Military Grid Reference System (MGRS) for the Future Joint Operations by the Sri Lankan Defense Forces

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28 MAY 2016

Thesis Submitted to the Faculty of Graduate Studies University of Sri Jayewardenepura for the Partial Fulfillment of Master's of Science Degree in GIS and Remote Sensing on 20th March 2016
DECLARATION OF THE CANDIDATE

I do hereby declare that work described in this thesis was carried out by me under the supervision of Mr CLK Navarathne and Dr HMI Prasanna and report on this thesis has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.

Date  28 March 2016  

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Heiyanthuduwa.
ACKNOWLEDGEMENT

I would express my deep gratitude to the two supervisors, Mr CLK Navarathne Dean Faculty of Social Science, University of Sri Jayewardenepura, Nugegoda, Sri Lanka and Dr HMI Prasanna, senior lecturer, Sabaragamuwa University. Whose gave me valuable advice, guidance and the patience amid with his entire crowded schedule to make this study success.

Then, I wish to express my genuine thanks and sincere gratitude to course Coordinator Prof. R. M.K Rathnayake of the GIS M.Sc. and Senior Lecturer in Department of Geography. I would like to give special thanks to all the lectures in Geography Department as well as all academic Lecturers in the University of Sri Jayewardenepura for their continuous support.

I offer my gratitude and especially thanks to all the members of the Center For Research and Development (CRD) that giving me the opportunity to collect relevant of information on this research. Then I offer my sincere thanks Mr. Dissanayake, Head of Geodetics branch, Survey Department and the staff who help me to collect relevant data and reports. And I would like to thanks to all that I missed to thank individually as well in personally who supported me in numerous ways to finish the study.

Finally, I wish to express my heartfelt gratitude to my friends and my family members for their willing support and encouragement throughout this study period to make a fruitful research.
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<th>Description</th>
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<tr>
<td>DMA</td>
<td>Defense Mapping Agency</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ITRS</td>
<td>International Terrestrial Reference System</td>
</tr>
<tr>
<td>LRRP</td>
<td>Long Range Reconnaissance Patrol</td>
</tr>
<tr>
<td>LTTE</td>
<td>Liberation Tigers of Tamil Eelam</td>
</tr>
<tr>
<td>MGRS</td>
<td>Military Grid Reference System</td>
</tr>
<tr>
<td>NATO</td>
<td>North Atlantic Treaty Organization</td>
</tr>
<tr>
<td>WGS84</td>
<td>World Geodetic system 1984</td>
</tr>
<tr>
<td>UPS</td>
<td>Universal Polar Stereographic</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
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Military Grid Reference System (MGRS) for the Future Joint Operations by the Sri Lankan Defense Forces
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ABSTRACT

The Military Grid Reference System (MGRS) is used by North Atlantic Treaty Organization (NATO) militaries for locating points on entire earth surface. The MGRS is derived from the Universal Transverse Mercator (UTM) grid system and based on WGS84 ellipsoid. The angular measurements converted to grid coordinates by using series of mathematical equations. Sri Lankan military forces use WGS84 and grid system based on National coordinate system. However using two systems will result difficulty in Military joint operations especially in target indication and obtaining indirect fire support and close air support for acquisition of targets. Therefore study was ultimately undertaken to develop a Military Grid Reference System for the use of military forces in Sri Lanka while maintaining the accuracy and precision in military joint operations.

In this study WGS84 system is used to project and develop military grid system for match our context. Accordingly system requires coordinate transformation between Geodetic/Projected coordinate systems and it takes considerable time which may resulted in accuracy issues. In this study algorithms use to develop computer program that converted from WGS84 values in to grid coordinates. After compute of sample data it finds that fitting scale factor for Sri Lankan context to develop MGRS that will minimize the error of coordinate’s conversion. As well as Statistical methods were used to find the exact value of scale factor by comparing the distance difference of geographic coordinates and grid coordinates. The parameter can used in order to evaluate MGRS for Sri Lankan context. Locally defined suitable MGRS could be used for Sri Lankan defense forces to minimize these issues and to achieve accuracy and the precision for effective joint operations in future.

Key words
Military Grid Reference System, coordinate transformation, joint operations, parameter, WGS84
Chapter One

INTRODUCTION

1.1 Introduction

The Military Grid Reference System (MGRS) is the geo coordinate standard used by North Atlantic Treaty Organization (NATO) militaries for locating points on the earth (wikipedia.org). The MGRS is derived from the Universal Transverse Mercator (UTM) grid system and the universal polar stereographic (UPS) grid system, but uses a different labeling convention. The MGRS is used for the entire earth. In the Global context there is lot of countries use their own coordinate system (MGRS) to use in Military operations. The grid coordinate may represent the location to nearest 10, 100 or 1000 meter increment.

Air power comprises the application of military strategy and strategic theory to the realm of aerial warfare. Airpower has been used to conduct lightning strategic strikes, to complement land offensives, to instill fear and lower morale similarly to a fleet in being, and to create broad-based destruction behind enemy lines. A mass technological base is considered necessary for the development of airpower. Moreover Air power plays a vital role in the war to bring down the power of enemy by using surprising air strikes to accurately hit vital strategic operational bases in enemy area. Especially in joint operations that the target acquisition is a significant part in an air attack. Particularly in air force which should able to attack targets of ground forces were given. In local context 30 years of insurgency was experienced in the country.

Then Sri Lankan military forces carry out a humanitarian operation to overcome the problem. Strategic air attack can be expected to break and enemy will bring down the political regime. Mainly air power used to control the power in enemy party. However target acquisition should be done properly by minimizing the civilian's damage. But there were some cases that civilians have been killed and injured in air attacks. In year 2006 the Sri Lankan Air Force have bombed Liberation Tigers of Tamil Eelam (LTTE) military complex targeting a meeting of top leaders in Puthukkudiyiruppu area. Also
there were some civilian settlements in the area. However media reported that six civilians were injured and rushed to hospital after Sri Lanka Air Force fighter jets dropped bombs near Puthukkudiyiruppu town.

Sri Lankan Army has deployed Long Range Reconnaissance Patrol (LRRP) in the battlefield to carry out reconnaissance and sabotage operations in deep battle space. Most of times targets were given by these ground forces. In military operations Sri Lanka Army used their grid System base on Sri Lankan National coordinating system, while the Air Force and Navy used WGS84 geodetic coordinate system. Accordingly it requires coordinates transformation between Geodetic/Projected coordinate systems and it takes considerable time which may resulted in accuracy issues. Locally defined suitable MGRS could be used for Sri Lankan defense forces to minimize these issues and to achieve accuracy for effective joint operations in future.

