The 20 Hz V-Map System packaged by Micro Aerial Projects L.L.C for precise UAV-camera exposure positioning.

1. Introduction.

Because of weight constraints most small UAVs are equipped with light weight GPS receivers that yield SBAS (WAAS or EGNOS) refined, real time, code based absolute positioning at accuracies typically ranging from one to three meters. While these accuracy levels are sufficient for most navigational purposes, higher levels of accuracy are needed for payloads specifically employed for precision measurements such as 3D modeling of structures by means of photogrammetry or airborne laser scanning. To meet centimeter level positioning requirements we have designed a hardware configuration that integrates dual frequency GPS (or optionally, single frequency GNSS) post-processed positioning capabilities with event marking, thus enabling precise positioning of cameras at the moment of exposure. In our approach we tried to keep the weight as low as possible. Hence we did not include RTK-capability. For those UAVs capable of the extra weight and power consumption associated with the data transmission hardware needed for RTK positioning we can implement the necessary components by special request.

The standard V-Map system now features the following components and functionalities:

- L1/L2 GPS phase measurements recorded on board at 20Hz
- Power input ranging from 5V to 36V
- LED indicator to monitor satellite reception
- LED indicator to monitor proper data storage
- Event marker port
- One PPS outputs
- Removable micro SD card for data retrieval
- Dual frequency helix antenna

The weight of the receiver excluding external cables and antenna is 120g.

On special request we can provide the following optional additions or configurations:

- TTL Communication Port for Data and System Configurations
- Full on board RTK functionality
- Remote RTK (RTK processing done on Laptop on the ground)

2. Description of the V-Map System.

Figure 1 below shows a typical V-Map assembly.

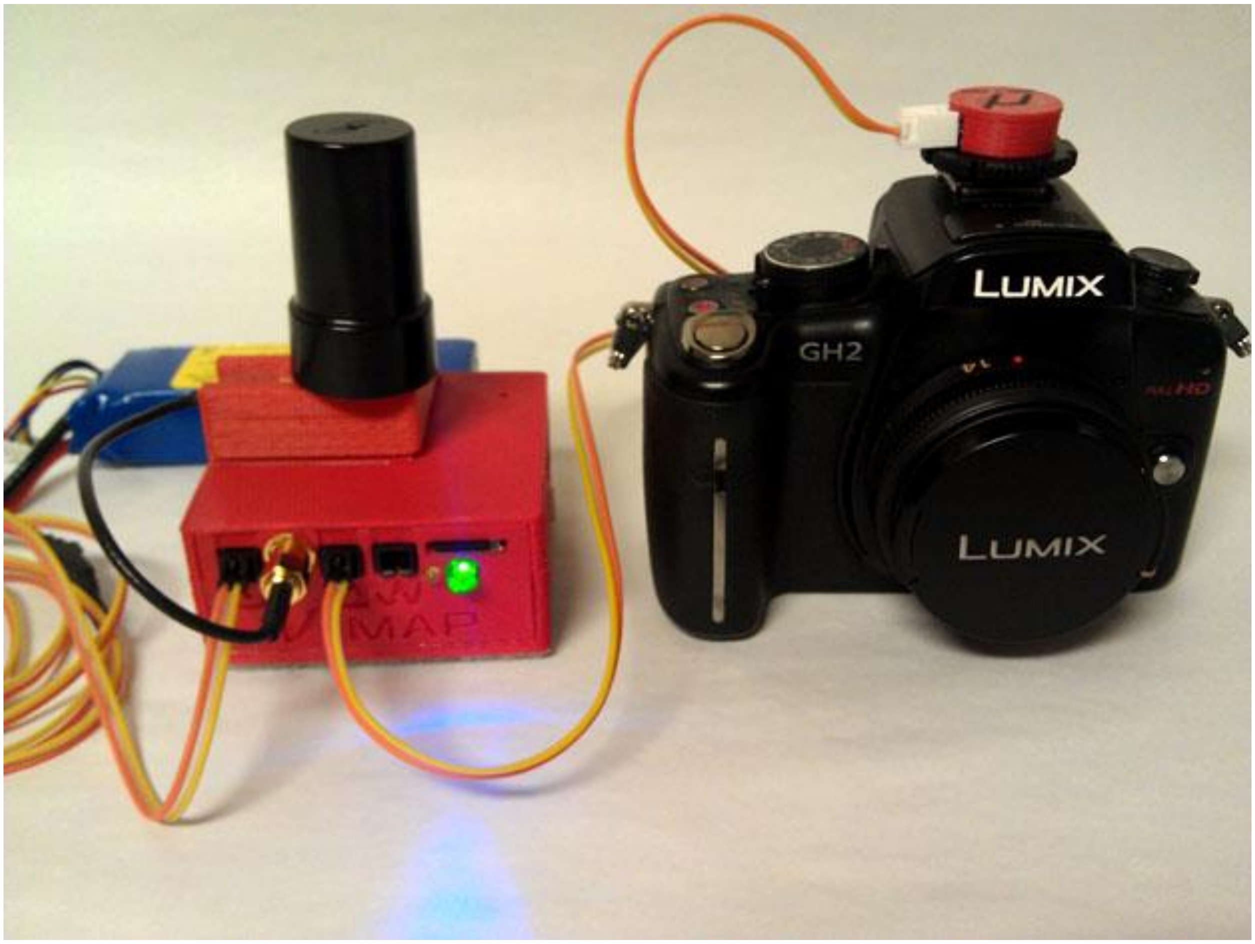

Figure 1: Typical V-Map Assembly (Camera and Battery are NOT included in the system – shown here for illustrative purposes only)

Figure 2 below shows the connection panel of the V-Map system.

