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# Progress in the Specification and Analysis of Image Quality*

## Rapid developments in sensor system technology, different measures of performance, and the requirement to relate image quality to photogrammetric tasks are discussed in relation to ISP activities.

### INTRODUCTION

Within commission i of the International Society for Photogrammetry, the Working Group on Optical and Modulation Transfer Functions (OTF/MTF) has been concerned with the application of these measures of performance to photogrammetric problems (Norton, 1975). For example, both OTF's and MTF's are used extensively in the design and analysis of imaging systems, and one of the primary concerns of the Working Group has been to document standards for OTF/MTF measurement procedures so as to insure comparability of results between laboratories testing wide-angle photogrammetric camera lenses. These problems are considered in further detail by Norton, Brock, and Welch (1977), and by Martin (1976), Rosenbruch (1976), and Tiziani (1977).

The procedures by which operational system performance can be evaluated without resorting to direct resolution tests also have been of interest to the Working Group. Photogrammetrists and earth scientists use image quality criteria to judge the potential applications of remote sensor data, and methods are required for the reliable prediction and measurement of operational system performance. These considerations led the previous Working Group to recommend the

*Abstract: In the four years since the XII Congress for Photogrammetry OTF/MTF procedures have been successfully demonstrated for the evaluation of photographic and electro-optical sensor system performance, and "Guidelines for Measuring Camera System MTF's" have been prepared. The reliability of predicted and measured photographic system MTF's is influenced by variations in component MTF's, non-linearity of the photographic process, target fidelity, and microdensitometer parameters. Generally, however, predicted MTF's have been found to correspond to within 10 to 15 percent of measured values, and this is adequate for system evaluation purposes. Specifications of performance for the current and planned Landsat sensors are considered in terms of MTF, IFOV, and EIFOV and are compared to Skylab photographic systems. Based on these analyses, it appears that the 30 m IFOV planned for the Thematic Mapper of the Landsat Follow-On program will result in images of comparable quality to those recorded by the Skylab S-190A MPF. Because of rapid developments in sensor system technology, the different measures of performance, and the requirement to relate image quality to photogrammetric tasks, the formation of an Image Quality Working Group is recommended.*

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continuation of investigations of MTF analysis techniques, with particular emphasis on edge gradient analysis (EGA) (De Belder, Jones, Sorem, and Welander, 1972). Interest also was expressed in the standardization of MTF analysis procedures and the establishment of tolerances for precision and accuracy.

As a consequence of these recommendations, "Guidelines for Measuring Camera System MTF's" (Table 1) were developed and incorporated in the current report (Norton *et al.,* 1977). These guidelines are intended as a procedural framework rather than as standards, and are based on analyses of aircraft and satellite images conducted by several investigators. The philosophical and technical implications of MTF analysis techniques as related to the prediction and measurement of photographic and electro-optical system performance are considered in this report. A recommendation concerning the future activities of the OTF/MTF Working Group also is presented.

## PHOTOGRAPHIC SYSTEMS

The image recorded by a photographic system is degraded by the lens, film, image motion, atmosphere, and reproduction process, and for theoretically correct assessments all of these factors nust be taken into account. In practice, however, the lens, film, and image motion control the quality of first-generation aerial photographs recorded by a photogrammetric camera system. An MTF (which illustrates the reduction in contrast that occurs as a function of spatial frequency ($\nu$) when a sinusoidal target is recorded by an imaging system) can be computed for each of these components and a total system MTF can be predicted with the following equation:

$$\underset{\text{system}}{\text{MTF}\,(\nu)} = \underset{\text{lens}}{\text{MTF}\,(\nu)} \times \underset{\text{film}}{\text{MTF}\,(\nu)} \times \underset{\text{image motion}}{\text{MTF}\,(\nu)}$$

where $\nu$ is the spatial frequency in cycles/mm.

This well-known cascade process is illustrated in Figure 1 for a typical photogrammetric camera system. Correspondingly, system MTF's can be derived from microdensitometer traces of targets recorded on operational imagery, and these measured MTF's can be compared to the predicted values to assess operational system performance. Because photogrammetrists and photointerpreters normally prefer to evaluate system performance in terms of resolving power, several techniques have been derived for determining resolution values from MTF's (Charman, 1975; Artishevskii and Chalova, 1976; Brock, 1976). Some principal methods for the prediction and measurement of system performance are summarized in Table 2.

