FAIREY SURVEYS

Newsletter

September 1969

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News of developments in the world of surveying and mapping

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SINGAPORE SURVEY

The wisdom of Sir Stamford Raffles' choice of the sparsely-inhabited island of Singapore as a trading centre 150 years ago is now a matter of history. Today the city of Singapore is a major commercial centre of the Far East with a population of just under 2 million, specialising still, as we all remember from our geography text books, in entrepôt trade.

During recent years, an extensive programme of industrial development, including conversion of certain military bases on the island for civilian use, has been a priority requirement. The need for large scale maps on which to plan this development was recognised and the aid of the Ministry of Overseas Development sought. The tender submitted by Fairey Surveys was accepted in February of this year and this set in motion an example of the international co-operation which is becoming quite common-place in the field of aerial surveying.

Detailed plans for each stage of the project were drawn up at Fairey headquarters in Maidenhead. The aerial photography was undertaken using an Australian registered aircraft, an Aero Commander, carrying a Wild RC 8 camera. Full coverage on panchromatic emulsion was achieved at 1 : 15,000 scale and selected runs over the coastal areas were also covered with infra-red, black and white film at the same scale. Ground control for mapping has been surveyed by Singapore-based field parties, using a net-work of cadastral beacons and geodetic levelling already in existence. Planimetric control will consist of fixes of identified photo-point positions from the nearest cadastral beacons, plus some additional levelling.

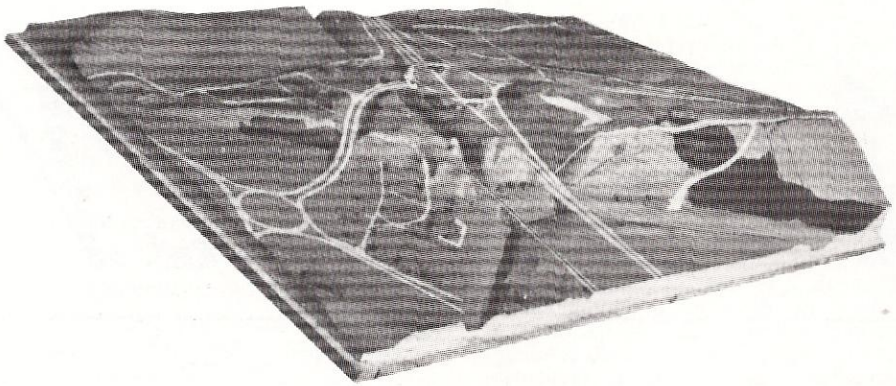
For purposes of aerial triangulation the area of 225 square miles will be treated as three blocks, and observations on a Zeiss Stereoplanigraph C8 began at Maidenhead as soon as the planimetric co-ordinates were received from Singapore. The stereoscopic measurements are being fed into the time-sharing computer terminal at Fairey Surveys' Maidenhead laboratories for strip adjustment on the PDP-1 computer. Subsequent block adjustment is now carried out on the IBM 7094.

Mapping at 1 : 2500 will be plotted on Wild A8 Autograph instruments. In the case of small off-shore islands, the Company will make use of earlier experience of island mapping in the Bahamas using the waterline as supplementary height control, the infra-red photography giving particularly clear depiction of this water line. The resultant contoured map manuscripts will then be completed in Singapore and Faireys final task will be the preparation of a series of map sheets, 412 in all, the whole project to be completed by the Autumn of 1970.

And Gibraltar

Planning the development of Gibraltar's urban areas and of its airstrip will be done from aerial photography and maps produced by Fairey Surveys Ltd. The flying has been completed and the photographs were flown back to England for processing and map-making at Fairey Surveys' Maidenhead laboratory. When the maps are completed in about three months time they will be used by the Chief Planning Officer of the Government of Gibraltar in the redevelopment of the Rock's economy along civil lines and away from the previous reliance on the income from the military bases. The Directorate of Overseas Survey, part of the Ministry of Overseas Development, is acting as advisor to the Government of Gibraltar in the execution of the contract.

Lighters and sampans load and unload ships moored in the Roads, Singapore. *Photo courtesy BOAC.*



A terrain model of the Puriton interchange on the M5 Motorway near Bridgwater, Somerset. Made to a scale of 1 :1250 for the Ministry of Transport South West Road Construction Unit.

