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Nossa capa

Mapa de Diogo Homem (1568), que complementa o documento publicado no número anterior, onde se destaca a nascente do rio Amazonas.

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Radar Mapping Using Single Images, Stereo Pairs and Image Blocks Methods and Applications

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Abstract

The present state of mapping with-radar is reviewed. Emphasis is on radargrammetric mapping with single images, stereo pairs and block adjustment. Applications to thematic mapping will be addressed as well. Examples presented concern radar mosaicking, sea-ice study and extra-terrestrial mapping (Moon, Venus).

1. Introductions

The application of side-looking radar images to topographic mapping had been studied intensively and nearly exclusively at military agencies until a few years ago. Civilian research at that time was limited. However, while the study of military radar mapping presently seems to have been deemphasized, it is being increasingly considered for civilian tasks. A number of operational mapping projects have been carried out with radar in different regions of the world. Brasil's RADAM — project is the most daring of these. At the same time the importance of radar appears to increase as a remote sensing tool to be used in conjunction with other data. This is particularly signified by recent decisions for radar imaging from satellites.

SEASAT-A will be launched by the U.S. National Aeronautics and Space Administration (NASA) in 1978 with the main purpose of studying the ocean surfaces (waves, ice) using radar. Projects are being discussed for the SPACE SHUTTLE payload in 1980 (Operational Flight Test OFT-2) and SPACE

LAB (1982 ?). Also extraterrestrial mapping is planned for Venus with a launch in 1983. In Europe similar plans exist: a radar scatterometer/side looking imager may be put into orbit with SPACE-LAB.

Simultaneously, research funds are available to take a closer look at the capabilities and limitations of radar imaging for remote sensing of sub-surface features, surface roughness, soil moisture, polarisation anomalies etc. Mapping with radar is thus a fast developing, fascinating field of study with valuable present applications and great future promise.

This short review will go over the basics of radargrammetry addressing the projection equation, stereo-radar and block-adjustment, however limiting itself to some essential facts. Then recent work will be reviewed concerning the applications of radargrammetric mapping to cartography, geology/planetology, measurement of sea-ice drift and oceanography. An attempt will be made to sketch a scenario for further progress with side-looking radar.

2. Single Image Radargrammetry

2.1 Mathematical Expressions

Radargrammetric projection equations have been formulated on many occasions in the literature. It is essential to differentiate between real-aperture and synthetic-aperture imaging. In both cases the basic fact remains that radar projection lines are circles concentric with respect to antenna (Figure 1).

However, with brute force radar (real aperture) the plane of a projection circle is normal to the longitudinal antenna axis, while with synthetic aperture radar (SAR) it is normal to the velocity vector of the antenna. From Figure 2 one may thus specify the following projection equation:

$$p = s + A \cdot r$$

where p , s are vectors in object space, while r is a vector in image space, defined by unit vectors u , v , w . A is a rotation matrix.

Vector r is a function of slant range r , look angle Ω and a system constant Φ (squint):

$$r = r (\sin \Phi, (\sin^2 \Omega - \sin^2 \Psi)^{1/2} \cos \Omega) \quad (2)$$

Matrix A describes the rotation of the image system u , v , w into the object system (x, y, z) : It is defined by the classical photogrammetric \int , ω , Ψ -angles of photogrammetry, provided however that real aperture radar is considered. For SAR it is a function of the velocity vector s of the antenna.

Further details may be found in the literature (Leberl, 1975; Leberl et al., 1976; Leberl, 1976). It is interesting to note that the radargrammetric difference between real-aperture and SAR has not been considered in a majority of radargrammetric studies.

2.2 Accuracies

Single image radar mapping accuracies achieved in the past depend on a number of factors of a particular project or experiment: type of radar system, resolution, stabilisation, density of ground control, type of con-

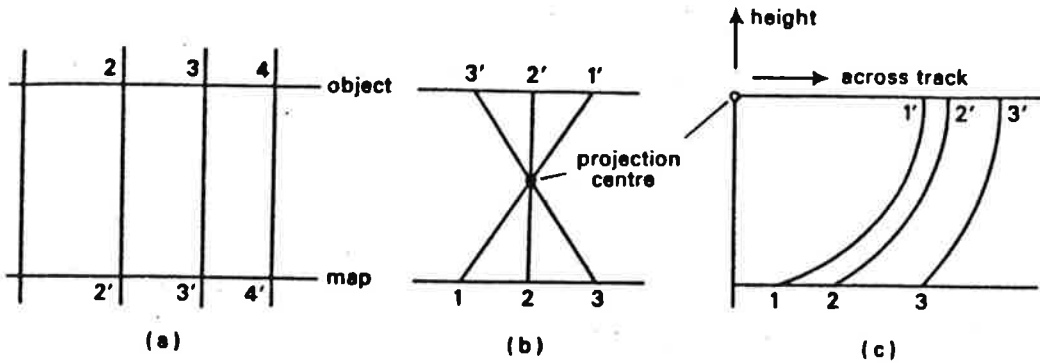


Figure 1: Projection lines for (a) the orthogonal, (b) the central and (c) the radar range projection. Note that projection lines are circles in case (c).

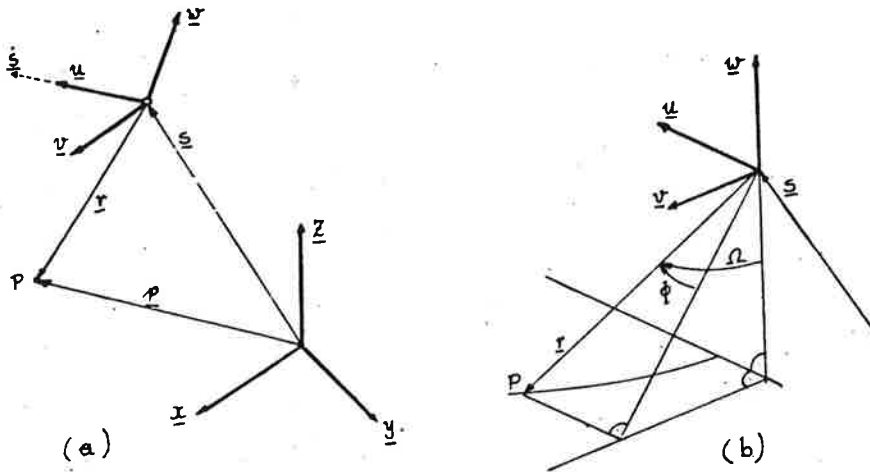


Figure 2: Definitions for the radar projection equations.

