

PRODUCT INFORMATION BULLETIN

IMU-based Geo-pointing, Geo-location and Geo-tracking

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Overview

When conducting surveillance missions with Wescam equipment, customers have a need to know where they are located and where the object of interest being viewed is located. Requirements also exist to minimize operator workload and maximize surveillance mission objectives by providing for enhanced steering functions and target tracking capabilities. Wescam offers a number of product features and functions to greatly enhance system ease-of-use, one of which is Geo-pointing.

Geo-Pointing - What is it?

For the MX series of products, the *Auto* feature enables a function called Geo-pointing. Geo-pointing allows the user to direct the optical line-of-sight (LOS) of the surveillance system to a known point at or above the Earth's surface, defined by its latitude, longitude and altitude. This feature also enables a function called Geo-location, which communicates the intercept point of the LOS and the Earth's surface, in terms of latitude, longitude and altitude, to the observer.

Geo-pointing - What are the benefits?

Geo-pointing relieves the observer of steering the system to compensate for the motion of the aircraft. If a target of interest is stationary, the system can lock onto the target's GPS location, and stay locked onto this location until another input is given. This is especially useful when using narrow-field-of-view sensors, where a small steering action can result in a large movement of the LOS across the target. Geo-pointing is also capable of moving (slewing) to a known GPS position. This position can be provided manually by the observer, or cued from other peripheral

attachments, such as radar, or moving maps.

Additionally, this feature is very robust to obstructions from clouds, fog and buildings, since it relies on Earth referenced positioning data, and not the acquired video image data.

Geo-location is useful because the intercept of the LOS with the target can be displayed in terms of latitude and longitude and then communicated to support mission tasks. For missions utilizing long range surveillance systems, the GPS location of the aircraft alone is not sufficient to support such tasks.

Geo-Pointing - How does it work?

To understand the basis of Geo-pointing it is useful to consider a 2 dimensional case where the aircraft position is known, in terms of latitude, longitude and altitude, the target altitude is known, and the orientation of the system LOS is known, relative to the Earth's surface. This case is shown pictorially in Figure 1. In this case, the location of the target can be determined by simple trigonometry. This calculation is repeated frequently as the aircraft changes its position and attitude,

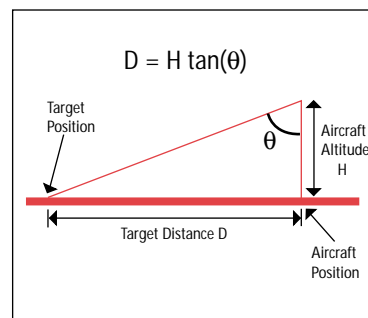


Figure 1. Geo-pointing, Calculating Target Distance D

and the LOS is adjusted accordingly. In a real-world scenario, complex 3 dimensional mathematical formulations are required to determine target location, and these need to account for errors due to mission profile, GPS data quality and imaging system characteristics.

Target Location Errors*		
System Configuration	MX Series	Competitor Systems
High End System • High end GPS/INS • LRF Sensor	1	1.9
Mid Level System • Aircraft GPS only • LRF Sensor	2	11+
Low Level System • Aircraft GPS only • No LRF • Integrated Moving Mapwith Elevation Data	7.5	20+

Table 1. Typical Target Location Errors for High, Mid and Low Level System Configurations
(* relative dimensionless units)



What Makes Us Different from the Competition?

Wescam's superior approach to Geo-pointing and Geo-location functions means fewer errors are introduced and hence greater overall accuracies are achieved, for similar system configurations, and mission applications.

The competitors' approach for Geo-pointing, based on a simplified 2 dimensional case, is shown in Figure 2. The goal of the calculations is to determine the angle Φ , which would be used to direct the LOS. This is achieved by first determining

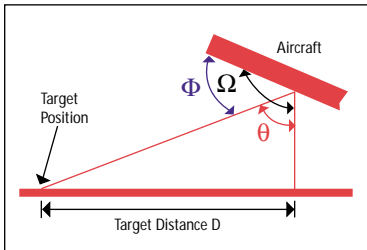


Figure 2. Competition's Method for Geo-pointing (Simplified 2D Case)

the angle θ from the current aircraft position, and the desired target position. The attitude of the aircraft, represented by the angle Ω is obtained from aircraft inertial navigational system (INS) data. Finally, the desired angle Φ is determined, and the LOS is commanded to this angle. These calculations would be performed periodically to compensate for the aircraft movement, and hence the changes in values for the angles above.

