Landsat 7 Orthorectified Imagery over Canada, Level 1 Product Specifications

Edition 1.0

2003-01-10

Government of Canada
Natural Resources Canada
Centre for Topographic Information
Customer Support Group
2144 King Street West, Suite 010
Sherbrooke, Quebec, Canada
J1J 2E8

Telephone: +01-819-564-5600 / 1-800-661-2638 (Canada and USA)
Fax: +01-819-564-5698
E-mail: ntdb@nrcan.gc.ca
URL: www.geobase.ca

Copyright Notice

REVISION HISTORY

Date	Version	Description
January - 2003	1.0	Original version

FUTURE WORK

Key word	Description

TABLE OF CONTENTS

ABBREVIATIONS

BSQ	Band sequence
CCRS	Canada Centre for Remote Sensing
CDED	Canadian Digital Elevation Data
CTI-S	Centre for Topographic Information – Sherbrooke
FGDC	(US) Federal Geographical Data Committee
GCMD	(NASA) Global Change Master Directory
GeoTIFF	Georeference Tagged Image File Format
GPS	Global Positioning System
GRS80	Geodetic Reference System of 1980
LCC	Lambert Conformal Conic
NAD83	North American Datum of 1983
NTDB	National Topographic Data Base
URN	Updated Road Network
UTM	Universal Transverse Mercator

TERMS AND DEFINITIONS

Orthorectified Image / Orthoimage

An image derived from a conventional perspective image by simple or differential rectification to remove image displacements caused by sensor tilt and relief of terrain.

1 Overview

Landsat 7 orthoimages are stored as raster data and comprise 9 spectral bands: a panchromatic band with a pixel size of 15 m, 6 multispectral bands with a pixel size of 30 m. and 2 thermal infrared bands with a ground resolution of 60 m. They have been produced in accordance with NAD83 (North American Datum of 1983) using the Universal Transverse Mercator[1] (UTM) projection.

The orthoimage data sets have been created with the most accurate control data available at the time. A variety of sources have been used for image correction, with the most accurate are given priority. The usual priority ranking is: GPS source for the National Road Network, provincial vector data, accurate National Topographic Data Base (NTDB) data, federal aerotriangulation data, and other sources. The accuracy is evaluated for each orthoimage data set. The control data, which have been extracted from sources as mentioned above, can consist of road intersection vector data or lake/island centroids. In some cases the intersection of the centre line of a surficial river may have been used. The control points are distributed homogeneously within the image in specific sectors. Sectors are located in the image surround, in the area of the image with the lowest and highest elevations, and in all other areas in which overlapping image base sectors are located.

The objective of the national orthoimage project is to produce a complete set of cloud-free (less than 10%) orthoimages covering the Canadian landmass using Enhanced Thematic Mapper (ETM+) data from the Landsat 7 satellite. Production, which began in fall 2000, will span a period of three to five years. The purpose is to promote the use of geomatics and educate by providing a Web and file transfer protocol (ftp) site that distributes Canada's geospatial data.

Data (choice of spectral bands) are available for download, without charge, in GeoTIFF, BSQ and PIX (PCI) formats using either Lambert Conformal Conic (LCC) or Universal Transverse Mercator (UTM) projection.

2 Data Identification

2.1 Spatial resolution ("scale")

The spatial resolution, or the spatial dimension on the earth covered by the size of a pixel (nominal ground sample distance), varies according to each spectral band in Landsat 7 orthoimages.

Landsat 7 Band No.	Spectral Location	Wavelength (in µm)	Resolution (pixel size in m)
1	Blue-green	0.450 – 0.515	30
2	Green	0.525 – 0.605	30
3	Red	0.630 – 0.690	30
4	Infrared (IR)	0.750 – 0.900	30
5	Mid infrared I (MIR 1)	1.550 – 1.750	30
6L	Thermal IR (Low gain)	10.400 – 12.500	60
6H	Thermal IR (High gain)	10.400 – 12.500	60
7	Mid infrared II (MIR II)	2.090 – 2.350	30
8	Panchromatic	0.520 – 0.900	15

[1] A description of the UTM projection can be found at: http://cartes.RNCan.gc.ca/maps101/nts.html.

