

PREFACE

According to the role of National Geographic Department on Prim Minister's Decree No 255 PM, dated August 16, 2005 regarding to Surveying, Aerial Photography and mapping activities in the territory of Lao People's Democratic Republic, National Geographic Department has improved and edited some part of Lao National Datum 1997 in order to make it suitable with the society in the present time which the technology always developed to the higher level and accurate data is a needed.

A geodetic datum provides a fundamental spatial framework to support the development of social-economic and enables infrastructure, all those work task needed to use data and this data must be accordingly to the Datum systematically and nation wide.

Until now, there have been several different geodetic systems used concurrently in Laos, The relationship between the Datum has been poorly understand and has caused inefficiencies in may mapping operations. In this situation National Geographic Department try to resolve and improved Lao National Datum 1997 and overcome through the completion of a new National Datum and a national Network of accurate survey control points. The relationship between the new datum and the existing datums has been determined as a part of this undertaking.

We do hope that; users of this book will give us feed back and comments, so that we can improve this book for a better work and to fulfill the needed of survey and mapping activities in Laos.

National Geographic Department would like to express our sincere thanks for your comments.

Sincerely Yours,

Vientiane, May, 2010

National Geographic Department

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i Introduction

A Survey and establish of Geodetic Network Control Points in Lao People's Democratic Republic has been carried out from May 18, 2006 to June 12, 2006 and completed the calculation and evaluation on July 5, 2007. The survey comprised:

- A primary geodetic network covering the entire country
- A secondary geodetic network in the south of the country
- A secondary geodetic network to the north of Vientiane

The Network has been established using satellite-based technology known as Global Positioning System (GPS). The survey Data was based on Asia-Pacific Regional Geodetic Project 1998 contained 05 points which now become base Station for WGS 84. A plan of the network is included as Diagram 1

This document is intended to provide the user with sufficient information to use the Lao National Geodetic Datum 1997 (new edition) and its associated coordinates on a routine basis, it provided the reader with a description of Lao National Geodetic Datum 1997 as well as its relationship to World Geodetic System 1984 (WGS 84)

ii The Purpose and Use of Geodetic Datum

The purpose of this book is to implement Prime Minister's Decree No 255 PM date August 16, 2005 regarding to surveying, Aerial Photography and Mapping activities in the territory of Lao People's Democratic Republic to an action. In order to make routine basis for users both governmental sector and private sector who involve with using of survey and mapping data and also using of GIS Technology