1.2 Problem Statement

Sri Lankan defense forces have been experienced fatal battle losses and defeats in battle against LTTE terrorists’ attacks, due to poor coordination between ground forces and Air Force in target indication and obtaining indirect fire support and close air support for acquisition of targets. When consider about the inaccurate target acquisition was aimed due to lack of transformation between coordinate systems. Therefore there is an urgent need to correct the problem in accurate level of target acquisition.

Joint military operation is an integration of various armed forces into one unified command. The synergy that results from the integration of armed forces maximizes the effectiveness and efficiency. The success of Joint Operations depends on synchronizing the command, control and execution of missions. In a Joint Operation scenario, ground forces are the “Local Navigators” working together with “Global Navigators” as Air Force and Navy to accomplish the mission. It is important for ground forces to indicate precise enemy target locations for Air Force engage effectively. If the target indication and engagement process fails due to lack of coordination, collateral damages may occur.
This has been widely experienced in many occasions in past 30 years of war causing heavy damages and losses. LTTE terrorists exploit these situations to gain the maximum advantage. However in the later part of the war inaccuracy was reduced by using various adhoc techniques. Therefore the research is to identify suitable MGRS for Sri Lankan context to overcome difficulties when conducting joint military operations.

1.3 Significance of the Study

There are global common MGRS used by military forces in the world based on WGS84 ellipsoid. The existing systems are mainly match to global context. Therefore there is a local MGRS want to use in Sri Lankan context. Armed forces use different coordinate systems in Military Operations. Sri Lankan Army uses their conventional grid System based on National coordinate system while the Air force and Navy used WGS geodetic coordinate system.

The closest geographic coordinate system to the Sri Lanka is Everest 1830 as shown in Figure 1.1. Therefore Everest 1830 used to formulate the Kandawala, National grid system of Sri Lanka.

![Figure 1.1: Everest 1830 ellipsoid](source: created by researcher)
Kandawala datum uses Piduruthalagala as its base point of False northing and easting. In the beginning, Survey department used 0N, 0E as its location. Due to negative coordinate values in south west region they changed it to 500,000N, 500,000E.

The transverse mercator projection on Everest ellipsoid (1830) with the following parameters is used to compute Kandawala co-ordinate system (Bomford, 1980).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central meridian</td>
<td>- E 80° 46' 18.16710&quot;</td>
</tr>
<tr>
<td>Latitude of Origin</td>
<td>- N 7° 00' 1.69750&quot;</td>
</tr>
<tr>
<td>Scale factor</td>
<td>- 0.9999238418</td>
</tr>
<tr>
<td>False Northing</td>
<td>- 500000m</td>
</tr>
<tr>
<td>False Easting</td>
<td>- 500000m</td>
</tr>
</tbody>
</table>

Pidurutalagala trigonometrical station is used as the latitude of origin and central meridian.

Since Everest 1830 is a local ellipsoid the global navigators mainly Sri Lanka Air Force and Sri Lanka Navy cannot use it. Thus the ground forces should adjust their grid system based on WGS 84 ellipsoid. Meanwhile ground forces difficult to use angular measurements (Lat/Long) they is a need of projected coordinate system. Accordingly the researcher is going to develop MGRS by using WGS84 ellipsoid.

There are several independent researches can be find about the transformation WGS84 to Kandawala grid system. But it is hard to find any researches relating to military grid system in Sri Lanka. Therefore this study identified technical or theoretical reason behind this problem and find out transformation parameters and evaluation of MGRS in suited for Sri Lanka. First task is to study existing Army grid reference system and find merits and demerits in the existing system. Then identify transformation parameters WGS84 to Sri Lankan Military Grid Reference system transformation.
1.4 Objectives

The principal aim of this study is going to develop Military Grid Reference System (MGRS) for the future joint operations by the Sri Lankan Defence forces. In order to accomplish the aim this study has the following objectives.

Main Objective

- To develop a Military Grid Reference System for the use of military forces in Sri Lanka.

Sub Objectives

- To identify Merits and Demerits in the existing Army grid reference system.
- To develop transformation tool.

1.5 Methodology

Mainly the research used only secondary data by using literature. This study used some mathematical algorithms and transformation techniques. Accordingly compute transformation parameters using mathematical functions and equations. When considering coordinate systems basically geodetic and geocentric systems. Accordingly the study discussed primarily coordinates transforms from geodetic to geocentric system and secondly transformation between Cartesian systems.

Since WGS84 is a geographic coordinates system following equation will use to transform to projected coordinate system. Mathematical concept of the equation can be view on Figure 1.2.
The researcher projects WGS84 ellipsoid to Sri Lankan context using coordinate transformation method. It involves theories of transformation ellipsoidal Latitude, Longitude \((\Phi, \lambda)\) coordinates to planar \((X, Y)\) coordinates of a flat surface.

A computer programme developed to computation of suitable parameters of the transformation to the Sri Lankan context. Then train the computer program using sample values to obtain good results. The researcher was determining optimum value for the scale factor by calculating distance difference between WGS ellipsoid values and MGRS values. A statistical distribution method was applied to use for calculating optimal values. Survey department control point network consists 272 GPS points and the researcher obtained a random sample from GPS points. All calculations are to be done using computer programme.
1.6 Limitations of the Study

When conduct the research on the basis of Military Grid Reference System (MGRS), there will some limitation and difficulties faced to investigate this research. They are

- **Lack of data**
  
  Mainly this research used geodetic coordinates of sample location. This data acquired from Survey Department. But field trails need to carry out to get coordinates of common points to verify the accuracy of the new system. The lacking data and information will limit the result of research.

- **Lack of prior research studies on the topic**
  
  Since this research focus on MGRS it was important to find previous researchers about the same topic. But due to the security issues the countries prevent to publish their MGRS. Hence it is hard to find any prior research studies about the topic.
➢ Research approach

The research is going to investigate about Military Grid Reference System on the basis of Sri Lankan context. The researcher achieved the result by using the sample data. These sample data obtained in a small geographical area in the country. The parameters of the map projection highly correlated when a network of points used to determine the parameters covers only a small Area of the country.

➢ Short period of time not enough deep research.

This is an academic research, which should be done within a period of time. Therefore, to do a deep study on Military Grid Reference System and conducting required field is immense. So for the study with the sample points to get better result, the researcher took particular geographical area as sample during the research period.

However with this particular limitation the research was conducted and found the result on basis of Military Grid Reference System in Sri Lankan context.
1.7 Chapter Outline

Chapter One

The chapter described the proposed research with preamble of the topic chiefly introducing the study and background of the study. As well as the problem statement, aim and objectives of the study, area of the study, significance, and brief description of the methodology was discussed.

Chapter Two

This chapter about the theoretical background of the subject mainly concerning with coordinates systems and coordinate transformation techniques. The main theme was to point out with definitions and theoretical background in global context as well as in local context. On the other hand chapter elucidated the existing researches that available for the subject area not only the regarding with the Sri Lankan context but also with many countries in the world conducting as literature review. However it was difficult to find any document pertaining to develop Military Grid Reference System (MGRS).

