Department of the Interior
U.S. Geological Survey

LEVEL 1G (L1G) PRODUCT EVALUATION CRITERIA

Version 1

December 2003

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December 2003

Prepared By:

D. Strande Date
IGS Data Quality Analyst
SAIC

Reviewed By:

R. Hayes Date
Calibration Validation Lead
SAIC

Reviewed By:

J. Storey Date
Chief Systems Engineer
SAIC

Approved By:

K. Kline Date
Landsat Mission Management Officer
U.S. Geological Survey

Reviewed By:

M. Headley Date
Landsat MMO Systems Engineer
SAIC

USGS EROS Data Center
Sioux Falls, South Dakota

Executive Summary

This document contains the thresholds and methodology that the Landsat Project will utilize in support of the Level 1G (L1G) product validation activities between the U.S. Geological Survey (USGS) and the International Ground Stations (IGS). The philosophy presented in this document represents the evaluation criteria applied to facilitate the validation and certification of systematically processed L1G products. This document also describes the standards that the Landsat Technical Working Group (LTWG) agreed upon to implement the radiometric (RAD) and geometric (GEOM) comparisons in support of L1G product validation activities.

Upon approval, this document will be configured and placed under the control of the Configuration Control Board (CCB).

The L1G product validation is maintained and supported by the U.S. Geological Survey's USGS/ Earth Resources Observation System (EROS) Data Center (EDC) of the United States Department of Interior (DOI) for operation at the USGS/EDC, Sioux Falls, SD 57198.

Document History

Document Number	Document Version	Publication Date	Change Number	Keywords
L7-PD-10.1	Version 1	December 8, 2003	LCCR 126	Original

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Section 1 Introduction

1.1 Background

This document provides specifications of the thresholds and methods for validation of Landsat 7 Enhanced Thematic Mapper Plus (ETM+) L1G products produced by the international network of Landsat receiving stations. The validations are performed under the initiative of the LTWG's subgroup on validation of Landsat 7 products.

Section 2 Thresholds

The following USGS/IGS data consistency thresholds were decided upon in the validation subgroup meeting at LTWG-11 on February 5, 2002, in Canberra, Australia. They are considered preliminary and will be addressed and revised after initial product validations.

2.1 Absolute (ABS) Geometric Error Threshold

T-GEOM-ABS = 230 m

RMSE-line <= T-GEOM-ABS
RMSE-sample <= T-GEOM-ABS

This is the Root Mean Square Error (RMSE) difference (in the line and sample components) between the IGS product band and the corresponding USGS product band.

2.2 Relative (REL) Geometric Error Threshold

T-GEOM-REL = 30 m

STDV-line <= T-GEOM-REL
STDV-sample <= T-GEOM-REL

This is the standard deviation (STDV) of the difference (in the line and sample components) between the IGS product band and the corresponding USGS product band.

2.3 Band-to-Band Geometric Error Threshold

T-GEOM-BAND = 0.17 pixels

RMSE-line <= T-GEOM-BAND
RMSE-sample <= T-GEOM-BAND

This is the Root Mean Square Error (RMSE) difference (in the line and sample components) between one of the IGS product bands and any of the other bands in the same product. The pixel size to be used in the threshold is the larger of the two bands in the comparison. For products resampled to pixel sizes other than the standard 30-meter (multispectral), 15-meter (panchromatic), and 60-meter (thermal), the registration results will be scaled to these nominal pixel sizes.

2.4 Radiometric Error Threshold

T-RAD-GAIN = 2%
T-RAD-BIAS varies by band and gain state as shown in Table 2-1.

Relative Gain <= T-RAD-GAIN
Relative Bias <= T-RAD-BIAS

Band	Low Gain	High Gain
Band 1	2.36	1.55
Band 2	2.42	1.60
Band 3	1.89	1.24
Band 4	1.94	1.28
Band 5	0.38	0.25
Band 6	0.13	0.07
Band 7	0.13	0.09
Band 8	1.95	1.28
*Units are Watts / (meter^2 * steradian * µm)*		

Table 2-1. Radiometric Error Threshold

The relative gain and relative bias are computed from the differences in at-aperture radiance between the IGS product band and the corresponding USGS product band as described in Section 3.3.

2.5 Scene Framing Error Threshold

T-FRAME = 9 km

This is the maximum along-track distance in which the IGS product does not overlap in the corresponding USGS product.

Section 3 Methodology

The validation process consists of comparing L1G products generated by the IGS to the corresponding reference products generated by the USGS. References[1] contains the specification of the products to be validated.

The validation includes comparisons in four aspects: metadata consistency, scene framing consistency, radiometric consistency, and geometric consistency. The following sections define methods for these comparisons.

3.1 Metadata

Metadata for the products must conform to what is specified in References [1]. This will be verified by visual inspection of the Fast Format Level 1 Metadata (MTL), Panchromatic Band Header File (HPN), Reflective Bands Header File (HRF) and Thermal Bands Header Files (HTM). To facilitate finding anomalies, software may be used to compare and find differences in the IGS and corresponding USGS files.

It is also verified indirectly to some extent by the successful ingest of metadata by the software used for the validation process.

The criteria for pass are no format errors.