Terrain Modelling

The demand for accurate terrain models continues to grow among a surprisingly varied range of users. Terrain models are not new, but the combination of a new material—rigid expanded polyurethane—and a special machine, which converts contour plans into terrain models by cutting into a block of the material, has led to a full scale production facility being set up at Fairey Surveys.

The system has several major advantages over traditional model-making methods. Not only is the tedium of building from contour "layers" avoided but steeply sloping sites now present no problems and models can also easily incorporate removable design features to show the effect of alternative proposals. Additionally, the material used is much lighter than conventional media such as wood, cardboard or plaster of paris, which means that the models are readily portable.

The machine is basically a pantograph with a target at one end which is used to follow the contours on a plan. At the other end, an electrically-driven cutting tool—the same diameter as the target—duplicates the movement of the target and sculpts out the plastic material, contour by contour. The models are produced to the same accuracy as the original map, the vertical scale being continuously variable if desired. Models as large as four feet square can be produced in one operation and even larger sizes in sections for later assembly.

The initial contour cutting and removal of surplus material results in a model in terraced form. This is desirable for many applications since it not only retains the character of the terrain but allows relative heights to be readily taken from the model. Alternatively the model can be smoothed to a true-to-nature appearance if desired. Prior to colouring and cartographic finishing the polyurethane is sealed so that it will take fine lines.

A feature of the increasing business in Fairey Surveys' new-style terrain models is the variety of applications. In addition to the conventional uses—by road construction engineers, town planners and architects—models have been prepared for conservationists studying catchment areas, boat designers and for educational and geological demonstration purposes.

Aerial Colour in U.S.A.

Our Churchill Fellowship recipient, L. W. Tarling (see Newsletter 2), has now returned to us after his extremely valuable technical visit to the United States of America.

Over 8,000 miles of travelling inside the U.S.A. and Canada has taken him into the offices and laboratories of most of the major survey organisations, both government and commercial.

Mr. Tarling's first reaction is that no greater use of colour is made in the U.S.A. than in the U.K. Photogrammetric mapping is carried out from black and white diapositives, although in government departments the original film is usually negative-colour multi-purpose photography with a natural-resources requirement for colour prints. Much interest is centred on multi-spectral installations and Mr. Tarling forsees the rapid development of this requirement.

The use of small-format, narrow-angle cameras to obtain improved colour fidelity right across the frame is much more widespread than in the U.K., especially by forestry agencies seeking type classification, type counting and diseased-vegetation data.

The course Mr. Tarling attended at the Eastman-Kodak Research Laboratories in Rochester, New York, gave him the opportunity to exchange ideas and experience with the scientists engaged in the solution of the problems associated with the use of colour film in aerial surveys. He was also able to visit instrument manufacturers and saw the latest equipment for processing colour films and for producing colour diapositives.

Topography by Numbers

The storage of information, its retrieval when required, and its display in a convenient form are likely to be important subjects for scientists and others in the coming decade. The aerial photograph is itself an excellent information store and the extraction of data displayed in the form of a map or plan, has already provided a number of elegant and efficient photogrammetric procedures. In recent years, a new form of display has made its appearance, known as the Digital Ground Model, or D.G.M., in which topographical information is extracted from the aerial photograph in the form of co-ordinates and heights, for storage on magnetic or punch tape.

The technique of measuring cross-sections for engineering works will be familiar to most readers. Such cross-sections can, of course, be measured on the aerial photograph and the results processed by computer, but the limitation of the method lies in the fact that consideration can only be given to ground lying a specified distance either side of the preliminary centre line. This limitation had to be accepted when the cross-sections were measured by ground methods but the aerial photograph offers a new freedom to the design engineer. Instead of cross-sections, he can now order a "Digital Ground Model", a vast bank of topographical information covering not only the preliminary line, but the whole of the area under review and containing all the elements which he needs for route planning and design.