Chapter Three

This chapter illustrate about the research design process. The sections of research design, subject selection, outcome measures, and conditions of testing, treatments and data analyses techniques described. Each section described separately. Mainly the procedure of data collection method characteristically secondary data sources, ways of data analyzing process and data presentation techniques are extensively describe. Mostly this chapter elucidate how the research was done.
Chapter Four

Chapter is most important for this study. Data presentation and analysis include this section. Mainly the aim and the objectives of developing Military grid reference system search to fulfill the main and minor objective as analysis with GIS & GPS tools. The whole processed data collection and analyzed result will describe as qualitatively and quantitatively with graphical representation of data through graphs, tables, figures and map.

Chapter Five

This chapter describe that the overall summery of the entire research process. The researcher concludes the research and opens a new dimension in future Joint operation conducted by the Sri Lankan defence forces.
Chapter Two

LITERATURE REVIEW OF MILITARY GRID REFERENCE SYSTEM

2.1 Introduction

This research was undertaken to develop MGRS for military joint operation on Sri Lankan context. In view of that the research examined existing coordinate system and how it can be used to militaries. There were no articles or reports to be find about existing military coordinates system. Thus the research mainly discussed on coordinate systems and the theories and mathematical concepts involve in coordinate transformation process. Coordinate transformations are accomplished by various methods. This review mainly discussed Bursa-Wolf transformation model and the Molodensky-Badekas model. In addition to this review discussed and evaluate US MGRS which is used by NATO forces in joint military operations to achieve positioning accuracy.

2.2 Earth Reference Models

2.2.1 Geometric Earth Models

A suitable geometrical mathematical surface is necessary to be defined for mapping Earth’s surface as its surface is very complex. Early ideas of the figure of the earth resulted in descriptions of the earth as an oyster (The Babylonians before 3000 B.C.), a rectangular box, a circular disk, a cylindrical column, a spherical ball, and a very round pear (Columbus in the last years of his life).

Ellipsoidal earth models are required for accurate range and bearing calculations over long distances. Loran-C and GPS navigation receivers use ellipsoidal earth models to compute position and waypoint information. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape
of the earth over the smoothed, averaged sea-surface to within about one-hundred meters to the physical surface of the earth.

2.2.2 Earth Reference Ellipsoid

The most fitted mathematical model of the earth surface is closer to Ellipsoid. Reference ellipsoids are usually defined by semi-major (equatorial radius) and flattening. Other reference ellipsoid parameters such as semi-minor axis (polar radius) and eccentricity can compute from these terms.

![Earth Reference Ellipsoid Diagram](http://www.colorado.edu/geography/gcraft/notes/datum/datum.html)

Figure 2.1 Earth Reference Ellipsoid

Source: http://www.colorado.edu/geography/gcraft/notes/datum/datum.html

One ellipsoid model could not match for the entire earth surface. Accordingly in the earth reference ellipsoids there were many reference ellipsoids are used in different nations and agencies for assign the locations in the earth surface pertaining to respective areas.
Table 2.1 Earth Reference Ellipsoids in Some Selected Nations

<table>
<thead>
<tr>
<th>Ellipse</th>
<th>Semi-Major Axis (meters)</th>
<th>1/Flattening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airy 1830</td>
<td>6377563.396</td>
<td>299.3249646</td>
</tr>
<tr>
<td>Bessel 1841</td>
<td>6377397.155</td>
<td>299.1528128</td>
</tr>
<tr>
<td>Clarke 1866</td>
<td>6378206.4</td>
<td>294.9786982</td>
</tr>
<tr>
<td>Clarke 1880</td>
<td>6378249.145</td>
<td>293.465</td>
</tr>
<tr>
<td>Everest 1830</td>
<td>6377276.345</td>
<td>300.8017</td>
</tr>
<tr>
<td>Fischer 1960 (Mercury)</td>
<td>6378166.0</td>
<td>298.3</td>
</tr>
<tr>
<td>Fischer 1968</td>
<td>6378150.0</td>
<td>298.3</td>
</tr>
<tr>
<td>GRS 1967</td>
<td>6378160.0</td>
<td>298.247167427</td>
</tr>
<tr>
<td>GRS 1975</td>
<td>6378140.0</td>
<td>298.257</td>
</tr>
<tr>
<td>GRS 1980</td>
<td>6378137.0</td>
<td>298.257222101</td>
</tr>
<tr>
<td>Hough 1956</td>
<td>6378270.0</td>
<td>297.0</td>
</tr>
<tr>
<td>International</td>
<td>6378388.0</td>
<td>297.0</td>
</tr>
<tr>
<td>Krassovsky 1940</td>
<td>6378245.0</td>
<td>298.3</td>
</tr>
<tr>
<td>South American 1969</td>
<td>6378160.0</td>
<td>298.25</td>
</tr>
<tr>
<td>WGS 60</td>
<td>6378165.0</td>
<td>298.3</td>
</tr>
<tr>
<td>WGS 66</td>
<td>6378145.0</td>
<td>298.25</td>
</tr>
<tr>
<td>WGS 72</td>
<td>6378135.0</td>
<td>298.26</td>
</tr>
<tr>
<td>WGS 84</td>
<td>6378137.0</td>
<td>298.257223563</td>
</tr>
</tbody>
</table>


2.2.3 Everest 1830 ellipsoid

Everest 1830 was defined by Sir George Everest, who was Surveyor General of India from 1830 to 1843 and it has served as reference for all mapping in India. Everest 1830 ellipsoid is the best fitted ellipsoid for Indian region. Accordingly Everest 1830 will match to Sri Lankan context, so to use it in another part of the earth will result in serious errors in measurement. For mapping Sri Lankan region, in order to obtain the most accurate locations and measurements, Sri Lanka Datum 99(SLD99) used as it derives from Everest Ellipsoid.
2.2.4 World Geodetic System 1984 (WGS 84)

The World Geodetic system 1984 (WGS84) was introduced by the United States Defense mapping Agency (DMA), initially for use with the Doppler positioning system, but later with the Global Positioning System (GPS). Moreover WGS 84 is an Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. WGS 84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, and gravity and geomagnetic fields. WGS 84 is the standard U.S. Department of Defense definition of a global reference system for geospatial information and is the reference system for the Global Positioning System (GPS). It is compatible with the International Terrestrial Reference System (ITRS). (Agency, 2014).

As shown in the figure 2.2, WGS 84 is the generalized earth-centered coordinate system provides a good overall mean solution for all places on the earth. However, for specific local measurements, WGS84 cannot account for local variations.

