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WHICH CALIBRATION-PULSE LOCATION METHOD IS ROBUST?

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I. ABSTRACT

The Threshold method, with high threshold and contiguous-block parameter values, was found to be a robust method of locating calibration pulses in the presence of light-leak and shutter-edge pulses within the calibration window. Tests used digitized calibration-window background and light-pulse data from the Landsat-5 Thematic Mapper (TM) instrument, analysed by special software on an Apple II+ personal computer and on a VAX 11/780 minicomputer.

II. INTRODUCTION

In any scanner system characterized by multiple sensor elements, precise within-band calibration is necessary for the production of images useful for operational applications. Such instruments are the present NASA-NOAA Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) or the future SPOT High Resolution Visible (HRV) imaging instruments and the NASA Multiple Linear Array (MLA).

One reason that the relative radiometric calibration of the Landsat TM instruments exceeds expectations (Engel & Weinstein, 1983; Salomonson & Mannheimer, 1983; Barker & Gunther, 1983; Anuta et al., 1983; Haas & Waltz, 1983; DeGloria, Benson & Colwell, 1983) is the system design for an onboard internal calibration (IC) system. Light from IC reference lamps, presented to the sensing elements by light pipes mounted on the back of a shutter (Engel & Weinstein, 1983; Engel, 1984), produce digitized background and calibration pulses that are recorded at the end of each scan line. The pulses are used on the ground in digital-image preprocessing to provide radiometric corrections (Barker & Gunther, 1983), resulting in high-quality images.

The ground processing locates the calibration light pulse within the calibration window (Barker & Gunther, 1983; Irons, 1984) of the telemetry data stream, identifies the lamp state, integrates the pulse within specified limits, and averages pulse-integration values over multiple scans for each lamp state (Barker et al., 1984).

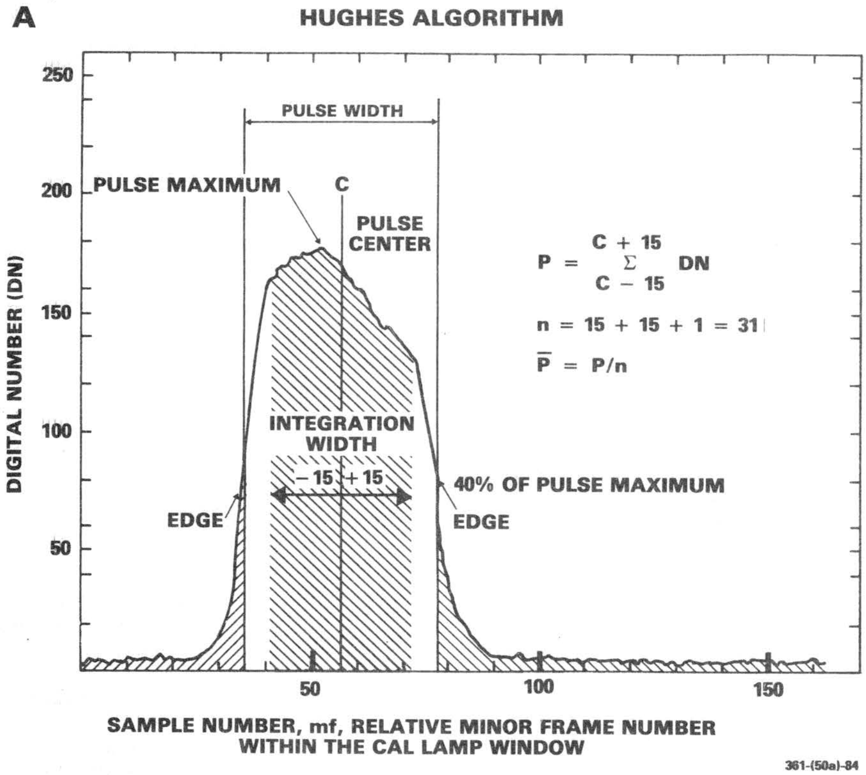
Early studies comparing three pulse-finding algorithms (i.e., Hughes, Difference of Averages, and Threshold) found that they all properly located the calibration pulse; they found the same pulse center +/- 1 pixel. New studies were started because of the detection of light-leak pulses within the calibration window for the Landsat-5 TM flight instrument (Gunther, 1984; Abrams, 1984).