Each band has 8-bit radiometry (values from 0 to 255). The customer can choose combinations of bands from those listed. Each Landsat 7 orthoimage covers an area approximately 183 km by 170 km.

2.2 Language

The language used in the dataset is English.

2.3 Character set

The character coding standard used for the dataset is UTF8.

2.4 Topic category

The main topic category of the Landsat 7 orthoimage dataset is image base maps Earth cover. According to the GCMD[2] (Global Change Master Directory) thesauri, imagery can be classified into science key words structured using a four-level hierarchy: category > topic > term > variable. The following list indicates which have been retained for Landsat 7 orthoimages.

CATEGORY > TOPIC > TERM > VARIABLE

- EARTH SCIENCE > ATMOSPHERE > RADIATION BUDGET > ALBEDO
- EARTH SCIENCE > RADIANCE OR IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > ENHANCED INFARED IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR INFRARED ALBEDO
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR INFRARED BANDS
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR IR
- EARTH SCIENCE > RADIANCE OR IMAGERY > ULTRAVIOLET WAVELENGTHS
- EARTH SCIENCE > RADIANCE OR IMAGERY > VISIBLE WAVELENGTHS > VISIBLE IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > VISIBLE WAVELENGTHS > VISIBLE IMAGERY > VISIBLE REFLECTANCE
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > REFORESTATION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST YIELDS
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST PROTECTION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST PRODUCTS/COMMODITIES
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST MENSURATION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST MANAGEMENT
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST FIRE SCIENCE
- EARTH SCIENCE > LAND SURFACE
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND CLASSES
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND COVER
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND MANAGEMENT
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND PRODUCTIVITY
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND RESOURCES
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND TENURE
- EARTH SCIENCE > LAND SURFACE > TOPOGRAPHY > LANDFORMS > TERRAIN MAJOR LANDFORM
- EARTH SCIENCE > LAND SURFACE > TOPOGRAPHY > LANDFORMS
- EARTH SCIENCE > HYDROSPHERE

[2] Information on NASA Global Change Master Directory (GCMD) can be found at: http://gcmd.nasa.gov.

2.5 Geographic box

The geographic box or minimum bounding rectangle (MBR) delineating the coverage of all existing and planned Landsat 7 orthoimages in Canada is:

- West Bounding Coordinate: 141° West (or -140°)
- East Bounding Coordinate: 52° West (or -52°)
- North Bounding Coordinate: 85° North (or 85°)
- South Bounding Coordinate: 42° North (or 42°)

2.6 Geographic description

The Landsat 7 orthoimages will cover the entire Canadian landmass with less that 10% of cloud in a period of 3 to 5 years.

2.7 Extent

The temporal extent for the content of the data is from 1999 to present.

2.8 Supplemental information

Landsat 7 data are collected from a nominal altitude of 705 kilometres in a near-polar, near-circular, sun-synchronous orbit at an inclination of 98.2º, imaging the same 183-km swath of the Earth's surface every 16 days. Each frame is denoted by a sequential Path and Row determined by the 16-day repeat cycle. Landsat sensors require 233 orbits. The Rows, indexed east/west, are generated by partitioning each Path into 23.92 seconds of spacecraft time in both directions at the equator, resulting in 248 Rows per complete orbit. The Landsat sensors continuously collect data which are segmented post-collection on the ground, using telemetry ephemeris data, into individual framed scenes. The orbital tracks can drift over time due to a variety of factors and are adjusted when necessary. The framing is unique for each orbit. Accordingly, the frame locations are not exact, but are within a tolerance of movement off the original satellite orbit. The satellite orbit results in a coverage side overlap of a minimum of 7.3% at the equator increasing to approximately 85% at 80º of latitude.

3 Geospatial Characteristics

3.1 Spatial representation type

The method used to spatially represent a Landsat 7 orthoimage is raster data.

3.2 Spatial representation (VD) (GD)

Landsat 7 orthoimages are composed of thousands of pixels. Each pixel of information covers a portion of the Earth's surface according to its spatial resolution (spectral bands). The pixels are located in a column (north/south) and row (east/west) axis reference system.

