INTERNATIONAL HYDROGRAPHIC ORGANIZATION

# USER's HANDBOOK

# ON

# DATUM TRANSFORMATIONS

# INVOLVING WGS 84

**3rd Edition, July 2003**
**(Last correction August 2008)**

**Special Publication No. 60**

**Published by the**
**International Hydrographic Bureau**
**MONACO**

**S-60**

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## TABLE OF CONTENTS



**APPENDICES**

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# PREFACE

IHO Publication S-60 USER'S HANDBOOK ON DATUM TRANSFORMATIONS INVOLVING WGS-84, contains transformation constants and formulas to relate local/regional geodetic datums to WGS-84. S-60 has been derived from a comprehensive Technical Report (TR8350.2, 3rd edition, 4 July 1997, corrected to 6/03) published by the National Imagery and Mapping Agency (NIMA) of the United States and kindly provided to the IHB to be published as an IHO Special Publication.

Reproduction of formulas, transformation constants and related local/regional datums does not imply that these data have been officially adopted by the concerned States or by the IHO. However the IHO strongly supports any move to reference charts to WGS-84. Member States are encouraged to refine their own transformation parameters and to report these to the IHB.

The US NIMA will continue to maintain the Technical Report from which S-60 has been produced . Corrections to the transformation constants and formulas will be published on the NIMA website (see below) and incorporated in S-60 in due course.

Users requiring a copy of the complete NIMA Technical report should contact:

Director
National Imagery and Mapping Agency
ATTN: ISDFR, Mail Stop D-82
4600 Sangamore Road
Bethesda, MD 20816-5003
USA
Fax: +1 301 226 7649

An electronic version of the complete Technical Report and corrections can be downloaded from http://www.nima.mil

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## 1. INTRODUCTION

IHO Technical Resolution B2.10 recommends that transformation notes be applied to all charts at scales larger than 1:500 000 to enable the navigator to use directly or to convert to chart datum and vice versa satellite-derived geographical positions which are in the World Geodetic System (WGS). The determination of the adjustment necessary to convert a position from the WGS 84 to the chart datum requires use of datum transformation constants which, by IHO Technical Resolution B1.1, are to be published by the International Hydrographic Bureau.

Hydrographers or their topographic mapping counterparts may through national efforts, obtain geodetic data in port areas from which the specific values for the appropriate datum transformation notes for their charts can be derived. Such values may differ from those obtained by use of the parameters listed in this publication. Where that is the case, use of these specific observation derived values may be more appropriate. Indeed, as the NIMA Technical Report points out, the most accurate approach for obtaining the WGS 84 data or coordinates is to acquire satellite positions and the related data at the site of interest.

Where such specific data exist, or where additional information on datums and ellipsoids used in local charts is held, IHO Member States are requested to inform the IHB and share that information in order that improved or additional datums transformation constants can be developed. Further, as the datum(s) utilized in the charts may not always be easily or clearly defined, cartographers are urged to take advice of geodetic experts when selecting methods appropriate to their specific datum transformation problem(s).

The ellispsoidal constants (a and 1/f) for the local datums, used to compute transformation constants, are given in Appendix A.

Appendix B lists the geodetic datums (reference systems) related to WGS 84 through satellite ties and the associated transformation parameters.

Appendix C lists transformation constants which were derived through non-satellite-ties.

Appendix D provides the Multiple Regression Equations parameters for continental size datums and for contiguous large land areas.

Appendix E provides formulas and transformation parameters to convert WGS 72 coordinates to WGS 84 coordinates.

Appendix F contains a list cross-referencing the identifications for local (regional) datums used in IHO Special Publication No. 57 (S-57) and in this publication.

## 2. WGS 84 COORDINATE SYSTEM

### 2.1 Definition

The WGS 84 Coordinate System is a Conventional Terrestrial Reference System (CTRS). The definition of this coordinate system follows the criteria outlined in the International Earth Rotation Service (IERS) Technical Note 21. These criteria are repeated below:

- It is geocentric, the center of mass being defined for the whole Earth including oceans and atmosphere.

- Its scale is that of the local Earth frame, in the meaning of a relativistic theory of gravitation.

- Its orientation was initially given by the Bureau International de l'Heure (BIH) orientation of 1984.0.

- Its time evolution in orientation will create no residual global rotation with regards to the crust.

The WGS 84 Coordinate System is a right-handed, earth fixed orthogonal coordinate system and is graphically depicted in Figure 2.1.

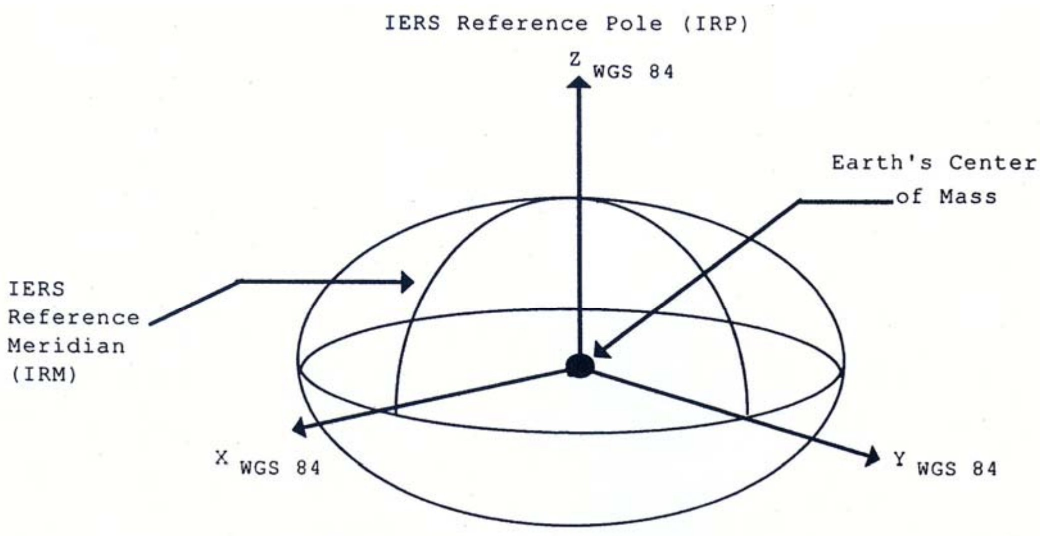


**Figure 2.1** The WGS 84 Coordinate System Definition

In Figure 2.1, the origin and axes are defined as follows:

Origin = Earth's center of mass

Z-Axis = The direction of the IERS Reference Pole (IRP). This direction corresponds to the direction of the BIH Conventional Terrestrial Pole (CTP) (epoch 1984.0) with an uncertainty of 0.005".

X-Axis = Intersection of the IERS Reference Meridian (IRM) and the plane passing through the origin and normal to the Z-Axis. The IRM is coincident with the BIH Zero Meridian (epoch 1984.0) with an uncertainty of 0.005".

Y-Axis = Completes a right-handed, Earth-Centered Earth-Fixed (ECEF) orthogonal coordinate system.

The WGS 84 Coordinate System origin also serves as the geometric center of the WGS 84 Ellipsoid and the Z-Axis serves as the rotational axis of this ellipsoid of revolution.

Readers should note that the definition of the WGS 84 CTRS has not changed in any fundamental way. This CTRS continues to be defined as a right-handed, orthogonal and Earth-fixed coordinate system which is intended to be as closely coincident as possible, with the CTRS defined by the International Earth Rotation Service (IERS) or, prior to 1988, its predecessor, the Bureau International de l'Heure (BIH).

## 2.2 Realization

An important distinction is needed between the definition of a coordinate system and the practical realization of a reference frame. Section 2.1 contains a definition of the WGS 84 Coordinate System. To achieve a practical realization of a global geodetic reference frame, a set of station coordinates must be established. A consistent set of station coordinates infers the location of an origin, the orientation of an orthogonal set of Cartesian axes, and a scale. In modern terms, a globally distributed set of consistent station coordinates represents a realization of an Earth-Centered Earth-Fixed (ECEF) Terrestrial Reference Frame (TRF). The original WGS 84 reference frame established in 1987 was realized through a set of Navy Navigation Satellite System (NNSS) or TRANSIT (Doppler) station coordinates.

The main objective in the original effort was to align, as closely as possible, the origin, scale and orientation of the WGS 84 frame with the BIH Terrestrial System (BTS) frame at an epoch of 1984.0. The set of estimated station coordinates put into practical use had an uncertainty of 1-2 meters with respect to the BTS.

Several independent studies have demonstrated that a systematic ellipsoid height bias (scale bias) exists between GPS-derived coordinates and Doppler-realized WGS 84 coordinates for the same site. This scale bias is most likely attributable to limitations in the techniques used to estimate the Doppler-derived positions. To remove this bias and obtain a self-consistent GPS-realization of the WGS 84 reference frame, DMA (the precursor of NIMA), with assistance from the Naval Surface Warfare Center Dahlgren Division (NSWCDD), developed a revised set of station coordinates for the GPS tracking network. These revised station coordinates provided an improved realization of the WGS 84 reference frame. To date, this process has been carried out twice, once in 1994 and again in 1996.

The two sets of self-consistent GPS-realized coordinates (Terrestrial Reference Frames) derived to date have been designated "WGS 84 (G730)" and "WGS 84 (G873)". The "G" indicates these coordinates were obtained through GPS techniques and the number following the "G" indicates the GPS week number when these coordinates were implemented in the NIMA precise ephemeris estimation process.

In summary, these improved station coordinate sets, in particular. WGS 84 (G873), represent the most recent realization(s) of the WGS 84 reference frame. Further improvements and future realizations of the WGS 84 reference frame are anticipated. As these changes occur, NIMA will take steps to ensure that the highest possible degree of fidelity is maintained and changes are identified to the appropriate organizations using the naming conventions described above.

### 2.3 Agreement with the ITRF

The WGS 84 (G730) reference frame was shown to be in agreement, after the adjustment of a best fitting 7-parameter transformations, with the ITRF92 at a level approaching 10 cm. While similar comparisons of WGS 84 (G873) and ITRF94 are still underway, extensive daily orbit comparisons between the NIMA precise ephemerides (WGS 84 (G873) reference frame) and corresponding IGS ephemerides (ITR94 reference frame) reveal systematic differences no larger than 2cm.

## 3. WGS 84 ELLIPSOID

Global geodetic applications require three different surfaces to be clearly defined. The first of these is the Earth's topographic surface. This surface includes the familiar landmass topography as well as the ocean bottom topography. In addition to this highly irregular topographic surface, a definition is needed for a geometric or mathematical reference surface, the ellipsoid, and an equipotential surface called the geoid.

While selecting the WGS 84 Ellipsoid and associated parameters, the original WGS 84 Development Committee decided to closely adhere to the approach used by the International Union of Geodesy and Geophysics (IUGG), when the latter established and adopted Geodetic Reference System 1980 (GRS 80). Accordingly, a geocentric ellipsoid of revolution was taken as the form for the WGS 84 Ellipsoid. The parameters selected to originally define the WGS 84 Ellipsoid were the semi-major axis (a), the Earth's gravitational constant (GM), the normalized second degree zonal gravitational coefficient ($\overline{C}_{2,0}$) and the angular velocity ($\omega$) of the Earth. These parameters are identical to those of the GRS 80 Ellipsoid with one minor exception.

In 1993, two efforts were initiated which resulted in significant refinements to these original defining parameters. The first refinement occurred when DMA recommended a refined value for the GM parameter. In 1994, this improved GM parameter was recommended for use in all high-accuracy orbit determination applications. The second refinement occurred when the joint NIMA/NASA Earth Gravitational Model 1996 (EGM96) project produced a new estimated dynamic value for the second degree zonal coefficient.

A decision was made to retain the original WGS 84 Ellipsoid semi-major axis and flattening values (a = 6378137.0 m, and 1/f = 298.257223563). For this reason the four defining parameters were chosen to be: a, f, GM and $\omega$. Further details regarding these parameters can be found in the complete Technical Report published by NIMA.

## 4. WGS 84 RELATIONSHIPS WITH OTHER GEODETIC SYSTEMS

### 4.1 General

One of the principal purposes of a world geodetic system is to eliminate the use of local horizontal geodetic datums. Although the number of local horizontal geodetic datums, counting island and astronomic-based datums, exceeds several hundred, the number of local horizontal datums in current use is significantly less and continues to decrease. Until a global geodetic datum is accepted, used and implemented worldwide, a means to convert between geodetic datums is required. To accomplish the conversion, local geodetic datum and WGS coordinates are both required at one or more sites within the local datum area so that a local geodetic datum to WGS datum shift can be computed. Satellite stations positioned within WGS 84, with known local geodetic datum coordinates, were the basic ingredients in the development of local geodetic datum to WGS 84 datum shifts.

Local horizontal datums were developed in the past to satisfy mapping and navigation requirements for specific regions of the earth. In the past couple of decades, development of global geocentric datums has become possible; WGS 84 and the ITRF are examples of such datums.

The most accurate approach for obtaining WGS 84 coordinates is to acquire satellite tracking data at the site of interest and position it directly in WGS 84 using GPS positioning techniques. Direct occupation of the site is not always possible or warranted. In these cases, a datum transformation can be used to convert coordinates from the local system to WGS 84.

### 4.2 Relationship of WGS 84 to the ITRF

As outlined under 2.3, the WGS 84 is consistent with ITRF. The differences between WGS 84 and ITRF are in the centimeter range worldwide. Therefore, for all mapping and charting purposes, they can be considered the same.

In recent years, some countries and regions have been converting to datums based on the ITRF. Such national or regional datums that are rigorously based on the ITRF can also be considered as identical to WGS 84. An example of such a datum is the European Terrestrial Reference Frame' 1989 (ETRF89).

