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SCAR

SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH

BULLETIN

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SCAR BULLETIN

No 22, January 1966

GEODETIC LINKS IN THE SOUTHERN HEMISPHERE

BY GEORGES R. LACLAVÈRE*

CONTENTS

Introduction

The question of geodetic connexions between continents is very topical at present and plans have recently taken great strides due to the possibility of using both active and passive satellites. Many measurements have already been made and other projects are in the planning stage. In the domain of feasible projects, it seems that one of the most interesting will be the connexion of the Antarctic continent with Australia and New Zealand. This project, which will soon be technically possible, presents, however, a peculiar problem. In almost all the cases envisaged so far it has only been necessary to connect two regions, or two continents, both of which have been geodetically surveyed and already possess a geodetic station network. In principle, only one station in each network needs to be linked in order to unify, by calculation, the two of them.

In the Antarctic there is no geodetic network and it does not appear possible to create one by classical methods. The solution of the problem of the Antarctica–Australia connexion rests in the application of one of several methods of measurement discussed below which include both optical and electromagnetic methods.

Optical methods

Optical methods of making geodetic measurements are based on the simultaneous photography of a visible satellite using fixed cameras. These are placed at a certain number of stations of which the positions of only some are known.

One can use active satellites of the flashing variety, (eg United States satellite ANNA) which automatically provide the synchronism for all the cameras, but there is a limit due to the necessity of widely spacing the flashes in time.

One can also use the passive satellites emitting, by reflexion, a continuous beam (Type ECHO). It is necessary, however, in order to obtain simultaneous photographs, to "create" the flashes, ie make synchronous images of the object. The method used consists in breaking the luminous trajectory of the satellite into a certain number of images taken by the different cameras at the same

* Directeur, Institut Géographique National, Paris.

instant (or at instants known with precision with respect to the same time base). These are obtained easily enough by means of a rotating shutter adapted to each camera.

Use of the optical method implies that one knows for each station the orientation of the camera in order to be able to determine the directions of the lines joining the ground station to the photographic stations of the satellite. In order to obtain this data it is sufficient to photograph the stars at a known instant on the same plate as the satellite by means of an appropriate shutter. (For the remainder of the time the stars appear as a continuous trail on the plate.)

Knowing the directions of the lines joining the different stations to the different positions of the satellite (S_1, S_2, S_3 . . .) allows one to calculate the positions of the stations which have to be determined (D, E, . . .) in terms of the known positions (*A*, *B*, *C*) (See Fig 1).

