Addis Ababa University
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering

PLANIMETRIC ACCURACY ASSESSMENT OF DIGITAL SPATIAL DATA FOR LARGE SCALE PLANIMETRIC MAPPING: THE CASE STUDY ON DIRE DAWA City, ETHIOPIA

A Thesis Submitted to

School of School of Civil and Environmental Engineering of

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In Partial Fulfillment of the Requirements for the Degree of Masters of

Science in Geodesy and Geomatics specialization in Geomatics

By

Ephrem Mulugeta

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List of Abbreviations

ASPRS	American Society for Photogrammetry and Remote Sensing
AUSPOS	Australian positioning service
CORS	Continuously Operating Reference Stations
DGPS	Differential global positioning system
E.G.I.A	Ethiopia geospatial information Agency
FGDC	Federal Geographic Data Committee
GCP	Ground control point
GIS	Geographical information system
GNSS	Global navigation satellite system
GPS	Global positioning system
IGS	International GPS Service
INSA	Information Network Security Agency
OPUS	Online positioning user service
RMSE	root-mean-square error
RTK	Real Time Kinematic

Abstract

This study assesses the planimetric (x, y) accuracy of digital spatial data used for mapping large scale planimetric maps in Dire Dawa city. These digital spatial data are Orthophoto and its line map (parcel and road center line) and Worldview-1 panchromatic satellite image. RTK GPS measurement technique was used as an independent source and point wise method were used to assess the planimetric accuracy the digital spatial data set. Due to unavailability of local CORS station which used as a reference during RTK GPS measurement second order GCPs which was established by E.G.I.A (Ethiopian Geospatial Information Agency) was used as a base station. But before conducting RTK GPS survey a 12 hour static GPS survey were conducted on selected two second order and one first order GCP established by E.G.I.A and the GPS data are processed with a tie to IGS CORS station found in Addis Abeba and two free online GPS data processing service provider that are AUSPOS and OPUS. For accuracy comparison OPUS processed coordinates result were taken. However, the positional accuracy of selected GCP has mean error of -0.77m and 2.4m on x and y direction respectively. Therefore due to discrepancy of coordinate obtained from E.G.I.A and processed coordinate planimetric accuracy of orthophoto was assessed twice for selected 20 points with reference to RTK survey coordinates computed from E.G.I.A GCP and computed coordinate from IGS station. The planimetric accuracy of orthophoto relative to GCP established by E.G.I.A has good accuracy than coordinate computed from current derived coordinate from IGS station. Based on this relative to E.G.I.A GCP the planimetric accuracy orthophoto for the selected 20 points has RMSE of 0.138m and 0.15m on X and Y direction respectively and with respect to computed coordinate the planimetric accuracy of orthophoto has RMSE of 0.67m and 2.498 on X and Y direction respectively. Thus to increase the significance and applicability of this study finding the remaining line and polygon feature of orthophoto and its line map and satellite image derived coordinate compared with RTK survey coordinate correction computed from reference E.G.I.A second order GCP.

Therefore the planimetric accuracy of orthophoto for the selected parcels, line and points are computed separately relative to RTK survey results thus the RMSE of these feature lie between 0.138m-0.22m and 0.12m – 0.24m on x and y direction respectively and 95% confidence level lie between 0.37cm and 0.55 cm and the planimetric accuracy of digital line map (parcel) RMSE are 0.173m and 0.196m on x and y direction respectively and 0.45m with 95% confidence level. The digital line map (road center line) also assessed its planimetric accuracy relative to coordinates obtained from RTK GPS survey coordinates and has RMSE of 0.148m and 0.191m on x and y direction respectively and 0.41m at 95% confidence level. Similarly the planimetric accuracy of worldview-1 satellite image assessed on similar sample parcel and line (flood protection fence) feature with that of orthophoto. Thus planimetric coordinates extracted from selected sample feature from satellite image are compared with Coordinates obtained from RTK GPS survey on similar feature. Based on this parcel feature has an RMSE of 1.73m and 2.06m on x and y respectively and 4.67m at 95% confidence level. The planimetric accuracy of line feature (flood protection fence) has RMSE of 1.89m and 2.25m on x and y direction respectively and 5.09m at 95% confidence level.

The planimetric accuracy assessment result obtained from orthophoto and its digital line map based national accuracy standard for legal cadastre 03/2015 and ASPRS international digital spatial data set accuracy standard are applicable for large scale urban cadastral map and . However the planimetric accuracy of worldview-1 satellite image is not applicable for large scale cadastral map production.

Keywords: Orthophoto, Digital line map, satellite image, planimetric accuracy, RMSE.

CHAPTER ONE

1. Introduction

1.1. Background Of The Study

Spatial data abounds in the modern world of today, obtainable in several kinds of categories and used both at a professional level and by the general public. It stretches far beyond the traditional paper-based maps onto information in digital form. The term includes all sort of thinkable map contents, aerial photographs and even satellite images, acquired by techniques by for example geodetic surveying, photogrammetry and remote sensing (Hunter, 1999). Alongside with the revolutionizing concept of the geographical information system (GIS), spatial data has nowadays extended use in spatial planning, cadastral management, agriculture, archaeology, geology, and the list can be continued (Kresse and Danko, 2012). Additionally, spatial data set the base in various forms of location-based services (LBSs), combining the capabilities of for example mobile smart phones and the global positioning system (GPS), utilized for navigation and way-finding (Jiang and Yao, 2006).