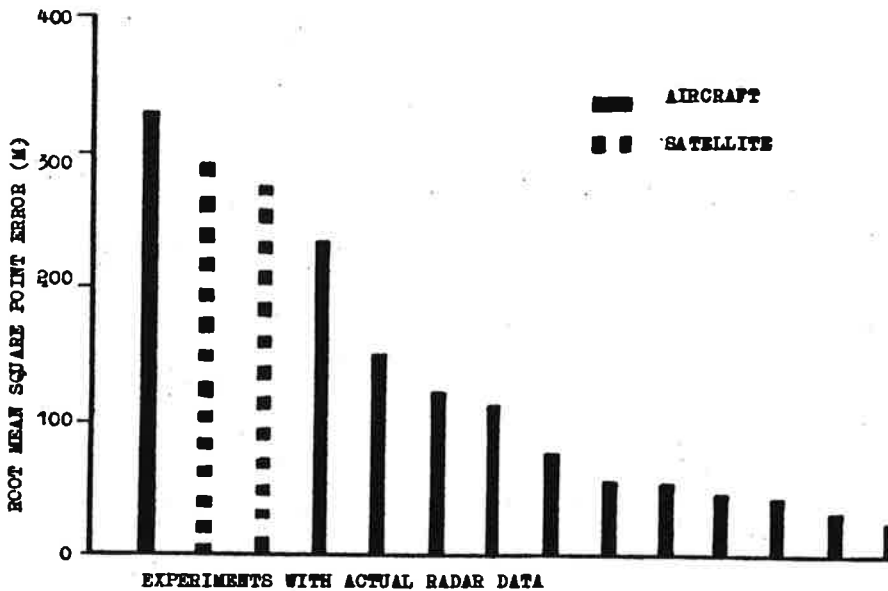


Figure 3: Accuracies achieved with single image radar mapping. Results depend strongly on specific project parameters. Satellite results are from the Apollo 17

trol, mapping method, ty terrain. Therefore results c study may not be genera Figure 3 illustrates the ran results that have been obt in the past.

In the best cases publ accuracies were of the orc the ground resolution. Suc sults were reported e. g. by cie et al. (1970). Very high sity of well identifiable gr control was available (abo points per 100 sq.km).

2.3 Rectification

Rectification is the tran sformation of the single radar i into a map projection. The ccess is usually photograph but can also be numeric graphical or any combinati the above. Using Equs. (1 (2) with measured navig data does enable one to t form a given radar image into the map co-ordinate tem (whereby the ground h must be known or assum be known). If in addition to vigation data also ground trol points are available the set of transformed radar i points can be matched to t control points. Generally match may be done with s sort of interpolation algori Many different procedur possible and have been ap in the past.

While numerically the p

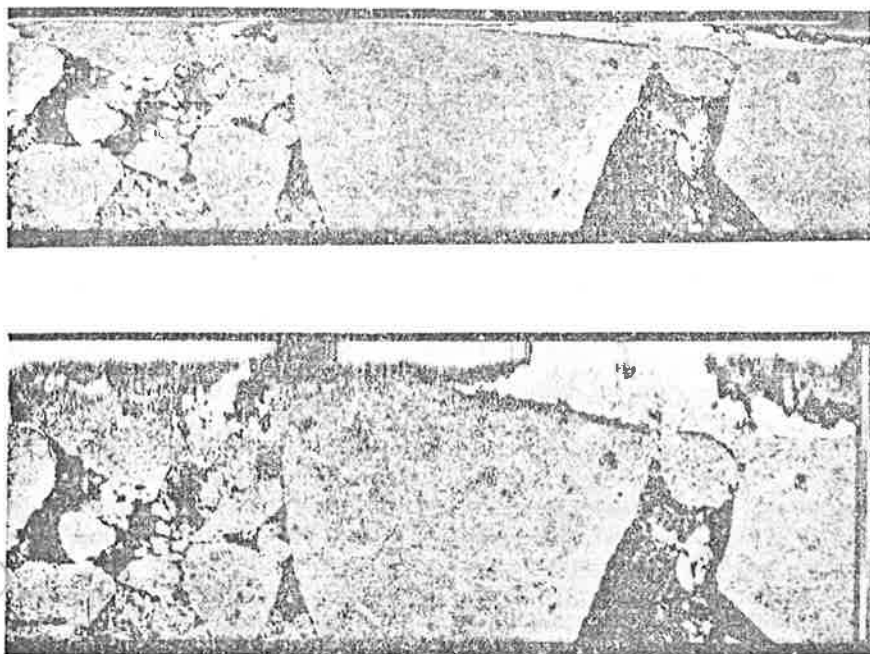


Figure 4: Example of radar image rectification using digital image processing. The distorted image (a) is in slant range presentation. Rectification is mainly a transformation to ground ranges. (Images courtesy Jet Propulsion Laboratory, taken with L-band synthetic aperture radar system over arctic sea ice).

practice if the photographic image is to be reproduced with correct geometry. The new technology of digital image processing permits complete flexibility for rectification (see Figure 4). All geometric corrections are possible. However this rectification is very expensive and tedious indeed and therefore totally unsatisfactory for any large mapping effort.

Jensen (1974) described an optical rectifier for radar image

strips to permit changes of the along-versus across-track scales. The instrument employed anamorphic lenses. Its performance was such that the rectified images were of degraded quality. The rectification was partial only (along track scale). The solution was therefore unsatisfactory.

Peterson (1976) has extended the optical correlator (for SAR) to achieve correction of along track scale. The solution is very

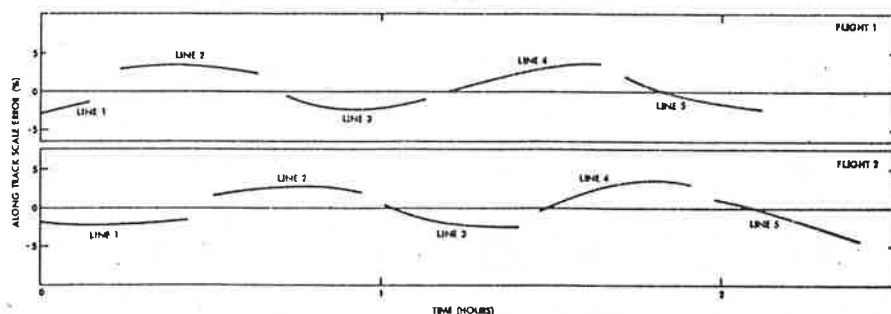


Figure 5: Scale error curves found in radar image strips (Leberl, Jensen and Kaplan, 1976). The periodicity of the along track scale errors as function of time is obvious.

straightforward and does not degrade image quality. Rectification of along track scale is achieved during the conversion of signal films to map films. The simplicity of the method makes it very attractive. However, it only applies to SAR. Its implementation requires prior numerical computation to determine the amounts of image deformations. On the basis of this correction curves can be produced for the along track scale (Figure 5).

3. Radar Stereo Mapping

3.1 Visual Stereo

Stereo viewing of overlapping radar imagery can greatly enhance the interpretation of the images by providing an improved means to observe morphological details, to determine slope angles and height differences and to improve cartographic mapping and point positioning accuracies.