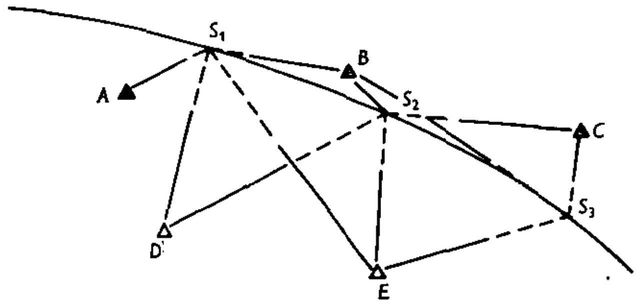
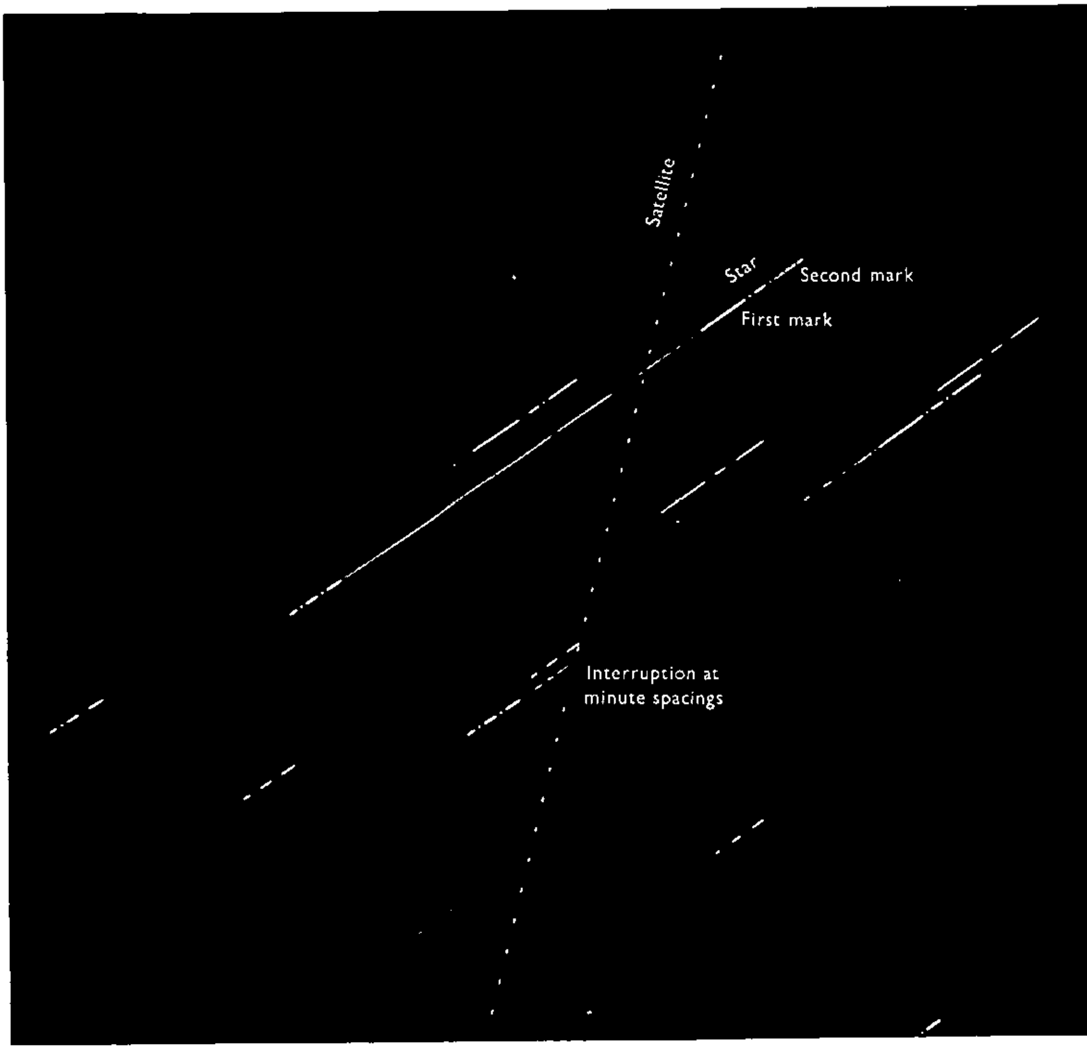


Fig 1. The optical method of fixing unknown ground stations (*D* and *E*) by means of synchronized photographs from all ground stations (*A*, *B*, *C*, *D* and *E*).

Applications of this method have already been made in several places after designing the equipment necessary for carrying out the observations. Amongst others, the Institut Géographique National, Paris, has studied and constructed ballistic cameras and used them principally in connection with satellites ECHO I and ECHO II.

The most rigorous conditions have been imposed for it is necessary to obtain for the distances measured a relative precision of the order of 1 in 100 000. This entails synchronization of the different cameras to $\frac{1}{1000}$ sec (due to the rapidly changing position of the ECHO satellites). On the other hand, one can determine the position of the satellite image on the photographic plates with an accuracy of 3 μm, and it is important to have a very stable camera. It was therefore necessary to construct massive cameras mounted on very stable bases, with short focal length objectives (30 cm), the aperture being limited to *f*/5 (which shows, nevertheless, the stars down to magnitude 6).

A simple shutter is adequate for the photography of stars. However, for the photography of satellites one has to use a revolving disk (provided with a window) the movement of which is controlled to $\frac{1}{1000}$ sec. This disk is graduated and serves as the limb of a chronoscopic device. The flashing lamps are triggered at all stations by the beats of time signals radioed by the same transmitter, thus



Star trails with time marks, and a satellite track with continuous interruptions.

(*Facing p* 399)

ensuring synchronism. Corrections are made for the travel times of the radio waves and the light waves between the satellite and the stations.

The photographs so obtained (see plate) are examined under a graduated microscope and the co-ordinates of the star images on the plate and of the different positions of the satellite, are determined. The complete reduction is then performed, by the least squares method, in a system with tri-rectangular axes having its origin at the centre of gravity of the earth. These computations give definitive co-ordinates for the unknown stations and for the satellite. Methods for flashing satellites can be applied with little difficulty to flashes from aircraft for the synchronization problem has already been solved.

