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# Geographical Control in East Antarctica

V.P. SRIVASTAVA AND H.B. MADHWAL

Survey of India, Dehradun

## Abstract

During the Tenth Indian Scientific Expedition to Antarctica, geodetic and geophysical controls were established in the area of Schirmacher Oasis and its surrounding nunataks, for map making and future scientific explorations. Global Positioning System (GPS) receivers were used in the icy continent by the Survey of India (SOI) scientists for establishing the precise positions of the selected locations.

## Introduction

Map making and exploration need accurate estimation of position. This is nowhere more true, than on the vast and monotonous expanse of ice of Antarctica with its few oasis and isolated nunataks.

Establishing a positional fix in the hostile weather conditions of this icy continent poses a challenge for surveyors engaged in position fixing and surveys. Normal classical methods, viz. triangulation, traverse and trilateration are not suitable due to strong winds and blizzards which are a common phenomenon in this region. The use of electromagnetic instruments is not advisable because of frequent magnetic storms which adversely affect the instrumentation of such equipment.

Giant strides in Space Geodesy and the capabilities of instrumentation, have now made it possible to venture in such hostile areas for map making and exploration. The development of GPS technology has the capability to give precise position fixing, required to provide vital control points for map making.

This paper describes the Global Positioning System, the processing technique used and discusses the results obtained from data acquired during the expedition.

## Global Positioning System

*NA* Vigation System with Time And flanging, NAVSTAR GPS is used in the field of navigation and geodetic positioning. The system provides accurate three dimensional estimates of position to the user on land, on sea and in the air on a world wide basis. Satellites are in orbit at an altitude of about 20,000 kilometres. Orbit time for

a satellite is 11 hours 58 minutes. These are in different orbital planes with an inclination of about 63 degrees. GPS satellites transmit signals on two frequencies, one at 1575.42 MHz (L1), and another at 1227.60 MHz (L2), which are used to minimise the ionospheric effects.

The Global Positioning System, used in translocation mode (using two receivers at the same time at two different places) can determine the distance between two locations of the receivers with an accuracy of a few centimetres. Observations taken in translocation mode minimise the errors due to ionosphere, troposphere and imposition of Selective Availability (SA). When observations are taken in point positioning mode, the positional accuracy deteriorates to within a range of 40 to 100 metres.

## Scheme of Observations

A tentative scheme for establishing the geodetic control in East Antarctica was made in Geodetic and Research Branch, Survey of India, Dehra Dun, as a prelude to the Antarctic expedition. On reaching the icy continent, the area was reconnoitred and the locations for control points were selected on exposed ground.

To determine the coordinates of the selected locations, two GPS receivers were used and observations were taken in translocation mode. In this process, a total of 34 vectors were observed to establish 15 geodetic control points. A chart showing the scheme of observation is given in Fig. 1.

## Processing and Results

Data collected on cassette tapes were transferred on the hard disk of a PC-AT computer and processed using Post Processing Software (POPS). During processing, the results were analysed and all residuals which were more than 19 cms in L1 and 24 cms in L2 frequencies, have been screened to eliminate possible cycle slips. Maximum Root Mean Square (RMS) of each distance was accepted within 10 cms.

To compute the coordinate of each station, an adjustment software using the technique of the 'Variation of Coordinates' was employed. Initial requirements for this adjustment program were (a) the coordinates of at least two points, and (b) the observed distances in continuous series forming geometrical figures.

In order to get the coordinates of the two initial stations, the station Maitri and Point 5 were selected as fixed stations and weighted mean of several epochs were computed from the coordinates obtained in the post processing of satellite data.

GPS technique gives the coordinates in the WGS 84 system but the height required for mapping and other scientific work is mostly with reference to the Mean Sea Level. To achieve this, sea level connections were made to the Indian station