It is without doubt that land is a precious resource. A country's economy relies either directly or indirectly on land information, and with sufficient and accurate land information we can better monitor and manage our land resources (Tyner, 2010). Mapping is just one essential tool that is needed to accomplish this very significant task.

Technological development in the field of photogrametry and remote sensing simplify the process of making different maps by providing wide coverage spatial data with short period of time. Development in these field has great significant for cartographers in providing data used for mapping. Currently satellite image and aerial photo are an alternative method to ground based surveying for acquisition of spatial data. Spatial information extracted from satellite image and aerial photo are major source of data for mapping a given area (Vieira et al, 2002).

With the aid of spatial data currently different kinds of maps are prepared from satellite image and aerial photo among these planimetric maps are the major ones. Planimetric maps are maps showing only the horizontal position of features on the Earths' surface which reveal geographic objects, natural and cultural physical features and entities (Tyner, 2010). Cadastral maps, urban planning maps and boundary maps are examples of planimetric maps.

In order for decisions and interpretations to be correctly made, data users greatly depend on that the data used meets a sufficient level of quality in terms of for example positional accuracy. However, as Goodchild (1995) remarks, spatial data is subject to a wide range of potential errors and uncertainties throughout the practice of data acquisition and processing. Part of the problem lies in the nature of the geographical space, i.e. the surface of the earth, as it is a complex and dynamic time dependent system compiled of both natural and human-made phenomenon. Such complexity challenges the quality of a data product. Nevertheless, data of uncertain nature, whether used as a tool in decision-making or in navigational purposes, may lead to poor decisions and misinterpretations causing resource loss or even accidents (Devillers et al., 2010). As a consequence, concerns about data quality has attracted immense research and driven data producers towards a standardizing of spatial data contents (Hunter et al., 2009). Additionally, rigorous quality assurance procedures (Sulaiman and Gudmundsdottir, 2013) and quality assessment techniques (Hunter, 1999) have been developed in order to comprehend measure and in turn limit the set of imaginable uncertainties inherent by spatial data.

Quality of spatial data is commonly dismantled into a number of components including accuracy, precision, consistency and completeness; each one representing a specific characteristic of the quality of a data set (Veregin, 1999). In turn, accuracy is usually determined for both horizontal and vertical coordinates. Horizontal/planimetric/ positional accuracy is an estimate of accuracy of the horizontal positions of the spatial objects that can be measured in terms of latitude and longitude or local easting and northing coordinates (Veregin, 1999). Whereas, the vertical positional accuracy refers to the uncertainty with which the vertical coordinates (ellipsoidal height/geocentric radius) of spatial objects can be measured.

Planimetric/horizontal/ accuracy, is a common way of expressing the quality of a spatial data set, is of concern in this study. It describes the accuracy of positions of spatial features as depicted within a data set by coordinates in plane (x, y). Again, giving the complexity of the geographical space, positions of features depicted within spatial data is always afflicted by uncertainties. Yet, it is a quality component of great importance giving that today commonly applied applications involving spatial data, such as in LBSs, relies on the accuracy of positions.

As previously noted, concerns about data quality in the form of for example positional uncertainties, have led to a standardization of spatial data production. Standardization organizations such as the Federal Geographic Data Committee (FGDC) in the United States, the

European Committee for Standardization (CEN), and the International Organization for Standardization (ISO), have clearly led the way in addressing the topic of spatial data quality (Delavar and Devillers, 2010). Standards on data quality express suggestions to be considered and requirements to be fulfilled so as to assure a sufficient level of quality.

Moreover, quality has been addressed by the development of techniques measuring uncertainties so that to understand potential integral problems of data products. In particular, assessment of planimetric (horizontal) accuracy has been a popular topic assessing a data set (X) in comparison to a reference data set (Q) of higher accuracy. Suggested method to assess planimetric /horizontal/ accuracy include point measures by well-defined points (FGDC, 1998).A popular statistical metric of planimetric/horizontal/ accuracy is the root-mean-square error (RMSE) (American Society for Photogrammetry and Remote Sensing, ASPRS Specifications and Standards Committee, 1990).

Although there is an ongoing shift towards the data user so as to evaluate the quality of a particular data product by its fitness-for-use (Devillers et al., 2010), data producers still have a responsibility towards users to ensure a sufficient level of quality of their products. Widely known, in terms of spatial data producers, are the national mapping agencies like the Ordnance Survey (OS) of Great Britain, the United States Geological Survey (USGS), the Survey of India, and the list can be continued. The mapping agencies use trained staff, engineers and expert on the fields regarding data acquisition, maintenance, application possibilities and so forth. For such agencies, assuring the quality of a data product is of fundamental concern.

In Ethiopia, Ethiopian Mapping Agency (E.M.A) and Information Network Security Agency (INSA) was responsible for providing spatial data as a service for the end-users of the data ranging from individuals, companies to other governmental agencies and administrations of Ethiopia such as the county councils and the municipalities. However currently the mandate of providing spatial data has been fully given to E.M.A and its name changed to Ethiopian Geospatial Information Agency (E.G.I.A).

