PAPER TWO

" GPS MEASUREMENTS IN PNG "

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GPS MEASUREMENTS IN PNG

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Abstract

The objective of this paper is to discuss potential future projects using GPS measurements and detail the approach to be used.

Unitech at present is negotiating for the purchase of GPS receivers. Once these are received a program of practical and research based projects will be commenced.

This paper details the proposed projects as well as the methodology that will be used. The methodology will include: (i) Initially processing each observation session's data in order to determine the internal consistencies of the results: (ii) All the observations will be combined and processed together, imposing extended free net constraints on some of the parameters to determine displacements of the control points in the sense of local and regional scales. This combined data approach is convenient to the deformations of long baselines determined from repeated observations. The use of GPS to cut slopes is demonstrated using "Continuous Monitoring of Cut Slopes in Japan", research undertaken in Japan.

Introduction

GPS offers several advantages over conventional terrestrial methods (triangulation, trilateration, levelling) that have been traditionally used for many deformation monitoring and applications. Due to its three-dimensional technique, GPS can provide the complete

displacements over the network observed. Three-dimensional baseline vectors can be determined repeatedly with high accuracy in a consistent, global coordinate system (Bock,1986). Intervisibility between sites is unnecessary, allowing greater flexibility in site locations and for better designed networks. Measurements can be taken during night or day, under varying weather conditions. On the other hand, GPS is not applicable to all deformation applications since some locations do not have the required visibility of the satellites.

The main objective of this paper is to seek funding for joint purchase of GPS equipment and perform joint research work with any Department interested in GPS related research work. In the course of the research work, we shall be able to:

(i) properly tie the national network (including all permanent and tide gauge stations) to Australian Geodetic Datum 1984 (AGD 84) and International Terrestrial Reference Frame (ITRF) for any future work on deformation studies. The tie of the stations to AGD 84 is necessary since, at the moment, PNG does not have any fiducial station where all observations can be tied to.

(ii) determine the crustal/plate tectonic motions, land sliding, ground subsidence, slope stability of surface mining and large excavation in open mining. Old stations established shall be incorporated with new ones well spread across the country so that any relative motion between, say the Markham Valley south of the Finisterre thrusts and the New Guinea highlands to the south of the Markham valley can be examined (Silver et al.,1991).

Purchasing GPS receivers and equipment will enable most projects to be undertaken at lower cost in PNG as compared to the high expenses borne by the country. Training will also be given to nationals locally instead of sending them abroad for training. Much emphasis on training and research will be on:

- Determination of geodetic control points for:

Geographic Information System and cadastral surveys, Inertial surveys, cartography, Hydrographic surveys.

- Monitoring object movements by repeated or continuous measurements:

Geophysical surveys (crustal/plate tectonics), land sliding, ground subsidence (mining, ground water withdrawal), subsidence of offshore structures, large excavation in open mining, slope stability of surface mining, settlement of buildings, construction of dams.

- Setting out local networks for the control of engineering projects:

Road construction, bridge construction, pipelines, waterways.

Crustal Movements and Plate Tectonics

Tectonic motion or deformation of the earth is very closely related to earthquakes. The motion of tectonic plates produces elastic stresses that are the cause of earthquakes. Because the scale of the processes involved (tectonic plates are thousands of kms on a side) these motions are not easily measured by conventional surveying (Stolz et al.,1990; Larson et al.,1992). Using space-based techniques such as Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR) and Global Positioning System (GPS) receivers it is possible to directly measure plate motions (Prescott,1986).

The present day PNG plate motion is not well understood and current research tends to concentrate on the deforming zones near the boundaries where earthquakes occur. The movements that we withness in PNG are due to two main divergent forces (see Fig. 1). The South Bismark sea plate is moving South-West compared to the northern part of PNG which produces a northerly migration of the PNG plate. The result may be a general fold and thrust.

Each new earthquake in PNG may tell us very little as there is no clear understanding of the flow of material in mountain belts (tectonics). What is needed to clarify this situation is more details of the regional strain and direct measurements using satellite geodesy.

Despite its short comings, satellite geodesy in particular GPS, has already managed to make significant impact on our understanding of what has been happening in other parts of the world (Herring et al.,1991; Blewitt et al.,1992; Gruddace et al.,1994). Positions will be determined in a local, regional and global frame (Ananga,1993) to determine regional rotation and measuring the internal deformations for areas such as Markham Valley in Morobe Province and the rift between Rabaul and New Britain, which in each case may not act as single units and that within each block there may be relative motion between regions borded by large faults. Some of the motions which take place without seismicity can be measured with the establishment of local and regional networks based on a unified datum tied to a specific tide gauge in PNG (Ananga,1993) and then to Australian Geodetic Datum 1984. The real drive for this research is then the need to understand crustal movements, plate tectonics and earthquakes, in order to predict them. These are long term goals and we hope to achieve them.