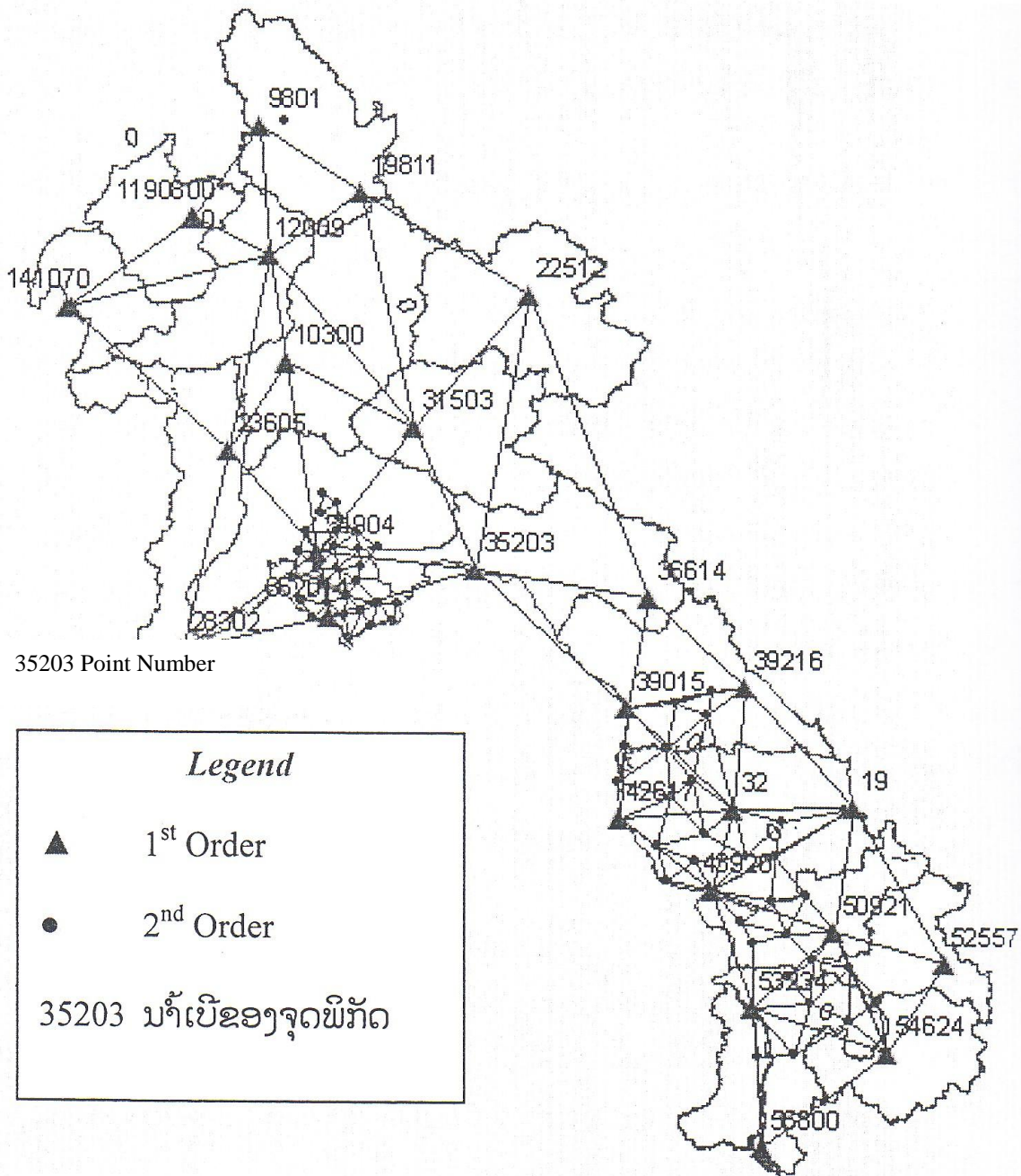
This Geodetic Datum is very important for social-economic development, research, science, contributing significant to the prosperity of the people of Laos.

3. The definition and meaning of Geodetic Datum

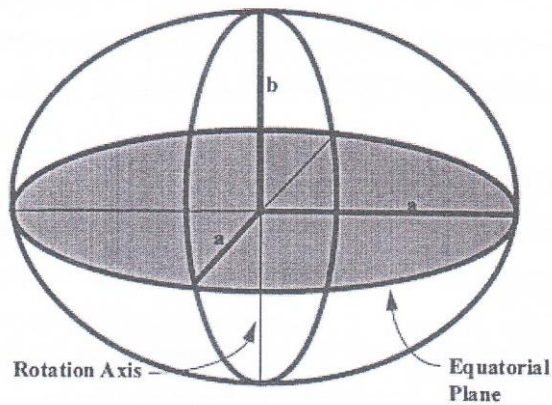
3.1 Geodetic Datum

A Geodetic Datum is a mathematical representation of the size and the shape of the earth. It usually takes the form of Spheroid which helps the calculation of the coordinate in the field easier.

Diagram 1
Lao National Geodetic Network



Horizontal Datum: Defined Point number 00001 located at Ban Nongteng, Sikhottabong District, Vientiane Capital as a starting point.



a = Semi-Major Axis

b = Semi-Minor Axis

Figure 1: Reference Ellipsoid

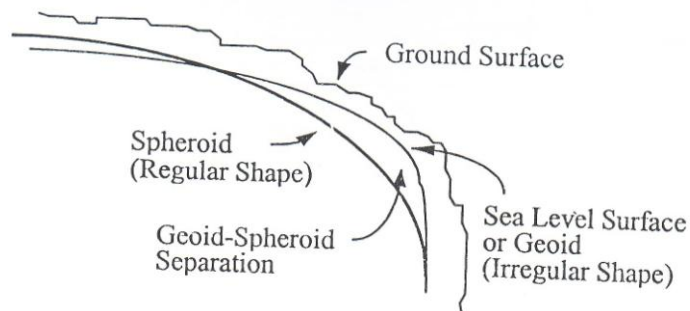


Figure 2: Relationship between Spheroid and Sea Level

Vertical Datum: Is a high of certain point in the earth surface compare to the main sea level measure as meter. Vertical datum in Laos accordingly to mean sea level of south China sea Called Hondau, Doson District, Socialist Republic of Vietnam.

