# Mid-Pulse Blues

AirGon

Lewis Graham
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We have been doing a lot of experimenting with various airplane and camera configurations for small Unmanned Aerial Systems (sUAS). We are very interested in the effect of camera quality on metric analysis. For example, does a better lens yield a more accurate surface model when extracting a dense image matching point cloud using an application such as Pix4D? What about the quality of the camera sensor? Since, as a general rule of thumb, a larger sensor (pixel size, not number of pixels) yields a high signal to noise (SNR) ratio, surely this results in a more accurate point cloud. Our current experiments (see Figure 1) revolve around overall camera speed and synchronization.

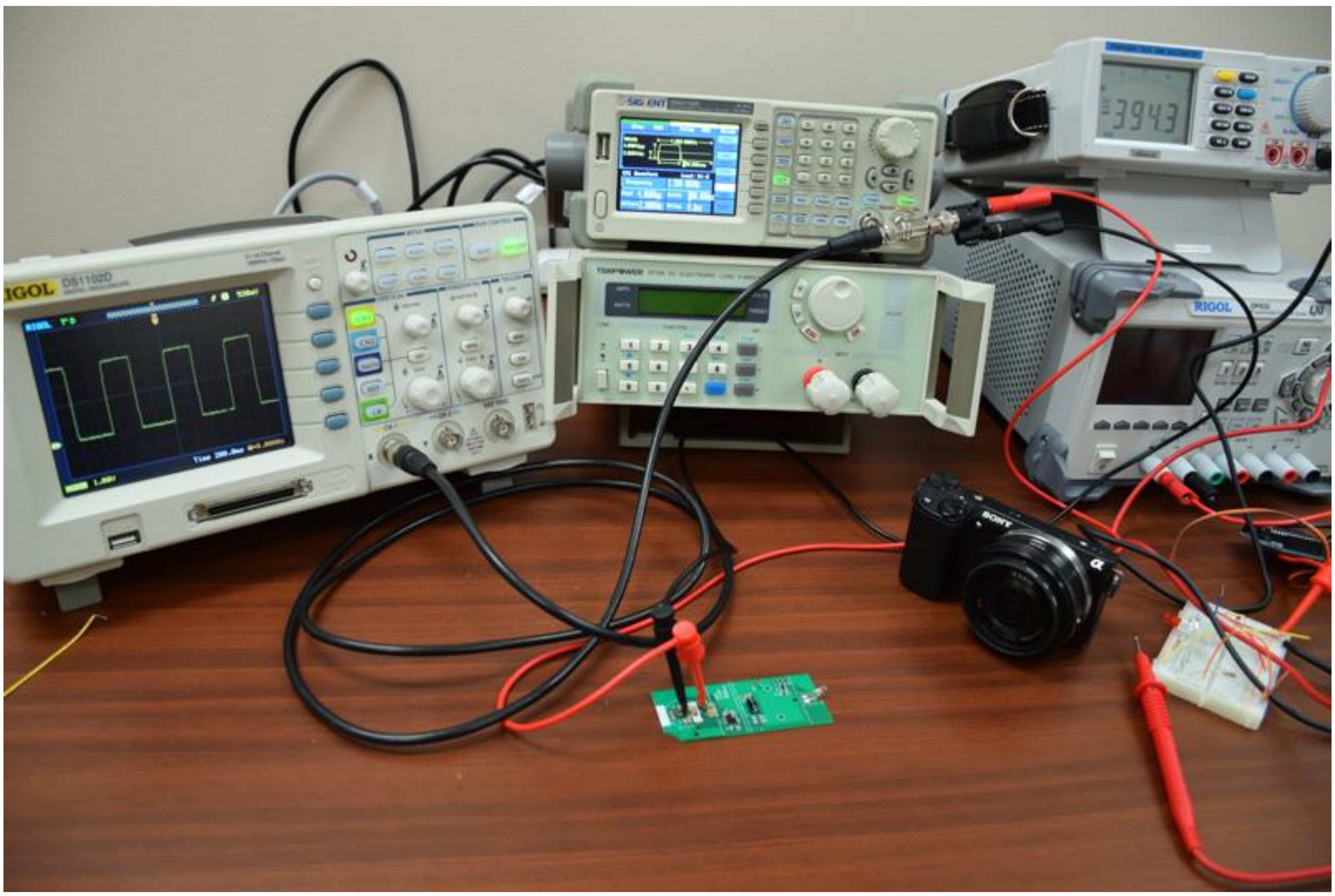

*Figure 1: Testing Cameras*

We need to fly fairly low (60 meters with our 20 mm lenses) to collect imagery of sufficient resolution to perform high quality volumetric analysis. In a fixed wing aircraft where the minimum forward speed is determined by the stall speed, we need a fairly fast shutter repeat rate to ensure adequate coverage (remember, for dense image matching, the general rule is 80% end lap and 60% side lap). Unfortunately, unlike photogrammetric systems, the cameras used in sUAS do not provide feedback in the form of a TTL line providing a mid-exposure pulse (MEP) trigger. This means that you cannot easily construct a sense line that will tell your autopilot when the camera has fired. It is usually a one way connection where the autopilot sends a signal to the camera, commanding an exposure.

There are several general methods in use for firing the sUAS camera. The first is via an "intervalometer." In this mode, you simply set the camera to fire on a periodic basis based on time. For example, you might set the camera to fire every 1.5 seconds. You then adjust the speed of the aircraft to obtain the desired end lap and side lap. Of course, the camera is continuously firing so you end up with images where they are not needed such as the turns at the end of flight lines and during the takeoff and landing sequences. A bigger problem with the interval approach is that the speed of the aircraft is not constant. This means that the images are not spaced at a constant distance apart. Most folks who fly in this mode trigger the camera as frequently as possible and simply eliminate all of the redundant images. A rather brute force approach, to say the least!