A number of different schemes are conceivable to produce overlapping imagery in such a way that visual stereo is possible. Figure 6 illustrates the most common ones: Same side and Opposite side (LaPrade, 1963; Rosenfeld, 1968). These schemes are the only ones possible for synthetic aperture radar. Cross-wise intersecting flight lines do not seem to produce valid visual stereo (Graham, 1975). Other types of stereo arrangements would be possible with real aperture radar, for example with convergent schemes using tilted antennas (Leberl, 1972; Bair & Carlson, 1974).

In order to view a three-dimensional model the two images of the stereo pair must be sufficiently similar: the image quality and object illumination must be comparable and the geometric differences (parallaxes) must not exceed a certain maximum. In photography this hardly ever presents a problem since sun angles do not change

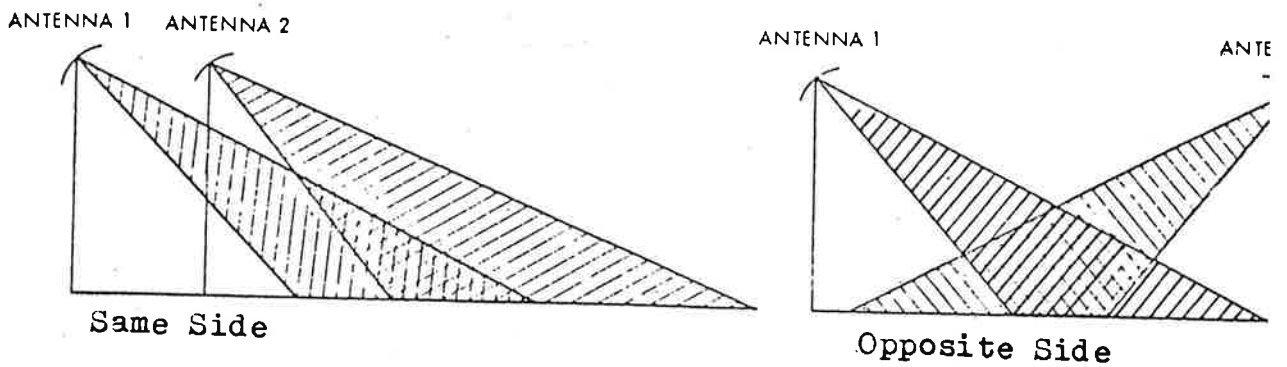


Figure 6: Basic flight configuration for stereo radar.

drastically in overlapping photos. In radar images however the illumination angles depend on the orientation and position of the sensor and so does the appearance of the images.

Figures 7 to 10 present examples of radar stereo pairs demonstrating some of the limits to stereo viewing. Figure 7 shows part of the Estrella mountains in Arizona, USA, imaged with an opposite side arrangement from an aircraft at 12 km altitude. It can be seen that slopes that reflect strongly in one image are in the radar shadow in the other image. A

stereo impression can be obtained in the flat areas of this stereo pair, but becomes very difficult in the mountains. Figure 8 demonstrates with a same side stereo pair taken with the same radar system, that there are no problems to stereo viewing.

Figures 9 and 10 present two Apollo 17 satellite radar stereo pairs taken of the lunar surface with same side geometry and very small stereo base. Look-angles however are much steeper than in the examples of Figure 7 and 8. This leads to larger relief displacements and to differen-

ces of image contents stereo-mates even with stereo bases. In the flat Figure 9 stereo viewing difficult. However, in the nin mountains stereo fus comes nearly impossible even more so in Figure 1 over the rugged Oriental on the Moon's for side:

From the above example following factors influencing radar stereo viewing can be identified:

- Stereo arrangement (same, opposite side);
- Look angles (angles dir);
- Stereo intersection angle;
- Ruggedness of the terrain.

Exact interrelations of these factors are present well understood. Past experiences lead however to the tentative conclusion that opposite side stereo can only be achieved in cases of flat or rolling terrain, while rugged terrain requires same side imaging. Stereo viewing improves with shallower look angles (45° off-nadir or more). With steeper look-angles (near nadir) the stereo base has to be reduced for successful viewing, thereby leading to reduced accuracy.

3.2. Stereo Computation

Proper radar stereo conditions may start off from

Figure 7: Example of same side stereo radar model of Estrella Mountains in Arizona, USA.

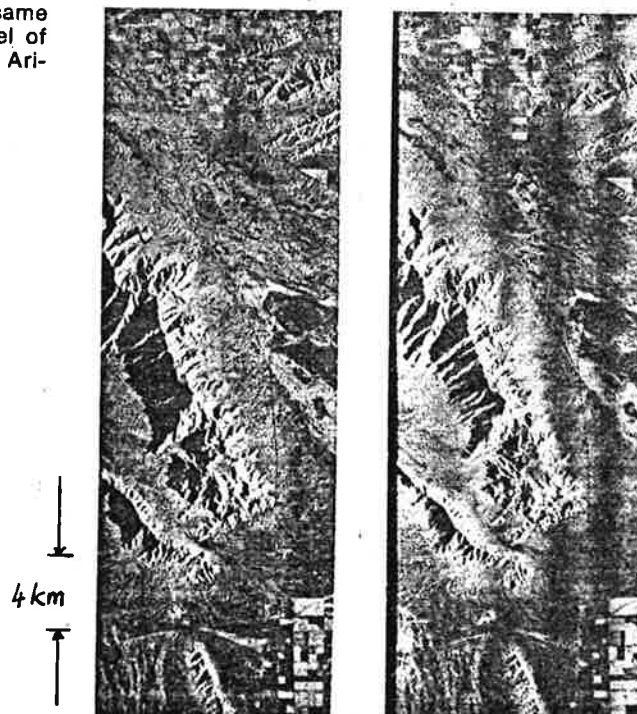
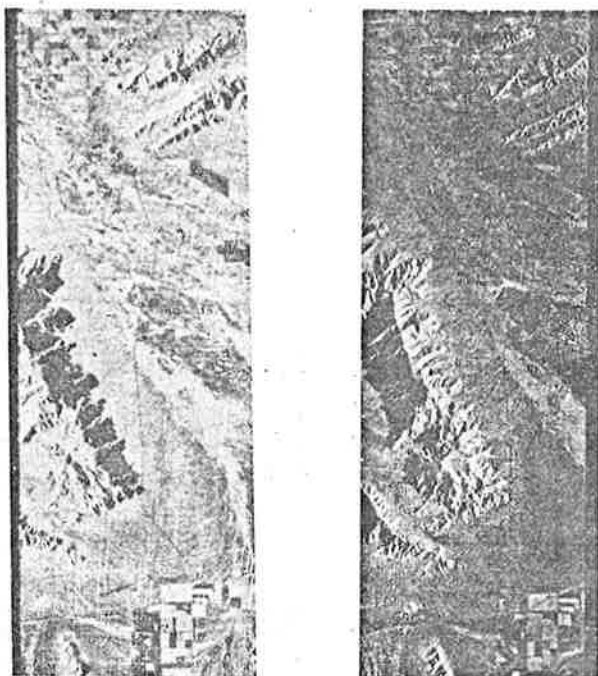


Figure 8: Example of opposite side stereo radar model, area same as in Figure 7.



