Precision Aircraft GPS Positioning Using CORS

By Mohamed M.R. Mostafa

One of the limitations of using integrated inertial/GPS systems to Directly Georeference airborne sensor data is the necessity of using a GPS base station or stations in order to obtain the positional accuracy required to meet the accuracy standards of certain mapping products. In some precise large-scale aerial survey applications having to place a number of GPS base stations in a remote or inaccessible location becomes quite problematic. The aerial survey industry has been using airborne GPS as a standard procedure to assist map production for the past decade. More recently, GPS-aided inertial systems such as Applanix POS AV have been successfully used to provide the full resolution of trajectory parameters, namely position, velocity, and attitude. This way, the entire set of translational, and rotational parameters of any airborne acquired image or laser scan line can be measured with respect to some mapping frame. Data acquisition procedure plays a role in the success of this method. Separation between the airborne and base station GPS receivers, satellite geometry as reflected by the Position Dilution of Precision (PDOP), signal multipath and many other parameters must be considered in order to achieve the maximum possible GPS positioning accuracy (see Table 1 for details on residual DGPS errors). Many times it is difficult or not practical to optimize these parameters. For example, since the sun angle required for aerial photography and the PDOP required for strong geometric positioning by GPS do not necessarily occur at the same time, aerial flight missions sometime inadvertently compromise the GPS PDOP in order to get a good sun angle.

Hence for high accuracy mapping applications where the highest GPS positioning accuracy is required, careful mission planning is therefore mandatory. A usual outcome of this is the requirement for a series of GPS base stations to be deployed in order to support the project. In inaccessible regions this can be very difficult. In other applications such as corridor surveying where the accessibility is usually quite good and the positional accuracy is often relaxed, a major problem is the cost of laying out base stations at regular intervals along the corridor, which can often be thousands of kilometers in length. On some other occasions, (as often is the case in a real production environment), the GPS base station data may simply be lost due to equipment problems or human error.

Therefore, the focus of this article is on the accuracy that can be obtained using the NGS CORS stations as base stations for airborne GPS positioning, and the possibility of using these stations to supplement, back up, or even replace the base stations usually deployed for a given project.

The USA Continuously Operating Reference Stations (CORS) is run by The National Geodetic Survey (NGS). CORS comprises a network of **253** sites (as of January 2002), containing geodetic quality GPS receivers. This network is currently growing at a rate of about 4 –10 sites per month. The NGS collects, processes, and distributes data from these sites in support of high-accuracy 3D positioning activities throughout the United States and its territories. For details about CORS, see www.ngs.noaa.gov. Figure 1 shows a map of the CORS stations in The USA.

Table 1. DGPS Residual Errors

Error	Error Characteristics
Orbital	• Correlated between satellites • Significantly reduced by between-satellite differencing (DGPS) • Using precise orbits and satellite clock corrections improves positioning accuracy for long baselines
Ionospheric	• Frequency-dependent, thus, dual frequency data eliminates the error for long baselines. • Broadcast model reduces the error by 50% • In double difference airborne kinematic case error is typically 1-2 PPM for mid-latitudes between sunspot highs
Tropospheric	• Frequency-independent, thus, cannot be removed by dual-frequency data • Dry component can be modeled and removed • Wet component needs meteorological data and more difficult to model because of the variable nature of water vapor • Over long baselines the wet component effect on positioning can be estimated for airborne applications
Multipath	• Site-dependent and, thus, cannot be removed using differential GPS • In kinematic applications, the multipath signature has a strong correlation with vehicle speed • Therefore, multipath gets random (and less) for higher speed

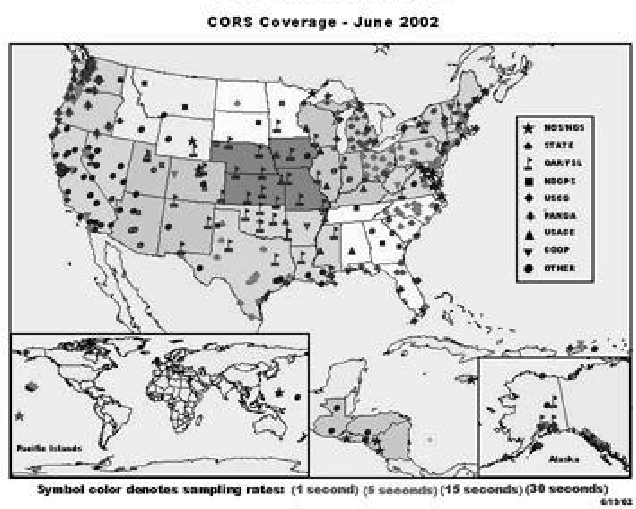

Figure 1. CORS in The USA

Accuracy Analysis

Two mapping projects have been recently used to assess the quality, reliability, repeatability, and feasibility of using the CORS in airborne mapping missions. These are called here the Aeromap Project and the HJW Project. In both projects the CORS stations in the proximity of the mapping area together with the airborne GPS data were

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used to analyze the accuracy achieved when using the multiple-base approach implemented in POSGPS, which incorporates the data from any available base station in the processing of the airborne GPS data. The separation between different CORS stations and the mapping area varied between 30 and 400 Km. The achievable accuracy in both projects is summarized in Table 2.

Table 2. Camera Exposure Station Position Accuracy Using CORS data (The Multiple-base Station Approach).

Position Component	Aeromap Project		HJW Project	
Statistics	Maximum (m)	RMS (m)	Maximum (m)	RMS (m)
Easting	0.16	0.05	0.14	0.07
Northing	0.21	0.05	0.12	0.05
Height	0.46	0.22	0.21	0.08
3D	0.53	0.23	0.28	0.12

Summary and Outlook

Briefly, in this article, the results and analysis from real mapping projects were presented to show the great potential of using the CORS for airborne GPS positioning in the United States. Other CORS networks are already established in different countries. Ongoing experiments with the foreign CORS networks will be presented in the direct georeferencing column. In addition, other methods of airborne GPS positioning will be presented in the direct georeferencing column.

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Further Reading

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