Gt Aide (Global) as Treatise in Field Planning

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By

AC Dinesh and Sajesh P.V.

Cambridge Scholars Publishing

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This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-1010-0
ISBN (Ebook): 978-1-0364-1011-7

Gt Aide (Global) freeware may be downloaded:

Dinesh is dedicating the Book and Freeware to his beloved grandsons: Aagney and Evaan….

TABLE OF CONTENTS

PREFACE

The publication of the book entitled "Gt Aide (Global) as Treatise in Field Planning" alongside its complementary freeware counterpart marks a significant breakthrough in the realm of learning and teaching various facets of field planning, particularly in geological mapping, exploration, and surveys. I take immense pride and joy in acknowledging the invaluable contributions of the authors and developers: Mr. AC Dinesh and Mr. Sajesh PV, both esteemed members of the Geological Survey of India (GSI).

Comprising six chapters and two sub-chapters, the book serves as a comprehensive guide, while the freeware offers six robust modules designed to assist users in navigating through coordinates, bearings, gridding, survey tracks, plotting sampling points and even get a global perception on volcanology and seismology. It is truly remarkable that the freeware is accessible to users without the need for formal training, underscoring its user-friendly design and inbuilt interface.

The main attraction of the book seems to be the number of tasks in each chapter that are meticulously crafted with dedication and through thought processes. I extend my heartfelt congratulations to Mr. Dinesh, a former Director at GSI, and Mr. Sajesh, a Senior Geologist at GSI, for their tireless efforts in conceptualizing this book and developing the accompanying freeware, which is poised to benefit students and researchers in the fields of geology and geography worldwide.

It is my sincere hope that students and researchers alike will fully harness the resources provided by the book and freeware, thereby gaining a comprehensive understanding of various aspects of field planning while fostering confidence in their abilities. Let us collectively embrace this remarkable tool as we continue to advance our knowledge and exploration of the Earth's dynamic processes.

ALL THE BEST WISHES!!

Janardan Prasad
Director General, Geological Survey of India, Kolkata, India-700016

INTRODUCTION

Fieldwork stands as a cornerstone in geological exploration, enabling direct observation, measurement, and data collection from Earth's structures. For a geologist, the initial phase of field planning involves precisely outlining the purpose. This objective can range from broad aims like comprehending an area's geological history to specific goals such as exploring a particular mineral presence (Compton, 1985, 3-10). Thoroughly reviewing existing literature, geological reports, maps, and satellite images plays a pivotal role in comprehending the known aspects and identifying gaps within the area of interest. Fieldwork, often conducted in remote or challenging terrains, necessitates meticulous planning that prioritizes safety measures. Logistics planning involves charting the most efficient routes, arranging transportation and lodging, and ensuring ample supplies and equipment. Depending on the fieldwork's objectives, diverse data collection methods like structure measurements, sampling rock, soil, or water, capturing photographs, or documenting observations are employed, dictating the necessary equipment (McPherson and Eric, 2002, 591-598). Subsequent to fieldwork, a scientific analysis and interpretation of the gathered data are imperative.

Geological field studies demand meticulous planning for effective data collection. The primary objective of this planning is to create a strategy enabling geologists to gather high-quality data while prioritizing safety for themselves and their team. Fieldwork encompasses crucial tasks like mapping, sampling, and measuring rock properties, pivotal for geological investigations. A critical aspect of this planning involves delineating the study area's polygon boundary. This step includes precise mapping via aerial photographs, topographic maps, and GPS surveys. Establishing the polygon boundary aids in defining the study area and plays a vital role in recognizing the distribution of geological features within that space.

Another significant facet of field planning involves gridding the study area at predetermined intervals for sample collection. This process divides the area into smaller units, ensuring even data collection across the entirety of the study area. Additionally, plotting tracks for conducting geophysical or geological surveys is crucial in field planning. This entails identifying specific routes or paths within the study area essential for data collection.

Planning these tracks involves various methods like GPS surveys and aerial photographs to guarantee comprehensive coverage of the study area.

Finally, strategically plotting sample points along the tracks at defined intervals forms a critical part of geological field planning. This step includes identifying precise locations along the tracks for collecting diverse data like soil, rock, water samples, or geophysical information. Ensuring regular intervals for sample points is vital, aiming for them to be representative of the entire study area. In sum, meticulous planning in geological field studies is imperative for efficient and effective data collection. Employing diverse mapping techniques, gridding methods, and track planning strategies ensures uniform and comprehensive data collection across the study area.

While various programs like ArcGIS, QGIS, Global Mapper, and Surfer serve similar purposes, the freeware Gt Aide (Global) stands out for its exceptional user-friendly interface. It is distinct in a way that even a student in geology or geo-informatics can navigate it with zero prior knowledge. What sets it apart is its immediate visualization of outputs over Google Earth creating KML (Keyhole Markup Language) files automatically in the back-end.

This student-oriented book delves into eight extensive chapters outlined below, each crafted to enhance your understanding effortlessly. Tailored exercises at the end of every chapter, meticulously designed and thoughtfully developed, guarantee a thorough mastery of every concept in field planning.

1. GEOGRAPHIC COORDINATES & UTM ZONES
2. GRIDS, TRACKS, SAMPLES
3. ADVANCED GRIDS, TRACKS, SAMPLES
4. FLEXI GRIDS
5. FLEXI LINES
6. BID CALCULATOR
7. EARTHQUAKES AND VOLCANOES: A GLOBAL DISTRIBUTION PERSPECTIVE
8. MULTIBEAM & DRONE SURVEY PLANNING
9. GENERAL TASKS

The chapter commences with ' Geographic Coordinates & UTM Zones' that is fundamental to any map or positioning system. Grasping the essentials of geographical coordinates holds immense importance for geology or geoinformatics user. With this focus, the authors have structured this chapter around engaging activities. Plotting equator, tropic of cancer, prime meridian, and more over Google Earth becomes effortless by just a click. The chapter introduces UTM Zones and UTM Coordinates in a user-friendly context, enabling user to easily convert between geographical coordinates and that of UTM. This approach fosters a clear understanding of the distinctions between the two systems.