(1) and (2) where vector p is the unknown and to be found from:

$$\begin{aligned} p &= s' + A' r' \\ p &= s'' + A'' r'' \end{aligned}$$

where (') denotes the left and (") the right image.

A simplified formulation is obtained when one assumes a stereo pair with parallel, perfectly straight and level flight lines. Figure 11 shows that in a ground range presentation a stereo parallax Δp can be found that relates to ΔH as follows:

$$\begin{aligned} \Delta H &= p' / \tan \Omega' \\ \Delta H &= p'' / \tan \Omega'' \\ \Delta p &= p' - p'' = \Delta H (\tan \Omega' - \tan \Omega'') \\ \Delta H &= \Delta p / (\tan \Omega' - \tan \Omega'') \end{aligned}$$

Equ. (4) is valid only if the projection circles can be approximated by straight lines p_a, p_b (Figure 11).

The situation for slant range geometry is slightly more complex. Even a flat ground will appear to be bowed in the radar stereo model. A discussion of this can be found in Leberl (1977) or in Leberl and Elachi (1977).

3.3 Accuracies

The range of accuracies achieved so far with stereo radar is similarly wide as that of single image mapping. Also here a large series of factors is of influence.

Figure 12 illustrates height accuracies obtained in the past. A conclusion may be that accuracies range from the resolution up to many tens of times the resolution, whereby stereo-arrangement and control density are the main factors of influence. A study by Gracie et al. (1970) concluded that stereo height measurements would be accurate to within ± 13 m. However the result applies to a density of 35 control points per 100 sqkm and very well identifiable test Dewideit (1977) achieved a + 25 m root mean square height error

Figure 9: Example of lunar satellite radar stereo model of the Apennin mountains. Stereo base is very small (3° angles of intersection). Good stereo viewability. (Courtesy Jet Propulsion Lab.).

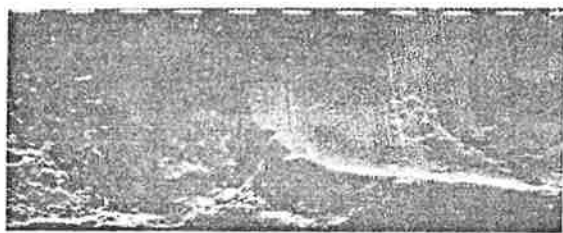
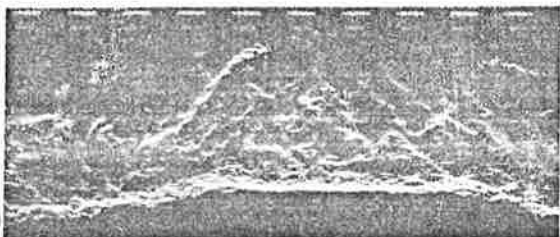


Figure 10: Lunar radar stereo model of the Oriental region on the Far Side of the Moon. Stereo viewability is poor. Same side geometry. (Courtesy Jet Propulsion Laboratory, USA).

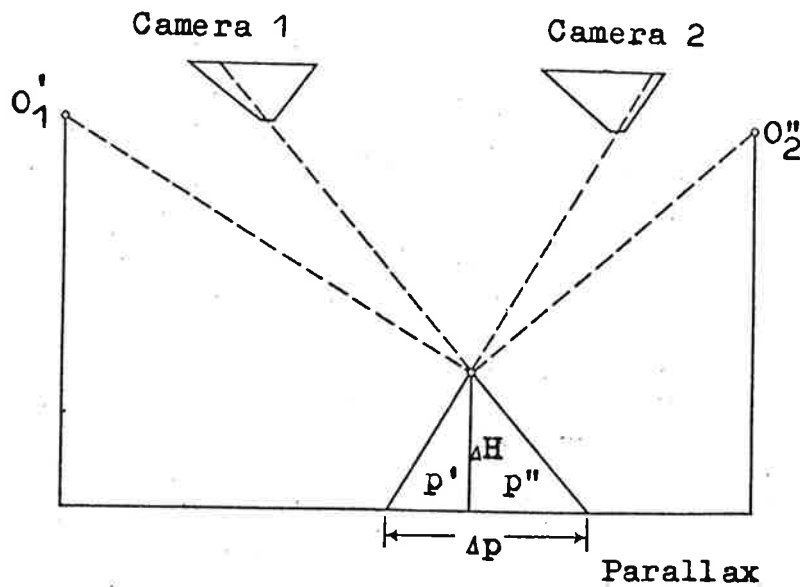


Figure 11: Definitions for the simple stereo-computation with side-looking radar. The stereo base $O_1 O_2$ of radar corresponds to a camera stereo base of (Camera 1 to Camera 2) to produce equivalent parallaxes.

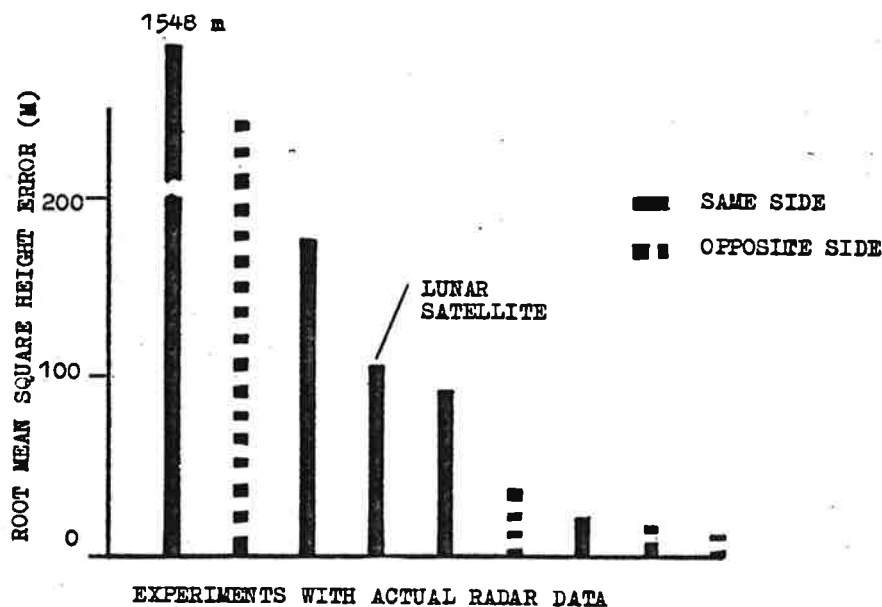


Figure 12: Accuracies achieved in experiments with radar stereo. Results strongly depend on project parameters.

root mean square height error using triple overlaps and high density of control. The computing effort was very considerable. With a more modest (and realistic) density of control that corresponds to a reconnaissan-

ce type survey, say 4 points per 10 000 sq km, height accuracies may deteriorate to ± 100 to ± 200 m and more (see for example Derenyi, 1975; Leberl, 1977 a).

