Department of the Interior
U.S. Geological Survey

LANDSAT 5 THEMATIC MAPPER (TM) LOOKUP TABLE (LUT) RELEASE VERSION DESCRIPTION DOCUMENT (VDD)

Version 5

April 2006

LANDSAT 5 THEMATIC MAPPER (TM)
LOOKUP TABLE (LUT) RELEASE
VERSION DESCRIPTION DOCUMENT

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Executive Summary

This Lookup Table (LUT) Version Description Document (VDD) describes the contents of the LUT generated by the Image Assessment System (IAS) team. The IAS is responsible for offline assessment of image quality to ensure compliance with the radiometric and geometric requirements of the spacecraft and the Enhanced Thematic Mapper Plus (ETM+) sensor throughout the Landsat Mission. In addition to assessment functions, the IAS is responsible for the radiometric and geometric calibration of the Landsat 7 satellite and ETM+. The IAS also became responsible for the routine radiometric and geometric calibration of the Landsat 5 TM following its transition to bumper mode operations in early 2002.

This document describes the LUT created for the Landsat 5 TM and accompanies the release of LUTs for the Landsat Thematic Mapper (TM) sensor. The Landsat Ground Station Configuration Control Board (GCCB) controls this document.

Document History

Document Number	Document Version	Publication Date	Change Number	Keywords
IAS-223.1	Version 1	August 18, 2003		Original
IAS-223.2	Version 2	January 21, 2004		
IAS-223.3	Version 3	March 29, 2004		
IAS-223.4	Version 4	January 5, 2006		
IAS-223.5	Version 5	April 10, 2006		

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Section 1 Introduction

Effective May 5, 2003, Landsat 5 (L5) Thematic Mapper (TM) data processed and distributed by the U.S. Geological Society (USGS)/Earth Resources Observation System (EROS) Data Center (EDC) will be radiometrically calibrated using a new procedure and revised calibration parameters. The modified approach involves discontinuing the use of the Internal Calibrator (IC) for the reflective bands (with the exception of the thermal band) and implementing a time-dependent calibration LUT. This document details the LUTs released for the Landsat 5 TM sensor and the changes made for each release.

Section 2 LUT File Structure

The LUT has 11 (3+6+2) columns. The first three columns are time-related. The next five columns list the band average time-dependent gain coefficients generated from the lifetime gain equations. The last two columns provide band average icing-corrected gain coefficients for bands 5/7. See Table 2-1.

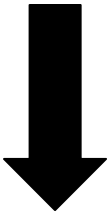
Table 2-1. LUT File Structure

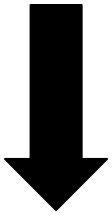
Column	Description
Column 1	Days Since Launch (DSL)
Column 2	Decimal year since launch
Column 3	Day of the year (DOY)
Column 4	Discrete band 1 average gain coefficients
Column 5	Discrete band 2 average gain coefficients
Column 6	Discrete band 3 average gain coefficients
Column 7	Discrete band 4 average gain coefficients
Column 8	Discrete band 5 average gain coefficients
Column 9	Discrete band 7 average gain coefficients
Column 10	Discrete band 5 average gain coefficients (Icing correction)
Column 11	Discrete band 7 average gain coefficients (Icing correction)

Sample values for each LUT are specified below.

L5 TM LUT (L7gain7a.txt) containing discrete band average gain coefficients over the instruments lifetime

