Loki™ - Frequently Asked Questions

Revision 2.2
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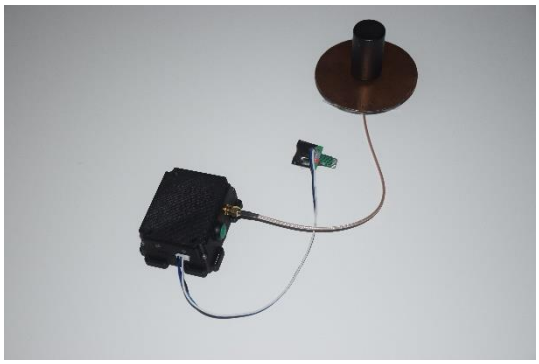
General:

1. What is Loki?

   Loki is a Global Navigation Satellite System (GNSS) Post-Process Kinematic (PPK) direct geopositioning hardware & software solution for low cost DJI drones as well as custom drones using digital single lens reflex (DSLR) cameras such as Nikon, Canon, Sony, etc. It is aimed at the high accuracy drone mapping community.



2. Why should I use Loki?

   Loki will greatly improve the accuracy of drone mapping projects. It allows a reduction in the number of ground control points needed to achieve a specified horizontal and vertical accuracy level. It can provide a reference to the geodetic network in circumstances where no ground control is possible.

3. How much does Loki cost?

   The Loki Core has a list price of $5,395. The Accessory Kit for the Inspire 2 has a list price of $550 and the DSLR Accessory Kits has a list price of $250. The Loki Core can be transferred from drone to drone, but an Accessory Kit is needed for each individual drone.

4. When will Loki ship?

   The DSLR and DJI Inspire 2 versions of Loki are shipping now. The Phantom 4 Pro and M200 versions were completed at the end of 2017 and are currently shipping as well.

5. What is the Loki warranty?

   The Loki Controller includes a one year return to factory warranty. This warranty does not cover damage to components caused by a crash or environmental damage (e.g. submersion, exposure to saturating rain, etc.) nor does it cover cables (including the personality cable). All firmware upgrades as well as mandatory board upgrades are covered by the warranty. Upgrades to new hardware versions are not included (although we do generally offer a discounted upgrade path for current system users).

6. How do I get updates to the Post Processing software?

   ASPSuite Advanced (the Loki post-processing software) is bundled with the Loki kit and includes 1 year of software updates. Each time you start ASPSuite, it automatically checks for updates. After the one year anniversary, you can purchase an extended service contract for Loki or a software update contract for the software only.

7. What is the cost of the post warranty support?

   A full Loki support contract (the first year is included with the original Loki purchase) is US $1,200 per year. This covers the Loki Controller (including the internal battery), the antenna and the ASPSuite software. Cables (including the personality cable) are not covered. The warranty and post-warranty support plan do not cover damage due to crashes or environmental damage such as rain, dust or submersion.

8. What is the cost of a software support contract for ASPSuite?

   The original Loki purchase includes all ASPSuite software updates for the first year. After that time, all updates are included if you purchase the Loki system extended warranty (US $1,200 per year). If you wish to cover the ASPSuite (Advanced Edition) software only, the annual maintenance fee is US $399.

Direct Geopositioning:

9. What is Direct Geopositioning?

   A Direct Geopositioning System (DGPS) is a method of computing the location of a camera (or other sensor) at the exact time that it acquires an image to cm level

accuracy. The DGPS comprises a Global Navigation Satellite System (GNSS) receiver, a camera event trigger and recording system (typically an SD memory card). Post-Processing software is used to compute location information from the onboard DGPS log and encode the acquired images with the resultant X, Y and Z locations.