The second chapter, 'Grids, Tracks, Samples' aims to elucidate the gridding of various polygon types, the methodology behind drawing survey tracks within polygon boundaries, and accurately plotting samples along survey tracks. This section also covers the extraction of geographical coordinates from KML files pertaining to polygons, lines and points. It also facilitates estimating the area and perimeter of a polygon, outlining grids around a point and generating rectangles using the end coordinates of their diagonals. In the subsequent chapter, 'Advanced Grids, Tracks, Samples' user explores creation of grids aligned parallel to two consecutive sides of a convex polygon. Additionally, the chapter explains the techniques of drawing survey tracks parallel or perpendicular to any side of a polygon, further enhancing their understanding in this domain.

The fourth chapter, 'Flexi Grids,' lives up to its name by facilitating the effortless creation of grids aligned to any given baseline or a point with a direction. Moving on, the fifth chapter, 'Flexi Lines' focuses on drawing survey tracks at given bearing, length and intervals concerning a point or a line. The sixth chapter, 'BID Calculator' elucidates the calculation methods for bearing, intersection point of two lines and destination point.

Further, Chapter Seven, titled "Earthquakes and Volcanoes: A Global Distribution Perspective" is added and is designed to enhance the user's understanding of the worldwide distribution of earthquakes and volcanism and their correlation with plate boundaries. Chapter eight ‘Multibeam and Drone Survey Planning’ is to make students familiarise about fundamentals of multibeam bathymetric survey and drone survey and their planning.

The last chapter “General Tasks” includes detailed formulas, worked-out examples, unsolved tasks and references to support comprehension. These tasks are meticulously designed to enable user to think and apply all necessary modules provided in the freeware, encouraging practical application through exercises. Before going into chapters, a brief introduction about Gt Aide (Global) freeware.

Gt Aide (Global) is a freeware tailored for UG and PG students in geology, geography, and geoinformatics, can be extending its usability to researchers and teachers. It comprises six modules: 'Coordinates', 'Grids, Tracks,

Samples', 'Advanced Grids, Tracks and Samples', 'Flexi Grids', 'Flexi Lines', and 'BID Calculator'. Each module is user-friendly yet potent, eliminating the need for formal training. The fundamental premise of Gt Aide follows a simple flow: module window → input data → output data. The tasks within each module are crafted to encourage student engagement, fostering learning, idea about exploration, and confidence-building.

Developed in Visual Basic, Gt Aide visualizes outputs (points, lines, polygons) over Google Earth by automatically creating kml files. Text outputs are opened in Notepad. The '.kml' and '.txt' files are being saved automatically in the software's Output folder. These outputs prove invaluable for field planning. The kml file, generated within the software, can be converted to shapefiles in both QGIS and ArcGIS.

The first module, 'Coordinates', introduces fundamental geographic coordinate concepts necessary for mapping. Students may effortlessly plot latitude circles, meridians, and explore over 10,000 cities having population exceeding 50,000. Querying into datasets is introduced, aiding students to get familiarized with queries.

The second module, 'Grids, Tracks, Samples', has numerous menus and sub-menus, accompanied by an extensive help file for easy learning. It teaches retrieving coordinates from kml files related to polygons, lines, or points. Drawing survey tracks within a polygon and plotting sample points along the tracks are made simple. The 'Advanced Grids, Tracks, Samples' module focuses on creating grids parallel to two adjacent sides of a convex polygon, significantly aiding mineral exploration in many cases. 'Flexi Grids' generates grids along a baseline at any internal grid angle, while 'Flexi Lines' effortlessly plots lines with respect to a line or a point.

The final module, 'BID Calculator', educates how to determine bearing of a line, destination point and intersection point. Handling single or multiple data sets gives users an added advantage. An additional dataset encompassing earthquakes, volcanoes, and plate boundaries aids users in comprehending global tectonism, seismicity, and volcanism, as well as their interrelations.

The detailed help file and set of solved/unsolved exercises bundled with the freeware Gt Aide (Global) may become a real asset for the students. The data input process across all modules is designed to be intuitive, enabling students to navigate Gt Aide with ease, almost akin to playing a computer game.

You may begin your journey into seamless field planning with Gt Aide (Global).

Best wishes for your endeavours!!!

CHAPTER ONE

GEOGRAPHIC COORDINATES AND UTM ZONES

1.1 Introduction

The Earth, not a sphere or a perfect ellipsoid, deviates in shape. It's influenced by factors like mountains, ocean basins, and crustal thickness variations, resulting in its observed irregular shape (Anderson, 2007, 62). The geoid is Earth's shape if measured at mean sea level, is an undulating surface differing by approximately a hundred meters from a well-fitting ellipsoid (Snyder, 1987, 8). To portray Earth and celestial bodies on a flat plane, a shift from physical to mathematically modelled surfaces (datum) is essential (Bugayevskiy and Snyder, 1995, 1). This chapter introduces and visualizes the global geographic coordinate system and UTM zones using Google Earth. It explores variations in the northern and southern hemispheres and clarifies the distinctions between geographic coordinates and UTM zones.

