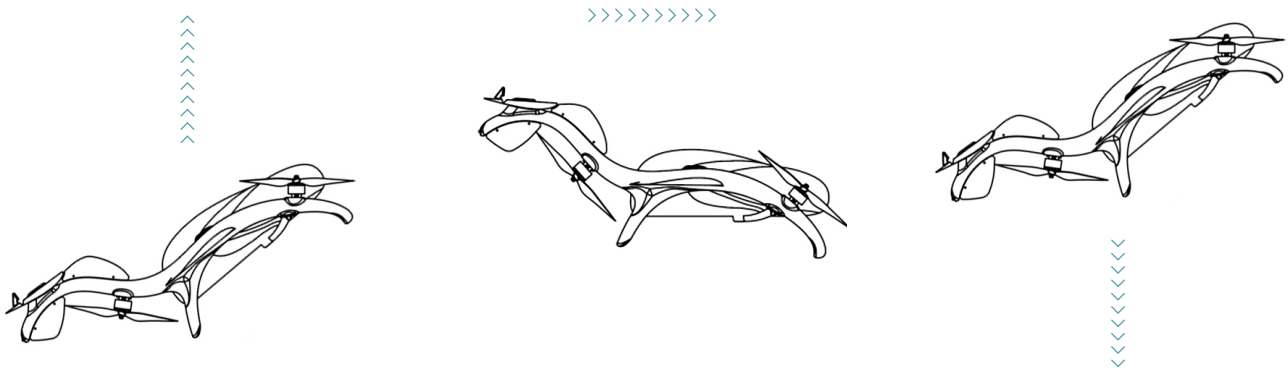
The FIXAR Autopilot software and hardware solution is installed onboard the UAV and controls the FIXAR 007 aircraft throughout its mission, while the FIXAR xGroundControl station manages the flight and monitors the flight plan execution.

FIXAR 007 UAV is an autonomous vertical take-off and landing aircraft. This means that the take-off and landing are made in the 'copter' mode. The mode performs a typical function and movement to the one of quadcopters: roll and pitch will move the UAV forward/backward/ left/right and accelerate it to the desired speed, while throttle is used for climbing and descending. One implemented addition: the yaw control is restricted by the wind direction, as the aircraft in this mode is always oriented against the wind.

Cruising is performed in the airplane mode. This mode performs a typical function and movement to airplanes: rolling with simultaneously pitching forward is used for turning left or right; pitching alone, without rolling, is used for the altitude control; throttle is used for maintaining the speed of flight.

The airplane nature of FIXAR 007 gives the efficiency of an airplane with its inherent cruising features and endurance. When performing aerial photography, quadcopter type aircrafts fly over the surface, halts and turns around following a defined route.

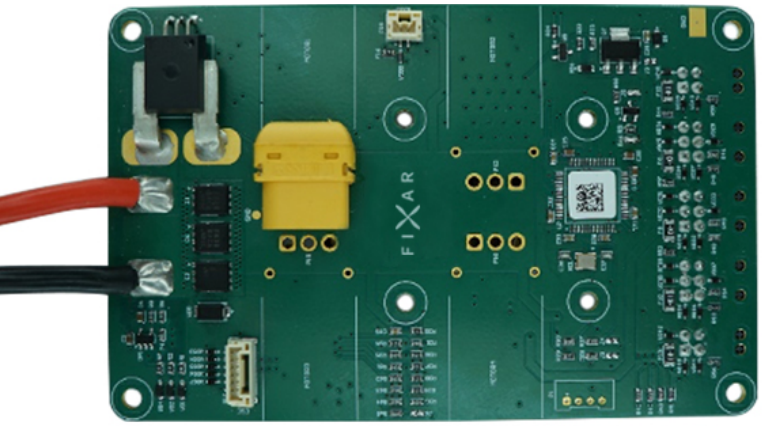
FIXAR 007 will behave as an airplane and will fly over the area, make a U turn and fly the opposite direction and covering this way a longer physical distance. **This implies that the less U turns are made in flight, higher the efficiency of the flight.**



TAKE-OFF **FLIGHT** **LANDING**

FIXAR AP autopilot - Ensures fully autonomous flight from take-off to landing, and the ability to fly in geomagnetic anomalies as no magnetometer sensors are used and need for its control.

