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The Large Format Camera in Retrospect

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Abstract. A stereopair of the Large Format Camera (LFC) imagery covering parts of the Red Sea Hills Region in eastern Sudan was evaluated for topographic mapping applications in developing countries. Conventional stereoscopic plotting instruments were used as measuring equipment. The data were then processed analytically. The same stereopair was then measured on an analytical plotter using its available software. The results show that although planimetric and height accuracy values obtained with the conventional plotter are lower than those achieved with the analytical plotter, accuracy values of $\sigma_p = \pm 35$m and $\sigma_h = \pm 30$m can easily be reached with conventional photogrammetric stereoplotters. This is an important conclusion for many developing countries where such stereoplotters are readily accessible; and where trained presonnel, who can operate, maintain and service such equipment is already available.

Introduction

The Large Format Camera (LFC), flown onboard Space Shuttle Transportation System (STS) 41-G Challenger vehicle from Kennedy Space Center (KSC) in Florida on October the 5th, 1984, was the second true metric camera to be flown in an orbital platform specifically for photogrammetric purposes. The first was the European Metric (MC), produced by Carl Zeiss (Oberkochen), which was installed in the European Spacelab and flown aboard the United States Shuttle Columbia in the period 28th November to 8th December, 1983. Each of these two metric cameras has some unique characteristics which are well-documented in literature [1, 2, 3].

Geometric evaluations of imagery obtained by the two cameras showed that the LFC has superior geometric fidelity [4, 5, 6, 7]. This was attributed to the following factors:

i) higher base/height ratios of the LFC;
ii) better resolving power of the LFC lens;

iii) imagery of the LFC was recorded on high definition Kodak 3414 film which has a higher resolving power compared to the Aerochrome IR film used for the MC photography;
iv) incorporation of an image motion compensation (IMC) device in the LFC.

This meant that although the MC represented a significant step forward towards achieving high resolution space photography, the geometric evaluation tests carried out in many parts of the world advocated that future space cameras should possess geometric fidelity similar to or better than that of the LFC if topographic mapping is to be contemplated from orbital metric space photography.

In developing countries, however, use of space photography for topographic mapping is fraught with problems. This is due to three main reasons. *Firstly,* analytical photogrammetric restitution is the only means to make full use of the potential of such photography. Unfortunately, in many developing countries, mensuration instruments needed to implement such highly sophisticated restitution methods are simply not available. *Secondly,* the stringent requirements for ground control e.g. establishment of dense network of ground control, (if possible using Global Positioning Systems (GPS), Inertial Surveying or Satellite Doppler Techniques) and the 4-5m uncertainty in ground control, are definitely difficult to meet in many parts of the developing world [7]. *Thirdly,* the 80% endlap needed to fully utilize the potential of the LFC is not always met in passes over developing countries.

These arguments practically screen out agencies in developing countries from making use of this new set of data. This is ironic, however, since developing countries are, no doubt, the main potential users of space imagery due to the poor topographic coverage in these countries.

On the other hand, it is rather surprising to note that almost all investigations concerning geometric fidelity and potential applications of the LFC imagery were carried out using highly sophisticated analytical plotters such as the Zeiss C-100, the Kern DSR-1 and the OMI-AP2-C [6, 7, 8]. To the best knowledge of the author, no serious evaluation of the LFC photos had been carried out using conventional analogue stereoplotters which are usually available in mapping agencies in developing countries. Literature about the LFC mentions that it is indeed possible to use LFC photography on conventional plotters. However, in this case, only the center half frames can be utilized since, for the left/right halves, the inner and exterior orientation geometry cannot be reconstructed on this type of stereoplotter [7]. In strips with 80% endlap, the center halves of subsequent frames overlap by 60% and a triple overlap of about 10% is available for model connection. Although such a configuration gives rise to a base/height ratio of only 0.3 and a vertical exaggeration factor of only 1.4, thus making stereoviewing and height determination less favorable, it can still prove useful to mapping agencies in many developing countries. the main advantage would be the availability of instruments that can deal with such a configuration.

