

Unmanned Stations in Antarctica

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“The scientific method consists in observation and experiment”

—*Henri Poincare*¹

A glance through a recent edition of the *Antarctic Pilot*² will reveal the impressive long term data already acquired by many countries in Antarctica during the last several decades.

Observations, that is the recording of relevant data, on a long term basis is an important first step in the understanding of most phenomena. This step necessarily precedes the stages of hypotheses and experiments needed to validate models and theories culled from a first appreciation of long term collected data.

If India is to benefit from her “Growing Focus on Antarctica”, she must expand time and effort on acquiring background data in different scientific disciplines. In this way we shall be able to indicate to others that we have a seriousness of purpose and a dedication to the cause of preserving Antarctica as a natural unpolluted laboratory for base line studies in many fields. One way to acquire reliable long term data is to accord a high priority to the deployment of unmanned stations that record and transmit data via satellite allowing for real time inspection of their outputs.

To quote Poincare again “In all sciences depending on observation, we must reckon with errors due to imperfections of our senses and of our instruments”

Instruments are imperfect and are known to fail even in normal circumstances. In environments as severe as the Antarctic, the chances of failure are greatly in-

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creased. If in addition one considers unmanned stations on that continent, the chances of failure begin to get very high indeed. This brings us to our further contention that unmanned stations (UMS) should transmit their data to enable a wintering party at base camp to take necessary corrective measures if a failure occurs.

This is why frequent reportage from an unmanned station is important. Radio communications are normally used except during severe weather conditions, when they are apt to fail. This being precisely the time when the need for such information is greatest. Transmission via satellite transmitting packages to a large extent circumvent problems relating to weather conditions and are ideal for such situations. Their drawback however is that dialogue, at least when using the Argos satellite packages, is not possible between receiving and transmitting stations, and an unmanned station cannot therefore be given instructions from base camp.

Unmanned stations must therefore be smart, to overcome this drawback. They must be capable of carrying out self tests, battery voltage tests, memory tests, etc. Also low power military specification CMOS devices must be used, and where possible ratiometric digitizers employed. Furthermore UMS should be capable of interrogating sensors repeatedly and run routines to weed out stray values and transmit only processed values and their scatter. This is needed because messages via Argos are restricted to 256 bits only.

The need for UMS in Antarctica has been established. These UMS are not restricted to meteorological parameters only. They can be designed to monitor magnetic field activity etc. We have also established the necessity for the UMS to be smart (that is processor based) and satellite transmitting.

We report next a description of our experiences on an UMS deployed during the First Expedition and follow up with some guidelines for a viable long term UMS embodying the desirable features described above, as also some special sensors for Antarctic work.

FIRST EXPERIENCES

January 1982 :

An unmanned station of the recording type was designed and installed at location Dakshin Gangotri.

(Latitude : $11^{\circ}38'13.618''S$ Longitude : $70^{\circ}45'12.963''E$). during the First Indian Antarctic Expedition 1982.

The station was programmed to interrogate meteorological sensors every 2^{13} secs (2 hours 16 minutes 32 seconds) and record their values. The values were stored on an incremental cassette recorder with a total capacity of 1.6 Mega bits equivalent to a 5 month capacity at the set interrogation interval.

The electronics was based on Intel's 8085 microprocessor which was programmed to sample each sensor four times and compute an average value. The

reference voltages as well as the temperature of the electronics package were also recorded. The Analog to Digital Converter (ADC) used was Intersil's 7107. The use of the 7107, and that of a high stability reference voltage source LM 299A, gave the system a theoretically good performance. Military specifications Integrated Circuits were used where available. The system was powered by sealed lead-acid GEL cells and secondary charging was achieved via normal lead-acid batteries of high capacity.