### 4.3 Local Geodetic Datum to WGS 84 Datum Transformations

For most applications involving maps, charts, navigation and geospatial information, WGS 84 coordinates will be obtained from a Local Geodetic Datum to WGS 84 Datum Transformation. This transformation can be performed in curvilinear (geodetic) coordinates:

$$\phi_{WGS\ 84} = \phi_{Local} + \Delta\phi$$

$$\lambda_{WGS\ 84} = \lambda_{Local} + \Delta\lambda$$

$$h_{WGS\ 84} = h_{Local} + \Delta h$$

where $\Delta\phi$, $\Delta\lambda$, $\Delta h$ are provided by the Standard Molodensky transformation formulas:

$$\Delta\phi'' = \{- \Delta X \sin\phi \cos\lambda - \Delta Y \sin\phi \sin\lambda + \Delta Z \cos\phi + \Delta a (R_N e^2 \sin\phi \cos\phi)/a + \Delta f [R_M (a/b) + R_N (b/a] \sin\phi \cos\phi\} \bullet [(R_M + h) \sin 1''\ ]^{-1}$$

$$\Delta\lambda'' = [- \Delta X \sin\lambda + \Delta Y \cos\lambda\ ] \bullet [(R_N + h) \cos\phi \sin 1''\ ]^{-1}$$

$$\Delta h = \Delta X \cos\phi \cos\lambda + \Delta Y \cos\phi \sin\lambda + \Delta Z \sin\phi - \Delta a\ (a/R_N) + \Delta f\ (b/a)\ R_N \sin^2\phi$$

Where: $\phi$, $\lambda$, h = geodetic coordinates (old ellipsoid)

$\phi$ = geodetic latitude. The angle between the plane of the geodetic equator and the ellipsoidal normal at a point (measured positive north from the geodetic equator, negative south).

$\lambda$ = geodetic longitude. The angle between the plane of the Zero Meridian and the plane of the geodetic meridian of the point (measured in the plane of the geodetic equator, positive from 0° to 180° E, and negative from 0° to 180°W).

h = N + H

where:

| | | |
|---|---|---|
| h | = | geodetic height (height relative to the ellipsoid) |
| N | = | geoid height (geoid undulation) |
| H | = | orthometric height (height relative to the geoid) |
| $\Delta\phi$, $\Delta\lambda$, $\Delta h$ | = | corrections to transform local geodetic datum coordinates to WGS 84 $\phi$, $\lambda$, h values. **The units of $\Delta\phi$ and $\Delta\lambda$ are arc seconds ("); the units of $\Delta h$ are meters (m).** |

NOTE: AS "h's" ARE NOT AVAILABLE FOR LOCAL GEODETIC DATUMS, THE $\Delta h$ CORRECTION WILL NOT BE APPLICABLE WHEN TRANSFORMING TO WGS 84.

$\Delta X$, $\Delta Y$, $\Delta Z$ = shifts between centers of the local geodetic datum and WGS 84 ellipsoid; corrections to transform local geodetic system-related rectangular coordinates (X, Y, Z) to WGS 84 related X, Y, Z values.

a = semi-major axis of the local geodetic datum ellipsoid.

b = semi-minor axis of the local geodetic datum ellipsoid.

b/a = 1 – f

f = flattening of the local geodetic datum ellipsoid.

$\Delta a$, $\Delta f$ = differences between the semi-major axis and flattening of the local geodetic datum ellipsoid and the WGS 84 ellipsoid, respectively (WGS 84 minus Local).

$e$ = first eccentricity.

$e^2 = 2f - f^2$

$R_N$ = radius of curvature in the prime vertical.

$R_N = a/(1 - e^2 \sin^2 \phi)^{1/2}$

$R_M$ = radius of curvature in the meridian.

$R_M = a(1 - e^2)/(1 - e^2 \sin^2 \phi)^{3/2}$

NOTE: All Δ-quantities are formed by subtracting local geodetic datum ellipsoid values from WGS 84 Ellipsoid values.

Appendix A lists the reference ellipsoid names and parameters (semi-major axis and flattening) for local datums currently tied to WGS 84 and used for generating datum transformations.

Appendix B contains horizontal transformation parameters for the geodetic datums/systems which have been generated from satellite ties to the local geodetic control. Due to the errors and distortion that affect most local geodetic datums, use of mean datum shifts (ΔX, ΔY, ΔZ) in the Standard Molodensky datum transformation formulas may produce results with poor quality of "fit". Improved fit between the local datum and WGS 84 may result only with better and more dense ties with local or regional control points.

Updates to the datum transformation parameters are identified through the use of cycle numbers and issue dates. Cycle numbers have been set to the numerical value of zero for all datum transformations appearing in the August 1993 Insert 1 and the WGS 84 TR8350.2 Second Edition. All new datums transformations will carry a cycle number of zero. As updates are made the cycle number will increment by one.

Datum transformation shifts derived from non-satellite information are listed in Appendix C.

### 4.4 Datum Transformation Multiple Regression Equations (MRE)

The development of Local Geodetic Datum to WGS 84 Datum Transformation Multiple regression Equations was initiated to obtain better fits over continental size land areas than could be achieved using the Standard Molodensky formula with datum shifts (ΔX, ΔY, ΔZ).

For Δϕ, the general form of the Multiple Regression Equation is:

$$\Delta\phi = A_0 + A_1 U + A_2 V + A_3 U^2 + A_4 UV + A_5 V^2 + \ldots + A_{99} U^9 V^9 \quad (4 - 1)$$

Where:

$A_0$ = constant

$A_0, A_1, \ldots A_{n\,n}$ = coefficients determined in the development.

$U = K(\phi - \phi_m)$ = normalized geodetic latitude of the computation point.

$V = k(\lambda - \lambda_m)$ = normalized geodetic longitude of the computation point.

K = scale factor, and degree-to-radian conversion.

$\phi, \lambda$ = local geodetic latitude and local geodetic longitude (in degrees), respectively, of the computation point.

$\phi_m, \lambda_m$ = mid-latitude and mid-longitude values, respectively, of the local geodetic datum area (in degrees).

Similar equations are obtained for $\Delta\lambda$ and $\Delta h$ by replacing $\Delta\phi$ in the left portion of Equation (4-1) by $\Delta\lambda$ and $\Delta h$, respectively.

Local geodetic datum to WGS 84 Datum Transformation Multiple regression equations for seven major continental size datums, covering contiguous continental size land areas with large distortion, are provided in Appendix D. The main advantage of MREs lies in modeling of distortion for better fit in geodetic applications. However, caution must be used to ensure that MREs are not extrapolated outside of the area of intended use. Large distortions can be realized in very short distances outside of the area where the stations that were used in the development of the MREs exist.

## 5. ACCURACY OF WGS 84 COORDINATES

Numerous techniques now exist to establish WGS 84 coordinates for a given site. The accuracy and precision achieved by these various techniques vary significantly. The most common, currently-available techniques are listed below:

- General geodetic solution for station coordinates, orbits, and other parameters of interest.
- Direct geodetic point positioning at a stationary, solitary station using a "geodetic quality", dual frequency GPS receiver and NIMA Precise Ephemerides and Satellite Clock states (note that the effects of Selective Availability (SA) must be removed).
- Same as above but using the Broadcast GPS Ephemerides and Clock States.
- GPS differential (baseline) processing from known WGS sites
- GPS Precise Positioning Service (PPS) navigation solutions
  - Instantaneous
  - Mean over some averaging interval
- Photogrammetrically-derived coordinates
- Map-derived coordinates from digital or paper products

Clearly, the above positioning techniques do not provide WGS 84 coordinates with uniform accuracy and statistical properties. Even within a given technique, accuracy variations can occur, due for example to the treatment of certain error sources such as the troposphere. Because of these variations and periodic algorithm improvements, full, characterization of the accuracy achieved by all the above techniques would be quite challenging and beyond the scope of this document.

Other techniques which are based on older, previously-established survey coordinates can also yield "WGS 84" coordinates with limited accuracy. These techniques may be suitable for certain mapping applications but must be treated very cautiously if a high level of accuracy is required. Some of these alternate techniques to obtain WGS 84 coordinates are listed below:

- TRANSIT Point Positioning directly in WGS 84 ($1\sigma$ = 1-2m)
- TRANSIT Point Positions transformed from NSWC-9Z2
- GPS differential (baseline) processing from a known (TRANSIT-determined) WGS 84 geodetic point position.
- By a WGS 72 to WGS 84 Coordinate Transformation.
- By a Local Geodetic Datum to WGS 84 Datum Transformation.

Because geospatial information often originates from multiple sources and processes, the absolute accuracy of a given WGS 84 position becomes very important when information from these various sources is combined in "Geographic Information Systems" or "geospatial databases". Because of their high fidelity, **surveyed** WGS 84 geodetic control points can often serve to improve or validate the accuracy of maps, image products or other geospatial information. Even GPS navigation solutions can serve a similar role, as long as the accuracy of these solutions is well-understood.

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# APPENDIX A

## LIST OF REFERENCE ELLIPSOID NAMES AND PARAMETERS (USED FOR GENERATING DATUM TRANSFORMATIONS)

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# REFERENCE ELLIPSOIDS
# FOR
# LOCAL GEODETIC DATUMS

## 1. GENERAL

This appendix lists the reference ellipsoids and their constants (a,f) associated with the local geodetic datums which are tied to WGS 84 through datum transformation constants and/or MREs (Appendices B, C, and D).

## 2. CONSTANT CHARACTERSTICS

In Appendix A.1, the list of ellipsoids includes a new feature. Some of the reference ellipsoids have more than one semi-major axis (a) associated with them. These different values of axis (a) vary from one region or country to another or from one year to another within the same region or country.

A typical example of such an ellipsoid is Everest whose semi-major axis (a) was originally defined in yards. Here, changes in the yard to meter conversion ratio over the years have resulted in five different values for the constant (a), as identified in Appendix A.1.

To facilitate correct referencing, a standardized two letter code is also included to identify the different ellipsoids and/or their "versions" pertaining to the different values of the semi-major axis (a).

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**Appendix A.1**

Reference Ellipsoid Names and Constants
Used for Datum Transformations*

| Reference Ellipsoid Name | ID Code | a (Meters) | $f^{-1}$ |
|---|---|---|---|
| Airy 1830 | AA | 6377563.396 | 299.3249646 |
| Australian National | AN | 6378160 | 298.25 |
| Bessel 1841 | | | |
| Ethiopia, Indonesia, Japan, and Korea | BR | 6377397.155 | 299.1528128 |
| Namibia | BN | 6377483.865 | 299.1528128 |
| Clarke 1866 | CC | 6378206.4 | 294.9786982 |
| Clarke 1880** | CD | 6378249.145 | 293.465 |
| Everest | | | |
| Brunei and E. Malaysia (Sabah and Sarawak) | EB | 6377298.556 | 300.8017 |
| India 1830 | EA | 6377276.345 | 300.8017 |
| India 1956*** | EC | 6377301.243 | 300.8017 |
| Pakistan*** | EF | 6377309.613 | 300.8017 |
| W. Malaysia and Singapore 1948 | EE | 6377304.063 | 300.8017 |
| W. Malaysia 1969*** | ED | 6377295.664 | 300.8017 |
| Geodetic Reference System 1980 | RF | 6378137 | 298.257222101 |
| Helmert 1906 | HE | 6378200 | 298.3 |
| Hough 1960 | HO | 6378270 | 297 |

* Refer to Appendices B, C, and D.
** As accepted by NIMA.
*** Through adoption of a new yard to meter conversion factor in the referenced country.

**Appendix A.1**
Reference Ellipsoid Names and Constants
Used for Datum Transformations*

| Reference Ellipsoid Name | ID Code | a (Meters) | $f^{-1}$ |
|---|---|---|---|
| Indonesian 1974 | ID | 6378160 | 298.247 |
| International 1924 | IN | 6378388 | 297 |
| Krassovsky 1940 | KA | 6378245 | 298.3 |
| Modified Airy | AM | 6377340.189 | 299.3249646 |
| Modified Fischer 1960 | FA | 6378155 | 298.3 |
| South American 1969 | SA | 6378160 | 298.25 |
| WGS 1972 | WD | 6378135 | 298.26 |
| WGS 1984 | WE | 6378137 | 298.257223563 |

* Refer to Appendices B, C, and D.
** As accepted by NIMA.
*** Through adoption of a new yard to meter conversion factor in the referenced country.

# APPENDIX B

## DATUM TRANSFORMATIONS DERIVED USING SATELLITE TIES TO GEODETIC DATUMS/SYSTEMS

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# DATUM TRANSFORMATION CONSTANTS
# GEODETIC DATUMS/SYSTEMS TO WGS 84
# (THROUGH SATELLITE TIES)

## 1. GENERAL

This appendix provides the details about the reference ellipsoids (Appendix A) which are used as defining parameters for the geodetic datums and systems.

There are 112 local geodetic datums which are currently related to WGS 84 through satellite ties.

## 2. LOCAL DATUM ELLIPSOIDS

Appendix B.1 lists, alphabetically, the local geodetic datums with their associated ellipsoids. Two letter ellipsoidal codes (Appendix A) have also been included against each datum to indicate which specific "version" of the ellipsoid was used in determining the transformation constants.

## 3. TRANSFORMATION CONSTANTS

Appendices B.2 through B.7 list the constants for local datums for continental areas. The continents and the local geodetic datums are arranged alphabetically.

Appendices B.8 through B.10 list the constants for local datums which fall within the ocean areas. The ocean areas and the geodetic datums are also arranged alphabetically.

The year of initial publication and cycle numbers have been provided as a new feature in this edition. This makes it possible for a user to determine when a particular set of transformation parameters first became available and if the current set has replaced an outdated set.

A cycle number of zero indicates that the set of parameters is as it was published in DMA TR 8350.2, Second Edition, 1 September 1991 including Insert 1, 30 August 1993 or that the parameters are new to this edition (1997 Publication Date). A cycle number of one indicates that the current parameters have replaced outdated parameters that were in the previous edition.

If transformation parameter sets are updated in future editions of this publication, the cycle numbers for each parameter set that is updated will increment by one.

4. ERROR ESTIMATES

The 1σ error estimates for the datum transformation constants (ΔX,ΔY,ΔZ), obtained from the computed solutions, are also tabulated. These estimates do not include the errors of the common control station coordinates which were used to compute the shift constants.

For datums having four or less common control stations, the 1σ errors for shift constants are non-computed estimates.

The current set of error estimates has been reevaluated and revised after careful consideration of the datum transformation solutions and the related geodetic information; the intent has been to assign the most realistic estimates as possible.

