

MULTI-TRIANGULATION TO GET GCP FOR OLD UNPREMARKED AERIAL PHOTOGRAPHS

Fahmi Amhar^a

^a Researcher in Mapping & Technical Manager of Kalimantan Mapping
National Coordinating Agency for Surveys and Mapping, Bakosurtanal
Cibinong Science Centre, Jl. Jakarta Bogor Km. 46 Cibinong, Indonesia
Telp. /Fax. +62-21-87901254; email: famhar@telkom.net, famhar@yahoo.com

TS 1 YF Youth Forum - Photogrammetry

KEY WORDS: GPS/INS, georeferencing, identification, triangulation, photographs, orientation, adjustment

ABSTRACT:

If a large number of old aerial photographs is exist but there is no premarked ground-control- and also no kinematics-GPS on board of photo-centre-position for aerial triangulation, then the post GCP-survey would be very hard. The most problem is to identify the place on photographs to the current situation and to get the place. In the first part, the experience of such project in Kalimantan will be explained. In the second part is the idea how to accelerate and optimised the whole GCP survey.

1. BACKGROUND

1.1 General Condition

Kalimantan (Borneo) is one of the largest islands in the world. The Indonesian part of Kalimantan is about 540,148 sqkm. The Island is just 43 % topographic mapped on 1:50.000 scale. A large part is not yet mapped due to: (1) the ever-cloudy situation; (2) the limited state budget to do systematic mapping over the whole island.

During the Era of Soeharto's government, the ministry for forestry has obligated to all forest concession holder company to make aerial photographs for their concession area. Between 1990-1993, each company made their photographs used different camera, aircrafts etc. These aerial photographs are stored to the ministry as evidence of the forest situation. No topographic map is made from these photographs.

After the end of Soeharto's regime, there is new condition, which focused to re-use the photographs. The paradigm of district wide-autonomy has increased the consciousness of the district authorities of Kalimantan, that they need also qualified topographic map in middle and larger scale. This demand is pushed by the facts of increasing illegal logging, wild forest fire, and claim from indigenous people for land-common-right and other environmental problem. These entire problems are acute.

There are some technology on the market to make topographical map for scale 1:50.000, i.e. (1) airborne photogrammetry using existing (forestry) photos; (2) airborne photogrammetry using new photos; (3) SPOT5-Stereo or ASTER-Stereo; (4) Airborne Interferometric SAR (IFSAR); and (5) Lidar Imaging. Due to the budget constraints, and the cloud situation, the option (1) is in favor.

The reason: topography data (DTM) is the most expensive part in topographic database and in the area is mostly not changed. Only the land cover is changed, and this should be updated from Landsat or Aster data. The option (1) shows the respect of the current government to save money and re-use the existing assets. The problem is this concept never proven for a large area.

In 2002 the National Coordinating Agency for Surveying and Mapping (Bakosurtanal) decided to use these aerial photographs to make new topographic map for part of East Kalimantan, about 80,000 sqkm (8 Million hectare) to execute in 2003. The financing plans about 14000 aerial photographs to be processed in this year.

1.2 The Selection of the Photographs

About 70000 aerial photographs of scale 1:15.000 – 1:22.000 were made for forest concession holder. The large scale is while the aircraft had to fly under the cloud. The photographs would be made mainly on forest area; also not what in the time of capture was cities, swamps, big river etc. Different holder means different project, different camera, different scale, different numbering system on photos and different photo quality. It was very hard job to select adequate and useful photos. There are many overlaps between photos. In other location, there are also individual gaps where no any photo exists. The overlaps are caused by the fact that some company has taken photographs several times, by some reason (unsatisfying of the previous result, regular update to know the last forest situation after fires, cut off or replant). The last and best quality photo will be taken to the next process.

The selection process used the photo-index database. Unfortunately, this database was in many cases inaccurate.

Some errors in rolls, runs, photos and counters number are detected. The approximated photo centre coordinates (APCC) was made by hand. At time of photography, no aerial camera was equipped with GPS or INS. In the fact, this APCC could be wrong for some miles (fig. 1).

