Chapter 7
Airborne Global Positioning System Techniques

7-1. ABGPS

Airborne Global Positioning System (ABGPS) technology may be employed to supplement and minimize ground survey control points required for aerotriangulation and rectification of aerial photography. ABGPS employs on-the-fly (OTF) survey techniques for initialization of a receiver while it is in motion. Additional information regarding GPS theory, OTF, and mission planning is addressed in EM 1110-1-1003, "NAVSTAR Global Positioning System Surveying." Similar to ground GPS data collection, ABGPS receivers lock on to a minimum number of navigation satellites to ensure maximum attainable accuracy of photo center locations. The photo center locations (X, Y, and Z) are then used to supplement minimal ground control data in aerotriangulation procedures. Figure 7-1 is a flowchart depicting a general airborne GPS task flow for aerotriangulation data collection.

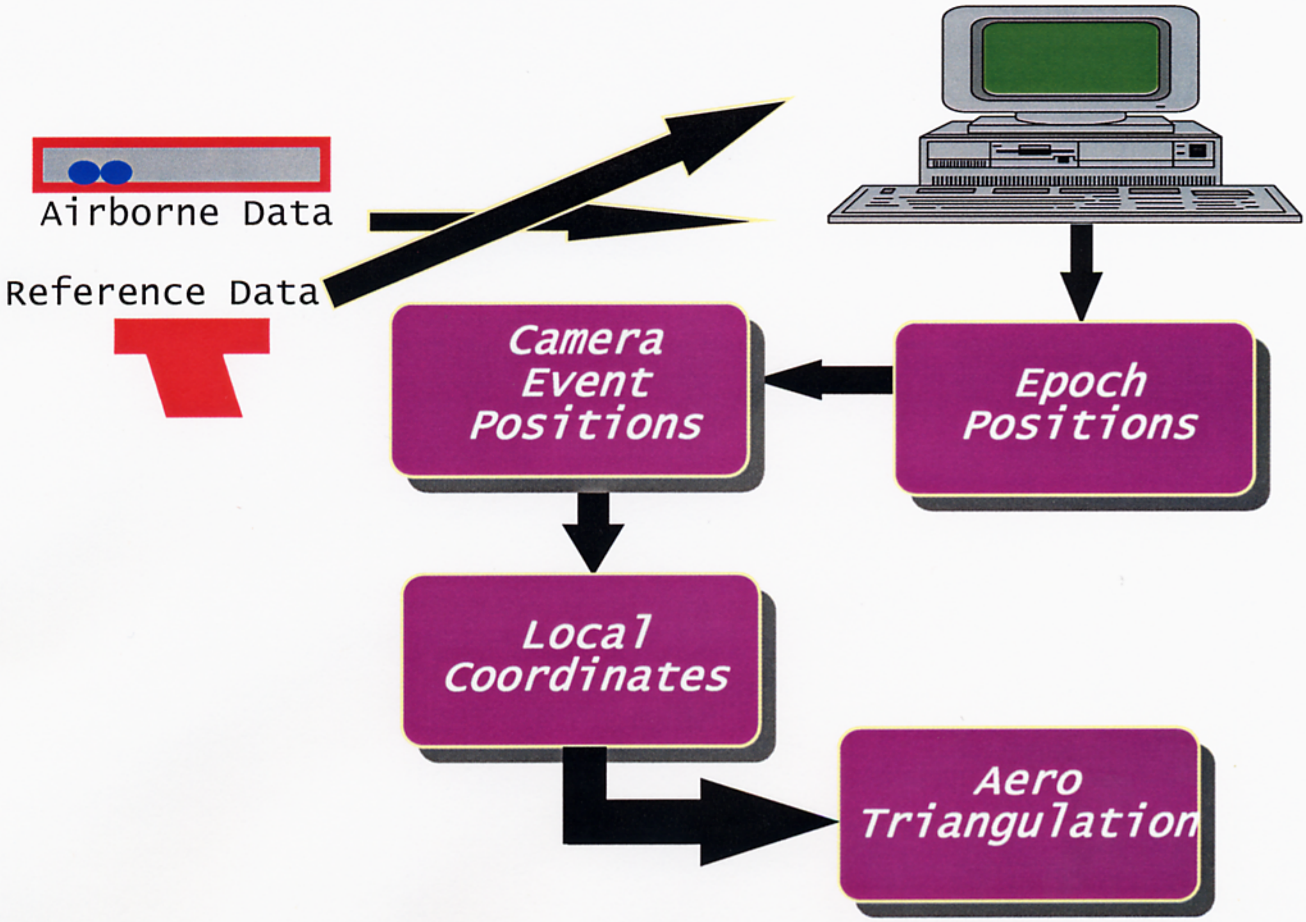

Figure 7-1. ABGPS data collection flowchart

7-2. Project Planning

Planning photography control for a mapping project with the ABGPS requires specialized experience. ABGPS technology is one of the tools to be considered for collection of necessary reference control for a photogrammetric mapping and is used in conjunction with other traditional ground survey methods. ABGPS contractors should be selected on their specific ABGPS experience. Planning an ABGPS controlled project should include the following considerations.

a. Basic Photogrammetric Mapping Requirements. Photo and mapping scale requirements.

b. Aerotriangulation Requirements. Aerotriangulation accuracy requirements for ABGPS photo center control and any ground control.

c. Satellite Availability. Satellite lock must be maintained throughout the flight operation.

d. Location. Placement and number of ground GPS receivers required for the project and the required data collection rate for the receivers.

e. Selection of reference ground control (Base Stations). Coordinate integrity of base stations and ground control must be validated.

f. Aircraft and ground crew logistics. Base ground stations and aircraft receivers must be using the same satellite configuration and limitations. Accuracy of the antenna camera offset must be validated. Detailed and accurate flight logs must be developed and maintained. Crew experienced in ABGPS data collection is imperative (i.e., Making sharp turns may cause loss of satellite lock).

g. Site Access. Site access for ground survey and ground receiver operation during the flight.

h. Flight Time. Flight time required for additional sidelap and cross flights which may be required for aerotriangulation.