**Appendix B.1**

Geodetic Datums/Reference Systems
Related to World Geodetic System 1984
(Through Satellite Ties)

| **Local Geodetic Datum** | **Associated*Reference Ellipsoid** | **Code** |
|---|---|---|
| Adindan | Clarke 1880 | CD |
| Afgooye | Krassovsky 1940 | KA |
| Ain el Abd 1970 | International 1924 | IN |
| American Samoa 1962 | Clarke 1866 | CC |
| Anna 1 Astro 1965 | Australian National | AN |
| Antigua Island Astro 1943 | Clarke 1880 | CD |
| Arc 1950 | Clarke 1880 | CD |
| Arc 1960 | Clarke 1880 | CD |
| Ascension Island 1958 | International 1924 | IN |
| Astro Beacon "E" 1945 | International 1924 | IN |
| Astro DOS 71/4 | International 1924 | IN |
| Astro Tern Island (FRIG) 1961 | International 1924 | IN |
| Astronomical Station 1952 | International 1924 | IN |
| Australian Geodetic 1966 | Australian National | AN |
| Australian Geodetic 1984 | Australian National | AN |
| Ayabelle Lighthouse | Clarke 1880 | CD |
| Bellevue (IGN) | International 1924 | IN |
| Bermuda 1957 | Clarke 1866 | CC |
| Bissau | International 1924 | IN |
| Bogota Observatory | International 1924 | IN |
| Campo Inchauspe | International 1924 | IN |
| Canton Astro 1966 | International 1924 | IN |
| Cape | Clarke 1880 | CD |
| Cape Canaveral | Clarke 1866 | CC |
| Carthage | Clarke 1880 | CD |
| Chatham Island Astro 1971 | International 1924 | IN |
| Chua Astro | International 1924 | IN |
| Co-Ordinate System 1937 of Estonia | Bessel 1841 | BR |
| Corrego Alegre | International 1924 | IN |
| Dabola | Clarke 1880 | CD |
| Deception Island | Clarke 1880 | CD |
| Djakarta (Batavia) | Bessel 1841 | BR |
| DOS 1968 | International 1924 | IN |
| Easter Island 1967 | International 1924 | IN |
| European 1950 | International 1924 | IN |

- See Appendix A.1 for associated constants a,f.

**Appendix B.1**
Geodetic Datums/Reference Systems
Related to World Geodetic System 1984
(Through Satellite Ties)

| Local Geodetic Datum | Associated*Reference Ellipsoid | Code |
|---|---|---|
| European 1979 | International 1924 | IN |
| Fort Thomas 1955 | Clarke 1880 | CD |
| Gan 1970 | International 1924 | IN |
| Geodetic Datum 1949 | International 1924 | IN |
| Graciosa Base SW 1948 | International 1924 | IN |
| Guam 1963 | Clarke 1866 | CC |
| GUX 1 Astro | International 1924 | IN |
| Hjorsey 1955 | International 1924 | IN |
| Hong Kong 1963 | International 1924 | IN |
| Hu-Tzu-Shan | International 1924 | IN |
| Indian | Everest | EA/EC** |
| Indian 1954 | Everest | EA |
| Indian 1960 | Everest | EA |
| Indian 1975 | Everest | EA |
| Indonesian 1974 | Indonesian 1974 | ID |
| Ireland 1965 | Modified Airy | AM |
| ISTS 061 Astro 1968 | International 1924 | IN |
| ISTS 073 Astro 1969 | International 1924 | IN |
| Johnston Island 1961 | International 1924 | IN |
| Kandawala | Everest | EA |
| Kerguelen Island 1949 | International 1924 | IN |
| Kertau 1948 | Everest | EE |
| Korean Geodetic System 1995 | WGS84 | WE |
| Kusaie Astro 1951 | International 1924 | IN |
| L. C. 5 Astro 1961 | Clarke 1866 | CC |
| Leigon | Clarke 1880 | CD |
| Liberia 1964 | Clarke 1880 | CD |
| Luzon | Clarke 1866 | CC |
| Mahe 1971 | Clarke 1880 | CD |
| Massawa | Bessel 1841 | BR |
| Merchich | Clarke 1880 | CD |
| Midway Astro 1961 | International 1924 | IN |
| Minna | Clarke 1880 | CD |
| Montserrat Island Astro 1958 | Clarke 1880 | CD |
| M'Poraloko | Clarke 1880 | CD |
| Nahrwan | Clarke 1880 | CD |

*  See Appendix A.1 for associated constants a,f.

**  Due to different semi-major axes. See Appendix A.1.

**Appendix B.1**
Geodetic Datums/Reference Systems
Related to World Geodetic System 1984
(Through Satellite Ties)

| Local Geodetic Datum | Associated*Reference Ellipsoid | Code |
|---|---|---|
| Naparima, BWI | International 1924 | IN |
| North American 1927 | Clarke 1866 | CC |
| North American 1983 | GRS 80** | RF |
| North Sahara 1959 | Clarke 1880 | CD |
| Observatorio Meteorologico 1939 | International 1924 | IN |
| Old Egyptian 1907 | Helmert 1906 | HE |
| Old Hawaiian | Clarke 1866 | CC |
| Old Hawaiian | International 1924 | IN |
| Oman | Clarke 1880 | CD |
| Ordnance Survey of Great Britain 1936 | Airy 1830 | AA |
| Pico de las Nieves | International 1924 | IN |
| Pitcairn Astro 1967 | International 1924 | IN |
| Point 58 | Clarke 1880 | CD |
| Pointe Noire 1948 | Clarke 1880 | CD |
| Porto Santo 1936 | International 1924 | IN |
| Provisional South American 1956 | International 1924 | IN |
| Provisional South Chilean 1963*** | International 1924 | IN |
| Puerto Rico | Clarke 1866 | CC |
| Qatar National | International 1924 | IN |
| Qornoq | International 1924 | IN |
| Reunion | International 1924 | IN |
| Rome 1940 | International 1924 | IN |
| S-42 (Pulkovo 1942) | Krassovsky 1940 | KA |
| Santo (DOS) 1965 | International 1924 | IN |
| Sao Braz | International 1924 | IN |
| Sapper Hill 1943 | International 1924 | IN |
| Schwarzeck | Bessel 1841 | BN |
| Selvagem Grande 1938 | International 1924 | IN |
| Sierra Leone 1960 | Clark 1880 | CD |
| S-JTSK | Bessel 1841 | BR |
| South American 1969 | South American 1969 | SA |

* See Appendix A.1 for associated constants a,f.
** Geodetic Reference System 1980
*** Also known as Hito XVIII 1963

**Appendix B.1**

Geodetic Datums/Reference Systems
Related to World Geodetic System 1984
(Through Satellite Ties)

| Local Geodetic Datum | Associated*Reference Ellipsoid | Code |
|---|---|---|
| South American Geocentric Reference System (SIRGAS) | GRS80** | RF |
| South Asia | Modified Fischer 1960 | FA |
| Timbalai 1948 | Everest | EB |
| Tokyo | Bessel 1841 | BR |
| Tristan Astro 1968 | International 1924 | IN |
| Viti Levu 1916 | Clarke 1880 | CD |
| Voirol 1960 | Clarke 1880 | CD |
| Wake-Eniwetok 1960 | Hough 1960 | HO |
| Wake Island Astro 1952 | International 1924 | IN |
| Zanderij | International 1924 | IN |

* See Appendix A.1 for associated constants a,f.

** Geodetic Reference System 1980

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **ADINDAN** | ADI | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Mean Solution (Ethiopia and Sudan) | ADI-M | | | | 22 | 0 | 1991 | -166 ±5 | -15 ±5 | 204 ±3 |
| Burkina Faso | ADI-E | | | | 1 | 0 | 1991 | -118 +25 | -14 ±25 | 218 ±25 |
| Cameroon | ADI-F | | | | 1 | 0 | 1991 | -134 ±25 | -2 ±25 | 210 ±25 |
| Ethiopia | ADI-A | | | | 8 | 0 | 1991 | -165 ±3 | -11 ±3 | 206 ±3 |
| Mali | ADI-C | | | | 1 | 0 | 1991 | -123 ±25 | -20 ±25 | 220 ±25 |
| Senegal | ADI-D | | | | 2 | 0 | 1991 | -128 ±25 | -18 ±25 | 224 ±25 |
| Sudan | ADI-B | | | | 14 | 0 | 1991 | -161 ±3 | -14 ±5 | 205 ±3 |
| **AFGOOYE** | AFG | Krassovsky 1940 | -108 | 0.00480795 | | | | | | |
| Somalia | AFG | | | | 1 | 0 | 1987 | -43 ±25 | -163 ±25 | 45 ±25 |

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | | ΔY(m) | | ΔZ(m) | | |
| **ARC 1950** | ARF | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Mean Solution (Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe) | ARF-M | | | | 41 | 0 | 1987 | -143 | ±20 | -90 | ±33 | -294 | ±20 | |
| Botswana | ARF-A | | | | 9 | 0 | 1991 | -138 | ±3 | -105 | ±5 | -289 | ±3 | |
| Burundi | ARF-H | | | | 3 | 0 | 1991 | -153 | ±20 | -5 | ±20 | -292 | ±20 | |
| Lesotho | ARF-B | | | | 5 | 0 | 1991 | -125 | ±3 | -108 | ±3 | -295 | ±8 | |
| Malawi | ARF-C | | | | 6 | 0 | 1991 | -161 | ±9 | -73 | ±24 | -317 | ±8 | |
| Swaziland | ARF-D | | | | 4 | 0 | 1991 | -134 | ±15 | -105 | ±15 | -295 | ±15 | |
| Zaire | ARF-E | | | | 2 | 0 | 1991 | -169 | ±25 | -19 | ±25 | -278 | ±25 | |
| Zambia | ARF-F | | | | 5 | 0 | 1991 | -147 | ±21 | -74 | ±21 | -283 | ±27 | |
| Zimbabwe | ARF-G | | | | 10 | 0 | 1991 | -142 | ±5 | -96 | ±8 | -293 | ±11 | |

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | ΔY(m) | ΔZ(m) |
| **ARC 1960** | ARS | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Mean Solution (Kenya and Tanzania) | ARS-M | | | | 25 | 0 | 1991 | -160 ±20 | -6 ±20 | -302 ±20 |
| Kenya | ARS-A | | | | 24 | 0 | 1997 | -157 ±4 | -2 ±3 | -299 ±3 |
| Tanzania | ARS-B | | | | 12 | 0 | 1997 | -175 ±6 | -23 ±9 | -303 ±10 |
| **AYABELLE LIGHTHOUSE** | PHA | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Djibouti | | | | | 1 | 0 | 1991 | -79 ±25 | -129 ±25 | 145 ±25 |
| **BISSAU** | BID | International 1924 | -251 | -0.14192702 | | | | | | |
| Guinea-Bissau | | | | | 2 | 0 | 1991 | -173 ±25 | 253 ±25 | 27 ±25 |
| **CAPE** | CAP | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| South Africa | | | | | 5 | 0 | 1987 | -136 ±3 | -108 ±6 | -292 ±6 |

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **CARTHAGE** | CGE | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Tunisia | | | | | 5 | 0 | 1987 | -263 ±6 | 6 ±9 | 431 ±8 |
| **DABOLA** | DAL | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Guinea | | | | | 4 | 0 | 1991 | -83 ±15 | 37 ±15 | 124 ±15 |
| **EUROPEAN 1950** | EUR | International 1924 | -251 | -0.14192702 | | | | | | |
| Egypt | EUR-F | | | | 14 | 0 | 1991 | -130 ±6 | -117 ±8 | -151 ±8 |
| Tunisia | EUR-T | | | | 4 | 0 | 1993 | -112 ±25 | -77 ±25 | -145 ±25 |
| **LEIGON** | LEH | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Ghana | | | | | 8 | 0 | 1991 | -130 ±2 | 29 ±3 | 364 ±2 |
| **LIBERIA 1964** | LIB | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Liberia | | | | | 4 | 0 | 1987 | -90 ±15 | 40 ±15 | 88 ±15 |
| **MASSAWA** | MAS | Bessel 1841 | 739.845 | 0.10037483 | | | | | | |
| Eritrea (Ethiopia) | | | | | 1 | 0 | 1987 | 639 ±25 | 405 ±25 | 60 ±25 |

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **MERCHICH** | MER | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Morocco | | | | | 9 | 0 | 1987 | 31 | ±5 | 146 | ±3 | 47 | ±3 | |
| **MINNA** | MIN | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Cameroon | MIN-A | | | | 2 | 0 | 1991 | -81 | ±25 | -84 | ±25 | 115 | ±25 | |
| Nigeria | MIN-B | | | | 6 | 0 | 1987 | -92 | ±3 | -93 | ±6 | 122 | ±5 | |
| **M'PORALOKO** | MPO | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Gabon | | | | | 1 | 0 | 1991 | -74 | ±25 | -130 | ±25 | 42 | ±25 | |
| **NORTH SAHARA 1959** | NSD | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Algeria | | | | | 3 | 0 | 1993 | -186 | ±25 | -93 | ±25 | 310 | ±25 | |
| **OLD EGYPTIAN 1907** | OEG | Helmert 1906 | -63 | 0.00480795 | | | | | | | | | | |
| Egypt | | | | | 14 | 0 | 1987 | -130 | ±3 | 110 | ±6 | -13 | ±8 | |

**Appendix B.2**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AFRICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10^4** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **POINT 58** | PTB | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Mean Solution (Burkina Faso and Niger) | | | | | 2 | 0 | 1991 | -106 ±25 | -129 ±25 | 165 ±25 |
| **POINTE NOIRE 1948** | PTN | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Congo | | | | | 1 | 0 | 1991 | -148 ±25 | 51 ±25 | -291 ±25 |
| **SCHWARZECK** | SCK | Bessel 1841 | 653.135* | 0.10037483 | | | | | | |
| Namibia | | | | | 3 | 0 | 1991 | 616 ±20 | 97 ±20 | -251 ±20 |
| **SIERRA LEONE 1960** | SRL | Clark 1880 | -112.145 | -0.54750714 | | | | | | |
| Sierra Leone | | | | | 8 | 0 | 1997 | -88 ±15 | 4 ±15 | 101 ±15 |
| **VOIROL 1960** | VOR | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Algeria | | | | | 2 | 0 | 1993 | -123 ±25 | -206 ±25 | 219 ±25 |

* This Δa value reflects an a-value of 6377483.865 meters for the Bessel 1841 Ellipsoid in Namibia.