10. Why use Direct Geopositioning?

    High accuracy aerial mapping requires a tie to the geodetic network (the coordinate or spatial reference system). You probably are familiar with these as State Plane reference systems, Universal Transverse Mercator (UTM) and so forth. One of the common ways to tie an aerial mapping project to a spatial reference system (SRS) is by the use of image identifiable targets (so-called Ground Control Points, GCP) whose locations are precisely determined using survey equipment. These ground control points are used in photogrammetric processing software to determine the locations (and orientation) of each photo at the point that it was acquired. A Direct Geopositioning System (DGPS) augments this process by directly determining the camera position on board the drone at the time of image acquisition. Using DGPS can reduce the amount of ground control needed for a given accuracy level. In some circumstances, a DGPS can eliminate the need for ground control entirely (although this requires great care and a carefully calibrated camera system).

    The bottom line is that a DGPS improves accuracy and significantly reduces project field time (and hence, cost).

11. What is GNSS RTK?

    Global Navigation Satellite System (GNSS) Real Time Kinematic (RTK) positioning solutions use a technique called differential carrier phase GNSS to derive the location of a navigation “rover” to centimeter level accuracy. The general principal is to place a survey grade GNSS “base” station at a precisely known location (there are straightforward techniques for determining the base station location). The base station determines what it thinks is its location using carrier phase GNSS. It then computes the error between where it knows it is located and the location computed from the GNSS. This difference is the error. A similar GNSS receiver in close proximity to the base (say 10 km or less) will have the same error as the base. By broadcasting this error from the base to the rover, the rover can apply the error correction, computing its location to centimeter accuracy. Since the error “vector” is reported via a communication link to the

rover, the moving ("kinematic") rover can make the correction in "real time" hence the name Real Time Kinematic GNSS.

12. What is GNSS PPK?

    Post-Processed Kinematic (PPK) GNSS positioning works exactly the same as RTK (see *What is GNSS RTK?*) except that the error vector is recorded by the base station rather than transmitted to the rover. The rover's position is corrected in a post-processing computation session rather than in real time.

13. Which should I use, PPK or RTK?

    It is really a question of the application. If you need to know the precise location of the rover while it is at a specific location, then RTK will be required. An example of this need would be the use of RTK for centimeter accuracy navigation. This could be a requirement for autonomous vehicle control such as autonomous machine control (AMC) of construction equipment. If discerning the location in the "back office" environment is sufficient, then PPK would be the correct choice. Figuring out the locations of photos for aerial mapping is a good example of an application where PPK is a good fit.

14. Which is more accurate, PPK or RTK?

    One of the inputs to an RTK or PPK solution is the exact position of the GNSS satellites at the time of the positioning operation (for example, the time a photo was taken). The position of GNSS satellites is continuously updated from ground-based tracking stations. An RTK system can make use only of positioning data available at the time of data collection. A PPK system, on the other hand, makes use of data before, during and after collection. These data are called "post-pass ephemeral" data. Since PPK is able to use longer observations, it is, in general, more accurate than RTK positioning.

15. Are there other advantages of using a PPK rather than RTK system?

    A PPK system does not require a radio link from the base to the rover. This not only simplifies deployment but also improves reliability. A radio link typically requires line of sight from the base to the rover. If the drone moves such that a stockpile or building is between the base and the rover, the radio link may be lost with the result of not being to find the location of the rover during the "black out" period.

16. Is a base station always required for DGPS?

    Some scheme for a base station is always required for differential GNSS computations such as DGPS. There are several options including:

    - A portable base station on a tripod mount. You should plan on this being in place for a minimum of 30 minutes (2 hours for improved accuracy).
    - A Permanent base station placed at the mapping site. This is a typical configuration for a mine site where a lot of survey is performed or automatic machine control (AMC) is being used.
    - A Virtual Reference System (VRS). This is a subscription service that uses permanent base stations such as those of a Continuously Operating Reference System (CORS) network.
    - A remote base station such as a single CORS station. This configuration is typically the least accurate of the four choices.

    Note that Loki currently requires a local base station – either portable or fixed. Loki currently works with CORS but we have noticed that some CORS stations will not provide a fixed solution. We are working to improve support for CORS and VRS but this will be sometime in the future.