Figure 2.2: WGS84 Earth Reference Ellipsoid

Table 2.2: WGS 84 Ellipsoid Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-major Axis</td>
<td>a</td>
<td>6378137</td>
<td>m</td>
</tr>
<tr>
<td>Semi-minor Axis</td>
<td>b</td>
<td>6356752</td>
<td>m</td>
</tr>
<tr>
<td>Flattening Factor</td>
<td>f</td>
<td>298.25722</td>
<td></td>
</tr>
</tbody>
</table>

Source: Implementation of the World Geodetic System 1984 (WGS 84)

That the earth does not have a geometrically perfect shape is well established, and the geoid is used to describe the unique and irregular shape of the earth. The geoid approximates mean sea level. The shape of the ellipsoid was calculated based on the hypothetical equipotential gravitational surface. A significant difference exists between this mathematical model and the real object. However, even the most mathematically sophisticated geoid can only approximate the real shape of the earth. (Fraczek, 2003)

Scientists determine WGS84 ellipsoid common to the all-world, Shown in figure 2.3

Figure 2.3: WGS 84 Ellipsoid

Source: Gravitational Potential of Nearly-Spherical Bodies ASEN5050 Final Project by Joshua Chong
The map shows the areas of the globe that would have above the theoretical surface of the WGS84 ellipsoid, or the theoretical and geometrically correct sea level (shown in blue). The sharp contrast between the blue and green indicates where the ellipsoid and geoid intersect. Moreover areas of the globe that would have above sea level the theoretical surface of the WGS84 ellipsoid (shown in red). Consequently WGS ellipsoid fitted to limited area of the world and they can use this system effectively. However other countries have to identifying a coordinate system which is relevant to their geographical area.

Figure 2.4: Earth Gravitational Model 2008 - EGM2008

Source: http://earthminfo.nga.mil/GandG/wgs84/gravitymod/egm2008/egm08_wgs84.html
2.3 Coordinate Systems

Coordinates System used to obtain the locations on the earth surface based on a measurement unit. Accordingly coordinates can be deriving from local, regional or global system. There is lot of definitions for a coordinate system. The mapping systems of various countries are based on their local coordinate systems. In the local coordinate systems.

Coordinates are used to identify locations on the earth’s surface are based on measurements of displacement from a given location. (Haitthcoat). Coordinate systems enable geographic datasets to use common locations for integration. A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations such as GPS locations within a common geographic framework. (ESRI, 1995-2010).

2.4 Coordinate Transformation

The success of a joint operation depends on synchronizing all the forces in to a common platform. Mainly transformation of coordinate between ground forces and Air Force is key to success the operation. This difference creates problems when converting data from one system to the other.

An example in 1998, U.S. and Canadian officials jointly adopted a Helmert transformation to convert positional coordinates between ITRF96 and NAD 83 (CORS96). The IERS has also adopted appropriate Helmert transformation for converting between ITRF96 and other ITRS realizations (Richard and Snyay,2000).

2.5 Different Transformation Methods

The mathematical relationships that are employed in accomplishing this task are referred to as transformation models. The process of mathematically converting data in one coordinate system to another is referred to as coordinate transformation. To achieve
this, control points must exist that have coordinates in both reference frames. The transformation can be three-dimensional (3-D), two dimensional (2-D), or even one-dimensional (1-D), depending on the given requirement.

There are several transformation models such as Bursa-Wolf, Molodensky-Badekas, Veis Model, Thomson-Krakiwsky Model, Helmert Similarity Transformation, Affine transformation. (Hofmann-Wellenhof et al,1997). Each of these models could be used to determine parameters that are necessary to convert data in a local geodetic frame into WGS84 frame and vice versa.

The Bursa–Wolf and Molodensky–Badekas transformations are conformal three-dimensional (3D) Cartesian coordinate transformations commonly used in surveying, photogrammetry and geodesy. They are also called similarity or seven-parameter transformations and they combine a scale change, three axes-rotations and three origin-shifts in a practical mathematical model of the relationships between points in two different 3D coordinate systems. They differ slightly in their operation; the Molodensky–Badekas transformation uses a centroid but the Bursa-Wolf transformation does not, hence additional information (the centroid coordinates) is required when using the Molodensky–Badekas transformation; a factor that makes the Bursa–Wolf transformation more popular. This paper aims to provide an explanation of both transformations.

2.5.1 Bursa–Wolf Transformation

Figure 2.5: Geometry of Bursa-Wolf model

![Geometry of Bursa-Wolf model](source.png)

Figure 2.5: Geometry of Bursa-Wolf model

Source : A Note On The Bursa-Wolf And Molodensky-Badekas, 2006
Figure 2.5 shows the geometry of the Bursa–Wolf transformation. The X,Y,Z axes of system 1 are rotated by very small angles from the X,Y,Z axes of system 2, and the origins of the two systems are displaced by translations in the directions of the X,Y,Z axes of system 2, and are vectors of coordinates in both systems and \( t \) is a vector of translations. The mathematical relationship between coordinates in both systems can be written in the form of a vector equation.

Alternatively, the Bursa–Wolf transformation may be written as:

\[
\begin{pmatrix}
  x_2 \\
y_2 \\
z_2
\end{pmatrix} = \begin{pmatrix} 1 + \delta s \\ -\gamma & 1 & \alpha \\ \beta & -\alpha & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ y_1 \\ z_1 \end{pmatrix} + \begin{pmatrix} \delta x \\ \delta y \\ \delta z \end{pmatrix}
\]

2.5.2 Molodensky-Badekas Transformation

Figure 2.6: Geometry of Molodensky-Badekas Transformation

Source: A Note On The Bursa-Wolf And Molodensky-Badekas, 2006
The transformation is between a non-global local datum and a geocentric global geodetic system. The rotations are to be considered about the three axes at the "initial" point of the local datum. The scale factor is also considered with respect to the initial point.

\[
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix}_i = \begin{bmatrix}
U \\
V \\
W
\end{bmatrix} + \begin{bmatrix}
\Delta U \\
\Delta V \\
\Delta W
\end{bmatrix} + \begin{bmatrix}
0 & \omega & -\psi \\
-\omega & 0 & \varepsilon \\
\psi & -\varepsilon & 0
\end{bmatrix} \begin{bmatrix}
U' - U \\
V' - V \\
W' - W
\end{bmatrix} + \Delta S \begin{bmatrix}
U - U' \\
V - V' \\
W - W'
\end{bmatrix},
\]

where "i" denotes any point common to the local datum and geodetic system and the \((U',V',W')\) are the coordinates of the "initial" point of the local datum.