Significant Economy

Several types of D.G.M. are being used at the present time. In the U.K. the Ministry of Transport, in collaboration with the County Surveyors Society, produced a system which uses the National Grid, spot heights being recorded on a regular grid pattern. In this system, the position of spot heights is predetermined and there is a danger that they will fall on undesirable positions for the depiction of ground relief. On the other hand, the regularity of positioning derives significant economy in the subsequent computer operations. An alternative system, also developed in the U.K., provides the computer with co-ordinates and heights which are measured at changes of slope on section lines which originate from the photogrammetric model rather than from the National Grid. The computer programme used, called Terra, has a number of important advantages over the Ministry of Transport's system, but of course requires greater computer storage.

It would be wrong at this stage to say that the advent of digital ground models has displaced conventional contouring and cross-sectioning as a means whereby the engineer can transform his ideas into fact. There are many difficulties yet to be overcome, but much effort is being devoted to their solution, particularly by official departments and by consulting engineers whose main interest is in the construction of major highway projects.

Tools of Exploration

Geophysics in Perspective

We are happy to include in this issue of our Newsletter a paper on geophysical surveys written by Dr. W. Domzalski, Ph.D., B.Sc., a geophysical and exploration consultant in private practice and well known internationally for his part in many major exploration programmes. Dr. Domzalski has acted on behalf of the U.N. as consultant to many Government Departments all over the world.

Applied geophysics, properly conceived, is both science and art. It is a mixture of physics, mathematics, geology and, above all, practical experience in the utilization of this type of data.

Regarding data acquisition, the geophysical techniques are among the most sophisticated in modern technology; they are based on strict physical principles and utilize advanced instrumentation providing high accuracies of measurement. Processing of data involves, in many cases, the utilization of advanced computer techniques and automation procedures.

The interpretation, however, does involve human judgement and experience and in that sense it is also an art. It is an art based on principles of physics because, although data acquired are accurate, their meaning has to be expressed in terms of elements of the earth crust—in geological terms. Thus the interpretation is not always unique and improves with a number of controlling factors which are available.

The variety of geophysical methods is greater than the number of physical principles on which they are based, because variants of methods exist which utilize the same given property of matter in different ways. This is particularly true in the field of electrical methods which are based on the conductivity of materials.

A general classification of commonly used geophysical methods can be attempted readily and is best achieved by considering the measurable property of matter Thus variations in density of rocks cause differential gravitational attraction by various rock masses and enable gravity surveys to be carried out. Similarly, magnetic susceptibility differences cause measurable variations in the ambient magnetic field which are observed in magnetic surveys. Various resistivities (conductivities) of rocks are measured directly or indirectly in a host of conductive (resistivity, spontaneous polarization, induced polarization) and inductive (electromagnetic) electrical methods using direct or alternating currents. Measurement of naturally occurring radiation is the basis of the radiometric method and in particular the gamma radiation is commonly observed in applied geophysics. Recently electromagnetic radiations of lower frequencies are becoming of interest viz. infra-red and multispectral surveys are in experimental stages.

Perhaps one of the most rapidly developing fields of geophysics is applied seismology which is the science of the propagation of seismic energy through the media of different elastic properties. The phenomenal development of instrumentation from the conventional apparatus to magnetic tape recording, and now digital recording and filtering, is due to the particular application of seismic methods to the exploration for petroleum.

If the general classification by the physical property utilized is relatively simple, the classification of fields of application is less so, because of their wide range. It must be understood however that this range is very much a function of conditions and given methods may, or may not be, applicable depending on those conditions. Thus, extreme topography imposes severe limits on a gravity survey, a highly conductive overburden may frustrate attempts to locate a sulphide deposit by electromagnetic survey, while poor reflecting characteristics of a geological horizon will defy even the most sophisticated seismic system. The application of geophysics ranges from the exploration for petroleum, minerals and water through being an aid in regional geological mapping, the determination of depth to the bedrock in dam site investigation, tunnelling, pipeline laying, to delineation of sand, gravel or clay deposits.

Geophysical methods are used on land, under the water, on the water, underground, in the air and in boreholes.

In each application the principle involved remains the same, but the instrumentation, field procedures and techniques of interpretation vary.

Development Pattern

The accent in the development of the new instrumentation is on a higher accuracy of measurement combined with better resolution and on the automation of recording and processing of data.