In this study among the digital geospatial data orthophoto and its digital line map (parcel and road center line) produced by Information Network Security Agency (INSA) planimetric accuracy was assessed by comparing coordinates of some selected points and linear features from orthophoto and digital line map against an independent data more obtained from RTK GPS measurement. The photogrammetric surveying was conducted in 2011/2012 at scale 1:2000 and has 15cm ground sample distance (GSD). The main applications of this orthophoto are to develop urban cadastral map and to facilitate urban land registry system of Dire Dawa City.

The other spatial data which its planimetric accuracy assessed under this study was World view 1 digital panchromatic orthorectified satellite image of Dire Dawa city taken on the year 2010/2011. This satellite image was purchased from Digital Globe Company by Ethiopian Geospatial Agency (E.G.A) and has 50cm ground sample distance. The application of this satellite image are to identify building which was built on the year 2010/2011 and to legalize those plot of land which there buildings are seen on the image furthermore to extract buildings and to include on cadastral map.

Significant application areas of spatial data require high quality in terms of planimetric/horizontal/accuracy. Thus, this study attempts to address the planimetric/horizontal/ accuracy digital spatial data (orthophoto ,line map and satellite image in order to put forward quality restrictions and potentialities of the data set.

1.2. Statement of the problem

Performing spatial data analysis operations on data of unknown accuracy will result in a product with low reliability and restricted use in the decision-making process, while errors deriving from one source can propagate through the database via derived products (Sulaiman and Gudmundsdottir, 2013). The quality of data is a function both of the inherent properties of those data and the use to which they are to be put. Hence, knowledge of error levels is necessary if data quality is to be estimated.

Among the digital spatial data satellite image, aerial photograph and its line map are currently in Dire Dawa used for different mapping application. Especially large scale of planimetric maps that require high accuracy like cadastral map and urban planning maps are produced from aerial photo and satellite image.

However accuracy of these digital spatial data sets is not yet assessed thus, decisions based on map information are to have expected results and the accuracy of the maps must be known. Otherwise, implementing such decisions will result error, and these error may be unacceptable. To effectively extract features from spatially referenced digital image, it is essential to first understand image accuracy and quality. Then, the question is: to what extent can the image contribute to metrically accurate geospatial information collection? Without understanding the image accuracy and quality and the capabilities and limitations of image, users wishing to adopt this technology risk forfeiting the full benefits of the image (Willneff, 2005).

1.3. Objective of the research

1.3.1. General objective

The general objective of this study is to assess the planimetric accuracy of digital spatial data for large scale planimetric mapping in Dire Dawa City.

1.3.2. Specific objectives

- Asses the planimetric accuracy of digital orthophoto
- Asses the planimetric accuracy of digital satellite image
- Asses the planimetric accuracy of digital line map (parcel and road centerline)

1.4. Significance of the study

This study provide relevant information about the planimetric accuracy of digital spatial data sources used for production of planimetric maps in Dire Dawa City these sources include digital orthophoto, digital line map and digital satellite image thus, the result enable the user mainly the municipality and land administration office help in deciding for what type of application they use these digital spatial data set.

1.5. Research questions

Does the planimetric coordinates derived from digital spatial data (orthophoto, digital line map, Worldview-1 satellite image) meet the national urban cadastral accuracy standard ?

1.6. Limitation of the study

Due to unavailability up to date digital spatial data mainly orthophoto, line map and satellite image the study limited to study long lasted digital data set which lasted five up to six year.

1.7. Structure of the thesis

This thesis has 5 Chapters. The first part includes detailed discussion of the background and the general over view digital spatial data. In addition some important parts are included in this chapter such as statement of problem, objectives of the research; relevance of the research; some questions answered by the study and limitation of the research are put with in this subdivision. To this end, Chapter 2 has incorporated the conceptual frame work on GPS surveying, general perspective of spatial data, spatial data quality and accuracy standards with assessment methods are reviewed furthermore source of digital spatial data are discussed. This chapter land administration system and cadastral system that discusses the dynamic nature

Chapter 3 deals with the general description of the study area, data; software's, materials and method used for accuracy assessment in the study are described in detail. Chapter 4 discusses with accuracy assessment results obtained from the digital spatial data used in this study and results are discussed in detail. The final Chapter 5 includes conclusion based on result obtained from the assessment mainly related to the applicability of digital spatial data source included in the study and major recommendations.

CHAPTER TWO

2. Review of Literature

2.1. Overview on Spatial Data

The practice of making use of geographical information, i.e. maps and other information referenced to the surface of the earth, is as old as the earliest human civilizations, dating from about 4000-3000 BCE, in the areas of Mesopotamia and Egypt (Koeman, 1993). As human civilizations have evolved, so have also the techniques of making maps and other geographically based information. As time has passed, map-making has reached more sophisticated levels contributed by professions of cartography, defined as the science, technique and art of map-making (Koeman, 1993), and geodetic surveying techniques for acquisition of geographical information (Kavanagh, 2003). Nevertheless, at the 20th century the introduction of the computer based environment opened up for new paradigms of geographical information, challenging the monopoly of the conventional paper-based maps through digital mapping techniques. A great milestone is thought to be in the late 1960s when Tomlinson (1967) introduced the notion and the concepts of the GIS. At the 1980s, the GIS had turned into a well-established computer-based system utilized for storing, managing, modeling, analyzing and visualizing geographical information in digital form information commonly known as spatial data (Coppock and Rhind, 1991).