DSL	YEAR	DOY	B1	B2	B3	B4	B5	B7	B5	B7
1	1984.1667	61	1.3945	0.7168	1.0216	1.1955	8.4840	15.2183	8.4659	15.2174
2	1984.1694	62	1.3941	0.7167	1.0213	1.1951	8.4832	15.2169	8.4454	15.2136
3	1984.1721	63	1.3937	0.7165	1.0210	1.1947	8.4824	15.2155	8.4236	15.2083
4	1984.1749	64	1.3933	0.7164	1.0206	1.1943	8.4816	15.2141	8.4010	15.2015
5	1984.1776	65	1.3929	0.7162	1.0203	1.1939	8.4808	15.2127	8.3779	15.1932
6	1984.1803	66	1.3926	0.7161	1.0200	1.1935	8.4800	15.2113	8.3548	15.1835
7	1984.1831	67	1.3922	0.7160	1.0197	1.1931	8.4792	15.2100	8.3320	15.1725
8	1984.1858	68	1.3918	0.7158	1.0194	1.1927	8.4783	15.2086	8.3099	15.1600
9	1984.1885	69	1.3914	0.7157	1.0191	1.1924	8.4775	15.2072	8.2890	15.1464
10	1984.1913	70	1.3910	0.7156	1.0188	1.1920	8.4767	15.2058	8.2696	15.1315
11	1984.1940	71	1.3906	0.7154	1.0184	1.1916	8.4759	15.2045	8.2520	15.1158
12	1984.1967	72	1.3902	0.7153	1.0181	1.1912	8.4751	15.2031	8.2365	15.0989
13	1984.1995	73	1.3898	0.7152	1.0178	1.1908	8.4744	15.2018	8.2234	15.0813
14	1984.2022	74	1.3895	0.7150	1.0175	1.1905	8.4736	15.2004	8.2127	15.0629
15	1984.2049	75	1.3891	0.7149	1.0172	1.1901	8.4728	15.1990	8.2047	15.0439
16	1984.2077	76	1.3887	0.7147	1.0169	1.1897	8.4720	15.1977	8.1995	15.0246
17	1984.2104	77	1.3883	0.7146	1.0166	1.1893	8.4712	15.1964	8.1971	15.0049
18	1984.2131	78	1.3879	0.7145	1.0163	1.1889	8.4704	15.1950	8.1976	14.9848





9428	2009.9753	356	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8327	13.8654
9429	2009.9781	357	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8346	13.8636
9430	2009.9808	358	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8366	13.8618
9431	2009.9836	359	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8386	13.8599
9432	2009.9863	360	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8405	13.8581
9433	2009.9890	361	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8426	13.8562
9434	2009.9918	362	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8446	13.8544
9435	2009.9945	363	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8467	13.8525
9436	2009.9973	364	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8487	13.8506
9437	2009.9999	365	1.2430	0.6561	0.9050	1.0820	8.2090	14.6950	7.8508	13.8488

Section 3 List of LUT in Effect

Table 3-1. lists all of the LUTs released. Note that the earlier LUTs released were during the testing phase on the development machine. This table lists only the official LUTs that went into the production system.

Table 3-1. LUT Versions and Release Dates

LUTs Version	Release Date
L5gain3a	May 05, 2003
L5gain4c	Sep 2003
L5gain5a	Jan 13, 2004
L5gain6a	Apr 05, 2004
L5gain7a	Jan 10, 2006
L5gain8a	Apr 12, 2006

Section 4List of Changed Units

4.1 LUT File Structures

No Changes

4.2 Modifications to Existing LUT Values

The following sections list the changes made to the newly generated or modified LUTs.

4.2.1 File: L5gain1a

The L5gain1a is the first LUT created and has only 9 (3+6) columns. The band average gains were calculated from the lifetime gain equations. At this point, the icing corrections were not made to the reflective cold focal plane bands (bands 5/7).

4.2.2 File: L5gain2a

Icing corrections were implemented for bands 5/7 gain and were added as two new extra columns (Columns #10 and #11). The icing-corrected gain coefficients were generated by “multiplying” the lifetime gain coefficients with icing correction factors.

4.2.3 File: L5gain3a

An outgassing event took place on Dec 12, 2002 (DSL=6861), and the icing correction factors were updated to reflect this change.

