UAVs for Production

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ABSTRACT

Unmanned airborne vehicles (UAV) are becoming commodity, it seems. They find use in many areas, and there is an overwhelming amount of conferences on all sorts of UAV-related topics. Certainly, they can be applied for good in our geospatial domain as well. Several years of experiences in use and applications of UAVs gave rise at GerMAP to set up a portfolio of both major UAV worlds, rotary wing UAVs and fixed wing UAVs. Each of them has its strong sides where it is best to make use of it. In this contribution GerMAP presents its fixed wing as well as rotary wing UAVs. Concluding remarks summarize the major properties of both types and give a prospect.

1. INTRODUCTION

GerMAP started out in early 2012 with business focus on UAVs in and for the geospatial industry. It took off with some experiences in practical applications of a fixed wing UAV for aerial mapping, at that time a SmartOneC from SmartPlanes AB, Sweden. Soon it became obvious to better expand the tool “UAV” in terms of wings pan, payload capacity, ways of applications, and to complement with the vertical take-off and landing (VTOL) capability. Thus, GerMAP decided to go for its own line of UAVs made from the point of view of aerial mapping and with the support of seasoned model aircraft builders. Driven by European regulations which permit to operate a UAV within visual line of sight (VLOS) there emerged the demand for big wings yet small aircraft weight. Maximum take-off weight (MTOW) is another major criterion for flight permits in Europe. Further, a sufficient amount of flying time which mainly depends on the type of task to get accomplished is yet another design-influencing parameter. As MTOW includes the ready to fly aircraft with its payload, it became important to find ways to minimize the weight of the aircraft for the maximum possible on payload, all under given legal constraints in order to obtain commercial flight permits easily. These and some other criteria heavily take influence on the design for UAVs which are oriented to serve as platforms for geospatial imaging and remote sensing. As of now GerMAP offers a line of fixed wing and rotary wing UAVs of under 5 kg MTOW.

2. FIXED WING UAV

With G212 and G180 GerMAP has two fixed wing UAVs available, each with specific properties for different constraints set by applications. While G212 is a so-called delta-wing UAV, the G180 is a conventional airplane with tail. G212, see Figure 1, has a wingspan of 212 cm and offers a wide payload bay of approx. 25 cm x 25 cm x 10 cm. It carries a payload of 1 kg for about 45 min. Due to its wide wingspan, black body and orange colored wingtips one can see it over 1 km away, which, when flown as a photogrammetric block with e.g. 70 % across track overlap, allows for a high resolution block size of e.g. 1.2 km² to be flown with 4 cm GSD in less than 35 min.

G212 like all other of GerMAP's UAVs is equipped with the ArduPilot resp. Pixhawk Open Source autopilots. Both operate on the common protocol MAVlink, and communicate with its counter part, the Open Source software MissionPlanner as ground control station. The concept of integrating readily available components and to tailorize them for specific needs offers the benefits of easy access to this technology for all who want to dig in, it ensures supply, and it offers a wide basis of

Figure 1: G212 – fixed wing UAV.

technology maintenance. Drawback might be that very specific implementations cannot be kept proprietary easily. Due to its large wingarea and its wing-geometry, G212 flies in cruise-speed with 14 m/s. This is beneficial for minimizing forward motion during exposure, as following consideration shows. With 14 m/s and a typical exposure time of 1/1250 s the UAV moves 11.2 mm during exposure. When exposing from 100 m above ground level (AGL) with e.g. a Sony Alpha 6000 one obtains roughly GSD 2.1 cm. If the UAV due to its aerodynamic properties has to fly 25 m/s, as some UAVs have to, it would move 20 mm during 1/1250 s exposure. Also, a higher UAV-speed puts higher demands on fast write-speed of image data onto storage in the camera which in turn reduces the number of available appropriate off-the-shelf cameras offering sustained high image data write speeds. Overall, G212 has a MTOW of close to 4 kg including up to 1 kg of payload, which in most cases is one or more cameras. Again, when integrating common components one can address a wide variety of cameras. This concept makes our wish alive: give some new wings to our cameras.

With the same motivation mind and additionally making it even easier to learn flying and mastering an UAV for beginners, GerMAP set up its G180, see Figure 2. This is a conventional airplane, more of the type of a slow cargo airplane with very moderate flying properties, very good visibility when operating far away, and short landing path. G180 can fly as slow as 10 m/s and maintains a cruise-speed of 12 m/s. It as well can carry about 1 kg of payload, and its cargo-bay measures about 30 cm x 9 cm x 7 cm which is thus smaller somewhat than in G212. Nevertheless, G180 can carry 2 or even more cameras, too. It is an important criterion to GerMAP that a fixed wing UAV can carry more than 1 camera at a time. Thus, combinations of RGB with NIR or two slightly oblique looking RGB cameras doubling swath width, or RGB with thermal camera are possible to be integrated.

Moreover, and as already shown, one can integrate a suspension mount for one or several cameras into a UAV. G180 and its brother G212 offer this kind of integration of sensors, which gives the flexibility GerMAP was looking for its UAVs. With a 6100 mAh battery G180 has an endurance of up to 55 min motor run time which adds up to some 60 min flying time, while its MTOW is 3.7 kg including approx. 1 kg of payload. A bigger and heavier LithiumPolymer (LiPo) battery, e.g. 9000 mAh, is possible too. Depending on the typical weight of the payload the type of motor is adapted which is also a change in weight. Typically, GerMAP adapts the UAV to the standard type of

Figure 2: G180 – fixed wing UAV.

application the user will have to fly. There is some room left for adaption before one hits the 5 kg MTOW-limit, which is in Germany one of the major parameters to obtain a commercial Generic Flying Permit.