3.2 World Geodetic Datum,

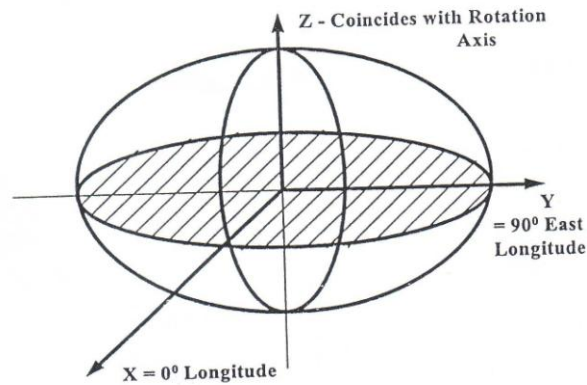
Mostly there are two geodetic datum have been using world wide such as: GEODETIC Coordinate System and Cartesian coordinate system,

Geodetic Coordinates are the system naturally associated with the spheroid. They allow positions on the earth's surface to be described in terms of latitude, longitude and height.

An X, Y, Z Cartesian Coordinate system may also be associated with the datum, such that:

- The positive X axis lies in the equatorial plane and passes through 0 degree longitude,
- The positive Y axis lies in the equatorial plane and passes through 90 degrees East longitude,

- The positive Z axis is parallel to the earth rotation axis and passes through 90 degrees North latitude,
- Datum transformation between two of these Geodetic Datum can be done as following formula:



a = Semi-Major Axis

b = Semi-Minor Axis

Figure 3: Reference Ellipsoid

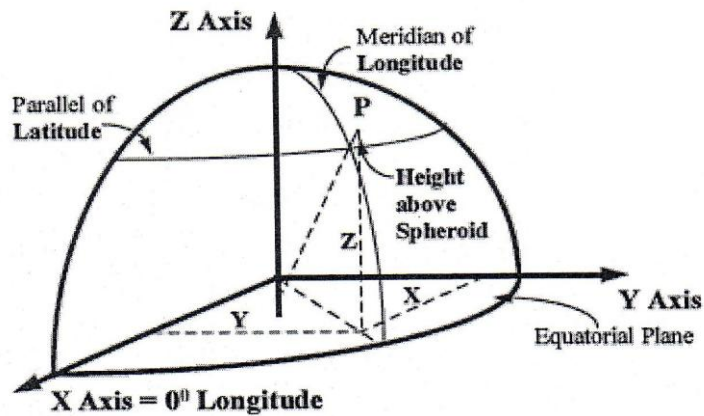


Figure 4: Geodetic Coordinate and Cartesian coordinate

Insert 1

Conversion - Cartographic to Cartesian

The formulae for converting latitude, longitude and spheroid to X, Y, Z are:

$$X = (N + h) \cos\phi \cos\lambda$$

$$Y = (N + h) \cos\phi \sin\lambda$$

$$Z = [(b^2/a^2)N + h]\sin\phi$$

Where:

X, Y, Z Are the Cartesian Coordinates of the point.

ϕ, λ Are that Latitude, Longitude of the point

h Is the height of the point above the spheroid

a,b Are the length of Semi-major and Semi-minor axes of the spheroid

N Is the radius of curvature in the prime vertical

Insert 2

Conversion - Cartesian to Cartographic

The formulae for converting X, Y, Z to latitude, longitude and spheroidal height are:

$$\phi = \text{Arctan} [(Z + e'^2 b \sin^3 \theta) / (p - e'^2 a \cos^3 \theta)]$$

$$\lambda = \text{Arctan} (Y / X)$$

$$h = (p / \cos \phi) - N$$

Where:

X, Y, Z Are the Cartesian Coordinates of the point.