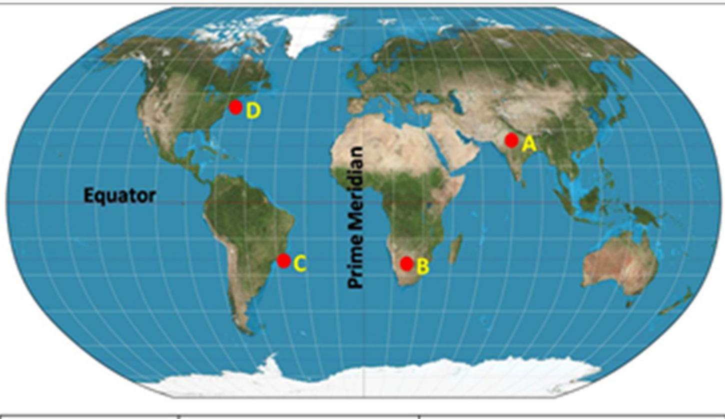
1.2 Geographic Coordinate System

The widespread global coordinate system is defined by lines of geographic latitude and longitude (Huisan and By, 2009, 207). A geographic coordinate system (GCS) employs a three-dimensional surface to delineate positions on the Earth. A datum serves as the fundamental coordinate reference system (surface), originating from a specific point. It acts as a model of Earth for mapping, chosen to achieve the optimal fit to the Earth's true shape (Usery, Finn and Mugnier, 2009, 89). Established datums enable defining the geographical reference system (GRS) through latitude and longitude coordinates. Variations occur based on referenced datums. Numerous datums, optimized for specific regions, exist globally.

Geographic Information Science (GISc) datasets commonly utilize Geographic Coordinate Systems (GCS) like World Geodetic System 1984 (WGS84) or North American Datum 1983 (NAD83), each tailored for specific worldwide or regional applications (Usery, Finn and Mugnier, 2009, 89). Mapping involves establishing control points across the area, with the datum defining foundational control for a region or continent (Mugnier, 2000, 784). Earth's points are located through a graticule of longitude and latitude lines. Meridians and parallels, referring to lines of longitude and latitude respectively, form the network of graticule. Parallels are circles parallel to the Equator, with degrees from 0° at the Equator to 90° at the poles. Each degree further divides into 60 minutes and each minute into 60 seconds of arc, providing precise location identification (Snyder, 1987, 8). Longitude meridians intersect at the Poles, crossing each latitude parallel at right angles. Dividing the Equator into 360 parts results in degrees of longitude, subdivided into minutes and seconds. Unlike a consistent degree of latitude, the lengths of degrees of longitude vary by latitude, equalling the degree of latitude only at the Equator and being shorter elsewhere (Snyder, 1987, 8). Longitude and latitude coordinates form the geographic coordinate system. Pinpointing specific Earth locations involves coordinate pairs (X, Y) in two-dimensional space, reference a horizontal datum, while triplets (X, Y, Z) signify position and encompass elevations referenced to a vertical datum. This comprehensive spatial understanding aids in precise positioning and mapping, bridging the gap between the physical world and mathematical representations, pinpointing specific Earth locations (Usery, Finn and Mugnier, 2009, 89). Longitude and latitude coordinates are expressed in degree decimals, geographic coordinates can also be presented in degree-minutes-seconds or degree-minutes, offering different formats for representing the same location (Fig. 1-1).

Gt Aide (Global) freeware offers a convenient tool to visualize meridians for end users. Longitudes, or meridians, are imaginary lines stretching from the North to the South Pole, converging at the poles. They range from -180 to +180 degrees. The Prime Meridian, passing through Greenwich, London, is marked as 0°. Other longitudes are numbered east or west from Prime Meridian that divide the globe into west and east hemispheres. Western hemisphere longitudes bear a negative sign (e.g., -12.5° or 12°30’ W), while those in the eastern hemisphere are unsigned (e.g., 12.5° or 12°30’ E). The opposite line to 0° longitude is 180°, signifies the International Date Line, separating calendar days (Metcalf, 2013, 5 and Howell, 2016, 14-18). The standard meridian serves as the reference for calculating a country's standard time. Similar to longitudes, latitudes are imaginary lines known as parallels, running horizontally east-west. The Equator marks 0° latitude, while other lines of latitude run parallel, measured in degrees north or south. Values range from -90° (South Pole in the southern hemisphere) to +90° (North Pole in the northern hemisphere). In the northern hemisphere, latitude values are positive, whereas in the southern hemisphere, they're negative (e.g., -22.5° or 22°30’S). The letters N or S indicate the hemisphere, and in Degree-Minute or Degree-Minute-Second formats, the signs are omitted.

The area between 23°30’ north and south of the Equator is termed the tropics. At these latitudes, specifically 23°30’N and 23°30’S, lie the Tropic of Cancer and the Tropic of Capricorn respectively. These lines, along with the Equator, signify various mathematical, astronomical, and climatological phenomena on Earth (Feeley and Stroud, 2018, 1). Zones stretching from the Tropic of Cancer to 40°N and from the Tropic of Capricorn to 40°S are labelled sub-tropics/temperate zones. At latitude 66°30′ N, the Arctic Circle denotes the southern extent of an area where there's at least one 24-hour period annually with no sunset and one with no sunrise. The duration of continuous day or night increases towards the North Pole, ranging from a single day on the Arctic Circle to six months at the pole. As the southern counterpart, the Antarctic Circle experiences precisely opposite daylight and darkness conditions compared to the Arctic Circle on any given date.



