Natural Resources Canada
Geomatics Canada

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NTDB Correction Matrices (CORMAT)

Product Specifications

Edition 2.00

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

Telephone: 1-800-661-2638 (Canada and the United States)
Fax: (819) 564-5698
E-mail: ntdb@NRCan.gc.ca
Web site: http://www.ctis.nrcan.gc.ca

Canada

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REVISION HISTORY

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April 2002	1.0	Original version – for internal use
July 2003	2.0	Distribution version

FUTURE WORK

Keyword	Description

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ACRONYMS AND ABBREVIATIONS

CORMAT	NTDB Correction Matrices
CTI	Centre for Topographic Information
GRS80	Global Reference System 1980
NAD83	North American Datum of 1983
NRCan	Natural Resources Canada
NTDB	National Topographic Data Base
NTS	National Topographic System
UML	Unified Modeling Language
UTM	Universal Transverse Mercator

TERMS AND DEFINITIONS

Correction Matrix

Set of points distributed on an arrayed grid with the interval of 100 m that covers the entire corresponding NTDB data set. Each grid point describes the planimetric correction (DX, DY) to be applied to the location (X, Y). The corrections do not modify the original edge matching between adjacent files.

DX, DY

Differences for each axis (X and Y) between the position of an object in the geometric reference used and the NTDB. The resultant position is obtained by adding the corrections to the original coordinates $(X, Y)r = (X, Y)o + (DX, DY)$.

Landsat 7 orthoimages

The geometrically corrected Landsat 7 images (orthoimages) are the data sources used to carry out planimetric enhancement of NTDB data sets.

Planimetric Enhancement

Planimetric enhancement consists in modifying the coordinates of NTDB data in order to superimpose entities onto a more accurate data source (geometric reference). The amplitude of the corrections is modeled with control points taken from the geometric reference.

1 Overview

The correction matrices for the National Topographic Data Base (NTDB), also known under the acronym CORMAT, are products derived from the planimetric enhancement of NTDB data sets at the 1:50 000 scale. The correction matrix enables users to enhance the geometric accuracy of the less accurate NTDB. The matrix is a set of points arrayed on a regular 100-m grid. Each point describes the planimetric correction (DX, DY) to be applied at this location. The position of the points is given in UTM (Universal Transverse Mercator projection) coordinates based on the North American Datum of 1983 (NAD83). Each file constitutes a rectangular area covering the entire corresponding NTDB data set. Its delimitation corresponds more or less to National Topographic System (NTS) divisions at the 1:50 000 scale.

All NTDB data sets at the 1:50 000 scale whose original accuracy was less than 30 m should be geometrically corrected by using the Landsat orthoimage as a spatial reference. The enhancement process should last until 2007; the matrices will be made available as work progresses.

The distribution of correction matrices will enable users who already have NTDB data to enhance their accuracy. As a result, they will be able to superimpose their data on Landsat 7 orthoimages used as spatial references. The matrices were created so as to preserve the edge matching of data when correcting adjacent files.

A CORMAT data set contains a list of coordinates and the corresponding corrections to be applied in the form X Y DX DY.

These data sets are delivered in ASCII format for DOS and are available via File Transfer Protocol (FTP). The files are compressed with PKZIP software (.zip).

An interpolation algorithm must be used to adequately correct the data (see Appendix A). Users must ensure that the correction matrix used will allow them to achieve their intended objectives by referring to the associated metadata.

2 Data Identification

2.1 Spatial Resolution (scale)

NTDB correction matrices are not representation data and have no scale as such. Nevertheless, since they are derived from planimetric enhancement of NTDB data sets at the 1:50 000 scale, they serve only to correct the geometry of NTDB data at this scale.

2.2 Language

NOT APPLICABLE - The data set only contains digital values.

2.3 Character Set

The standard character set used for the data is ISO-8859-1.

2.4 Topic Category

The themes describing the data are: location and planimetric enhancement.