This is a breakthrough solution for long range drones. With settings streamlined, the FIXAR AP can be used as an autopilot for the airplane, copter, and hybrid modes of the aircraft.



- Designed specifically for FIXAR aerodynamics.
- Fully autonomous flight including take-off and landing.
- Navigation algorithm using lidar sensor for accurate landing.

The closed-source **FIXAR xGroundControl station** has an intuitive interface capable of being installed on any laptop with the latest Windows operating system. The process of entering the initial information is as simple as possible.

For example, when a photo camera model is selected as payload, the columns with its characteristics will be filled in automatically.

- 3D visualization for developing and editing flight missions.
- Automatic terrain tracking when setting a flight route.
- Map cache for launch in the absence of Internet.
- Confidential information always remains secure.

Manufacturer's Recommendations For Improved Performance Of Aerial Photography With FIXAR 007:

1. **Selection of the optimal longitudinal and lateral overlaps of the aerial photos**
2. **Course line arrangement features**
3. **Selection of the (route) course orientation with reference to the area configuration**
4. **Specifics of planning aerial photography of a linear object**

RECOMMENDATION 1

Selection of the optimal longitudinal and lateral overlaps of the aerial photos

One of the key parameters in aerial photography is the overlap of aerial photos from the same patch of land taken from different points. Longitudinal and lateral overlaps of aerial photos are distinguished. The magnitudes of overlapping are expressed as percentage of the size of the respective side of an aerial photo.

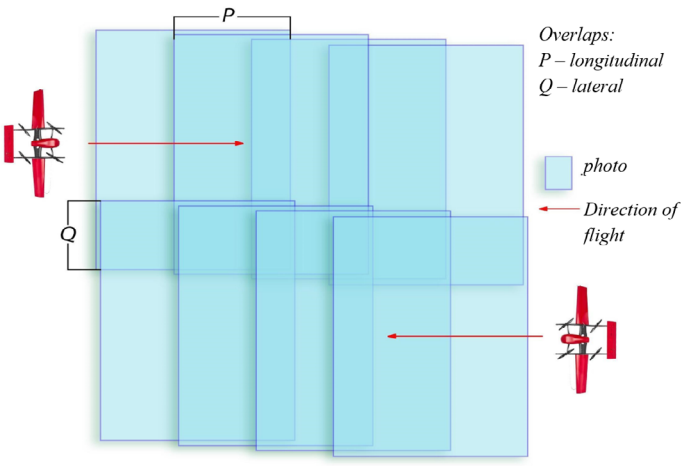


Image 1: Longitudinal (P) and lateral (Q) overlaps in adjacent course of flight.

When planning a mission at the FIXAR xGroundControl station, the user defines the settings for the photo camera chosen from the list of payloads:

- Lateral and longitudinal overlaps of the images
- Linear resolution (centimeters per pixel)