The Institut Géographique National, in 1964, made by the above method applied to satellite ECHO I, a geodetic connexion between France and north Africa which is of the order of 1500 km. During 1965, work has proceeded on linking the Azores and Madeira to the mainland of Europe and Africa, the distances varying between 1500 and 2500 km.

Other equipment, such as the Wild BC 4 camera, is available using the same principles. These cameras were used particularly by the United States Coast and Geodetic Survey for measurements within the United States and for connexions with Bermuda and Antigua.

For the case of the Antarctica–Australia link the following special factors must be considered:

(*a*) The distance involved is of the order of 3000 km, and for such distances the heights of satellites ECHO I and II are insufficient. This difficulty will be overcome in 1966 when the United States launches its PAGEOS satellite having a polar orbit and an altitude of 4200 km. This satellite will also be used for a world triangulation programme.

(*b*) Unfortunately the present types of cameras, eg those of the Institut Géographique National or the Wild BC 4 will no longer suffice. It will be necessary to reconstruct them with objective lenses of much greater diameter, of the order of 200 mm, involving a corresponding increase in the size of the camera.

(*c*) The climatic conditions, which are particularly severe in the Antarctic, will pose certain delicate problems for the proper functioning of the cameras, particularly for the disk-shutter which can only function out-of-doors in the present design.

(*d*) Finally, and most important, the meteorological conditions could be a serious obstacle as the average cloudiness between Australia and Antarctica is 7/10 with a maximum during the southern summer. For optical geodetic measurements with satellites the cloudiness must not exceed 1/10; this value about the time of the equinox appears to have a frequency of the order of 20 per cent. This leads to a probability of 1/25 for successful simultaneous sightings from two stations and 1/125 for sightings from three stations.

In spite of this, the useful transits of PAGEOS will be numerous and it appears that the observations can be made for two or three months about an equinox.

Electromagnetic methods

The possibilities offered by electromagnetic means appear very interesting. They are more expensive and more complex than the optical ones, which are relatively cheap, and in particular they require active satellites. Putting the system into operation, however, does not make undue demands on the personnel and it can more easily be accomplished under Antarctic conditions. The two systems which can now be considered are those known as TRANSIT and SECOR.

TRANSIT

The system which depends on TRANSIT satellites, together with the necessary ground stations, was put into operation by the United States Navy in 1959. Up till now the system has been mainly used for studies of satellite dynamics and of the earth's gravity field. However, it is also possible, given the orbit, to deduce the positions of ground stations which are unknown.

The TRANSIT procedures are quite simple. The satellite emits a signal having a very stable frequency which is received by the ground station. By virtue of the Doppler effect the frequency received differs from that emitted by a quantity proportional to the radial velocity of the satellite with respect to the station. The latter has an oscillator of which the frequency, in principle, is equal to the satellite emission frequency. These two waves are used to set up an interference pattern and one obtains the well known beat phenomena. On integrating this frequency, called "Doppler frequency", between times t_1 and t_2, one obtains the difference, r_1-r_2, of the radial distances between the two instants.

If the orbit is also known at the times t_1 and t_2, the positions of the satellite at times t_1 and t_2 are also known. The ground station then finds itself on a hyperboloid of revolution of which the foci are the positions of the satellite at times t_1 and t_2. During a single passage of the satellite one can make many such measurements of the Doppler integral and the station is defined by the intersection of the corresponding hyperboloids. The intervals of time used in the integration are defined by signals from the satellite itself. In practice a counter registers the number of beats, from the first signal, for each of the following signals. The difference between the successive readings of the counter gives the integral of the frequency between the two signals.

As in the SECOR system, the principal errors are due to ionospheric and tropospheric refraction. The effect of the former, which depends on frequency according to a law known at least in an approximate manner, can be annulled by employing two different emission frequencies. The tropospheric refraction on the other hand does not depend on wavelength and must be eliminated by calculations based on a theoretical model deduced from meteorological observations made at the time of the measurements.

SECOR

SECOR (Sequential Collation of Range) was designed by the Corps of Engineers of the United States Army, and the first satellite equipped with this system was launched in January 1964.

The distance between the satellite and each ground station is measured continuously and recorded on magnetic tape at the same time as the signals emitted by an electronic pendulum. The principles involved are analogous to those used in the tellurometer. The ground station emits a modulated carrier wave and the satellite receives the signal and retransmits it, without changing the phase, on a carrier wave with a slightly different frequency. The ground station then measures the phase difference which exists between the emitted and re-transmitted signals. From this difference one can deduce the distance with an ambiguity of n times the half wavelength. In classical fashion the interdeterminancy is removed by employing four different modulation frequencies corresponding to very coarse, coarse, fine, and very fine. With the last, one uses two carrier waves of different frequencies in order to eliminate ionospheric refraction.