The three angles \((\omega, \psi, \varepsilon)\) correspond to the small rotations taken positive in the counter clock-wise mode, when viewed from the end of the respective axes (at the "initial" point) towards the origin. Note: When the "initial" point of the local datum \((U',V',W')\) is not provided, assume values of \((0,0,0)\). (Deakin, 2006)

**2.6 National Coordinate System**

**2.6.1 Historical Background**

The control network of Sri Lanka was established by Mr. J.E.Jackson in 1933 with 94 principal trigonometrically stations by means of triangulation techniques. Later this network was densified through second order, third order, & minor trigonometrical stations. Primary, secondary & tertiary traverse network between the trigonometrical stations was also developed to distribute control further. The accuracy of the above network was around 1:20,000.
Figure 2.7: Sri Lanka Old Control Point Network

Source: The Triangulation of Ceylon by JE Jackson, 1933
2.6.2 Control Point Network

In 1961, control points for Plane Table Survey and Aerial Surveying were established by geodetic surveying and traversing using theodolite (transit) and tape (chain). In Geodetic Surveying, latitude and longitude of many primary stations were determined by Geodetic Astronomy using observations to stars, and base lines were established using invar tapes. In between primary stations and base lines, triangulation stations were established by triangulation using precise theodolites. Between triangulation stations control points were established by resection and traverse. In the 1960s, all the computations in surveying were done using mechanical calculators and log tables.

2.7 Sri Lanka Datum 1999 (SLD 99)

In 1993 the geodetic control network of Sri Lanka was upgraded by using precise baselines measured using global positioning system. The transformation parameters were computed from the local datum called Everest 1830 to global datum called WGS84. Hence Global Positioning System receivers can be used to obtain the national grid system centimeter level accuracy. Finally in 1999 the entire horizontal network was upgraded and the new control network consist with 272 principle control points (includes old trigonometrical stations & FBMM) as follows.

(http://www.survey.gov.lk/)

1) No of 1st order GPS stations = 10
2) No of 2nd order GPS stations = 194
3) No of Trigonometrical stations = 48
4) No of FBMM = 20

The above system was named as SLD99. Hence SLD 99 is consistent with 272 primary control points including GPS base station at (Institute of Surveying Mapping, Diyatalawa) ISMD.
Figure 2.8: Sri Lanka Old Control Point Network

Source: Survey General Department, 2010
Parameters related to SLD 99 are given below.

Reference Local Ellipsoid: Everest-1830

Semi Major axis: \( a = 6377276.3450 \text{m} \)

Semi Minor axis: \( b = 6356075.4131 \text{m} \)

Parameter Datum Transformation (from WGS84 to Reference Local Ellipsoid)

Transformation Method: Bursa Wolf

Translation \( \delta X \) : 0.2933 m

Translation \( \delta Y \) : -766.9499 m

Translation \( \delta Z \) : -87.7131 m

Rotation about X axis: 0.1957040"

Rotation about Y axis: 1.6950677"

Rotation about Z axis: 3.4730161

Scale factor: 1.0000000393

Parameter Datum Transformation (from WGS84 to Reference Local Ellipsoid)

Some hand held type GPS devices supports only 3-Parameters for datum transformation instead of 7-Parameters described above.

Translation \( \delta X \) : 97.000 m

Translation \( \delta Y \) : -787.000 m

Translation \( \delta Z \) : -86.0000 m
Table 2.3: Comparison of Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Old System (200000)</th>
<th>New System (500000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude of the Origin</td>
<td>80° 46' 18.160000'' E</td>
<td>80° 46' 18.167100'' E</td>
</tr>
<tr>
<td>Latitude of the Origin</td>
<td>07° 00' 01.729000'' N</td>
<td>07° 00' 01.697500'' N</td>
</tr>
<tr>
<td>Scale factor</td>
<td>0.9999238418</td>
<td>0.9999238418</td>
</tr>
<tr>
<td>False Northing</td>
<td>200000 m</td>
<td>500000 m</td>
</tr>
<tr>
<td>False Easting</td>
<td>200000 m</td>
<td>500000 m</td>
</tr>
</tbody>
</table>

Source: Karunaratne, 2007

Pidurutalagala Trigonomerical Station in old Triangulation Network has been used as the origin of the projection as used in the old system. It has been slightly shifted in the new system (SLD 99) as shown in the comparison table 2.3.

2.8 Military Joint Operations

Joint operation is a form of combined arms warfare on a larger, national scale. In a joint operation, Army, Navy, Air Force, and Special Forces are meant to work together, rather than planning and executing military operations separate from each other. Determining the best way to integrate the capabilities of the different military services—increasing (jointness) has been a continuous challenge in modern warfare. There were many lessons learnt in the history.

In Vietnam, the Air Force, Army, and Navy all fought completely different air wars, and Army and Marine generals sometimes disagreed on basic strategy on the ground. Almost a decade later in Grenada, tactical coordination between the Army and Marine Corps had improved only marginally. Incompatible communication systems caused numerous problems between ground forces and naval aviators, and led to a friendly fire incident that wounded 17 soldiers. By the 1991 Gulf War, inter-service cooperation had progressed, but not enough; the Army excluded the Marines from much of their ground operations planning and all of the services disagreed on how to use their respective air assets. More than 40 years after the creation of the Department of Defense, the U.S.
armed forces still struggled to shoot, move, communicate, plan, or cooperate as a fully joint force. (Dempsey, 2013) When conducting a military joint operation following principles are very important.

2.8.1 Principles of Joint Operations

- Objective
- Offensive
- Mass
- Maneuver
- Economy of force
- Unity of command
- Security
- Surprise
- Simplicity
- Restraint
- Perseverance
- Legitimacy

(Department of Defense, 2011)

Joint operation planning consists of planning activities associated with joint military operations by combatant commanders (CCDRs) and their subordinate joint force commanders (JFCs) in response to contingencies and crises. It transforms national strategic objectives into activities by development of operational products that include planning for the mobilization, deployment, employment, sustainment, redeployment, and demobilization of joint forces. It ties the military instrument of national power to the achievement of national security goals and objectives and is essential to securing strategic end states across the range of military operations (Mullen, 2011).

"The lessons gained from military history indicate that the key to military victory lies regardless of military size of the opposing forces in remaining ahead of the enemy in time sensitive SCORE loop of C 412 process. If a defending force or weapon system can with some accuracy and sufficient warning find out where the attacker is or what his future course of action would be, it would be easier to defeat him by occupying a position of advantage or by massing a superior force at the point of decision" (Major General Gurbaksh Sing, 1996).
C 412 referred in his statement indicates Command, Control, Communication, Coordination, Information and Interoperability throughout history, nations that successfully coordinated simultaneous land and sea actions won their battles. Those that did not, lost. Although the ancients coordinated forces on land and sea, modern military planners must also deal with air and space. These new media change the situation quantitatively, not qualitatively. Multi-Service coordination still seeks to solve problems revealed when Pericles balanced his naval and land forces to defend Athens (John and Shalikashvili, 1997).