2.5 Geographic Box

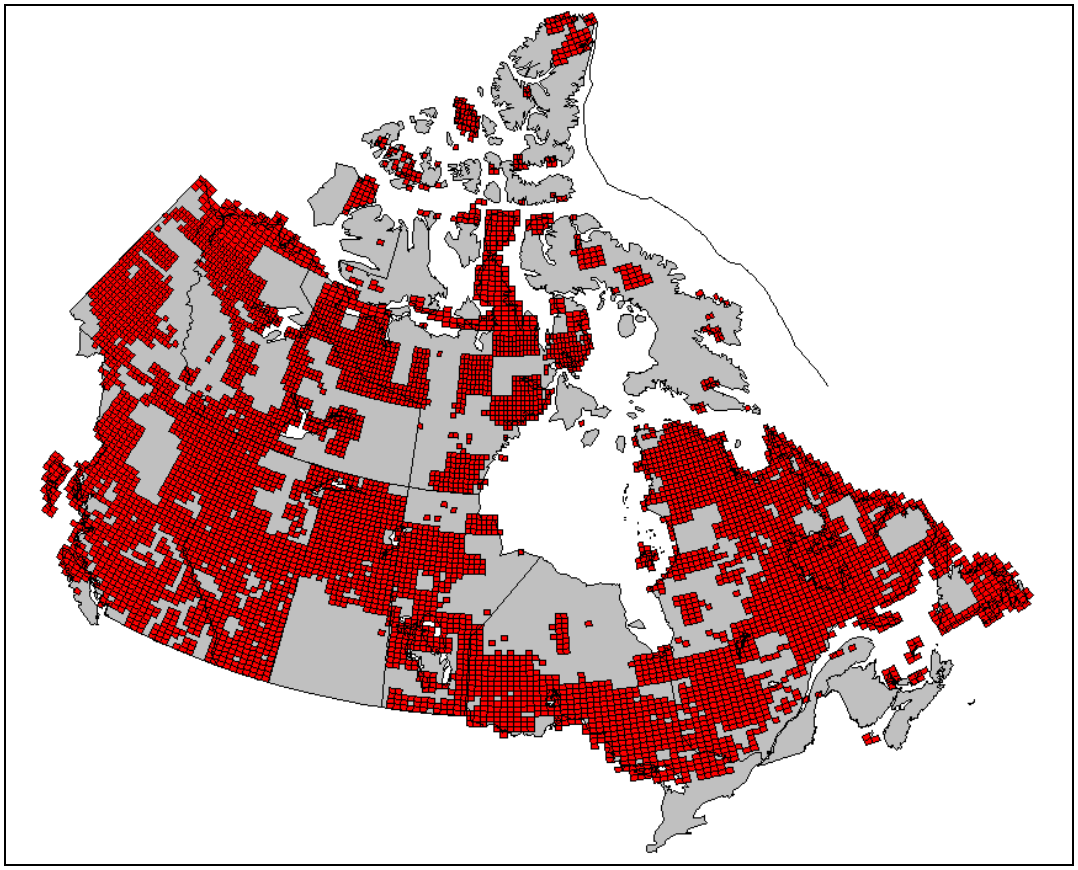
The minimum bounding rectangle for covering all the correction matrices for Canada is defined as:

- North bounding latitude: 84° North (84°)
- South bounding latitude: 41° North (41°)
- East bounding longitude: 52° East (-52°)
- West bounding longitude: 141° East (-141°)

2.6 Geographic Description

The data will be available for continental Canada, where the coverage of NTDB data at the 1:50 000 has an original accuracy of less than 30 m (see Figure 1).

Figure 1
Expected CORMAT coverage



2.7 Extent

The extent of a **correction matrix** (CORMAT) corresponds to a rectangular area defined by the minimum and maximum UTM coordinates of the perimeter of the corresponding uncorrected NTDB data set, increased by 200 m (see Figure 2). Since the matrix uses a Cartesian (X, Y) division system and the NTDB a geographic system, two adjacent matrices overlap slightly (see Figure 3).

In a CORMAT data set, the **positions** or grid intersections are in UTM coordinates (X,Y) rounded off to the nearest 100 m and cover the entire data set. The number of **points** (positions) in a correction matrix varies depending on data set latitude and its position with respect to central meridian in the UTM zone. The points of the correction matrix perimeter are located outside of the NTDB data set to be corrected (see Figure 2).

Each position contains **corrections** that constitute the differences (DX, DY) in metres between the position of an object on the Landsat image used and that of the corresponding object in the NTDB data set. The values vary from -1 200 m to +1 200 m.