The future may bring an improved radar stereo capability from aircraft sensors if navigation improves; an satellite sensors only if look angles are varied sufficiently one pass to the overlapping over a given area. However active mode of operation is an inherent weakness of differing image contents angles vary, good visual fusion only with very look angles.

4. Block Adjustment and Mosaicking

4.1 General

Actual radar mapping projects result in blocks of overlapping image strips (Radam Proradam: 60%, West-Vi 25% and 60%). Mapping thus be based on an adjustment to densify the generally net of control points and advantage of the available redundancy in the overlaps. radar block adjustment has applied to planimetry, the original images (1975; Leberl, Jensen and plan, 1976). Threedimensional radar block adjustment has studied in a laboratory environment by DBA-Sy (1974) and by Dowdell. The approaches however not practical under constraints.

Radar mosaicking has carried out on three levels of sophistication: (a) no control points are used. The images simply compiled to fit each into mosaics; (b) production strips are flown along parallel lines (for example north-south and tie-lines are flown across example east-west). The tie-lines are controlled by ground control points or by tracking of the aircraft (e.g. Shoran) and the production lines are compiled into mosaics to fit the tie-lines. all production strips are controlled by continuous tracking of the aircraft (Shoran); or a

adjustment is carried out to control all radar images for mosaicking.

Of these the most satisfactory have been mapped not only in South America, but also in Africa and other parts of the world.

A recent extension of the mere use of radar for mapping is the image strips (Peterson, 1976) in a recorelation. Mosaicking is greatly simplified by the method as compared to other approaches.

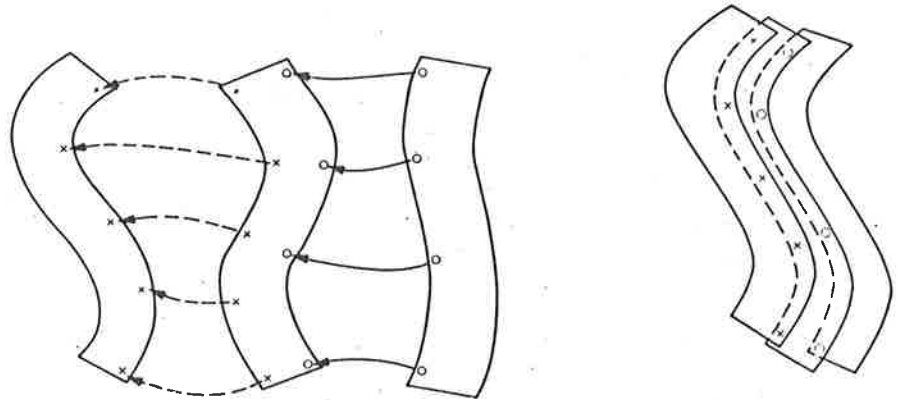


Figure 13: Principle of internal radar block adjustment. Tie-points are used to tie the strips (or stereo models) into a coherent block.

4.2 Method of Block Adjustment

Internal Adjustment

The block adjustment is based on a fit of the radar image strips with respect to each other overlap of images (Figure 13). A coherent image block is obtained as shown in Figure 13 (b). Spline functions are used to describe image corrections Δx (along flight) and Δy (across flight). A spline consists of pieces of polynomials according to Figure 14; each of the pieces is:

$$\Delta x = a_{i0} + a_{i1}(x - x_i) + a_{i2}(x - x_i)^2 + a_{i3}(x - x_i)^3 \quad (4)$$

$$\Delta y = b_{i0} + b_{i1}(x - x_i) + b_{i2}(x - x_i)^2 + b_{i3}(x - x_i)^3$$

where the condition applies:

$$x_{i-1} \leq x < x_i \quad (5)$$

This condition implies that a polynomial piece is valid only in the range delimited by values x_{i-1} and x_i .

Additional conditions apply to enforce a smooth transition from one polynomial piece to the next: the derivatives of 0th, 1st, 2nd order are made identical at the joints of polynomials. We find:

for the function value (0th derivative):

$$a_{i0} \pm a_{i1} \cdot D + a_{i2} \cdot D^2 + a_{i3} \cdot D^3 = a_{i+1,0} \quad (6)$$

for the tangent (1st derivative):

$$a_{i1} + 2a_{i2} \cdot D + a_{i3} \cdot D^2 = a_{i+1,1} \quad (6)$$

for the curvature (2nd derivative):

$$2a_{i2} + 6a_{i3} \cdot D = 2a_{i+1,2} \quad (8)$$

D is the length of the polynomial piece:

$$D = x_{i+1} - x_i \quad (10)$$

External Adjustment:

The coherent radar image block must be transformed into the net of ground control points. The principle is illustrated by Figure 15. Any method of interpolation can be used to fit the image block to the control points.

Internal and external adjustment can be carried out sequentially or simultaneously. A sequential solution has the advantage of low programming and computational efforts. The ge-