As a consequence of the vast development undertaken with GISs, eventually a complete science of research dedicated to GISs and related subjects was taken form, coined by Goodchild (1992) as the geographical information science (GIS science). It involves the more traditional fields of studies such as geography and cartography.

GIS science can be seen as the main contributor to the recent decades of progresses made with spatial data used today. Nonetheless, alongside with GISs and the GIS science research field, other geospatial technologies and fields of studies of for example geodesy, geodetic surveying, photogrammetry and remote sensing, formed into an interdisciplinary field commonly known as geoinformatics, or geomatics (Konecny, 2003; Kavanagh, 2003), has over time inevitably extended the amount, level of richness and thus usefulness of spatial data collected and utilized today.

In the literature, the term spatial is often used synonymous with the term geographical or even geospatial (Shi, Fisher and Goodchild, 2002); here on the term spatial, as in spatial data, is emphasized.

Spatial data itself is explained as a simplified depiction, or model, containing information about locations, shapes and relationships of geographical phenomenon, both naturally occurring and human-made, as associated with the surface or near-surface of the earth (Prescott, 1996). Data of spatial character constitutes of three fundamental components, or dimensions, distinguished by Longley et al. (2005) as ‘place’, ‘attributes’ and ‘time’. Place, also called space (Chrisman, 1991), indicates the linkage of the data to a location on the geographical space, preferably in a systematic way defined by a geodetic reference system. In fact, without a location connected to a spatial data set, the data would be named ‘non spatial’ or ‘a spatial’ attributes, or theme (Sinton, 1977), is a property of a feature, entity or phenomenon found within the geographical space that links to a spatial data set commonly in tabular form. Finally, spatial data is in essence fixed to a particular moment in time, thereby the temporal component.

Categories of spatial data, commonly utilized today, are represented by either the raster or vector GIS data storage types (Decker, 2001). The raster format is grid based, i.e. it consists of individually divided cells or pixels arranged in a matrix of columns and rows, where each cell contains a unique value. For instance, on a raster DEM each cell contains a unique elevation value corresponding to a specific location on the geographical space. Spatial data stored in raster format includes for instance DEMs, digitally scanned paper maps (digital raster graphics) as well as raster imagery like aerial photographs (photography-based imagery and orthophotographs) and satellite imagery. On the contrary, the vector data format stores geographical features in the form of points, lines and polygons (areas). Geographical information stored in vector format includes everything from land use and land cover classes, to elevation models (by for example a triangulated irregular network, TIN). orthophoto, satellite image and Google earth image as investigated within the scope of this study, is an example of a raster data and digital line map are example of vector data which categorized under spatial data. Collection of spatial data is accomplished through for example, photogrammetry or remote sensing technique which are the main concern of this study.

2.2. Spatial Data collection

Development of technology in the field of remote sensing and photogrammetry collection digital spatial data become an alternative method to ground based surveying for acquisition of spatial data and has great significant for cartographers in providing data used for mapping. Currently spatial data extracted from satellite image and aerial photo are major source of data for mapping a given area (Vieira et al, 2002).

2.2.1. Digital Satellite image

Remote sensing is defined, as the measurement of object properties on the earth's surface using data acquired from aircraft and satellites. It is therefore an attempt to measure something at a distance, rather than in situ. Since we are not in direct contact with the object of interest, we must rely on propagated signals of some sort, for example optical, acoustical, or microwave(Jay Gao, 2009).. Remote-sensing systems, particularly those deployed on satellites, provide a repetitive and consistent view of the earth that is invaluable to monitoring short-term and long-term changes and the impact of human activities.

Remote sensing provides data sources from which we can update geographical features, such as changes in coast lines or expansion of urban areas. In addition, these data also offer very rich descriptions of geographical features due to the high sensitivity of optical and non optical sensors in capturing the electromagnetic and other characteristics of the features. Recent trends in remote sensing technology have expanded our ability in several dimensions: increasing spatial resolution (submeter level images); increasing spectral resolution (hyperspectral imaging); augmenting sensor capabilities to observe all aspects of the Earth systems (atmosphere, hydrosphere, lithosphere, and biosphere/astrosphere); and increasing coverage frequency for monitoring. Together with other spatial data collecting efforts, such as data gathered from airborne platforms, spatial data are collected at exploding rate. Tremendous progress has been made in remote sensing data acquisition, with tens of satellites launched for different application. Consequently, a wide range of satellite data has become available at a drastically reduced price. Over the years the spatial and spectral resolutions of these data have been improved. Satellite data of a finer spatial resolution have opened up new fields of applications that were not possible with data of a poor spatial or spectral resolution before. In addition to multispectral data, it is possible to obtain satellite data in hundreds of spectral bands. These remotely sensed data with improved viewing capabilities and improved resolution have not only opened up new areas of successful applications, but also created specific fields in digital image analysis (Chaowei et al, 2011).

About a decade ago space borne remote sensing experienced another trend, namely, the advent of very high spatial resolution satellite imagery. Their spatial resolution is so fine that it is comparable to that of airborne photographs. A few successful satellite programs have recorded images with a spatial resolution on the order of meters and submeters. So far more than twelve of them have become available for digital analysis. The majority of these sensors record only a panchromatic band that is intended mostly for cartographic mapping, even though environmental monitoring is possible with the data. All systems record optical data near the visible light and NIR portion of the spectrum (Jay Gao, 2009). Among this World view-1 is the one which its planimetric accuracy are investigated in this study.