3.3 Coverage and continuity

The Landsat sensors continuously collect data, which are segmented post-collection on the ground, using telemetry ephemeris data, into individual framed scenes. The orbital tracks can drift over time due to a variety of factors and are adjusted when necessary. The framing is unique for each orbit. Accordingly, the frame locations are not exact, but are within a tolerance of movement off the original satellite orbit. The satellite orbit results in a coverage side overlap of a minimum of 7.3% at the equator, increasing to approximately 85% at 80 degree of latitude.

3.4 Data segmentation (VD)

NOT APPLICABLE

4 Data Model (VD)

NOT APPLICABLE

5 Data Dictionary / Feature Catalogue (VD)

NOT APPLICABLE

6 Coordinate Reference System

Landsat 7 orthoimages are available in two projected coordinate reference systems: Lambert Conformal Conic (LCC) and Universal Transverse Mercator (UTM).

6.1 Horizontal reference system

The horizontal reference datum used is NAD83CSRS (North American Datum of 1983 for Canadian Spatial Reference System) and the Geodetic Reference System of 1980 (GRS80) ellipsoid served as a reference.

6.1.1 Horizontal coordinate system

Data are in metres.

6.1.2 Unit of measure (coordinate system axis units)

The data are stored in 2 dimensions for both projections (LCC and UTM): there are 2-coordinate system axis (north-south and west-east).

The unit of measure for data coordinates in X (north-south) and Y (west-east) axis is metres adjusted to the spatial resolution (pixel dimension) of each spectral band (15, 30 or 60 m).

In Canada, for LCC projection, the standard parallels are 49º North and 77º North, the latitude of projection origin is also 49º North and the longitude of central meridian is 95º West. The false easting and the false northing are both equal to 0 (zero) m.

For UTM projection in Canada, the scale factor at central meridian is 0.9996, the longitude of the central meridian is determined with the formula (180° – λ) / 6° + 1), where the latitude of projection origin is 0 (zero), the false easting is 500 000 m, and the false northing equals 0 m.

6.2 Vertical reference system

NOT APPLICABLE

7 Data Quality

7.1 Scope

The data quality information applies to each Landsat 7 orthoimage dataset.

7.2 Lineage

Orthoimages are produced from control points located in sectors in the image corner and in the middle of the east and the west boundaries (6 base sectors). Additional sectors are used in minimum and maximum elevation areas within the image. The theoretical limit of overlapping images has been used to create additional sectors (where projected base sectors of overlapping images are located). A minimum of 3 control points by sector has been selected. The Digital Elevation Model (DEM) accuracy has a small impact on orthoimage accuracy (tan 7 * DEM accuracy). Elevations attached to entities used as control points are derived from provincial DEMs, federal DEMs, or from aero-triangulation models. Various DEMs can be used for rectification depending on availability. The horizontal accuracy given for the orthoimage uses the worst DEM accuracy in the calculation. The DEM used can be provincial, NTDB data at the 1:50 000, or NTDB data at the 1:250 000, depending on availability. The process uses a provincial DEM, if available, to complete the gaps with DEMs derived from NTDB 1:50 000 contours; remaining gaps from DEMs derived from 1:250 000 contours are then completed. Since DEM accuracy has little impact on image accuracy, the worst DEM accuracy (including slope impact) serves in assessing orthoimage accuracy. At the end of the process, all valid control data and image entities are kept in a database. The correction model can be recreated at any time using the control data and image information. The correction model is not provided.

The originator and the source data used to produce Landsat 7 orthoimages are U.S. Geological Survey (raw image); Centre for Topographic Information - Sherbrooke (National Topographic Data Base (NTDB)); CTIO (aerotriangulation); and provincial data, specifically British Columbia: provincial vector data and provincial DEMs; Alberta: provincial vector data and provincial DEMs; Saskatchewan: NTDB data; Manitoba: federal aerotriangulation and GPS road network; Ontario: provincial vector data and federal aerotriangulation; Quebec: provincial vector data and federal aerotriangulation; New Brunswick: provincial vector data; Nova Scotia: NTDB data; Prince Edward Island: NTDB data.