Figure 2
Coverage of a correction matrix
(example for NTS map sheet 002C11)

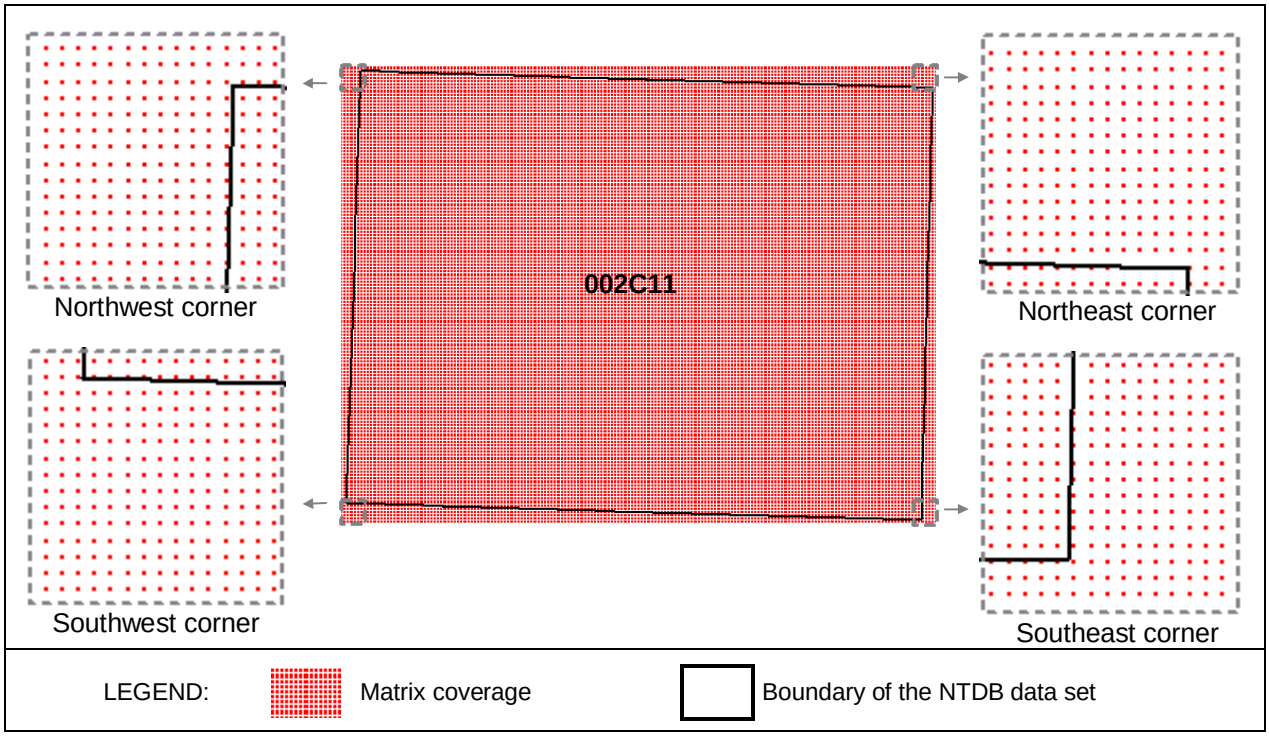
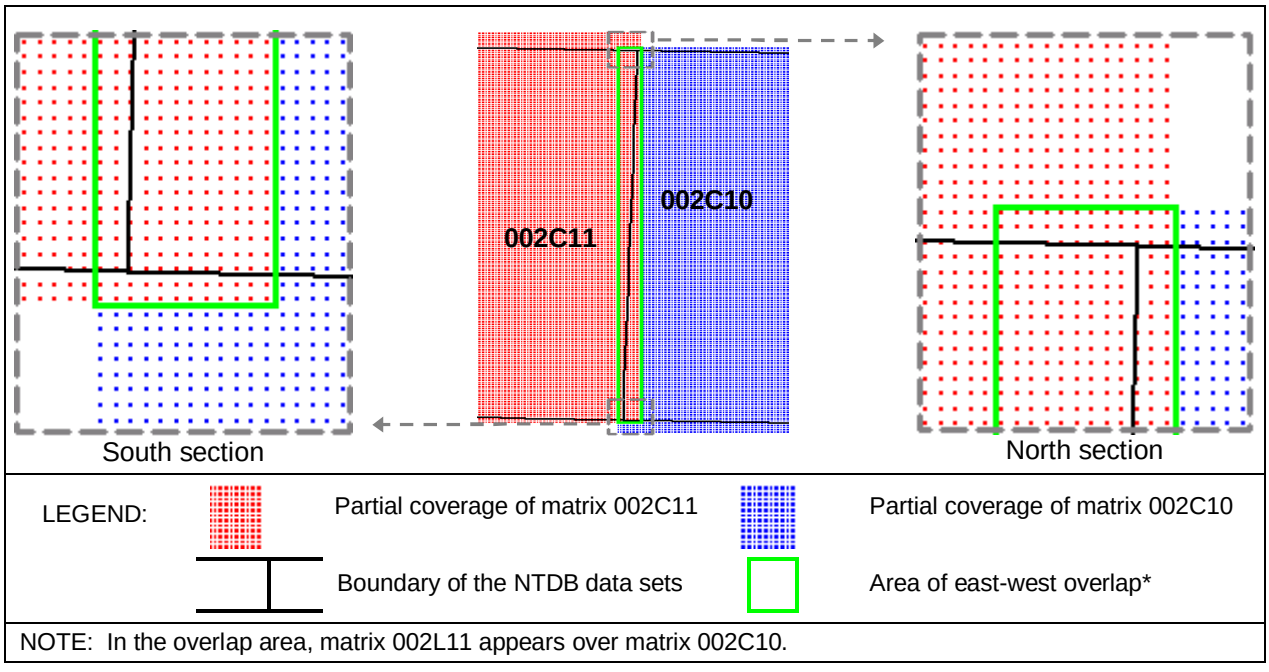