The main disadvantage of this implementation is that the inherent noise in the aircraft INS data, used to stabilize the LOS position, translates into LOS jitter, and hence decreased pixel resolution on target. Compensation actions to filter this noise will only result in reduced responsiveness to aircraft

maneuvering. This method also introduces errors due to angular positioning of the turret to the aircraft and turret to the INS axes, as well as increasing the latency of the data used to compensate for the LOS angle.

Wescam's implementation to Geo-pointing is similar to that used by most high performance targeting systems, relying on an IMU which is directly mounted to the optical bench, as depicted in Figure 3.

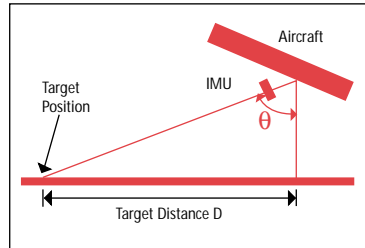


Figure 3. Wescam's Method for Geo-pointing (simplified 2D Case)

The angle θ is determined by processing the data from the IMU attached to the LOS directly, without needing to rely on additional aircraft referenced inertial data for the short term positioning corrections. Velocity and acceleration data from the aircraft are used only to provide long term accuracy corrections.

The advantages of this method are that no jitter is introduced onto the LOS, and hence the pixel resolution on target is not compromised. The short term compensation actions required to maintain the LOS at a fixed location, do not depend on aircraft referenced data, but depend solely on the on-board IMU. Additionally, no errors due to turret mounting relative to aircraft and IMU exist.

What Other Factors Affect Geo-pointing Accuracy?

Independently of the system based factors described above, the

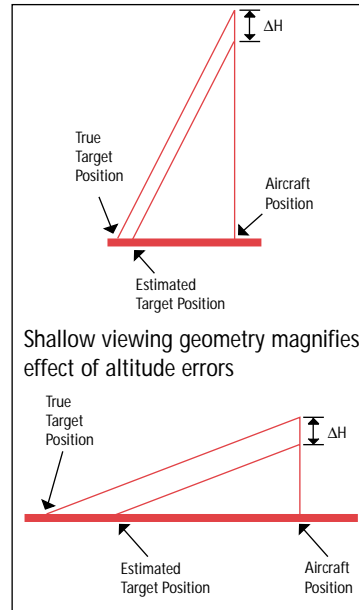


Figure 4. Geo-pointing Errors Due to Shallow Viewing Angles

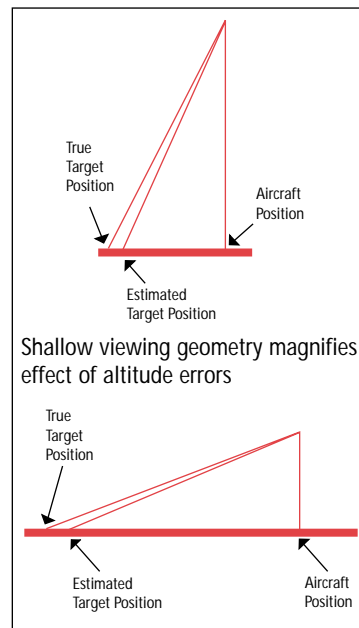


Figure 5. Geo-pointing Errors Due to Shallow Viewing Angles

accuracy of Geo-pointing also depends on mission application type.

Fundamental errors due to viewing geometry, as shown in Figures 4 and 5 may be introduced. The error between the predicted target position and the true target position

are magnified for missions where the LOS viewing angle is shallow (i.e. low altitude flight, long range surveillance). In addition, the geometry of the terrain modifies the effect of LOS errors. Uncorrected, these errors could mean that when the LOS is directed to a true target GPS location, the target will not be visible in the field-of-view.

How Do Geo-pointing Accuracies Vary With System Configuration?

The imaging system characteristics can be improved by the addition of a Laser Rangefinder (LRF) sensor, and by the integration of a moving map containing elevation data. Hence the accuracy advantages of the MX series products over competitor products depend on both application, and system configuration. Typical accuracies (target location errors) are presented in Table 1 above, for three types of system configuration.

The MX series offers outstanding accuracy without the need to utilize GPS data. This results in reduced system integration efforts and complications.

Geo-tracking

The *Auto-aid* feature builds on the Geo-pointing and Geo-location functions by enabling Geo-tracking. Geo-tracking allows the LOS to be directed on a path along the Earth's surface, or above the Earth's surface, in the form of a geographically-based slew rate. This is a useful steering mode for objects that are moving at a constant rate. It is also robust to aircraft movement and obscurations, and requires the use of a GPS receiver and antenna.