Position Fixing in Antarctica

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ABSTRACT

Antarctica with large desolate areas, snow and ice cover, few land marks, hostile weather and bad radio propagation conditions poses problems for position fixing. The Expedition used a portable land sea satellite position fixing system and least square and 3 D techniques to determine the following positions:

Automatic Weather Station,	
Dakshin Gangotri	**— 70°45' 12". 963S: 11°38' 13".618E**
Base Camp (Hut)	**— 69°59'12".672S:11°55'7".263E**
Base Camp	**— 69°59'23".119S: H°56'26".83E**

The positions obtained were within a few metres.

INTRODUCTION

Antarctica with large desolate areas, snow and ice cover, few land marks and even fewer geodetic marks is a challenge for position fixing and surveys. The weather accompanied by strong wind and snowfall also hampers position fixing. Accurate position fixing is a prime requirement for scientific work especially surveys and exploration. The radio propagation conditions in Antarctica are also not favourable for the operation of radio positioning systems. However, the development of satellite navigation systems in recent years has provided a tool for position fixing. The present note describes the use of satellite navigation system, its calibration and performance in Antarctica.

SATELLITE POSITION FIXING

The Satellite position fixing system provides accurately all the three coordinates (latitudes, longitudes and height). The advantage of the system is that it requires reference only to the satellites and can be used anywhere in the world irrespective of the time of the day or weather.

The system is based on six satellites in polar orbits. The orbits of 5 satellites which are currently in use form a "cage' around the earth, fixed in inertial space with the earth rotating beneath the orbit cage. The earth revolves beneath the orbit of satellites about 27° longitude per orbit (Fig. 1). The

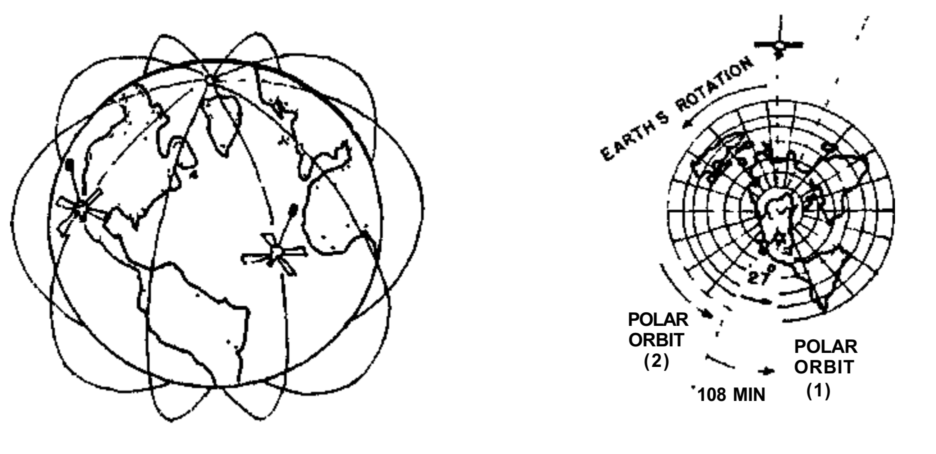

Fig. 1 : Orbits of satellites viva vis the earth.

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periodicity of position fixing is dependent on the availability of acceptable passes which depends on various factors and varies from the poles to the equator. The time between acceptable passes may range from less than an hour to many hours. The problem of the availability of satellites can be enhanced by the use of a constellation of satellites. A constellation of four such satellites criss-cross the poles in orbits and are equally separated at the equator. At poles the satellite passes are directly overhead (Fig. 2).