Satellite images constitute one of the vital elements in providing many of the much-needed spatial inputs to digital cadastral maps. The fact that Remote Sensing (RS) imagery is in digital form so that it could be zoomed at any required scale making it is fundamental tool, quicker, and cheaper as compared to aerial photographs (Ondulo and Kalande, 2006). RS images on the wide area can be achieved more repeatedly and economically compared to aerial photos (Jeong et al., 2003). The use of RS images also plays an important role for extracting and updating land related information. One advantage of using RS images is that they provide a historical record of the areas that can be revisited in the future to see what changes have taken place. In this way old images can provide valuable evidence where conflicts occur in parcel boundaries (Ali ,2012). In this way, RS imagery can be used as an alternative to traditional land surveying approach for spatial data acquisition where most measurements can be done in the office (Tuladhar, 2005). The locational accuracy of maps is utmost important for certain applications like cadastral survey, infrastructure/ utility maps, urban land use, land planning, and land consolidation works. Cay et al. (2004) showed that using 1 m resolution imagery and GPS controls, it is possible to achieve an accuracy of ±2 m. In this way, the recent advances in space-based data capturing techniques (imaging) have revolutionized the field of cadastral surveying and mapping. All these improvements in satellite imaging have led to availability of better quality data/pictures for mapping applications (Ajai, 2002). Mamoru et al. (2002) considered the possibility of IKONOS imagery for making topo-cadastral maps and their results suggested that IKONOS imagery has advantageous characteristics of interpretation for making and updating middle-scale (1:25,000) topographical maps compared with analogue aerial photo. They showed that horizontal accuracy of IKONOS ortho imagery varies between 1.0 and 1.2 m in flat areas. Corlazzoli and Fernandez (2004) investigated the potential use of SPOT-5 ortho image for cadastral surveying. In not so mountainous terrain and in planned build up areas it is quite easier to generate topographic maps and QuickBird images can be used without problems up to the map scale of 1:4000 (Jacobsen et al., 2008). The selection and use of different types of satellite images mainly depend upon the requisite level of details, the quality of data required as well as the category of terrain to be surveyed for cadastral purposes. Cay et al. (2004) concluded that the use of satellite image is more economical in terms of cost and time rather than the use of classical process.

In this study worldview-1 ortho rectified Satellite image were used. This satellite was launched into a sun-synchronous orbit 496 km in altitude on September 18, 2007. It has a period of 94.6 minutes with a 10:30 a.m. descending node. The payload of this satellite is a panchromatic camera only. It captures data of a 0.50-m nadir spatial resolution at 11 bits of quantization, covering a swath width of 16 km. This resolution degrades to 0.59 m at the viewing angle of 25°. In total, 500,000 km^{2}of ground areas can be sensed by the satellite in a single day. Similar to Cartosat-2, WorldView-1 does not record multispectral data. What distinguishes WorldView-1 from other satellites is its agility in tilting the scanning mirror. It can be tilted over a wide range of angles rapidly to retarget the ground in order to image it stereoscopically. These features of WorldView-1 imagery make it suitable for cartographic applications, defense, and national security, instead of general land use mapping, and environmental monitoring (Jay, 2009).

2.2.2. Photogrammetry

The two fundamental elements (measurements) used to derive spatial positions are: direction and distance. These elements can be obtained either by direct observation, or indirectly, by measuring a quantity which is a function of these elements. Measurements made with a theodolite, a level or tapes are direct observations of the fundamental elements. The measurement of distances with an electronic distance measuring (EDM) device is indirect observation, since the distances are derived by recording the time of propagation of the electromagnetic wave between two points. Positioning by the global positioning system (GPS) is done by means of distances to satellites which are based on accurate observations of the time of travel of the electromagnetic signal. Images can also be used for spatial positioning, and measurements made in images are also considered indirect observations with respect to the two fundamental elements.

Images are utilized in two distinct manners: by performing either metric or interpretative analysis. In the metric analysis, quantitative measurements are made in the image and then geometric information, such as spatial position, distance, area, shape, size, volume, distribution of objects are derived. This operation is called photogrammetry. The definition of photogrammetry is therefore: the science of obtaining reliable measurements by means of images for the determination of the geometric properties of objects.

Photogrammetry has become an exceptionally valuable tool in land surveying. To mention just a few uses in the field, aerial photos can be used as rough base maps for relocating existing property boundaries. If the point of beginning or any corners can be located with respect to ground features that can be identified on the photo, the entire parcel can be plotted on the photo from the property description. All corners can then be located on the photo in relation to identifiable ground features which, when located in the field, greatly assist in finding the actual property corners. Aerial photos can also be used in planning ground surveys.

Following the development of technology, digital photogrammetry started to be used widely for mapping application. Especially digital orthophoto is a very popular product due to its diversity of use, particularly in its use as base information for Geographic Information Systems. Further, recent developments in the very important area of intelligent image analysis techniques for the automation of feature extraction, object recognition and object classification make use of digital orthophotos (pierre,1990). In connection to this Zinabu, Tulu, Berhan, 2017 as stated in (Sirba, 2009) work extraction of parcel feature using photogrammetric surveying become an alternative technique to ground based surveying and this technique become popular and used by different countries for modernizing land management system.