As technological developments added air power to the joint coordination equation, multi-Service coordination became even more complex. Establishing a permanent structure to coordinate land, sea, and air forces recognized that multiplying force effectiveness through joint action was critical to military success.

Ground units and ground combat operations shall be serviced with MGRS coordinates. To support homeland security and homeland defense, the federal Geographic Data Committee (FGDC) US National Grid (USNG) standard when referenced to North American Datum 1983 (NAD83) is operationally equivalent to and is an accepted substitute for MGRS coordinates referenced to WGS 84. (Walter and Sharp, 2007).
2.9 US Military GRID Reference System (MGRS)

The Military Grid Reference System (MGRS) is an alpha-numeric system for expressing UTM / UPS coordinates. A single alpha-numeric value references a position that is unique for the entire earth. The components of MGRS values are as follows: The first two characters represent the 6° wide UTM zone.

Leading zeroes are included so that Zone 9 is “09”. For polar areas outside the UTM area, these characters are omitted. The third character is a letter designating a band of latitude.

Beginning at 80°S and proceeding northward, the 20 bands are lettered C through X, omitting I and O. The bands are all 8° high except band X, which is 12° high. Outside the UTM area, A and B are used near the South Pole, Y and Z near the North Pole.

The major advantages of the MGRS are in data management and visualization, flexibility in establishing geographic location, and data representation. The MGRS typically takes the form of a list of alphanumeric strings or an ESRI polygon geodatabase or shapefile. More over the strings or squares can be queried any number of ways to derive the characteristics of data holdings. Visualization of data holdings using any number of attributes is facilitated within the MGRS.
Figure 2.9: MGRS GRID Zones

Source: http://earthinfo.nga.mil/GandG/coordsys/grids/universal_grid_system.html#zz4
Example: This example would show the sample location

Figure 2.10: MGRS 19T GRID Zone Designator

**19TDJ3858897366**

- **UTM Zone**: 19
- **Latitude Band**: T
- **MGRS column**: D
- **MGRS row**: J
- **MGRS Easting**: 38588
- **MGRS Northing**: 97366
2.10 Sri Lankan Army Grid Systems

Sri Lankan army used their own grid system for their military operations. This system is based on National coordinate system (Kandawala Sri Lanka Grid System) and maintains the clarity and brevity in military communication. Army soldiers used manual 1:50000 maps in the battle field to mark the locations. However this system creates integer ambiguity and maps are not up to date.

Figure 2.11: 1:50000 Map Sheets
Source: Survey General Department, 2010
Example: Coordinates in Kandawala System (130174, 473238)

This coordinate can be represented in Army grid as follows:

Six figure: 301 732. Accuracy 100m

Eight figure: 3017 7323 Accuracy 10m

Ten figure: 30174 73238 Accuracy 1m

(Sri Lanka Army Map Reading Guidance, 2008)

Researcher found that it is hard to find any research or article about MGRS pertaining to any country due to security issues. Thus this review discussed different coordinates systems and transformation methods. Moreover common mathematical models are that can be used in transformation process. It reviewed not only in global context but also in the local context. Mainly WGS84 and SLD99, national coordinate system and its application of military joint operations.
Chapter Three

METHODOLOGY

The previous chapter focused on the basic concepts as well as the relevant literature regarding the research. This chapter provides outline about the methodology of the research. Mainly this chapter examines data collection process, analysis techniques and data presentation of research design. In order to satisfy the objectives of this study develop Military Grid Reference System (MGRS) is going to undertake answer the research questions as beginning of this thesis. As discussed in the previous chapter there are several draw backs in the existing system. Consequently the new MGRS developed by using following method. The new system will ensure the accuracy and precision while maintaining the easiness.

3.1 Study Area

Sri Lanka is located in the Indian Ocean, southeast of India, between 5°55' and 9°51' N latitude, and 79°41' and 81°53' E longitude. Its area is approximately 65,610 sq. km.; with a coastline of about 1,620 km.

Sri Lanka and the southern tip of India stand on the same continental shelf and are separated by a shallow sea, the Palk Strait, which is barely 30 m deep. However, the shelf ends more abruptly in the south and east of Sri Lanka, averaging 22.5 km in width and rarely extending beyond 40 km. Within the shelf area, estimated to cover about 30,000 sq. km., the mean water depth is about 75 m, but the submarine elevations drop abruptly to 900 m within 3 km and 1,800 m within about 15 km of the shelf’s edge. Beyond this there is a steep descent of over 5,500 m bringing it to the general bottom level of the Indian Ocean (MaddumaBandara, 1989).
Sri Lankan Military forces involved operations in Land Sea and air areas. In accordance with the experience of war against Tamil tiger’s cooperation of these theatres of operations is much important. Accordingly this system needs to address these 03 theatres of operation. Consequently the study area includes land and sea area of the country.

3.1.1 Maritime jurisdiction

Maritime jurisdiction Under the Maritime Zones Law No. 22 of 1976, Sri Lanka has proclaimed several areas of national maritime jurisdiction, in conformity with the provisions of the United Nations Convention on the Law of the Sea (Fig.3.1). The maritime jurisdiction of Sri Lanka covers the following major areas:

Internal waters

Defined as waters in the landward side of the baseline from which the limits of the territorial sea is measured. Internal waters include numerous embayment and areas of coastal sea, as well as all of Sri Lanka’s inland waters, and are treated as integral parts of Sri Lanka’s national territory.

Historic waters

Include the Palk Bay, Palk Strait, and Gulf of Mannar areas claimed on the basis of traditional use by Sri Lankans. The Historic waters in the Palk Bay and Palk Strait are considered to form part of Sri Lanka’s internal waters, while those in the Gulf of Mannar form part of the territorial sea.

The Territorial sea extends to a distance of 12 nautical miles. Sri Lanka asserts its sovereign rights over this area, including the right to control movement of foreign ships and aircraft through the water and air spaces of the territorial sea. The extent of the Territorial Sea is reported to be 21,500 sq. km. (MFOR, 2002).
The Contiguous zone extends to a distance of 24 nautical miles, within which Sri Lanka asserts its rights to take measures necessary to secure the enforcement or prevent the contravention of its laws relating to security, immigration, health, sanitation, customs or other revenue matters.

The Exclusive Economic Zone extends to a distance of 200 nautical miles from the baseline. Within this zone Sri Lanka asserts, among others, sovereign rights to explore, exploit, conserve and manage natural resources, both living and non-living and, exclusive rights to authorize regulate and control scientific research. The area enclosed by the exclusive economic zone (EEZ) is reported as 517,000 sq. km. (MFOR, 2002), which is 7.8 times the total land area of the country. Sri Lanka’s only international border is its maritime boundary with India. In the north western quadrant of Sri Lanka the EEZ and other areas of maritime jurisdiction adjoin those of India and as a result are restricted to narrower zones than around the rest of the island.
Figure 3.1 Study Area - Maritime jurisdiction

Source: Survey General Department, 2015
3.2 Data and Data Collection Techniques

Mainly the research is used only secondary data by using literature. These data obtained from the geodetic branch of the National survey department. Survey Department has all the control point coordinates. Moreover, survey department establish and maintain base point’s coordinates and currently updating the control point network by using recent sophisticated GPS devices.