Many remote areas in developing countries are hardly mapped or explored. Some of the existing topographic coverage in these countries is either very old and out-dated or simply absent. In such areas, topographic coverage even at small scales will be most welcome. Provision of ground control for such a coverage solely by ground or aerial survey methods is always hindered by financial limitations since in these countries resources allotted for mapping are usually scarce. However, previous investigations [7] showed that with LFC photography, large areas can be controlled with very few ground control points (typically one point per 18000 km^2) if around 20m accuracy in planimetric position and elevation is acceptable. Surely, such level of accuracy is quite sufficient in remote areas in developing countries. As an example, at a scale of 1/1,200,000, a single LFC frame (46 cm × 23 cm) covers 552 km × 276 km i:e 152,352 km^2. That is the equivalent of 800 aerial photographs (23 cm × 23 cm format) at 1/40,000 scale. This vast area can be controlled by only eight control points. Clearly, this is a very attractive advantage for mapping authorities in developing countries.

Since conventional universal stereoplotters are almost always available in mapping agencies in developing countries, and if it is possible to plan and acquire future LFC center half frames with 80% forward overlap, mapping agencies in developing countries can still take full advantage of the large image format using their existing conventional instrumentation. Further, photogrammetric control densification based on a sparse ground control field can provide ground control points over large areas for the geometric correction and registration of other satellite imagery, a fact most important to mapping authorities in developing countries.

This paper reports the results of an experiment concerned with the evaluation of LFC imagery on conventional analogue stereoplotters. The aim is to produce maps at scale of 1/100,000 and smaller since many areas in developing countries are not mapped even at such small scales. A Wild A-10 universal stereoplooter (resolution ≅ 10 μm) equipped with a digital read-out system was used as a stereocomparator and the mathematical algorithms of space resection/interesection and relative/absolute orientation were utilized. The same photos were then measured on a Wild AC-1 analytical plotter and the model evaluated using the software of the instrument. The results of the two instruments were then compared with each other and with results of investigations carried out elsewhere. Map compilation was also attempted. The results of the experiment are believed to be of value to mapping agencies in developing countries where conventional stereoscopic plotters are directly available.

Test Area and Material

A stereopair from the LFC taken from orbit no. 2 on the 5th of October 1984 and covering parts of the Red Sea Hills region in Eastern Sudan was selected for the purpose of the experiment. On this strip, overlap is 80% thus making center half frames overlap by 60%. The stereopair is formed from the center half frames of photos number 91 and 92. The photos were at an approximate scale of 1:1,200,000 and were in the form of third generation black and white film transparencies.

The selection of this model was dictated by availability of recently completed 1:100,000 scale topographic maps of the area. This was the largest scale available for the test area in this part of the country. A set of positively identified points were measured on the Wild A-10. Some of these were used as control points to effect the solutions while others were used as check points on which assessment of the imagery was based. The corresponding terrain coordinates of these points were scaled off the 1:100000 scale maps of the test area. For each point, four rounds of coordinate measurements were taken and the precision of measurement was computed as standard deviation from the mean. This was found to be ± 11.2 μm and was viewed as satisfactory.

The measured image coordinates of the control points together with the inner orientation parameters of the camera i:e the focal length, the fiducial coordinates, and distortion characteristics were used to compute the terrain coordinates of the check points. These were then compared with their ground equivalents as derived from topographic maps. The root-mean-square error values (σ) of the discrepancies between computed and map coordinates of the check points were then derived and used to evaluate the accuracy of the LFC photos.

Method of Evaluation and Results

The measured plate coordinates were first transformed to a photo coordinate system with origin at the principal point and then refined for known systematic errors namely, lens distortion, atmospheric refraction, and earth curvature, using standard mathematical models of these errors [9]. A zone-to-zone transformation of the map coordinates of points was also carried out.

Two mathematical algorithms were used for the geometric testing of the LFC photos used in this study:

i) space resection/intersection: Here, instead of carrying out space resection for each photo separately, both photos in the stereopair are treated simultaneously as one unit. This method relies on a combination of the collinearity and coplanarity condition equations as explained in detail by Shortis [10].

ii) a conventional relative and absolute orientation solution.