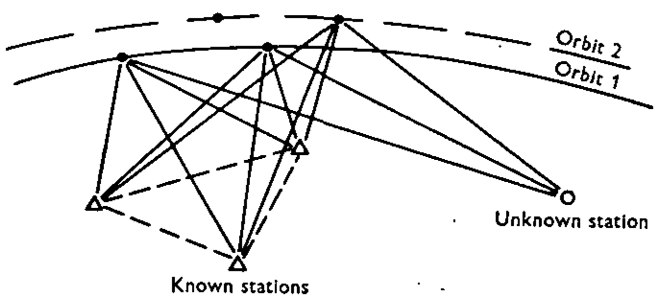


Fig 2. The SECOR method of simultaneous range measurement.

In practice, the measurements of distance between the satellite and the ground stations, known and unknown, are not simultaneous but follow each other at $\frac{1}{20}$ sec intervals. The ground stations, although somewhat large, can nevertheless be carried on ships, lorries, aircraft or even helicopters.

In general one uses four ground stations and the positions of three of them must be known. The measurements can be carried out in three different ways:

(*a*) In the simultaneous method (Fig 2) the distances of the satellite to four stations are measured in rapid succession. It is necessary therefore, that the satellite should be above the horizon simultaneously at all these stations. The position of the satellite is calculated, with respect to the known stations, from the intersection of three spheres of radius equal to the distances measured. When one has determined three positions of the satellite (not necessarily on the same transit), the position of the unknown station is itself given by the intersection of three other spheres. One must ensure that the geometry of the figures provides maximum accuracy.

(*b*) In the orbital method (Fig 3) the satellite orbit is calculated on the basis of measurements made by the three known stations. The unknown position is calculated from the positions of the satellite deduced from the orbital parameters. It is necessary to have at least two passages of the satellite to determine this position. This method, which is less precise than the one described above, is used when the satellite is never visible simultaneously by four stations.

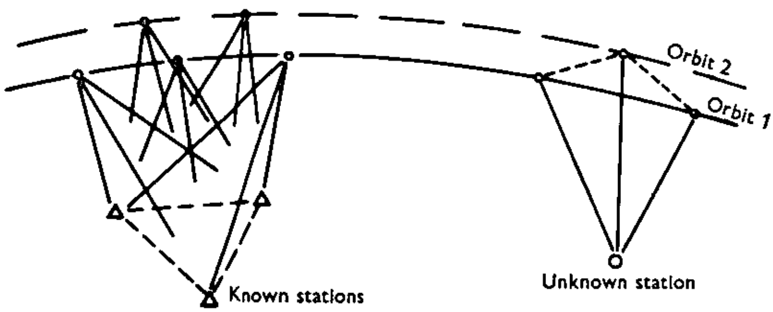


Fig 3. The use of the SECOR method when the satellite is not simultaneously visible at known and unknown stations.

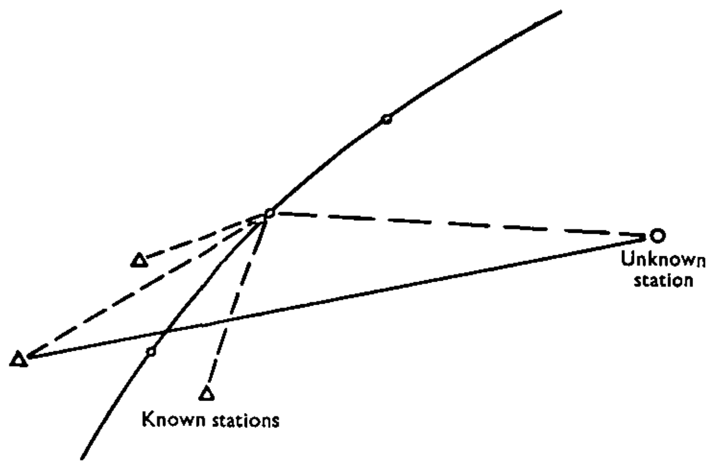


Fig 4. A special case of the SECOR simultaneous method.

(*c*) Finally, in the method of the transverse line (Fig 4), which is a special case of the simultaneous mode, one seeks to determine the distance between one of the known stations and the unknown one by making the measurements at about the time when the sum of the distances of the satellite to these two stations goes through a minimum. This distance is well determined even if the diagram can only be poorly constructed.