Figure 3
East-west overlap between adjacent correction matrices
(example for NTS map sheets 002C10 and 002C11)



2.8 Planimetric Enhancement of the NTDB

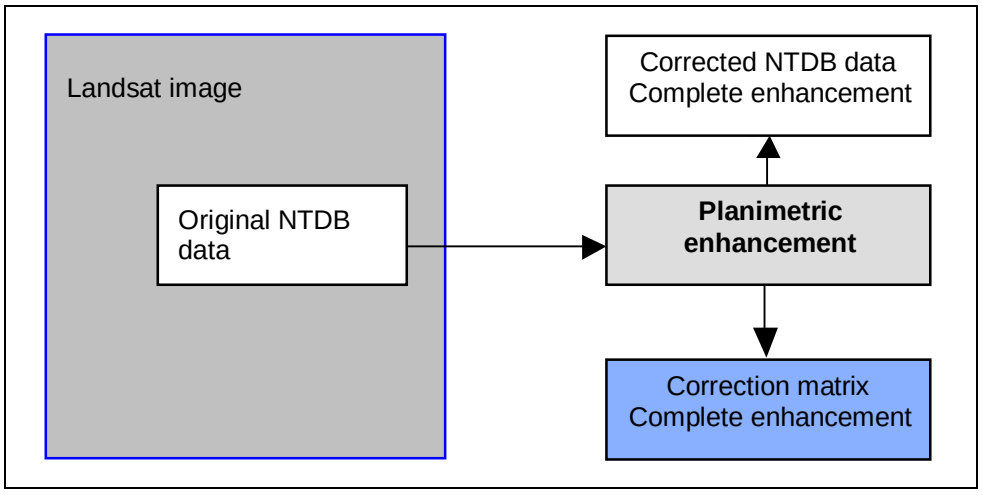
The planimetric enhancement of an NTDB data set consists in modifying the coordinates of entity occurrences in order to superimpose a more accurate data source, such as Landsat 7 orthoimages. The enhancement is carried out by modeling the modifications to be made with control points extracted from the image. The control points are selected from among phenomena that are easily identifiable and whose geographic location has not changed over time. As a result, enhancement improves the file's overall geometric accuracy. Nevertheless, phenomena whose geometry changed between the NTDB capture date and the image capture date, could not be superimposed.

Two types of planimetric enhancement can be applied to NTDB data in accordance with the Landsat orthoimage used to completely or partially cover the NTDB data set. The metadata associated with the corrected NTDB data set (metadata polygon) indicate if the enhancement carried out is complete or partial. All the files will eventually be completely enhanced.

2.8.1 Complete Planimetric Enhancement

The Landsat orthoimage used completely covers the original NTDB data set (see Figure 4). The NTDB data set has therefore been completely enhanced and so has the derived correction matrix.