On the stereopair, 33 points were positively identified. Of these 17 were used as control points for both solutions, while the remaining points (16 in total) were used as check points. The results are shown in Table (1) as root-mean-square errors. The following standard formulae were used in compiling the contents of Table 1:

$$\sigma = \pm \left[\frac{\sum v_i^2}{n-u} \right]^{1/2}$$ for the control points, and

$$\sigma = \pm \left[\frac{\sum v_i^2}{n} \right]^{1/2}$$ for the check points

where, v_i = residual at a control or check point i,

n = number of control or check points used; and
u = minimum number of control points used to solve the system.

The same stereopair was then inserted in the Wild AC-1 analytical plotter and manipulated using the plotting mode (program PMO) of the instrument thus using the instrument as a stereocomparator. After inner and relative orientations were performed, the same 17 control points were used to perform absolute orientation in the

Table 1. Root-mean-square errors obtained using the WILD A-10 as a measuring instrument

R.M.S.E.(m)	Space resection/Intersection solution		Relative/Absolute orientation solution	
	Control points	Check points	Control points	Check points
σ_E	± 25.2	± 25.7	± 24.7	± 25.1
σ_N	± 24.7	± 23.9	± 24.5	± 23.8
σ_P	± 35.3	± 35.1	± 34.8	± 34.6
σ_h	± 30.1	± 28.6	± 29.5	± 28.3

AC-1. The floating mark was then moved to the other 16 check points and their ground coordinates were printed out. The residuals were then manually calculated and used to compute the root-mean-square error values in eastings, northings and height. The results are shown in Table 2.

Table 2. Root-mean-square errors obtained using the WILD AC-1 analytical plotter

R.M.S.E.(m)	Control points (n=17)	Check points (n=16)
σ_E	± 19.2	± 19.4
σ_N	± 17.8	± 19.2
σ_P	± 26.2	± 27.3
σ_h	± 24.6	± 25.4

In an earlier investigation, the present author carried out an experiment to evaluate the geometric accuracy and thematic content of Metric Camera and Large Format Camera imagery covering a wider area including the test area of this experiment. A stereocomparator was used as the measuring instrument while a standard Wild ST4 stereoscope with 6X oculars was utilized as the photointerpretation equipment. The procedures followed, the results obtained and the relevant discussions of the results were reported in Ali [11] and need not be repeated here. Suffice it to say that for the LFC models, the interpretational tests carried out to ascertain which of the features appearing on the 1/100,000 scale topographic maps could be identified on the LFC photographs, showed that the percentage of the information which could be extracted from the LFC photographs over the test area was estimated as 80%. This figure was obtained by examining on the photos the list of the most prominent features shown on 1/100,000 scale maps namely, lines of communications, settlements and cultural features, hydrology, vegetation and relief features.

Judging on that experience, the most prominent features of the present model were plotted with the A-10 at a scale of 1:100000 (Fig. 1). This can be compared with Fig. 2 which represents features traced directly from the 1:100000 scale maps of the area.

Discussion of the Results

When the Wild A-10 universal plotter is used as a stereocomparator, it is clear that similar accuracy values were obtained with both solutions. This is true for both

