WHITE PAPER

UNMANNED AERIAL VEHICLES PRODUCTIVITY

A drone industry common stereotype is to evaluate the quality of an aircraft by the duration of the flight. This concept has historically been formed around the fact that since Unmanned Aerial Vehicles came to the market, they are commonly related and acknowledged in the format of a quadcopter type aircraft for video recording, when the main feature is to provide high-quality video collected from different angles and perspectives. Naturally, for the task, flight duration is of key importance.

When evaluating the productivity of an aircraft, metrics should be applied based on industry-specific demands. For the task in hand, we propose to consider the use of drones for aerial photography, which are designed for mapping, geodesic, land surveying and cadastral work.

Key metrics for productivity assessment

1. **Quality of collected data**
2. **Quality of overlaps**
3. **Aircraft performance**
4. **Payload**

How collected data quality is assessed?

Key criteria in assessing quality of the aerial photography:

- Photography center coordinates accuracy obtained from onboard geodetic GNSS receiver;
- High-definition and image clarity of photo materials obtained (no deformations). Assessment is made in terms of linear resolution (centimeters per pixel) and variation of the linear magnification factor (distortion).

In order to improve productivity in terms of area per time unit, wider angle lenses are used, which allow you to capture terrain bands as wide as possible.

Wider angle lenses produce distortion by the edges of images resulting in the necessity to narrow the field of the processed material of images in order to stitch up together the orthophoto plan. Is important to recognize the right balance between the flight route and the lenses operation, taking into account the size of the camera sensor.

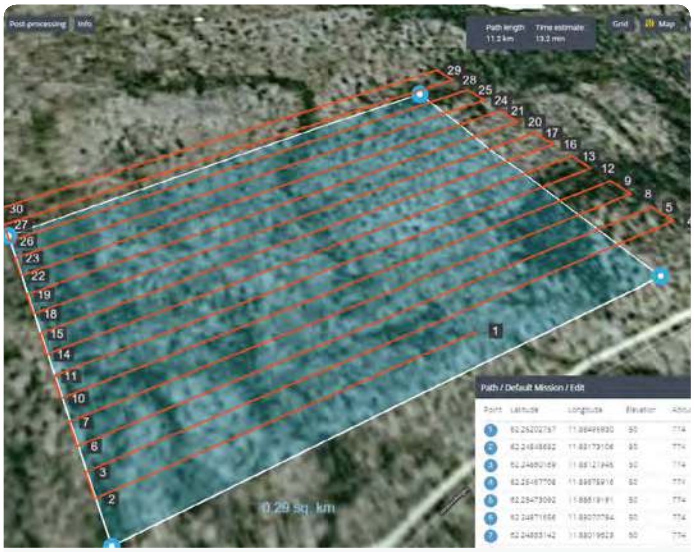
As a rule, cameras with sensor resolution less than 16 megapixels are considered unsuitable for aerial photography. But the size of the matrix itself is relevant (larger the matrix, clearer the image can be obtained).

Why is it important to consider the image overlapping quality when calculating productivity?

Calculation of aerial photography parameters set a very important stage of preparatory work. Correct calculated parameters allow extending the area covered in one single flight of the aircraft, while maintaining the quality of photographic materials.

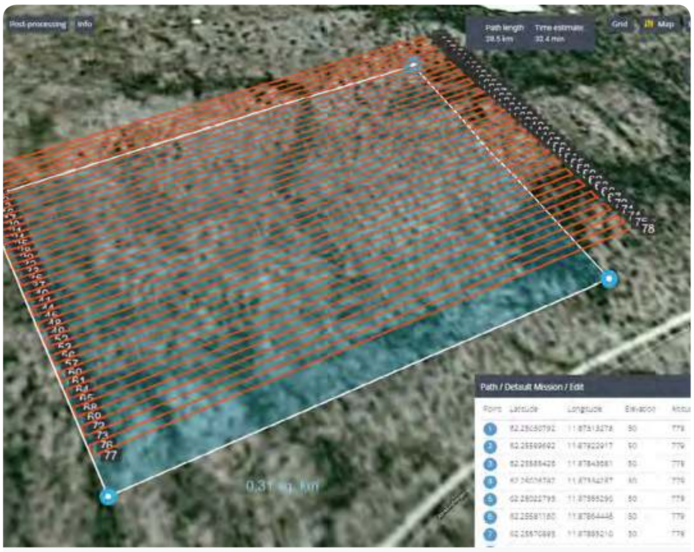
The aircraft performs the task by covering the area in tacks (straight patches). Distances between tacks lined up in parallel, which are set by the overlap between the aerial photographs.