ϕ, λ Are that Latitude, Longitude of the point

h Is the height of the point above the spheroid

a,b Are the length of Semi-major and Semi-minor axes of the spheroid

N Is the radius of curvature in the prime vertical

e^2 is the eccentricity squared = $(a^2 - b^2) / a^2$

e'^2 is the eccentricity squared = $(a^2 - b^2) / b^2$

θ is an auxiliary quantity = $\text{Arctan} (Z a / p b)$

$$p = \sqrt{X^2 + Y^2}$$

3.3 Map Projection Coordinates

A third coordinate system is that provided by a map projection. A map projection is used to enable the curved surface of the spheroid to be presented on a flat sheet of paper (in order words, a map). The projection process results in the map's features being distorted. However, the magnitude of the distortion can be calculated, allowing corrections to be made when necessary.

A rectangular Grid coordinate system is associated with every map projection. Map projections coordinates are described in terms of Easting and Northing, being distance to the East and North of an origin. They are usually expressed in units of meters or feet.

There are a large number of map projections available for use. Each can be implemented on any spheroid. One of the most commonly used is the Transverse Mercator projection, known as the Gauss-Kruger System in some parts of the world. The formula for converting Latitude and Longitude to Grid easting and northing are too complex to be quoted in this document. However they can be found in any reference book on map projections.

The formula for converting Latitude and Longitude to Grid easting and northing

Insert 3

Universal Transverse Mercator (UTM)

Universal Transverse Mercator (UTM) is a global implementation of the Transverse Mercator Projection; it divides the earth into 60 zones, each being bounded by meridians of longitude (extending from the North Pole to the South Pole)

Each UTM zone is 6 degrees wide. The meridian at its center is referred to the Central Meridian is assigned the coordinates:

East: 500,000.000 meters

North: 0.000 meters

A scale factor of 0.9996 is applied to all grid distances to minimize the absolute distortions across the zone.

3.4 Horizontal Datum and Vertical Datum

Geodetic Datums are usually classified into two categories. There are known as local geodetic datums and geocentric datums as WGS 84.

A local geodetic datum is a datum which best approximates the size and shape of a particular part of the earth's surface.

(Please refer to figure 5 for more detail)

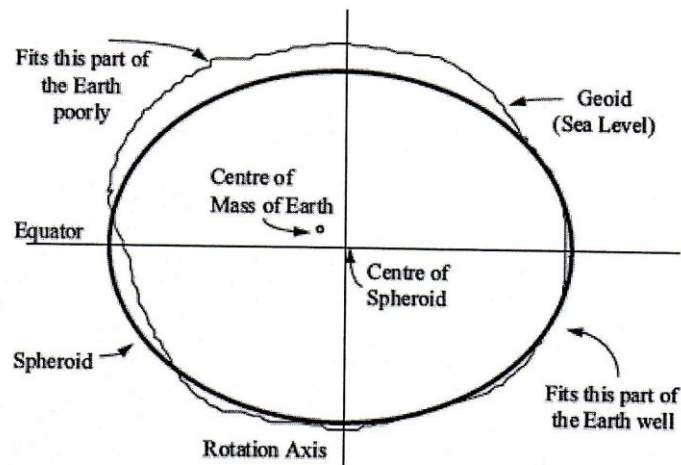


Figure 5: Local Geodetic Datum

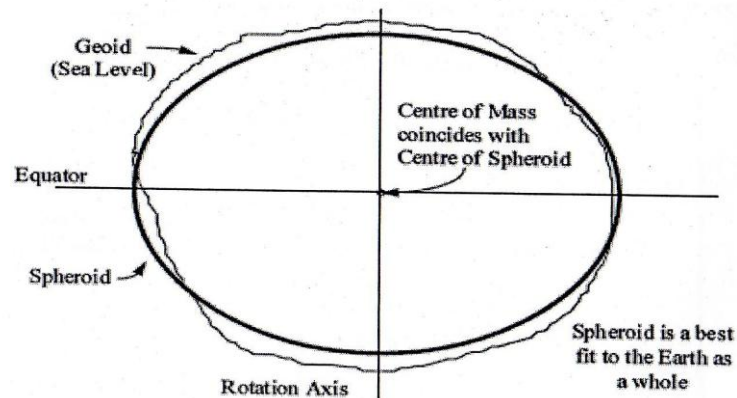


Figure 6: Geocentric Geodetic Datum

The Lao National Datum 1997 is an example of a local datum. Its spheroid is a good approximation to the size and shape of the sea level surface in the region of Laos but a poor approximation in other parts of the world.