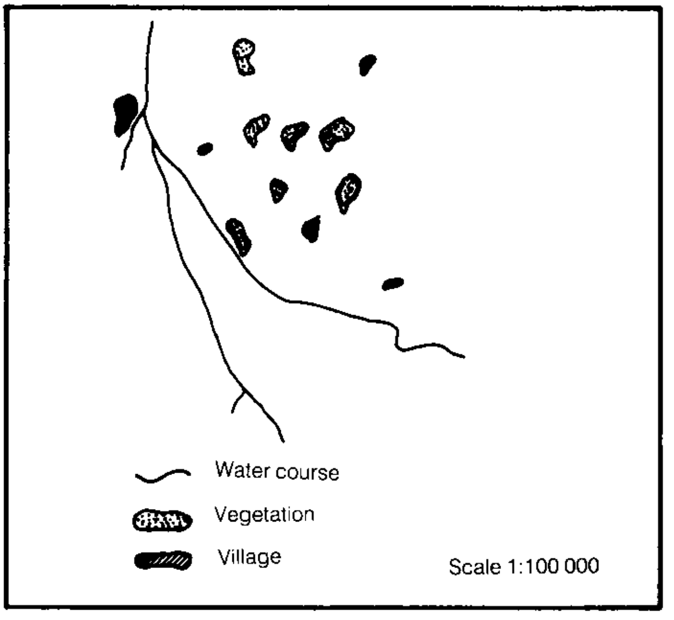

Fig. 1. Features plotted from part of the LFC model

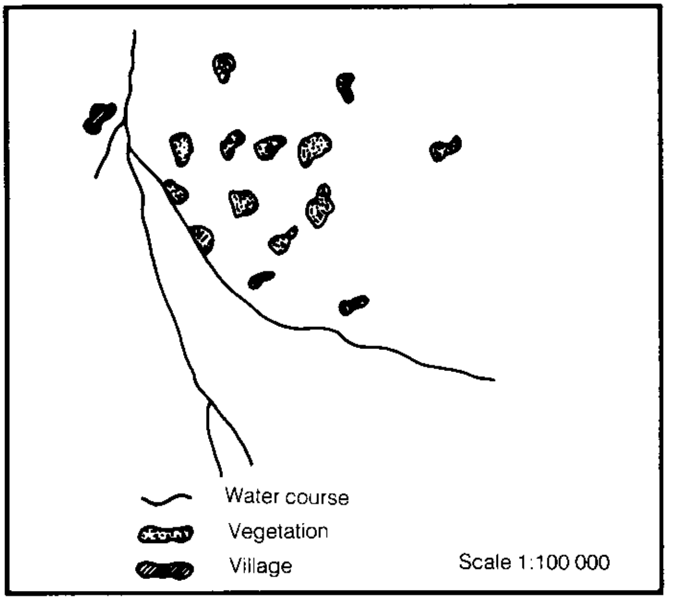

Fig. 2. Features as directly traced from 1:100 000 map.

control and check points and for planimetric and height accuracies. Thus, with this type of instrument, planimetric and height accuracy values of $\sigma_p = \pm 35m$ and $\sigma_h = \pm 30m$ could easily be achieved if an appropriate number of ground control points is available.

With the analytical plotter AC-1, the following results were obtained.

$\sigma_p = \pm 26.2m$, $\sigma_h = \pm 24.6m$, for the control points

$\sigma_p = \pm 27.3m$, $\sigma_h = \pm 25.4m$, for the check points

Admittedly, the accuracy figures obtained with the Wild AC-1 analytical plotter are better than those obtained with the Wild A-10. This is an expected outcome, however, since analytical plotters are more accurate i.e. measurement accuracy of typically a few micrometers for analytical plotters as compared to ± 10 micrometers at the best for analogue plotters [12; p. 648]. It should be noted, however, that the A-10, and other similar instruments, are well-known conventional analogue stereoplotters that do not need highly sophisticated electronic hardware and software for their operation. This is a clear advantage for many countries in the developing world.

NATO specifications for topographic mapping state permissible error values of ± 0.3mm in planimetry and 0.5 contour interval at publication scale for final map production. Table 1 and Table 2, therefore, show that while results obtained with the Wild AC-1 analytical plotter easily meet 1/100000 scale mapping standards with 50m contour intervals, those obtained with the Wile A-10 are only compatible with 1/120000 scale and smaller with 65m - 70m (and definitely 80m) contour intervals. Although this figure is much larger than the 40m or 20m value often required at these scales, it can still be of value in poorly-mapped, remote and mountainous regions in developing countries.

Fig. 2 shows that the plotted map agrees with the original map to a satisfactory level. Use of a map measurer and a digital planimeter showed that almost 85% of the features shown on the map could be compiled from the LFC stereomodel. This is only slightly lower than the figure quoted by Derenyi and Newton [7] (95%) using advanced analytical plotters.

Comparison with Other LFC Results

Some of the results of geometric investigations carried out elsewhere on the LFC photography will now be quoted for comparison. These are shown on Table 3. The results obtained by Togliatti and Moriondo [13] represent the best results heretofore obtained for the LFC imagery. In this test, however, large scale maps were used to derive the ground coordinates of the 364 planimetric and the 663 vertical control points. In the tests carried out by Derenyi and Newton [7] and Newton and Derenyi [8], ground control points based on a recent inertial survey compaign were used. A number of ground control patterns were tried. The figures shown on Table 3 were based on 9 control points (and 109 check points) and a bundle adjustment programme.

