Remote Sensing Brief

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A Low-Cost Photo-Scale Protractor for Small Scale Photography

Construction is described, and equations and tables for using the Protractor are given.

ABSTRACT: *Photo-scale protractors are not generally available for use in interpretation of extremely small scale aerial photography. Standard comparator reticles were used to construct a photo-scale protractor for small-scale photography. Equations for use with programmable calculators are given so that the photo-scale protractor can be used for any photo scale. A table is presented for adapting the photo-scale protractor to nine scales ranging from 1:50,000 to 1:130,000.*

AERIAL PHOTOGRAPHY at scales of 1:50,000 and smaller is becoming widely available. Photography at these scales provides an excellent primary base for renewable resource data; however, measurements of distance and area are difficult on small-scale photography. Conventional photo-scale protractors do not provide the fineness needed nor are the translations or conversions close enough for the areas and distances measured.

To replace the conventional photo-scale protractor, we have adapted Finescale* comparator reticles as depicted in this note (Figure 1). These reticles are available through Ben Meadows Company at a cost of about $3.00 per pair. The reticle printed in black was found to be more visible on color photography while the white printing is easier to discern on black-and-white photography. For our use we have selected reticles labeled Azimuth and Bearing Circle, Holes-decimal inch sizes, Circles-decimal- and fractional-inch sizes, and a linear scale of 1/2-inch by 0.005-inch division. There are many other versions available including Circles-metric sizes and a linear scale of 15-mm by 0.1-mm division. We selected the decimal-inch size circles and holes because of the wider range of circle diameters available. There are 28 diameters available on the reticles we selected ranging from 0.001 to 0.125 inches as compared with 20 diameters ranging from 0.1 to 2.0 mm available on the metric size circle reticle.

We have mounted the reticles in a 2-mm-thick piece of Plexiglas. A rectangular (3.5 by 17 cm) piece was used, although other shapes would serve equally well. Holes of appropriate size (19 mm) were drilled with a sharp wood bit, the openings were smoothed, and the reticles were glued in place with clear epoxy. The completed device can then be easily used directly under any stereoscope with magnifications of 2× or more.

Equations for computing distances and areas, with the following reticles, are given below.

Reticle # 121—½-inch by 0.005-inch division
Reticle # 128—Holes-decimal-inch sizes
Reticle # 141—Circles-inch sizes

(1) Feet per inch, at scale, is calculated by dividing photo scale reciprocal by 12.

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PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 48, No. 6, June 1982, pp. 941-943.

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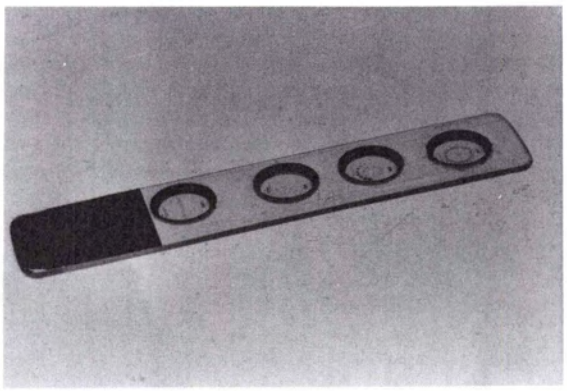

FIG. 1. Photo-scale protractor with four reticles ready for use under stereoscope.

Feet per inch is converted to feet per 0.005 inch by multiplying feet per inch by 0.005.

(2) Area in hectares, given circle diameter in inches at scale, can be calculated by

$$A = \frac{\pi}{107{,}656}\left(\frac{D}{2} \cdot F\right)^2$$

where A is area in hectares, D is circle diameter in inches, and F is feet per inch.

Area in acres, given circle diameter in inches at scale, can be calculated by replacing 107,656 (square feet per hectare) with 43,560 (square feet per acre) in Equation 2.

(3) Circle diameter in inches, given area in hectares at scale, can be calculated by

$$D = \frac{2}{F}\sqrt{\frac{107{,}656}{\pi} A}$$

where A is area in hectares, D is circle diameter in inches, and F is feet per inch.

Similarly, circle diameter in inches, given area in acres, can be calculated by replacing 107,656 with 43,560 in Equation 3.

The data in Table 1 are provided so that users may quickly apply this photo-scale protractor to nine different photo scales ranging from 1:50,000 to 1:130,000. These data allow users to derive the following information:

- area in hectares for each circle diameter found on the reticles;
- area in square metres, by multiplying the number of hectares by 10,000;
- approximate circle diameter for 1-hectare and 1-acre areas;
- feet per inch; and
- feet per 0.005 inch.