When the source is provincial data, digital vector data and DEMs (in some cases) have been used as control data. If the source is federal or multisource, federal (road network, NTDB, aerotriangulation) and/or provincial data have been used. Orthoimage accuracy has been computed in reference to the control data used. The control points have been derived from road and river intersections and lake/island centroids.

7.3 Completeness

The data set is derived from Landsat 7 raw image level L1G. It has been processed using control points based on the most accurate control available data in the country. The methodology ensures homogeneous distribution of control points within the image. The parametric model was developed by Dr. Thierry Toutin at the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada. This model is based on principles related to orbitography, photogrammetry, geodesy, and cartography. It reflects the physical reality of the complete viewing geometry and corrects distortions that occur due to platform, sensor, Earth, and cartography projection. The Digital Elevation Model (DEM) is the most accurate source available as of the date of orthorectification. It can be a combination of provincial data, Canadian Digital Elevation Data (CDED) at the 1:50 000, or at the 1:250 000.

7.4 Logical consistency

Control points are chosen in predefined areas in the image to ensure good and equitable distribution. The image area planned for control-point selection has been reduced by 4.5 km in the east and west boundaries of the image. This reduction ensures that the same control points are reused in the next image update. Tests were done on 3 images to determine the best location for control points in an image in order to achieve greater accuracy. These images contained various types of terrain and were very representative of the Canadian landmass. Various control-data types and accuracy were used for these images. The tests concluded that control points in 6 base sectors in the image surround and in the minimum and maximum elevation sectors deliver the best accuracy. Overlapping images are considered and corresponding base sectors are added. These additional sectors (between 4 to 10) do not improve the accuracy, but ensure that the same control points are reused in image overlaps. When accurate control (sub-pixel) is used, the correction model is a good indicator of the derivation of the orthoimage's accuracy.

7.5 Positional accuracy

Orthoimage planimetric accuracy depends on control data, the digital elevation model (DEM), and the method used to extract the positions of the control points in the image. The best sources of control data currently available **in Canada** were used to generate the orthoimages. A number of control sources were used to correct the Landsat 7 images, namely provincial vector data, roads resulting from the global positioning system (GPS), data from the National Topographic Data Base (NTBD), and geometrically corrected aerial photography (orthophotos). The control points extracted from the sources generally represent road intersections and centres of mass of lakes or islands. Different DEMs also served in generating these orthoimages: provincial DEMs and Canadian Digital Elevation Data (CDED) at the 1:50 000 and the 1:250 000 scales. Planimetric accuracy is obtained by analyzing the parametres of the geometric correction model (SRIT), the accuracy of the source data used to correct the image, and DEM accuracy. Once all errors have been combined, the accuracy is calculated to a level of confidence of 90% (Circular Map Accuracy Standard (CMAS) (CCSM, 1984)).

The planimetric accuracy for the orthoimages in Southern Canada is about 20 m, compared to about 30 m in the northern part of the country. It should be noted that only control data within Canada was used. The planimetric accuracy of the part of the image located outside of Canada may therefore be lower. Each orthoimage has a different planimetric accuracy.

7.6 Temporal accuracy

There is no temporal attribute for Landsat 7 orthoimages besides the date of image capture.

7.7 Thematic (attributes) accuracy

Six (6) multispectral bands are available with a resolution of 30 m. A panchromatic band 8 was added, with a resolution of 15 m. Band 6 now has high-gain and low-gain bands with a resolution of 60 m.

8 Metadata

There are 2 levels of metadata to describe Landsat 7 Orthorectified Imagery, as shown in following figure: collection and product/dataset. The higher level of metadata covers the entire data collection: it applies to the series of available datasets (group of features), database, etc. The other level, called product or dataset level metadata, gives specific information about each dataset.