Depending on the percentage of overlapping, you get different parameters of the area. Greater set overlap, lower will be the productivity, but at the same time, higher will be the accuracy of the data obtained (since there will be images of the terrain from more angles, and when stitched into a three-dimensional model it is of colossal importance).



FIXAR XGroundControl overlap setting:
Transverse - 40%; Longitudinal - 50%;

Overall path length - 11.2 km;
Estimated flight time - 13.2 min.



FIXAR XGroundControl overlap setting:
Transverse - 80%; Longitudinal - 80%;

Overall path length - 28.5 km;
Estimated flight time - 32.4 min.

How can the productivity of a drone be calculated based on its flight performance?

The defined productivity of the drone is literally common understood and measured by - how much money the operator company earns per time unit. This criterion is easily reduced to the amount of the filmed area in a unit of time, as the cost of work is actually assessed by the area of the footage.

Productivity will depend on what linear resolution is required: the more centimeters per pixel requested, less productivity will be met, and vice versa.

The footage area taken in a unit of time directly depends on the drone's speed. Higher the speed the drone travels, larger the area that can be covered. However, at the same time, the drone's speed is directly proportional to the quality of images taken (with insufficient exposition the images will be blurred).

On this basis, the cruising speed has to be correctly selected for aerial survey missions, enabling clear and high-quality images to be obtained (this is not related to how fast the aircraft can fly).

Why is the productivity calculated per time unit and not per flight?

To correct measure and quantify the resources spent, the best approach is to set an hourly rate. The aircraft productivity should take into account factors outside the drone operation and include:

- Assembly and installation of the aircraft,
- Planning and development of a flight plan,
- Flight mission completion work and required tests.

Considering how easy the aircraft is assembled or how user-friendly interface it provides are some of the important assessments to be taken.

Productivity comparison of drones with different design

Criteria	FIXAR 007	Average copter	Average plane
SPEED OF FLIGHT	**72 km/h**	**32 km/h**	**72 km/h**
MAX PAYLOAD	**2 kg per 60km**	**1 kg per 15 km**	**0.5 kg per 60 km**
PREPARATION TIME	**5 minutes**	**15 minutes**	**60 minutes**
EFFECTIVE FLIGHT DISTANCE	**60 km**	**15 km**	**66 km**

Airplane type drones

A long-range airplane in average can be operated 2 hours at a cruising speed of about 70-75 km/h in a full charge and traveling up to 150km.

When calculating the productivity of the aircraft, it is necessary to take into account the time spent by the aircraft operator on flight preparation and work completion:

- Installation of a catapult system (on average 5-10 min.);
- Assembling the UAV (on average 15-20 min.);
- Pre-flight preparation (on average 5 min.);
- Planning and developing a flight plan (on average 15-20 min.);
- Aircraft recovery can be problematic in windy conditions. Because it uses a parachute system, the aircraft can be blown away hundreds of meters of target.

All summed up, the preparation and completion work take an average of 45 to 60 minutes. By converting these indicators into an hourly rate, presents that the total productivity of the work performed falls significantly. Considering a 3 hours project, 1/3 of its time is spent with the pre and post flight preparation. 150 km/3 hours = 50 km of effective travel per hour.

Quadcopters

The time required to prepare a copter type aircraft is about 15 minutes, taking into account its assembly time and the planning of a flight plan. The landing radius is small however the current operational range of such aircrafts is limited to a maximum of 30 km, due to the fact that these devices fly relatively slow (approximately 8 m/s). The power consumption of Quadcopters is similar to the one of FIXAR aircrafts.
Important to point out the distribution of operational time in a single flight: copters operate approximately 60 minutes in the still air and about 40 minutes in windy conditions. As a result, the productivity of the copters falls in relation to the wind conditions.