Places	Degree Decimal		Degree Minute Second	
	X (Longitude)	Y (Latitude)	X (Longitude)	Y (Latitude)
A (New Delhi)	77.2058°	28.6176°	77° 12'20.88"E	28° 37' 3.36"N
B (Namibia)	18.4908°	-22.9688°	18° 29' 26.88"E	22° 58' 7.68"S
C (Rio de Janeiro)	- 43.1731°	-22.9073°	43° 10' 23.16"W	22° 54' 26.28"S
D (New York)	-74.0063°	40.7116°	74° 0' 22.68"W	40° 42'41.76"N

Fig. 1-1 Variations in longitude and latitude values across the four hemispheres.

1.3 Geographic Coordinate Representation: Degree Decimal and Degree-Minutes-Seconds

Longitude and latitude coordinates are typically presented in degrees, minutes, and seconds format, like 15° 20' 30" (15 degrees, 20 minutes, 30 seconds). Cartographers utilize spherical coordinates, expressing them in degree-minutes-seconds (DMS) and decimal degrees (DD). In DMS representation, minutes span from 0 to 60. For instance, New Delhi's DMS coordinates are Latitude: 28°36'41.61"N and Longitude: 77°13'10.56"E. Expressed in DD, New Delhi's coordinates are Longitude: 77.2205°E and Latitude: 28.6091°N. Converting minutes and seconds to decimal degrees involves dividing minutes by 60, seconds by 3600, and adding the results to get the decimal equivalent. This conversion uses the following formula:

$$Degrees\ decimal\ = Degree + \left(\frac{Minutes}{60}\right) + \left(\frac{Seconds}{3600}\right)$$

To transform 15° 20' 30" into decimal degrees, begin by converting minutes and seconds into their degree equivalents, then sum up the outcomes as follows:

$$\frac{20'}{60} = 0.3333°$$
$$30''/3600 = 0.0083°$$
$$0.3333° + 0.0083° = 0.3416°$$

Therefore, the final result is obtained by adding these calculated values to the initial degrees:

$$15° + 0.3416° = 15.3416°$$

$$15°\,20'\,30'' = 15.3416°$$

To convert a degree decimal (DD) of 15.3416° to Degree-Minute-Second format, begin by finding the integer degrees (D), which equals the whole number part of the degree decimal (DD).

Here, d = 15°

Then, calculate the integer minutes (M). It equals the whole number part of the decimal degrees (DD) minus the integer degrees (D) multiplied by 60.

$M = (DD - D) X\ 60$
$= (15.3416 - 15) X\ 60$
$= 20.496$

Therefore, M= 20'

Now, determine the seconds (S); it equals the decimal minutes (dM) minus integer minutes (M) multiplied by 60.

$S = (\text{dM} - M) \times 60$
$= (20.496 - 20)\ X\ 60$
$= 0.496\ X\ 60$
$= 29.76 \sim 30$

The final result is obtained by assembling the integer degrees (D), integer minutes (M), and seconds (S) as required in the Degree-Minute-Second format: 15.3416°= 15° 20’ 30".

1.4 Explore the World with Gt Aide: A Visual Approach for Learning Geographic Coordinates

Acquiring proficiency in the fundamental geographic coordinate system is essential for geologists and geographers. Gt Aide (Global) streamlines this process through Google Earth visualizations that are much appealing and facilitate a clearer understanding of intricate concepts. The primary features of the 'Coordinates' module in the freeware Gt Aide (Global) are outlined in Fig. 1-2 to Fig. 1-12. The 'Coordinates' module of Gt Aide (Global) provides a comprehensive overview of geographic coordinates by visualizing them on the Google Earth platform. It allows users to plot and visualize semi-circles of longitudes and circles of latitudes at any interval simultaneously on Google Earth (see Fig. 1-3A and 1-3B). With a simple 'click,' user can plot latitude circles or longitude semi-circles on Google Earth (Fig. 1-4), aiding in identifying locations sharing the same latitude and longitude worldwide with ease. In Fig. 1-5, Null Island, an imaginary point where the Prime Meridian intersects the Equator (0°N, 0°E), is illustrated for reference (Latitude = Longitude = 0°).

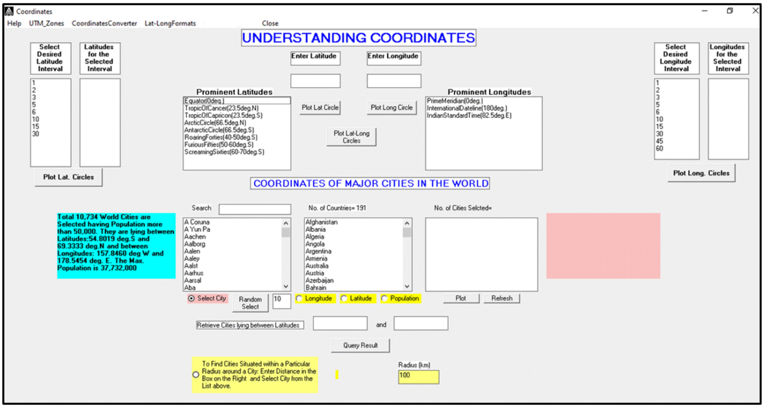


Fig. 1-2 'Coordinates' Module-window of Gt Aide (Global).