Conclusions

The conditions that must be realized before a geodetic link can be made between Australia and Antarctica can be summarized as follows.

Employment of optical methods requires the launching of a PAGEOS satellite in a polar orbit with sufficient altitude, about 4000 km. It will be necessary to improve existing observing devices by augmenting their optical performance, which will in turn give rise to other construction difficulties.

The electromagnetic methods appear more directly usable and more practical, given the appropriate satellites in suitable orbits. This is actually not the case with the TRANSIT satellites nor the SECOR satellites. With this reservation, this kind of experiment is the most promising for it will no doubt allow, although not in the immediate future, geodetic connexions to be made not only between Antarctica and Australia but with all the neighbouring continents.

THE INTERNATIONAL ANTARCTIC METEOROLOGICAL RESEARCH CENTRE, MELBOURNE

BY W. J. GIBBS*

An account of the establishment, in February 1959, of the International Antarctic Analysis Centre was given by Gibbs (1960) and the progress of the Centre was reviewed by Phillpot (1964). This article gives a short account of a notable new development in the field of international scientific co-operation—the World Weather Watch—and examines how this will affect the work of the International Antarctic Analysis Centre.

The World Weather Watch concept envisages a world-wide meteorological system and was stimulated by two Resolutions—1721 (XVI) and 1802 (XVII)—of the United Nations Organization (UNO) aimed at encouraging international co-operation in the peaceful uses of outer space. At the request of the United Nations the World Meteorological Organization devised a system of co-ordinated facilities and services provided mainly by individual member nations and supplemented by international organizations to ensure:

(*a*) systematic observation of the state of the atmosphere,

(*b*) the timely and co-ordinated collection and dissemination of the results of these observations and processed meteorological information,

(*c*) the processing of data and production of weather analyses and forecasts by a number of World and Regional Centres; national services will have access to the raw data and to the products of the Centres.

The World Weather Watch is a natural outcome of the work of the World Meteorological Organization, and its predecessor, the International Meteorological Organization, in promoting international uniformity in meteorological practices and scientific co-operation essential for the development of a World Weather Service.

The World Meteorological Organization plan for World, Regional and National Centres envisages the linking of the Centres by a World Weather

* Director, Commonwealth Bureau of Meteorology, Melbourne, Chairman and Executive Officer, Joint Working Party controlling the IAMRC.

Watch telecommunications system enabling any Meteorological Service to obtain its requirements without having to process all the data and carry out all the work itself.

A World Centre requires:

(1) association with a large communications facility for obtaining meteorological data from as much of the world as possible, and the speedy dissemination of the analysis products, preferably by facsimile;

(2) access to world-wide data provided by meteorological satellites;

(3) adequate data processing equipment to convert conventional data rapidly into objective analyses, numerical weather predictions, etc, for large areas;

(4) staff facilities to blend the conventional and satellite data to produce comprehensive analyses and prognostic charts;

(5) facilities for training meteorologists in the specialized work involved;

(6) a research facility not only for practical operational purposes, but also for more fundamental research into problems particularly on a global scale; and

(7) close liaison with a World Data and Charting Centre to assist in providing documentation to research groups in all countries interested in hemispheric and world problems.

Three World Centres will be established, two in the Northern Hemisphere (in Washington and Moscow) and one for the Southern Hemisphere in Melbourne. The first stage of the Melbourne centre will be the establishment of a Southern Hemisphere Analysis Centre (SHAC) and steps have been taken to bring this into operation early in 1966, the essential requirements being the availabliity of data, staff and accommodation.

The establishment of the Southern Hemisphere Analysis Centre as the first step in the World Weather Watch plan is a logical development from the International Antarctic Analysis Centre which has operated for more than six years.

The International Antarctic Analysis Centre has been a very worth-while project, and the effort put into it by Argentina, Australia, France, Japan, the United States, USSR, SCAR and WMO has produced valuable results. Scientists generally, and meteorologists in particular, are grateful for the vision shown by SCAR in initially pressing for the establishment of the project, its persistence with the effort in the face of many difficulties, the value of ICSU's action in establishing a special financial fund to assist the Centre, and the support of those countries which have contributed to the fund.

Although the operation of the Centre has been hampered by inadequate staff and incomplete synoptic information resulting from poor telecommunications, a series of daily analyses has been produced, operational analysis statements have been issued and used in Antarctica and other places, and a chart record built up which provides a valuable foundation for the establishment of the new Southern Hemisphere Analysis Centre. It is noteworthy that these analysis products have been prepared by a team of international meteorologists combining their individual skills and abilities.