**Appendix B.3**
Transformation Parameters
Local Geodetic Datums to WGS 84

**Continent: ASIA**

| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **AIN EL ABD 1970** | AIN | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Bahrain Island | AIN-A | | | | 2 | 0 | 1991 | -150 | ±25 | -250 | ±25 | -1 | ±25 | |
| Saudi Arabia | AIN-B | | | | 9 | 0 | 1991 | -143 | ±10 | -236 | ±10 | 7 | ±10 | |
| **DJAKARTA (BATAVIA)** | BAT | Bessel 1841 | 739.845 | 0.10037483 | | | | | | | | | | |
| Sumatra (Indonesia) | | | | | 5 | 0 | 1987 | -377 | ±3 | 681 | ±3 | -50 | ±3 | |
| **EUROPEAN 1950** | EUR | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Iran | EUR-H | | | | 27 | 0 | 1991 | -117 | ±9 | -132 | ±12 | -164 | ±11 | |
| **HONG KONG 1963** | HKD | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Hong Kong | | | | | 2 | 0 | 1987 | -156 | ±25 | -271 | ±25 | -189 | ±25 | |
| **HU-TZU-SHAN** | HTN | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Taiwan | | | | | 4 | 0 | 1991 | -637 | ±15 | -549 | ±15 | -203 | ±15 | |

**Appendix B.3**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: ASIA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10^4** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **INDIAN** | IND | Everest | | | | | | | | |
| Bangladesh | IND-B | Everest (1830) | 860.655* | 0.28361368 | 6 | 0 | 1991 | 282 ±10 | 726 ±8 | 254 ±±12 |
| India and Nepal | IND-I | Everest (1956) | 835.757* | 0.28361368 | 7 | 0 | 1991 | 295 ±12 | 736 ±10 | 257 ±15 |
| **INDIAN 1954** | INF | Everest (1830) | 860.655* | 0.28361368 | | | | | | |
| Thailand | INF-A | | | | 11 | 0 | 1993 | 217 ±15 | 823 ±6 | 299 ±12 |
| **INDIAN 1960** | ING | Everest (1830) | 860.655* | 0.28361368 | | | | | | |
| Vietnam (near 16°N) | ING-A | | | | 2 | 0 | 1993 | 198 ±25 | 881 ±25 | 317 ±25 |
| Con Son Island (Vietnam) | ING-B | | | | 1 | 0 | 1993 | 182 ±25 | 915 ±25 | 344 ±25 |
| **INDIAN 1975** | INH | Everest (1830) | 860.655* | 0.28361368 | | | | | | |
| Thailand | INH-A | | | | 6 | 0 | 1991 | 209 ±12 | 818 ±10 | 290 ±12±3 |
| Thailand | INH-A1 | | | | 62 | 1 | 1997 | 210 ±3 | 814 ±2 | 289 |

See Appendix A

**Appendix B.3**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ASIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **INDONESIAN 1974** | IDN | Indonesian 1974 | -23 | -0.00114930 | | | | | | |
| Indonesia | | | | | 1 | 0 | 1993 | -24 ±25 | -15 ±25 | 5 ±25 |
| **KANDAWALA** | KAN | Everest (1830) | 860.655* | 0.28361368 | | | | | | |
| Sri Lanka | | | | | 3 | 0 | 1987 | -97 ±20 | 787 ±20 | 86 ±20 |
| **KERTAU 1948** | KEA | Everest (1948) | 832.937* | 0.28361368 | | | | | | |
| West Malaysia and Singapore | | | | | 6 | 0 | 1987 | -11 ±10 | 851 ±8 | 5 ±6 |
| **KOREAN GEODETIC SYSTEM 1995** | KGS | WGS84 | 0 | 0 | | | | | | |
| South Korea | | | | | 29 | 0 | 1997 | 0 ±1 | 0 ±1 | 0 ±1 |
| **NAHRWAN** | NAH | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Masirah Island (Oman) | NAH-A | | | | 2 | 0 | 1987 | -247 ±25 | -148 ±25 | 369 ±25 |
| United Arab Emirates | NAH-B | | | | 2 | 0 | 1987 | -249 ±25 | -156 ±25 | 381 ±25 |
| Saudi Arabia | NAH-C | | | | 3 | 0 | 1991 | -243 ±20 | -192 ±20 | 477 ±20 |

* See Appendix A

**Appendix B.3**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: ASIA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **OMAN** | FAH | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Oman | | | | | 7 | 0 | 1987 | -346 ±3 | -1 ±3 | 224 ±9 |
| **QATAR NATIONAL** | QAT | International 1924 | -251 | -0.14192702 | | | | | | |
| Qatar | | | | | 3 | 0 | 1987 | -128 ±20 | -283 ±20 | 22 ±20 |
| **SOUTH ASIA** | SOA | Modified Fischer 1960 | -18 | 0.00480795 | | | | | | |
| Singapore | | | | | 1 | 0 | 1987 | 7 ±25 | -10 ±25 | -26 ±25 |
| **TIMBALAI 1948** | TIL | Everest | 838.444* | 0.28361368 | | | | | | |
| Brunei and East Malaysia (Sarawak and Sabah) | | | | | 8 | 0 | 1987 | -679 ±10 | 669 ±10 | -48 ±12 |

* See Appendix A

**Appendix B.3**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ASIA | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | |
| Name | Code | Name | Δa(m) | Δf x 10^4 | | Cycle Number | Pub. Date | ΔX(m) | | ΔY(m) | ΔZ(m) |
| **TOKYO** | TOY | Bessel 1841 | 739.845 | 0.10037483 | | | | | | | |
| Mean Solution (Japan, Okinawa, and SouthKorea) | TOY-M | | | | 31 | 0 | 1991 | -148 ±20 | | 507 ±5 | 685 ±20 |
| Japan | TOY-A | | | | 16 | 0 | 1991 | -148 ±8 | | 507 ±5 | 685 ±8 |
| Okinawa | TOY-C | | | | 3 | 0 | 1991 | -158 ±20 | | 507 ±5 | 676 ±20 |
| South Korea | TOY-B | | | | 12 | 0 | 1991 | -146 ±8 | | 507 ±5 | 687 ±8 |
| South Korea | TOY-B1 | | | | 29 | 1 | 1997 | -147 ±2 | | 506 ±2 | 687 ±2 |

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**Appendix B.4**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: AUSTRALIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | ΔY(m) | ΔZ(m) |
| **AUSTRALIAN GEODETIC 1966** | AUA | Australian National | -23 | -0.00081204 | | | | | | |
| Australia and Tasmania | | | | | 105 | 0 | 1987 | -133 ±3 | -48 ±3 | 148 ±3 |
| **AUSTRALIAN GEODETIC 1984** | AUG | Australian National | -23 | -0.00081204 | | | | | | |
| Australia and Tasmania | | | | | 90 | 0 | 1987 | -134 ±2 | -48 ±2 | 149 ±2 |

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**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: EUROPE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **CO-ORDINATE SYSTEM 1937 OF ESTONIA** | EST | Bessel 1841 | 739.85 | 0.10037483 | | | | | | |
| Estonia | | | | | 19 | 0 | 1997 | 374 ±2 | 150 ±3 | 588 ±3 |
| **EUROPEAN 1950** | EUR | International 1924 | -251 | -0.14192702 | | | | | | |
| Mean Solution {Austria, Belgium, Denmark, Finland, France, FRG (Federal Republic of Germany)*, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland} | EUR-M | | | | 85 | 0 | 1987 | -87 ±3 | -98 ±8 | -121 ±5 |

* Prior to 1 January 1993

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: EUROPE** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **EUROPEAN 1950 (cont'd)** | EUR | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Western Europe {Limited to Austria, Denmark, France, FRG (Federal Republic of Germany)*, Netherlands, and Switzerland} | EUR-A | | | | 52 | 0 | 1991 | -87 | ±3 | -96 | ±3 | -120 | ±3 | |
| Cyprus | EUR-E | | | | 4 | 0 | 1991 | -104 | ±15 | -101 | ±15 | -140 | ±15 | |
| Egypt | EUR-F | | | | 14 | 0 | 1991 | -130 | ±6 | -117 | ±8 | -151 | ±8 | |
| England, Channel Islands, Scotland,and Shetland Islands** | EUR-G | | | | 40 | 0 | 1991 | -86 | ±3 | -96 | ±3 | -120 | ±3 | |
| England, Ireland, Scotland, and Shetland Islands** | EUR-K | | | | 47 | 0 | 1991 | -86 | ±3 | -96 | ±3 | -120 | ±3 | |

* Prior to 1 January 1993
** European Datum 1950 coordinates developed from Ordnance Survey of Great Britian (OSGB) Scientific Network 1980 (SN 80) coordinates.

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: EUROPE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10$^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **EUROPEAN 1950 (cont'd)** | EUR | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Greece | EUR-B | | | | 2 | 0 | 1991 | -84 | ±25 | -95 | ±25 | -130 | ±25 | |
| Iran | EUR-H | | | | 27 | 0 | 1991 | -117 | ±9 | -132 | ±12 | -164 | ±11 | |
| Italy | | | | | | | | | | | | | | |
| Sardinia | EUR-I | | | | 2 | 0 | 1991 | -97 | ±25 | -103 | ±25 | -120 | ±25 | |
| Sicily | EUR-J | | | | 3 | 0 | 1991 | -97 | ±20 | -88 | ±20 | -135 | ±20 | |
| Malta | EUR-L | | | | 1 | 0 | 1991 | -107 | ±25 | -88 | ±25 | -149 | ±25 | |
| Norway and Finland | EUR-C | | | | 20 | 0 | 1991 | -87 | ±3 | -95 | ±5 | -120 | ±3 | |
| Portugal and Spain | EUR-D | | | | 18 | 0 | 1991 | -84 | ±5 | -107 | ±6 | -120 | ±3 | |
| Tunisia | EUR-T | | | | 4 | 0 | 1993 | -112 | ±25 | -77 | ±25 | -145 | ±25 | |

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

**Continent: EUROPE**

| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **EUROPEAN 1979** | EUS | International 1924 | -251 | -0.14192702 | | | | | | |
| Mean Solution (Austria, Finland, Netherlands, Norway, Spain, Sweden, and Switzerland) | | | | | 22 | 0 | 1987 | -86 ±3 | -98 ±3 | -119 ±3 |
| **HJORSEY 1955** | HJO | International 1924 | -251 | -0.14192702 | | | | | | |
| Iceland | | | | | 6 | 0 | 1987 | -73 ±3 | 46 ±3 | -86 ±6 |
| **IRELAND 1965** | IRL | Modified Airy | 796.811 | 0.11960023 | | | | | | |
| Ireland | | | | | 7 | 0 | 1987 | 506 ±3 | -122 ±3 | 611 ±3 |
| **ORDNANCE SURVEY OF GREAT BRITAIN 1936** | OGB | Airy | 573.604 | 0.11960023 | | | | | | |
| Mean Solution (England, Isle of Man, Scotland, Shetland Islands, and Wales) | OGB-M | | | | 38 | 0 | 1987 | 375 ±10 | -111 ±10 | 431 ±15 |

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: EUROPE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **ORDNANCE SURVEY OF GREAT BRITAIN 1936 (cont'd)** | OGB | Airy | 573.604 | 0.11960023 | | | | | | | | | | |
| England | OGB-A | | | | 21 | 0 | 1991 | 371 | ±5 | -112 | ±5 | 434 | ±6 | |
| England, Isle of Man, and Wales | OGB-B | | | | 25 | 0 | 1991 | 371 | ±10 | -111 | ±10 | 434 | ±15 | |
| Scotland and Shetland Islands | OGB-C | | | | 13 | 0 | 1991 | 384 | ±10 | -111 | ±10 | 425 | ±10 | |
| Wales | OGB-D | | | | 3 | 0 | 1991 | 370 | ±20 | -108 | ±20 | 434 | ±20 | |
| **ROME 1940** | MOD | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Sardinia | | | | | 1 | 0 | 1987 | -225 | ±25 | -65 | ±25 | 9 | ±25 | |

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: EUROPE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | ΔY(m) | ΔZ(m) |
| **S-42 (PULKOVO 1942)** | SPK | Krassovsky 1940 | -108 | 0.00480795 | | | | | | |
| Hungary | SPK-A | | | | 5 | 0 | 1993 | 28 ±2 | -121 ±2 | -77 ±2 |
| Poland | SPK-B | | | | 11 | 0 | 1997 | 23 ±4 | -124 ±2 | -82 ±4 |
| | SPK | Krassovsky 1940 | -108 | 0.00480795 | | | | | | |
| Czechoslovakia* | SPK-C | | | | 6 | 0 | 1997 | 26 ±3 | -121 ±3 | -78 ±2 |
| Latvia | SPK-D | | | | 5 | 0 | 1997 | 24 ±2 | -124 ±2 | -82 ±2 |
| Kazakhstan | SPK-E | | | | 2 | 0 | 1997 | 15 ±25 | -130 ±25 | -84 ±25 |
| Albania | SPK-F | | | | 7 | 0 | 1997 | 24 ±3 | -130 ±3 | -92 ±3 |
| Romania | SPK-G | | | | 4 | 0 | 1997 | 28 ±3 | -121 ±5 | -77 ±3 |

**Appendix B.5**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: EUROPE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | ΔY(m) | ΔZ(m) |
| **S-JTSK** | CCD | Bessel 1841 | 739.845 | 0.10037483 | | | | | | |
| Czechoslovakia * | | | | | 6 | 0 | 1993 | 589 ±4 | 76 ±2 | 480 ±3 |

* Prior to 1 January 1993

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**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: NORTH AMERICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **CAPE CANAVERAL** | CAC | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Mean Solution (Florida and Bahamas) | | | | | 19 | 0 | 1991 | -2 ±3 | 151 ±3 | 181 ±3 |
| **NORTH AMERICAN 1927** | NAS | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Mean Solution (CONUS) | NAS-C | | | | 405 | 0 | 1987 | -8 ±5 | 160 ±5 | 176 ±6 |
| Western United States (Arizona, Arkansas, California, Colorado, Idaho, Iowa, Kansas, Montana, Nebraska, Nevada,New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming) | NAS-B | | | | 276 | 0 | 1991 | -8 ±5 | 159 ±3 | 175 ±3 |

**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

**Continent: NORTH AMERICA**

| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10^4** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **NORTH AMERICAN 1927 (cont'd)** | NAS | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Eastern United States (Alabama, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin) | NAS-A | | | | 129 | 0 | 1991 | -9 ±5 | 161 ±5 | 179 ±8 |

