

PHASE ONE INDUSTRIAL

CopterSystems: Building Stable UAV Platforms for Photogrammetry

Introduction

CopterSystems GmbH was established in early 2012 as a manufacturer of high-end copter solutions for a variety of applications. The CopterSystems staff is made up of members with different engineering backgrounds, working together with a number of consultants from the aviation industry. CopterSystems is well-known as a pioneer in the German UAV market. Roman Paulus, the founder and CEO of the company was one of the first to use UAV technology for photogrammetry and other sensor based airborne applications in Germany.

From Roman's perspective, most of the early UAVs were not designed for professional use and weren't able to lift real photogrammetry cameras into the air. This made him look for experts in the field of UAV manufacturing to set up a strong team of professionals. Some of his team members were early pioneers of UAVs. Dating back to when copter designs were not used in photogrammetry at all, and over the years moved quickly into this field.

Enter Phase One

Recently, more and more potential customers have approached CopterSystems and asked for Phase One aerial cameras to be used as a sensor option for UAVs. The main reason for the requests was that the UAV operators want to use UAVs for professional photogrammetry and this creates a higher demand on the functionality and stability of the UAVs. Many users have had disappointing experiences after spending money for UAV's, which performed more like toys than serious UAVs.

Since the photogrammetric results achieved with a Phase One aerial camera have been proven on manned aircraft missions, operators were interested in applying the capabilities of the cameras to the UAV market.

One of the features that stood out was the pinpoint accuracy provided by these metric calibrated cameras. All cameras employ mechanisms to solidly lock their lens to the camera body. Despite inflight vibrations, the rigidity of the camera and lens provide metric data with pinpoint accuracy for mapping and other applications.

CopterSystems researched the features of the Phase One aerial cameras and liked the way they function, especially how easily they are controlled from the ground.



Building the UAV

The demand reached a point when CopterSystems made a decision to develop a special UAV for Phase One cameras, which they called the CS-P.O.C. After CopterSystems made the decision to use Phase One iXU cameras for their solution, they started to develop a UAV around the camera. Their main goals were to:

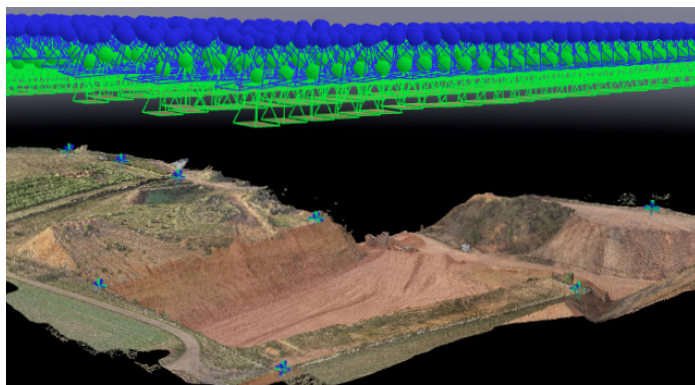
- Maintain full control of the camera and the UAV from the ground
- Able to fly waypoints with a high accuracy
- Secure the camera as much as possible
- Make the UAV as stable as possible

As in all aviation design, security is the number one concern to deal with. With this in mind, the CS-P.O.C. was built with a high redundancy. The CS-P.O.C. offers a dual flight controller, dual power supply via rechargeable batteries, safety given by six rotors, a dual GNSS board and a dual remote control. Even in case one of these systems stops working, the second one takes over and enables a safe landing or a safe return.

With the latest technology of engines, the six rotor UAV is three times more powerful than what is needed for lift off capacity to weight ratio. For a precise and smooth flight, only one third of the maximum engine power is needed, so if the UAV encounters strong wind conditions, the stability will not be at risk. The stability of the flight is essential, not just for the security of the UAV, but a stable flight means that the correct overlapping enables the necessary spacing of images, which is needed to make a final orthophoto and at the same time avoid black spots. The success of a photogrammetric flight depends on the stability of the UAV.

To control the CS-P.O.C., CopterSystems use a German-made remote control, which gives an operator complete control of the UAV and camera during the entire mission. The Live View feed from the iXU 1000 with its 100 MP sensor or the iXU 150 with its 50 MP sensor, can be streamed, and the operator can use it to maneuver the UAV to the correct position when waypoints are not used. Being able to view the exact field of view of the camera is a real benefit when the system is used for inspection. Other camera parameters (e.g. aperture, ISO, shutter speed and more), can be controlled by the remote control as well and enabling the operator to get the best image quality possible while flying.