The Centre was initially established for three main purposes;

(i) to produce, for operational purposes, regular synoptic analyses for the surface and upper air for the area between the South Pole and lat 30° S;

(ii) to maintain records in the form of analysed charts and plotted data suitable for research purposes;

(iii) to investigate problems of Antarctic meteorology.

Because of the shortage of professional staff, progress has been somewhat slower than expected, particularly in research, but there is an impressive collection of analysed and plotted data which attests the achievements of the Centre, and the few research papers which have been produced are of high standard.

The establishment of a World Centre of the World Weather Watch in Melbourne relieves the International Antarctic Analysis Centre of the one commitment for routine data and chart processing, and it is now free to concentrate on research related to Antarctic meteorology. The title of the Centre has accordingly been changed from International Antarctic Analysis Centre (IAAC) to International Antarctic Meteorological Research Centre (IAMRC).

Adequate staff will be available to assist research meteorologists in the Centre which will continue to be controlled by H. R. Phillpot, formerly Leader of IAAC, and the Bureau of Meteorology has appointed an additional meteorologist to work there. An additional substantial facility will become available with the expected installation of an electronic computer in the Bureau in 1966–67, although access to a computer is practicable at present.

At the present time there are only two overseas representatives, a Japanese meteorologist, K. Yoshida, with financial support from the ICSU Special Fund and WMO, and a United States research assistant from the University of Wisconsin, W. Knapp. An invitation is therefore extended to any accredited scientist to take advantage of the facilities offered. It is emphasized that whilst the removal of the chart analysis commitment will leave research meteorologists completely free to pursue the lines of their individual interest, facilities will be available for overseas meteorologists attached to IAMRC to work in the Southern Hemisphere Analysis Centre if they wish to develop and extend their synoptic analysis experience.

References

GIBBS, W. J. 1960. International Antarctic Analysis Centre. *Polar Record*, Vol 10, No 64 p 86–89 (*SCAR Bulletin*, No 4, p 54–57).

PHILLPOT, H. R. 1964. International Antarctic Analysis Centre. *Polar Record*, Vol 12, No 77 p 225–28 (*SCAR Bulletin*, No 17, p 326–29).

MEETING OF THE SCAR EXECUTIVE COMMITTEE, NEW YORK,

27 SEPTEMBER 1965

Present: Dr L. M. Gould (President), Rear Admiral R.N.M. Panzarini (Vice-President), Dr G. de Q. Robin (Secretary). (Mr H. W. Wells attended the meeting at the invitation of the President).

SCAR Tenth Anniversary

It was decided that:

(*a*) A SCAR manual will be prepared at the Scott Polar Research Institute.

(*b*) The proposed "Antarctic Day" should be held in early October 1966, shortly after the return of delegates from the IX SCAR Meeting.

The thanks of the Executive Committee to the Anniversary Committee were recorded.

IX SCAR Meeting

(*a*) The dates of this meeting are 19 to 24 September 1966.

(*b*) It was agreed to forward a request for Antarctic exhibits for display during September to November in Santiago to National Committees.

Symposium on Antarctic Oceanography

(*a*) It was agreed that the Symposium on Antarctic Oceanography should be held from 13 to 16 September 1966 in Santiago, Chile.

(*b*) It was reported that the *Eltanin* should be in port in Valparaiso during the Symposium, and it was hoped that a visit to the ship would be arranged.

UNESCO Congress on Antarctic Research

An enquiry from UNESCO about their sponsorship of a Congress on Antarctic Research was discussed. Hesitation was felt over acceptance of the UNESCO offer, which lay in the field of ICSU activity.

The Secretary agreed to draft a letter to National Committees telling them of the UNESCO offer, and requesting their opinion on the desirability of holding a large multi-discipline congress as suggested by UNESCO.

General Assembly of ICSU, Bombay

It was agreed that Ing. Gén. G. R. Laclavère be asked to report on behalf of SCAR if neither the President nor Secretary of SCAR found it practicable to attend.

SCAR Budget

A rough estimate indicated that a probable surplus of over $4000 would be achieved by the end of 1965, but this would largely disappear by the end of 1966, owing to expenses associated with the meetings in Chile.

SCAR Working Groups

(*a*) *Biology.* In view of increasing activity in this field, and because of the importance of marine biology to the Symposium on Antarctic Oceanography, it was agreed that the working group should meet in Santiago at the time of the IX SCAR Meeting.