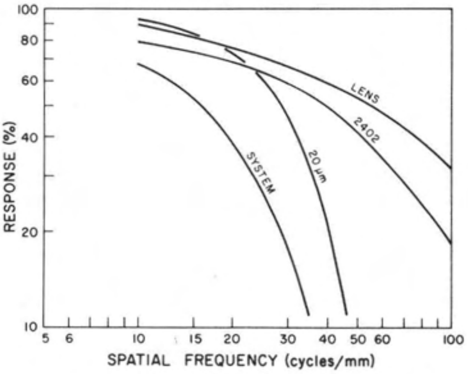

FIG. 1. Lens, film, image motion, and total system MTF's for a photogrammetric camera system.

Of the techniques listed in Table 2, methods 2 and 3 are frequently used to assess photographic system performance. However, as with resolution, objections are occasionally raised concerning the reliability of MTF analyses, particularly with respect to:

- Errors or variations in the MTF's of lenses and films due to non-standardized measurement techniques and variable development conditions.
- Non-linearity of the photographic process,
- Target fidelity, and
- Degradations introduced by the microdensitometer and film granularity.

In the following paragraphs these factors are considered in relation to practical photogrammetric camera system performance evaluation.

### ERRORS OR VARIATIONS IN COMPONENT MTF'S

The shaded area in Figure 2 represents the range of on-axis MTF's for the lens systems of two Wild RC 8's (Universal Aviogon), a Zeiss RMK AR 15/23 (Pleogon AR), and a Zeiss RMK A 30/23 (Topar A) as measured by Rosenbruch (1976), Martin (1976), and Welch and Halliday (1973) using different techniques. The extreme variations in the measured lens MTF's range from about 10 percent response at 10 cy/mm to 20 percent at 100 cy/mm. Variations of this magnitude are reduced to an insignificant level when the lens MTF's are cascaded with

TABLE 1. GUIDELINES FOR MEASURING CAMERA SYSTEM MTF'S

Standard procedures for measuring camera system[1] performance in terms of modulation transfer functions (MTF's) should yield results which are representative of camera system capabilities under both laboratory and operational conditions. In conducting such evaluations the following minimal conditions should be considered:

a. *Target.* Edge (natural or man-made), bar, sinusoidal or line targets may be employed, providing the contrast ratio between the target and background is recorded on the straight-line portion of the film D-log E curve. Contrast ratios of 3:1 to 6:1 are appropriate, with a low-light reflectance of approximately 10 percent recommended. Spatial frequencies for bar and sinusoidal targets should range from approximately 2 to 60 cycles/mm in sufficient increments to provide adequate data points to define the MTF curve. Edge targets should have a minimum image size which is several times larger than both the effective slit of the microdensitometer and the spread function of the photogrammetric camera system. Typical widths of photogrammetric camera system spread functions vary from 30 to 100 $\mu$m depending on the film employed.

b. *Sensitometry.* All evaluations should be conducted using the *original* film. Sensitometric data for the developed film should be obtainable from density measurements of a step tablet impressed on the film via a sensitometer prior to development.

c. *Microdensitometry.* Microdensitometer parameters should be selected to avoid effects of coherence, noise and instrumental degradation of the system MTF. Typically, numerical apertures of the condensing objective should be equal to or larger than that of the enlarging objective. Effective slit sizes of 1 by 80 $\mu$m to 3 by 500 $\mu$m are recommended, with the smaller slits reserved for use with fine-grain, high definition imagery.

d. *Data Reduction.* Reduction techniques involving the use of a computer are recommended, although close attention must be given to insure that the computational procedures yield consistent and reliable results.

e. *Final Results.* Reports should include: date of photography, camera system and photographic parameters, processing procedures, analysis techniques/equipment, format location/orientation of target, methods of data reduction, and plots of modulation versus spatial frequency.

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[1] Camera system is taken to include camera-filter-film combination.

other component MTF's such as that for 20 $\mu$m of image motion (Figure 3), indicating that variations in individual system components must be rather large before their effects on image quality will be noticed. For example, the range of predicted system resolution values (as determined by method 3a in Table 2) due to the variation in lens MTF's is 36 to 41 lpr/mm and 41 to 47 lpr/mm for 1.6:1 and 2:1 contrast targets recorded under static laboratory conditions on EK 2402 film (Figure 2), and 28 to 30 and 30 to 33 lpr/mm when 20 $\mu$m of image motion is introduced (Figure 3).

In actual tests of Wild RC8 and Zeiss RMK A 30/23 cameras loaded with EK 2402 film, laboratory resolution values for a 2:1 contrast target averaged 41 lpr/mm and operational values for a 1.8:1 target contrast (at the camera lens) averaged 27 lpr/mm, confirming the predicted estimates (Welch and Halliday, 1973). It is évident from this example that

FIG. 2. Shaded area represents the range of Wild and Zeiss camera lens MTF's recorded by various investigators. Also shown is an MTF for 20 $\mu$m of image motion and TM curves for EK 2402 film adjusted for different target contrasts.