Cameras and Direct Geopositioning Systems:

17. How does the DGPS know when the camera takes a picture?

    The position computed by the DGPS must be synchronized to each camera exposure if the camera location at the time of the photograph is to be precisely known. A camera specifically designed for airborne photogrammetric applications includes an output signal that sends a pulse when the camera shutter is half-way through snapping a picture. This signal is called a Mid-Exposure Pulse (MEP). A DGPS has several "event marker" inputs that will record the precise time that a signal appears on one of the event markers. By routing a camera's MEP output to a DGPS event marker input, the photos can be synchronized to the DGPS computed positions.

18. What is a DSLR camera?

Strictly speaking, digital single lens reflex (DSLR) camera is a camera with a mirror behind the lens that routes the image to a view finder. When the user presses the shutter release button, the mirror moves out of the way, exposing the digital sensor to the lens-formed image. It is the same as (now old fashioned) film-based single lens reflex cameras with the film replaced by a digital sensor. Newer prosumer digital cameras are "mirrorless" but are still often referred to as DSLR. Unlike smaller consumer cameras and most DJI drone cameras, the DLSR cameras have an attachment for a flash unit.

19. What is a Mid-Exposure Pulse?

See the question "How does the DGPS know when the camera takes a picture?". A Mid-Exposure Pulse (MEP) is a signal sent from the camera to the DGPS that signals the DGPS each time the camera snaps a picture. It is called "mid-exposure" since, ideally, we bracket the time of the exposure. In reality, the exposure is usually sufficiently fast and the drone speed sufficiently slow that the point during the exposure that we declare the event makes no material difference.

20. How is an MEP realized on a DSLR camera?

A DSLR camera does not have an MEP output (see the question *How does the DGPS know when the camera takes a picture?*). However, a DSLR does have the ability to add a flash strobe unit. We tap into the flash unit to detect when the camera has taken a picture by simply connecting to the camera "hot shoe" and switching on the flash of the camera.

21. How do you derive an MEP from a DJI Phantom 4 Pro or X4S camera?

Ah, that is the real secret sauce of the Loki! The DJI Inspire 2 drone with X4S camera does not have a Mid-Exposure Pulse (MEP) output nor do they support any sort of external flash. To overcome this limitation, GeoCue/AirGon designed a hardware circuit that replaces the SD card of the drone. A custom computer on our SD card insert called a Complex Programmable Logic Device (CPLD)

"listens" to messages on the drone SD bus. From this message traffic, we are able to synthesize an MEP and send this signal to the Loki Controller. GeoCue has a patent pending on this and a variety of other methods of synthesizing a MEP or correlating an effective MEP to other events.

22. Does my camera need to be calibrated?

    Yes. For accurate aerial mapping, regardless of your use of direct geopositioning, the camera must be calibrated to achieve results of the highest possible accuracy.

23. How can I calibrate my camera?

    There are generally two options for calibrating a mapping camera:

    - In Situ – this uses ground control points (GCP) that have been surveyed to known locations and the direct geopositioning information provided by Loki. Most Structure from Motion (SfM) processing packages such as PhotoScan Pro (which is a component of the AirGon Bring Your Own Drone Mapping Kit) and Pix4D include the capability of performing In Situ calibration.
    - Laboratory – A laboratory camera calibration consists of taking multiple images from different perspectives of a printed target (typically 1.2 m x 1.2 m). Calibration software is included with Agisoft PhotoScan and Pix4D Mapper.

24. Does the Loki training include camera calibration?

    No. Camera calibration instructions should be provided by the vendor you have selected for your Structure from Motion (SfM) software. If you selected the AirGon Bring Your Own Drone Mapping Kit (a very wise choice!) then the included 8 hours of BYOD Mapping Kit training does cover camera calibration.

25. Will AirGon calibrate my camera?

    Yes, we will calibrate your camera for a flat fee of $100. You must pay shipping to and from AirGon's Huntsville, Alabama USA offices. In the case of drones with detachable cameras (e.g. the DJI Inspire 2, the M200 and, of course, DSLR cameras), it is only necessary to send the camera.