Beside the interactive control the UAV offers, the UAV was built with a stable camera setup for a pure nadir view or a gimbal mount. This allows an operator to change the camera position from a straight nadir, straight forward and even pointing up. This flexibility to aim the camera at objects over a 180 degree radius, enables operators to point the camera straight up under bridges for inspection of the lower surfaces of a bridge.



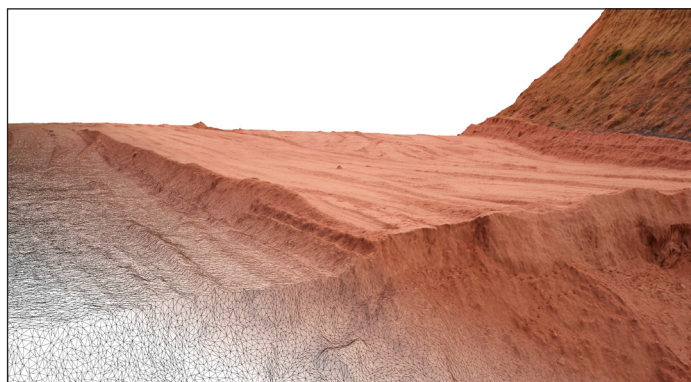
Project: Sand Mine

During a demonstration for a survey company in the south of Germany, CopterSystems flew a CS-P.O.C. carrying a Phase One iXU 150 with a 50 MP sensor, equipped with a Schneider-Kreuznach 55 mm lens over a sand mine. The complete site was approximately 400 by 500 meter and a ground sample distance (GSD) of 0.75 cm was chosen. In total, 444 images were captured during the flight, which resulted in 21 lines, with a different number of images for each line due to the shape of the area.

The post processing was done with Pix4D software. During the project, an average of 52,689 key points per image were measured with a median of 37,682 matches per calibrated image. Thirteen ground control points (GCPs) were used with a mean RMS error of 0.01 meter. The job calibration showed that the interior orientation of the camera was within the calibration tolerance, and the values were almost

Phase One A/S is based in Copenhagen with offices in New York, London, Cologne, Tel Aviv, Tokyo and Hong Kong. Phase One Industrial is a division of Phase One and is dedicated to research, development and manufacturing of advanced hardware and imaging software solutions that meet the unique requirements of aerial photography users.

identical to the lab calibration executed by Phase One several month prior. The block bundle adjustment used 16,398,349 2D key point observations and 3,481,706 3D key point observations. The mean re-projection error in pixels was at 0.138515. For the 13 GCPs, a final RMS error and sigma of 0.012 [m] in X, 0.007 [m] in Y and 0.011 [m] in Z was achieved. All these numbers show a much better result than the expected two centimeter as a priori.



Based on this data, a further DTM and 3D point cloud, as well as an orthophoto, were generated, and the results showed the full photogrammetric potential of the CS-P.O.C. with a Phase One iXU 150 as a survey tool. The survey company which executed the project, together with CopterSystems, was very impressed by the complete workflow and how little time this project took to complete. A major factor was due to the shape of the mine. The UAV was able to capture parts of the mine that were classified as unstable to walk on. Using photogrammetry enabled the survey company to measure points in these areas as well and increase the complete results of the mass calculation to a higher standard than was previously known before.

Takeaways

Roman Paulus commented, "Over the years, we have gained practical experience from users around the world and we decided to build a solution that combines the best aerial camera and UAV. Therefore, we chose to go with the Phase One iXU camera. Once this decision was made, we planned the entire UAV around the camera, which enabled us to choose the best components, to match that weight, performance, flight time and stability and of course, safety!"

"After the proof of concept was finished, we flew several projects and can proudly present a solution to bring photogrammetry with a UAV to a new stage for actual survey work. We offer a complete solution with sub-centimeter accuracy for a relatively low investment. With this system, you can easily generate 3D point clouds, DTMs, orthophotos as well as having the ability for all kind of inspection work. This is the product that customers have been asking for and now, it is ready to serve this market."

About Phase One

To find out more about Phase One products, please visit <http://industrial.phaseone.com> and set up an appointment with one of our aerial photography experts for a demonstration.

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