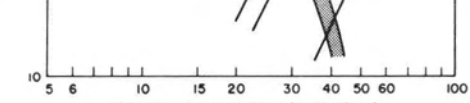

FIG. 3. The range (shaded area) is reduced when the lens MTF's are cascaded with that for 20 $\mu$m of image motion. TM curves are for EK 2402 film.

reasonable variations in lens (or film) MTF's (e.g., ±10 percent) are unlikely to significantly affect system performance as judged by MTF, resolution, or overall image interpretability.

### NON-LINEARITY OF THE PHOTOGRAPHIC PROCESS

The non-linearities of the photographic process introduced by the film D-log E curve and adjacency effects were discussed by De Belder, Jones, Sorem, and Welander (1972) and remain of concern. However, non-linearity problems can be minimized by selecting targets that are recorded on the straight-line portion of the D-log E curve and produce a $\Delta D$ of approximately 0.4 to 1.0 (Figure 4a). The situations in Figure 4b and 4c, representing targets recorded on the toe and shoulder of the D-log E curve, should be avoided. If MTF's must be derived from second-generation images (as in the case of Skylab), extreme target density values should lie on the linear portions of the D-log E curves of both first-and second-generation products. Assuming that targets are recorded on the straight-line segment of the D-log E curve, the film $\gamma$ can be used to numerically compute the exposure values required for MTF calculations, thus avoiding time consuming point-by-point interpolations from the D-log E curve.

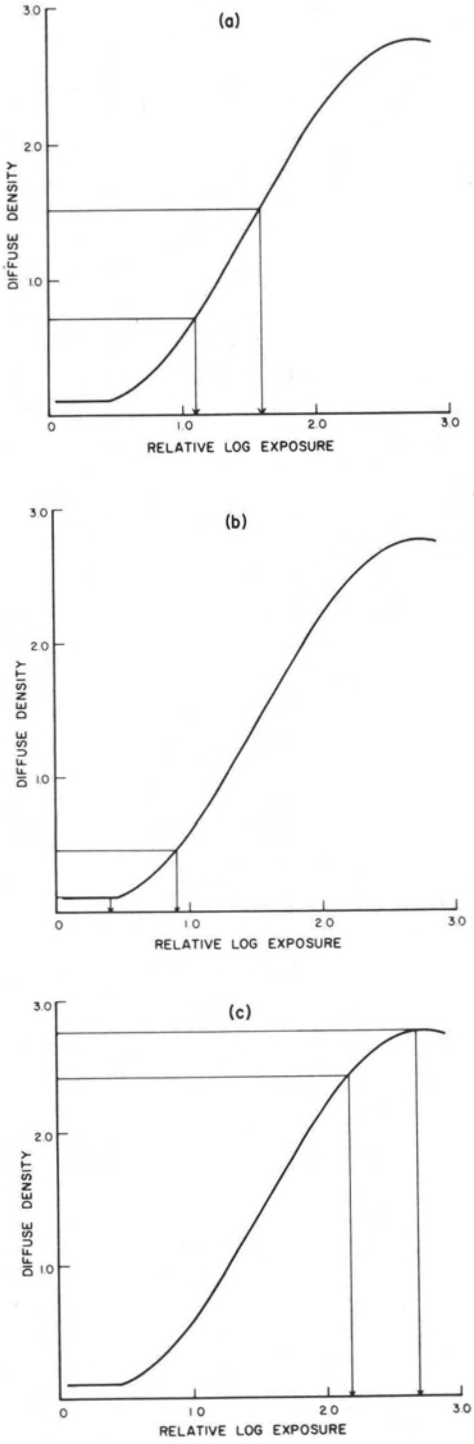

FIG. 4. Non-linearity problems associated with the determination of system MTF's may be minimized by assuring that the target is recorded on the straight line portion of the D-log E curve as in Figure 4a. Avoid using targets recorded on the toe and shoulder as in Figures 4b and 4c.

### TARGET FIDELITY

Most operational system performance evaluations are based on measurements of imaged edges (method 2a in Table 2), and the size and sharpness of these edge targets is of critical importance. Size requirements for imaged edge targets are determined primarily by the width of the system spread function, which for most photogrammetric camera systems varies from 30 to 100 $\mu$m, with 40 to 60 $\mu$m representative of on-axis conditions for Wild or Zeiss Cameras employed with a typical mapping film. For an image recorded by a sensor system with a 40 to 60 $\mu$m spread function a pattern of adjacent light and dark squares each having an image dimension of approximately 200 by 200 $\mu$m is the minimum acceptable target size. Obviously, larger targets will reduce errors in slit alignment and permit multiple scans from different sections of the edge to be taken and averaged. At relatively large scales (e.g., >1:50,000) typical edge targets are found among the geometric constructions of man, whereas at very small scales (e.g., ~1:3,000,000 of Landsat and Skylab S-190A Multispectral Photographic Facility