Mechanically, the station consisted of a meter long aluminium pipe of 4.5 inch diameter which was mounted on a steel tetrapod and stabilised by 4 stainless steel guy wires. The electronics was based within a 0.5 inch thick black High Density Polyethylene (HDPE) cylinder of external diameter 30 cms and a height of 60 cms. The intervening spaces were filled with expanded polystyrene foam. The initial results obtained at site showed that the interior temperature was maintained at about 10°C above the outside ambient. The sealed lead-acid GEL cells were contained in a second HDPE cylinder and were totally sealed with connections brought via 'O' ring fitted underwater connectors.

The data recorded on tape during the short sojourn at Dakshin Gangotri, was retrieved prior to departure and a new tape loaded. The meteorological values recorded showed good correlation with the values broadcast by the Russian Station located about 10 kms distance from Dakshin Gangotri.

February 1983

On the 15th February 1983 a small team from the Second Indian Expedition Contingent landed at Dakshin Gangotri and surveyed the condition of the Automatic weather Recording Station left behind by the First Expedition.

The team reported that one of the four guy wires holding the mast had worked loose, causing the mast to tilt considerably to one side. The bins containing the electronics, tape unit and the sealed batteries were undamaged, however, as also the underwater connectors, interconnecting cables and "O" ring seals. The mast was reinstalled vertically by the team.

Three of the five external sensors were in good condition. These were the air and surface thermometers and the humidity sensor. The cup anemometer however was missing and the wind vane was partially broken.

The other remaining external units were the heavy duty batteries, which showed no external damage and had a terminal voltage of 12 volts instead of the nominal 24 volts. The secondary external batteries were replaced by new 120 AH, 24 volts batteries.

The bin containing the sealed batteries was opened and checked. These were found in good condition and showed a terminal voltage of 12 volts instead of the nominal 20 volts. They were not replaced. The original cassette tape was replaced and the electronics was checked for proper functioning before resealing the bin.

The data tape from the Unmanned Recording Station set up by the First Expedition was recovered by the Second Expedition. The station performed well and the entire tape showed valuable and consistent recorded data. The temperature records showed progressive cooling with the advance of the Antarctic winter with a minimum recorded temperature of -29°C . The wind data was consistent with published results of long term experiments showing winds generally from the south and south east sectors. The maximum wind speed recorded in the 6 months of recording was 85 mph from a southerly direction.

January 1984

On the 23 January 1984, a small contingent from the Third Indian Scientific Expedition visited Dakshin Gangotri and surveyed the status of the Unmanned Recording Station left there two years ago. They reported the following :

- The solar panel arrays left there were not seen anywhere. These were presumably blown away as they were large in area and the base would provide little resistance to the wind.
- Two of the four stainless steel guy wires that had been spiked into the rocky terrain to hold the mast down had worked themselves loose.

The wind/sensors were not seen. (The second expedition had reported the missing anemometer and partially broken wind vane).

- The two temperature sensors as well as the humidity sensor were in good condition.
- The secondary lead-acid batteries were intact and in good electrical condition.
- The bin containing the sealed GEL cells was opened and found to have performed its duty of sealing properly. The cells themselves were in good electrical condition and two cells were brought back for inspection.
- The cassette which had been replaced by the Second Expedition was recovered. The entire electronics package was also dismantled and brought back to the Institute.

The team re-erected the mast, set up the guy wires in position and left the site with the electronics unit and some samples of batteries.

Future Stations

What have our first experiences taught us ? We have learnt that :

1. Commercially available sensors are easily and readily available for all

- parameters to be measured. At Dakshin Gangotri no extreme wind or temperature conditions had been recorded.
2. At -35°C , electronic components are generally nearing their working limits and hence military specifications components are a must. These were used in our Dakshin Gangotri station which could be the reason for the success of the weather station. The heating aspect of the electronics is an important one and has to be maintained to ensure system functioning throughout the winter.
 3. Data tapes have limited storage capacity and these have to be regularly serviced. The batteries also need replacement. The sensors and the mechanical structures would have to be periodically checked if uninterrupted data are to be obtained. It would, of course, be possible to construct a weather station with low power devices. This should include enough battery back up so as to maintain the collection of data throughout the winter.
 4. The obvious next step would be the inclusion of satellite transmitters for a daily Antarctic weather report in India. An extension of this scheme would be a matrix of stations which would allow a comprehensive weather map to be prepared daily for use by other permanently-stationed teams in the vicinity.