Loki:

26. What is included in the Loki system?

    The Loki kit includes everything you need to do direct geopositioning with a DJI Inspire 2 (with X4S camera) or a DSLR with a flash hot shoe (kits for the Phantom 4 Pro and DUI M200 series should be available by the end of 2017). The components include:

    - Loki Core:
        - System Controller (including the Septentrio AsteRx-m2 GNSS Engine)
        - Maxtena (M1227HCT-A2-SMA) L1/L2 GPS/GLONASS active GNSS antenna
        - USB-C Charging/Data cable
        - ASPSuite, Advanced Edition (post-processing software)
        - Passport to monthly Loki/ASPSuite training
        - 1 Year Software & Hardware Support
        - Select a drone specific personality kit:
            - DJI Inspire 2 with X4S Camera (not part of Loki!):
                - Personality Cable for Inspire 2
                - Antenna Mounting Kit with ground plane
                - Antenna Cable
                - Controller mounting kit
            - DSLR Kit:
                - Personality Cable for DSLR
                - Antenna Mast Kit with ground plane
                - Antenna Cable
                - Controller mounting straps

27. How is the Loki system powered?

    The Loki controller is self-contained, relying on an internal Lithium-Polymer (LiPo) battery for power for both the controller and the (included) active antenna. This battery will power the Loki for approximately 4 hours. The battery is recharged when Loki is plugged into a computer for data transfer. On custom drones, Loki can be powered during flight via the USB-C connector.

28. What if I forget to turn Loki off?

    On the DJI Inspire 2 drone using the SD card personality cable, Loki detects the power state of the drone and powers up/down accordingly. On DSLR configurations, Loki is powered up by a momentary switch on the Loki Controller.

It automatically powers down if 15 minutes have passed since the last MEP was sent to the Controller.

29. How do I know the status of the Loki Controller?

    There are two LED status lamps on the Loki Controller:

    - Battery – Yellow when Loki is charging. Green when the Loki is plugged into USB power and fully changed.
    - Satellite Lock – Yellow when Loki is acquiring satellites. Green when Loki has acquired sufficient satellites for differential carrier phase GNSS.

30. Can I use Virtual Reference Station with Loki?

    No. At this time, Loki requires a local base station. It does not currently function with a remote CORS station or with a Virtual Reference System (VRS). We do plan on offering VRS support at some point in the future.

31. Can I use a remote CORS station with Loki?

    Not reliably. We get a valid CORS solution about 80% of the time. We are working to improve our reliability when working with CORS.

32. How are the Loki-derived positions passed to my Structure from Motion (SfM) software?

    The Loki ASPSuite post-processing software encodes the image EXIF data with the camera exterior orientation (the computed X, Y, Z position of the exposure station) and ancillary information for camera calibration (should you choose to supply this). The exterior orientation also can be output as a comma separated values (CSV) file. The output of ASPSuite will flow directly into Agisoft PhotoScan and Pix4D Mapper. We will soon have a seamless workflow to the DroneDeploy cloud hosted processing system.

33. How much does a Loki system weigh?

    The mass of the complete Loki system, including antenna, mount, Loki Controller and personality cable for a DJI kit is 220 grams.

Loki on DJI Drones:

34. How does Loki mount to a DJI Phantom 4 Pro?

    Loki installs with mounting rods secured to the Phantom 4 Pro via removable O-rings. The personality and antenna cables are secured in place with tape (included in the Loki kit). We recommend that the personality cable not be removed from the drone once it has been installed.

35. How does Loki mount to a DJI Inspire 2?

    The Loki antenna has a ground plane-equipped mount that straps onto the nose of the Inspire 2 with Velcro straps. The Loki Controller attaches to the underbelly of the Inspire 2, again with Velcro straps. The antenna and personality cables are secured in several spots with tape (supplied in the accessory mounting kit).

36. How do I transfer images from a DJI with Loki installed?

    The Loki "personality cable" plugs into the SD card slot on the DJI Inspire 2 drones. The personality cable has a built-in 32-GB storage system. Images are transferred from the drone to your processing computer by using the computer to drone USB cable supplied with your DJI Drone (we discourage removal and replacement of the Personality Cable for downloading images since the DJI micro SD slot is fragile).