**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: NORTH AMERICA** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **NORTH AMERICAN 1927 (cont'd)** | NAS | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | | |
| Alaska (Excluding Aleutian Islands) | NAS-D | | | | 47 | 0 | 1987 | -5 | ±5 | 135 | ±9 | 172 | ±5 | |
| Aleutian Islands | | | | | | | | | | | | | | |
| East of 180°W | NAS-V | | | | 6 | 0 | 1993 | -2 | ±6 | 152 | ±8 | 149 | ±10 | |
| West of 180°W | NAS-W | | | | 5 | 0 | 1993 | 2 | ±10 | 204 | ±10 | 105 | ±10 | |
| Bahamas(Excluding San Salvador Island) | NAS-Q | | | | 11 | 0 | 1987 | -4 | ±5 | 154 | ±3 | 178 | ±5 | |
| San Salvador Island | NAS-R | | | | 1 | 0 | 1987 | 1 | ±25 | 140 | ±25 | 165 | ±25 | |
| Canada Mean Solution (Including Newfoundland) | NAS-E | | | | 112 | 0 | 1987 | -10 | ±15 | 158 | ±11 | 187 | ±6 | |
| Alberta and British Columbia | NAS-F | | | | 25 | 0 | 1991 | -7 | ±8 | 162 | ±8 | 188 | ±6 | |

**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: NORTH AMERICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | | ΔY(m) | | ΔZ(m) | | |
| **NORTH AMERICAN 1927 (cont'd)** | NAS | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | | |
| Eastern Canada (Newfoundland, New Brunswick, Nova Scotia, and Quebec) | NAS-G | | | | 37 | 0 | 1991 | -22 | ±6 | 160 | ±6 | 190 | ±3 | |
| Manitoba and Ontario | NAS-H | | | | 25 | 0 | 1991 | -9 | ±9 | 157 | ±5 | 184 | ±5 | |
| Northwest Territories and Saskatchewan | NAS-I | | | | 17 | 0 | 1991 | 4 | ±5 | 159 | ±5 | 188 | ±3 | |
| Yukon | NAS-J | | | | 8 | 0 | 1991 | -7 | ±5 | 139 | ±8 | 181 | ±3 | |
| Canal Zone | NAS-O | | | | 3 | 0 | 1987 | 0 | ±20 | 125 | ±20 | 201 | ±20 | |
| Caribbean (Antigua Island, Barbados, Barbuda, Caicos Islands, Cuba, Domini-can Republic, Grand Cayman, Jamaica, and Turks Islands) | NAS-P | | | | 15 | 0 | 1991 | -3 | ±3 | 142 | ±9 | 183 | ±12 | |

**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: NORTH AMERICA | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | | ΔY(m) | | ΔZ(m) | |
| **NORTH AMERICAN 1927 (cont'd)** | NAS | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | |
| Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua) | NAS-N | | | | 19 | 0 | 1987 | 0 | ±8 | 125 | ±3 | 194 | ±5 |
| Cuba | NAS-T | | | | 1 | 0 | 1987 | -9 | ±25 | 152 | ±25 | 178 | ±25 |
| Greenland(Hayes Peninsula) | NAS-U | | | | 2 | 0 | 1987 | 11 | ±25 | 114 | ±25 | 195 | ±25 |
| Mexico | NAS-L | | | | 22 | 0 | 1987 | -12 | ±8 | 130 | ±6 | 190 | ±6 |
| **NORTH AMERICAN 1983** | NAR | GRS 80 | 0 | -0.00000016 | | | | | | | | | |
| Alaska (Excluding Aleutian Islands) | NAR-A | | | | 42 | 0 | 1987 | 0 | ±2 | 0 | ±2 | 0 | ±2 |
| Aleutian Islands | NAR-E | | | | 4 | 0 | 1993 | -2 | ±5 | 0 | ±2 | 4 | ±5 |
| Canada | NAR-B | | | | 96 | 0 | 1987 | 0 | ±2 | 0 | ±2 | 0 | ±2 |

**Appendix B.6**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: NORTH AMERICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10$^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **NORTH AMERICAN 1983 (cont'd)** | NAR | GRS 80 | 0 | -0.00000016 | | | | | | | | | | |
| CONUS | NAR-C | | | | 216 | 0 | 1987 | 0 | ±2 | 0 | ±2 | 0 | ±2 | |
| Hawaii | NAR-H | | | | 6 | 0 | 1993 | 1 | ±2 | 1 | ±2 | -1 | ±2 | |
| Mexico and Central America | NAR-D | | | | 25 | 0 | 1987 | 0 | ±2 | 0 | ±2 | 0 | ±2 | |

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: SOUTH AMERICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **BOGOTA OBSERVATORY** | BOO | International 1924 | -251 | -0.14192702 | | | | | | |
| Colombia | | | | | 7 | 0 | 1987 | 307 ±6 | 304 ±5 | -318 ±6 |
| **CAMPO INCHAUSPE 1969** | CAI | International 1924 | -251 | -0.14192702 | | | | | | |
| Argentina | | | | | 20 | 0 | 1987 | -148 ±5 | 136 ±5 | 90 ±5 |
| **CHUA ASTRO** | CHU | International 1924 | -251 | -0.14192702 | | | | | | |
| Paraguay | | | | | 6 | 0 | 1987 | -134 ±6 | 229 ±9 | -29 ±5 |
| **CORREGO ALEGRE** | COA | International 1924 | -251 | -0.14192702 | | | | | | |
| Brazil | | | | | 17 | 0 | 1987 | -206 ±5 | 172 ±3 | -6 ±5 |

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: SOUTH AMERICA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **PROVISIONAL SOUTH AMERICAN 1956** | PRP | International 1924 | -251 | -0.14192702 | | | | | | |
| Mean Solution (Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, and Venezuela) | PRP-M | | | | 63 | 0 | 1987 | -288 ±17 | 175 ±27 | -376 ±27 |
| Bolivia | PRP-A | | | | 5 | 0 | 1991 | -270 ±5 | 188 ±±11 | -388 ±14 |
| Chile | | | | | | | | | | |
| Northern Chile (near 19°S) | PRP-B | | | | 1 | 0 | 1991 | -270 ±25 | 183 ±25 | -390 ±25 |
| Southern Chile (near 43°S) | PRP-C | | | | 3 | 0 | 1991 | -305 ±20 | 243 ±20 | -442 ±20 |
| Colombia | PRP-D | | | | 4 | 0 | 1991 | -282 ±15 | 169 ±15 | -371 ±15 |
| Ecuador | PRP-E | | | | 11 | 0 | 1991 | -278 ±3 | 171 ±5 | -367 ±3 |

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: SOUTH AMERICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **PROVISIONAL SOUTH AMERICAN 1956 (cont'd)** | PRP | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Guyana | PRP-F | | | | 9 | 0 | 1991 | -298 | ±6 | 159 | ±14 | -369 | ±5 | |
| Peru | PRP-G | | | | 6 | 0 | 1991 | -279 | ±6 | 175 | ±8 | -379 | ±12 | |
| Venezuela | PRP-H | | | | 24 | 0 | 1991 | -295 | ±9 | 173 | ±14 | -371 | ±15 | |
| **PROVISIONAL SOUTH CHILEAN 1963*** | HIT | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Southern Chile (near 53°S) | | | | | 2 | 0 | 1987 | 16 | ±25 | 196 | ±25 | 93 | ±25 | |

* Also known as Hito XVIII 1963

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: SOUTH AMERICA** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **SOUTH AMERICAN 1969** | SAN | South American 1969 | -23 | -0.00081204 | | | | | | | | | | |
| Mean Solution(Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad and Tobago, and Venezuela) | SAN-M | | | | 84 | 0 | 1987 | -57 | ±15 | 1 | ±6 | -41 | ±9 | |
| Argentina | SAN-A | | | | 10 | 0 | 1991 | -62 | ±5 | -1 | ±5 | -37 | ±5 | |
| Bolivia | SAN-B | | | | 4 | 0 | 1991 | -61 | ±15 | 2 | ±15 | -48 | ±15 | |
| Brazil | SAN-C | | | | 22 | 0 | 1991 | -60 | ±3 | -2 | ±5 | -41 | ±5 | |
| Chile | SAN-D | | | | 9 | 0 | 1991 | -75 | ±15 | -1 | ±8 | -44 | ±11 | |
| Colombia | SAN-E | | | | 7 | 0 | 1991 | -44 | ±6 | 6 | ±6 | -36 | ±5 | |

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: SOUTH AMERICA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | No. of Satellite Stations Used | Transformation Parameters | | | | | | | | |
| Name | Code | Name | Δa(m) | Δf x $10^4$ | | Cycle Number | Pub. Date | ΔX(m) | | ΔY(m) | | ΔZ(m) | | |
| **SOUTH AMERICAN 1969 (cont'd)** | SAN | South American 1969 | -23 | -0.00081204 | | | | | | | | | | |
| Ecuador (Excluding Galapagos Islands) | SAN-F | | | | 11 | 0 | 1991 | -48 | ±3 | 3 | ±3 | -44 | ±3 | |
| Baltra, Galapagos Islands | SAN-J | | | | 1 | 0 | 1991 | -47 | ±25 | 26 | ±25 | -42 | ±25 | |
| Guyana | SAN-G | | | | 5 | 0 | 1991 | -53 | ±9 | 3 | ±5 | -47 | ±5 | |
| Paraguay | SAN-H | | | | 4 | 0 | 1991 | -61 | ±15 | 2 | ±15 | -33 | ±15 | |
| Peru | SAN-I | | | | 6 | 0 | 1991 | -58 | ±5 | 0 | ±5 | -44 | ±5 | |
| Trinidad and Tobago | SAN-K | | | | 1 | 0 | 1991 | -45 | ±25 | 12 | ±25 | -33 | ±25 | |
| Venezuela | SAN-L | | | | 5 | 0 | 1991 | -45 | ±3 | 8 | ±6 | -33 | ±3 | |

**Appendix B.7**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: SOUTH AMERICA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **SOUTH AMERICAN GEOCENTRIC REFERENCE SYSTEM (SIRGAS)** | SIR | GRS80 | 0 | -0.00000016 | | | | | | |
| South America | | | | | 66 | 0 | 1997 | 0 ±1 | 0 ±1 | 0 ±1 |
| **ZANDERIJ** | ZAN | International 1924 | -251 | -0.14192702 | | | | | | |
| Suriname | | | | | 5 | 0 | 1987 | -265 ±5 | 120 ±5 | -358 ±8 |

**Appendix B.8**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ATLANTIC OCEAN | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **ANTIGUA ISLAND ASTRO 1943** | AIA | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Antigua, Leeward Islands | | | | | 1 | 0 | 1991 | -270 | ±25 | 13 | ±25 | 62 | ±25 | |
| **ASCENSION ISLAND 1958** | ASC | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Ascension Island | | | | | 2 | 0 | 1991 | -205 | ±25 | 107 | ±25 | 53 | ±25 | |
| **ASTRO DOS 71/4** | SHB | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| St. Helena Island | | | | | 1 | 0 | 1987 | -320 | ±25 | 550 | ±25 | -494 | ±25 | |
| **BERMUDA 1957** | BER | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | | |
| Bermuda Islands | | | | | 3 | 0 | 1987 | -73 | ±20 | 213 | ±20 | 296 | ±20 | |
| **CAPE CANAVERAL** | CAC | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | | |
| Mean Solution (Bahamas and Florida) | | | | | 19 | 0 | 1991 | -2 | ±3 | 151 | ±3 | 181 | ±3 | |

**Appendix B.8**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: ATLANTIC OCEAN** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **DECEPTION ISLAND** | DID | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Deception Island, Antarctica | | | | | 3 | 0 | 1993 | 260 | ±20 | 12 | ±20 | -147 | ±20 | |
| **FORT THOMAS 1955** | FOT | Clarke 1880 | -112.145 | -0.54750714 | | | | | | | | | | |
| Nevis, St. Kitts, Leeward Islands | | | | | 2 | 0 | 1991 | -7 | ±25 | 215 | ±25 | 225 | ±25 | |
| **GRACIOSA BASE SW 1948** | GRA | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores) | | | | | 5 | 0 | 1991 | -104 | ±3 | 167 | ±3 | -38 | ±3 | |
| **HJORSEY 1955** | HJO | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Iceland | | | | | 6 | 0 | 1987 | -73 | ±3 | 46 | ±3 | -86 | ±6 | |

**Appendix B.8**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ATLANTIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **ISTS 061 ASTRO 1968** | ISG | International 1924 | -251 | -0.14192702 | | | | | | |
| South Georgia Island | | | | | 1 | 0 | 1991 | -794 ±25 | 119 ±25 | -298 ±25 |
| **L. C. 5 ASTRO 1961** | LCF | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Cayman Brac Island | | | | | 1 | 0 | 1987 | 42 ±25 | 124 ±25 | 147 ±25 |
| **MONTSERRAT ISLAND ASTRO 1958** | ASM | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Montserrat, Leeward Islands | | | | | 1 | 0 | 1991 | 174 ±25 | 359 ±25 | 365 ±25 |
| **NAPARIMA, BWI** | NAP | International 1924 | -251 | -0.14192702 | | | | | | |
| Trinidad and Tobago | | | | | 4 | 0 | 1991 | -10 ±15 | 375 ±15 | 165 ±15 |
| **OBSERVATORIO METEOROLOGICO 1939** | FLO | International 1924 | -251 | -0.14192702 | | | | | | |
| Corvo and Flores Islands (Azores) | | | | | 3 | 0 | 1991 | -425 ±20 | -169 ±20 | 81 ±20 |

**Appendix B.8**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ATLANTIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **PICO DE LAS NIEVES** | PLN | International 1924 | -251 | -0.14192702 | | | | | | |
| Canary Islands | | | | | 1 | 0 | 1987 | -307 ±25 | -92 ±25 | 127 ±25 |
| **PORTO SANTO 1936** | POS | International 1924 | -251 | -0.14192702 | | | | | | |
| Porto Santo and Madeira Islands | | | | | 2 | 0 | 1991 | -499 ±25 | -249 ±25 | 314 ±25 |
| **PUERTO RICO** | PUR | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Puerto Rico and Virgin Islands | | | | | 11 | 0 | 1987 | 11 ±3 | 72 ±3 | -101 ±3 |
| **QORNOQ** | QUO | International 1924 | -251 | -0.14192702 | | | | | | |
| South Greenland | | | | | 2 | 0 | 1987 | 164 ±25 | 138 ±25 | -189 ±32 |
| **SAO BRAZ** | SAO | International 1924 | -251 | -0.14192702 | | | | | | |
| Sao Miguel, Santa Maria Islands (Azores) | | | | | 2 | 0 | 1987 | -203 ±25 | 141 ±25 | 53 ±25 |