i. Experience. Experience of personnel in planning and implementing an ABGPS project to include aerotriangulation and ABGPS data.

j. Aircraft Cost. Additional cost of aircraft use equipped with ABGPS.

k. Postprocessing. Experience and cost of personnel in post processing ABGPS data (including RINEX data) for use in aerotriangulation.

7-3. Other Considerations

Issues to be considered include:

a. Overlap. The amount of forward overlap (endlap) and sidelap required and how it affects the amount of control for aerotriangulation.

b. Ground Control. The number and placement of ground GPS receivers affects the amount of additional ground surveys.

c. Communications. The communications link between the ground crews and the flight crew.

Additional information regarding planning may be obtained from the FGDC 1996 Geospatial Positioning Accuracy Standards and EM 1110-1-1003, "NAVSTAR Global Positioning System Surveying."

7-4. Ground Receiver

In order to achieve maximum accuracy, receivers must be capable of tracking both coarse acquisition (C/A) and pseudorange (P-code). They must provide dual frequency (L1 and L2), and multichannel capability. The receivers should be capable of recording carrier phase data during the flight. The distance between the ground receiver and the airborne receiver depends upon the type of receiver but generally can be within 20 to 50 km if the geoid model is known throughout the project area. These data captured at the established ground station provide correctional information to maximize the accuracy of the airborne position. See Figure 7-2 for typical ground receiver data collection.

Figure 7-2. Typical ground receiver data collection

7-5. Airborne Receiver

ABGPS receiver software must be capable of OTF ambiguity resolution. The receiver must be a dual frequency receiver capable of tracking both the C/A and P-Code satellite signal data. Figure 7-3 is a schematic illustration of an ABGPS configuration. The basic components of a an airborne GPS system are:

a. GPS antenna. This unit intercepts the ranging signals from at least four satellites.

b. GPS receiver. This unit houses the GPS receiver which logs the raw data. The receiver is interfaced with a computer which is the heart of the flight management system, providing navigation information and real-time position stationing.

c. Operator terminal. This is the interface between the camera operator and all of the integrated sensors allowing supervision of the survey flight. The computer can control the camera operation automatically.

d. Aerial camera. The camera may have several flight controlling features which lessen stress for both pilot and photographer while producing precise high-definition photos:

(1) Gyro-stabilizing mount eliminates pitch, roll, and yaw to assure vertical photography.