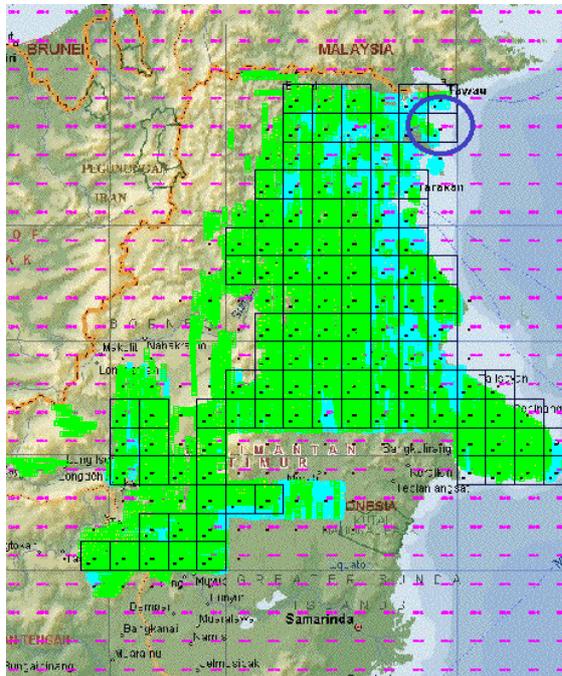


Fig.1. Overview of the project location
a square is map sheet 1:50.000 (15' x 15')

From the pre-selected photos, a paper copy will be made. The paper copy will be then layout to get the optimal combination between photogrammetry quality and minimum cost. The Potential GCP placement will be done simultaneously on the layout, and thereafter the layout will be snapshot to have good documentation.

1.3 The Selection of Potential GCP

A big problem for this project is the fact that: (1) there a large number of aerial photos; (2) the photos are heterogeneous; (3) the photos are older than 5 years; (4) there is no premarked ground control on photos; (5) there is no kinematics-GPS on board of photo-position for aerial triangulation. In addition, the post GCP-survey would be very hard. The problem is focused also to identify the place on photographs to the current situation and to get the place.

The problem to make post-GCP for successive aerial triangulation is to identify the suitable points. These natural GCP should fulfil at least 4 requirement: (1) the point must be good geometrically distributed, (2) the point must be clear identifiable on photographs, (3) the point could be found again now – although gap of more than 10 years, (4) the point must be accessible – partially using helicopter. Points (1) and (2) will be decided by photogrammetrist on the office. Point (3) will be decided by photogrammetry-surveyor on field. In case of survey by helicopter, point (4) will be decided by pilots.

For one full sheet (ca. 160 photos) at least nine GCP must be found and some others must be selected as reserves. In the reality, this job is often very difficult due to the low quality of the photos or the fact of the objects (just jungle without texture, or texture but without access possibility (fig.3).



Fig. 2. Lay outing of Photo and Planning GCP location

1.4 GCP Survey using Helicopter

For GCP survey using helicopter, a good plan must be established. Due to the difficult area, a good logistic base camps and fuel points must be selected. Base camp is normally place where there is minimal a house which could be used for several day for crew. Important is water. Food should be brought by our self. Electricity must be also generated by own generator. Fuel to the fuel point must be transported by boats or land vehicle. This fuel point must be place where helicopter can land, although it is not a helipad.

During the survey, all necessary equipment must be taken to the field, including some laptop computers, also CD writer for backup, printer, GPS navigator, digital camera, etc. For communication, satellite hand phone will be used. Unfortunately, the data channel is not yet established, so data store to the office could not be done. Consequently, a special procedure is applied to guarantee that in all data is saved. Data is copied to two laptops, USB-Hard disk, and some CD. Regularly, the CD is sent by snail-mail to the office if post office is found. The whole campaign is about 60 days, and we don't know what happened during these days. To avoid data loss if accident is occurred, during moving, laptops, USB-HD and CD bearer should not be in same helicopter. The campaign will be carried out by three helicopters.

Helicopter operation is rather expensive, but in almost points in the jungle of Kalimantan, it is the only way to get the points. The more serious problem is to identify the point, since the photographs is made about 10 years ago. In Kalimantan jungle, the most accurate point for ground controls is manmade objects like bridge or county-office house. Once it is created, a renovation is rather seldom. The second accurate point is Mouth River to another river. However, sedimentation or erosion could change this landscape. The third and last alternative is logging road or logging airstrips. Some of them are changed, leaved already or many new are created, so identifying is very difficult.

1.5 The Conventional Way of Survey

The aerial photographs were prepared especially for survey. They are scanned, and the scanned photo will be printed in special frame with approximated photo centre coordinates (APCC), place to make field sketch and GCP number in the photo. The GCP number is made so that a relation to the map sheet, photo (in Aerial Triangulation Process) and GPS is easy. The used Trimble GPS Geodetic Receiver can accept only four alphanumeric codes, while the PAT-B Bundle Photogrammetric Adjustment Software can accept maximum eight digits code. An equivalent table is made in MS-Excel table, which can rename everything in one key press.

The preparation is also including the optimal route of helicopter, so that during the expensive flight hours, maximum number of GCP could be measured. While the photos preparation could be done in the office, the route preparation must be often modified in base camp to the actual situation.

