# REVISION OF THE NATIONAL MAP SERIES IN SOUTH AFRICA

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## Introduction

In South Africa the Directorate of Surveys and Mapping is responsible for the production and subsequent continuous maintenance of maps of the national series ranging from the 1:10 000 orthophoto map to the ICAO 1:1 million world aeronautical chart, as well as a 1:2½ million wall map of Southern Africa and the 1:7½ million 'Africa South of the Sahara' wall map. With the exception of the 1:10 000 orthophoto map series, the initial mapping of the entire area of South Africa has been completed and the main emphasis has shifted to revision and metrication of the 1:50 000 and smaller-scale series.

It took nearly 40 years to complete the initial mapping at a scale of 1:50 000. The last of the 1916 standard 15 minutes of longitude by 15 minutes of latitude sheets covering South Africa was published in 1976 and since then some 600 sheets which did not conform to specification have been remapped. In recent years attention has been focussed on revision and metrication. South Africa officially changed over to the metric system in 1970, by which time a substantial part of the series had been completed. Most of the pre-1970 sheets which of necessity had to stand over until the series had been completed were included in the remapping programme.

At present 45% of the series is available with 20 metre contours and a further 30% is in various stages of the revision and metrication programme. As far as possible revision and metrication is being carried out in conformity with a systematic programme designed to ensure that sheets are updated at intervals varying with the state of development of the terrain, but with the interval between successive revisions not exceeding 20 years. Aerial photography at a scale of 1:150 000 is being used with considerable success in monitoring changes as a result of development as well as for the dual purpose of producing 1:50 000 orthophotos for detail revision and to plot 20 metre contours in the flatter areas.

The problems connected with map revision in a country where the terrain varies from highly-industrialised metropolitan areas such as the Witwatersrand to vast semi-desert regions are indeed complex. Decentralisation has resulted in the establishement of scores of rural growth points while the need for orderly and sound community life has seen the development of extensive new housing projects. Consequently sheets which previously may have required limited revision every fifteen years have suddenly had to be remapped.

The dilemma which the organisation faces is how to utilise the ever-improving computer technology which is being placed at the disposal of photogrammetrists and cartographers in a cost-effective manner. Automation, especially computer-assisted stereoplotting, has been applied for a number of years and while there has been an increased demand for information in digital form, the requirement for up-to-date conventional mapping has not abated. While the theorists ponder about the problem of translating the graphic data of the 1916 sheets into digital data, the process of revision must continue. The necessity for developing analogue methods compatible with the advanced computer technology has not been ignored and there is no reason why the present procedures cannot be adapted to needs of the future.

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Use of Trade names does not signify endorsement by the Directorate of Surveys and Mapping