Some of control points will be taken to compute datum transformation parameters and the rest of the points will be used as check points to evaluate the validity of computed parameters.

3.3 Computation Method

This study will use some mathematical algorithms and transformation techniques. Accordingly compute transformation parameters using mathematical functions and equations. The researcher is going to develop MGRS based on the WGS84 ellipsoid and following equations are basically used on the transformation process.

![WGS84 Ellipsoid Diagram](http://www.colorado.edu/geography/gcraft/notes/WGS84Ellipsoid/datum.html)

Figure 3.2 – WGS84 Ellipsoid

Source: http://www.colorado.edu/geography/gcraft/notes/WGS84Ellipsoid/datum.html
The figure 3.3 shows the WGS84 ellipsoid with its major axis (a) and minor axis (b).

\[ a = 6378137.0000\text{m} \]
\[ b = 6356752.3142\text{m} \]

The researcher projected WGS84 ellipsoid to Sri Lankan context using coordinate transformation method. It involves theories of transformation ellipsoidal Latitude, Longitude (Φ, λ) coordinates to planar (X,Y) coordinates of a flat surface. Following equations are mainly involving on the process.

\[ e^2 = \frac{a^2 - b^2}{b^2} \]
\[ R = \sqrt{NM} \]

Where

\[ N = \frac{a}{\sqrt{1-e^2 \sin \phi}} \]
\[ M = \frac{a(1-e^2)}{(1-e^2 \sin^2 \phi)^{3/2}} \]

(Φ₀, λ₀) are the WGS84 coordinates of the Piduruthalagala trigonometrical point and

(Φ, λ) are Latitude and Longitude values of point P. All these angular measurements converted to radians.

The Cassini coordinates of the Easting can be written as follows

\[ Ec = R \sin^{-1}(\sin \Delta \lambda \cos \phi) \]

Where \( \Delta \lambda = \lambda - \lambda_0 \)

Then X coordinates (Easting) of the MGRS

\[ X = E_{TM} = Ec \left( 1 + \frac{E_c^2}{6R^2} \right) \]

And Y coordinates (Northing)

\[ Y = N_{TM} = R \left( 90 - \phi_0 - \frac{PM}{R} \right) \]

where \( \frac{PM}{R} = \tan^{-1} \left( \frac{\cos \Delta \lambda}{\tan \phi} \right) \)

Calculated finally.
Then added the appropriate false easting and false northing values \((X, Y)\) MGRS coordinates can be written as follows.

\[
X_{\text{mgrs}} = X + 500000 \\
Y_{\text{mgrs}} = Y + 500000
\]

To calculate \((X, Y)\) of the National Coordinate System(SLD99) Piduruthalagala trigonometrical station was used as the based station, same point is used in the proposed MGRS. Also to avoid confusion with the grid coordinates of the MGRS false easting and false northing values and use the maritime operation zone use 500000m N and 500000m E.

A java programme to compute MGRS coordinates was developed using these mathematical equations and the program attach as Annex A. All the input and output values append into single file and it can be used as Spread sheet or database file.

3.3 Data Analysis

The researcher calculated distance difference between given set of latitude and longitudes and there relevant MGRS coordinate. Then compute two ellipsoid distance by using Latitute and logitute values. At the same time calculate grid distance between relevant points. After that calculates the difference for sample points. Statistical methods were used to analyse the data and determine the error.

This chapter provides describe detail about research method and following chapter is going to elucidate the result of the study regarding used method and materials of the research.
Chapter Four

RESULT AND DISCUSSIONS

The previous chapter focused on detail description of research methodology and this chapter organized to present analyzed result of coordinates transformation to full fill the expected objective. The objective of this thesis was to develop Military Grid Reference System (MGRS) for the future joint operations by the Sri Lankan defence forces. In this chapter interpreted and explained the result, justify the research approach and critically evaluated the study to fulfill objectives of the research.

16 Sample point sets were taken from the control point network of the Survey Department. Moreover these points were taken to cover entire geographical surface of the country. The points are shown on the figure 4.1 and it can clearly identified two set of points which were taken nearby distance for calculation the error of the new system .Accordingly minimize the error and it would help to develop precise MGRS for Sri Lankan context.
Figure 4.1: Sample points
Source: Created by researcher Department
Differences of WGS84 ellipsoid distances and projected MGRS distances were computed using computer program and given in the following table.

Table 4.1 – Distance difference between WGS84 and MGRS coordinates

<table>
<thead>
<tr>
<th>id</th>
<th>X1</th>
<th>Y1</th>
<th>Lat1</th>
<th>Long1</th>
<th>X2</th>
<th>Y2</th>
<th>Lat2</th>
<th>Long2</th>
<th>Dwgs84</th>
<th>Dmgrs</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>424879.3</td>
<td>487029.9</td>
<td>6.88309</td>
<td>80.08979</td>
<td>425187.1</td>
<td>486951.5</td>
<td>6.88239</td>
<td>80.09258</td>
<td>318.30</td>
<td>317.64</td>
<td>0.66</td>
</tr>
<tr>
<td>2</td>
<td>426843.9</td>
<td>459790.3</td>
<td>6.63764</td>
<td>80.10795</td>
<td>426678.1</td>
<td>459616.7</td>
<td>6.63607</td>
<td>80.10645</td>
<td>240.59</td>
<td>240.08</td>
<td>0.50</td>
</tr>
<tr>
<td>3</td>
<td>468128.6</td>
<td>419759.8</td>
<td>6.27721</td>
<td>80.48273</td>
<td>467933.5</td>
<td>419852.2</td>
<td>6.27805</td>
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<td>0.46</td>
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<td>468908.1</td>
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<td>80.93131</td>
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<td>221.60</td>
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<td>7.23918</td>
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<td>560473.5</td>
<td>526741.9</td>
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<td>81.32110</td>
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<td>303.22</td>
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<td>7.90058</td>
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<td>550554.6</td>
<td>599706.3</td>
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<td>81.23168</td>
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<td>7</td>
<td>504724.9</td>
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<td>80.81469</td>
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<td>592547</td>
<td>7.83453</td>
<td>80.81584</td>
<td>299.66</td>
<td>299.03</td>
<td>0.63</td>
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<td>8</td>
<td>410450</td>
<td>655927.3</td>
<td>8.40486</td>
<td>79.95594</td>
<td>410239.9</td>
<td>655698</td>
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<td>Y1</td>
<td>Lat1</td>
<td>Long1</td>
<td>X2</td>
<td>Y2</td>
<td>Lat2</td>
<td>Long2</td>
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<td>Dmgs</td>
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Source: Created by researcher
It is clearly seen that the difference of distances vary from each other. It is also seen that differences are closer in certain areas and higher in other areas. The average distance of WGS84 coordinates 387.24m. The error is vary from .46m to 1.09 m. The mean of the error calculating using

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

Mean = 0.78m

Which mean the coordinates transformation occur 0.78m average error by concerning these 16 point sets.