**Appendix B.8**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: ATLANTIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **SAPPER HILL 1943** | SAP | International 1924 | -251 | -0.14192702 | | | | | | |
| East Falkland Island | | | | | 5 | 0 | 1991 | -355 ±1 | 21 ±1 | 72 ±1 |
| **SELVAGEM GRANDE 1938** | SGM | International 1924 | -251 | -0.14192702 | | | | | | |
| Salvage Islands | | | | | 1 | 0 | 1991 | -289 ±25 | -124 ±25 | 60 ±25 |
| **TRISTAN ASTRO 1968** | TDC | International 1924 | -251 | -0.14192702 | | | | | | |
| Tristan da Cunha | | | | | 1 | 0 | 1987 | -632 ±25 | 438 ±25 | -609 ±25 |

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**Appendix B.9**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: INDIAN OCEAN** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **ANNA 1 ASTRO 1965** | ANO | Australian National | -23 | -0.00081204 | | | | | | |
| Cocos Islands | | | | | 1 | 0 | 1987 | -491 ±25 | -22 ±25 | 435 ±25 |
| **GAN 1970** | GAA | International 1924 | -251 | -0.14192702 | | | | | | |
| Republic of Maldives | | | | | 1 | 0 | 1987 | -133 ±25 | -321 ±25 | 50 ±25 |
| **ISTS 073 ASTRO 1969** | IST | International 1924 | -251 | -0.14192702 | | | | | | |
| Diego Garcia | | | | | 2 | 0 | 1987 | 208 ±25 | -435 ±25 | -229 ±25 |
| **KERGUELEN ISLAND 1949** | KEG | International 1924 | -251 | -0.14192702 | | | | | | |
| Kerguelen Island | | | | | 1 | 0 | 1987 | 145 ±25 | -187 ±25 | 103 ±25 |
| **MAHE 1971** | MIK | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Mahe Island | | | | | 1 | 0 | 1987 | 41 ±25 | -220 ±25 | -134 ±25 |

**Appendix B.9**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: INDIAN OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **$\Delta a(m)$** | **$\Delta f \times 10^4$** | | **Cycle Number** | **Pub. Date** | **$\Delta X(m)$** | **$\Delta Y(m)$** | **$\Delta Z(m)$** |
| **REUNION**<br>Mascarene Islands | REU | International 1924 | -251 | -0.14192702 | 1 | 0 | 1987 | 94 ±25 | -948 ±25 | -1262 ±25 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: PACIFIC OCEAN** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **AMERICAN SAMOA 1962** American Samoa Islands | AMA | Clarke 1866 | -69.4 | -0.37264639 | 2 | 0 | 1993 | -115 ±25 | 118 ±25 | 426 ±25 |
| **ASTRO BEACON "E" 1945** | ATF | International 1924 | -251 | -0.14192702 | | | | | | |
| Iwo Jima | | | | | 1 | 0 | 1987 | 145 ±25 | 75 ±25 | -272 ±25 |
| **ASTRO TERN ISLAND (FRIG) 1961** | TRN | International 1924 | -251 | -0.14192702 | | | | | | |
| Tern Island | | | | | 1 | 0 | 1991 | 114 ±25 | -116 ±25 | -333 ±25 |
| **ASTRONOMICAL STATION 1952** | ASQ | International 1924 | -251 | -0.14192702 | | | | | | |
| Marcus Island | | | | | 1 | 0 | 1987 | 124 ±25 | -234 ±25 | -25 ±25 |
| **BELLEVUE (IGN)** | IBE | International 1924 | -251 | -0.14192702 | | | | | | |
| Efate and Erromango Islands | | | | | 3 | 0 | 1987 | -127 ±20 | -769 ±20 | 472 ±20 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: PACIFIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **CANTON ASTRO 1966** | CAO | International 1924 | -251 | -0.14192702 | | | | | | |
| Phoenix Islands | | | | | 4 | 0 | 1987 | 298 ±15 | -304 ±15 | -375 ±15 |
| **CHATHAM ISLAND ASTRO 1971** | CHI | International 1924 | -251 | -0.14192702 | | | | | | |
| Chatham Island (New Zealand) | | | | | 4 | 0 | 1987 | 175 ±15 | -38 ±15 | 113 ±15 |
| **DOS 1968** | GIZ | International 1924 | -251 | -0.14192702 | | | | | | |
| Gizo Island (New Georgia Islands) | | | | | 1 | 0 | 1987 | 230 ±25 | -199 ±25 | -752 ±25 |
| **EASTER ISLAND 1967** | EAS | International 1924 | -251 | -0.14192702 | | | | | | |
| Easter Island | | | | | 1 | 0 | 1987 | 211 ±25 | 147 ±25 | 111 ±25 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: PACIFIC OCEAN** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **GEODETIC DATUM 1949** | GEO | International 1924 | -251 | -0.14192702 | | | | | | |
| New Zealand | | | | | 14 | 0 | 1987 | 84 ±5 | -22 ±3 | 209 ±5 |
| **GUAM 1963** | GUA | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Guam | | | | | 5 | 0 | 1987 | -100 ±3 | -248 ±3 | 259 ±3 |
| **GUX l ASTRO** | DOB | International 1924 | -251 | -0.14192702 | | | | | | |
| Guadalcanal Island | | | | | 1 | 0 | 1987 | 252 ±25 | -209 ±25 | -751 ±25 |
| **INDONESIAN 1974** | IDN | Indonesian 1974 | -23 | -0.00114930 | | | | | | |
| Indonesia | | | | | 1 | 0 | 1993 | -24 ±25 | -15 ±25 | 5 ±25 |
| **JOHNSTON ISLAND 1961** | JOH | International 1924 | -251 | -0.14192702 | | | | | | |
| Johnston Island | | | | | 2 | 0 | 1991 | 189 ±25 | -79 ±25 | -202 ±25 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: PACIFIC OCEAN | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | | **ΔY(m)** | | **ΔZ(m)** | | |
| **KUSAIE ASTRO 1951** | KUS | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Caroline Islands, Fed. States of Micronesia | | | | | 1 | 0 | 1991 | 647 | ±25 | 1777 | ±25 | -1124 | ±25 | |
| **LUZON** | LUZ | Clarke 1866 | -69.4 | -0.37264639 | | | | | | | | | | |
| Philippines (Excluding Mindanao Island) | LUZ-A | | | | 6 | 0 | 1987 | -133 | ±8 | -77 | ±11 | -51 | ±9 | |
| Mindanao Island | LUZ-B | | | | 1 | 0 | 1987 | -133 | ±25 | -79 | ±25 | -72 | ±25 | |
| **MIDWAY ASTRO 1961** | MID | International 1924 | -251 | -0.14192702 | | | | | | | | | | |
| Midway Islands | | | | | 1 | 1 | 2003 | 403 | ±25 | -81 | ±25 | 277 | ±25 | |
| Midway Islands | | | | | 1 | 0 | 1987 | 912 | ±25 | -58 | ±25 | 1227 | ±25 | |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: PACIFIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **OLD HAWAIIAN** | OHA | Clarke 1866 | -69.4 | -0.37264639 | | | | | | |
| Mean Solution | OHA-M | | | | 15 | 0 | 1987 | 61 ±25 | -285 ±20 | -181 ±20 |
| Hawaii | OHA-A | | | | 2 | 0 | 1991 | 89 ±25 | -279 ±25 | -183 ±25 |
| Kauai | OHA-B | | | | 3 | 0 | 1991 | 45 ±20 | -290 ±20 | -172 ±20 |
| Maui | OHA-C | | | | 2 | 0 | 1991 | 65 ±25 | -290 ±25 | -190 ±25 |
| Oahu | OHA-D | | | | 8 | 0 | 1991 | 58 ±10 | -283 ±6 | -182 ±6 |
| **OLD HAWAIIAN** | OHI | International 1924 | -251 | -0.14192702 | | | | | | |
| Mean Solution | OHI-M | | | | 15 | 0 | 2000 | 201 ±25 | -228 ±20 | -346 ±20 |
| Hawaii | OHI-A | | | | 2 | 0 | 2000 | 229 ±25 | -222 ±25 | -348 ±25 |
| Kauai | OHI-B | | | | 3 | 0 | 2000 | 185 ±20 | -233 ±20 | -337 ±20 |
| Maui | OHI-C | | | | 2 | 0 | 2000 | 205 ±25 | -233 ±25 | -355 ±25 |
| Oahu | OHI-D | | | | 8 | 0 | 2000 | 198 ±10 | -226 ±6 | -347 ±6 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| **Continent: PACIFIC OCEAN** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **PITCAIRN ASTRO 1967** | PIT | International 1924 | -251 | -0.14192702 | | | | | | |
| Pitcairn Island | | | | | 1 | 0 | 1987 | 185 ±25 | 165 ±25 | 42 ±25 |
| **SANTO (DOS) 1965** | SAE | International 1924 | -251 | -0.14192702 | | | | | | |
| Espirito Santo Island | | | | | 1 | 0 | 1987 | 170 ±25 | 42 ±25 | 84 ±25 |
| **VITI LEVU 1916** | MVS | Clarke 1880 | -112.145 | -0.54750714 | | | | | | |
| Viti Levu Island (Fiji Islands) | | | | | 1 | 0 | 1987 | 51 ±25 | 391 ±25 | -36 ±25 |
| **WAKE-ENIWETOK 1960** | ENW | Hough | -133 | -0.14192702 | | | | | | |
| Marshall Islands | | | | | 10 | 0 | 1991 | 102 ±3 | 52 ±3 | -38 ±3 |

**Appendix B.10**
Transformation Parameters
Local Geodetic Datums to WGS 84

| Continent: PACIFIC OCEAN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Local Geodetic Datums** | | **Reference Ellipsoids and Parameter Differences** | | | **No. of Satellite Stations Used** | **Transformation Parameters** | | | | |
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x 10⁴** | | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **WAKE ISLAND ASTRO 1952** | WAK | International 1924 | -251 | -0.14192702 | | | | | | |
| Wake Atoll | | | | | 2 | 0 | 1991 | 276 ±25 | -57 ±25 | 149 ±25 |

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## APPENDIX C

## DATUM TRANSFORMATIONS DERIVED USING NON-SATELLITE INFORMATION

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# DATUM TRANSFORMATION CONSTANTS
# LOCAL GEODETIC DATUMS TO WGS 84
# (THROUGH NON-SATELLITE TIES)

## 1. GENERAL

This appendix provides the details about the reference ellipsoids (Appendix A) used as defining parameters for the local geodetic datums which are related to WGS 84 through non-satellite ties to the local control.

There are ten such local/regional geodetic datums, and one special area under the European Datum 1950 (ED 50).

## 2. LOCAL DATUM ELLIPSOIDS

Appendix C.1 lists alphabetically the local geodetic datums and their associated ellipsoids. Two letter ellipsoidal codes (Appendix A) have also been included to clearly indicate which "version" of the ellipsoid has been used to determine the transformation constants.

## 3. TRANSFORMATION CONSTANTS

Appendix C.2 alphabetically lists the local geodetic datums and the special area under ED 50 with the associated shift constants.

The year of initial publication and cycle numbers have been provided as a new feature in this edition. This makes it possible for a user to determine when a particular set of transformation parameters first became available and if the current set has replaced an outdated set.

A cycle number of zero indicates that the set of parameters are as they were published in DMA TR 8350.2, Second Edition, 1 September 1991 including Insert 1, 30 August 1993 or that the parameters are new to this edition (1997 Publication Date). A cycle number of one indicates that the current parameters have replaced outdated parameters that were in the previous edition.

If transformation parameter sets are updated in future editions of this publication, the cycle numbers for each parameter set that is updated will increment by one.

## 4. ERROR ESTIMATES

The error estimates are not available for the datum transformation constants listed in the Appendix C.2.

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**Appendix C.1**
Local Geodetic Datums
Related to World Geodetic System 1984
(Through non-Satellite Ties)

| Local Geodetic Datum | Associated [*] Reference Ellipsoid | Code |
|---|---|---|
| Bukit Rimpah | Bessel 1841 | BR |
| Camp Area Astro | International 1924 | IN |
| European 1950 | International 1924 | IN |
| Gunung Segara | Bessel 1841 | BR |
| Herat North | International 1924 | IN |
| Hermannskogel | Bessel 1841 | BR |
| Indian | Everest | EF |
| Pulkovo 1942 | Krassovsky 1940 | KA |
| Tananarive Observatory 1925 | International 1924 | IN |
| Voirol 1874 | Clarke 1880 | CD |
| Yacare | International 1924 | IN |

[*] See Appendix A.1 for associated constants a, f.

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**Appendix C.2**

Non-Satellite Derived Transformation Parameters

Local Geodetic Datums to WGS 84

| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | Transformation Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **BUKIT RIMPAH** | BUR | Bessel 1841 | 739.845 | 0.10037483 | | | | | |
| Bangka and Belitung Islands (Indonesia) | | | | | 0 | 1987 | -384 | 664 | -48 |
| **CAMP AREA ASTRO** | CAZ | International 1924 | -251 | -0.14192702 | | | | | |
| Camp McMurdo Area, Antarctica | | | | | 0 | 1987 | -104 | -129 | 239 |
| **EUROPEAN 1950** | EUR-S | International 1924 | -251 | -0.14192702 | | | | | |
| Iraq, Israel, Jordan Kuwait, Lebanon, Saudi Arabia, and Syria | | | | | 0 | 1991 | -103 | -106 | -141 |
| **GUNUNG SEGARA** | GSE | Bessel 1841 | 739.845 | 0.10037483 | | | | | |
| Kalimantan (Indonesia) | | | | | 0 | 1987 | -403 | 684 | 41 |
| **HERAT NORTH** | HEN | International 1924 | -251 | -0.14192702 | | | | | |
| Afghanistan | | | | | 0 | 1987 | -333 | -222 | 114 |

**Appendix C.2**
Non-Satellite Derived Transformation Parameters
Local Geodetic Datums to WGS 84

| Local Geodetic Datums | | Reference Ellipsoids and Parameter Differences | | | Transformation Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **Name** | **Δa(m)** | **Δf x $10^4$** | **Cycle Number** | **Pub. Date** | **ΔX(m)** | **ΔY(m)** | **ΔZ(m)** |
| **HERMANNSKOGEL** | HER | Bessel 1841 | 739.845 | 0.10037483 | | | | | |
| Yugoslavia (Prior to 1990) Slovenia, Croatia, Bosnia and Herzegovina, Serbia | | | | | 0 | 1997 | 682 | -203 | 480 |
| **INDIAN** | IND-P | Everest | 827.387* | 0.28361368 | | | | | |
| Pakistan | | | | | 0 | 1993 | 283 | 682 | 231 |
| **PULKOVO 1942** | PUK | Krassovsky 1940 | -108 | 0.00480795 | | | | | |
| Russia | | | | | 0 | 1993 | 28 | -130 | -95 |
| **TANANARIVE OBSERVATORY 1925** | TAN | International 1924 | -251 | -0.14192702 | | | | | |
| Madagascar | | | | | 0 | 1987 | -189 | -242 | -91 |
| **VOIROL 1874** | VOI | Clarke 1880 | -112.145 | -0.54750714 | | | | | |
| Tunisia/Algeria | | | | | 0 | 1997 | -73 | -247 | 227 |
| **YACARE** | YAC | International 1924 | -251 | -0.14192702 | | | | | |
| Uruguay | | | | | 0 | 1987 | -155 | 171 | 37 |

* See Appendix A.1

# APPENDIX D

# MULTIPLE REGRESSION EQUATIONS FOR SPECIAL CONTINENTAL SIZE LOCAL GEODETIC DATUMS

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## MULTIPLE REGRESSION EQUATIONS

1. GENERAL

This appendix provides the Multiple Regression Equations (MREs) parameters for continental size datums and for contiguous large land areas (Table D-1).