Ethiopia also developed high resolution orthophoto for modernizing land management system especially, for urban area where land is scarce. Thus for 23 town aerial photo capturing and digital line map preparation were conducted among these to Dire Dawa is the one.

2.3. Spatial Data Accuracy

Quality of spatial data is the fundamental concept of this study. Therefore it must be manifested some principles of spatial data quality, what issues is involved with quality of spatial data, and some facts about how quality of spatial data is handled.

However, to begin with, what is quality? The ISO 9000 standard (ISO, 2005) defines quality as the "degree to which a set of inherent characteristics fulfils requirements". In terms of spatial data quality, Prescott (1996) comprehensively outlines quality as "an essential or distinguishing characteristic necessary for the spatial or cartographic data to be fit-for-use; fitness for use; meeting an expectation; degree of excellence; conformance to a standard; completeness; logical consistency; accuracies of position and attributes; lineage" . Correspondingly, quality is about meeting satisfaction with a data product. A satisfactory level is commonly met by 'conformance to a standard' (Prescott, 1996) or a specification, i.e. by a specified set of regulations for a data producer to follow in order to meet an agreeable quality level.

Nevertheless, the notion 'fitness-for-use' is in the literature often applied for defining the quality of spatial data (Chrisman, 1984; Chapman, 2005; Devillers et al., 2010). The concept of fitness-for-use defines the quality of a data set based on how it fits, or suits a specific task or application. Concerns about fitness-for-use has been realized through implementing metadata, i.e. data about data, which is to communicate data quality information to a potential consumer in order for the consumer to assess on the potential application areas of a data set.

Following the above discussion, Devillers et al. (2002), distinguishes between two main definitions of spatial data quality. On the one hand, a data producer defines quality primary based on a set of regulations directed by a standard or a specification. Thus, quality is assessed and defined commonly by numerical values. On the other hand, from a data user perspective, quality is defined based on the usability of a data set in the context of a specific task or application, i.e. through the concept of fitness for-use; realized mainly by metadata quality information. Either way, in this study the focus is put onto the issue of spatial data quality defined from the perspective of a Data producer.

2.3.1. Spatial data accuracy Issues

Imperfect quality of spatial data has been an ongoing issue since the early days of digital mapping and the use of GIS, in many aspects divergent from conventional paper-based maps. Thus GIS science researchers have been enlightened to factors influencing the spatial data quality in terms of inaccuracies, i.e. by the data inherent errors and uncertainties (Hunter et al., 2009). Error is the opposite of accuracy (Veregin, 1999); thus, as Gahegan and Ehlers (2000) suggest, when an inaccuracy within a data set is known, it is best explained as an error. On the contrary, when an inaccuracy is not known, it is best described by the term uncertainty. Moreover, the term accuracy is explained as the closeness to which an observed or measured value is conforming to a true value (Chrisman, 1991). In relation to quality issues, the term precision, or sometimes called resolution, is also important. It describes the quantity of details that can be distinguished in a data (Chapman, 2005).

Problems of uncertainties arise furthermost due to the complexity of the geographical space, as it is a three-dimensional (3D) space with features of natural and humanmade phenomena changing over time (Goodchild, 1995). Hence, as noted by Chrisman (1991), there is no perfect method for geographical representation which would enable for an ideal copy of the surface of the earth, either as a paper map or within a computerized environment of a GIS. As a result, the complexity of geographical phenomena restricts representations of spatial features to traditional cartographic measures of generalisation (such as by simplification and aggregation) (Goodchild, 1995), and thereby limits the spatial precision of spatial features depicted within a GIS (Veregin, 1999). In addition, since the earth and its phenomenon are affected by time, the surface of the earth depicted by spatial data may over time become irrelevant (Fisher, 1999).

Robinson and Frank (1985) note the uncertainties of data due to measurement techniques. Collection of spatial data is accomplished through for example geodetic surveying techniques, photogrammetry or remote sensing. For example, in the case of photogrammetric surveying rectification process is affected by the accuracy and spatial distribution of the ground control points, the aerial triangulation process, and digital elevation, and the method/software used for rectification. These errors reduce the spatial accuracy of photogrammetric data and cause geometric distortion and misorientation of linear features. As zinabu state in Lawali and Waziri (2014) showed that orthorectification process reduces geometric errors inherent within photography and imagery. The variables contributing to geometric errors include camera and sensor orientation, systematic error associated with camera and topographic relief displacement, and earth curvature. As zinabu state in Greenfeld (2001) also explained that orthophotos generally offer significant benefits, but all orthophotos are not generated with equal accuracy. In general, the accuracy and quality of orthophoto varies based on the accuracy of the source data. Other contributing error factors include the characteristics and calibration of equipment used for image capture such as the camera and/or scanner.