We are now in a position to define what a future station will contain.

(1) *Sensors*

Special sensors for Antarctic type environments are available. Any type of sensor left unprotected in the open environment will develop problems and it may safely be assumed that such a sensor will be inoperational during the winter months. Temperature, wind and humidity sensors need to be situated in protected housings between observations. If ice is allowed to cover a temperature or humidity sensor for instance, the recorded values will be misleading as the ice layer will form an insulating barrier to the environment that it is supposed to measure. Similarly wind sensors could freeze into position recording zero wind speed and constant wind speed and constant wind direction.

(2) *'Smart' Stations*

Temperatures in the Antarctica could be as low as -85°C . At these temperatures, electronic components, recording devices with moving parts, batteries etc. do not function.

- (a) The first imperative therefore is to provide heating for the section.

- (b) To reduce the size of the station, power consumption has to be reduced and this indicates the use of military specifications chips, where possible.
- (c) Data should be recorded on more than one device type say CMOS memories and E² PROMS.
- (d) In order to assess the quality of recording, the housing ambients such as temperature and humidity should be recorded. More than one real time clock, independently powered, should be monitored. Battery voltages and regulated voltages should be used as health monitors. The digitisers used (it is advisable to use more than one) should be of the ratiometric type and automatically carry out checks of zero drift, full scale drift (with respect to an independently powered reference source) etc. This will allow the data to be analysed in terms of the performance of the measuring system.
- (e) To reduce the volume of circuitry, the raw data should be processed to some degree before storage. Thus a processor based instrument is essential. Sensor outputs should be sampled several times, and the data analysed for scatter, before a single value and associated scatter is stored. The system should also check its memory and carry out a check sum on its program. The results of these tests should also be recorded.
- (f) As there is great probability of failure of an unmanned recording station, it is obvious that reportage of some sort must be incorporated to allow remedial action, if necessary, to be taken. After a comparison of the methods of radio transmission likely to be successful in the Antarctic, the system that shows itself best suited for this purpose are Platform Transmit Terminals that transmit every second a message of 256 bits. These are picked up by the passing NOAA satellites carrying the Argos package on board. The Argos System is a well set up system which retransmits this information to a Center at Toulouse, from where one may either retrieve the data on ordinary telex lines or using another satellite system, the Inmarsat system, receive data at up 2,400 band on telephone lines. Either method will ensure that recorded Antarctic data is available anywhere in the world, including base camp in Antarctica itself, within a couple of hours of its recording.
- (g) An extension of the single UMS would be a matrix of such stations appropriately sited to allow synoptic weather maps to be produced, as well as make available data to test models of weather prediction.

CONCLUSIONS

The need for wide coverage uninterrupted base line data in several fields is an accepted fact. From the experiences gained, and the scientific requirements of long term data, we have proposed a matrix of such unmanned meteorological stations that both record as well as transmit data.

The type of station that will suit this purpose has been shown to be one that

- (a) has special sensors for extreme conditions.
- (b) has facilities for heating the recording and transmitting sections.
- (c) contains military specifications CMOS devices.
- (d) records on more than one type of device to provide security through redundancy.
- (e) is 'smart' that is a system that will check several parameters to ensure its proper functioning.
- (f) contains some on board processing capability with checks for the digitiser and scatter of acquired data.
- (g) is satellite transmitting, allowing the health of the stations to be monitored as well as allowing reception of data at a location remote from the station.

If efforts are expanded at this stage when there is a Growing Focus on Antarctica, then we can rest assured that in a decade from now, we shall be the contented custodians of wide coverage synoptic data in a variety of fields.

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