FIXAR

The total preparation time (assembly + flight plan) for the FIXAR 007 OUTDOOR model is similar to the one of copters: approximately 5 minutes. The operational range with a full charge in real wind conditions is 45-55 km. In an operational perspective FIXAR type aircraft is comparable to the one of an airplane type aircraft. Thanks to its effective design, FIXAR type aircraft can travel longer but doesn't require extensive preparation time as Airplane type models would.

One other important benefit to take into account and compared with airplane type unmanned aircraft systems is that FIXAR doesn't require a catapult or a dedicated location to take off and enabling FIXAR to be operated in any remote location.

Airplane type aircrafts, several times, require a take-off location many kilometers away from the destination target area resulting in the unnecessary consumption of battery charge and consumption of valuable project time, when in turn FIXAR can be launched instantaneously from any location thanks to its VTOL (Vertical Takeoff and Landing technology)

Payload weight importance in productivity calculation

As previously described, in order to produce high quality geodetic images, is necessary to use high definition cameras and sensors, which relates to larger cargo volume and a heavier weight. Devices that can have more accurate and heavier sensors on board have the advantage of maintaining accurate productivity metrics.

Heavier the payload, lower is the aircraft power reserve. Coppers type aircraft with no payload will travel 60km ; with a 1kg payload the distance reduces to 30 km, etc.

An Airplane type craft and similar to FIXAR in size (wing span length) is able to carry up to 500 grams payload, whereas FIXAR offers a maximum payload weight of up to 2 kg.

Copters type aircraft offer the capacity to lift up to 2 kg of payload, but with a very limited travel distance. Because of its unique patented aerodynamic design, the FIXAR models can carry up to 2 kilograms of payload, but also travel up to 25 km with the 2 kilograms of payload.

FIXAR in figures

A FIXAR aircraft traveling in cruising mode without a payload or with a payload of up to 500 grams does not influence its energy consumption. As a result, if you don't have the need to carry a payload, you are then able to install a larger capacity battery and increasing the FIXAR aircraft flight range.

Cruising mode with up to 150 g payload: 75 km

With aerial photography camera weighing 400-500 grams: 45 - 50 km of aerial mapping or 55 km of linear route

With a 2-kg lidar: 25 km of travel

SWIVEL CAMERA

SONY DSC-RX1 RM

SONY A6000

SKY EYE-T50 3-AXIS

SKY EYE-30-HZ-S

REDEDGE-MX

PARROT SEQUOIA

LASER SCANNER

EAGLE EYE-10IE

FIXAR DISPENSER DSMK1800

FIXAR CARGO BOX

Conclusion

The maximum power charge or flight time of an unmanned aerial vehicle is NOT the main metrics or indicators to assess drone productivity. The efficiency of aerial photography or image recording is equal to the area of the footage shot per unit of time for an area object, or kilometers of flight per unit of time if it is a linear object.

When choosing an unmanned aerial vehicle and assessing its effectiveness, it is important to take into consideration the needs of a particular task, as well as the conditions necessary for its execution.

FIXAR 007 is a VTOL (vertical take-off and landing) system. Vertical take-off and landing airplanes provide the convenience of a quadcopter, but has the range and efficiency inherent in the traditional design of the airplane.

The aircraft can take off and land anywhere, requiring no bulky launchers (so-called catapults) or parachute devices.

FIXAR patented system (from FIXed Angled Rotors) assumes complete absence of any complex mechanisms (offering high system's reliability), better wind resistance in take-off and landing modes, and absence of "ballast" eating up the useful payload weight.

Combining the advantages of a professional quadcopter and an unmanned airplane, the FIXAR drones with unique software onboard are boosting the efficiency of work in such areas as, precision farming, surveying, monitoring of industrial objects, geodetic and construction surveys, mapping and 3D terrain modeling, laser scanning of the terrain, high-altitude aerial photography, "last mile" delivery, search and rescue of people.