**Table D.1**

**DATUMS WITH MULTIPLE REGRESSION EQUATIONS**

| DATUM NAME | AREA COVERED |
|---|---|
| Australian Geodetic 1966 | Australian Mainland |
| Australian Geodetic 1984 | Australian Mainland |
| Campo Inchauspe | Argentina |
| Corrego Alegre | Brazil |
| European 1950 | Western Europe (Austria, Denmark, France, W. Germany*, The Netherlands, and Switzerland.) |
| North American 1927 | CONUS and Canadian Mainland |
| South American 1969 | South American Mainland (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Peru, Paraguay, Uruguay, and Venezuela. |

* Prior to October 1990.

2. APPLICATIONS

The coverage area for MREs application are defined in detail for each datum. MREs coverage area should never be extrapolated and are not to be used over islands and/or isolated land areas.

The main advantage of MREs lies in their modeling of distortions for datums, which cover continental size land areas, to obtain better transformation fit in geodetic applications.

**Multiple Regression Equations (MREs)**
**for Transforming**
**Australian Geodetic Datum 1966 (AUA) to WGS 84**

Area of Applicability: **Australian Mainland (excluding Tasmania)**

MRE coefficients for ø and λ are:

$$\Delta ø'' = 5.19238 + 0.12666\,U + 0.52309\,V - 0.42069\,U^2 - 0.39326\,UV + 0.93484\,U^2V + 0.44249\,UV^2 - 0.30074\,UV^3 + 1.00092\,U^5 - 0.07565\,V^6 - 1.42988\,U^9 - 16.06639\,U^4V^5 + 0.07428\,V^9 + 0.24256\,UV^9 + 38.27946\,U^6V^7 - 62.06403\,U^7V^8 + 89.19184\,U^9V^8$$

$$\Delta\lambda'' = 4.69250 - 0.87138\,U - 0.50104\,V + 0.12678\,UV - 0.23076\,V^2 - 0.61098\,U^2V - 0.38064\,V^3 + 2.89189\,U^6 + 5.26013\,U^2V^5 - 2.97897\,U^8 + 5.43221\,U^3V^5 - 3.40748\,U^2V^6 + 0.07772\,V^8 + 1.08514\,U^8V + 0.71516\,UV^8 + 0.20185\,V^9 + 5.18012\,U^2V^8 - 1.72907\,U^3V^8 - 1.24329\,U^2V^9$$

Where: $U = K\,(ø + 27°)$; $V = K\,(\lambda - 134°)$; $K = 0.05235988$

NOTE: Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case:

| AUA | Shift | WGS 84 |
|---|---|---|
| ø = (-)17° 00' 32.78"S | Δø = 5.48" | ø = (-)17° 00' 27.30"S |
| λ = 144° 11' 37.25"E | Δλ = 3.92" | λ = 144° 11' 41.17"E |

**Multiple Regression Equations (MREs)**
**for Transforming**
**Australian Geodetic Datum 1984 (AUG) to WGS 84**

Area of Applicability: **Australian Mainland (excluding Tasmania)**

MRE coefficients for ø and λ are:

$$\Delta\phi'' = 5.20604 + 0.25225\,U + 0.58528\,V - 0.41584\,U^2 - 0.38620\,UV - 0.06820\,V^2 + 0.38699\,U^2V + 0.07934\,UV^2 + 0.37714\,U^4 - 0.52913\,U^4V + 0.38095\,V^7 + 0.68776\,U^2V^6 - 0.03785\,V^8 - 0.17891\,U^9 - 4.84581\,U^2V^7 - 0.35777\,V^9 + 4.23859\,U^2V^9$$

$$\Delta\lambda'' = 4.67877 - 0.73036\,U - 0.57942\,V + 0.28840\,U^2 + 0.10194\,U^3 - 0.27814\,UV^2 - 0.13598\,V^3 + 0.34670\,UV^3 - 0.46107\,V^4 + 1.29432\,U^2V^3 + 0.17996\,UV^4 - 1.13008\,U^2V^5 - 0.46832\,U^8 + 0.30676\,V^8 + 0.31948\,U^9 + 0.16735\,V^9 - 1.19443\,U^3V^9$$

Where: $U = K\,(\phi + 27°)$; $V = K\,(\lambda - 134°)$; $K = 0.05235988$

NOTE: Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case:

| AUG | Shift | WGS 84 |
|---|---|---|
| ø = (-)20° 38' 00.67"S | Δø = 5.50" | ø = (-)20° 37' 55.17"S |
| λ = 144° 24' 29.29"E | Δλ = 4.11" | λ = 144° 24' 33.40"E |

**Multiple Regression Equations (MREs)**
**for Transforming**
**Campo Inchauspe Datum (CAI) to WGS 84**

Area of Applicability: **Argentina (Continental land areas only)**

MRE coefficients for ø and λ are:

$$\Delta\phi'' = 1.67470 + 0.52924\ U - 0.17100\ V + 0.18962\ U^2 + 0.04216\ UV + 0.19709\ UV^2 - 0.22037\ U^4 - 0.15483\ U^2V^2 - 0.24506\ UV^4 - 0.05675\ V^5 + 0.06674\ U^6 + 0.01701\ UV^5 - 0.00202\ U^7 + 0.08625\ V^7 - 0.00628\ U^8 + 0.00172\ U^8V^4 + 0.00036\ U^9V^6$$

$$\Delta\lambda'' = - 2.93117 + 0.18225\ U + 0.69396\ V - 0.04403\ U^2 + 0.07955\ V^2 + 1.48605\ V^3 - 0.00499\ U^4 - 0.02180\ U^4V - 0.29575\ U^2V^3 + 0.20377\ UV^4 - 2.47151\ V^5 + 0.09073\ U^3V^4 + 1.33556\ V^7 + 0.01575\ U^3V^5 - 0.26842\ V^9$$

Where: $U = K\ (\phi + 35°)$; $V = K\ (\lambda + 64°)$; $K = 0.15707963$

NOTE: Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case :

| CAI | Shift | WGS 84 |
|---|---|---|
| ø = (-)29° 47' 45.68"S | Δø = 1.95" | ø = (-)29° 47' 43.73"S |
| λ = (-) 58° 07' 38.20"W | Δλ =-1.96" | λ = (-) 58° 07' 40.16"W |

**Multiple Regression Equations (MREs)**
**for Transforming**
**Corrego Alegre Datum (COA) to WGS 84**

Area of Applicability: **Brazil (Continental land areas only)**

MRE coefficients for ø and λ are:

$$\Delta\phi'' = -0.84315 + 0.74089\,U - 0.21968\,V - 0.98875\,U^2 + 0.89883\,UV + 0.42853\,U^3 + 2.73442\,U^4 - 0.34750\,U^3V + 4.69235\,U^2V^3 - 1.87277\,U^6 + 11.06672\,U^5V - 46.24841\,U^3V^3 - 0.92268\,U^7 - 14.26289\,U^7V + 334.33740\,U^5V^5 - 15.68277\,U^9V^2 - 2428.8586\,U^8V^8$$

$$\Delta\lambda'' = -1.46053 + 0.63715\,U + 2.24996\,V - 5.66052\,UV + 2.22589\,V^2 - 0.34504\,U^3 - 8.54151\,U^2V + 0.87138\,U^4 + 43.40004\,U^3V + 4.35977\,UV^3 + 8.17101\,U^4V + 16.24298\,U^2V^3 + 19.96900\,UV^4 - 8.75655\,V^5 - 125.35753\,U^5V - 127.41019\,U^3V^4 - 0.61047\,U^8 + 138.76072\,U^7V + 122.04261\,U^5V^4 - 51.86666\,U^9V + 45.67574\,U^9V^3$$

Where: $U = K(\phi + 15°)$; $V = K(\lambda + 50°)$; $K = 0.05235988$

NOTE: Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case :

| COA | Shift | WGS 84 |
|---|---|---|
| ø = (-)20° 29' 01.02"S | Δø = -1.03" | ø = (-)20° 29' 02.05"S |
| λ = (-)54° 47' 13.17"W | Δλ = -2.10" | λ = (-)54° 47' 15.27"W |

**Multiple Regression Equations (MREs)**
**for Transforming**
**European Datum 1950 (EUR) to WGS 84**

Area of Applicability : **Western Europe* (Continental contiguous land areas only)**

MRE coefficients for ø and λ are :

$$\Delta\phi'' = -2.65261 + 2.06392\,U + 0.77921\,V + 0.26743\,U^2 + 0.10706\,UV + 0.76407\,U^3 - 0.95430\,U^2V + 0.17197\,U^4 + 1.04974\,U^4V - 0.22899\,U^5V^2 - 0.05401\,V^8 - 0.78909\,U^9 - 0.10572\,U^2V^7 + 0.05283\,UV^9 + 0.02445\,U^3V^9$$

$$\Delta\lambda'' = -4.13447 - 1.50572\,U + 1.94075\,V - 1.37600\,U^2 + 1.98425\,UV + 0.30068\,V^2 - 2.31939\,U^3 - 1.70401\,U^4 - 5.48711\,UV^3 + 7.41956\,U^5 - 1.61351\,U^2V^3 + 5.92923\,UV^4 - 1.97974\,V^5 + 1.57701\,U^6 - 6.52522\,U^3V^3 + 16.85976\,U^2V^4 - 1.79701\,UV^5 - 3.08344\,U^7 - 14.32516\,U^6V + 4.49096\,U^4V^4 + 9.98750\,U^8V + 7.80215\,U^7V^2 - 2.26917\,U^2V^7 + 0.16438\,V^9 - 17.45428\,U^4V^6 - 8.25844\,U^9V^2 + 5.28734\,U^8V^3 + 8.87141\,U^5V^7 - 3.48015\,U^9V^4 + 0.71041\,U^4V^9$$

Where : $U = K(\phi - 52°)$; $V = K(\lambda - 10°)$; $K = 0.05235988$

NOTE Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case :

| EUR | Shift | WGS 84 |
| --- | --- | --- |
| ø = 46° 41' 42.89"N | Δø = -3.08" | ø = 46° 41' 39.81"N |
| λ = 13° 54' 54.09"E | Δλ = -3.49" | λ = 13° 54' 50.60"E |

* See Table D.1 (Page D-3) for the list of countries covered by the above set of MREs.

**Multiple Regression Equations (MREs)**
**for Transforming**
**North American Datum 1927 (NAS) to WGS 84**

Area of Applicability: **Canada (Continental contiguous land areas only)**

MRE coefficients for ø and λ are:

$$\Delta\text{ø}'' = 0.79395 + 2.29199\,U + 0.27589\,V - 1.76644\,U^2 + 0.47743\,UV + 0.08421\,V^2 - 6.03894\,U^3 - 3.55747\,U^2V - 1.81118\,UV^2 - 0.20307\,V^3 + 7.75815\,U^4 - 3.1017\,U^3V + 3.58363\,U^2V^2 - 1.31086\,UV^3 - 0.45916\,V^4 + 14.27239\,U^5 + 3.28815\,U^4V + 1.35742\,U^2V^3 + 1.75323\,UV^4 + 0.44999\,V^5 - 19.02041\,U^4V^2 - 1.01631\,U^2V^4 + 1.47331\,UV^5 + 0.15181\,V^6 + 0.41614\,U^2V^5 - 0.80920\,UV^6 - 0.18177\,V^7 + 5.19854\,U^4V^4 - 0.48837\,UV^7 - 0.01473\,V^8 - 2.26448\,U^9 - 0.46457\,U^2V^7 + 0.11259\,UV^8 + 0.02067\,V^9 + 47.64961\,U^8V^2 + 0.04828\,UV^9 + 36.38963\,U^9V^2 + 0.06991\,U^4V^7 + 0.08456\,U^3V^8 + 0.09113\,U^2V^9 + 5.93797\,U^7V^5 - 2.36261\,U^7V^6 + 0.09575\,U^5V^8$$

$$\Delta\lambda'' = -1.36099 + 3.61796\,V - 3.97703\,U^2 + 3.09705\,UV - 1.15866\,V^2 - 13.28954\,U^3 - 3.15795\,U^2V + 0.68405\,UV^2 - 0.50303\,V^3 - 8.81200\,U^3V - 2.17587\,U^2V^2 - 1.49513\,UV^3 + 0.84700\,V^4 + 31.42448\,U^5 - 14.67474\,U^3V^2 + 0.65640\,UV^4 + 17.55842\,U^6 + 6.87058\,U^4V^2 - 0.21565\,V^6 + 62.18139\,U^5V^2 + 1.78687\,U^3V^4 + 2.74517\,U^2V^5 - 0.30085\,UV^6 + 0.04600\,V^7 + 63.52702\,U^6V^2 + 7.83682\,U^5V^3 + 9.59444\,U^3V^5 + 0.01480\,V^8 + 10.51228\,U^4V^5 - 1.42398\,U^2V^7 - 0.00834\,V^9 + 5.23485\,U^7V^3 - 3.18129\,U^3V^7 + 8.45704\,U^9V^2 - 2.29333\,U^4V^7 + 0.14465\,U^2V^9 + 0.29701\,U^3V^9 + 0.17655\,U^4V^9$$

Where : $U = K\,(\text{ø} - 60°)$; $V = K\,(\lambda + 100°)$; $K = 0.05235988$

NOTE : Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case :

| NAS | Shift | WGS 84 |
|---|---|---|
| ø = 54° 26' 08.67"N | Δø = 0.29" | ø = 54° 26' 08.96"N |
| λ = (-)110° 17' 02.41"W | Δλ = -3.16" | λ = (-)110° 17' 05.57"W |