This paper summarizes the results of studies using simulation methods to determine which pulse location method was robust, i.e., yielded correct pulse location information. A more detailed report is found in Gunther (1984).

III. METHODS

Two pulse-location methods were investigated in this study (Figure 1). The Hughes method was used by the SCROUNGE ground processing system for early Landsat -4 TM images. The Threshold method is being used by the TM Image Processing System (TIPS) for both Landsat -4 and -5 TM images (Salomonson & Mannheimer, 1983; Barker & Gunther, 1983).

The two methods differ in how they determine the edge locations of the pulse, and therefore the pulse width and center (Gunther, 1984). The Hughes method searches outward from a maximum value to find edge values that are a certain percentage of the maximum (Barker & Gunther, 1983). The Threshold method



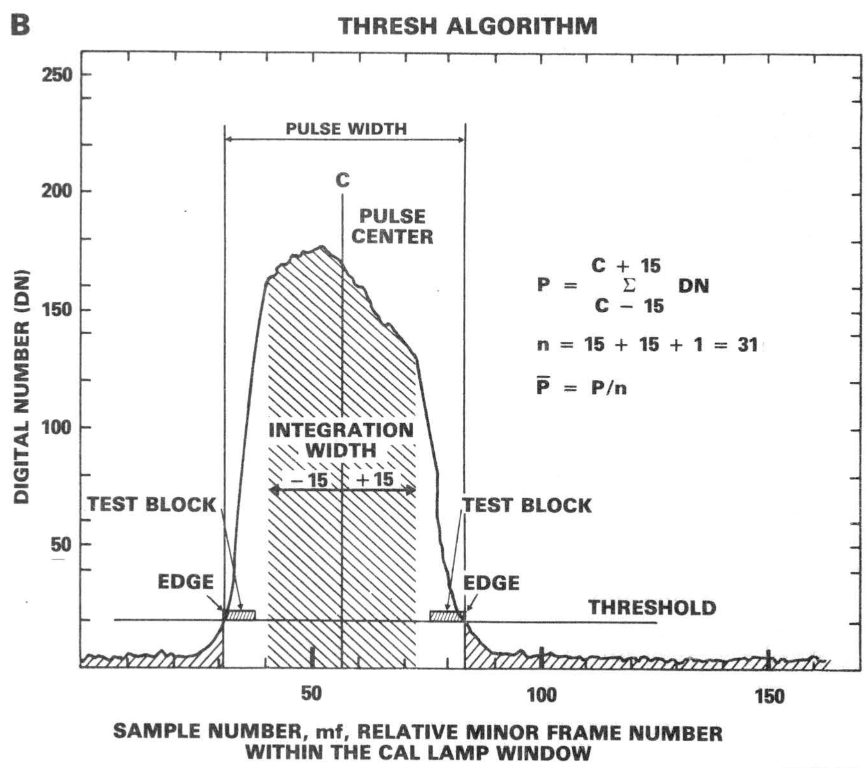


Figure 1. A comparison of methods for locating and integrating calibration lamp light pulses (after Gunther, 1984).

searches inward from the edges of the calibration window to find a block of contiguous pixel values all above a particular lower limit (threshold), at leading and trailing edges of the calibration pulse.

Computer programs incorporating the two methods were run on Apple-II+ and VAX 11/780 computers. The TM Radiative and Algorithmic Performance Program (TRAPP), running on a VAX 11/780 under the Virtual Memory System (VMS) operating system and the Transportable Applications Executive (TAE), reads calibration pulse data written onto 9-track computer compatible tapes (CCTs). TRAPP examines TM image data line by line and provides calibration statistics for all eight lamp states. The Apple-II Calibration Pulse Integrator (CPI) program runs on any Apple-II series personal computer using the DOS 3.3 operating system. CPI uses calibration pulse data for a single pulse, and therefore for only one lamp state at a time (Gunther, 1984).