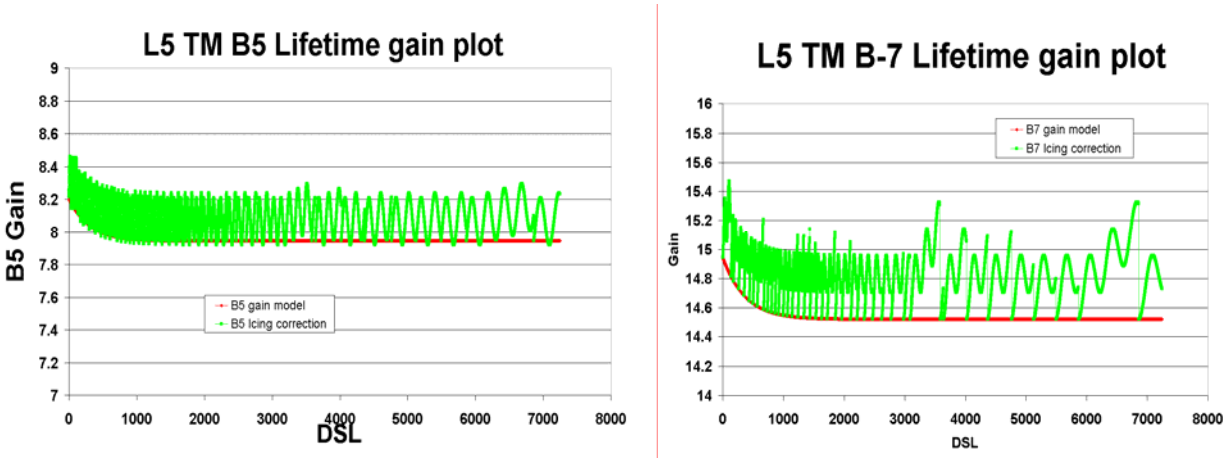


Figure 4-1. L5 TM Bands-5/7 lifetime gain plot (L5gain3a)

4.2.4 File: L5gain4a

The icing-corrected gain coefficients were generated by “dividing” the lifetime gain coefficients by icing correction factors. The updated icing corrected gain curve is a mirror image of the previous LUT gain curves from L5gain3a.

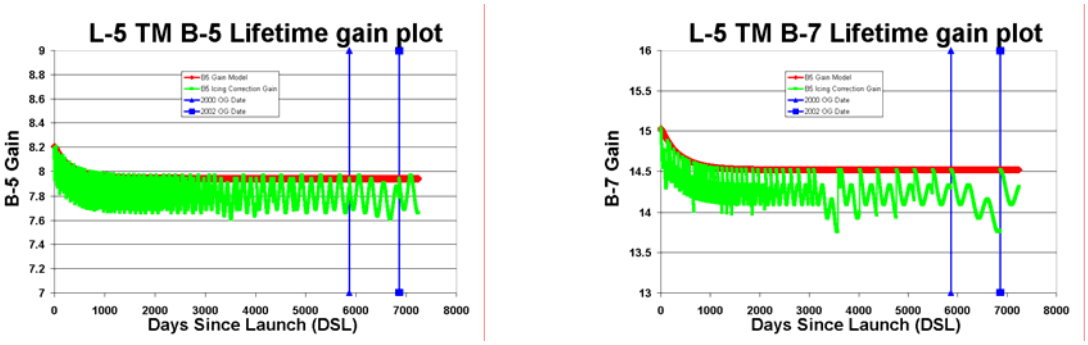


Figure 4-2. L5 TM Bands-5/7 lifetime gain plot (L5gain4a)

4.2.4.1 File: L5gain4b

The second column in the LUT contains the decimal year over the lifetime of the instrument. The fraction part of the year was slightly refined to get the true Day of the Year (DOY).

The icing correction algorithm was slightly modified by updating the Band 7 thin film model parameters:
N17 from 1.2608 to 1.2606;
K17 from 0.00247 to 0.002472;
N27 from 1.6676 to 1.6677;
D27 from 327.44 to 326.9;
M7 from 0.06353 to 0.06224;
B7 from -23.22 to -18.59;
T17 from 68.55 to 68.54;

The bands-5/7 gain model coefficients were slightly updated.
Band 5 Coefficients
a50=0.254503
a51=1.09271
a52=7.944

Band 7 Coefficients
a70=0.496719
a71=0.979471
a72=14.52

4.2.4.2 File: L5gain4c

The second column in the LUT was slightly modified to account for the decimal year rollover that occurred on the last day of every year. The reason for this change was that the National Land Archive Production System (NLAPS) script uses only the first four digits from the year column (#2) and the day of year (#3) to get the time-related information.

4.2.5 File: L5gain5a

This update will affect bands 5/7 over the lifetime of the instrument (No change for reflective bands). Previously, the gain model was tied to the cross-cal gains (b5=7.9440, b7=14.5200). Now these gains have been slightly tweaked to take icing into consideration. Thus, the new gain models are now tied to b5=8.2090, b7=14.6950. This update for the LUT will introduce a change (improvement) of three percent in bands 5 and one percent in bands 7.