## Aerial Photography

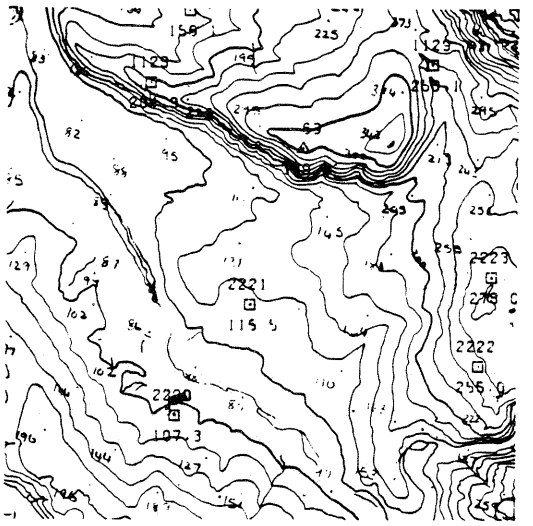
Since 1977 when experimental work was first commenced to ascertain whether it would be possible to use ultra-small scale aerial photography to meet the specification of the 1:50 000 series, the programme has continued unabated. It has been possible to acquire orthophotography covering approximately 100 000 square kilometres (150 sheets) annually at a cost of USD 1,25 per square kilometre. The aircraft used is a Lear Jet 24 to which various modifications have been made to enable the aircraft to fly at the extreme limit of its ceiling while carrying a maximum fuel load. The aircraft is however not fitted with sophisticated navigational equipment and the considerable additional expenditure is not justified. To obtain a contact scale of 1:150 000 using a Zeiss RMK A 8,5/23 aerial survey camera, a minimum flying height of 12,75 kilometres above ground elevation is required and assuming an average ground height of 1,5 kilometres, the minimum flying height above sea level is 14,25 kilometres. The certified flying height of the Lear Jet is only 12,5 kilometres and the aircraft consequently operates well above its certified ceiling. Formation of ice on the optical glass of the camera port at such high altitudes has caused considerable problems. The solution has been to blow warm air over the glass plate but since it is extremely difficult to distribute this air equally across the surface, cracking of the glass plate has occurred during flights causing pressure reduction in the cabin. The specification requires strips of photography to be flown along predetermined flight lines in an east-west/west-east or north-south/south-north direction with a minimum fore and aft overlap of 90%, the strips normally following the centre lines of the 1:50 000 standard sheets that are to be revised. At least 10% coverage is required beyond the boundaries of the task and the maximum deviation in the flight line position must normally not exceed 1,5 kilometres when flying east-west/west-east at a scale of 1:150 000. A north-south/south-north direction of flight gives a greater tolerance in navigation and the allowable deviation from the predetermined flight line is approximately 2,3 kilometres. Experience has however shown that the jet streams encountered at this altitude tend to flow in an easterly direction and this makes navigation in the north-south/south-north direction more difficult. The flying height has generally been between 12 and 13,75 kilometres above mean ground elevation. At this latter height the tolerance increases to approximately 2 kilometres along an east-west/west-east flight line. Notwithstanding the fact that the aircraft is being flown above its certified ceiling and that no sophisticated navigational aids are available, it has been found that the average deviation of the flight line is of the order of 500 metres.

## Metrication of Contours of the 1:50 000 Series

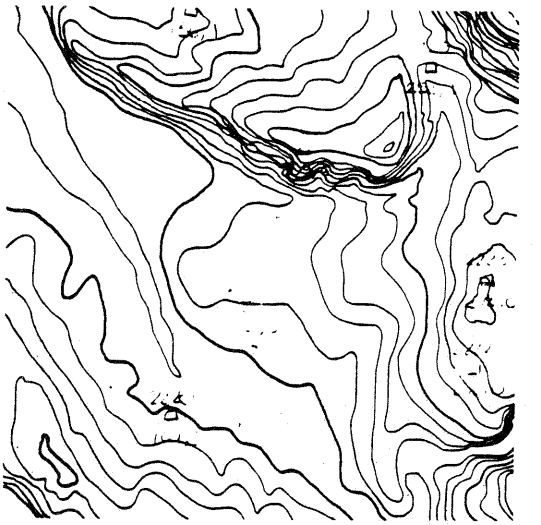
The greatest task in the revision process is the metrication of the contours of the 1:50 000 series. As mentioned in the introduction some 900 sheets of the 1916 covering the series have been published with 20 metre contours and a further 500 are in various stages of revision.
Comprehensive investigations which were conducted proved that the 1:150 000 ultra-small scale aerial photography could also be used to plot 20 metre contours at a scale of 1:50 000 provided the average slope of the terrain did not exceed 10°. At this scale the specification requires that 90% of all elevations tested must be within one-half a contour interval and the remaining 10% within one-half and one contour interval. This accuracy has easily been maintained and the machine time for plotting of the 20 metre contours has been consistently reduced by a factor of five to six times compared with that for standard 1:50 000 aerial photography. It is estimated that at least 75% of the sheets that remain to be metricated fall

within the flatter areas of South Africa where this method can be applied with success. In the remaining areas, standard 1:50 000 aerial photography will be used for the metrication of the contours. As can be expected there is a striking difference in character between contouring obtained from 1:50 000 and 1:150 000 aerial photography, but the accuracy of the latter is well within the specification.

20 metre contours at 1:50 000 from different aerial photography.