(*b*) *Communications.* A report from the Chairman of the working group indicated that Antarctic communications appeared to be operating reasonably and that it had not been necessary for the group to take any action recently. The possible usefulness of a group meeting was considered by the Executive Committee. It was not thought necessary to press for a working group meeting at this stage.

(*c*) *Geodesy and Cartography.* In view of the meeting of the working group at the VIII SCAR Meeting, and its overall efficient functioning, it was not considered necessary to hold a Working Group meeting at IX SCAR.

(*d*) *Geology.* The Executive Committee noted that the *Proceedings of the Symposium on Antarctic Geology* had been published in February 1965 and that sales now exceeded 1000 copies so that SCAR funds will now start to benefit from Royalties. The Executive Committee wished to record their sincere thanks to Dr R. J. Adie for editing the proceedings and producing a highly successful and important symposium volume.

(*e*) *Geomagnetism.* It was considered unlikely that the working group would wish to meet at IX SCAR.

(*f*) *Glaciology.* The Executive agreed with the opinion of several members of the working group, namely that it would not be practicable to meet in Santiago. All efforts of the group should be concentrated on the Symposium on Antarctic Glaciology the following year.

(*g*) *Logistics.* The Chairman of the Group, M. Paul-Emile Victor, reported that he has been taking active steps to appoint a new secretary, with a view to developing the programme of the group. The Executive Committee welcomed this activity.

(*h*) *Meteorology.* It was reported that Mr Morton Rubin had been investigating possible locations for the SCAR/WMO/IAMAP Symposium on Polar Meteorology. An offer to provide facilities at the WMO headquarters in Geneva was likely to be accepted. The Symposium would probably be held in early September 1966.

(*i*) *Oceanography.* In view of the associated Symposium, the working group should meet during the IX SCAR Meeting in Santiago. It was reported that the Secretary of SCAR was handling working group correspondence until a new secretary of the group was appointed. It was suggested that the group might appoint a chairman from among its members who would be helped by a secretary who may not necessarily be a full member of the group.

(*j*) *Solid earth geophysics.* The Executive Committee welcomed the appointment of Dr R. D. Adams as Secretary. A report from Dr Adams indicated that a meeting of the group was considered desirable. There appeared to be a chance of organizing an effective meeting in Tokyo during the Pacific Science Congress, but the possibility of a meeting at the IX SCAR Meeting was also being considered.

After approving a minor amendment suggested by the South African National Committee, the Executive Committee ratified the resolutions of the meeting of the working group held in Berkeley, 1963, since the required procedures approved by VIII SCAR in 1964 had now been completed*.

(*k*) *Upper atmosphere physics.* No decision on holding a meeting of the working group at the IX SCAR was taken.

* See p 148–49.

(*l*) *Summary*. The Executive Committee decided that the Working Groups on Oceanography and Biology should meet at the time of IX SCAR, and that the possibility of adding one further working group meeting to IX SCAR should remain open.

Pacific Science Conference

The proposal to hold three half-day meetings on Antarctic research during the Pacific Science Congress was noted with pleasure. The Secretary of SCAR was asked to provide appropriate help from SCAR if he could be of practical assistance.

SCAR National Reports

It was agreed that their content and format should be considered at IX SCAR. The necessity for rapid exchange of National Reports for 1965 was stressed.

Satellite studies

A note forwarded by the Polar Committee of the United States Academy of Sciences on the use of a multi-sensor satellite in a polar orbit was received. It was considered that an international approach to such studies was desirable, and that further consideration to be given the matter at the IX SCAR Meeting.

SCAR Officers

It was noted that the three-year term of office of the Vice-President had just expired, but since he was eligible for re-election he was asked to continue until the IX SCAR Meeting, when a formal vote could be taken.

The Executive Committee recorded their thanks to the officers of working groups who have been active during the past year, and to the staff of the SCAR Secretariat for the way in which they have kept SCAR matters moving.

The Executive Committee recorded their thanks for arrangements made for their meeting by the Polar Committee of the United States Academy of Sciences.

SCAR Solid Earth Geophysics Working Group: Resolutions arising from the meeting at Berkeley, California, 1963

(*a*) That two new seismic observatories equipped with standard VELA UNIFORM instruments be established, one in South Georgia and the other in the Antarctic Peninsula. If feasible, the new French and Japanese stations should also be equipped with similar instruments, as has been done at the new South African station.