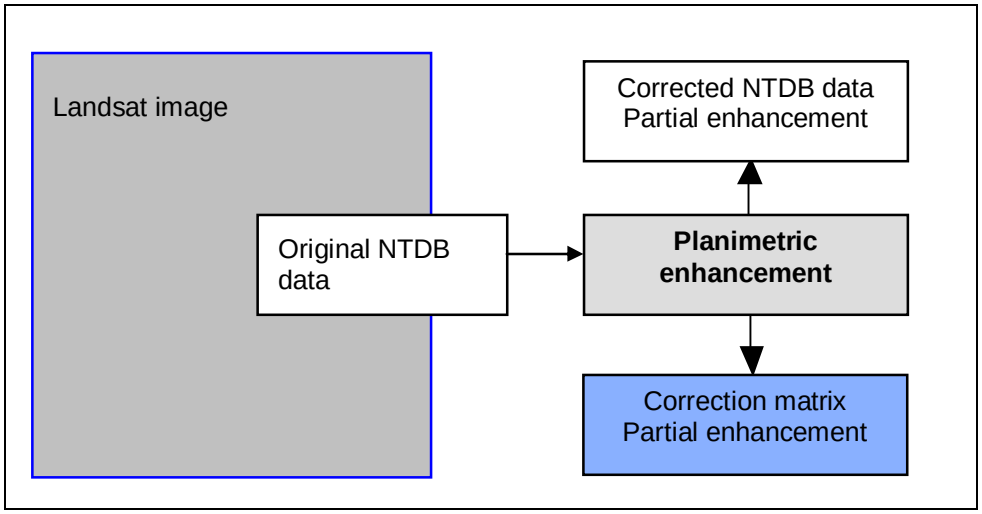
Figure 4
Complete planimetric enhancement



2.8.2 Partial Planimetric Enhancement

The Landsat orthoimage used partially covers the original NTDB data set (see Figure 5). The NTDB data set has therefore been partially enhanced and so has the derived correction matrix. The enhancements will approach zero in the part not covered by the image.

Figure 5
Partial planimetric enhancement



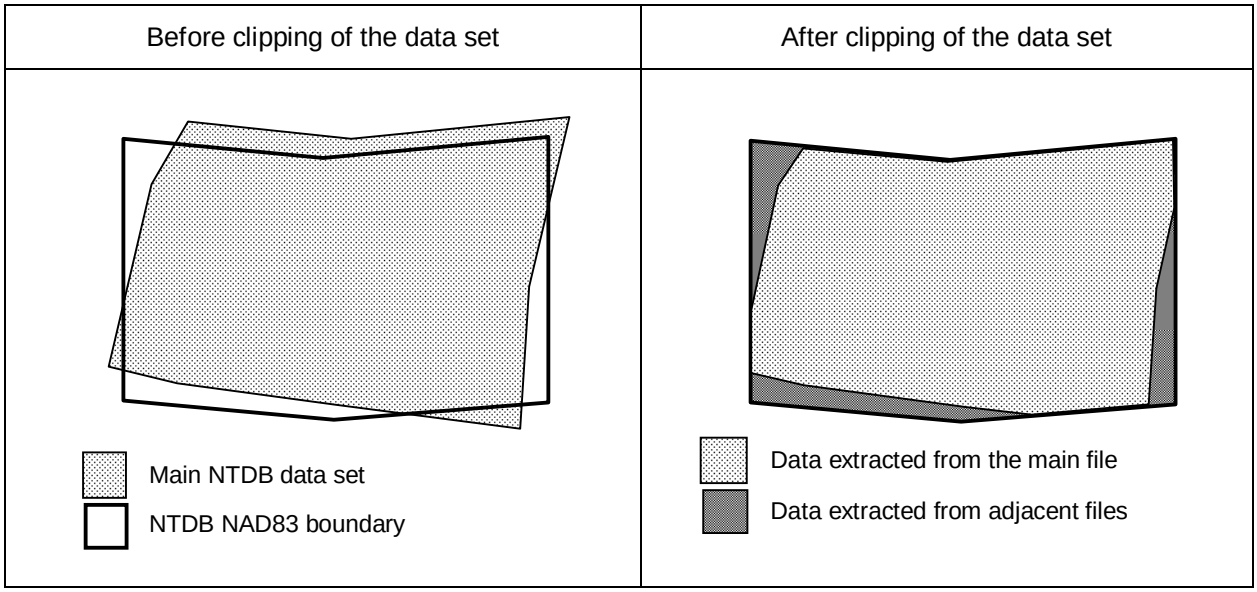
2.9 Edge Matching and Clipping of NTDB Data

Planimetric enhancement moves NTDB data in different directions. This affects the coverage of the original data set, which means that the resultant data set must be delimited so that it complies with territory boundaries (or neatline) (see Figure 6). The process is carried out by restructuring data at the neatline in accordance with NTDB standards (*National Topographic Data Base, Standards and Specifications*, *Edition 3.1).*

In 95% of cases, the accuracy of the original data made it possible to carry out edge matching between adjacent NTDB data sets. Data continuity is unaffected by planimetric enhancement and the subsequent clipping of the data sets. These operations only move entity occurrences along the neatline towards adjacent data sets. The resultant matrix therefore integrally reproduces the enhancement to the NTDB data set.