1:50 000 Aerial Photography



1:150 000 Aerial Photography

Photogrammetric control points for contouring from the 1:150 000 ultra-small scale aerial photography are transferred directly from previously controlled aerial photography at scales varying between 1:36 000 and 1:60 000, resulting in a dense control pattern. When it is required to use 1:50 000 aerial photography, it has often been found necessary to undertake aerial triangulation to supplement the transferred control. The image from the existing hydrography (blue) plate is transferred by means of the 'kwik-proof' method onto K + E Stabilene matt film or by means of diazo 'rub-on' onto K + E Stabilene Scribe-coat, depending on whether it is intended to produce a pencil plot of the contours or to scribe them directly. During the process of contouring, the drainage pattern is carefully checked and amended where necessary. Although digital data is also acquired and stored on magnetic tape it is generally not used for the plotting of the contours on an automatic digital plotting table.

Production of 1:50 000 Orthophotos

The production of orthophotos at a scale of 1:50 000 is undertaken on the Wild OR1 system. The digital terrain data is acquired during the process of profiling or contouring and three Kern PG2 stereoplotters, a Zeiss Planimat E2 all connected to Wild Aviotab TA1 digital plotting tables, a Wild A10 and a Zeiss Planimat D2 are used for this purpose. The elevation data for this series is stored in regular grids and it is hoped that a grid will eventually be available for each of the 1916 1:50 000 sheets covering the Republic of South Africa. This high density elevation data base provides information concerning the terrain surface which is of great importance to planners and other scientists. The orthophoto however is primarily used for the detail revision of the standing material of the 1:50 000 series.