(*b*) That seismic refraction studies of the crust be undertaken so as to form two or more crustal profiles oriented at right angles to the Antarctic coast and extending from beyond the peripheral ridge across the continental shelf area; also that measurements of the crust using large explosions in a deep shot hole be tried in the interior of Antarctica.

(*c*) That gravity, magnetic and heat flow measurements be made along the oceanic profiles referred to in (*b*), using a shipborne meter for deeper oceanic regions and an underwater meter (bottom meter) for depths under 100 m—that is, close to the shore.

(*d*) That the United States undertake earth tide studies at the South Pole as a parallel programme to one planned by the USSR at "Vostok" and Mirny; and that the measurements be carried out at a ring of sites about each station rather than at a single site.

(*e*) That gravity measurements be made simultaneously in connexion with precision levelling from the coast up on to the ice plateau similar to measurements being carried out by the USSR from Mirny to "Vostok".

(*f*) That a more precise gravity connexion be made to stable base sites in the Antarctic Peninsula area for control of the gravity work being carried out in the area by British, Chilean, Argentine and United States investigators; and that both Mirny and "Syowa" be connected to the United States station network as well as the French stations.

(*g*) That measurements of heat flow in the exposed rock regions of Antarctica, and through the floor of the surrounding ocean, become an integral part of all future Antarctic programmes.

(*h*) That current station and traverse magnetic programmes be maintained; and that airborne measurements, which for the most part consist of isolated profiles, be organized so as to obtain systematic coverage of areas of geological or subglacial interest.

(*i*) That, as the limited number of telluric current studies that have been made or are being carried out by New Zealand, USSR and British investigators show considerable promise, this programme be expanded by all participating countries.

SCAR GLACIOLOGICAL CENTRES AND INFORMATION EXCHANGE CENTRES

The *Ad hoc* Working Group of Delegates and Advisers which met during the VII SCAR Meeting in Cape Town, 1963, recommended the establishment in each SCAR country of a Glaciological Centre and an Information Exchange Centre. The following are the addresses of designated centres:

Glaciological Centres		Information Exchange Centres
	Argentina	
Instituto Antártico Argentino, Cerrito 1248, Buenos Aires, Argentina.		Instituto Antártico Argentino. Address as opposite.
	Australia	
Dr U. Radok, Department of Meteorology, University of Melbourne, Parkville N2, Victoria, Australia.		J. Deeble, National Committee for Antarctic Research, Australian Academy of Science, Gordon Street, Canberra City ACT, Australia

Belgium

No centres designated. Correspondence to be addressed either to:

W. De Breuck,
Labo voor Fysische Aardrijkskunde,
Rozier 6,
Ghent, Belgium

or

Professor E. Picciotto,
Service de Géologie et de Géochimie Nucléaires,
50, avenue Franklin Roosevelt,
Brussels 5, Belgium

Chile

Instituto Antártico Chileno,
Morandé 71, Correo 8,
Santiago, Chile

For Meteorology:
Oficina Meteorológica de Chile,
Casilla 717, Santiago, Chile

For Oceanography:
Instituto Hidrográfico de la Armada,
Casilla 324, Valparaiso, Chile

France

Professor A. Bauer,
Centre d'études glaciologiques des régions arctiques et antarctiques,
47 avenue du maréchal Fayolle
Paris 16ème, France

Comité National Français des Recherches Antarctiques,
39ter, Rue Gay-Lussac,
Paris 5e, France

Japan

Professor T. Yoshikawa,
Department of Geography,
University of Tokyo,
Bunkyo-ku, Tokyo, Japan

Polar Section,
National Science Museum,
Ueno Park, Tokyo,
Japan

New Zealand

The Director,
Geological Survey,
Box 368, Lower Hutt,
Wellington, New Zealand

The Secretary,
National Committee on Antarctic Research,
P.O. Box 8018,
Wellington, New Zealand

Norway

Norsk Polarinstitutt,
Middelthungst. 27B,
Postboks 5054 Majorstua,
Oslo, Norway

Norsk Polarinstitutt,
Address as opposite.

South Africa

The Director,
Geological Survey,
PO Box 401,
Pretoria, South Africa

The Secretary,
Scientific Committee for Antarctic Research,
CSIR, PO Box 395,
Pretoria, South Africa

United Kingdom

Scott Polar Research Institute,
Cambridge, England

The Royal Society,
Burlington House,
London, W1

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Permanent Working Groups of SCAR

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Solid Earth Geophysics

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