In the other cases, the accuracy of the original data did not allow for edge matching with the adjacent data sets. The displacements along the neatline have different amplitudes and directions between adjacent data sets. In such instances, the edge matching involves more complex operations in order to ensure continuity of the entities between adjacent data sets. The resultant matrix does not reproduce the differential displacements and the operations carried out along the edge of the NTDB data set.

Figure 6
Clipping of an NTDB data set after planimetric enhancement



2.10 Correction Matrix Uses

Correction matrices are products derived from the planimetric enhancement of NTDB data sets. The correction matrix enables users to enhance the geometric accuracy of less accurate data from the National Topographic Data Base (NTDB) at the 1:50 000 scale. The resultant data sets can then be superimposed on Landsat 7 orthoimages (CanImage product) used as the spatial reference. The correction matrices were created so as to preserve the edge matching of the data when adjacent data sets are corrected.

Each coordinate pair in original NTDB data set has four displacements (DX, DY) within a radius of 100 m in the corresponding correction matrix. The X and Y displacement values to be used can be interpolated from these points. The resultant coordinates are obtained by adding the displacement values to the original coordinates.

The user must refer to the product's metadata in order to assess if the planimetric enhancement can be applied to his own NTDB data.

The correction matrix can be used with data that are not from the original NTDB data set as long as they are for reference and comply with the original tiling.

Some commercial software applications can use planimetric correction matrices. A correction algorithm, however, is described in Appendix A for users who do not have this type of software.

3 Geospatial Characteristics

3.1 Spatial Representation Type

The correction matrix is represented by a series of original location points (in reference to the original NTDB data set) and attributes indicating the displacement to be made.

3.2 Spatial Representation

The correction matrix is comprised of a set of points (for positioning) regularly spaced every 100 m in both directions (abscissa – X and ordinate – Y). Each original point is associated with a displacement vector, that is, a destination point (delta X and delta Y). This is all represented in a file containing tabular data. The user must construct the geometry for the vector points.

3.3 Coverage and Continuity

The correction matrix covers a right rectangle delimited by the minimum and maximum UTM coordinates of the uncorrected NTDB data set at the 1:50 000, increased by 200 m. Since the matrix uses a Cartesian (X, Y) division system and the NTDB a geographic system, adjacent matrices are superimposed by at least 200 m.

The coordinates of the points comprising the correction matrix are in UTM coordinates (X,Y) rounded off to the nearest 100 m. The superimposed points in two adjacent matrices are identical (X, Y, DX, DY).

4 Data Model

4.1 Data Modeling Schema

The data modeling schema used is in UML (*Unified Modeling Language*).

4.2 Application Schema (conceptual model)

CORMAT data are point entities identifying positions in the original NTDB data set that are associated with attributes indicating the displacement to be applied during planimetric correction of the data set. Each CORMAT entity occurrence is unique and independent. There are no relations or associations between CORMAT entities or other external entities. The fields in the CORMAT data file, which are also the attributes for each CORMAT point entity, are given in the following list:

CORMAT ENTITY
X COORDINATE Y COORDINATE DELTA X DELTA Y

5 Data Dictionary / Feature Catalogue

ATTRIBUTE NAME	DATA TYPE (OUTPUT FORMAT)	DESCRIPTION
X COORDINATE	STRING (999999)	The Cartesian X coordinate of the original point expressed in metres in the Universal Transverse Mercator projection (UTM). It is rounded off to the nearest 100 m.
Y COORDINATE	STRING (9999999)	The Cartesian Y coordinate of the original point expressed in metres in the Universal Transverse Mercator projection (UTM). It is rounded off to the nearest 100 m.
DELTA X	STRING (±9999.9)	The displacement (delta) in metres along the X-axis between the X coordinate of the original point and its corrected spatial location.
DELTA Y	STRING (±9999.9)	The displacement (delta) in metres along the Y-axis between the Y coordinate of the original point and its corrected spatial location.

6 Coordinate Reference System

The CORMAT product uses a two-dimensional coordinate reference system (X, Y) according to the Universal Transverse Mercator projection (UTM).

6.1 Horizontal Reference System

The North American Datum of 1983 (NAD83) is used as the horizontal reference system.

6.1.1 Horizontal Coordinate System

The data are stored in Cartesian coordinates (abscissa (X) and ordinate (Y)) expressed according to the UTM projection.