TABLE 1. SCALES, SIZES, AND CONVERSIONS FOR 17 PHOTO SCALES FROM 1:50,000 TO 1:130,000

Photo Scale Reciprocal	50,000	60,000	70,000	80,000	90,000	100,000	110,000	120,000	130,000
Feet Per Inch	4,166.	5,000.	5,833.	6,666.	7,500.	8,333.	9,116.	10,000.	10,833.
Feet Per 0.005 Inch	20.83	25.00	29.16	33.33	37.50	41.66	45.83	50.00	54.16
1 Ha. Circle Dia. In In.	0.088	0.074	0.063	0.055	0.049	0.044	0.040	0.037	0.034
1 Acre Circle Dia. 'In.'	0.056	0.047	0.040	0.035	0.031	0.028	0.025	0.023	0.021
		Photo Scale Reciprocal					Photo Scale Reciprocal		
	50,000	60,000	70,000	80,000	90,000	100,000	110,000	120,000	130,000
Circle Diameter In Inches			Hectares				Hectares		
0.001	0.00012	0.00018	0.00024	0.00032	0.00041	0.00050	0.00061	0.00072	0.00085
0.002	0.00050	0.00072	0.00099	0.00129	0.00164	0.00202	0.00245	0.00291	0.00342
0.003	0.00113	0.00164	0.00223	0.00291	0.00369	0.00455	0.00551	0.00656	0.00770
0.004	0.00202	0.00291	0.00397	0.00518	0.00656	0.00810	0.00980	0.01167	0.01369
0.005	0.00316	0.00455	0.00620	0.00810	0.01025	0.01266	0.01532	0.01823	0.02140
0.006	0.00455	0.00656	0.00893	0.01167	0.01477	0.01823	0.02206	0.02626	0.03082
0.007	0.00620	0.00893	0.01216	0.01588	0.02010	0.02482	0.03003	0.03574	0.04195
0.008	0.00810	0.01167	0.01588	0.02075	0.02626	0.03242	0.03923	0.04669	0.05479
0.009	0.01025	0.01477	0.02010	0.02626	0.03323	0.04103	0.04965	0.05909	0.06935
0.010	0.01266	0.01823	0.02482	0.03242	0.04103	0.05066	0.06130	0.07295	0.08562
0.015	0.02849	0.04103	0.05585	0.07295	0.09233	0.11399	0.13792	0.16414	0.19264
0.016	0.03242	0.04669	0.06355	0.08300	0.10505	0.12969	0.15693	0.18676	0.21918
0.020	0.05066	0.07295	0.09929	0.12969	0.16414	0.20265	0.24520	0.29181	0.34248
0.025	0.07916	0.11399	0.15515	0.20265	0.25648	0.31664	0.38313	0.45596	0.53512
0.030	0.11399	0.16414	0.22342	0.29181	0.36933	0.45596	0.55171	0.65658	0.77058
0.032	0.12969	0.18676	0.25420	0.33202	0.42021	0.51878	0.62773	0.74705	0.87675
0.035	0.15515	0.22342	0.30410	0.39719	0.50270	0.62061	0.75094	0.89369	1.04884
0.040	0.20265	0.29181	0.39719	0.51878	0.65658	0.81060	0.98083	1.16727	1.36992
0.045	0.25648	0.36933	0.50270	0.65658	0.83099	1.02592	1.24136	1.47732	1.73380
0.047	0.27978	0.40289	0.54837	0.71625	0.90650	1.11914	1.35416	1.61156	1.89134
0.050	0.31664	0.45596	0.62061	0.81060	1.02592	1.26656	1.53254	1.82386	2.14050
0.053	0.50270	0.72389	0.98529	1.28691	1.62875	2.01080	2.43307	2.89556	3.39826
0.070	0.62061	0.8 369	1.21641	1.58878	2.01080	2.48247	3.00379	3.57476	4.19538
0.078	0.77058	1.10963	1.51033	1.97268	2.49668	3.08232	3.72961	4.43854	5.20912
0.094	1.11914	1.61156	2.19351	2.86500	3.62601	4.47656	5.41664	6.44625	7.56539
0.100	1.26656	1.82386	2.48247	3.24241	4.10368	5.06627	6.13019	7.29544	8.56201
0.109	1.50481	2.16692	2.94943	3.85231	4.87558	6.01924	7.28328	8.66771	10.17252
0.125	1.97901	2.84978	3.87887	5.06627	6.41201	7.91606	9.57843	11.39912	13.37814

The following warnings should be noted in the use of such a device:

(1) The measurements made with this device can only be accurate relative to the scale of the portion of the photograph being measured;
(2) Error in linear measurements will be the same as the error in photo scale while error in area measurements will be a function of the square of the error in photo scale;
(3) When the shape of the area being measured does not conform to a shape depicted on the reticles, the reticles can only be used as a reference; and
(4) In areas of great topographic relief, relatively large errors in measurement may occur which are unrelated to scale due to the monocular nature of this photo aid.

(Received 16 May 1981; revised and accepted 27 December 1981)

International Symposium on Land Information at the Local Level

University of Maine at Orono
9–13 August 1982

This Symposium—sponsored by the Land Information Institute, the Institute for Modernization of Land Data Systems, and the University of Maine at Orono, and cosponsored by some seven national and international professional organizations, including the American Society of Photogrammetry—will include sessions on

- Political and Governmental Realities at the Local Level and the Land Information Process
- Needs
- International Perspectives
- System Development
- Technology

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National Conference on Energy Resource Management

The Baltimore Hilton Hotel, Baltimore, Maryland
9–12 September 1982

The theme of this Conference, jointly sponsored by the American Planning Association's Energy Planning Division and the Eastern Regional Remote Sensing Application Center of NASA's Goddard Space Flight Center, is the integration of remotely sensed data with geographic information systems for application in energy resource management.

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