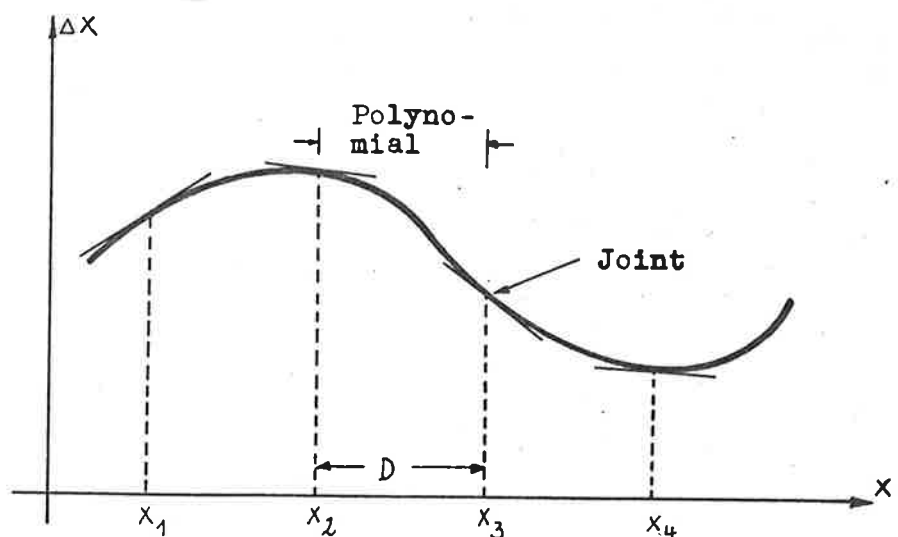
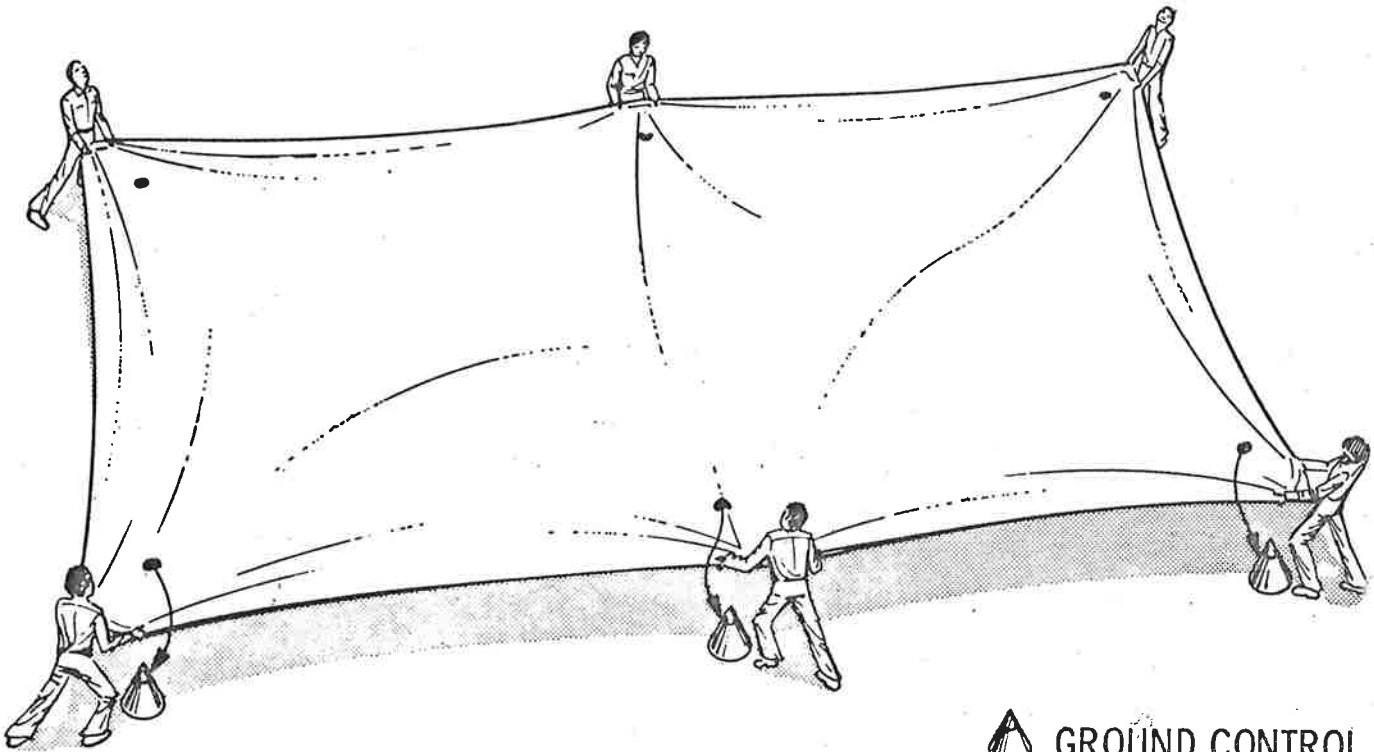


Figure 14: Spline-function or piece-wise polynomial. The function is composed of polynomial pieces defined over a range D . Conditions exist at joints that adjacent polynomials are not discontinuous.



 GROUND CONTROL

Figure 15: Principle of external radar block adjustment: the coherent block is made to fit to the ground control points. Methods of fitting are numerical interpolation.

nerally limited density of ground control and dominating effect of periodical ("systematic") image errors permit to conclude that a sequential solution does not produce results significantly inferior to a simultaneous approach (Leberl, 1974).

4.3 Results

Block adjustment accuracy has been evaluated in a controlled experiment with images from the U.S.A. (Leberl, Jensen, Kaplan, 1976). The result is shown in Figure 16. The absis-

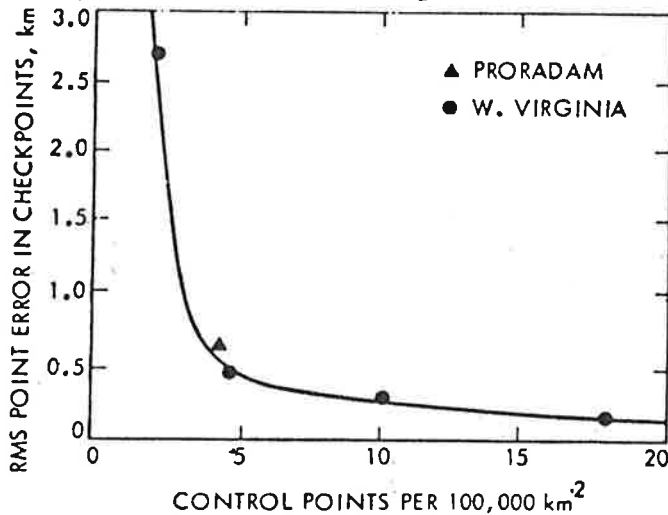


Figure 16: Accuracy of radar block adjustment for mosaicking: data are from an experimental radar block in West-Virginia (Leberl, Jensen and Kaplan, 1976) and from the Colombiar. Proradam (Leberl, 1977a).

sa shows the density of control, the ordinate the root mean square point errors in check points. The images had side-laps of 20%.

An equal distribution of ground control produces the best results. A point density of 15 points per 100 000 sqkm can result in r.m.s. point errors of about ± 150 m (or coordinate errors of ± 100 m).

DBA-Systems (1974) and Dovidelt (1977) obtained results that were about 3 x the resolution of the radar images, however using an unpractically high density of about 10 control points per 100 sq km (1000 points per 100 000 sq km!).

5. Some Recent Applications of Radar Mapping

5.1 Geology / Planetology

The application of side-looking radar for mapping the geo-

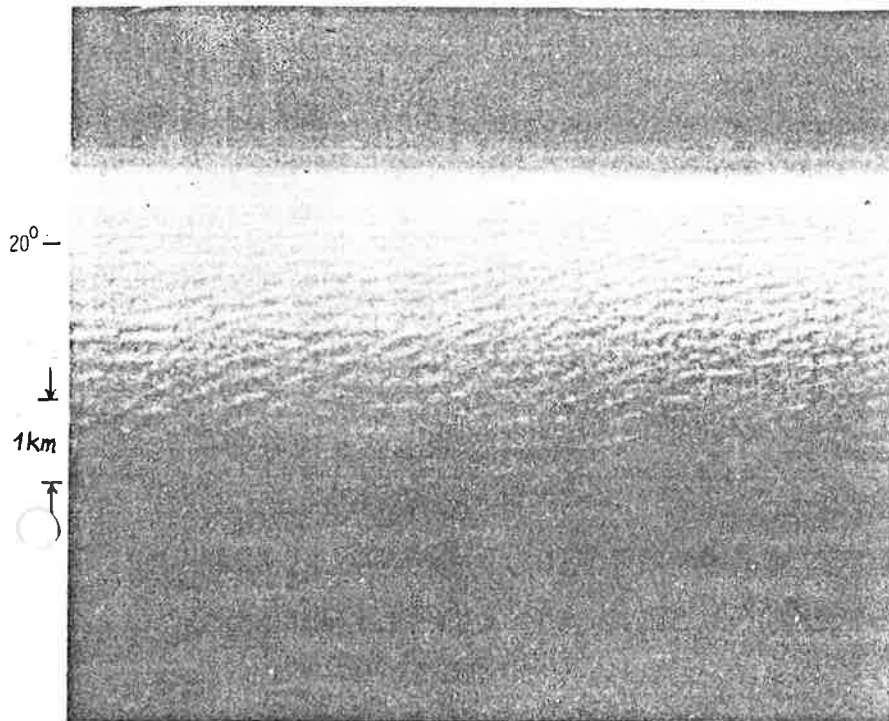


Figure 17: Example of a radar image of ocean waves taken with the L-band SAR of the Jet Propulsion Laboratory, USA.