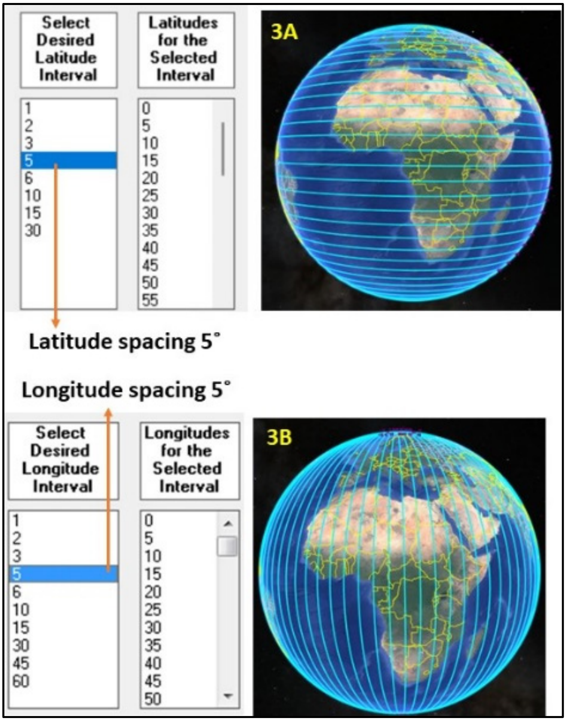


Fig. 1-3 Latitude (3A) and Longitude (3B) depicted at 5° intervals on Google Earth utilizing Gt Aide (Global).

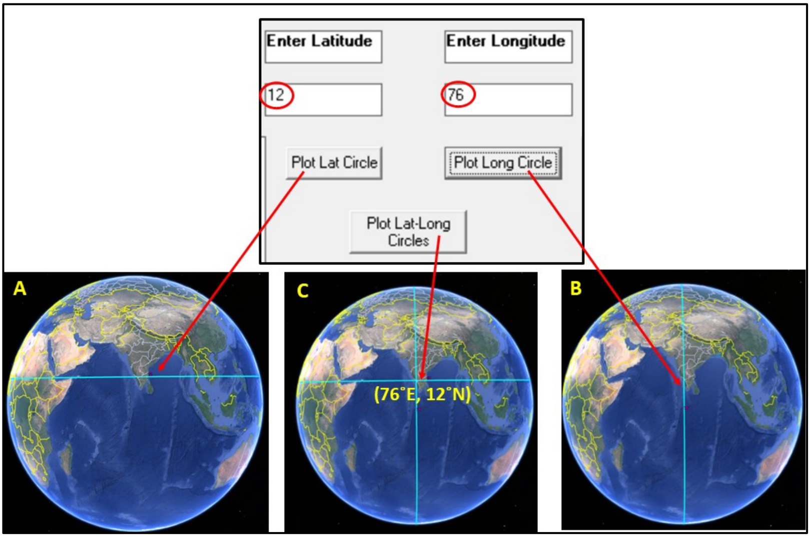


Fig. 1-4 Illustrates the visualization on Google Earth of (A) the selected latitude 12°N, (B) longitude 76°E, and (C) the convergence point of 76°E, 12°N.

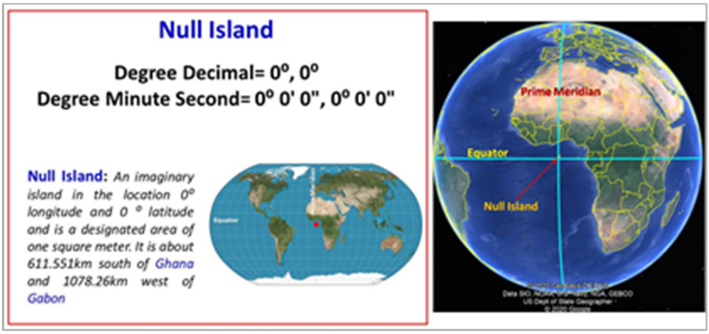


Fig. 1-5 Null Island, the point where the Prime Meridian (0°) intersects with the Equator (0°).

In addition to these functionalities, Gt Aide (Global) freeware facilitates the swift plotting of significant latitude circles (Fig. 1-6), including *the Equator, Tropic of Cancer, Tropic of Capricorn, Arctic Circle, Antarctic Circle, Roaring Forties, Furious Fifties, and Screaming Sixties*. Similarly, important longitudes such as the *Prime Meridian* and *International Date Line* are provided in the freeware for convenient visualization on Google Earth (Fig. 1-7).

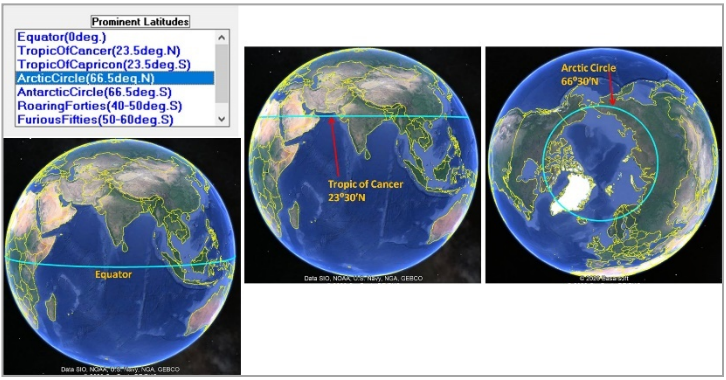


Fig. 1-6. Significant latitude circles, namely the Equator, Tropic of Cancer, and Arctic Circle, visualized on Google Earth.

Fig. 1-7 Longitude semicircles, the Prime Meridian and Indian Standard Time lines, visualized on Google Earth.

The 'Coordinates' module includes an option designed to allow users to practice and gain a deeper understanding of geographic coordinates, exploring how longitude and latitude vary across different locations (Fig. 1-8). Gt Aide (Global) freeware offers a rich dataset of 10,734 entries from 191 countries, encompassing vibrant cities worldwide (with populations exceeding 50,000). This diversity enables users to engage in various exercises. In addition to visualizing places on Google Earth, the longitude and latitude values are presented on Notepad, facilitating easy copying for further use. Users can choose a location from the provided Table or input a known place in the 'Search' box (Fig. 1-8) for plotting on Google Earth. The 'Random Select' option allows users to pick any number of places for visualization (Fig. 1-9). Furthermore, users can narrow down their selection to places falling within specific latitudes or longitudes by entering the required data (Fig. 1-10). Additionally, exercises involving important places within a certain radius of a chosen location are available, serving as educational opportunities, as illustrated in Fig. 1-11.