IV. RESULTS

The author found that:

- Both the Hughes and Threshold methods properly located the calibration pulse if there was no false signal (Figure 2).
- Both the Hughes and Threshold methods properly located the calibration pulse if the false signal was small in peak value compared to the calibration pulse value (Figures 3 and 4).
- Both the Hughes and Threshold methods failed to properly locate the calibration pulse if the false signal was large in peak value compared to the calibration pulse (Figures 3 and 4).
- Both the Hughes and Threshold methods properly located the calibration pulse if the calibration window was restricted in size to eliminate the false signals.

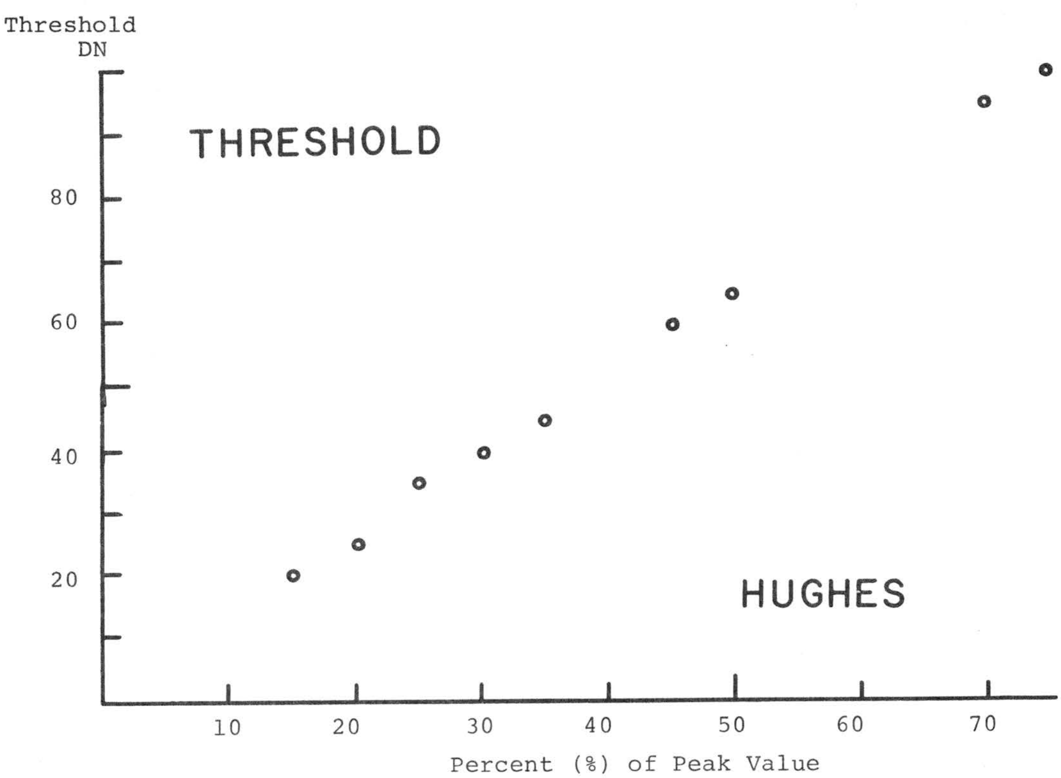


Figure 2. Comparison of the Hughes and Threshold pulse-locating methods, using a data set without a light leak (false signal). The plot shows the parameter values for each method that yielded identical pulse-location results. Data in Gunther (1984).