Band 5 Coefficients
a50=0.262993
a51=1.09271
a52=8.209

Band 7 Coefficients
a70=0.502705
a71=0.979471
a72=14.695

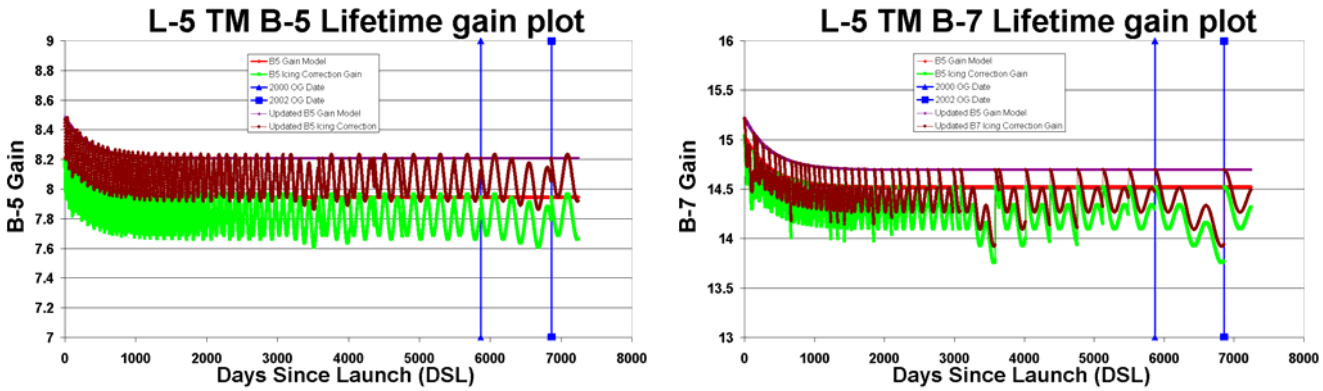


Figure 4-3. L5 TM Bands-5/7 lifetime gain plot (L5gain5a)

4.2.5.1 File: L5gain5b

The earlier LUTs were extrapolated until the end of 2003 (DSL=7245). The new LUT was created and extended until the end of 2005 (DSL=7976). The bands 5/7 icing

corrections coefficients still use December12, 2002 (DSL=6861) as the last outgassing date. The LUT5a and LUT5b should be identical until DSL=7245.

The January and February 2004 data processed were calibrated using the "last gain numbers" (DSL=7245) from the current LUT. This is not a problem for bands 1-4 because the gain is a fixed number (b1=1.243, b2=0.6561,b3= 0.905, b4=1.082); however, for bands-5/7, there is an icing correction that varies each day. Since last month, we have been using a fixed gain number (b5=7.921, b7=14.492).

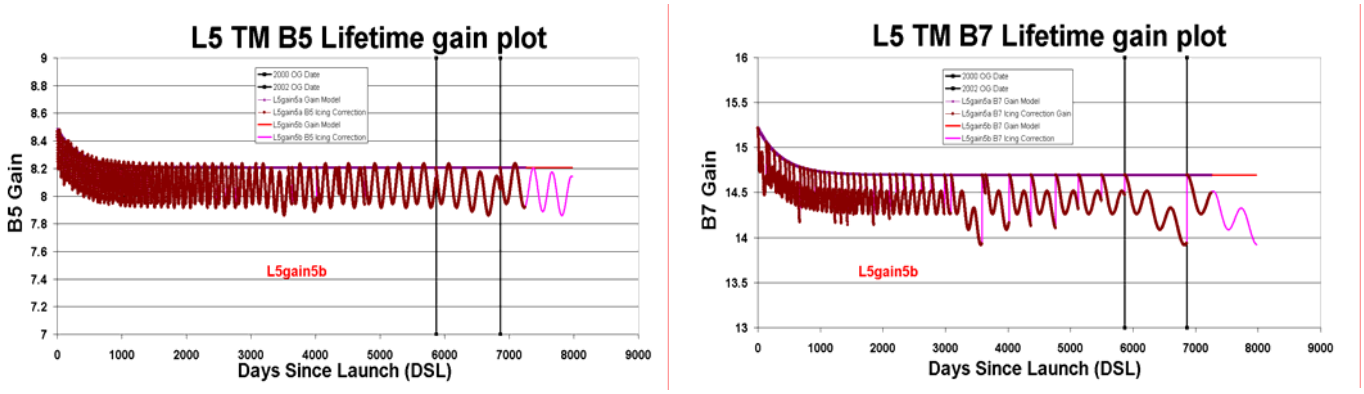


Figure 4-4. L5 TM Bands-5/7 lifetime gain plot (L5gain5b)

4.2.6 File: L5gain6a

An outgassing event took place on Mar 25, 2004 (DSL=7330), and the icing correction factors were updated to reflect this change.