Murai [6] used an analytical plotter and a bundle adjustment programme; while Trinder *et al.* (see [7]) used a stereocomparator and a bundle adjustment programme. Lo [14] and Ali [15] used simple measuring instruments (stereoscopes and parallax bars) to derive height acuracies only.

Table 3. LFC Results reported by other investigators (root-mean-square errors)

Investigator	Measuring instrument	Source of ground control	No. of control points	σ_p(m)*	σ_h(m)*
Togliatti and Moriondo [13]	Zeiss C-100 analytical plotter	Large scale maps, some geodetic control	24	±7	±7
Derenyi and Newton [7]	OMI-AP2-C	Large scale maps, some derived by inertial survey	4	±14	±14
Derenyi and Newton [7]	"	"	6	±15	±17
Newton and Derenyi [8]	"	"	9	±14	±16
Trinder *et al* (See (7))	Stereocomparator	1/50000 scale maps	12	±25	±28
Murai [6]	Stereocomparator	Medium scale maps (1/50000)	12	±27	±24
Elniweiri [23]	Kern DSR-1 analytical plotter	1/100000 scale maps	34	±24	±30
Lo [14]	Stereoscope and specially designed parallax bar	Large scale maps (1/24000)	6	–	±63
Ali [15]	Conventional stereoscope and parallax bar	1/100000 scale maps, some derived photogrammetrically	12	–	±53

* root-mean-square error at the check points.

Comments and Conclusions

The planimetric and height accuracy values achieved in this experiment using the Wild AC-1 analytical plotter are comparable with those obtained by Murai [6] and Trinder *et al.* (see [7]). The author, however, believes that the low accuracy of the ground control used is to blame for the relatively poor accuracy results obtained in this test. On the other hand, the very high accuracy figures reached by Togliatti and Moriondo [13], Derenyi and Newton [7], and Newton and Derenyi [8] can be attributed to the very high density of ground control used (one control point in 25 km × 25 km for the Italian test) and to the large scale (1:25000) of the maps used to derive terrain coordinates of the test points. Such ground control density is simply unattainable in poorly surveyed and poorly mapped areas of the world.

The results obtained in this experiment with the Wild A-10 universal plotter being used as a measuring instrument are, no doubt, poorer than other results obtained using the analytical plotter. This should, however, be expected since analogue stereoplotters are less accurate than stereocomparators or analytical plotters. Nevertheless, planimetric accuracy values of ±35m could easily be achieved with universal plotters being used as stereocomparators as evident from the results of this experiment. Also, height accuracies of ± 30m could well be obtained with these instruments, assuming moderate relief conditions.

The plotting phase of the test showed that about 85% of the features on the maps could be compiled from the stereomodel using the Wild A-10 universal plotter. It is believed that the results of this experiment are of interest to mapping agencies in developing countries where resources allotted for mapping are usually scarce. Conventional plotters are almost everywhere in developing countries and when such large areas can be controlled with so few points, it is economically feasible to use Doppler satellite or Global Positioning Systems to acquire them.

Before concluding, a valid point regarding application of satellite imagery for cartographic applications remains to be considered. Although the MC and the LFC were true metric space cameras of known geometric characteristics, the problem of manually recovering the exposed film remains a serious disadvantage if mapping from metric space photography is to be operational.

Other satellite sensors e.g. Landsat Multispectral Scanners (MSS), Return Beam Vidicon (RBV) and Thematic Mapper (TM); and SPOT High Resolution Visible (HRV) do not suffer from this limitation. Further, imagery collected by these sensors is usually recorded onboard the satellite and telemetered to suitable ground stations in digital format. This allowed full digital processing and manipulation of these images to be carried out in order to produce multitude of output data. Images from these sensors were considered by photogrammetrists for cartographic applications. Initially, the look towards these images was rather conservative. However, in Septmeber 1985, the Remote Sensing Society (U.K) held a meeting in London to discuss the role of space imagery for topographic mapping applications. At that conference, the following conclusions were drawn [16]:

i) Landsat MSS is limited to 1/500,000 scale mapping with no height information:
ii) Landsat TM digital products meet or exceed 1/100,000 scale U.S. Map Accuracy standards for horizontal control and may even meet 1/50,000 scale map accuracy standards [17]:
iii) Data corrected to the Universal Transverse Mercator (UTM) projection are preferable to those on the Space Oblique Mercator (SOM) projection. With UTM the offset between ground coordinates and satellite coordinates is constant throughout the scene, so only a single rectification is necessary.
iv) Landsat TM data should not be considered for elevation mapping purposes as the amount of horizontal displacement between adjacent paths is not enough to measure relief and obtain relative or absolute contours.
v) Relief has virtually no impact on horizontal map accuracy statistics in all terrain types except with very large relief displacements over short distances.

The encouraging results reported at the 1985 conference, therefore, pointed out to the fact that Landsat TM data were suitable for at least 1/100,000 scale mapping. The conference also reported results of SPOT simulated data and it was shown that SPOT data may well be suitable for 1/50,000 scale with 40m contour intervals [18]. With the Launch of SPOT in February 1986, this has turned out to be correct [19, 20].

The possibility of generating digital terrain models (DTM) from Landsat TM and SPOT data as well as from linear array camera images was reported by a number of investigators [21, 22]. These studies demonstrated that non-metric space imagery, although lacking the excellent fidelity of the metric camera, can well serve the purposes of the topographic mapping and charting community in producing medium and small scale topographic maps and revising existing ones at this scale range. The widespread use of micro-computer based systems such as digital image processing and geographic information systems (GIS) has already heralded the use of non-metric satellite imagery for resource surveys and development in many countries in the world, both industrial and developing. However, in this respect the main problem facing the majority of developing countries in making use of this new set of data is technology transfer, such as in receiving stations, processing hardware and software, analytical plotters, maintenance of equipment etc. Until this technology transfer reaches a satisfactory level, imagery produced by metric space cameras, such as the MC and the LFC, may well be of value to earth scientists in developing countries as demonstrated by the results of the present experiment.

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References

[1] Itek. "Large Format Camera-Description and Applications." *Itek Optical Systems Information Pamphlet,* No. PFR (1978), 78-0457.

[2] Mekel, R.F.; Salmon, J.G. and Sims, B.A. "Mission Ephemiris for Maiden Voyage of the Large Format Camera (LFC) Aboard the Space Transportation System (STS)." *Mission* 41-G, *NASA* JSC-20383 Report, 1985.

[3] Doyle, F.J. "Mapping with Large Format Camera." *International Archives of Photogrammetry and Remote Sensing,* 26, Part 4 (1986), 731.

[4] Davison, M. "Evaluation of Spacelab Photography for Small Scale Mapping." *Photogrammetric Record,* 11, No. 66 (1985), 695-697.

[5] Rackham, L.J. "An Evaluation of Spacelab Metric Camera Imagery of Sudan." *Survey Review,* 29, No. 224 (1985), 55-62.

[6] Murai, S. "Cartographic Accuracy of Stereo Space Photographs Taken by Large Format Camera - A Case Study in Japan." *International Archives of Photogrammetry and Remote Sensing,* 26, Part 4 (1986), 732-737.

[7] Derenyi, E. and Newton, L. "Accuracy of Three-dimensional Coordinate Determination Using Large Format Camera Photography." *International Archives of Photogrammetry and Remote Sensing,* 26, Part 4 (1986), 14-22.

[8] Newton, L. and Derenyi, E. "Control Extension Utilizing Large Format Camera Imagery." *Proc.* 52nd *Annual Meeting of the American Society of Photogrammetry and Remote Sensing,* Washington, D.C. (1986), 456-465.

[9] Ghosh, S.B. *Analytical Photogrammetry,* 2nd ed., New York: Pergamon Press, 1988.

[10] Shortis, M.R. "Sequential Adjustments of Photogrammetric Engineering Models." *Ph.D. Thesis,* City Univ., London, 1980.

[11] Ali, A.E. "Comparative Evaluation of the Geometric Accuracy and Thematic Content of the Metric Camera and the Large Format Camera Imagery of Sudan." *Australian Journal of Geodesy, Photogrammetry and Surveying,* 52 (1990), 83-98.

[12] Moffitt, F.H. and Mikhail, E.M. *Photogrammetry,* 3rd ed., New York: Harper and Row, 1980.