TABLE 2. PRINCIPAL METHODS OF SYSTEM PERFORMANCE EVALUATION.

| Prediction | Measurement | Comments |
|---|---|---|
| 1. Resolution (R)<br>$\frac{1}{R_{sys}} = \frac{1}{R_{lens}} + \frac{1}{R_{film}} + \ldots$ | 1. a. Resolution, read from imaged targets in lpr/mm | 1. a. Resolution values easily and rapidly determined from images to within ±15%. Target contrast is critical. |
| | b. Visual Edge Matching (VEM) | b. Image edge matched to a calibrated edge of similar sharpness and contrast to determine resolution. Expensive microscope and appropriate edge matrices are required (Itek). |
| | c. Edge Spacing | c. Image edge fitted to the space between the elements of a high-contrast resolution target reticle installed in a microscope. Equipment expense relatively low. USAF technique. |
| 2. $\mathrm{MTF}(\nu)_{sys} = \mathrm{MTF}(\nu)_{lens} \times \mathrm{MTF}(\nu)_{film} \times \ldots$ | 2. a. Microdensitometer measurements of edge (EGA) or line (LSF) targets. | 2. a. No special man-made targets required. Complex analysis procedures. |
| | b. Mathematical operation on microdensitometer measurements of same terrain area recorded by small and large scale aircraft and/or satellite images (SMA). | b. Imagery for the same time period at small and large scales, and digital microdensitometer are required. Involves complex computer routines. |
| 3. System resolution from MTF<br>a. Spatial frequency at the intersection of MTF and film TM curves. | 3. a. Application of % difference in spatial frequency between predicted and measured MTF's at a specified threshold modulation level to resolution values determined from laboratory tests. | 3. Useful methods of determining system resolution from MTF's. |
| b. Spatial frequency corresponding to a pre-determined theshold response point on the predicted system MTF. | b. Spatial frequency corresponding to a known threshold modulation. | |
| 4. EIFOV<br>Width of a half-cycle at the spatial frequency corresponding to 50 percent response on the system MTF. | 4. Width of a half-cycle at the spatial frequency corresponding to 50 percent response on the *measured* system MTF. | 4. Recently introduced for comparing electro-optical systems on a uniform basis. |

(MPF) images) reduced ground resolutions of 60 to 250 m permit the use of field boundaries and shorelines. For the analysis of satellite images with ground resolutions of 15 to 30 m for low-contrast targets (as produced by the Skylab S-190B Earth Terrain Camera (ETC) ) the edges formed by large airfield runway patterns provide suitable targets.

The fidelity of a target recorded by a wide-angle photogrammetric camera system is also influenced by target orientation and format position. For example, edges oriented perpendicular to the flight direction will be degraded by image motion and those in the corners modified by lens aberrations. These problems may be taken into account by noting the orientation of the edge with respect to the flight line and selecting edges within approximately 10 degrees of the optical axis. Unless an obvious flaw in the imagery is apparent upon visual examination, analyses of targets near the center of the format will indicate whether or not satisfactory system performance has been obtained.

Although techniques relying on edge measurements are excellent for analyzing operational imagery, the search for suitable targets can be an exceedingly frustrating task. Consequently, a record should be kept of the geographic location, size, and contrast of edge targets selected for evaluation purposes. A filing system can simplify the task of analyzing repeat or cyclic missions.

### DEGRADATIONS INTRODUCED BY THE MICRODENSITOMETER AND FILM GRANULARITY

Slit size is perhaps the most important parameter governing microdensitometer performance. For photogrammetric photography with maximum spatial frequencies of 50 to 60 cy/mm, slits of 2 by 200 μm or 3 by 200 μm can be used without introducing noticeable degradations into the system. These apertures minimize the troublesome problems of false or erratic response due to coherence and film granularity without resorting to digital smoothing functions, and are significantly larger than the approximate 1 by 80 μm slit frequently used with fine-grained, high-resolution images (Gliatti, 1976; Gerencser, 1976). The relationship between the microdensitometer MTF for various slit widths (based on $(\sin x)/x$ functions) and the MTF of a typical photogrammetric system is shown in Figure 5. Even for a 3 μm slit width, microdensitometer response is better than 90 percent at the spatial frequency limit of the camera system.