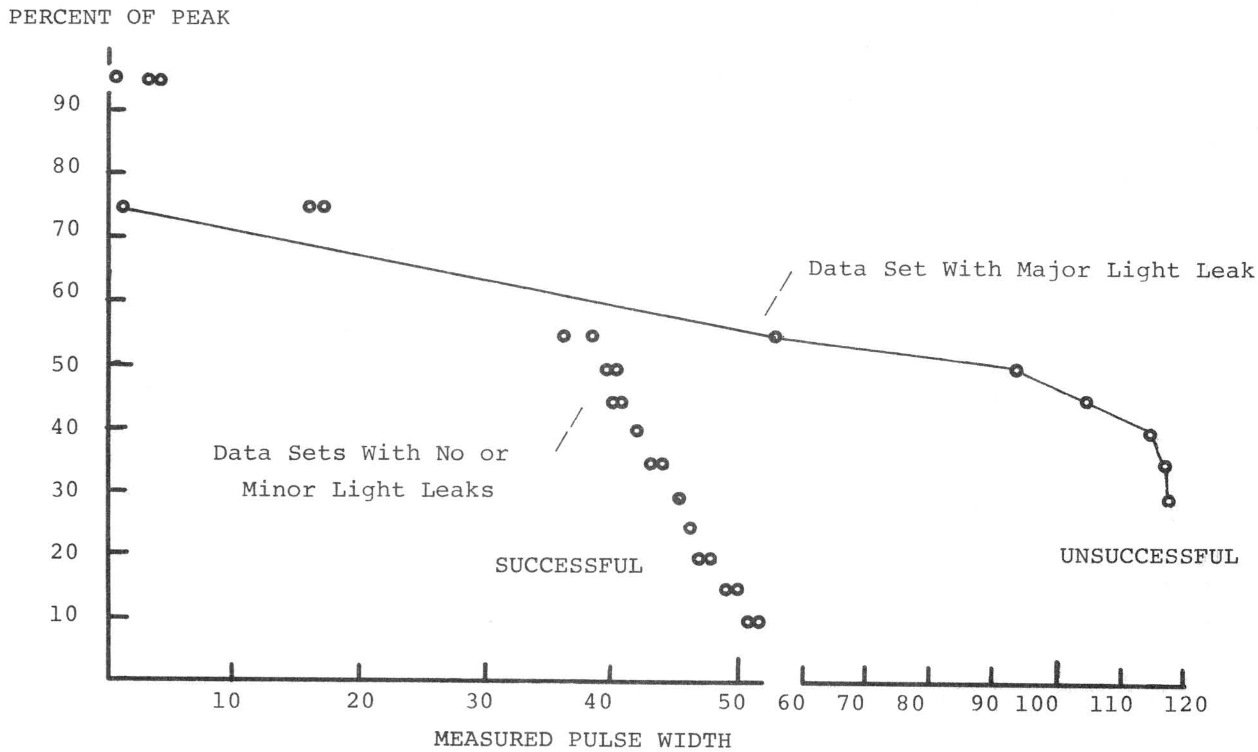


Figure 3. A comparison of the success of the Hughes method using data sets having light leaks of different magnitudes within the full Landsat-5 TM calibration window.