[13] Togliati, G. and Moriondo, R. "Large Format Camera: The Second Generation Photogrammetry Camera for Space Cartography." *Internal Report,* Politechnico di Milano, Italy. 1986.

[14] Lo, C.P. "Parallax Bar Height Measurements from Large Format Camera Photography." *Photogrammetric Record,* 12, No. 7 (1987), 485-491.

[15] Ali, A.E. "A Parallax Bar Heighting Experiment With Metric Camera and Large Format Camera Photography." To be published in the *Journal of King Saud University,* Vol. 4, *Engineering Sciences,* No.2 (1992).

[16] Bryant, N.A.; Zobrist, A.L.; Walker, R.E. and Gokhman, B. "Landsat Thematic Mapper Geodetic Accuracy: Implications of Geocoded Map Compatibility." *Advanced Technology for Monitoring and Processing Global Environmental Data,* Remote Sensing Society, Reading (U.K), (1985), 257-273.

[17] Welch, R.; Jordan, T.R. and Ehlers, M. "Comparative Evaluations of the Geodetic Accuracy and Cartographic Accuracy of Landsat 4 and Landsat 5 thematic Mapper Image Data." *Photogrammetric Engineering and Remote Sensing,* 51 (1985), 1249-1262.

[18] Welch, R. "Cartographic Potential of SPOT Data." *Photogrammetric Engineering and Remote Sensing*, 51 (1985), 1085-1091.

[19] Jaques, B. and Lopez, R. "Looking Down for Money." *Space Markets*, 2 (1986), 73-80.

[20] Galtier, B. "The Potential of SPOT for Topographic Mapping." *Proceedings of the 20th International Symposium of Remote Sensing of Environment*, 4-10 Dec., Nairobi, Kenya, Vol. 1, (1986), 403-409.

[21] Swann, R.; MacDonald, J.S.; Westwell-Roper, A.; Wood, S. and Laing, W. "The Automated Extraction of Digital Terrain Models Satellite Imagery." *Proceedings of the 20th International Symposium of Remote Sensing of Environment*, 4-10 Dec., Nairobi, Kenya, Vol. 1 (1986), 411-424.

[22] Cooper, P.R.; Friedman, D.E. and Wood, S.A. "The Automatic Generation of Digital Terrain Models from Satellite Images by Stereo." *Acta Astronautica* 14 (1986).

[23] Elniweiri, A.E.H. "An Investigation into the Accuracy of Landsat, MOMS, MC, LFC and SPOT Images for Small and Medium Scale Mapping in Sudan." *Ph.D. Thesis*, University of Glasgow (U.K), (unpublished) 1988.

نظرة خلفية للكاميرا ذات التغطية الواسعة

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ملخص البحث. نموذج صوري من الكاميرا المترية ذات التغطية الواسعة يغطي المنطقة الشرقية من تلال البحر الأحمر في السودان أخضع لتقويم دقيق لمعرفة إمكانية رسم خرائط طبوغرافية من هذا النوع من الصور في الدول النامية. وقد تم قياس هذا النموذج أولاً في إحدى ماكينات الرسم الأتوغرافي التقليدية، والتي تمتلكها معظم دور المساحة في الدول النامية. ثم قيس هذا النموذج بعد ذلك في إحدى الماكينات التحليلية الحديثة والتي يديرها جهاز حاسب آلي وذلك بغرض مقارنة نتائج الجهازين. وقد أوضحت نتائج التجربة أنه بالرغم من أن النتائج التي تم الحصول عليها بواسطة الماكينة التحليلية الحديثة أكثر دقة من تلك التي حصل عليها من الجهاز التقليدي إلا أنه يمكن بسهولة الحصول على دقة موضعية أفقية مقدارها ± ٣٥ مترا ودقة رأسية مقدارها ± ٣٠ مترا عند استخدام الجهاز التقليدي. هذه النتائج تعتبر ذات أهمية خاصة بالنسبة لكثير من الدول النامية والتي تمتلك دور المساحة فيها كثير من هذه الأجهزة التقليدية مع وجود الكادر الفني المدَرّب على تشغيل وصيانة مثل تلك الماكينات.