### PHOTOGRAPHIC SYSTEM PERFORMANCE

It is apparent from the preceding discussion that the evaluation of system performance based on MTF's requires a skilled analyst with considerable knowledge of the photographic process and of the factors governing image quality. In fact, a high degree of subjectivity is involved in selecting edges and conducting measurements from which the MTF's are determined objectively. Because of the complexities involved in MTF analyses, they are sometimes regarded with suspicion (Corbett, 1974). It would appear, however, that MTF procedures should be judged on the basis of results obtained in recent applications (Welch and Halliday, 1973; Welch, 1974b; Gerencser, 1976; Gliatti, 1976; Hakkarainen, 1976; Welch, 1976), of which a few examples based on the author's experience with aircraft and satellite photography are summarized in the following paragraphs.

In an extensive series of tests of photogrammetric camera systems good correspondence was obtained between predicted and measured square-wave transfer functions (Figure 6). The standard deviations of the *measured* transfer functions averaged about ±10 percent in response, which is the threshold for noticeable differences in image quality (Welch and Halliday, 1973).

The steps in the calculation of measured MTF's for the various S-190A MPF Skylab camera/film/duplicating film combinations using the EGA technique are illustrated in Figure 7. These measured MTF's correspond to within 6 percent of predicted curves obtained by cascading the MTF of the lens with those of the appropriate films and duplicating films, confirming that S-190A system performance was about as expected (Welch, 1974b).

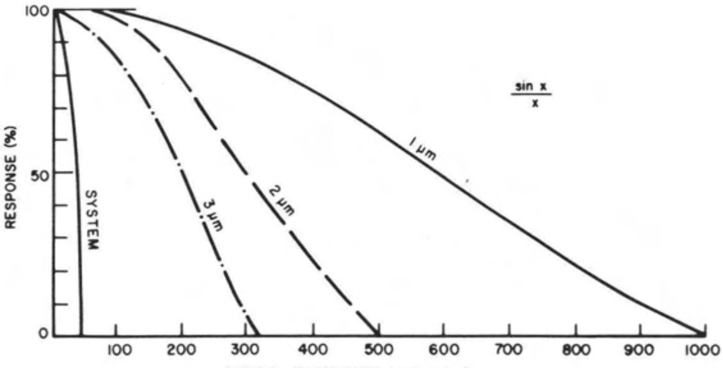

FIG. 5. $(\sin x)/x$ functions for microdensitometer slit widths of 1, 2, and 3 μm compared to the MTF of a photogrammetric camera system.

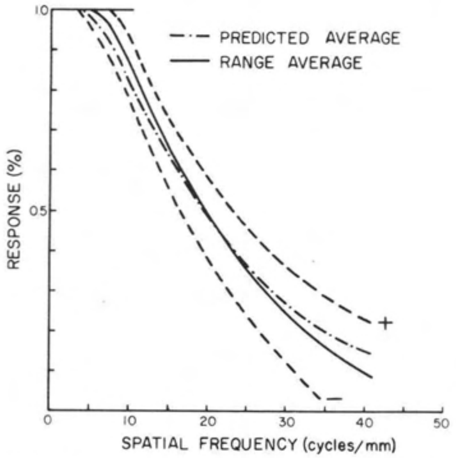

FIG. 6. Range average (measured) and predicted average square-wave transfer functions for photogrammetric camera systems. Standard deviation from the range average is indicated by the dashed lines.

A procedure similar to that employed for the S-190A system evaluations also was utilized to assess Skylab S-190B ETC system performance (Figure 8). Component MTF's were cascaded to produce predicted curves, and measured MTF's were developed from the edge traces of airfield runway patterns. With the exception of the SO-242/2447 film-duplicating film combination, the predicted and measured values correspond to within 10 percent (Welch, 1976).

The agreements between predicted and measured MTF's in these and other applications confirm that MTF analysis techniques are appropriate for evaluating operational camera system performance (Welch and Halliday, 1975; Welch, 1975). Resolution estimates developed from these MTF's using the procedures indicated in Table 2 have been equally reliable.

### ELECTRO-OPTICAL SYSTEMS

The introduction of satellites for remote sensing tasks in the early 1970's led to the requirement for obtaining imagery of vast areas over extended periods of time. A traditional camera system obviously was unsuited for this purpose because of limited film supply and the need to recover and process the data on a timely basis. As a consequence, electro-optical systems employing various mixes of lenses, mirrors, detectors, and tape recorders were developed. Well-known examples of such systems include the return-beam vidicons (RBV's) and