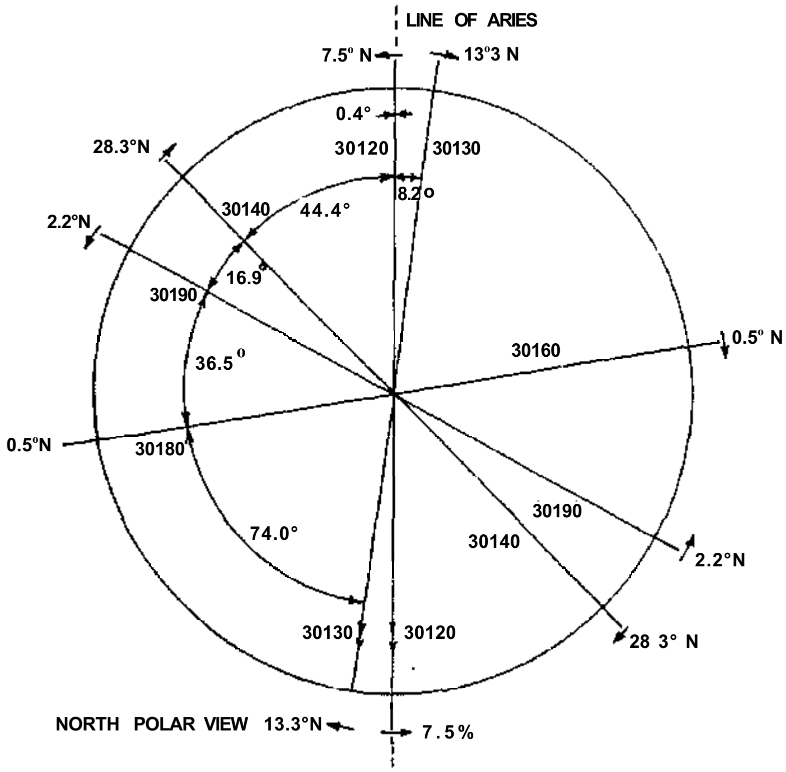

Fig. 2 : Orbits of the five operational satellites.

The satellites transmit signals on two frequencies i.e., 150 MHz and 400 MHz. By receiving the signals on dual channels the refraction effects due to propagation in the earth's ionosphere and troposphere are eliminated. Each satellite transmits continuous radio waves (carrier waves) of a very stable frequency. On these carrier waves every 2 minutes a time signal and a signal containing information of the orbit parameters is modulated. The doppler-shift is determined at the receiver-end during the transit of the satellite by measuring the change in difference between the frequency of the received signal and that of a reference oscillator. From the observed doppler-shift the difference in distance between the observing station and two satellite positions (at the beginning and at the end of the two-minutes observation period) is computed. The position (geographic coordinates) of the observing station is thus computed by the receiver. The same process is repeated and another satellite position computed at the next acceptable pass.

The supplementary observations and calculations improve the accuracy of the position by means of adjustment procedure. The orbital errors can be minimised by using the maximum number of passes. The 3D multiple pass and multiple point relative accuracy techniques provide higher accuracy. When individual passes are processed together by least-square techniques, the contribution is weighted individually depending on the pass geometry and number of doppler counts. The results

could be achieved closer to 1 metre if more than fifty good passes are observed and processed. The positions (Fig, 3) obtained during the first survey can be obtained in subsequent surveys within the specified accuracy of one sigma level.