During the survey itself, the pilot flies his helicopter along the given route. Near the APCC, the surveyor will seek the suitable place for GCP and compare the aerial photos and actual field. If the place is decided and the pilot accepted, the helicopter will land. During about 15 minutes, a GPS measurement will be done and a field sketch will be made both by the Photogrammetric surveyor (fig. 3) and GPS surveyor (fig.4). He sees what could be not found in air photo. After finished, and helicopter is up again, the surveyor takes a snapshots over the area from helicopter (fig. 9). This snapshot is evidence that he is there, and the place is identical to the planned GCP in the air photo. The surveyor must have a discipline in recording the code of snapshots and GCP.

In a helicopter normally there are four people: pilot, photo-surveyor, GPS measurer and an assistant. In one survey day, normally 8-10 GCP is expected per team within six working hour. It is the maximum working hour for the pilot. The most time is to find the point (identification).



Fig. 3. Helicopter in a GCP location

Return to the base camp, all GPS data (fig. 6) and snapshots will be downloaded to the laptops. The GPS will be post processed differentially. GPS receiver at base camp is the main station, and it is always turned on during the campaign days start from the base camp. The base camp GPS station and the GPS permanent station at the office make together good baseline.

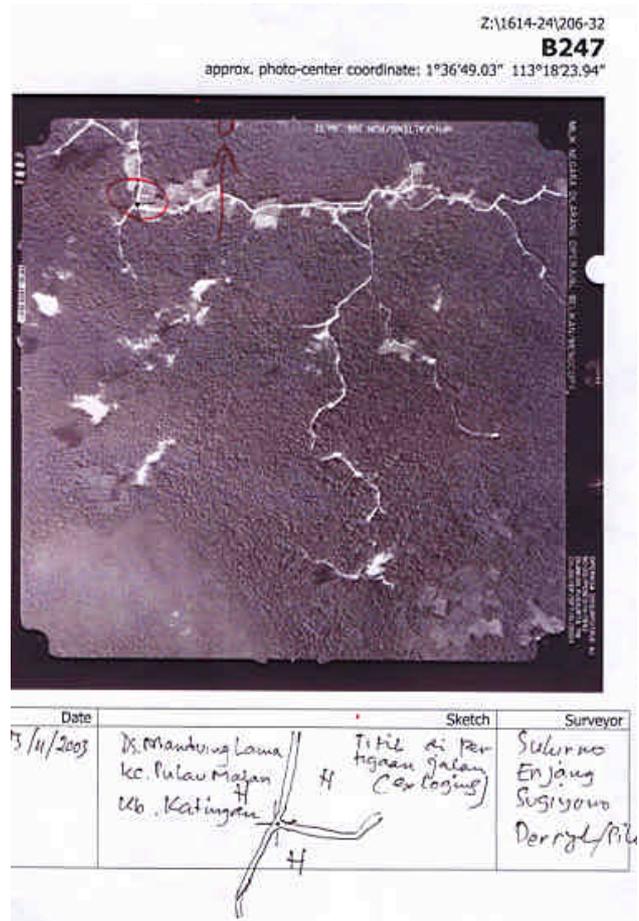


Fig.4. Field-sketch on air photo by photogrammetrist

BADAN KOORDINASI SURVEI DAN PEMETAAN NASIONAL (BAKOSURTANAL)		NO. STASIUN	
FORMULIR PENGAMATAN GPS DAN DEKRIPSI TITIK GPS		B247	
PENGATATAN DATA LAPANGAN			
NAMA PROYEK	TANGGAL	13-11-2003	
NAMA OPERATOR	NO. STASIUN	B247	
STASIUN ID	COORDINAT	PENDEKATAN	
NAMA LOKASI	LINTANG	01 55 38.2 S	
SESSION ID	Bujur	113 28 46.2 E	
HARI (UTC)	Tinggi	82.8	
RECEIVER	MERK	NO. SERI	
PEREKAMAN (UTC)	MULA	SELESAI	AWAL AKHIR
ANTENA	NO. SERI	Tinggi	VERTIKAL
		(METER)	SLANG
			RADIUS
TEMPERATUR (°C)			
TEKANAN mmHg			
KELEMBABAN %			
TIME EPOCH	5 det	MIN (SV)	3
NAMA FILE	DISK. NOMOR	TOTAL DARI	150
SKETSA LOKASI			
LOKASI	Mandung Lama di Pulau Majau		
PENCAMPUR	S. R. A. B. 247		
LOKASI			
DIBUAT OLEH	TANGGAL		

Fig.5. Field-sketch by GPS-surveyor

82473170.dat	F:\KaltengSurvei\Gps\DATA\TEAM02\20031113\RAW	90 KB	DAT File
82473170.eph	F:\KaltengSurvei\Gps\DATA\TEAM02\20031113\RAW	11 KB	EPH File
82473170.ion	F:\KaltengSurvei\Gps\DATA\TEAM02\20031113\RAW	1 KB	ION File
82473170.mes	F:\KaltengSurvei\Gps\DATA\TEAM02\20031113\RAW	2 KB	MES File