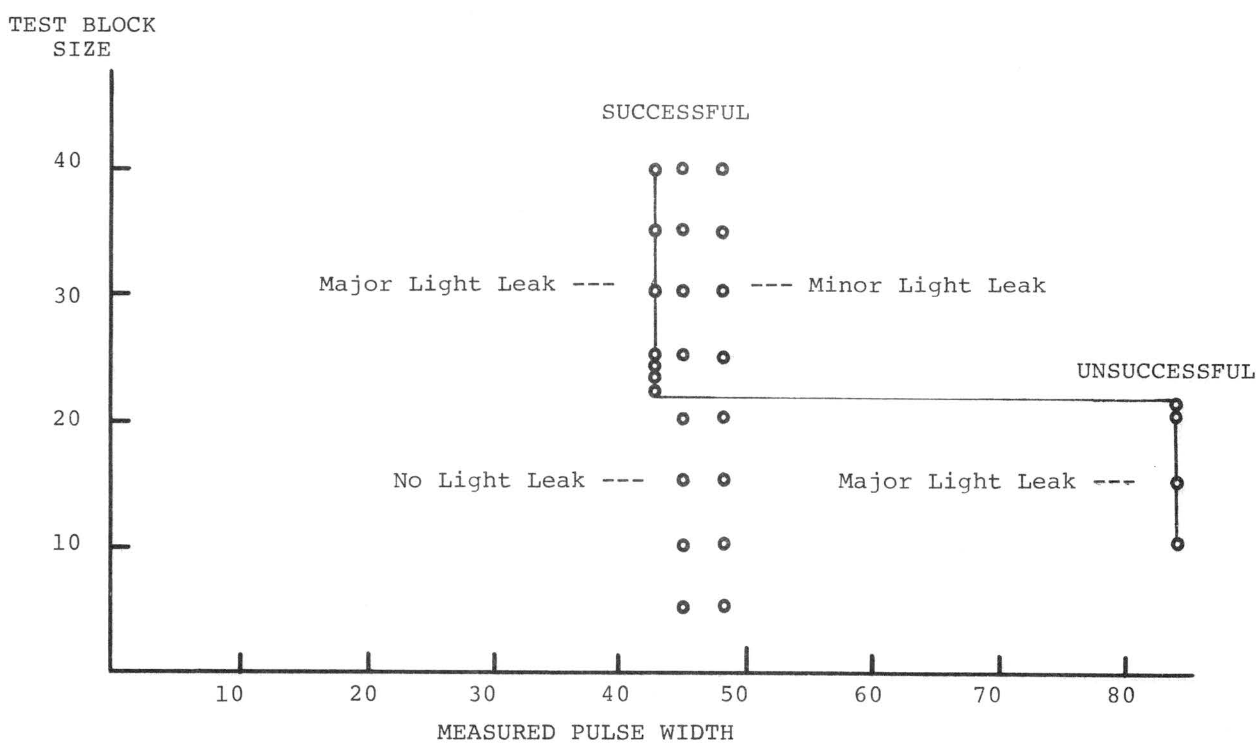


Figure 4. A comparison of the success of the Threshold method, using the above data.

o The Threshold method, at full calibration window size, rejected the false signal if the contiguous-block test parameter was set large enough, since the false signals were significantly narrower than the calibration pulse (Figures 4 and 5). Use of a larger threshold value also helped to exclude false signals (Figure 5).

V. RECOMMENDATIONS

The author recommends using the Threshold method with large threshold and contiguous-block parameter values as a robust method of locating calibration pulses in advanced sensor systems.