A magnetic balance type of magnetometer which several years ago was in wide use was crude compared to today's proton precession, or optical pumping (magnetic resonance) type of magnetometer, with sensitivity increased tenfold and, in some cases, a hundredfold.

Perhaps the most spectacular developments were in the field of airborne geophysics. This is due equally to the almost unlimited accessibility, capability and speed of data acquisition, and to the possibility of recording simultaneously many varying parameters. It is not uncommon for a geophysical survey aircraft to be equipped with magnetometer, electromagnetic (inductive) equipment and gamma ray spectrometer (which itself records four different parameters) and various ancillary equipment including positioning camera, radio-altimeter, Doppler navigator and possibly an additional facility for radiolocation.

The increased rapidity of data acquisition is also characteristic of seismic marine surveys. This development necessitated the creation of computer equipped data reduction centres, where processing of seismic records is automated to the highest possible degree.

It is of interest to review briefly the utilization of geophysics by different industries.

The exploration industries are to the fore and, above all, the petroleum exploration industry is in the absolute lead. It is perhaps a controversial question whether the petroleum industry uses geophysics because it can afford to pay for more sophisticated exploration methods, or whether it is in a position to be able to afford them, because in the first instance it used geophysics to boost up its exploration programmes and increase its discovery rate. Whatever is the true position on this issue, it is a fact that the mining industry has not generally found itself anywhere near the same level of geophysical expenditure—even allowing for lesser turnover.

Perhaps so far the civil engineering industry has been slow in using techniques which are suitable and giving more attention to the possible adaptation of existing techniques to its particular needs. With the exception of dam site investigations by seismic and electrical methods, the application of geophysics has been less than sporadic in other fields of engineering where the determination of near surface rock types, structures, layers and properties could be of great assistance. Vibration measurements and determination of elastic properties of rocks in situ are necessary in many problems. However, it is only by application, modification and research that suitable techniques are developed which are applicable to particular problems. This is perhaps realized but not necessarily practised.

(Continued overleaf)

Fairey Surveys Dove aircraft fitted with magnetometer. The fibre-glass stinger at the tail houses a sensing head which must be positioned at least 6 feet clear of the aircraft metal.

Geophysics in Perspective

(Continued from previous page)

A few statistical considerations are revealing and illustrate the points discussed. The total amount of money spent on exploration geophysics in the whole world (with the exception of communist countries) is of the order of £230 million pounds per annum. The participation per industry is as follows:

oil industry	**93.5%**
mining industry	**5.5%**
engineering industry	**1.0%**

The distribution of expenditure by the oil industry per method employed can be summarized as follows:

seismic	**98.5%**
gravity	**0.8%**
aeromagnetic	**0.5%**
others	**0.2%**

Among seismic methods marine surveys account for about one-third of all seismic work.

Regarding airborne geophysical surveys the last available compiled statistics over a twelve months period indicate that over half a million line miles of aeromagnetic surveys were flown in oil exploration and over 1¼ million line miles of combined aerogeophysical surveys were flown in mining exploration. In the latter case the split per method is as follows:

aeromagnetic	**70%**
combined aeromagnetic and electromagnetic	**20%**
electromagnetic	**6%**
radiometric	**4%**

Average cost of aeromagnetic surveys is about £2.7 per line mile. This figure varies considerably according to the circumstances. It is interesting to note that about 50% of all geophysical expenditure occurs in North America.

Airborne Data Acquisition

With advances in data processing the simultaneous acquisition of data by various recording devices becomes not only more feasible, but can be envisaged as a routine type of survey in the future. The two operational media lend themselves best to such mode of application: marine and aerial. Of the two, the aerial is more flexible in coverage capability and with the exception of the seismic mode of survey can utilize, or can be envisaged to utilize a wide range of techniques for the remote sensing of the surface and subsurface.

At present the aerial photography and conventional aerial geophysical methods are not entirely compatible in simultaneous application: the former is carried out at higher altitudes than the latter. However the gap is decreasing as for example the high sensitivity magnetometer could be flown for geological purposes at altitudes approaching those of photo mapping flights.