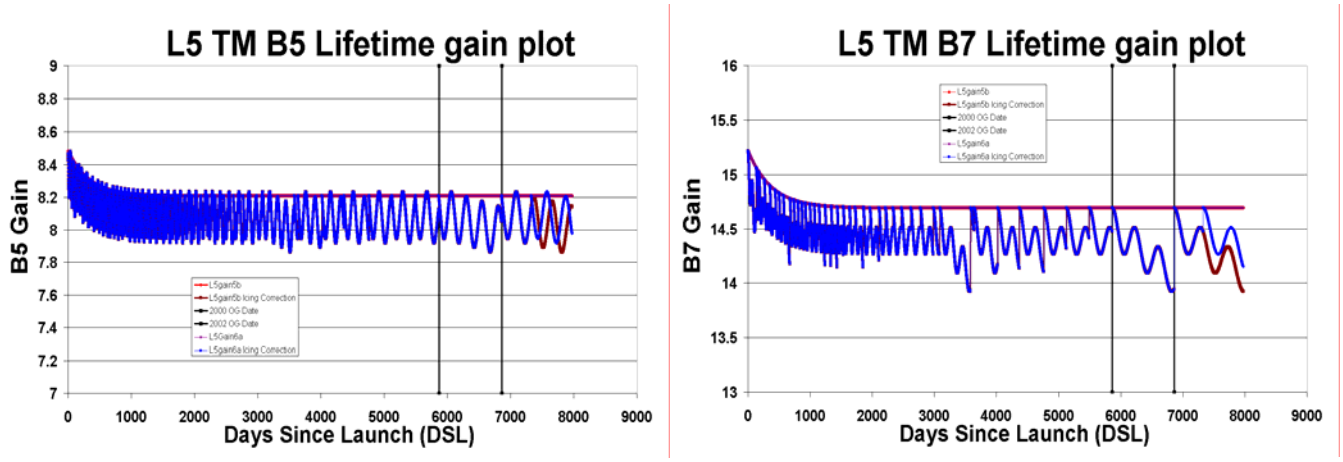


Figure 4-5. L5 TM Bands-5/7 lifetime gain plot (L5gain6a)

4.2.7 File: L5gain7a

The earlier LUTs were extrapolated until the end of 2005 (DSL=7976). The new LUT was created and extended until the end of 2009 (DSL=9437). The bands 5/7 icing corrections coefficients still use March 25, 2004 (DSL=7330) as the last outgassing date. The LUT7a and LUT6a should be identical until DSL=7976.

The reason for extending the LUT until the end of 2009 was to be consistent with the estimated end of L5 TM mission: December 2009 based on remaining fuel and assuming 9:30AM MLT crossing minimum criteria.

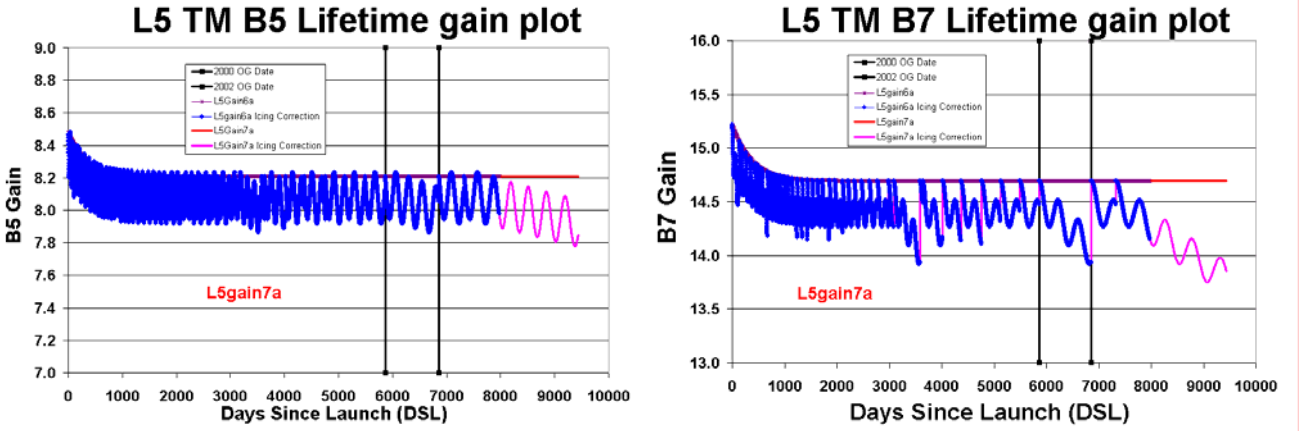


Figure 4-6. L5 TM Bands-5/7 lifetime gain plot (L5gain7a)

4.2.8 File: L5gain8a

An outgassing event took place on Mar 17, 2006 (DSL=8052), and the icing correction factors were updated to reflect this change.