(2) Internal drift reference allows external drift control.

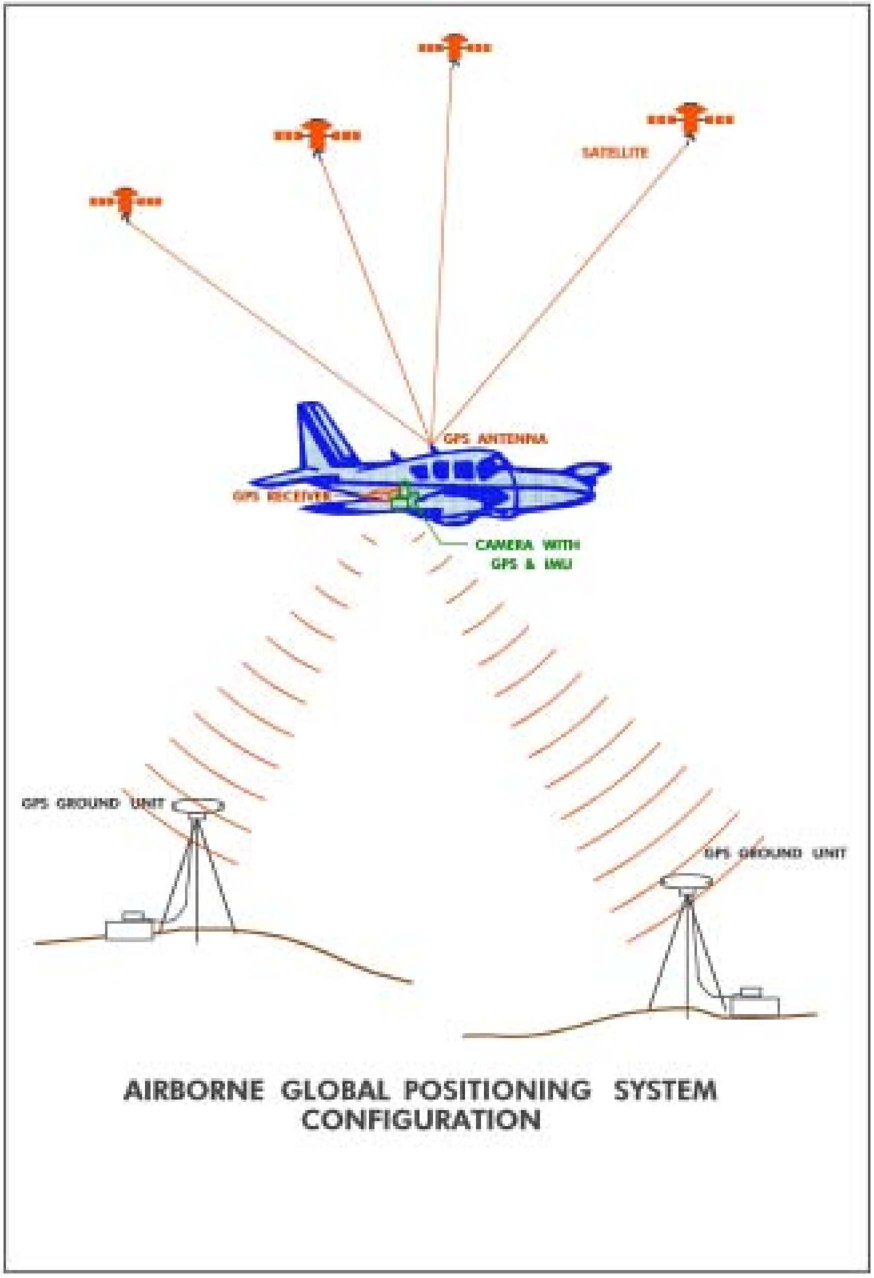

Figure 7-3. ABGPS configuration

(3) Precision lens system provides faithful color rendition and false color differentiation.