For a random sample of n observations from a normally distributed population, the sample mean distribution is normally distributed with mean and variance as follows:

$$\bar{x} \sim N \left( \mu, \frac{\sigma^2}{n} \right)$$

These error values can show a normal distribution

The standard deviation can be calculated using following equation and it shows the vary of the error.

$$SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}$$

SD = 0.247
Chapter Five

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Chapter focuses on the implications of the findings of the study. To implicate the findings from both the research process and results of the study are discussed in line with the structure of the thesis. The first section of this chapter begins with a summary of key findings. The effective recommendations and future also included.

In this study mainly discussed about Military Grid Reference System for forces Joint operations in the Sri Lankan context. As discussed North Atlantic Treaty Organization forces already are using MGRS for their military operations for the entire world. The MGRS basically derived from WGS84 ellipsoid and it converts the angular measurement values to projected grid coordinates. The MGRS system was designed to simplify the specification of position and passing of coordinates for soldiers.

Primarily researcher found that MGRS WGS84 system also can be applied to Sri Lankan context with the necessary parameters. In this manner the scale factor is the most important and the vital parameter. In this study whatever the method is used to compute scale factor for MGRS, control points were selected in such way that those are scattered all over the country. The check points were also selected to cover the most of the area.

Mainly a java based programme used to compute the MGRS coordinates for given Lat/Long values. Initially UTM parameters use to compute the Easting and Northing of MGRS and determine the suitable values for parameters. The scale factor determine by considering maximum allow error in the MGRS. The researcher found that scale factor ($k_0=.99978$) is suit to the Sri Lankan military operation theaters.
It is consider distance values for calculate the error. Computed distance between the given 02 sets of Lat/Lng values compare with the MGRS coordinates difference.

A significant error occurred and it is vary from place to place. Accordingly the system developed with the scale factor that minimize the error and found the precise value to each area in local context.

When consider about the local context. The UTM method use to convert Lat/Long in to MGRS coordinates. Difference of computed and given values are not significant, when it is considered the corresponding changes will have to be occurred in coordinates. This result implies that Army, Navy and Air Force can use the system in joint operations. The Air Force and Navy already use the WGS84 coordinate system and this system provides Military grid system based on WGS84 basis for ground forces.

Consequently the study hoped to conduct for developed a military grid reference system in Sri Lanka. Particularly study determined result produce with limited time and the nature of work as WGS84 system parameters basically can apply local context. Significantly system precisely used to military joint operations in Sri Lanka.

5.2 Recommendations

Study was to develop that WGS84 based MGRS could be use in Sri Lankan context in Military operations. System basically conducted to support accurate target indication in field of military operation. Mainly in the study that height values were not consider in the developing MGRS. Therefore in the future study height values will be integrated in to the system by using local height module.

Since limited time and the considering the budget of the research the researcher was not able to done a field trial and obtain available data. However for a deep study it is need to done field observation to improve the accuracy of the system.
Accordingly developed MGRS system can be used in the future in any joint operation. At the same time it is recommended to test this system in Commonon Strike operation which is annually conducting by the Sri Lankan Military forces.

On the other hand developed MGRS system can be used to war game application as well as it will be applied to security purpose WebGIS application or Simulation system. Consequently study would help to develop a proper MGRS system by using the global context grid system as a model to the local context with more precise and accessible manner.
REFERENCES


National Geospatial-Intelligence Agency (2014) STANDARDIZATION DOCUMENT. 2-1.2-2


Peter H. Dana. (1994). Department of Geography, University of Texas at Austin.


function Wgs2Mgrs() {
    var a = 6378137;
    var b = 6356752.3142;
    var lan0 = 80.77171;
    var fi0 = 7.00047;
    var lan = document.getElementById('txtLng').value;
    var fi = document.getElementById('txtLat').value;
    var e = Math.sqrt((Math.pow(a,2)-Math.pow(b,2))/Math.pow(a,2));
    var lan0 = lan0*Math.PI/180;
    var fi = fi*Math.PI/180;
    var N = a/Math.pow(1-Math.pow(e,2)/Math.pow(Math.sin(fi),2), 0.5);
    var M = a*(1-Math.pow(e,2))/Math.pow((1-(Math.pow(e,2)*Math.pow(Math.sin(fi),2))), (3/2));
    var R = Math.sqrt(N*M);
    var Xc = R*Math.asin(Math.sin(lan)*Math.cos(fi));
    var Xutm = Xc*(1+(Math.pow(Xc,2)/6/Math.pow(R,2)));
    var PM = Math.atan(Math.cos(lan)/Math.tan(fi));
    var PM1 = PM*180/Math.PI;
    var Yutm = R*(90-fi0-PM1)*Math.PI/180;
    var X = 500000+Xutm;
    var Y = 500000+Yutm;

    document.getElementById('divEast').innerHTML = X.toString();
    document.getElementById('divNorth').innerHTML = Y.toString();
    document.getElementById('divError').innerHTML = e.toString();

    writeToFile(X.toString(),Y.toString(),e.toString());
}
function resetPage(){
    document.getElementById('divEast').innerHTML = "";
    document.getElementById('divNorth').innerHTML = "";
    document.getElementById('divError').innerHTML = "";
    document.getElementById('txtLng').value = "";
    document.getElementById('txtLat').value = "";
}

function writeToFile(x, y, z){
    try{
        if (window.XMLHttpRequest){// code for IE7+, Firefox, Chrome, Opera, Safari
            xmlhttp=new XMLHttpRequest();
        }else {// code for IE6, IE5
            xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
        }
        xmlhttp.onreadystatechange=function(){
            if(xmlhttp.readyState==4 && xmlhttp.status==200){
                var res = xmlhttp.responseText;
                alert("Converted Successfully");
                //showBoundaryMap(res);
                //document.getElementById('txtVillage').value = "";
                //alert("Project Names-");
            }
        }
        var url="write_data.php";
        url=url+"?Command=search_info";
        url=url+'&x='+x;
        url=url+'&y='+y;
        url=url+'&z='+z;
        //alert(url);
        xmlhttp.open("GET",url,true);
        xmlhttp.send();
    }catch(err){
        alert("Error in Saving User Details in to Temp = "+err);
    }
}
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