3.5 Datum Transformation

The Geodetic coordinates of a point are dependent on the datum to which they are related. The latitude, Longitude and Spheroid height of a point defined on datum “1” (for example, Lao National Datum 1997) will almost certainly be different from the latitude, longitude and height for the same point defined on the datum “2” (For example, WGS 84). The difference may be a consequent of:

- The ellipsoid being different shape
- The centers of ellipsoid being displaced, possibly by hundreds of meters (see figure 10)
- The coordinate axes of the two datums not being parallel or being subject to a scale difference (See figure 11)

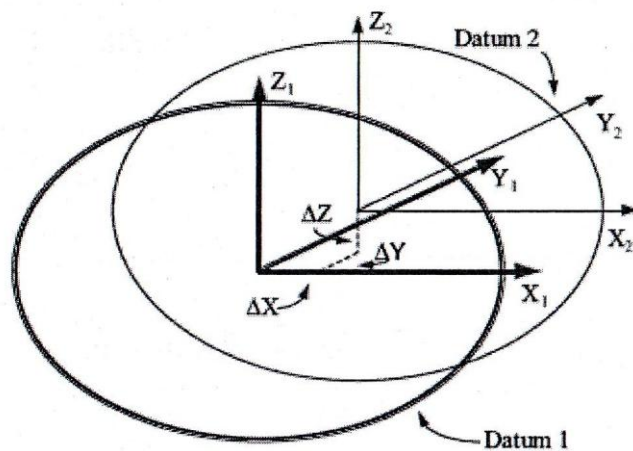


Figure 7: 3-Parameters Transformation

Coordinates can be converted from one datum to another if the relationship between the two datums is known. If the Cartesian coordinate axes of the two datums are known to be parallel and identically scaled, they can be simply related through a three or seven parameter transformation

Insert 4

Three-Parameter Transformation Formulae

$$X_1 = X_2 + \Delta X$$

$$Y_1 = Y_2 + \Delta Y$$

$$Z_1 = Z_2 + \Delta Z$$

Where:

X_1, Y_1, Z_1 = Cartesian Coordinates of Datum 1

X_2, Y_2, Z_2 = Cartesian Coordinates of datum 2

$\Delta X, \Delta Y, \Delta Z$ = the difference between the centers of the two spheroids.

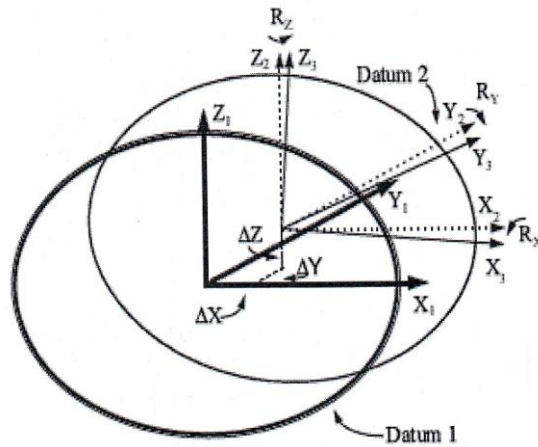


Figure 8: Seven-Parameter Transformation

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Seven-Parameter Transformation Formulae

$$\begin{pmatrix} X_1 \\ Y_1 \\ Z_1 \end{pmatrix} = \begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{pmatrix} + S_C \begin{pmatrix} 1 & R_Z & -R_Y \\ -R_Z & 1 & R_X \\ R_Y & -R_X & 1 \end{pmatrix} \begin{pmatrix} X_2 \\ Y_2 \\ Z_2 \end{pmatrix}$$

Where:

X_1, Y_1, Z_1 = Cartesian Coordinates of Datum 1

X_2, Y_2, Z_2 = Cartesian Coordinates of datum 2

$\Delta X, \Delta Y, \Delta Z$ = the difference between the centers
of the two spheroids

R_X, R_Y, R_Z = Cut Angles of X_3, Y_3, Z_3

S_C = Multiplier indicated the differences
Between two scales.