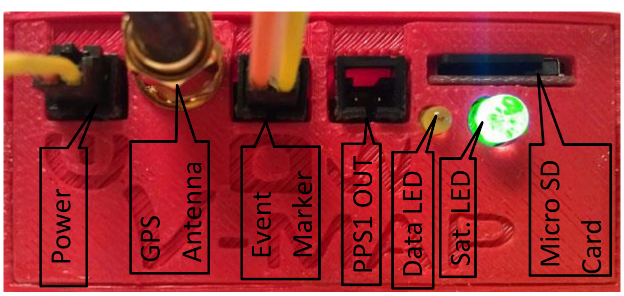

Figure 2: V-Map System connection panel

3. **Operation of the V-Map System**

Our standard system has been configured for post-processed kinematic dual frequency (L1/L2) GPS plus SBAS applications with event marking. The standard rate of observation is 5Hz. The system does not require any operation other than proper connections to the antenna, the camera and a reliable power source with voltage ranging from 5 to 32V. Maximum power consumption is 500mA at 12V.

Once powered up the satellite LED light on the V-Map receiver will turn red. Once a stand alone solution has been resolved (i.e. sufficient GPS satellites have been detected), the red satellite LED will show an additional green light. To confirm that the observed data is actually being recorded, the data LED will flash orange in erratic patterns whenever data is being written to the micro SD card. During normal operation it should thus flash continuously. If no SD card has been inserted, the data LED will repeatedly give three orange flashes in a very regular rhythm. Ideally take-off should commence only once a minimum of six satellites are being observed. For long distances to the nearest GPS reference station it may be wise to record for some three minutes prior to take-off. (The longer the GPS baseline, the longer it may take to resolve integer ambiguities).

If after about 30 to 60 seconds no green light appears on the satellite LED there is a good possibility that no satellites are visible (for example in a building with concrete or metal roof) or the connection to the GPS antenna is faulty. Make sure that the GPS antenna cable connectors are firmly secured.

After landing the power to the V-Map system should be disconnected. The SD-card can then be removed to retrieve the raw observations and event times that were recorded during the flight.

The system creates a sequentially named separate file for each session. Each session file contains the raw observations as well as the events in Ashtech's proprietary ATOM format. The session files are automatically named by the system. A session file is opened on powering the system up and data recording commences once the system is observing a minimum number of four satellites. Files are closed when the system is powered down. Session files comprise the letters LOG followed by a 5 digit integer as shown in figure 3 below.

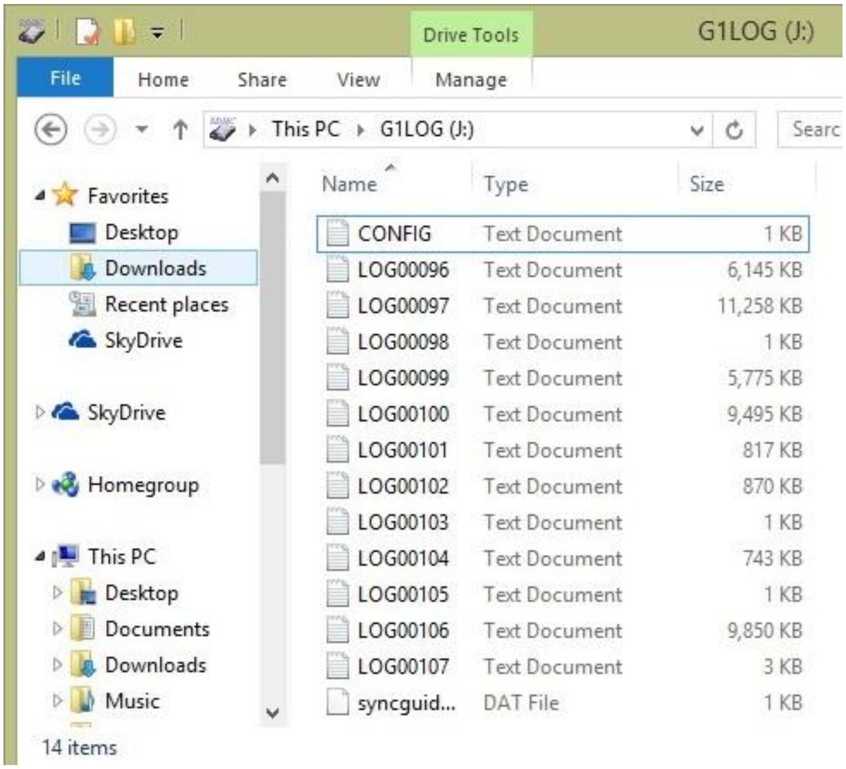

Figure 3: Raw Observation File Names

Note also that the timestamps of the raw observation files all default to Saturday, January 01, 2000, 12:00:00 AM. Hence the file name is really the only meaningful file property variable for use in the allocation of files to corresponding GPS observation sessions.

