Photogrammetrische Woche 1991
Schriftenreihe, Heft 15, 1991
Institut für Photogrammetrie

GPS FOR PHOTOGRAMMETRY - EXPERIENCE AND PROJECTS IN FRANCE

Y.Egels, Paris

1. INTRODUCTION

I.G.N, the French geographic institute, is involved for a long time in using airborne measurements to reduce the need of ground control points in aerial triangulation. I.G.N produces a large quantity of maps in countries devoid of dense geodetic equipment, and where the standard stereopreparation is long, difficult and expensive. It has implemented in many countries the use of airborne profile recorder, initially with radar altimeter, and then with laser distancemeter. But this method, needing supplementary flights, and of quite poor precision, had to bee superseded by a new one.

The following methods where taken in consideration: measure of the vertical distance between the plane and the ground simultaneously with the picture with the laser, measure of the atmospheric pressure with an electronic barometer, measure of distance between the plane and 4 radio transponders (Trident).

Only the second method has a practical interest, because the hardware is very cheap, completely autonomous, and gives an altimetric precision compatible with medium scale cartography. The cartography of the coastal area in Guyanne, at the scale of 1/25000 has been produced with this method in September 1987, with a barometer CROUZET 44, and the altimetric precision was about 1.25 meter.

The use of laser altimeter was abandoned for two reasons: first, the identification of the laser impact on the ground (not visible on the photo) is a very difficult operation, and of poor reliability; secondly, the addition of distances between plane and ground in the bundle adjustment gives only scaling information, which are not the most useful. Localization with Trident system requires the availability of 4 radio transponder, on known geodetic points, with electric power supply, at less than 100 km from the plane position. These constraints make the method difficult to use in many countries; the accuracy of the localization (1-2 meters in planimetry, worse in altimetry) was considered as inadequate for the photogrammetric use.

2. FIRST EXPERIMENTS WITH GPS

In 1986, the company SERCEL, manufacturer of GPS receivers, asked IGN for testing the quality of reception on a plane. This first flight shows the possibility of using geodetic GPS on fast planes, with a good accuracy on relative positions. I.G.N. decided then to explore the feasibility of aerotriangulation without ground control points.

The most important production of I.G.N. is medium scale cartography, and so the first experiments were made with pictures at the scale 1/30000. During the flight, a SERCEL receiver TR5-S.B was in the plane connected to an antenna DORNE-MARGOLIN, with recording period of 0.6 second, and link with a WILD RC10 camera, modified to output a signal with a known delay after the opening of lens.

The post-processing method of GPS record used by SERCEL (trajectography) does not need a fixed receiver on the ground, but gives only relative position of the plane. The bundle adjustment software of I.G.N. was modified to take this particularity in account. For each projection center measured by GPS, the following equation was added:

$$\begin{bmatrix} XS \\ YS \\ ZS \end{bmatrix} = \begin{bmatrix} X_{gps} \\ Y_{gps} \\ Z_{gps} \end{bmatrix} + \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix}$$

with $\Delta X, \Delta Y, \Delta Z$ three coordinates of an unknown translation vector for each photo strip (when the plane banks at the end of the strip, the reception of satellites is often interrupted, and the relative position is lost). This translation includes the gap between the camera and the GPS antenna, which can be considered as constant during the strip for the expected accuracy (about 50 cm).

Four test flights were made in August 1987, in Lunel, Vichy, Albertville and Manosque, with a Mystere 20, at an altitude of about 5000m, and a speed of 600 km/h. Each site has been covered by 4 strips of 14 pictures, and two perpendicular strips of 9 pictures. The ground control points have been measured with standard topometric methods (without targeting). The aerial triangulation was first computed without the GPS equations, and the differences between GPS measurement of the projection centers and the results of aerial triangulation were computed. Afterwards, the GPS measurement were incorporated to the adjustment, and only one ground control point was

Photogrammetrische Woche 1991
Schriftenreihe, Heft 15, 1991
Institut für Photogrammetrie

retained, all the others being used as check points. In Albertville and Manosque, only 3 satellites were in sight, the Hdop was very high, specially in Albertville, and the data of the electronic barometer were used to initialize the altitude of the plane. Even in that case, the altimetric results are quite not so bad! In Lunel and Manosque, the ground control points were tranferred from old field work, and there quality was low.