(4) Forward motion compensation (FMC) to compensate for the forward motion of the aircraft during the exposure cycle.

(5) Automatic exposure meter.

e. Pilot display. This unit provides the pilot with continuous graphic guidance information.

7-6. ABGPS Project Configuration

ABGPS is not necessarily less expensive than obtaining conventional ground control. ABGPS does not eliminate the need for ground control but it can reduce the requirement significantly for many projects. As stated above, the decision to use ABGPS should consider the required scale and accuracy specifications of mapping. At the time of writing this document, it is generally accepted that mapping projects requiring mapping scale specifications of 1 in. =100 ft mapping with 2-ft contours or smaller can realize significant savings in time with the use of ABGPS. ABGPS technology usually provides maximum benefit for projects that can be accomplished in blocks of photography with more than a single flight strip. A large block of photography can generate additional time and cost for aerial photography and aerotriangulation but should reduce time and cost of obtaining ground control. This is not necessarily true when projects consist of single flight lines or irregular blocks. Figure 7-4 depicts a flight and ground control plan of a mapping project flown in an ABGPS block configuration. ABGPS technology is dynamic, constantly improving, and becoming more available and more cost effective. Improved receivers and software, coupled with more accurate geoid models and global datums, are allowing ABGPS control to reduce to a minimum the amount of ground control required for even large-scale projects. When planning a photogrammetric project, ABGPS should be considered along with other options, being careful neither to eliminate its feasibility nor force the limitation of this technology to fit the specific project specifications. Conditions, which might make utilization of ABGPS worthwhile, include:

a. Access. Difficulty in obtaining access to ground control locations (i.e., military exclusions, hazardous sites, uncooperative land owners, remote terrain).

b. Area. Projects with large areas to be controlled for mapping.

c. Schedule. Reduced ground survey time can allow a more flexible production schedule.

7-7. Quality Control

It must be understood by the user that the control philosophy of the photogrammetric mapping contractor substantially influences the accuracy of the final mapping product. ABGPS is simply one of the tools that the Contractor may choose to use to collect necessary ground control data for adjustment of aerial photography to the earth for mapping. This suggests that the user's representative should be knowledgeable about planning photogrammetric mapping projects that include the use of ABGPS. Quality Control (QC) for ABGPS projects should be similar to QC for any ground control collected for a mapping project. Table 7-1 may be used as a guide for an Airborne GPS Quality Control Plan. Experienced Contractors should use and provide a similar plan for each project.

Additional information regarding QC may be found in EM 1110-1-1003, “NAVSTAR Global Positioning System Surveying.” QC procedures for ABGPS projects should be part of the selection procedures for highly qualified contractors. Prior to mission implementation, the Contracting Officer (or his technical representative) should be assured that the Contractor’s QC procedures and ground control plan will provide the required accuracies for the photogrammetric mapping. Quality assurance (QA) testing of the ABGPS results may be required for some projects. QA testing may include third-party independent ground surveys reestablishing selected reference points and known hard points visible in the final mapping. These points may be withheld from the primary survey contractor and the mapping contractor until the project is completed and used as an initial check of the mapping accuracy. QA testing procedures will follow ASPRS guidelines.