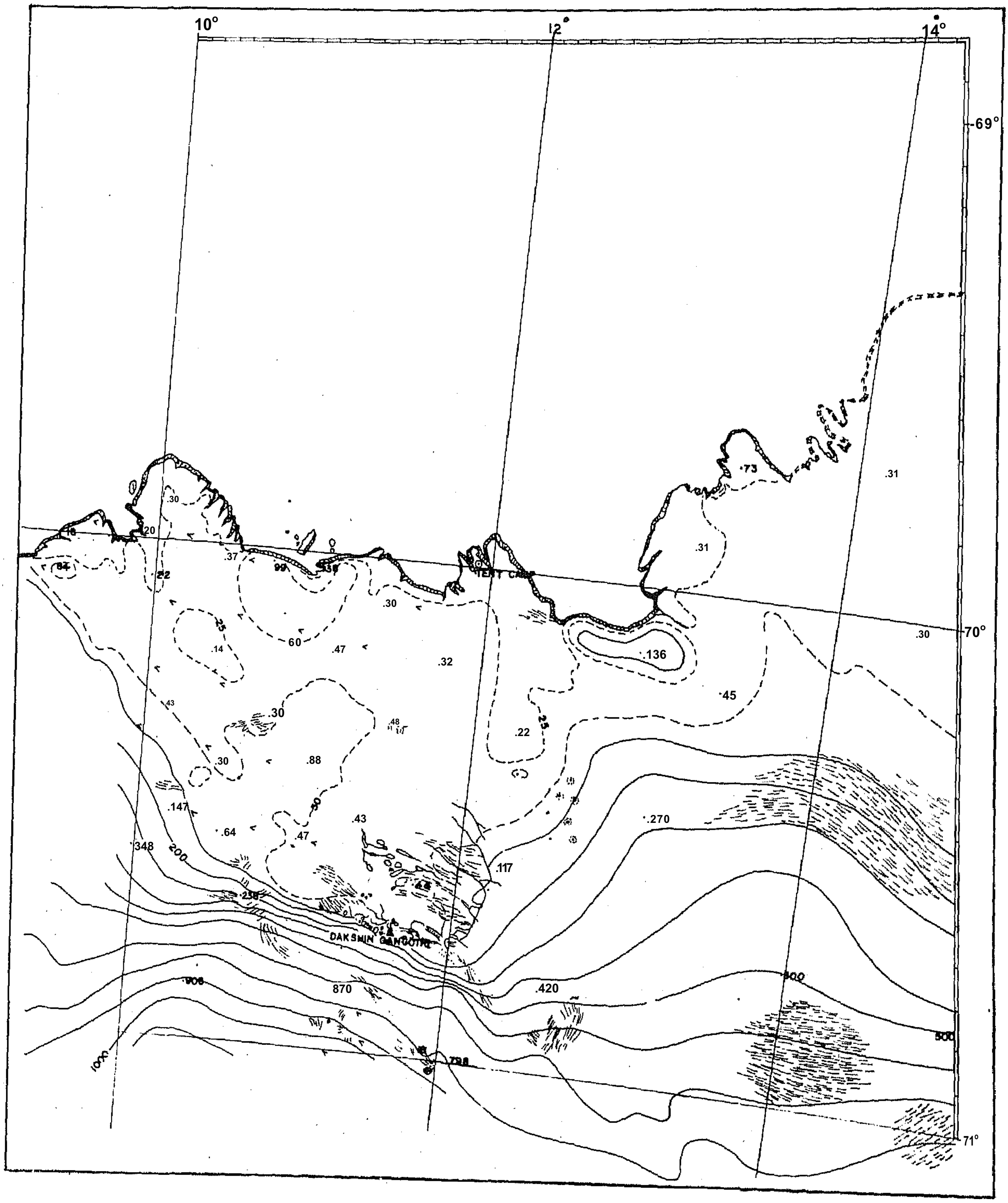

Fig. 3 : Map showing the positions fixed by Satellite Navigation during the Expedition.

Fig. 4
Satellite Navigation receiver in operation at Dakshin Gangotri.

		04
		04
		04
		03
		150.12
70	45	12.963
11	38	13.618
		4.0
		6.3
		8.9
015182200		
015182359		
015182559		
015182759		
015182959		
015183159		
015183400		
015183600		
015183800		

Fig. 5
Satellite Navigation receiver printout showing the coordinates obtained for Dakshin Gangotri.

DESCRIPTION OF THE EQUIPMENT USED

A JMR Sea Land Surveyor, a microprocessor based satellite receiver equipment was used tor position fixing for both land and sea operation (Fig. 4) in Antarctica. The equipment consists of a receiver, an antenna and an external 12 V DC power source. The receiver has an inbuilt battery which is sufficient to maintain power to the oscillator and memory circuits upto 24 hours during transportation between sites. The receiver incorporates a magnetic tape cassette unit on which complete data may be recorded for later reprocessing while a hard copy printer provides instant on-site results (Fig. 5). TI 743 can also be interfaced where 115 or 230 V AC is available. In order to prolong battery life and also to reject non-valid data the receiver may be used in an 'Auto alert' mode. In this mode, the satellite alerts are computed and the unit automatically switched on during acceptable passes.

DISCUSSION OF RESULTS

The Satellite Position Fixing System was used at three different locations in Antarctica. The passes for high elevation (greater than 60°) and low elevation (less than 20°) were not used for calculation. The results of position fixing for the three locations are shown in Table 1 the position shown is a mean value of independent results with standard deviation in metres of the individual results from the mean. The 3D position is graphically depicted in Fig. 3.

TABLE 1

Results of three dimensional solution

Station	Lat. (mean)	Long.(mean)	Height (m)	Std dev. of Lat. (m)	Std dev. of long. (m)	Std dev. of height (m)
Dakshin Gangotri	70°45'12".963 S	11°38'13".618E	150.12	6.3	8.9	4.0
First Indian Base Camp (Hut)	69°59'12".672 S	11°55'7".263 E	35.00	3.9	3.2	2.4
Base Camp	69°59'23".119S	11°56'26".83E	44.25	10.8	17.1	10.6

The satellite fixes observed at Antarctica indicate that there is no apparent relationship between the standard deviation values and the number of observations. The standard deviation values are bimodal rather than normal distribution. Since sufficient number of passes could not be collected to define (the passes were less than the minimum 30 required for accuracy) adequacy of observations for location as also the height computation the results could not eliminate potential errors. Future position fixing in the area could examine the relationship between standard deviation and the size of the sample in this area the sources of error affecting the height.