Site	EMQ with out GPS	EMQ of GPS measurement	EMQ with GPS and no ground
VICHY	X : 0.55 m Y : 0.54 m Z : 0.49 m	X : 0.51 m Y : 0.46 m Z : 0.35 m	X : 0.65 m Y : 0.64 m Z : 0.88 m
LUNEL	X : 0.77 m Y : 0.73 m Z : 0.60 m	X : 0.39 m Y : 0.41 m Z : 0.26 m	X : 0.72 m Y : 0.67 m Z : 0.61 m
ALBERTVILLE	X : 0.76 m Y : 0.82 m Z : 0.63 m	X : 5.30 m Y : 1.46 m Z : 0.97 m	X : 4.71 m Y : 3.29 m Z : 1.07 m
MANOSQUE	X : 0.99 m Y : 0.80 m Z : 0.59 m	X : 1.19 m Y : 0.87 m Z : 1.51 m	X : 1.31 m Y : 1.06 m Z : 0.93 m

The conclusion of this first study was the practical feasibility of the method, and that the quality of the test data was to low to give a valid conclusion about the accuracy of GPS for photogrammetry.

3. ACTUAL TESTS

I.G.N decided then to wait an opportunity to do a new experiment in better conditions, with targeted test field, at big scale (1/3500), with more modern receivers, and with more satellites in sight. For navigation purpose, the planes were equipped with GPS receivers SERCEL NR103, which have geodetic capacities (monofrequence, 10 channels), and Sagem asked for an experiment with receiver Ashtech. In June 1991, all the conditions were joined to continue the test. The first flight took place at the end of June with Ashtech receiver, on Beechcraft King Air, in true kinematic mode. 200 benchmarks were measured by topometric method, with an accuracy of about 2cm. The pictures were made at scale 1/3500, in 3 strips of 16 photos, with transversal and longitudinal overlap of 60%. The speed of the aircraft was 290 km/h.

Due to the expected accuracy, the bundle adjustment software has been

modified to integrate the shift between the camera and the antenna, which was measured by topometric means before take-off. The vector, known in aircraft-linked coordinates system, is transformed into ground system by the bundle rotation matrix. It is not completely exact, but the approximation is justified by the short distance separating the camera and the antenna (1.84 m in planimetry, 1.82 m in altimetry) The processing is not actually finished, but the first partial results seem to show a very good accuracy (between 5 and 10 cm) for some camera position, but other points are very far from the GPS position (up to 8 meters). It is probably due to synchronization problems (about 0.1 s) between the RC10 camera and the receiver, and all residuals are in line with the plane's trajectory.

4. FUTURE EXPERIENCES AND USE OF GPS

A second flight with Sercel NR103 receiver must be made in July, to test the trajectographic mode of processing, which is practically interesting, because it do not need any ground equipment simultaneous with the flight. The accuracy is probably lower than the true kinematic method, but sufficient for current use.

I.G.N. has to realize the cartographic coverage of the occidental part of Guyanne, along the Surinam border. This area is one of the most difficult to penetrate due to the primary forest, an traditional field work is economically impossible. The aerial photography, scheduled for the second semester of 1991, will cover 30000km² at the scale 1/50000, and GPS will be used for navigation as well as for geometric equipment. No field work is forecasted.

REFERENCES

BROSSIER R. : Le nouveau systeme APR-Laser de l'Institut Géographique National, Bulletin SFPT n° 94, 1984.

BROSSIER R.,MILLION C.,REYNES A. :Applications photogrammétriques du récepteur GPS TR5S-B à l'Institut Géographique National, Proceedings of the ISPRS congress, Comission I, WG I/3, Vol 27 part 1, KYOTO 1988

MILLION C. : L'utilisation des mesures saisies en vol en aérotriangulation, Thèse de doctorat de l'université de PARIS VI, PARIS 1991