Moreover, Robinson and Frank (1985) points out the problem with the human subjective interpretation of spatial features. Distinguishing of spatial features is concerned with a wide range of uncertainties. Although the complexity of most geographical features, Fisher (1999) differentiate between well-defined features and poorly-defined. Well-defined includes furthermost human-made features, which can be measured with high accuracy and precision. On the other hand, poorly-defined features involve almost any naturally occurring object found within the geographical space. For example, Goodchild (1995) clarifies the problem with an example of soil classification made by two independent soil scientists. Due to individual subjectivity, the resulted map products would most likely be dissimilar in terms classification of features and spatial positions. Thus, uncertainties associated with spatial data are known to be present in all stages of data production, from data collection, processing and representation. Therefore, spatial data can only function as a simplified model of the real world. The aforementioned quality issues impose great research challenges for the decade to follow (Goodchild, 2010).

2.3.2. Spatial data planimetric Accuracy

In geographic or spatial data accuracy can be divided in to positional and thematic accuracy of spatial data. Positional accuracy determines how closely the position of discrete objects shown on a rectified image (map) or in a spatial database agree with the true position on the ground, while thematic accuracy refers to the non positional characteristic of a spatial data entity, the so-called attributes (which are derived from radiometric information) (Jassen et al, 1994).

Positional accuracy also divided in to two these are horizontal (planimetric) and vertical accuracy. Horizontal accuracy is the horizontal (radial) component of the positional accuracy of a data set with respect to a horizontal datum, at a specified confidence level (ASPRS, 2013).

All locations on maps and georeferenced images are expressed by a set of values: x-and y-coordinates for horizontal location. Many data sets also include elevations, which are represented by the letter z. however this study only carried out on planimetric accuracy assessment

Decisions about resources require maps, and effective decisions require accurate maps or at least maps of known accuracy. For centuries, maps have provided important information concerning the distribution of resources across the earth. Maps help us to measure the extent and distribution of resources, analyze resource interactions, identify suitable locations for specific actions (e.g., development or preservation), and plan future events.

Following the advancement in technology different kinds of map can be prepared from different source for instance it can be prepared from ground survey, aerial photo, and satellite image (Tyner, 2010). Thus the accuracy of the final map prepared depends on the accuracy of the specific data source used to produce that map.

If our decisions based on map information are to have expected results, then the accuracy of the maps must be known. Otherwise, implementing such decisions will result in surprises, and these surprises may be unacceptable.

Thus, Establishment of the standards is critical in implementing consistency in spatial data accuracy. Therefore in United states of America the two well known that is American Society for Photogrammetry and Remote Sensing's (ASPRS) and Federal Geographic Data Committee (FGDC) set standards and implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy.

Widely known, in terms of the assessment of positional accuracy, is the concept of 'well-defined points'. In the United States, the approach is commonly suggested by standards, such as by the NMAS (United States Bureau of the Budget, 1947), the ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) and more recently, by the FGDC published NSSDA on positional accuracy (FGDC, 1998). Corresponding well-defined points are identified both on X and on Q. The independent reference source (Q) is acquired using for example a geodetic surveying technique such as by a total station or by a GNSS technique like the GPS, or by a photogrammetric method towards for example high resolution imagery (FGDC, 1998; Wasström et al., 2008). In term of linear features, the identification of well-defined points includes furthermost right-angled intersections of especially man-made objects such as roads, canals, house corners etcetera.

The accuracy standards, such as the ones above mentioned, recommend either the calculation of the Euclidean distance, i.e. the minimum distance between two spatial features (Peuquet, 1992), or the differences in x and y of corresponding pair of points. Determined differences enable for knowledge about the positional deviations between selected points on X in relation to corresponding points on Q . Producing an overall quality assessment of the positional accuracy requires the selection of multiply test points, i.e. by well-defined points, commonly by a sample, randomly or manually specified. FGDC (1998) recommend a minimum requirement of 20 test points. The sample will represent the positional accuracy as a magnitude of the whole. Deviations derived by the accuracy assessment should preferably be statistically handled so that to obtain an overall report of the positional accuracy of X relative to Q.

In order for decisions and interpretations to be correctly made, data users greatly depend on that the data used meets a sufficient level of quality in terms of for example positional accuracy. However, as Goodchild (1995) remarks, spatial data is subject to a wide range of potential errors and uncertainties throughout the practice of data acquisition and processing. Part of the problem lies in the nature of the geographical space, i.e. the surface of the earth, as it is a complex and dynamic time dependent system compiled of both natural and human-made phenomenon. Such complexity challenges the quality of a data product. Nevertheless, data of uncertain nature, whether used as a tool in decision-making or in navigational purposes, may lead to poor decisions and misinterpretations causing resource loss or even accidents (Devillers et al., 2010). As a consequence, concerns about data quality has attracted immense research and driven data producers towards a standardizing of spatial data contents (Hunter et al., 2009).

Thus different researchers assess the accuracy of digital spatial data in order to evaluate the accuracy of the data set for the demanded application. In this connection to P. Agrafiotis , A. Georgopoulos (2015) assess the comparative horizontal accuracy of orthorectified high resolution satellite imagery from Pleiades-1B satellites image(0.50m GSD), GeoEye-1 satellite image(0.50m GSD) and orthomosic aerial image that has 0.50m GSD the study use point wise accuracy assessment and the RMSExy for 26 check points were computed thus based on this computation Pleiades-1B satellites image has 0.646m, GeoEye-1 satellite image 0.86m and orthomosic aerial image has 0.649. Thus the researchers suggest that the satellite image can be used as an alternative for large scale map production.