**Multiple Regression Equations (MREs)**
**for Transforming**
**North American Datum 1927 (NAS) to WGS 84**

Area of Applicability : **USA (Continental contiguous land areas only; excluding Alaska and Islands)**

MRE coefficients for ø and λ are :

$$\Delta\phi'' = 0.16984 - 0.76173\ U + 0.09585\ V + 1.09919\ U^2 - 4.57801\ U^3 - 1.13239\ U^2V + 0.49831\ V^3 - 0.98399\ U^3V + 0.12415\ UV^3 + 0.11450\ V^4 + 27.05396\ U^5 + 2.03449\ U^4V + 0.73357\ U^2V^3 - 0.37548\ V^5 - 0.14197\ V^6 - 59.96555\ U^7 + 0.07439\ V^7 - 4.76082\ U^8 + 0.03385\ V^8 + 49.04320\ U^9 - 1.30575\ U^6V^3 - 0.07653\ U^3V^9 + 0.08646\ U^4V^9$$

$$\Delta\lambda'' = -0.88437 + 2.05061\ V + 0.26361\ U^2 - 0.76804\ UV + 0.13374\ V^2 - 1.31974\ U^3 - 0.52162\ U^2V - 1.05853\ UV^2 - 0.49211\ U^2V^2 + 2.17204\ UV^3 - 0.06004\ V^4 + 0.30139\ U^4V + 1.88585\ UV^4 - 0.81162\ UV^5 - 0.05183\ V^6 - 0.96723\ UV^6 - 0.12948\ U^3V^5 + 3.41827\ U^9 - 0.44507\ U^8V + 0.18882\ UV^8 - 0.01444\ V^9 + 0.04794\ UV^9 - 0.59013\ U^9V^3$$

Where : $U = K(\phi - 37°)$; $V = K(\lambda + 95°)$; $K = 0.05235988$

NOTE : Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case :

| NAS | Shift | WGS 84 |
|---|---|---|
| ø = 34° 47' 08.83"N | Δø = 0.36" | ø = 34° 47' 09.19"N |
| λ = (-)86° 34' 52.18"W | Δλ = 0.08" | λ = (-)86° 34' 52.10"W |

**Multiple Regression Equations (MREs)**
**for Transforming**
**South American Datum 1969 (SAN) to WGS 84**

Area of Applicability : **South America (Continental contiguous land areas only)**

MRE coefficients for ø and λ are :

$\Delta\phi''$ = $- 1.67504 - 0.05209\ U + 0.25158\ V + 1.10149\ U^2 + 0.24913\ UV - 1.00937\ U^2V$
$- 0.74977\ V^3 - 1.54090\ U^4 + 0.14474\ V^4 + 0.47866\ U^5 + 0.36278\ U^3V^2$
$- 1.29942\ UV^4 + 0.30410\ V^5 + 0.87669\ U^6 - 0.27950\ U^5V - 0.46367\ U^7$
$+ 4.31466\ U^4V^3 + 2.09523\ U^2V^5 + 0.85556\ UV^6 - 0.17897\ U^8 - 0.57205\ UV^7$
$+ 0.12327\ U^9 - 0.85033\ U^6V^3 - 4.86117\ U^4V^5 + 0.06085\ U^9V - 0.21518\ U^3V^8$
$+ 0.31053\ U^5V^7 - 0.09228\ U^8V^5 - 0.22996\ U^9V^5 + 0.58774\ U^6V^9$
$+ 0.87562\ U^9V^7 + 0.39001\ U^8V^9 - 0.81697\ U^9V^9$

$\Delta\lambda''$ = $- 1.77967 + 0.40405\ U + 0.50268\ V - 0.05387\ U^2 - 0.12837\ UV - 0.54687\ U^2V$
$- 0.17056\ V^3 - 0.14400\ U^3V + 0.11351\ U^5V - 0.62692\ U^3V^3 - 0.01750\ U^8$
$+ 1.18616\ U^3V^5 + 0.01305\ U^9 + 1.01360\ U^7V^3 - 0.29059\ U^8V^3 + 5.12370\ U^6V^5$
$- 5.09561\ U^7V^5 - 5.27168\ U^6V^7 + 4.04265\ U^7V^7 - 1.62710\ U^8V^7$
$+ 1.68899\ U^9V^7 + 2.07213\ U^8V^9 - 1.76074\ U^9V^9$

Where : $U = K(\phi + 20°)$; $V = K(\lambda + 60°)$; $K = 0.05235988$

NOTE : Input ø as (-) from 90°S to 0°N in degrees.

Input λ as (-) from 180°W to 0°E in degrees.

Quality of fit = ± 2.0 m

Test Case

| SAN | Shift | WGS 84 |
|---|---|---|
| ø = (-)31° 56' 33.95"S | Δø = -1.36" | ø = (-)31° 56' 35.31"S |
| λ = (-)65° 06' 18.66"W | Δλ = -2.16" | λ = (-)65° 06' 20.82"W |

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# APPENDIX E

# WGS 72 TO WGS 84 TRANSFORMATION

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## WGS 72 to WGS 84 TRANSFORMATIONS

1. Situations arise where only WGS 72 coordinates are available for a site. In such instances, the WGS 72 to WGS 84 Transformation listed in Table E.1 can be used with the following equations to obtain WGS 84 coordinates for the sites:

$$\phi_{WGS\ 84} = \phi_{WGS\ 72} + \Delta\phi$$

$$\lambda_{WGS\ 84} = \lambda_{WGS\ 72} + \Delta\lambda$$

$$h_{WGS\ 84} = h_{WGS\ 72} + \Delta h$$

2. As indicated in Table E.1, when proceeding directly from WGS 72 coordinates to obtain WGS 84 values, the WGS 84 coordinates will differ from the WGS 72 coordinates due to a shift in the coordinate system origin, a change in the longitude reference, a scale change (treated through $\Delta r$), and changes in the size and shape of the ellipsoid. In addition, it is important to be aware that $\Delta\phi$, $\Delta\lambda$, $\Delta h$ values calculated using Table E.1 do not reflect the effect of differences between the WGS 72 and WGS 84 EGMs and geoids. The following cases are important to note:

a. Table E.1 equations are to be used for direct transformation of Doppler-derived WGS 72 coordinates. These transformed coordinates should agree to within approximately ±2 meters with the directly surveyed WGS 84 coordinates using TRANSIT or GPS point positioning.

b. Table E.1 should not be used for satellite local geodetic stations whose WGS 72 coordinates were determined using datum shifts from [36]. The preferred approach is to transform such WGS 72 coordinates, using datum shifts from [36], back to their respective local datums, and then transform the local datum coordinates to WGS 84 using Appendices B and C.

c. Table E.1 should be used only when no other approach is applicable.

**Table E.1**
Formulas and Parameters
to Transform WGS 72 Coordinates
to WGS 84 Coordinates

| | |
|---|---|
| FORMULAS | $\Delta\phi'' = (4.5 \cos \phi) / (a \sin 1'') + (\Delta f \sin 2\phi) / (\sin 1'')$<br><br>$\Delta\lambda'' = 0.554$<br><br>$\Delta h = 4.5 \sin \phi + a \; \Delta f \sin^2 \phi - \Delta a + \Delta r$ (Units = Meters) |
| PARAMETERS | $\Delta f = 0.3121057 \times 10^{-7}$<br><br>$a = 6378135$ m<br><br>$\Delta a = 2.0$ m<br><br>$\Delta r = 1.4$ m |
| INSTRUCTIONS | To obtain WGS 84 coordinates, add the $\Delta\phi$, $\Delta\lambda$, $\Delta h$ changes calculated using WGS 72 coordinates to the WGS 72 coordinates ($\phi$, $\lambda$, h, respectively).<br><br>Latitude is positive north and longitude is positive east (0° to 180°). |

# APPENDIX F

# ACRONYMS

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# APPENDIX F

| Local/regional datum | S-57 | S-60 |
|---|---|---|
| WGS 72 | 1 | * |
| WGS 84 | 2 | * |
| European 1950 (European Datum) | 3 | EUR |
| Postdam Datum | 4 | ** |
| Adindan | 5 | ADI |
| Afgooye | 6 | AFG |
| Ain el Abd 1970 | 7 | AIN |
| Anna 1 Astro 1965 | 8 | ANO |
| Antigua Island Astro 1943 | 9 | AIA |
| Arc 1950 | 10 | ARF |
| Arc 1960 | 11 | ARS |
| Ascension Island 1958 | 12 | ASC |
| Astro Beacon "E" 1945 | 13 | ATF |
| Astro DOS 71/4 | 14 | SHB |
| Astro Tern Island (FRIG) 1961 | 15 | TRN |
| Astronomical Station 1952 | 16 | ASQ |
| Australian Geodetic 1966 | 17 | AUA |
| Australian Geodetic 1984 | 18 | AUG |
| Ayabelle Lighthouse | 19 | PHA |
| Bellevue (IGN) | 20 | IBE |
| Bermuda 1957 | 21 | BER |
| Bissau | 22 | BID |
| Bogota Observatory | 23 | BOO |
| Bukit Rimpah | 24 | BUR |
| Camp Area Astro | 25 | CAZ |
| Campo Inchauspe | 26 | CAI |
| Canton Astro 1966 | 27 | CAO |
| Cape | 28 | CAP |
| Cape Canaveral | 29 | CAC |
| Carthage | 30 | CGE |
| Chatam Island Astro 1971 | 31 | CHI |
| Chua Astro | 32 | CHU |
| Corrego Alegre | 33 | COA |
| Dabola | 34 | DAL |
| Djakarta (Batavia) | 35 | BAT |
| DOS 1968 | 36 | GIZ |
| Easter Island 1967 | 37 | EAS |
| European 1979 | 38 | EUS |
| Fort Thomas 1955 | 39 | FOT |
| Gan 1970 | 40 | GAA |
| Geodetic Datum 1949 | 41 | GEO |
| Graciosa Base SW 1948 | 42 | GRA |
| Guam 1963 | 43 | GUA |
| Gunung Segara | 44 | GSE |
| GUX 1 Astro | 45 | DOB |
| Herat North | 46 | HEN |
| Hjorsey 1955 | 47 | HJO |
| Hong Kong 1963 | 48 | HKD |
| Hu-Tzu-Shan | 49 | HTN |
| Indian | 50 | IND |
| Indian 1954 | 51 | INF |
| Indian 1975 | 52 | INH |
| Ireland 1965 | 53 | IRL |
| ISTS 061 Astro 1968 | 54 | ISG |

*   See Appendix E.
**   not listed in S-60.

| Local/regional datum | S-57 | S-60 |
|---|---|---|
| ISTS 073 Astro 1969 | 55 | IST |
| Johnston Island 1961 | 56 | JOH |
| Kandawala | 57 | KAN |
| Kerguelen Island 1949 | 58 | KEG |
| Kertau 1948 | 59 | KEA |
| Kusaie Astro 1951 | 60 | KUS |
| L. C. 5 Astro 1961 | 61 | LCF |
| Leigon | 62 | LEH |
| Liberia 1964 | 63 | LIB |
| Luzon | 64 | LUZ |
| Mahe 1971 | 65 | MIK |
| Massawa | 66 | MAS |
| Merchich | 67 | MER |
| Midway Astro 1961 | 68 | MID |
| Minna | 69 | MIN |
| Montserrat Island Astro 1958 | 70 | ASM |
| M'Poraloko | 71 | MPO |
| Nahrwan | 72 | NAH |
| Naparima, BWI | 73 | NAP |
| North American 1927 | 74 | NAS |
| North American 1983 | 75 | NAR |
| Observatorio Meteorológico 1939 | 76 | FLO |
| Old Egyptian 1907 | 77 | OEG |
| Old Hawaiian | 78 | OHA |
| Oman | 79 | FAH |
| Ordnance Survey of Great Britain | 80 | OGB |
| Pico de las Nieves | 81 | PLN |
| Pitcairn Astro 1967 | 82 | PIT |
| Point 58 | 83 | PTB |
| Pointe Noire 1948 | 84 | PTN |
| Porto Santo 1936 | 85 | POS |
| Provisional South American 1956 | 86 | PRP |
| Provisional South Chilean 1963 (also known as Hito XVIII 1963) | 87 | HIT |
| Puerto Rico | 88 | PUR |
| Qatar National | 89 | QAT |
| Qornoq | 90 | QUO |
| Reunion | 91 | REU |
| Rome 1940 | 92 | MOD |
| Santo (DOS) 1965 | 93 | SAE |
| Sao Braz | 94 | SAO |
| Sapper Hill 1943 | 95 | SAP |
| Schwarzeck | 96 | SCK |
| Selvagern Grande 1938 | 97 | SGM |
| South American 1969 | 98 | SAN |
| South Asia | 99 | SOA |
| Tananarive Observatory 1925 | 100 | TAN |
| Timbalai 1948 | 101 | TIL |
| Tokyo | 102 | TOY |
| Tristan Astro 1968 | 103 | TDC |
| Viti Levu 1916 | 104 | MVS |
| Wake-Eniwetok 1960 | 105 | ENW |
| Wake Island Astro 1952 | 106 | WAK |
| Yacare | 107 | YAC |
| Zanderij | 108 | ZAN |

| **Local/regional datum** | **S-57** | **S-60** |
|---|---|---|
| American Samoa | 109 | AMA |
| Deception Island | 110 | DID |
| Indian 1960 | 111 | ING |
| Indonesian 1974 | 112 | IDN |
| North Sahara 1959 | 113 | NSD |
| Pulkovo 1942 | 114 | PUK |
| S-42 (Pulkovo 1942) | 115 | SPK |
| S-JYSK | 116 | CCD |
| Voirol 1960 | 117 | VOR |
| Average Terrestrial System 1977 | 118 | ** |
| Compensation Geodesique du Quebec 1977 | 119 | ** |
| Finnish (KKJ) | 120 | ** |
| Ordnance Survey *of* Ireland | 121 | ** |
| Revised Kertau | 122 | ** |
| Revised Nahrwan | 123 | ** |
| GGRS 76 (Greece) | 124 | ** |
| Nouvelle Triangulation de France | 125 | ** |
| RT 90 (Sweden) | 126 | ** |
| Geocentric Datum *of* Australia (GDA) | 127 | ** |
| BJZ54 (A954 Beijing Coordinates) | 128 | ** |
| Modified BJZ54 | 129 | ** |
| GDZ80 | 130 | ** |

** not listed in S-60.

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