A second approach is to set a waypoint in the autopilot at each point where you wish to collect an image. A tolerance is set such that when the aircraft is within a certain radial distance of the waypoint, the camera trigger fires. This is the preferred method of firing a camera and the one most often used in manned aircraft photogrammetric systems. Unfortunately, most sUAS autopilots are limited in the number of waypoints they can store since their design aim was navigation, not photogrammetric mapping. For example, the PixHawk system that we use is limited to about 360 waypoints; far too few for a typical mapping mission.

A third approach and the one we employ is to fire the camera based on distance traveled over ground. This distance is computed every 200 milliseconds by the autopilot, using input from the on-board Global Navigation Satellite System (GNSS) receiver. This nice thing about this approach is that it does not require trigger waypoints and it is immune to changes in the aircraft speed (since the distance is being computed in real time based on speed over ground, SOG).

In the waypoint and distance interval modes, you have to ensure that the maximum frame rate of the camera is not violated. The Canon Sxxx series of cameras have a maximum frame rate of about 2.1 seconds. The NEX 5 has a maximum frame rate of about 0.9 seconds. These are times determined in our laboratory testing (see Figure 1) as opposed to the manufacturer's specification.

If you exceed the maximum frame rate of the camera, you typically get dropped frames. This can result in a weak solution in the dropped image locations or even a hole in the point cloud. One of the reasons that you might exceed the frame rate, in spite of careful mission planning, is a tail wind. If the minimum airspeed of your plane is, for example, 10 m/s and you have a 10 m/s tail wind, then the aircraft speed over ground is 20 m/s. If you have set your camera trigger to every 15 meters then you will be commanding the camera to fire every 15 m/(20 m/s) = 0.75 seconds. The likely outcome is that you will trigger the camera every other pulse, resulting in a spacing of 30 m.

As we develop profiles for particular cameras, we will publish them in our newsletter (here) and also on our new online knowledge base. Stay tuned!