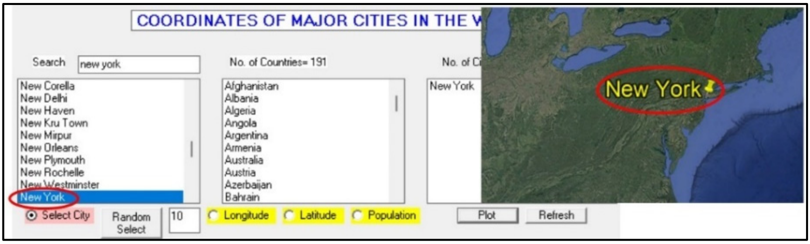


Fig. 1-8 Selection and Plotting of 'New York' from the List on Google Earth.

As mentioned earlier, geographic coordinates can be presented in different formats, such as degree decimal or degree minute second. To simplify the conversion between these formats, the 'Lat-Long converter' option is available in the 'Coordinates' menu (refer to Fig. 1-12). This functionality allows for the conversion of datasets from one format to another, including text format.

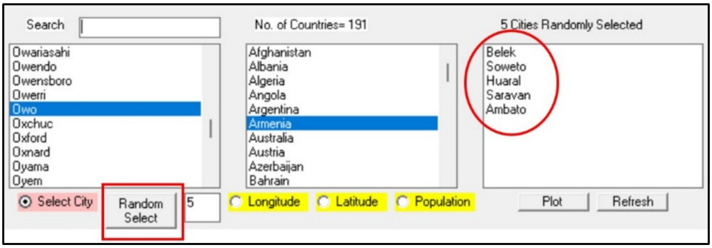


Fig. 1-9 Selection of Five Places Using the 'Random Select' Option.

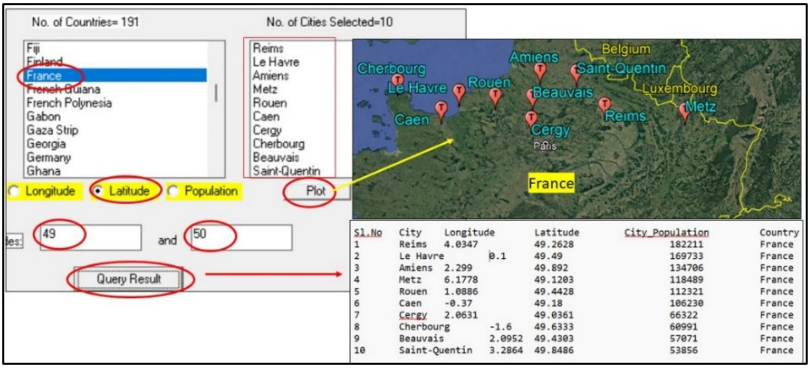


Fig. 1-10 Visualization of places in France falling between selected latitudes on Google Earth. Coordinates of the places automatically displayed in Notepad.

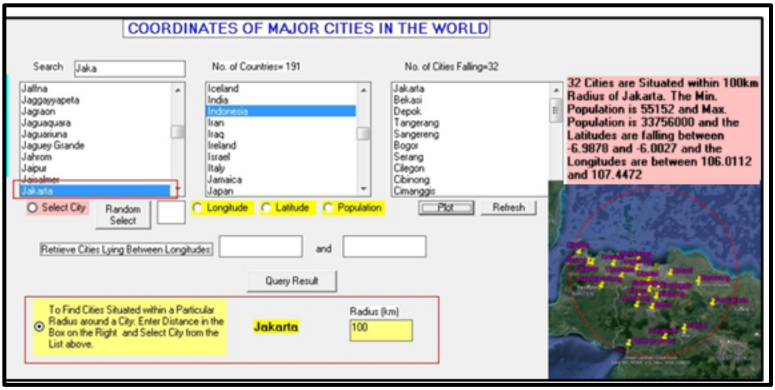


Fig. 1-11 Visualization of places around a designated location within a Selected Radius on Google Earth. Coordinates of the places are automatically displayed in Notepad.

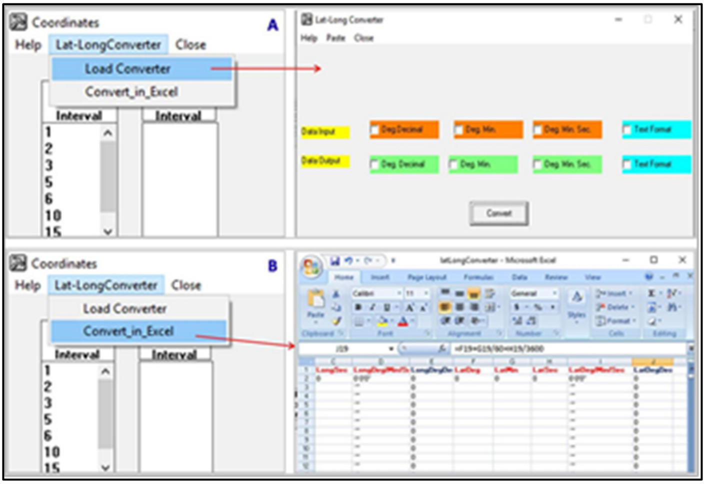


Fig. 1-12 Lat-Long Converter Options in Gt Aide (Global) (A) Lat-Long Converter Window and (B) Lat-Long Converter in Excel.