3D Position	Best PDOP Position [2.3]	Mean Position [918]
Latitude:	1:35'38.25980" S	1:35'38.25572" S
Longitude:	113:18'07.23414" E	113:18'07.23219" E
Height [m]:	83.0	84.0

Fig. 6. GPS raw data file and absolute

1.6 Identification Validation

Validations begin with the comparison between air photo (fig 7 and fig. 8) and snapshots (fig. 9) and between GPS empirical route to the planned route. When the data is valid, then the GCP will be drawn on AutoCAD with the air photo background (ungeoreferenced) with special prepared Auto LISP program, to guarantee the consistency in style, numbering system and filename.

Although identification is done carefully, from about 500 GCPs, 50 GCPs were in wrong location (misidentification). It means at least 6 working days with helicopter etc. Although until the end of the project, the conventional way is continuing to be used, a new approach should be developed.

There is idea with cross-strip (new aerial photography). The problem is then how to identify the new air photos to the old one. Cross strips could be reducing the demand of GCP, but the error (misidentification) in GCP of cross-strips will influence very large to the whole project.

In addition, the solution is still the minimum nine GCP measurements for each map sheet, but the way of survey should be improved

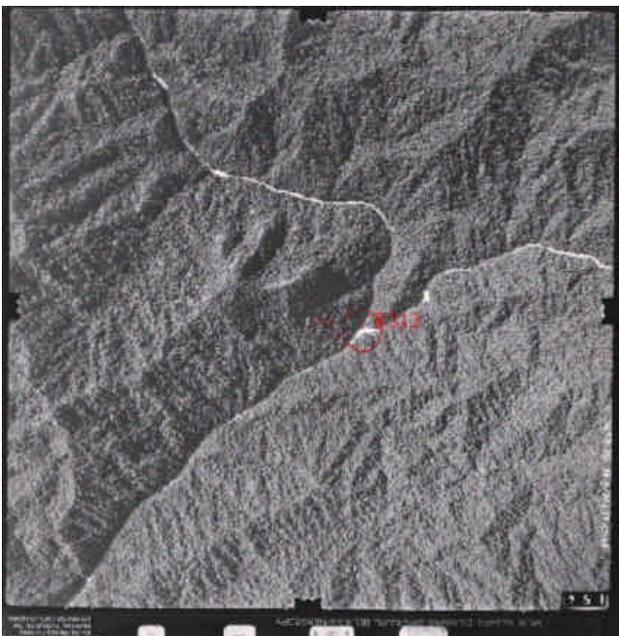


Fig. 7. GCP on air photo



Fig. 8. GCP on air photo (enlargement)



Fig. 9. The actual place (12 years later)

2. MULTI-TRIANGULATION

To speed up the work, following strategy could be done: (1) a stable or low vibrating helicopter should be selected. (2) A small digital metric camera will be mounted on helicopter. (3) The camera should be connected to kinematical-differential-GPS (KiDGPS). (4) Over the potential GCP, the helicopter will fly a round the point and make several oblique snapshots photographs. (5) The projection centre for each snapshot will be derived by adjustment of all KiDGPS measurement using geodetic GCP on base camp. (6) The photo-GCP will be identified using the actual snapshots and the old aerial photographs, where the potential photo-GCP should be found and its coordinate will be derived by forward resection using all projection centres of all snapshots of the photo-GCP. (7) The computation could be in one bundle adjustment includes KiDGPS-base-line measurement, new-snapshots-forward-resection, and old-photo aerial triangulation.

There are also three kind of triangulation in apply:

(1) The triangulation to get the the center coordinates of all snapshot. This is done by the use of all Kinematic Differential GPS data and might be additional information from inertial system if any.

(2) The triangulation to get the GCP on the ground with the bundle block adjustment. This triangulation can be done after identification from several snapshots using the (old) aerial photograph for gross orientation.

(3) The aerial triangulation itself, to orientate the (old) aerial photographs using the GCP.

All of these triangulation could be done simultaneously in an adjustment with adequate software.

With this method it is hoped that for most cases, a landing of helicopter is not more necessary. Landing is the most critical phase in the survey. Some potential GCP is not measured due to the impossibility for the helicopter to have save landing.

This method should be tested during the end of the project in 2003. The result of the test should be then compared to the conventional one. Unfortunately, an accident of one of helicopter (crash against power line) has stopped the whole operation. Mid 2004, the experiment is planed to be continued.

Conclusion

This paper should give the idea of multi-triangulation as a solution in a situation, where only old unpremarked aerial photographs are exist. The briefly idea should encourage researcher in photogrammetry to share the information, idea and experience. Not all detail could be given in this paper due to the restriction during the process of patent application.

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