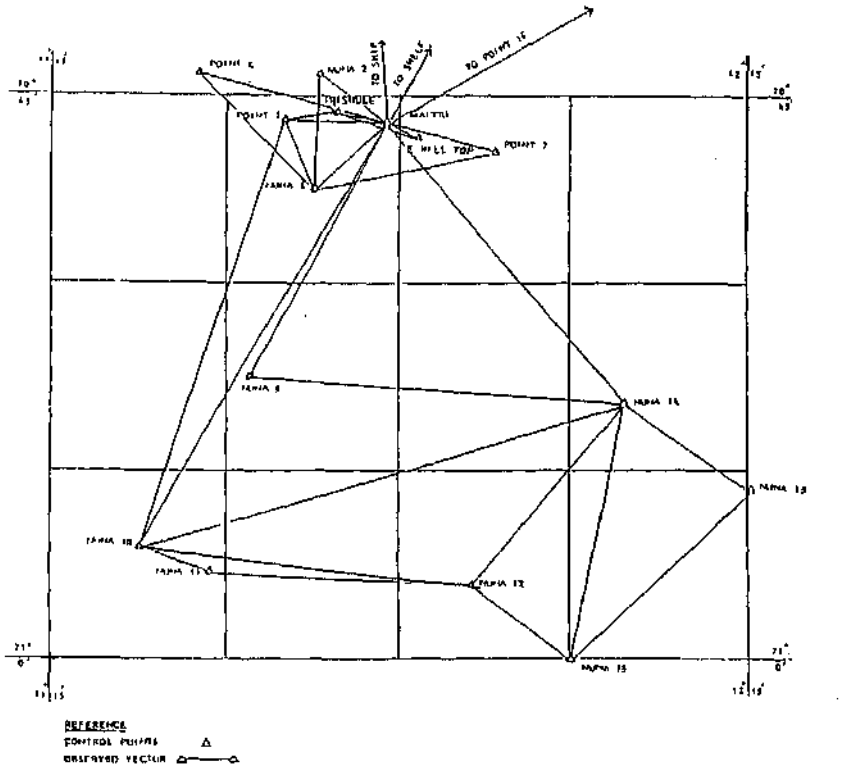


*Fig.]. Survey observation scheme during Antarctic Expedition 1990-91.*

Maitri from two different sites near the sea, using GPS receivers in translocation mode. Having known the sea level height of Maitri station, the difference of height (WGS 84) for each vector was computed and used in a level-net adjustment program. In this way the height for each control point with reference to Maitri station was obtained. The height of Maitri Station was fixed with reference to sea level in the adjustment procedure, therefore, adjusted heights of all control points are in terms of the sea level.

Thus, latitude, longitude and height of the control point were obtained. A list of coordinates is given in Table 1.

## Conclusion

GPS observations theoretically can be fitted to the horizontal and vertical datum by holding fixed the coordinates of two horizontal control stations and the MSL height of three vertical control bench marks.

In the present situation, no horizontal or vertical control was available in the area, therefore, two horizontal control stations which were held fixed, were computed

**Table 1: Adjusted Coordinates**

| Sl. No. | Name of Station | Latitude | | | Longitude | | | Height (metres) |
|---|---|---|---|---|---|---|---|---|
| | | ° | ' | " | ° | ' | " | |
| 1 | Maitri | 70 | 45 | 51.733 | 11 | 44 | 02.570 | 117 |
| 2 | Point 6 | 70 | 44 | 22.407 | 11 | 27 | 40.812 | 99 |
| 3 | Nuna 2 | 70 | 44 | 24.071 | 11 | 39 | 33.788 | 128 |
| 4 | Trishule | 70 | 45 | 31.492 | 11 | 40 | 19.999 | 226 |
| 5 | Point 5 | 70 | 45 | 41.030 | 11 | 35 | 59.026 | 157 |
| 6 | E hill top | 70 | 46 | 16.777 | 11 | 46 | 26.917 | 154 |
| 7 | Point 7 | 70 | 46 | 40.459 | 11 | 53 | 41.982 | 138 |
| 8 | Nuna8 | 70 | 47 | 39.833 | 11 | 37 | 13.240 | 501 |
| 9 | Nuna 9 | 70 | 52 | 36.366 | 11 | 31 | 50.608 | 776 |
| 10 | Nuna 14 | 70 | 53 | 43.381 | 12 | 04 | 12.061 | 500 |
| 11 | Nuna 15 | 70 | 55 | 37.120 | 12 | 15 | 19.200 | 742 |
| 12 | Nuna 10 | 70 | 57 | 01.527 | 11 | 23 | 05.038 | 1081 |
| 13 | Nuna 11 | 70 | 57 | 36.116 | 11 | 29 | 40.294 | 1043 |
| 14 | Nuna 12 | 70 | 57 | 58.457 | 11 | 50 | 54.942 | 1026 |
| 15 | Nuna 13 | 71 | 00 | 12.578 | 12 | 00 | 01.629 | 958 |

from the weighted means of the observations taken by GPS receivers. The vertical control point value was obtained from the sea level connection. These were considered the best estimate for the present.

Future endeavours of the Antarctica expedition envisage:

- Sea level connections to Maitri station using more number of GPS observations taken from different sites.
- Further extension of GPS control and densification.
- Repetitive observations at a few selected sites for monitoring the crustal movements.
- Possible use of precise ephemeris or P code to obtain better estimation of coordinates in point positioning mode.
- Improvement in present data by acquiring precise ephemeris and clock offset data from NGS or DMA.