3. ROTARY WING UAV

Multicopters are rotary wing UAVs. Most known are quadcopters, multicopters with 4 rotors. There area a variety of designs with 3, 4, 6, 8, and even more rotors and different rotor arrangements, e.g. rotors placed in X, Y, V shapes with rotors in one or two levels, latter ones called co-axial rotors (top and bottom rotors, mounted on one, usually vertical axis). Certainly, quadcopters boosted the popularity of multicopters, and their necessary flight control electronics make it very easy to learn maneuvering them in a very short amount of time, sometimes within half a day. There are quite many multicopter manufacturers. This convinced GerMAP to go with a highly specialized multicopter-manufacturer partner, Rotorkonzept Multikoptermanufaktur UG, Germany. GerMAP's G47-X8 is a co-axial octocopter, see Figure 3, with a MTOW of 3.8 kg. It is a very compact X8-octocopter with only 47 cm distance from motor-axis to motor-axis. Its compact set-up with slightly towards the outside inclined motor-axis for its 4 co-axial pairs of contra-rotating rotors make G47-X8 rather stable in wind up to 4 bft. An integrated video camera downlinks the scene as seen from the maneuvering G47-X8. This offers the pilot a "first person view" (FPV) on the video screen which is attached to the remote control device. Additionally, this video signal is overlaid with flight parameters, such as remaining battery voltage, speed, artificial horizon and more.

The helps the pilot in placing G47-X8 in higher altitudes exactly in front of an object, e.g. a bridge pylon or wind-mill rotor-blade, which needs to be visually inspected and documented with images. A high precision 2-axis gimbal stabilizes the camera. Single images may such be triggered by the pilot with a single push button on the remote control device, much like a remote shutter. Or, a photogrammetric block might be flown with nadir looking, stabilized camera. Alternatively, the

Figure 3: G47-X8 – rotary wing UAV, co-axial octocopter.

gimbal platform may be populated with a thermal camera and a small RGB camera, e.g. GoPro. The pilot can switch forth and back between video stream from either the integrated camera, see in Figure 3 the small optics below the bright spot, or the HD-video from the gimbal-mounted highres camera and record these video streams. The gimbal platform stabilizes payloads up to 800 g. And with approximately 600 g of payload G47-X8 maneuvers up to 20 min. Ultrasonic or LIDAR sensors can be integrated and used for high precision landings or for ground-following during remote sensing tasks. Like its sister fixed wing UAVs G47-X8 operates a Pixhawk autopilot and gets controlled via the MissionPlanner ground control station software. This way the user easily can manage rotary wing and fixed wing UAVs including flight mission preparation.

G47S is based on G47-X8 but tailored for surveillance, see Figure 4. It houses in its sensor dome a thermal camera, a RGB camera, and a laser pointer. All 3 sensors are 2-axis mounted, i.e. can be manually controlled in their attitude, declination and elevation, via the remote control device. G47S is made for almost-all weather conditions, i.e. it takes some rain, snow, fog, cold, wind. Different resolutions of up to 640 x 480 pixels in the thermal camera are available. Also may the sensor system get mounted into a dome-protected 2-axis gimbal.

With its 4.9 kg G47S almost reaches the 5 kg limit and can stay up in air for about 15 min. A battery swap takes 1-2 min. The pilot may switch between thermal camera or RGB camera and can see and record the life-stream on the attached video screen.

Figure 4: G47S – surveillance rotary wing UAV.

4. CONCLUSIONS

In many UAV-service projects over the years we've seen that UAVs cover a wide range of applications. National regulations influence to some extent design and applicability of UAVs. As such it would be e.g. desirable to fly higher than 100 m AGL which would make UAV-mapping even more efficient, since many applications can get along with e.g. 5 cm GSD or even less. Current off-the-shelf consumer cameras delver from 100 m AGL already 3 cm GSD and better. Nevertheless, there are manifold applications where UAVs are of great help to industry and society, and they enable business. Aerial mapping via UAVs is only one of many ways of how to make use of UAV-technology. Standard photogrammetric image processing systems can handle UAV-imagery. Tailorized and highly automated image processing systems make it easy for non-specialists to derive good results and deliverables.

Rotary wing UAVs have the big advantage of easiness of learning how to operate them. Their vertical take-off and landing capability make them ideal for narrow, e.g. urban, environments. Their copter nature make them also ideal for inspection and observation tasks, see G47S. Due to their property of having to operate many motors in order to stay in air, their energy consumption is significantly higher than that of fixed wing UAVs. Thus, shorter flying times and more frequent changes of battery power may be the consequence. Usually, rotary wing UAVs are compact and made of a wireframe-like carbon body, which is hard to see in distances of more than 200 meters away, which is then the limit for VOLS-operations. This is mostly when fixed wing UAVs are more efficient to operate, since they are far further away visible, e.g. > 1.5 km, and thus cover significantly larger areas in one flight mission. However, airplanes need a corridor for start and landing. A major property of fixed wing UAVs is furthermore the fact that they require clearly much more time to learn to fly them.

For both types of UAVs it is mandatory that the pilot is capable to maneuver and fly them under manual control, which the pilot of a “remotely piloted aircraft system” (RPAS) should be able to take over at any given time. For both types of UAVs there are demand and applications.

It would be great to have both systems combined into one UAV, a vertical take-off and landing airplane. This combines the famous best of both worlds properties. As mostly, such a best of both advantage comes with a disadvantage, here being shorter flying times as traditional airplanes of comparable size. First implementations of UAV-VTOL-airplanes in the market give proof of concept, and it will be interesting to see further developments in the UAV domain.