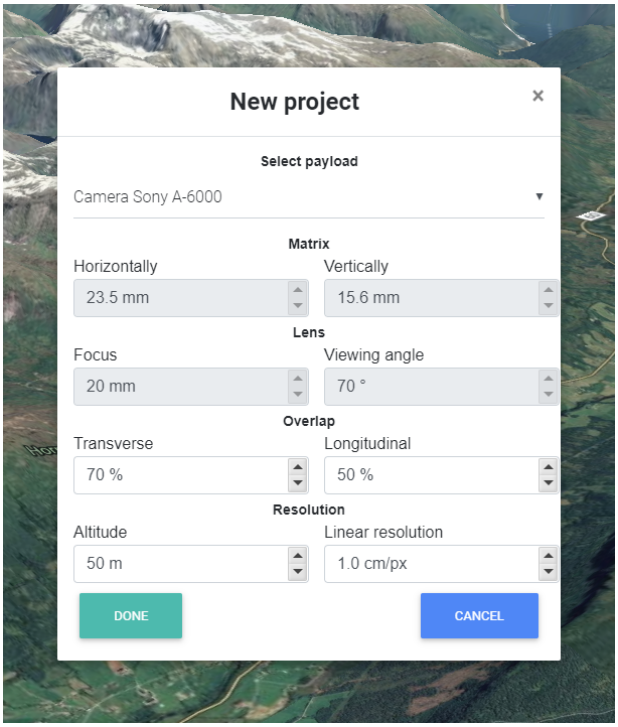


Image 2: Setting the camera parameters for a new flight plan in the xGroundControl station.

Aerial Photogrammetric Mapping Guidelines establish the minimum required value of longitudinal and lateral overlaps, which should be 60% and 30%, respectively. Smaller values will lead to photogrammetric discontinuity and the inability to build a 3D terrain model.

UAV-operators who are used to work with copter type (multi-copter) aircrafts tend to set greater values for image overlaps up to 90-95% when defining the flight plan. The efficiency factor of specific works is usually disregarded in such case.

CONCLUSION: Despite the fact that a high % of overlapping increases the accuracy of the obtained materials, an excessive number of photos significantly reduces the overall productivity of the work.

When using FIXAR 007, it is recommended to operate with the longitudinal overlap of 60% and the lateral overlap of 80%, which will make sure that the resulting photo materials can be stitched into a common orthophoto plan.

RECOMMENDATION 2

Course arrangement features

A standard set by the aviation industry regulations and that has been formed accordingly, accepts that during aerial survey operations, it is better to position a course at an angle to the wind. Such recommendation is related to the fact that aerial photography from large aircraft is carried out in time intervals, which leads to a change in the actual distance between the centers of images (the photo base). ***Note:*** *Photo base is the distance between the main points of two neighboring aerial photos.*

UAV operators with experience in Manned Aviation, when building a route, tend to build a flight route taking into account the wind direction (sideways). However, this approach is ineffective for UAV's because the aircraft trajectory isn't stable in strong side wind. Such situations can lead to the so-called non-parallelism of the photo base in relation to the side of the aerial photo. The non-parallelism (also called "herringbone") is determined by the angle X (image 3). For cameras with a focal length f = 100 mm (3.9 in), this angle should not exceed 5°; for cameras with f = 200-300 mm (7.9 - 11.8 in), 10-12°; and for cameras with f = 500 mm (19.7 in), X<14°.

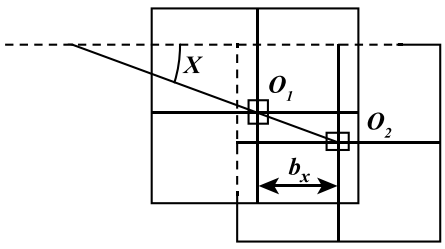


Image 3: Diagram for determining non-parallelism.

In order to compensate for the non-parallelism, the overlap of photos has to be set with a higher percentage. And as referred in the previous paragraph, reduces the efficiency and improves the post-processing of materials in special photogrammetric programs (for example, Agisoft Metashape). Risk of distortions may occur when building the orthophoto plan.

Modern autonomous control systems, such as FIXAR 007, take coordinate-based aerial photos. The system automatically calculates the coordinates, taking into account the preset resolution and overlaps. Simultaneously, the FIXAR xGroundControl algorithm ensures that the photo base is kept uniform, regardless of the aircraft speed. As a note FIXAR 007 is capable of flying upwind and downwind with the images being taken at a specified set of coordinates.

CONCLUSION: FIXAR takes coordinate-based aerial photographs (not referenced to intervals, as in Manned Aviation), so it is recommended to fly downwind or upwind. Even in cases where the aircraft flies against the wind, the risk of getting distorted raw footage is eliminated (though in windy weather the power consumption increases).