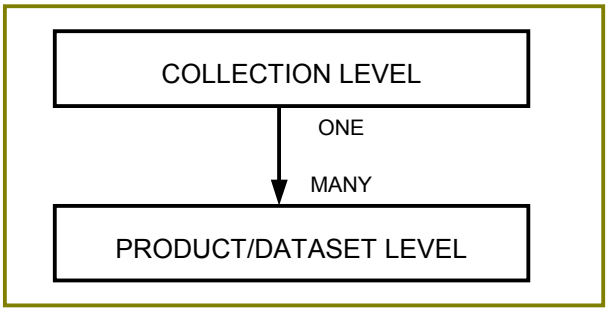

Figure 1: Metadata Levels

The Landsat 7 Orthorectified Imagery metadata are available via GeoBase Portal (in the Data section at http://www.geobase.ca) and GeoConnections Discovery Portal (in the Data section at http://geodiscover.cgdi.ca).

9 Data Portrayal / Data Transfer Format / Physical Model

NOT APPLICABLE

10 Data Delivery

10.1 Format information

The available output file format for the product are: GeoTIFF, BSQ, and PIX which are briefly described in Appendix A.

The packaging method specifies how the item is to be packaged before delivery. Currently two package methods are available, for Windows and for UNIX. PKZIP compression software is used to reduce file size.

A complete Landsat 7 orthoimage is about 400 Mb in size, which can take a fair amount of time to download. Therefore, an orthoimage can be downloaded in entirety or in parts. The available partitions are: north half, south half, east half, west half, northwest quarter, northeast quarter, southwest quarter, and southeast quarter.

10.2 Medium information

The Landsat 7 orthoimage datasets are available on-line via an FTP site. The customer is informed by e-mail when the process is complete and the file is available for transfer.

10.3 Constraints information

The constraints information for data access and data use are defined in the GeoBase Unrestricted Use Licence Agreement (http://www.geobase.ca/ - Data/Licence section).

11 Data Capture and Maintenance

New Landsat 7 orthoimages will be made available to the public as soon as they are produced. The Landsat 7 raw image must be cloud-free (less than 10% of coverage) in Canada before being orthorectified. The production of Landsat 7 orthimages depends on the availability of source control information and the capacity of the originator agency to generate them.

APPENDIX A: File Formats

There are three file formats available for GeoBase Landsat 7 Orthorectified Imagery over Canada: GeoTIFF, BSQ and PIX. Note that all files require image enhancement for best viewing. The 743 composite images (only available in GeoTIFF) have had histogram clipped linear enhancement applied.

GeoTIFF

The GeoTIFF[3] is a Tagged Image File Format. The georeferencing tag permits the addition of geographic information such as projection, datum, and coordinate parameters to imagery or other raster-based data. Adobe Systems (http://www.adobe.com/) holds the copyright for TIFF specifications. GeoTIFF is a highly flexible and platform-independent format supported by numerous software packages. The format specifications for GeoBase Landsat 7 orthorectified imagery in GeoTIFF are uncompressed, 8-bit, band-separated GeoTIFF. The enhanced 743-color composite image is not band separated.

If your viewing software does not recognize one of the tags, the component is simply ignored and the image will be displayed. GeoTIFF files can be viewed using the widest range of software packages and is recommended for non-geomatics professionals.

BSQ

Band Sequential (.bsq) is a binary flat raster image type that can be used by most geomatics software platforms. This format is sometimes referred to as RAW and has no embedded header or trailing information. Though the image file is universal, an accompanying ASCII accessory file with all needed descriptors of the target image file is required. Each geomatics software platform has its own proprietary version of this descriptor file and this simple ASCII file is easy to create in any text editor. Consult your software's help files to find out the layout and key words necessary for use on your system. All necessary parameter information is contained in the metadata or auxiliary file (.aux) that is included with all downloads of GeoBase Landsat 7 orthorectified imagery.

PIX

The .pix format is a proprietary image format from PCI Geomatics Enterprises Inc, (http://www.pcigeomatics.com/). This data format is a self-contained unit that can internally store lookup tables, vector segments, orbital information, and more. Import of pix files into other geomatics software platforms is limited. This format is recommended for owners of PCI Geomatics software.

---

[3] Information about the GeoTIFF standard can be found at: http://www.remotesensing.org/geotiff/geotiff.html.