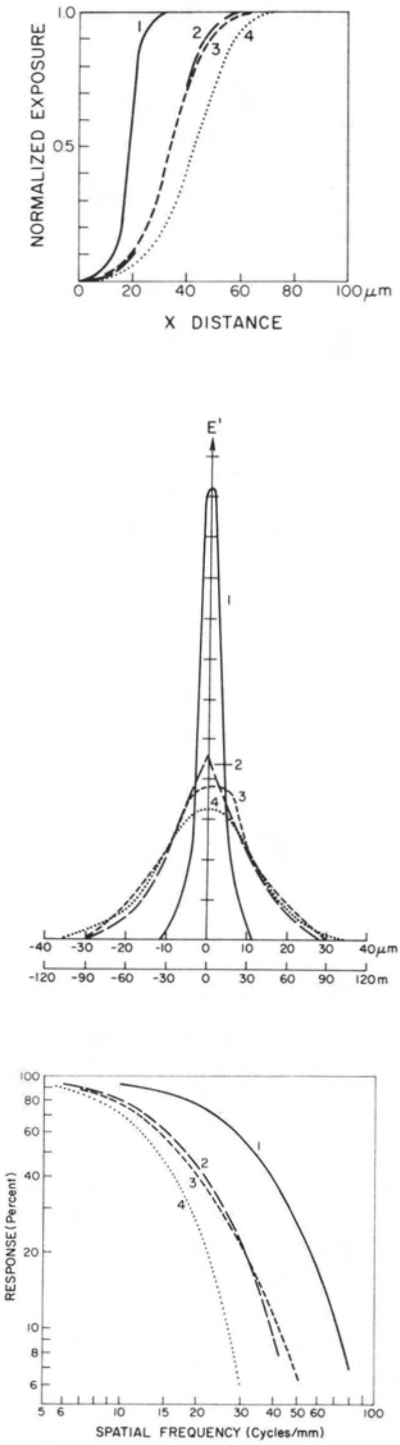

FIG. 7. Edge traces (top), spread functions (middle), and measured MTF's (bottom) for panchromatic (1), color (2), b & w infrared (3), and color infrared (4) second-generation S-190A MPF photographs.

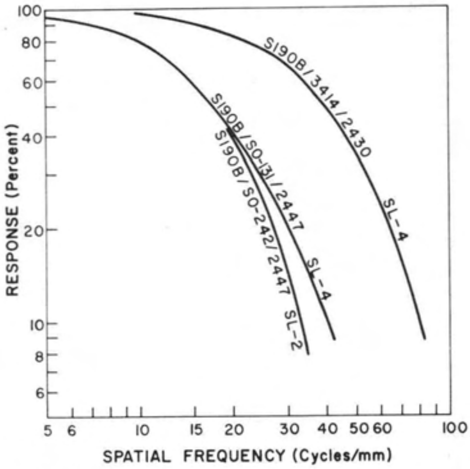

FIG. 8. Measured MTF's for second-generation Skylab ETC photographs (camera/original film/duplicating film).

multispectral scanners (MSS) of Landsats-1, -2, and -C (1977) and the conical scanner of Skylab (NASA, 1976). Other types of electro-optical systems being considered for earth survey applications include an improved multispectral scanner (the Thematic Mapper) for the Landsat Follow-On (formerly EOS/Landsat-D), and camera systems in which arrays of photodiodes or charge-coupled devices (CCD's) replace film in the image plane (Slater, 1974; 1975a; Bisbee, 1975).

Two parameters which are commonly used to define the performance goals of electro-optical systems are the radiometric and spatial resolution. Radiometric resolution is expressed as noise equivalent signal (NES) and is the aperture radiance that gives a signal-to-noise ratio of unity. The factors governing the radiometric resolution of electro-optical sensor systems are considered in detail by Slater (1974).

Spatial resolution for electro-optical systems is defined by NASA in terms of instantaneous field-of-view (IFOV) or effective instantaneous field-of-view (EIFOV). IFOV relates to the earth area subtended by a sensor detector from a nominal altitude and is generally specified in milliradians or the equivalent ground dimension. If referred to an MTF, the IFOV corresponds to the cutoff spatial frequency, $\nu_c$ (Figure 9).

EIFOV, by contrast, is taken as the equivalent ground width of a *half cycle* at the spa-