6.1.2 Unit of measure (coordinate system axis units)

The measuring unit for the data is the metre (m). Coordinates are expressed as whole numbers.

For the UTM projection in Canada, scale factor at the central meridian is 0.9996; the longitude of the central meridian is determined by the formula: (180° – λ) / 6° + 1) where λ is the longitude; the latitude of the origin of the projection is 0° (zero); the fictive abscissa (X) is 500 000 m and the fictive ordinate (Y) is 0 m.

6.2 Vertical Reference System

NOT APPLICABLE

7 Data Quality

7.1 Scope

The information about data quality applies to each data set.

7.2 Lineage

Correction matrices are products derived from the planimetric enhancement of NTDB data sets at the 1:50 000. All NTDB data sets whose original accuracy is less than 30 m should eventually undergo planimetric enhancement and the corresponding correction matrices made available.

A geometrically corrected NTDB data set is superimposed on the CanImage product using Landsat 7 orthoimages. Since the accuracy of Landsat 7 orthoimages is generally greater than 30 m, the resultant data has significantly higher accuracy. The accuracy of the resultant orthoimages and data is rigorously established and entered in their respective metadata. Particular attention was given to the quality of the superimposition of the resultant NTDB data and orthoimages used.

7.3 Completeness

All CORMAT entity occurrences located within the planimetric boundaries (X, Y) in a CORMAT file are present as well as their attributes.

7.4 Logical Consistency

The data comply fully with the conceptual schema, the domain of values, the format, and topological features described in these product specifications.

7.5 Positional Accuracy

The position of CORMAT entity occurrences depends on that in the original NTDB data set.

The resultant absolute matrix accuracy (MAA90%) is calculated by combining the absolute accuracy of the Landsat orthoimage (LAA90%) to the relative accuracy of the planimetric enhancement (ERA90%).

$$MAA90\% = (LAA90\%^2 + ERA90\%^2)^{1/2}$$

The relative planimetric accuracy is measured with a representative random sampling of the superimposition differences between the orthoimage and the resultant NTDB data sets. The assessment is carried on groups of nine data sets. The maximum acceptable value for accidental error is 15 m. The maximum acceptable value for bias is 7.5 m.

Each file is systematically examined to detect any outliers.

Given the density of points in the correction matrix, the interpolation discrepancies between different software are negligible.

7.6 Temporal Accuracy

No time measurement is available for correction matrices since they are associated with the data capture date.

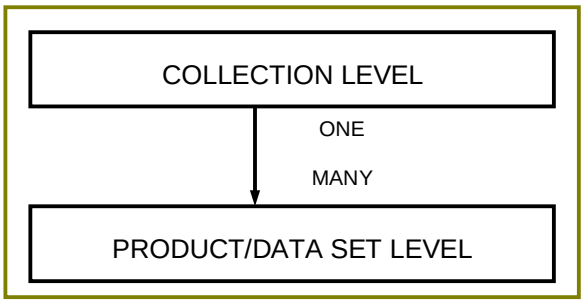
7.7 Thematic (attributes) Accuracy

NOT APPLICABLE

8 Metadata

There are normally two levels of metadata to describe a product, as indicated in the figure below: *collection* and *product/data set*. The upper level of metadata covers the entire data collection: it applies to the series of available data sets (entities groups), to the database, etc. The other level, called *product or data set,* contains the information specific to each data set.

Figure 7
Metadata levels



CORMAT collection and data set metadata are solely available online from the CTI Web site (http://www.ctis.NRCan.gc.ca - See section on Digital Topographic Data / NTDB Correction Matrices).

9 Data Portrayal / Data Transfer Format / Physical Model

9.1 Conversion Process

At the end of the conversion process, the data are sorted in ascending rank according to the ordinate (Y) values, then the abscissa (X) values. The points in the data set are sorted from the southwest corner to the northeast corner.

9.2 Files

The pattern for CORMAT file names is: <NTS>_<ed><ver>_MATCOR.txt. The NTS number follows the pattern 999A99; the data set edition (<ed>) and version (<ver>) are added in the format 9999 (e.g. 002C12_0100_MATCOR.txt).

9.3 Directories

NOT APPLICABLE

10 Data Delivery

10.1 Format Information

Data sets are in ASCII format. An example of a CORMAT ASCII file is given in Appendix B. PKZIP compression software is used to reduce file size.

The average size of a correction matrix ranges from 3 to 5 MB.

10.2 Medium Information

The files are available directly online via the CTI FTP site.