Once the raw observations and the event times have been retrieved they can be combined with Reference Station Observations (or, in case a GNSS positioning service is available, with Virtual Reference Station Observations) in a post-processing session to determine accurate positions of the GPS antenna at the moment of exposure. A utility to convert the raw data from binary format to RINEX is available for download at http://hemispheregnss.com/Download/Rinex/RinexConverterTools_v1.8.7.zip. Of course the vector between GPS Antenna phase center and Camera Projection Center at the moment of exposure needs to be estimated to correct for the offset between GPS antenna and Camera Projection Center.

For synchronization in hybrid survey systems, the V-Map system is capable of giving 1 PPS output.

4. Mounting Options

The V-Map system has been designed to be UAV-independent. It can be used as an air-borne rover, an on-the-pole rover or as a reference station.

Figure 4: V-Map System mounted on a small Survey Copter

In this example the V-Map system is powered by the UAV flight battery. Note also that the navigational GPS unit was moved to the side to allow for centering of the V-Map antenna above the camera (mounted below the airframe).

Figure 5 below shows a pair of pole-mounted V-Map systems being deployed in a post-processed kinematic survey of ground control points. In this case the operator takes a picture while the V-Map antenna is centered over the survey mark. The recorded event is then used in post-processing to determine the coordinates of the survey mark. In other words the camera is being used instead of the typical data logger.

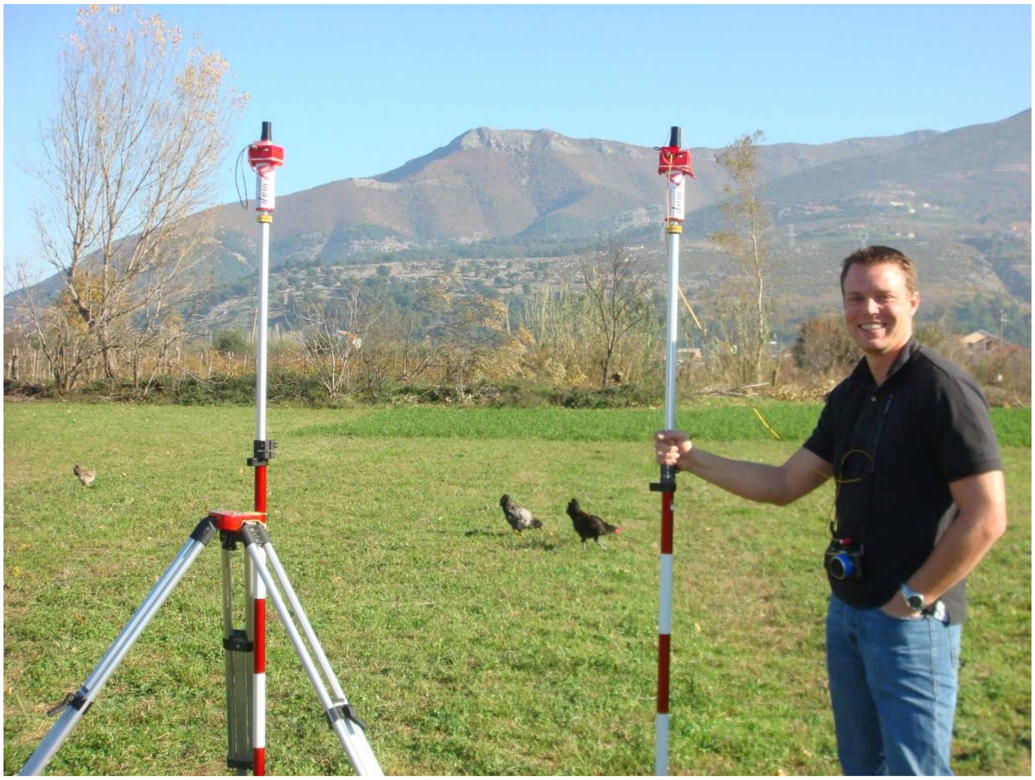

Figure 5: A pair of pole mounted V-Map Systems being employed in a post-processed kinematic survey.

Figure 6 shows in detail an optional V-Map pole-mount which accommodates a light weight 11V LiPo battery capable of powering the V-Map system for 4 hours.

Figure 6: Optional Battery and Pole Mount for V-Map System

5. Technical Specifications of Standard Configuration

Weight (including GPS Antenna, hot shoe adaptor, and SD Card)	150g
Dimensions	82x72x32.5mm
Power Supply	5-32V 500mA max.
Recording Frequency	20Hz

Last updated: July 2014