Orthophoto produced from new aerial photography

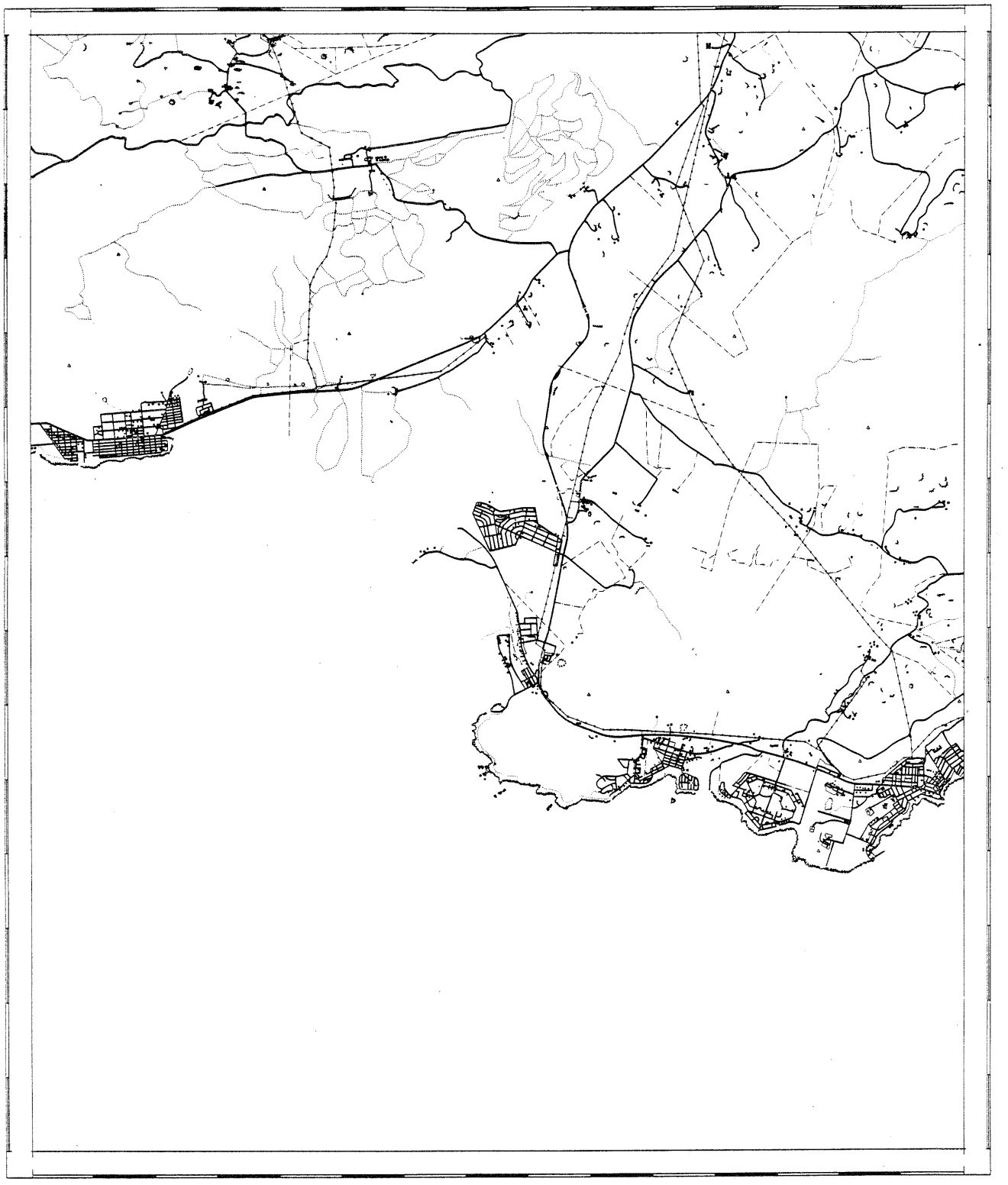
1:50 000 Revision Procedure

The image from a composite positive of the culture (black) and vegetation (green) separation plates of the present edition is transferred onto K + E Stabilene matt film by means of the 'kwik-proof' method. This composite blue overlay, which is subsequently used for the plotting of all amendments to sheet, is combined with the orthophoto negative to produce a bromide print on which the culture and vegetation appear in white superimposed on the orthophoto. The bromide print is carefully examined to evaluate the standard of the original compilation and to determine whether the changes of detail justify a field annotation. In the farming areas, cultivation shows up exceptionally well on the orthophoto so that the method is particularly suited to the revision of this very important feature of the landscape. Similarly it is easy to spot changes in the communication network. Realignments of roads and railways, new roads and extensions to townships are all quickly detected. The surveyor undertaking the revision indicates all mistakes, misinterpretations, incorrect compilation and other shortcomings by means of blue crosses. At the same time all obsolete topographical detail is indicated in a similar manner. Finally all new detail is annotated directly onto the bromide.

Generally it has been found that an inspection on the ground is necessary. Fences, telephone lines and power lines are normally not visible on the photography. Fence lines can often however be deduced especially where there is a difference in the degree of grazing, or in the state of cultivation on either side of the fence. Co-ordinates on the national triangulation system are also readily available for fences running along cadastral boundaries as well as for all major power lines. Telephone lines in most instances run alongside roads and it is debatable whether it is necessary to depict them at all. Once the field work is complete all the new detail is transferred to the composite positive by direct tracing from the orthophoto, or if necessary by stereo-compilation from the 1:150 000 aerial photography. Finally an auto-reversal showing only the additions is made.

The amendments required to each scribed separate comprising the sheet are studied to determine whether duplicate scribed separates are required. A reverse negative on Du Pont CRW-4 film is then made of each required scribed separate. The negatives so made are placed in register with the deletion sheet and all obsolete detail, mistakes and misinterpretations are duffed out. The duffed negatives are then used to prepare a duplicate scribed separate on K + E Stabilene Reproscribe. The image from the film positive showing the additions only is then transferred onto the Reproscribe by means of the diazo 'rub-on' process. Scribing is then undertaken in the normal manner. Where the corrections to a scribed separate are minimal, the affected areas are directly duffed and the image of the new detail is transferred by means of the same process after resensitising the original. No difficulty has been experienced in maintaining existing line gauges and in most cases it has been possible to match outdated type. Where this has not been possible a new names plate has been prepared. It has been conservatively estimated that the time required for revising a sheet by means of this procedure is about 40% of that required for remapping. Concern has been expressed about the possible degeneration of accuracy with successive revisions. Although sufficient data is not available at this stage the results obtained appear to indicate that no appreciable deterioration has in fact taken place.