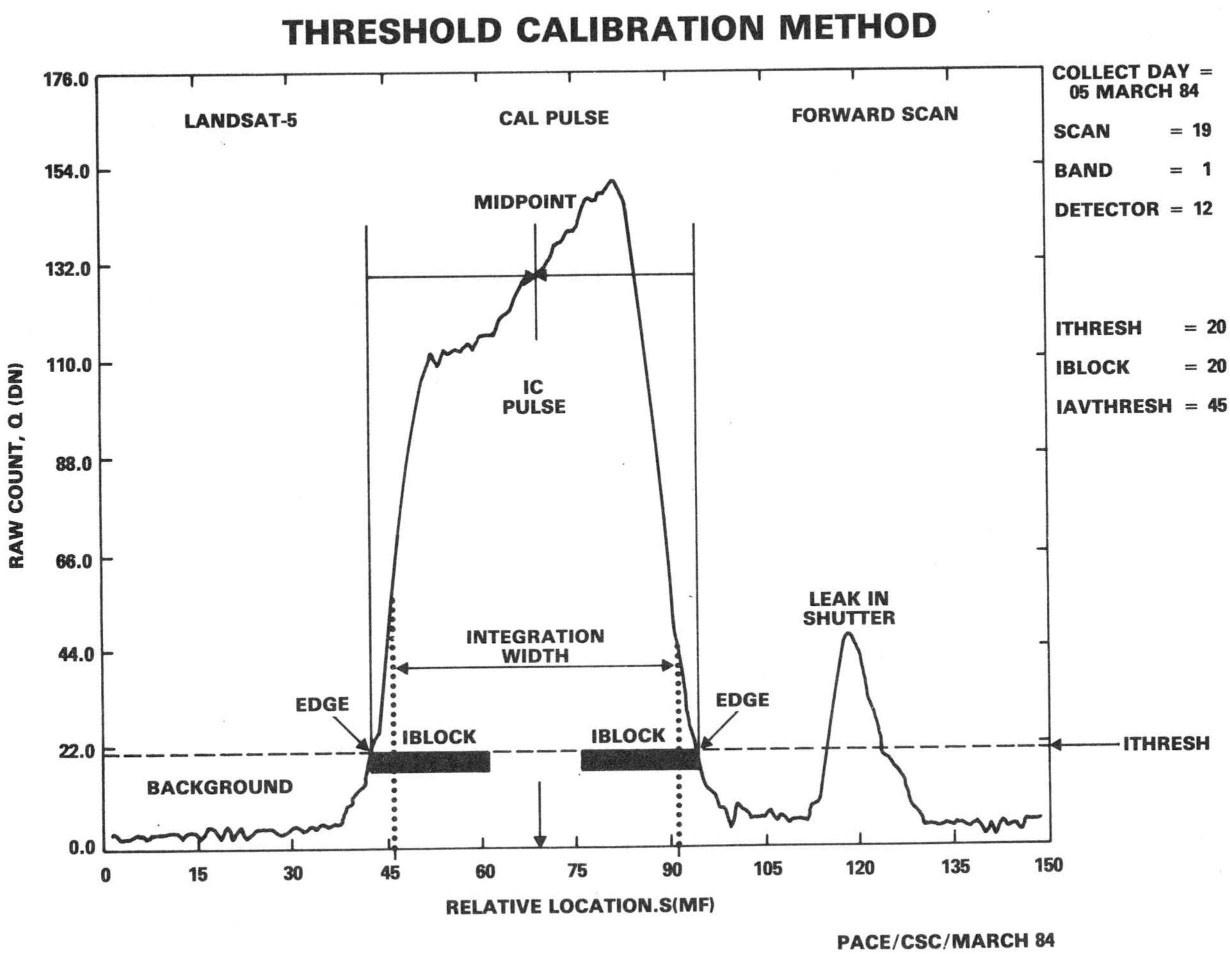


Figure 5. Robust calibration-pulse location (modified from Gunther, 1984).

VI. REFERENCES

Abrams, R. B., Characterization of Landsat -5 Thematic Mapper Reflective Bands Computer Sciences Corporation, CSC/TM-84/6094, Silver Spring, MD, 1984

Anuta, P., L. Bartolucci, E. Dean, F. Lozano, E. Malaret, C. McGillem, J. Valdes, & C. Valenzuela, Landsat-4 Data Quality Analysis Proceedings, Pecora-8 Symposium, Sioux Falls, South Dakota, October 4-7, 1983, pp. 96-108

Barker, J. L., D. L. Ball, K. C. Leung, & J. A. Walker, Pre-Launch Absolute Radiometric Calibration of Landsat-4 Protoflight Thematic Mapper Landsat-4 Science Investigations Summary, NASA CP-2326, Greenbelt, MD, 1984, Vol. 1, pp. 130-139

Barker, J. L., & F. J. Gunther, Landsat-4 Sensor Performance Proceedings, Pecora -8 Symposium, Sioux Falls, South Dakota, October 4-7, 1983, pp. 46-74

DeGloria, S. D., A. S. Benson, & R. N. Colwell, Evaluation of Landsat-4 Image Quality for the Interpretation of Forest, Agricultural and Soil Resources Proceedings, Pecora-8 Symposium, Sioux Falls, South Dakota, October 4-7, 1983, pp. 147-161

Engel, J. L., Thematic Mapper (TM) Instrument Description Landsat-4 Science Investigations Summary, NASA CP-2326, Greenbelt, MD, 1984, Vol. 1, pp. 41-61

Engel, J. L., & O. Weinstein, The Thematic Mapper - An Overview IEEE Transactions on Geoscience and Remote Sensing, Vol. GE-21, no. 3, 1983, pp. 258-265

Gunther, F. J., A Comparison of Landsat-5 Thematic Mapper Calibration Pulse Integration Methods Computer Sciences Corporation, CSC/TM-84/6097, Silver Spring, MD, October 1984

Haas, R. H., & F. A. Waltz, Evaluation of Thematic Mapper Data for Natural Resource Assessment Proceedings, Pecora -8 Symposium, Sioux Falls, South Dakota, October 4-7, 1983, pp. 122-133

Irons, J. R., An Overview of Landsat-4 and the Thematic Mapper Landsat-4 Science Investigations Summary, NASA CP-2326, Greenbelt, MD, 1984, Vol. 1, pp. 62-64

Salomonson, V. F., & H. Manneimer, An Overview of the Evolution of Landsat-4 Proceedings, Pecora-8 Symposium, Sioux Falls, South Dakota, October 4-7, 1983, pp. 32-44

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