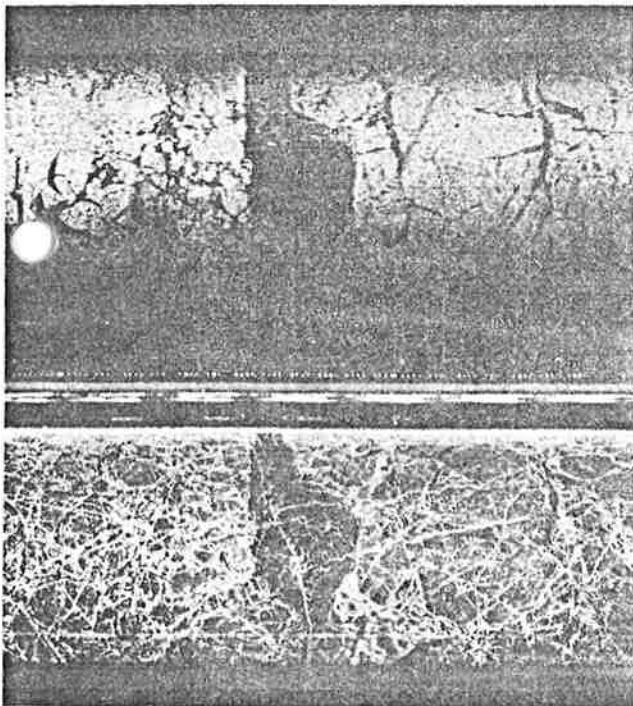


Figure 18: Examples of SAR images of arctic sea ice at wavelengths of 3 cm (above) and of 25 cm (below) (X — and L-band). (Courtesy of Jet Propulsion Laboratory, USA).

logy or surface of the Earth and of other planets (Moon, Venus) is based on two kinds of information:

(a) they show topographic detail, vegetation borders, drainage etc and are thus used like photography;

(b) radar image brightness is related to surface roughness and dielectric constant. It is thus an indicator for soil moisture in vegetated areas; and for surface roughness in arid areas.

Particularly the item (b) is one of great promise for the future role of SAR and SLAR. Work is under way to fully understand this phenomenon. A number of satellite projects are planned to evaluate the use of radar for geologic mapping (Shuttle OFT-2 in 1980; SpaceLab in 1982). A planetary mission to Venus is planned for 1983 (Venus Orbital Imaging Radar — VOIR) to explore the planet's surface topography and geology.

5.2 Oceanography

An important satellite side-looking radar experiment is SEASAT-A with a launch planned for May 1978. Radar images are to be produced of the ocean surface to study wave pattern (Figure 17) and related ocean surface phenomena.

5.3 Sea and Lake Ice

Figure 18 presents two examples of arctic sea ice images produced with aircraft SAR at wavelengths $\lambda = 3$ cm and $\lambda = 25$ cm (X- and L-band). Sea- and lake-ice can very well be imaged and studied with radar images. The longer wavelength radar penetrates through the snow cover and through part of the ice. The image appears therefore different from the shorter X-band radar wavelength. Ice images permit the study of ice motion (Leberl et al. 1976) and enable the shipping routes to be constantly monitored, even under adverse weather and ice

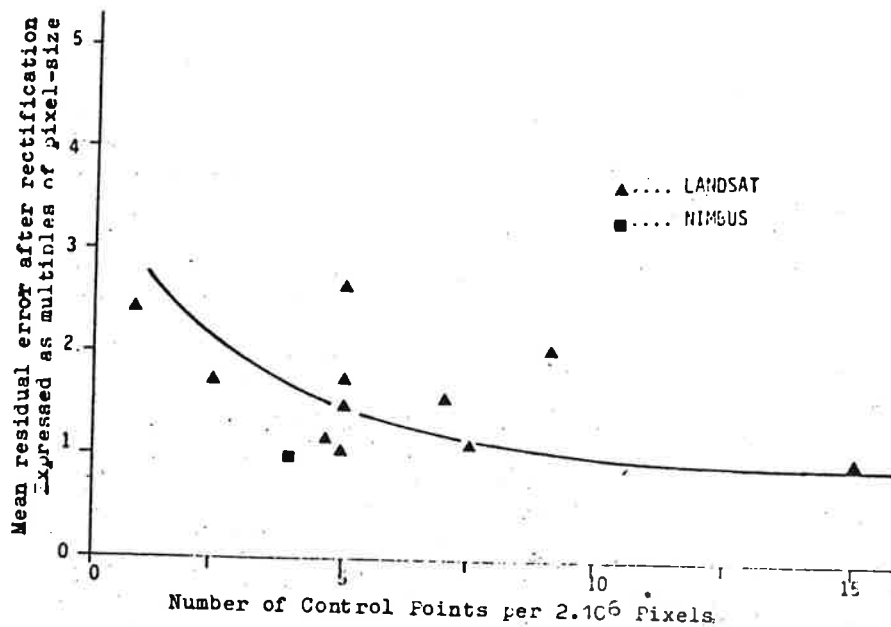


Figure 19: Accuracy of planimetric mapping with satellite scanner images, expressed in multiples of the pixel size (Pixel size of Landsat is about 80 m, for Nimbus about 9.5 km).

conditions (Schertler et al., 1975).

5.4 Cartographic and Thematic Mapping

From the above it is evident that side looking radar can also be used for cartographic mapping reconnaissance surveys for land use, forestry, soils etc. Brazil's Radam (Roessel and de Godoy, 1974) was and is a prime example for this. Large regions have been mapped not in South America, but also in Africa and other parts of the world.

A recent extension of the mere use of radar for mapping is the combination was only experimental and purely for the purpose of enhanced image interpretation. The geometric accuracy of satellite imaging with Landsat scanner data is however such that the combined use of satellite images and radar

radar should also be considered for cartographic (geometric) mapping. Figure 19 presents experimental results of geometric mapping with Landsat (Leberl, 1977). It turns out that a relatively modest control density can already lead to mapping accuracies of about ± 70 to ± 100 m (coordinate errors).