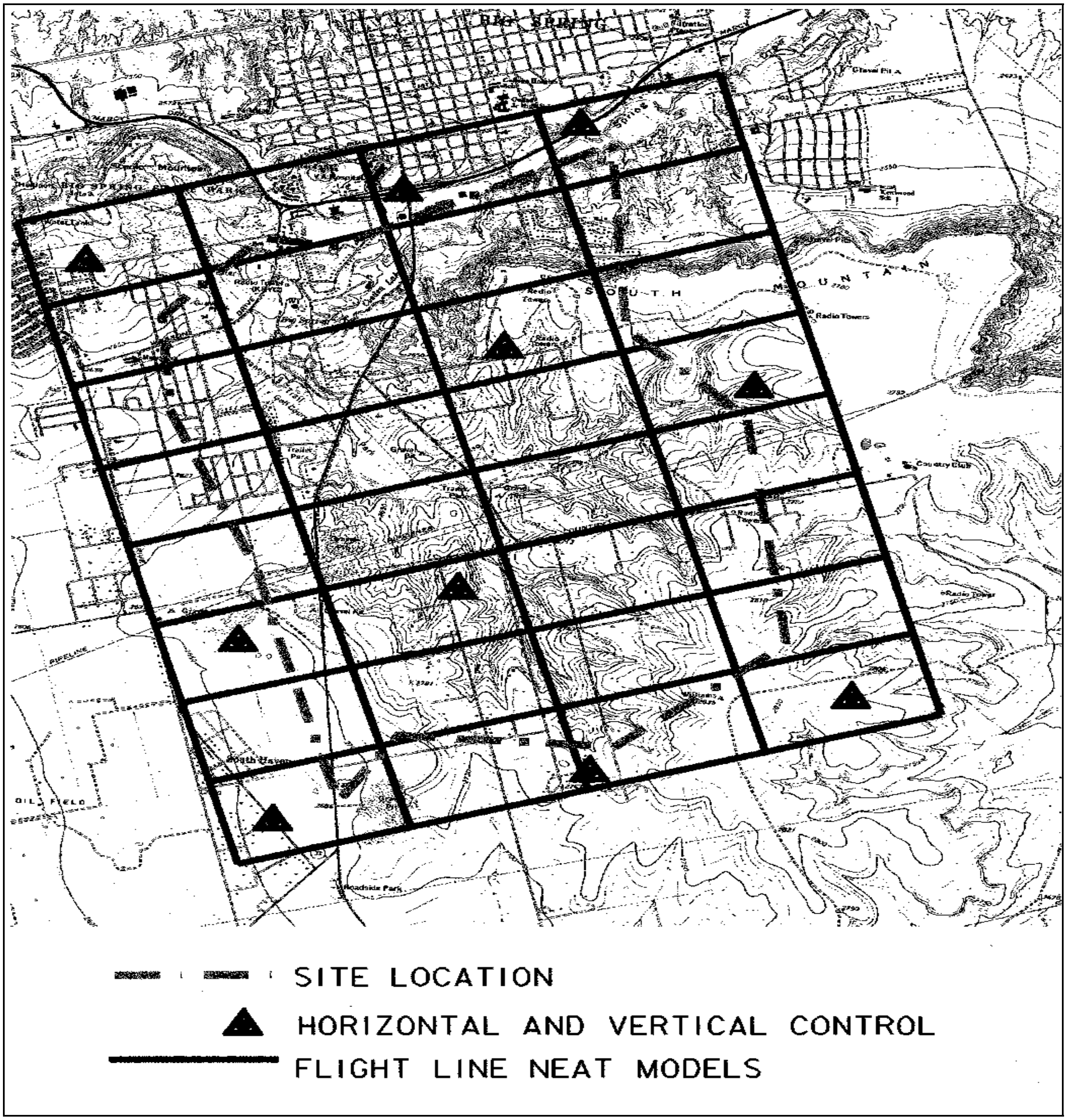

Figure 7-4. ABGPS flight and ground control plan

Table 7-1
Airborne GPS Quality Control Plan

Project Planning

Review project specifications

1. Location and size of area
2. Map & photo scale, contour interval
3. Review survey data (i.e., vertical and horizontal datums, accuracy of ground control)
4. Review and confirm GPS planning (i.e., base station requirements).

Aircraft and Camera Operation

1. Verify the camera antenna offset.
2. Perform check of all equipment to include GPS units in aircraft and the camera operation.

Airborne GPS Data Acquisition

1. Ensure comunication between air and ground crew.
2. Ensure all equipment (air and ground) are in good working condition.
3. Ensure proper preflight system check (antenna height).
4. Ensure that data are properly downloaded and stored.

Airborne GPS Data Processing

1. Review raw data.
2. Process and evaluate base station and aircraft data.
3. Review flight lines and GPS event numbers. Correlate aerial film event numbers to the flight and exposure number.
4. Correlate GPS event numbers to the lettered flight line and exposure number.
5. Create final control file, i.e., photo number, easting, northing, elevation.
6. Data backup of all data sets.