10.3 Constraints Information

The information related to constraints affecting data access and use is provided in NRCan's unrestricted use agreement (See section on Digital Topographic Data / NTDB Correction Matrices at http://www.cits.rncan.gc.ca/).

11 Data Capture and Maintenance

The production (acquisition) of CORMAT data sets depends on the availability of source data (NTDB data sets, Landsat°7 images, and so on) and CTI production capacity (human and financial resources).

While these data will not be maintained or updated, non-compliant data sets and those containing anomalies will be corrected and replaced.

APPENDIX A: Bilinear Interpolation Algorithm for Planimetric Correction

```
Definitions of the Mnemonics Used

XMAX    Maximum X coordinate in the correction matrix
XMIN    Minimum X coordinate in the correction matrix
SQRT    Square root function
R100    Function rounded off to the nearest 100 units (100=R100(149.5), 200=R100(150.0))
READ    Read function


For each coordinate (X, Y) in the original NTDB data set...;

Define the coordinates of the four adjacent points in the matrix;
   CX[1]=R100(X-49.5); CX[2]=R100(CX[1]);  CX[3]=R100(X+49.5); CX[4]=R100(CX[3]);
   CY[1]=R100(Y+49.5); CY[2]=R100(Y-49.5); CY[3]=R100(CY[2]);  CY[4]=R100(CY[1]);

   Processing loop for the four adjacent points "P" (P=1 to 4);
      Find the line "LINE" which contains the point "P" in the matrix;
      LINE=1 + (CX[P]-XMIN)/100 + (CY[P]-YMIN)/(XMAX-XMIN+100);

      Read the point "P" from the line "LINE" in the correction matrix;
      READ(CX[P] CY[P] DX[P] DY[P]);

      Calculate the weighting factor associated with the point "P";
      WG[P]=1-(SQRT((X-CX[P])**2 + (Y-CY[P])**2)/SQRT(100**2 + 100**2));
   End loop;

   Interpolation of the correction to be made;
   SUMWX=DX[1]*WG[1] + DX[2]*WG[2] + DX[3]*WG[3] + DX[4]*WG[4];
   SUMWY=DY[1]*WG[1] + DY[2]*WG[2] + DY[3]*WG[3] + DY[4]*WG[4];

   SUMW= WG[1] + WG[2] + WG[3] + WG[4];

   DXBL=SUMWX/SUMW;
   DYBL=SUMWY/SUMW;

   Planimetric correction of the coordinates with the interpolated value;
   X=X+DXBL;  Y=Y+DYBL;
```

APPENDIX B: Example of an NTDB Correction Matrix in ASCII Format

Extract from file 002C11

```
315100 5373600   -11.5     7.3 (southwest corner)
315200 5373600    -9.3     8.3
315300 5373600    -5.9     9.8
315400 5373600    -2.9    11.2
315500 5373600     0.2    12.6
315600 5373600     0.5    12.4
315700 5373600     0.6    12.2
315800 5373600     0.7    11.9
315900 5373600     0.9    11.5
316000 5373600     1.0    11.1

... (362 points)

352300 5373600    13.0    28.9
352400 5373600    14.8    26.8
352500 5373600    15.0    26.6
352600 5373600    15.0    26.5
352700 5373600    15.5    25.9
352800 5373600    16.0    25.3
352900 5373600    16.5    24.7
353000 5373600    16.9    24.1
353100 5373600    17.4    23.4
353200 5373600    17.9    22.8 (southeast corner)

... (111 544 points)

315100 5402900   -31.0   -16.4 (northwest corner)
315200 5402900   -31.0   -16.5
315300 5402900   -30.9   -16.5
315400 5402900   -30.9   -16.6
315500 5402900   -30.9   -16.7
315600 5402900   -30.8   -16.8
315700 5402900   -30.8   -16.9
315800 5402900   -30.8   -17.0
315900 5402900   -30.7   -17.1
316000 5402900   -28.1   -18.7

... (362 points)

352300 5402900    81.2   -75.0
352400 5402900    81.2   -75.0
352500 5402900    81.2   -75.0
352600 5402900    80.6   -74.2
352700 5402900    77.7   -69.7
352800 5402900    75.8   -66.7
352900 5402900    73.3   -62.9
353000 5402900    70.8   -59.1
353100 5402900    68.4   -55.4
353200 5402900    66.6   -52.6 (northeast corner)
```

NOTES

- This file contains a total of 112 308 points (382 X by 294 Y).
- This file covers 38 100 m (east-west direction) by 29 300 m (north-south direction).