A next step of cartographic radar mapping would thus be the combined block adjustment with satellite and airborne scanner and radar images.

6. Conclusion

Radar earth science applications other than the classical ones to general purpose land mapping and delineation of geological lineaments are rapidly being developed. Major recent applications concern planetology, surface roughness, soil moisture, ocean waves, sea and lake ice, vegetation types and health, snow surveys etc. Several satellite projects promise to help further development of radar applications

(Seasat A, Space Shuttle, OFT-2, Space-Lab, VOIR)

The applications rely on photogrammetric processing of the image strips. Basic applications are here reviewed concerning single images, stereo and block adjustment. It is shown that block adjustment on a digital computer, even with modest effort can produce coordinate accuracies of about ± 100

References

- Bair L.G. and G.E. Carlson (1975) Light Measurement with Stereo Photogrammetry, *Photogrammetric Engineering and Remote Sensing*, Vol. XLI.
- DBA-Systems (1974) *Research and Investigations for Radar Control Extensions*, DBA-System P.O. Drawer 550 Melbourne, USA, Defense Documentation Center Report No. 530784L.
- Derenyi E.E. (1975) Topographic Accuracy of Side Looking Radar, Paper presented at the 41st Symposium on Photogrammetry (ISP), 13th Congress of the International Society of Photogrammetry, Washington D.C.
- Dowideit G. (1977) Eine Blockanpassung für Aufzeichnungen des Seitwärts-Radar (SLAR), *Bildmessung und Luftbildwesen*, Nr. 1, V 45 pp. 17-23.
- Gracie G. et al. (1970) *Stereo Analysis*, USAETL, Ft. Belvoir, Virginia, Report No. FTR-1339-1
- Graham L. (1975) Flight Planning: Stereo Radar Mapping, *Photogrammetric Engineering and Remote Sensing*, Vol. XLI.
- Harris G. and L. Graham (1976): Satellite Radar Synergism, Presented at the International Society for Photogrammetry (ISP), 13th Congress, Helsinki, Finland.
- Jensen H. (1974) Deformations of Imagery — Results from Airborne Surveys, Proceedings, Symposium Comm. III of ISP, Stuttgart, F.R.G. in *Deutsche Geodatische Kommission, Series A, Nr. 214*.
- LaPrade G. (1963) *An Analytical Experimental Study of Stereo*

- Radar, *Photogrammetric Engineering*, Vol. XXIX.
- Leberl F. (1975) Sequential and Simultaneous SLAR Block Adjustment, *Photogrammetria*, Vol. 31, No. 1.
- Leberl F., H. Jensen, J. Kaplan (1976) Side-Looking Radar Mosaicking Experiment, *Photogrammetric Engineering and Remote Sensing*, Vol. XLII.
- Leberl F., T. Farr, L. Bryan, C. Elachi (1976) Study of Arctic Sea Ice Drift from L-Band Side Looking Radar Imagery, *Proceedings*, 42nd Annual Convention of the American Soc. for Photogrammetry, Washington D.C., USA.
- Leberl F., C. Elachi (1977) Mapping With Satellite Side-Looking Radar, *Proceedings*, GDTA Symposium on Remote Sensing, Paris, France, September, 21 — 23.
- Leberl F. (1977 a) Imaging Radar Applications to Mapping and Charting *Photogrammetria*, Vol. 32.
- Leberl F. (1977 b) Herstellung von Kartenunterlagen mittels Satellitenphotographie und Fernerkundungsverfahren, *Geowissenschaftliche Mitteilungen*, Technische Univ. Vienna (in press).
- Peterson R.K. (1976) The Correction of Anamorphic Scale Errors in Holographic Radar Imagery, Goodyear Aerospace Scale Errors in Holographic Radar Imagery, Goodyear Aerospace Corp. Report Code 99696, Litchfield Park, Arizona, USA
- Roessel J. van, R. de Godoy (1974) SLAR Mosaics for Project RADAM, *Photogrammetric Engineering*, Vol. XL.
- Rosenfield G.H. (1968) Stereo Radar Techniques, *Photogrammetric Engineering*, Vol. XXXIV.
- Schertler R.J. et al. (1975) Great Lakes All-Weather Ice Information System, *Proceedings*, 10th Symposium on Remote Sensing of the Environment, Ann Arbor, Michigan, USA.

SÓCIO DA SBC NA CHEFIA DE CURSO NA ESIE

Depois de ocupar a subchefia da 2ª Divisão de Levantamento do Serviço Geográfico do Exército, e de breve passagem, de retorno, ao COC, assume a Chefia do Curso de Formação de

Sargentos Topógrafos da EsIE, o nosso muito caro sócio e amigo TC Norival dos Santos Júnior. É para a SBC motivo de muita satisfação este evento

pois se constitui em argumento forte para que fortaleçam nossas relações de amizade junto àquele conceituado centro de instrução especializada.

IBGE recomenda adoção do Datum SAD-69

Como se sabe o IBGE é o Órgão Nacional responsável pelo estabelecimento da Rede Geodésica de Apoio Fundamental no território brasileiro.

Em consequência dessa responsabilidade, é ainda, o Órgão que dita as normas para esse tipo de trabalhos e, também, determina o melhor ponto de referência para ajustamento das cadeias de triangulação e da malha de poligonais, ou seja o "Datum".

Dentro dessa ordem de idéias

- e,
- considerando terem sido concluídos os estudos gravimétricos e astrogeodésicos definitivos para o estabelecimento do Datum Brasileiro;
- considerando que esse Datum está sendo adotado por

todos os países do Continente Sulamericano e, em consequência será o Datum Sulamericano, cuja sigla é DSA, mais conhecido como SAD-69;

- considerando que o Datum Astronômico de Córrego-Alegre, até então utilizado como ponto de referência para o mapeamento sistemático, é provisório;
- considerando que a diferença entre um e outro é pouco significativa no campo cartográfico;
- considerando que o Datum de Córrego-Alegre já não satisfaz à finalidade geodésica se se considera a extensão do Continente Sulamericano;
- considerando que deve haver uniformidade de princípios, quer se trate da finali-

dade geodésica ou cartográfica.

Conclui o IBGE:

Que se utilizem, para todas as finalidades, os novos valores do Datum SAD-69, cuja origem é o Vértice de Triangulação Chuá, situado nas proximidades da cidade de Uberaba-MG, de Coordenadas Geodésicas, Azimute para o vértice Uberaba (a partir do Sul) e Afastamento Geoidal, seguintes:

Latitude $-19^{\circ} 45' 41.6527''S$
 Longitude $48^{\circ} 06' 04.0639''W$
 Azimute $271^{\circ} 30' 04.05''$
 Afastamento Geoidal $N = 0 \text{ m.}$

Os parâmetros do elipsóide de referência são:

Semi-eixo maior
 $a = 6\,378\,160 \text{ m.}$
 Achatamento $f = 1/298.25$