1.5 Exploring Universal Transverse Mercator (UTM) Zones

Various cartographic examples of Cartesian coordinate systems exist, with the Universal Transverse Mercator (UTM) standing out. Originating in the 1940s by the United States Army Corps of Engineers, UTM employs the WGS84 (World Geodetic System 1984) reference ellipsoid. Widely accepted globally, it is a prevalent choice for cartography and geographic information systems (GIS) applications (DeMers, 2017, 1). Geographic information systems (GIS) employ two primary coordinate systems: geographic and projected. Projected systems like UTM, Albers Equal Area, or Robinson utilize map projections, translating Earth's spherical surface to a Cartesian plane. These coordinate frameworks, both geographic and projected, establish a basis for defining real-world locations within GIS applications (Huisan and By, 2009, 207).

1.5.1 UTM Zones

The UTM system divides the Earth into 60 zones, each 6 degrees of longitude wide, spanning from 80°S to 84°N latitude. Zone 1 starts at 180°W and progresses eastward to zone 60 at 180°E (USGS, 1999, 157).

UTM coordinates require band numbers, as each zone has its transverse Mercator projection, minimizing distortion in the north-south-oriented zone. The Transverse Mercator projection, with a rotated cylinder, touches Earth at the 60 central meridians, ensuring reduced distortion with a scale factor of 0.9996 (DeMers, 2017, 1).

Military Grid Reference System (MGRS)

Derived from UTM and UPS (Universal Polar Stereographic), the Military Grid Reference System (MGRS) is used by NATO (North Atlantic Treaty Organization) for global location pinpointing, combining elements from both systems to cover the Earth comprehensively. MGRS uses a point reference system. Each of its zones comprises 20 latitudinal bands, 8 degrees each. These bands, labelled from C to X, avoid using "I" and "O" to prevent confusion with numbers. Zone X extends by 4 degrees, totalling 12 degrees, covering all Northern Hemisphere land. Zones A, B, Y, and Z don't exist in UTM; they're reserved for the Universal Polar Stereographic projection at the poles. MGRS ensures global coverage, even though the top and bottom zones don't align perfectly with corresponding latitudes due to this extension and allocation for polar projections. Geographic coordinate and UTM systems possess equal accuracy; they simply represent different methods of pinpointing a location on the Earth's surface (DeMers, 2017, 4).

Northing and Easting

The UTM system starts by determining the zone number for Earth positioning. To avoid negatives, it uses northings for north distances and eastings for east distances, all measured in meters for convenience. In the UTM system, each zone's origin is where the central meridian meets the equator. To prevent negatives, the central meridian within a zone is fixed at 500,000 meters East, denoted as the zone's "false easting". In the UTM system, eastings span from 166,000m to 834,000m at the equator, narrowing towards the poles due to converging meridians, limited to six digits due to the false origin. Northern Hemisphere northings rise in meters from zero at the equator. In the Southern Hemisphere, they decrease from 10,000,000m at the equator to around 11,00,000m at 80°S latitude. UTM northings, without referencing lettered zones, can extend up to seven digits in meters (DeMers, 2017, 2).

1.5.2 Locating a Position Using UTM Coordinates

A position on the Earth is given by the UTM zone number and the easting and northing planar coordinate pair in that zone. The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian. To avoid dealing with negative numbers, the central meridian of each zone is defined to coincide with 5,00,000 meters East. In any zone, a point that has an easting of 4,00,000 meters is about 100,000m (100km) west of the central meridian. UTM eastings range from about 1,66,000 meters to 8,34,000 meters at the equator.

In the northern hemisphere, positions are measured northward from zero at the equator. The maximum "northing" value is about 93,00,000 meters at latitude 84 degrees North, the northern end of the UTM zones. In the southern hemisphere, northings decrease southward to about 11,00,000 meters (1,100 km) at 80 degrees South, the southern end of the UTM zones. For the southern hemisphere, its northing at the equator is set at 1,00,00,000 meters so no point has a negative northing value.

The co-ordinates thus derived define a location within a UTM projection

-zone either north or south of the equator, but because the same co-ordinate system is repeated for each zone and hemisphere, it is necessary to additionally state the UTM longitudinal zone and either the hemisphere or latitudinal zone to define the location uniquely world-wide. For example: the CN Tower is at 43.64255°N, 79.38714°W, which is in UTM zone 17, and the grid position is 6,30,084 m east, 48,33,438 m north. Two points in Zone 17 have these coordinates, one in the northern hemisphere and one in the south. Hence, 79.30031°W, 46.63998°S are the geographic coordinates for the same UTM coordinates in the southern hemisphere. One of two conventions is used to locate CN Tower:

1. Append a hemisphere designator to the zone number, "N", thus "17N 630084, 4833438". This supplies the minimum information to define the position uniquely.
2. Supply the grid zone, i.e., the latitude band designator appended to the zone number, thus "17T 630084, 4833438".
3. The provision of the latitude band along with northing supplies redundant information (which may, as a consequence, be contradictory if misused).

Because latitude band "S" is in the northern hemisphere, a designation such as "38S" is unclear. The "S" might refer to the latitude band (32°N–40°N) or it might mean "South". It is therefore important to specify which convention is being used, e.g., by spelling out the hemisphere, "North" or "South", or using different symbols, such as − for south and + for north.

1.5.3 More Details about the UTM Coordinate System

Along the equator, a UTM Zone easting starts about 1,66,000 m and ends about 8,34,000m. Whereas, at 80°N, the easting starts about 4,42,000m and ends about 5,58,000m. Fig. 1-13 and 1-14 illustrate the variations in the easting-northing values from the equator to the pole, with respect to central meridian.