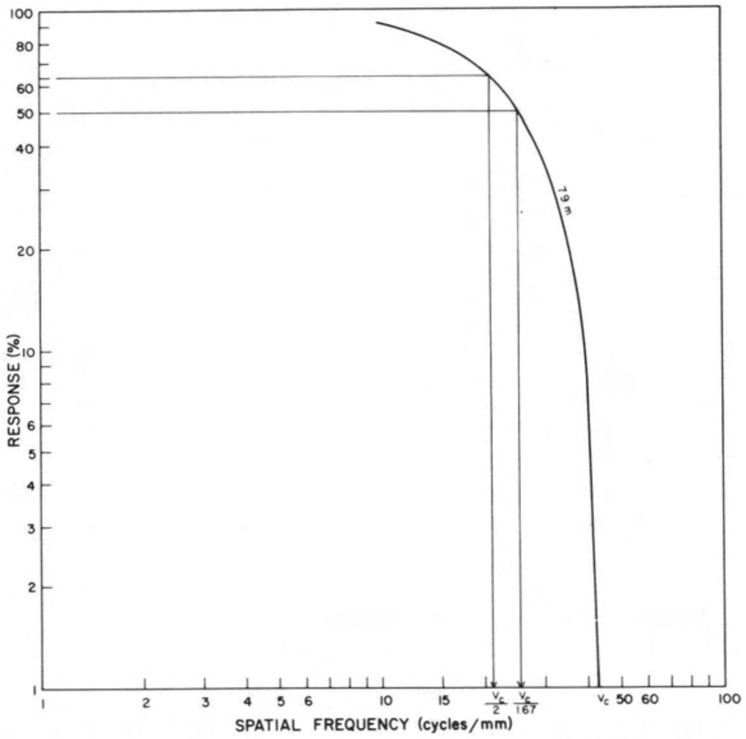

FIG. 9. MTF for the Landsat MSS detector (79 m), with frequencies corresponding to cutoff ($\nu_c$), EIFOV ($\nu_c/1.67$), and $\nu_c/2$ noted for a 70 mm image format.

tial frequency defined by the 50 percent modulation point on the system MTF (NASA, 1973). As with photographic systems, the total MTF is the cascade of the component MTF's, i.e.,

$$\underset{\text{sys}}{\text{MTF}\ (\nu)} = \underset{\text{optics}}{\text{MTF}\ (\nu)} \times \underset{\text{detector}}{\text{MTF}\ (\nu)} \times \underset{\text{image smear}}{\text{MTF}\ (\nu)}$$

For the systems being discussed detector size limits performance (as does the film in many photogrammetric camera systems), and the MTF for a square detector is given by a sinc function. In Figure 9, the MTF for the Landsat MSS detectors which have IFOV's of 79 by 79 m is plotted for the 70 mm image format scale of 1:3,369,000. The cutoff spatial frequency, $\nu_c$, is 42.6 cy/mm, whereas the spatial frequency for 50 percent modulation occurs at $\nu_c/1.67$. Thus, the MSS EIFOV corresponds to a spatial frequency of 25.5 lpr/mm, or a ground dimension of 66 m (i.e., 1/51 mm × 3,369,000). By comparison, the half-cycle for a ground dimension of 79 m (IFOV) occurs at a spatial frequency of $\nu_c/2 = 21.3$ cy/mm, which has a modulation of 64 percent. The EIFOV concept is based on the assumption that other system components will degrade the detector MTF to approximately 50 percent response at the spatial frequency equivalent to $\nu_c/2$. The 16 percent difference in the ground dimensions of the IFOV (79 m) and the detector EIFOV (66 m) is relatively insignificant. For example, referring to Figure 10, a detector MTF approximates the MSS system MTF obtained from analyses of band 5 images using EGA, line-spread function (LSF), and scale matching analysis (SMA) techniques. Thus, the detector MTF can be employed to approximate system performance (Welch, 1974a; Schowengerdt, Antos, and Slater, 1974; Schowengerdt, 1976).

Although somewhat simplified, these measures of performance can be used to evaluate planned earth satellite sensor systems. For example, Landsat-C, scheduled for 1977, will employ an MSS and two RBV's similar to those of Landsat-1 and -2. However, a thermal channel (10.4 to 12.6 μm) with an IFOV equivalent to 238 m will be added as a 5th band for the MSS; and the focal length of the RBV's (both operating in the 0.5-0.75 μm spectral band) will be increased from 125 mm to 236 mm. The Landsat Follow-On mission (~1980) will include an improved multispectral scanner, the Thematic Mapper, operating in five discrete spectral bands from 0.45 to 1.75 μm, plus a sixth thermal infrared band of 10.4 to 12.5 μm. IFOV's of 30 m are planned for bands 1 to 5 and 120 m for band 6.

These planned systems may be compared with those of Landsat-1 and -2 using the EIFOV concept. Referring to Figure 11, MTF's have been calculated for detectors with IFOV's of 238, 120, 79, and 30 m respectively and the corresponding spatial frequencies for the 50 percent modulation point noted as 8, 17, 26, and 66 cy/mm for an image scale of 1:3,369,000 (70 mm format). If visual interpretability is assumed to increase logarithmically with linear increases in image resolution (as with photographic systems), an approximate 40 percent gain in image interpretability will be realized by improving the IFOV by factors of 2 to 3. Although these calculations are approximate, they do provide a basis for estimating the potential applications of the Landsat data.