4 The Lao national Geodetic Datum 1997

4.1 Datum Definition parameter

The Lao National Geodetic Datum 1997 is a local geodetic datum by the following parameters,

Spheroid Kraaovskiy 1940

$a = 6378245.000$; $1/f = 298.3$

Original Station: Vientiane (Nongteng); point № 00001

The Cartesian coordinate axes of the Lao national Geodetic Datum 1997 are defined as being parallel to those of WGS 84

4.2 Source of Geodetic Datum in Laos

- **From 1997 to 2007**

WGS84 coordinates for stations in Laos have been delivered using GPS technology. A series of 25 GPS points were observed at 13 primary network stations distributed throughout the country. The observations were made between 27 June 1997 and 30 July 1997 each observation session was approximately 23 hours in duration.

Final WGS84 coordinates were calculated by best fitting the GPS primary network to the point position values. The resulting for Vientiane (Nongteng) Astro pillar was then adopted as the WGS84 original value in Laos before 2007.

- **From 2008 to present**

In 1998, GPS observations were made. National Geographic Department in co-operation with Asia Pacific Regional Geodetic Project (APGRP), there was 10 days of observation and 24 hours in duration and connects to 7 points (Primary control network points) and these points also connect to International Terrestrial Reference Frame Work (ITRF) of the countries in the Asia-Pacific region such as: Australia, China and Japan.

Spheroid WGS 84:

$a = 6378137.000$

$b = 6356752.3142$

$1 / f = 298.257223563$

The result of Calculation

VIEN	00001	-1314797.636	5923043.672	1961129.571
HOUA	14107	-1084448.866	5887162.305	2195042.992
KHON	56800	-1689963.939	5951481.713	1545756.323
LAKX	36614	-1567312.588	5855889.643	1978061.444
SANN	22152	-1451207.624	5801838.027	2211983.029

4.3 Geodetic Transformation in Laos

The transformation parameters to be added to Lao National Datum 1997 Cartesian Coordinates to produce WGS84 Cartesian Coordinates are:

$\Delta = +46.012$ meters (0.090 meter)

$\Delta = -127.108$ meters (0.109 meter)

$\Delta = -38.131$ meters (0.000 meter)

The other axis of Lao National Datum defined as being parallel to WGS 84, cut angle therefore zero

Transformation of Geodetic Coordinate

	North/Latitude	East/Longitude	Height/Z
Lao 1997 UTM Coordinate (Zone 47)	2,318,968.203 m	749,848.646 m	Ht m 542.895 m
Lao 1997 Geodetic Coordinates	20° 57' 14.26760"	101°24'09.83460"	Ht 542.895 m
Lao 1997 XYZ Coordinates	-1,178,216.948 m	5,481,867.362 m	2,266,832.192 m
Transformation Parameters	46.012 m	-127.108 m	-38.131 m
WGS84 XYZ Coordinates	-1,178,170.822 m	5,841,740.141 m	2,266,832.192 m
WGS84 Geodetic Coordinates	20°57' 14.72320"	101°24'09.14017"	Ht 512.610 m

Remarks:

To transform WGS84 coordinates to Lao National Geodetic Datum 1997, reverse the signs on the three transformation parameters before applying.

4.4 GPS, WGS84 and the Lao National Geodetic Datum 1997

The global positioning system generates position information in the WGS84 coordinate system. This is significantly different to the coordinates system of the Lao national Geodetic Datum 1997. A datum transformation will usually be needed to transfer positions information from one datum to the other.

GPS base lines which are outputs as XYZ vectors maybe directly used in conjunction with Lao National Geodetic Datum 1997 Cartesian coordinates. This is possible because the axes of the Lao Datum are parallel to those of the WGS84 system. However, the vector must be in XYZ format.

Any vector express in terms of Latitude, Longitude and Spheroid height must go through a transform process.

Finally, it should be noted that GPS relative positioning computations need WGS 84 coordinate for a base station before baseline processing can commence. Ideally, these coordinates should be accurate to within ten meters of the base station's true position. As Lao National Geodetic Datum coordinates differ from WGS84 coordinates by approximately 25 meters horizontally and 34 meters in height, it is not acceptable to use Lao national Geodetic Datum 1997 coordinate as base station values. WGS84 coordinates must be used.