It is certainly not too far-fetched to envisage simultaneous acquisition of: aeromagnetic, electromagnetic (artificial or natural fields), radiometric data, infra red imagery, thermal (temperature) recordings and indeed recordings of multispectral information.

The platforms for instrumentation are becoming more elaborate and operate higher up: from helicopter, fixed winged aircraft of low and high altitude to artificial satellites and space stations of the future.

The importance of research into the application of a technique is probably generally acknowledged. However, such research must be backed by sufficient demand for the utilization of practical results by the industries concerned, and those industries should be prepared to participate financially in the development of techniques from the application of which, they hope to benefit eventually. This fortunately has been the pattern regarding the development of geophysical techniques for oil exploration. A few figures quoted previously suggest that this is not the case regarding other fields of application. However it may not be too much to hope that traditional attitudes will be modified, particularly in view of the fact that established boundaries between oil and mining industries are becoming less well defined, as mutual diversifications become common, and interchange of ideas takes place.

Apart from the development of new techniques and instruments and improvements in the existing techniques, an aspect of importance is the integration of acquired data and the intertwining of the modes of data acquisition. Thus a novel approach is that which combines the speed of aeromagnetic coverage with greater accuracy of calculated parameters in seismic method, by running marine surveys involving marine seismic and marine magnetometer with compatible aeromagnetic surveys over the same offshore area. Aeromagnetic interpretation is improved through seismic data and utilized for interpolation between seismic lines, which can be spaced further apart. Considerable economies may arise in survey costs and the range of acquired information is increased.

Combined interpretation of magnetic, electromagnetic, radiometric and photogeological data is carried out frequently and does improve the reliability of conclusions. However, it is again necessary to remember that conclusions are tentative and are based on *an* interpretation. An interpretation, based on measurement of physical properties of matter, but utilizing human judgement and experience.

If you require further information on items featured in Fairey Surveys Newsletter or would like to be added to the mailing list for future issues:

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News in Brief

A co-operative survey has been completed on behalf of 5 major oil companies. The area—offshore Portugal—required 17,500 line kilometres of total magnetic intensity survey utilising Dove G-AWFM aircraft equipped with Barringer 101B proton magnetometer, Doppler navigation system in addition to Decca Navigator which will be used for that part of the area for which coverage is available. Flying commenced on July 12th and data reduction and compilation into contour form has been completed and produced at 1:200,000 scale within 10 weeks.

Two senior members of the company were among the 300 delegates from over 35 countries, who attended the joint meeting at Brighton between the Institute of Petroleum and the American Association of Petroleum Geologists.

A recently awarded contract will involve the production of over 300 map sheets at scales of 1:1000 and 1:2000 for the Municipality of Dubai. This is the second major mapping project to be carried out by Fairey Surveys in Dubai within the last five years.

Flying has been completed of an area in the Kingdom of Saudi Arabia for which orthophoto maps are to be produced. Twenty-four map sheets at 1: 50,000 scale will be produced as a pilot scheme for standard topographic mapping in the Kingdom. This is the first orthophoto mapping project to be completed by a United Kingdom company.

D.C. 3 Dakota G-AHCT with Captain G. W. Milsom and crew has returned from photographing storm weather cloud build-up over North East India and is presently engaged on similar meteorological studies over the U.K.

Terrain models have been made for each of the four proposed sites for the 3rd London Airport.

Aerial photography has been completed of 20,000 acres of the City of Coventry. The photography is at 1:5,000 scale and will be used for a Traffic Study.

Orders have been received for the tripod-mounted drawing pens, featured in Newsletter 1, from Tanzania, U.S.A. and South Africa as well as from University departments, medical research units and local government offices in the U.K.

Current U.K. mapping projects include:—
1:500 survey for A31 improvement scheme over the Hogs Back—well known Surrey beauty spot.
Transmission line surveys in East Anglia at
1:2500 with a 2 foot contour interval for C.E.G.B.
1:1250 scale survey of the Ferrybridge "C" power stations also for C.E.G.B.
1:500 survey of 26 kilometres in Berkshire for the South Hinksey—East Ilsley by-pass. Contours at 0.5 metres vertical interval will be plotted and in addition cross-sections will be recorded on punched tape for design study.

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