37. How is the Loki system turned on and off?

    On the DJI Inspire 2, the Loki Controller monitors the drone via the personality cable. When the DJI is powered on, the Loki Controller powers up. When the DJI is powered down, the Loki powers down.

38. What impact does Loki have on flight time?

    Not nearly as dramatic as you might think. In a recent test we performed of running a Phantom 4 Pro from fully charged to 15% remaining battery capacity in calm air, we observed the following results:

    - Flight time without Loki = 24 minutes
    - Flight time with Loki = 20 minutes

    This was an actual mapping mission, not a hover test. Thus we observed a 17% reduction in flight time as a result of the added mass of the Loki. We have not yet performed the equivalent test on the Inspire 2 but expect the same or better performance.

39. Which is the better DJI platform for Loki – the Phantom 4 Pro or the Inspire 2?

    In general, the Inspire 2 with X4S camera is a much better mapping platform than the Phantom 4 Pro, regardless of Loki. The Inspire 2 is much more wind resistant and can operate in colder weather. Due to its higher mass, it is a more stable platform and thus can remain on the planned flight lines in heavier wind conditions.

40. Can I use Loki on a DJI m200 drone?

    At the time of this version of the FAQ (September 22, 2017), we have started developing an interface for the m200 with X4S camera. We expect to have a solution by the end of 2017.

Loki on drones carrying DSLR cameras:

41. How does Loki mount to the drone?

    The Loki Controller box includes mounting slots around all four edges of the base. You can fabricate a bracket or simply wire tie the Controller onto a drone body mounting plate. The antenna includes a mounting bracket, mast and ground plane. The mast can be mounted in a standard GNSS antenna mast mount.

42. Does Loki trigger my DLSR camera?

    This version of Loki does **not** trigger the camera. Thus, you will have to continue to use your current camera triggering mechanism.

43. My current camera trigger system includes a wire to the flash hot shoe. Can Loki still connect?

    Yes. Loki includes a "stackable" hot shoe connection. Our MEP signal is fed out of the stack by a PC cable of the same type used on a slave flash unit. This cable is included with the DSLR accessory kit option.

Workflow:

44. What software tools are required to use Loki in a drone processing workflow?

    The Loki DGPS workflow accepts raw GNSS data from a base station, GNSS positioning information from the Loki Controller and raw images from the drone. These data, along with ephemeris data downloaded from the web, are used to refine the positions of the images to high accuracy DGPS values. These high accuracy values are written to an output text file (a comma separated values, CSV, file) that is fed into your downstream Structure from Motion (SfM) point cloud processing software (such as PhotoScan, Pix4D, DroneDeploy, ContextCapture and others). The refined values (as well as accuracy tags) can also be written to the image Exchangeable Image File (EXIF) header data for applications that can read directly from the image EXIF (Pix4D, DroneDeploy).

    This flow is accomplished within the AirGon Sensor Package Software Suite (ASPSuite). Thus, for refined image coordinate computations, all required software is included with the Loki system.

45. What downstream software will Loki support?

    Loki will support any image to point cloud software (Structure from Motion, SfM) that can accept image locations encoded into the photo EXIF data or as an ancillary Comma Separate Values (CSV) file. Examples include PhotoScan Pro, Pix4D, ContextCapture and cloud platforms such as DroneDeploy.

46. What is your recommended solution for a desktop, end-to-end processing flow for DJI drone mapping?

    The components of the flow are shown in the diagram below. These components are included in the combination of the Loki ASPSuite and the AirGon Bring Your Own Drone (BYOD) Mapping Kit. They include:

    - DJI Ground Station Pro – Flight planning and mission control
    - ASPSuite – Loki DGPS post-processing
    - Agisoft PhotoScan Pro – Point cloud and image generation (as well as In Situ camera calibration)
    - LP360 (sUAS licensing level) – Accuracy assessment, data reprojection, data cleaning, data classification, data analysis, product creation