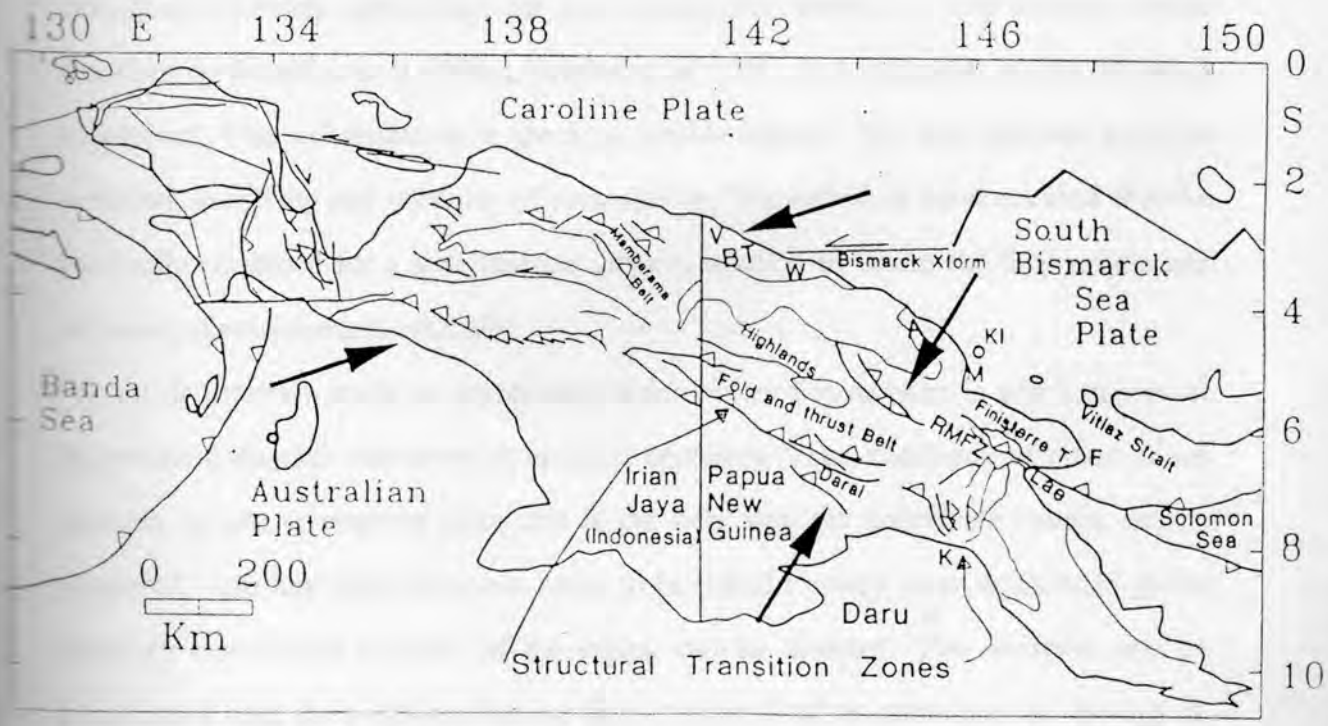

Fig. 1. Crustal Movement deformations of Papua New Guinea Island (Silver et al.,1991)

Network Design, Observations and Data Processing

A great deal of thought and care will be spent on the network. The station spacings and siting are to be planned in such a way that sub-block motion can easily be detected, and there must be several stations within each of the areas bounded by the surface faults (see Fig. 1). If possible most of the stations will be on bedrock.

GPS observations shall be collected in conjunction with permanently observed Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) in Australia (Ananga,1993). This will enable precise orbit computations and to define the coordinate frame of PNG to AGD84 and also to the global reference frame especially International Terrestrial Reference Frame (ITRF). The GPS data will be processed using the BERNESE v3.3 software. The software takes in raw GPS data and outputs relative baseline coordinates and covariance matrices. The daily data shall initially be processed individually. Models appropriate for the tropospheric, setting up and receiver errors described by Schaffrin et al.,(1988), Brunner et al.(1991) and Ananga et al.,(1994b) shall be adopted. This will enable us to check up trouble stations. This approach will give the precision, sensitivity and reliability of each session. The individual baselines shall then be rigorously combined for a simultaneous network solution to obtain the final results and measures of precision and reliability.

For any deformation study, an appropriate choice of coordinate system in which to present the results from each measurement epoch is necessary. Thus, continuity of observations between epochs is essential since this is the only way the coordinate results can be compared. Also any adopted system needs to be linked formally to an established global frame so that overall motions of the region can be detected. The situation may be complicated since even stations that we may consider fixed or stable may be moving. In this case we shall adopt the models described by Holdahl (1992) and Ananga et al.,(1994a).

From the analysis of the above statements and what other researchers have previously done with GPS, it is suggested that the application of GPS to geodetic and geophysical problems in PNG will be essential.

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