Note the following formulae for finding out western and eastern boundaries and central meridian of a UTM zone.

UTM Zone = 31+ (longitude/6)
Western boundary= (zone no. * 6) - 186
Eastern boundary= (zone no. * 6) - 180
Central meridian= (zone no. * 6) – 183

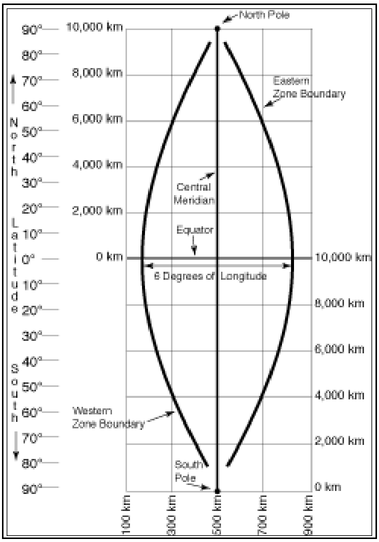


Fig. 1-13 Illustrates UTM zone in Northern and Southern Hemispheres vis-à-vis Northing and Easting.

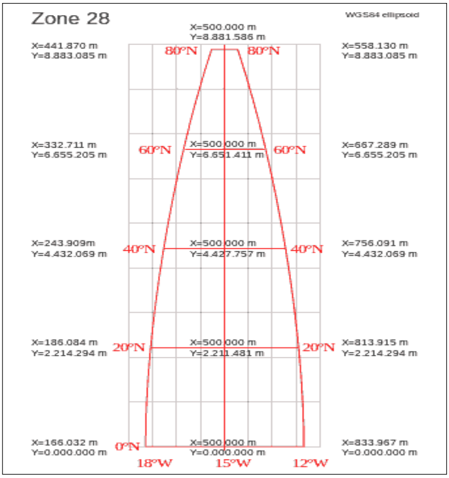


Fig. 1-14 Illustrates the variation of eastings and northings from equator to 80˚N in the UTM zone 28.

1.5.4 Gt Aide (Global) and UTM Zones

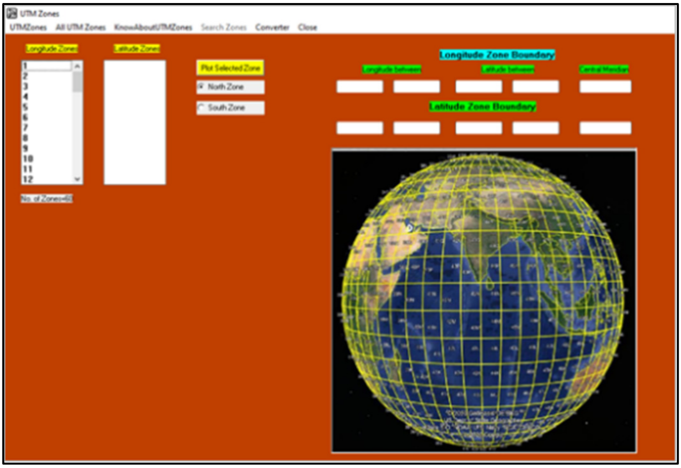


Fig. 1-15 Opening window of 'UTM Zones'.

Metadata of all UTM Zones are incorporated in the freeware database (Fig. 1-15). User is able to select any zone and get the details and plot it over Google Earth (Fig. 1-16). Further, one can convert the geographic coordinates to UTM easting and northing and vice versa. This module helps the user to understand the basics of UTM Zones, their numbering, calculation of zone number, central meridian, zone boundaries, false easting etc.

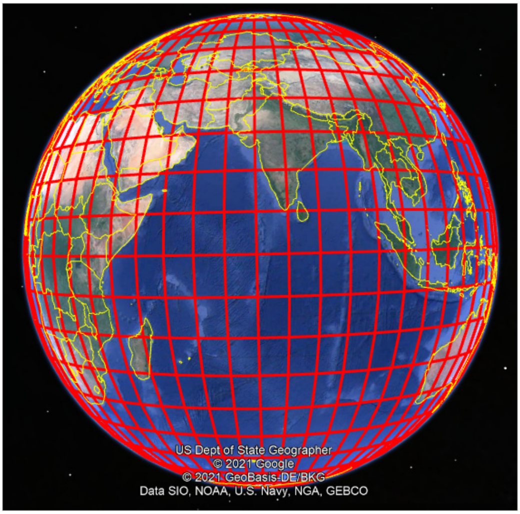


Fig. 1-16 All UTM Zones opened from Gt Aide on Google Earth.

1.5.5 UTM Conversion Tool

This sub-module incorporates the conversion of Geographic Coordinates (GC) to UTM and vice versa (Steven Dutch in 2011). Users can employ this sub-module to seamlessly transform between two coordinate systems. In Fig-17, the 'converter' window displays input boxes for geographical coordinates (longitude and latitude), allowing users to convert them into UTM Easting and Northing, along with the associated UTM Zone number. Conversely, users can input UTM Easting, Northing, and UTM Zone number to convert them into geographical coordinates. Upon entering longitude, users can also determine the UTM Zone, western boundary, eastern boundary, and central meridian. Furthermore, users have the capability to convert coordinates for multiple points from geographical coordinates (Lat Long) to UTM coordinates and vice versa (Fig. 1-17). This is achieved by pasting data in a tab-delimited format from Excel, following the structure outlined in Tables 1-1 and 1-2. includes Point No., which can be a number or string, and the Hemisphere ("N" or "S") should be placed in another column for accurate conversion. The output data are also shown in