Positive of original scribed sheet of culture (black) plate before deleting obsolete detail



Positive of reproscribe of culture (black) plate with new detail added

Revision of 1:50 000 Specification

The Directorate is currently considering the revision of the specification of the series. Modern map production techniques coupled with the anticipated future use of automated cartography have prompted amendments and modifications in the symbolisation used, while at the same time every effort has been made to enhance the aesthetic appeal of the map. Experimental work has indicated that the introduction of four colour process printing would be advantageous. It has been gratifying to find that the relief (brown) plate could be produced by a combination of different tints using bi-angle screens. Similarly certain symbols especially on the vegetation (green) plate can be replaced by the combination of different tints as well as by the use of stipples. To enable this to be accommodated the outlines of vegetation boundaries have been scribed during the revision procedure. On the culture plate most dots have been eliminated from the linear symbols while the number of dashes have been restricted to an absolute minimum. The cross ticks which were previously added to industrial railway lines and the traditional symbol for single tracks have also been replaced. In all previous editions the double lines or casings of roads were scribed and the colour-fills added by means of masking. Wherever possible this has been changed by scribing the fill to the required width and producing the casings by photographic means. In all instances the changes that are being introduced should be suitable for automated processing.

Revision of Other Series

The 1:10 000 is an orthophoto map series showing names, a limited amount of explanatory annotation and cartographic enhancement to augment interpretation, and contours at 5 metre intervals. This mapping which is only available in diazo prints is generally confined to urban and peri-urban areas of dense detail and to rural areas with growth potential. Although the series was only started fourteen years ago it is already firmly established with an existing coverage of more than 5700 standard 5 minutes of longitude by 5 minutes of latitude sheets. It is significant that despite the relative newness of the series, many sheets were soon out of date and had to be revised. Already more than 450 sheets have run to second and even third editions. One of the prime advantages of orthophoto mapping is the simplicity and speed of revision. The series is revised by using 1:32 000 wide angle aerial photography flown along pre-determined flight lines and as close as possible to those of the original photographic task. This enables the existing photogrammetric control points to be transferred directly to the new aerial photography. The 1:10 000 orthophoto is produced in the normal manner making use of the digital terrain data previously acquired. The orthophoto negative is combined with a positive of the contour sheet and the names overlay to produce a bromide on which all the existing information appears in white superimposed on the orthophoto. All additions, deletions, mistakes and other shortcomings are indicated on this print and thereafter transferred to the relevant overlays. It has on occasions been necessary to rescribe portions of the contour overlay on account of the many changes that have occurred as a result of extensive township and industrial development. The contouring has seldom been dense enough to justify the use of duplicate scribe-coat since the saving in time would have been minimal.

The 1:50 000 method of revision is particularly suited to the 1:250 000 series where the cycle of revision will not normally exceed ten years. The current editions of this 70 sheet fully-metricated series are based on larger-scale mapping. Two versions of the series are published : a topographical map without administrative information, on which relief is

emphasised by layer tints, and an administrative edition with the same topographical base and contours but omitting the layer tints and carrying an overprint of magisterial district and cadastral boundaries. In this series the advantages of four colour process printing are also appreciable. The previous editions carried pastel layer tints and these have now been replaced by buff tints. It is now possible to show various vegetation classes in green by a combination of different colour tints. The 1:150 000 ultra-small scale aerial photography has been used for updating maps by direct stereo-compilation at 1:250 000. The use of duplicate scribe material has significantly reduced the time required for this revision. Additionally the specification has been adapted for automated processing. While an attempt is made to revise the 1:50 000 series prior to updating 1:250 000 sheets it will be appreciated that due to different cycles of revision this is not always possible. Nevertheless 1:150 000 ultra-small scale aerial photography is always acquired prior to updating being done.

The new 23-sheet 1:500 000 series commenced in 1974 and completed in 1984 is based on information derived from the 1:250 000 series and other larger scale mapping. The earlier sheets done in 1974 are currently being revised and use is being made of the 1:150 000 ultra-small scale aerial photography. Changes to the specification have been effected without any difficulty and the introduction of four colour process printing will be undertaken progressively. The specification is suitable for the anticipated future use of automated cartography. Whenever possible the series is revised concurrently with the 1:250 000 series. This has resulted in significant saving in costs especially in field work and aerial photography and has ensured that maps of different series covering the same area are of the same vintage. The series is published in three versions, a topographical edition, an administrative edition showing magisterial district boundaries and an aeronautical edition. The aeronautical edition retains the foot as unit of measure. For convenience the contour overlay and layer tints of the metric topographical edition are used but with spot heights converted to feet and the metre contour evaluations omitted. The content of the maps and the presentation of the data are good and the specification can easily be adapted to meet the needs of the computer age.