RECOMMENDATION 3

Selection of the (route) course orientation with reference to the area configuration

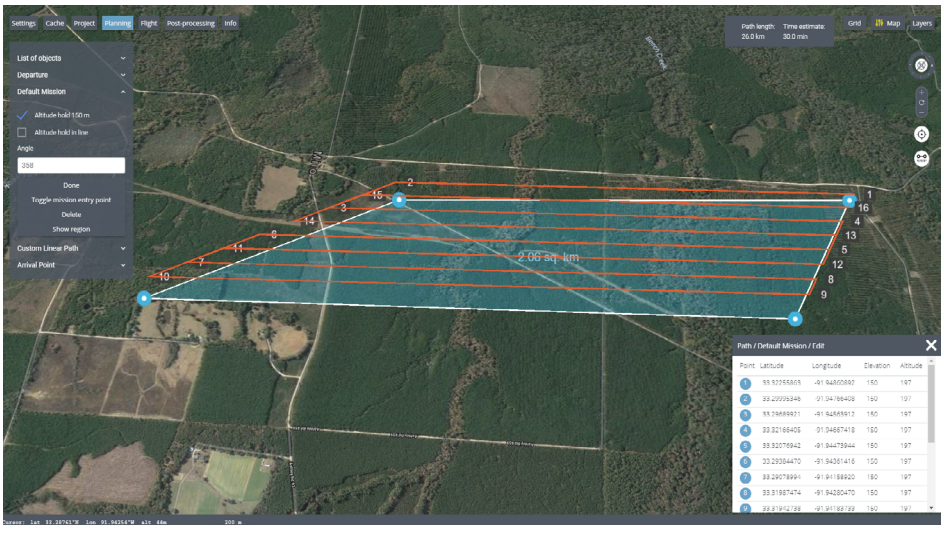
Owing to its high aerodynamic performance, the FIXAR 007 is capable of taking aerial images of areas located at a considerable distance from the launch site to the return to the pre-planned landing site.

The hovering mode of FIXAR is used for vertical take-off and landing and is not being used in level flight, which is similar to an airplane-type UAV. The FIXAR 007, like any airplane, makes a U-turn on a pre-designed trajectory. Performing this on a cross-hatch route, time is lost and power consumption is increased.

Proper course direction reduces the number of U-turns, thereby reducing flight time and battery power consumption.

CONCLUSION: In order to optimize power consumption, when preparing a flight plan, it is recommended defining the flight route along the longest side of the area object, thus optimizing the total length of the route and the time it will take to complete it.

A *route length 33.5 km (20.8 mi)*
flight time 37.2 min



B *route length 26 km (16.1 mi)*
flight time 30 min

Image 4: Orientation of flight courses relative to the longer side of the aerial survey area.

RECOMMENDATION 4

Specifics of planning aerial photography of a linear object

The norms of classical photogrammetry state that when taking photos of linear objects, it is necessary to fly around the object in three times and therefore eliminating the risk of getting discontinued photos.

In practice, however, this is not always necessary. It is also important to keep in mind that to fly three-times over a point, the take-off and landing sites will all have different coordinates, which implies ineffective empty backhauls.

Image 5: Planning the aerial survey of a linear object in the xGroundControl station at a strip width of 50 m (164 ft).

The built-in autopilot in the FIXAR 007 UAV controls the flight from one point of the set coordinates to another, strictly along the line of the set path. Therefore, when a turn with an angle of more than 15 degrees is encountered at linear objects, the FIXAR 007 covers it by making a loop, thus strictly following the flight route, excluding the possibility of the absence of the corresponding overlap of aerial images.

CONCLUSION: Guided by practical experience, as well as taking into account the aerodynamic design of the FIXAR 007 aircraft, the manufacturer guarantees that with two over flights you can get the required amount of photographic material for the subsequent stitching.

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TIP: *When building linear routes, it is recommended to use vector maps, which have more accurate display coordinates, allowing you to plan the route more accurately on the curves of linear objects.*