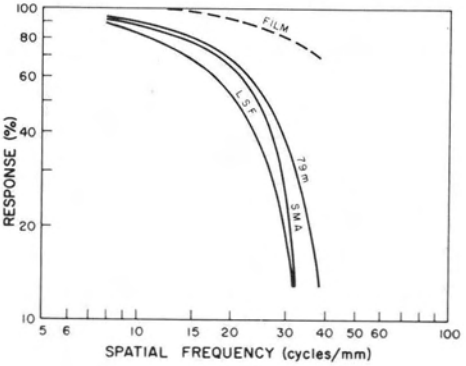

FIG. 10. MSS detector MTF compared to measured band 5 image MTF's determined by scale matching (SMA) and line-spread function (LSF) analyses (Schowengerdt, Antos, and Salter, 1974).

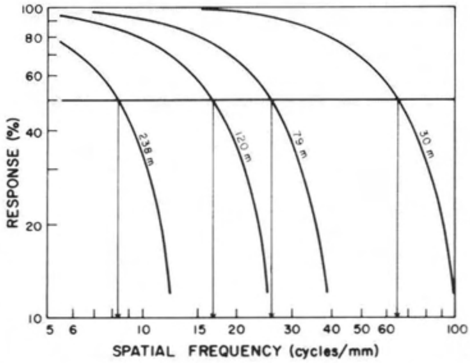

FIG. 11. Detector MTF's corresponding to IFOV's of 30, 79, 120, and 238 m. Spatial frequencies for equivalent EIFOV's are noted.

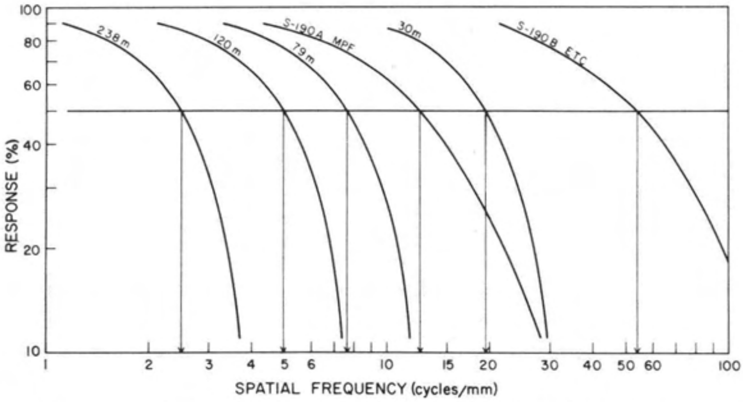

FIG. 12. MTF's for earth satellite sensor systems adjusted to an image scale of 1:1,000,000.

A similar approach can be utilized to compare the various Landsat sensors with the photographic systems employed on Skylab. In Figure 12, for example, MTF's for the Landsat and high-resolution black-and-white Skylab sensor systems have been adjusted to the 1:1,000,000 image scale planned for future first-generation Landsat products (NASA, 1976). Based on these MTF's, the images provided by the 30 m IFOV of the Thematic Mapper will be of slightly higher quality than equivalent scale second-generation products from the S-190A MPF.

MTF's also have been employed by Slater (1975b) to compare two hypothetical earth satellite systems with equivalent EIFOV's: a photographic system providing analog imagery and an electro-optical system in which a solid state array of CCD's replaces the film and provides digital output. This study demonstrates the ground resolution advantages of the photographic system and its superiority for cartographic tasks requiring the visual examination and mensuration of imaged objects. The electro-optical system, however, has a better signal-to-noise ratio, resulting in improved discrimination of small spectral reflectance differences. Consequently, the electro-optical system is recommended for remote sensing applications in the earth sciences, whereas the photographic system is preferred for cartographic tasks.

## CONCLUSION

In the four years since the XII Congress for Photogrammetry, the utilization of OTF/MTF in the design and evaluation of photographic and electro-optical remote sensor systems has increased significantly despite the requirements for complex instrumentation and analysis procedures. For photogrammetric tasks, however, these (and other) measures of system performance must be translated into measures of quality which relate to the interpretability and measurability of image detail. Today, this problem is magnified by the fact that photogrammetrists are receiving image data recorded in analog and digital formats by diverse photographic and electro-optical systems. Scales vary considerably, as do the measures of performance and quality. The term "resolution," for example, may refer to lpr/mm, TV lines, IFOV, EIFOV, metres/bar, metres/lpr, etc., depending on the system being discussed and the reference background of the discussant. Consequently, it appears appropriate to recommend that the OTF/MTF Working Group be expanded to an Image Quality Working Group. Investigations of measures of system performance and image quality, and their relationships to photogrammetric problems could be the assigned tasks of this proposed working group.

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