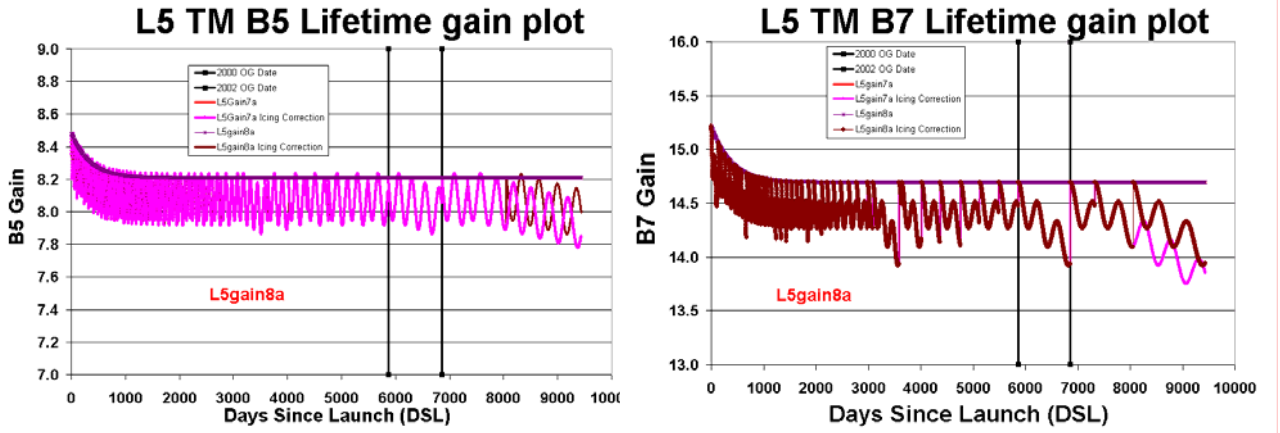


Figure 4-7. L5 TM Bands-5/7 lifetime gain plot (L5gain8a)

Table 4-1. Summary of LUT Modifications

LUT Version	Modifications
L5gain1a	No Icing Correction
L5gaib2a	Icing corrections were implemented for bands-5/7
L5gain3a	Outgassing event on Dec 12, 2002 (DSL=6861)
L5gain4a	Bands-5/7 gain coefficients mirror image of L5gain3a
L5gain4b	Fraction part in column-2 refined to get true Day of Year
L5gain4c	Decimal rollover at the end of the year
L5gain5a	Bands-5/7 cross-cal gains tweaked to take icing into account
L5gain5b	LUT extended until the end of 2005 (from DSL 7245 to 7976)
L5gain6a	Outgassing event on Mar 25, 2004 (DSL=7330)
L5gain7a	LUT extended until the end of 2009 (from DSL 7976 to 9437)
L5gain8a	Outgassing event on Mar 17, 2006 (DSL=8052)

Section 5 Operational Changes Expected

Prior to May 5, 2003, the L5 TM calibration procedure in NLAPS (previously used in TIPS) used the instrument's response to the Internal Calibrator (IC) on a scene-by-scene basis to determine the gain and offset to be applied. The implementation of the LUT-based approach will lead to a superior L5 TM data product that will be comparable to L7 ETM+ radiometery and will provide the basis for continued long-term studies of the Earth's land surfaces.

Appendix A Acronyms

CPF	Calibration Parameter File
DOY	Day of the Year
DSL	Days Since Launch
EDC	EROS Data Center
EROS	Earth Resources Observation Systems
ETM+	Enhanced Thematic Mapper Plus
GCCB	Ground Station Configuration Control Board
IAS	Image Assessment System
IC	Internal Calibrator
L5	Landsat 5
L7	Landsat 7
LUT	Lookup Table
NLAPS	National Land Archive Production System
TIPS	Thematic Mapper Image Processing System
TM	Thematic Mapper