3.2 Geometry

3.2.1 Absolute and Relative Geodetic Accuracy

Comparing the IGS product band 8 to the USGS product band 8 will validate the absolute and relative geodetic accuracy. Because the radiometric differences between these two products should be very small (or at least linear), a validation method based on cross-correlation is suitable.

Features suitable for cross-correlation assessments are selected in the USGS product band 8. 100 points in a 10 by 10 grid are selected over the image. Small size (32 by 32 pixels) image chips are extracted around the features. The normalized cross-correlation function is computed over a search window around the predicted position in the IGS product band 8. The subpixel position for the corresponding point in the IGS product is located at the (interpolated) maximum of the cross-correlation function.

The ground coordinate Universal Transverse Mercator (UTM) is calculated for the point positions in both the USGS and the IGS images. Their deviations are calculated by subtracting the IGS point coordinate from the USGS point coordinate. The RMSE and Standard Deviation (STDV) are then calculated using all point deviations for line and sample directions, respectively. The RMSE and STDV are then compared to their respective threshold. The criteria for pass are:

RMSE-line <= T-GEOM-ABS (230 m)
RMSE-sample <= T-GEOM-ABS (230 m)
STDV-line <= T-GEOM-REL (30 m)
STDV-sample <= T-GEOM-REL (30 m)

3.2.2 Band Registration Accuracy

The band registration accuracy will be validated by band-to-band comparisons in the IGS product. One band (e.g., band 3) is selected as the reference band. 100 points in a 10 by 10 grid are selected as in the geodetic accuracy assessment, and their corresponding positions are to be found in the remaining bands. For the preferred scenes in arid areas, the correlation between bands may be high enough to make cross-correlation successful; however, we may run into cases where this will fail because of too uncorrelated bands. This is not uncommon in band-to-band comparisons involving the thermal infrared band 6. Comparisons between bands of differing resolutions (i.e., the panchromatic and thermal bands) will be performed by artificially reducing the resolution of the higher resolution band using an image pyramid technique (See References [3]).

For all band-to-band comparisons, the ground coordinate (UTM) is calculated in both bands, and their deviations are calculated by subtraction. The RMSE deviation is then calculated using all point deviations for line and sample directions, respectively. The RMSE deviation is then compared to their respective threshold after division by the pixel size in the band with the larger pixels. The criteria for pass are:

RMSE-line <= T-GEOM-BAND
RMSE-sample <= T-GEOM-BAND

3.3 Radiometry

The at-aperture radiance calculated in the IGS product must be consistent with the USGS product. The threshold is expressed as a maximum percentage deviation between the at-radiance values in the IGS product compared to the corresponding value in the USGS product. The direct approach of overlaying and calculating the difference between products is likely to fail due to geometrical differences between images. Instead, a statistical approach will be used.

For each band in both products, the data must be transformed to radiance units using calibration factors from metadata. The mean and standard deviation for the entire scene must be calculated, excluding areas outside the scene. The relative gain and bias between the IGS and USGS bands as functions of the mean and STDV of the scenes must be calculated.

The criteria for pass are:

Relative Gain = $| STDV_{IGS} - STDV_{USGS} | / STDV_{USGS} <= $ T-RAD-GAIN (2%)
Relative Bias = $| MEAN_{IGS} - (STDV_{IGS} / STDV_{USGS}) * MEAN_{USGS} | <=$ T-RAD-BIAS

If the IGS scene falls outside of these radiometric thresholds, the scenes may be analyzed more closely using homogenous regions of interest.

3.4 Scene Framing

The IGS scene is required to cover the USGS frame to a specified minimum extent. The threshold is expressed as a maximum along-track distance in which the IGS product does not overlap in the corresponding USGS product. The validation is performed using band 8.

First, the hypothesis that the IGS scene completely covers the along-track extent of the USGS scene must be verified by visual inspection. If the IGS scene cover is complete, no measurements have to be made.

If there is only a partial cover, the extent of cover shortage must be measured. First, at the top border in an IGS scene (if not covering USGS top border), a point must be found that can also be identified in the USGS scene. Then the along-track distance (LT) to the top border in the USGS scene and the distance (LB) to bottom border (if not covered) must be measured. The criteria for pass are:

LT+LB <= T-FRAME

Appendix A Abbreviations and Acronyms

ABS	Absolute
CCB	Configuration Control Board
DOI	Department of Interior
EDC	EROS Data Center
EROS	Earth Resources Observation Systems
ETM+	Enhanced Thematic Mapper Plus
GEOM	Geometric
HPN	Panchromatic Band Header File
HRF	Reflective Bands Header File
HTM	Thermal Bands Header File
IGS	International Ground Station
km	Kilometer
L1G	Level 1 (processing) Geometrically (corrected)
LB	Distance to bottom border of a scene
LCCR	Landsat Configuration Change Request
LT	Along-track distance to top border of a scene
LTWG	Landsat Technical Working Group
MMO	Mission Management Officer
MTL	Level 1 Metadata
RAD	Radiometric
REL	Relative
RMSE	Root Mean Square Error
SAIC	Science Applications International Corporation
STDV	Standard Deviation
USGS	United States Geological Survey
UTM	Universal Transverse Mercater

References

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