4.5 Relationship to Other Geodetic Datum

4.5.1 Vientiane Datum 1982

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Vientiane Datum 1982

The Vientiane datum 1982 was established to support survey work under taken in cooperation with the Soviet Union. It is defined by the following parameters:

Spheroid Krassovsky
(a = 6378245.000, b = 6356863.018)
Original Station Vientiane (Nongteng)
Latitude N 18°01'31.6301"
Longitude E 102°30'56.6999"
Spheroidal Height 223.56 meters

Note:

- The Latitude and Longitude of the original station were determined by astronomy.
- The spheroidal height was defined as being equal to the mean sea level height for the original station. The Geoid-Spheroid separation at Vientiane (Nongteng) was therefore zero.

The transformation parameters to be added to Lao National Datum 1997 Cartesian coordinates to provide Vientiane Datum 1982 Cartesian coordinates are:

$\Delta X = +2.227$ meters (Standard Error = 0.79 meters)

$\Delta Y = -6.524$ meters (Standard Error = 1.46 meters)

$\Delta Z = -2.178$ meters (Standard Error = 0.79 meters)

To transform Vientiane Datum 1982 coordinates to Lao National Geodetic Datum 1997, reverse the signs on the three transformation parameters before applying.

4.5.2 Indian Datum 1954

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Indian Datum 1954

The Indian Datum 1954 was introduced to Laos in 1967/1968. Its purpose was to support surveys for a hydro Power project on the Mekong River. The Datum is believed to have been an extension of the Thai datum at the time. It appears only to have been used in the vicinity of Vientiane.

There is no specific original station for the Indian Datum 1954 in Laos. However, its spheroid is:

Everest 1830

(a = 6377276.345, b = 6356075.413)

In the vicinity of Vientiane, the transformation parameters to be added to Lao national Geodetic datum 1997 Cartesian coordinates to produce Indian Datum 1954 Cartesian coordinates are:

$\Delta X = -168.711$ meters (Standard Error = 0.034 meters)

$\Delta Y = -951.155$ meters (Standard Error = 0.034 meters)

$\Delta Z = -336.164$ meters (Standard Error = 0.034 meters)

To transform Indian Datum 1954 coordinates to Lao National Geodetic Datum 1997, reverse the signs on the three transformation parameters before applying.

Insert 8

Indian Datum 1960

This datum is understood to have extensively used to support U.S sponsored 1:50,000 mapping between 1963 and 1975. The mapping utilized control which had been established by France from 1902. However, it is not clear whether the control values were recomputed by other agencies.

It is considered unlikely that any of the French survey control marks still survive. Consequently it had not been possible to compute new transformation parameters as part of Lao national Datum project. Parameters relating Indian datum 1960 to WGS84 have been obtained from the U.S National Imagery and Mapping Agency (NIMA). They have been combined with the parameters relating Lao national Geodetic Datum 1997 to WGS84 to provide the following estimates:

The Spheroid for Indian Datum 1960 in Laos is:

Spheroid: Everest 1830

(a = 6377276.345, b = 6356075.413)

The transformation parameters to be added to Lao national Datum 1997 Cartesian coordinates to produce Indian Datum 1960 Cartesian coordinates are:

$\Delta X = -153$ meters

$\Delta Y = -1012$ meters

$\Delta Z = -357$ meters

5. Reference Information.

All the information above, if you interested in or you have any comment or queries please contact us, the address is:

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(***) The detail of the information, provided by National Geographic Department

1. Lao National Geodetic Datum 1997 (First Edition)
2. Report of updating on Lao Geodetic Network 97 by Andrew Tyson 1997, TA, Land Titling Project.
3. Proceeding of the second workshop on Regional Geodetic Network (Ho Chi Minh City, Vietnam July 12-13, 1999)
4. DMA Technical Report. Department of Defense World Geodetic System 1984 (DMA TR 83502, September 30/ 1987)
5. Where in the World are we? (Version 1.7) Andrew Jones.

Resource Information Group; Department of Environment, Heritage and Aboriginal Affairs in cooperation with the South Australian Spatial Information Committee, August 1999.