South Africa has assumed responsibility for sixteen sheets of the World Aeronautical Chart ICAO 1:1 000 000 series covering Africa south of latitude 16°S. This is the only unmetricated map series published by the Directorate. The re-drawing of the series on a new topographic base has been completed and all new sheets have been published. As with the larger-scale series, the main pre-occupation for the immediate future is updating and revision. New editions showing aeronautical information are published at regular intervals but it is also necessary to revise the topographic base periodically. Changes at this scale are however minimal and appears to be confined to the culture plate. The introduction of four colour process printing is also receiving attention.

The Southern Africa 1:2 500 000 Wall Map was first produced in two versions in 1962. A topographical version shows 500 metre contours and layer tints, and an administrative version omits the layers and has a blue overprint of magisterial district boundaries. The first edition preceded the completion of the 1:50 000 series of South Africa, at a time when over-border source material was possibly less reliable. A second, revised edition was produced in 1968, and a third in the early seventies. The map was then completely re-drawn and updated, making full use of accurate larger-scale mapping of the whole of South Africa and South West Africa/Namibia, and of the best available material for over-border areas, and this fourth edition was published in 1979. Such is the popularity of this map that a fifth edition, updated to 1984, is at present awaiting publication. The standard of the reproduction material is so good that revision has been effected without any

difficulty. Four colour process printing will be used in the latest edition reducing the number of printing plates from eight to four. The combination of various colour tints has produced a pleasing and valuable cartographic product which reflects the cultural and political changes of the last two decades. The map is admirably suited for automated cartography and will almost certainly be the first task where graphical data of an entire sheet will be converted to digital data for the subsequent output of positives on a laser photographic printer.

The Africa South of the Sahara 1:7 500 000 Wall Map covers the continent of Africa south of latitude 16°N, and includes Madagascar. The topographical version shows layer tints, but the political version has a base tint with the relief effectively depicted by means of hill shading. All international boundaries are emphasised in contrasting bands of colour. Main road and rail communications and names are also clearly shown. The first edition was published in 1971, and so great was the demand that a second printing had to be made almost immediately. A second, revised edition, reflecting the many political changes in Africa was published in 1978. A third updated edition is currently awaiting publication. Four colour process printing will be used reducing the number of printing plates from twelve to four. Revision was undertaken without any difficulty, the only problem being the many changes and variations in the place names of newly-independent states. This map is also very suitable for automated cartography.

## The Future

There can be little doubt that during the next decade or two there will be significant advances in the acquisition, editing, compilation and display of map data. In the revision process the classical photogrammetric method of stereo-compilation now plays an ever-diminishing role and the emphasis is shifting to high resolution aerial photography, orthophotographs and satellite imagery. To utilise these to the fullest extent in computer-assisted cartography, the capabilities of raster scanning systems to translate the graphic information of the 1916 sheets of the 1:50 000 series into digital data are currently being investigated. It has long been accepted that manual digitising is too labour intensive to be economically justifiable, while automated line following techniques have presented practical problems with high density linework. Presently the SCI-TEX RESPONSE-280 SYSTEM appears to offer the best capability for rapid revision once the data has been captured and edited. It would however be unrealistic to believe that this equipment presents instant solutions to the many problems connected with raster-to-vector conversions and the considerable time required to edit the data. The cost of the equipment with only one interactive display and editing console is high and it is doubtful whether more than 30 sheets per year could be converted into edited digital data with this minimum configuration. To maintain a revision cycle not exceeding 20 years it would be necessary to revise approximately 120 sheets per year. To meet this target at least three display and editing consoles would be required. It will also be necessary to acquire a sophisticated interactive graphics editer such as the INTERGRAPH, should input from other sources and the eventual creation of Geographical Information System be envisaged. Quite clearly the immediate challenge is to decide whether the acquisition of this equipment will be cost-effective. We, in our organisation, have always adopted a progressive attitude insofar as the introduction of proven new technology and methods are concerned and face the future with confidence.