Similarly S.Rao,etal (2014) assess the usefulness high-resolution satellite imagery for re-survey of cadastral maps in India in this study CARTOSAT-2 panchromatic satellite image that have 1m GSD and GEO-EYE-1 multispectral satellite image that have 0.5m GSD were used for assessment. The positional accuracy assessment was undertaken parcel wise 159 parcel feature were extracted from the two satellites were compared using their attributes viz area, perimeter and position. Around 80% of the parcels can be derived with precision, meeting the standards for survey/re-survey and the researchers suggest use of HRSI will result in increased throughput, area prioritization for ground survey, faster maintenance and updating of cadastral maps in more economical manner.

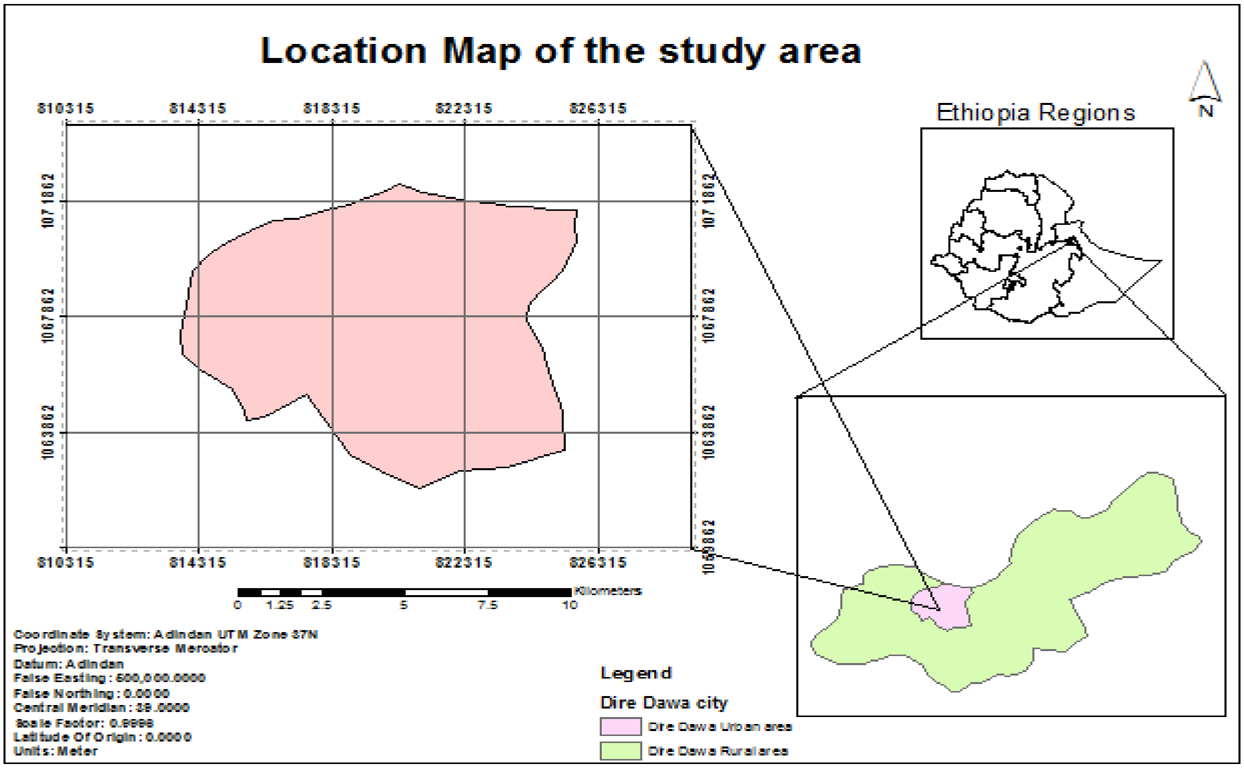
In Ethiopia, Angot Yedegera Tor (2013) was assessed the accuracy of worldview-1 satellite image for rural land registry system in this research coordinates extracted from satellite image compared with RTK GPS coordinate and its accuracy statistically compared in terms percentile. Thus based on this only 46.4% of all the coordinates have discrepancies below 1m and the remaining are above 1m discrepancy relative to RTK GPS survey coordinates and the researcher conclude that worldview-1 satellite image Angot Yedegera, do not meet the requirement of 1m accuracy for rural land management system.

CHAPTER THREE

3. Materials and method

3.1. Description of the study area

Dire Dawa city is located between $9^{0}27'$N and $9^{0}49'$N latitude and $41^{0}38'$E and $42^{0}19'$E longitude, and in the eastern marginal catchment of Awash basin. East Hararge Administrative zone of Oromiya Regional State borders it in the south and southeast and Shinele zone of Somalia Regional State in the north, east and west. Dire Dawa city is accessible by airplane, train and cars, and is about 515kms road distance to the east of Addis Ababa and 311kms to the west of Djibouti port. The total area of the region is about 128,802ha; out of this urban accounts for 2684ha (2%) and the balance 98% is for rural IDP. The total Dire Dawa area can be divided in to three major areas; the south and south-eastern part of the city is characterized by a chain of mountains and upland at the foot of the mountain chain covering 45%; and low lying flat land accounting for 40% of the land area (Ephrem G, 2006).



Source: E.G.I.A, 2007.

Figure 3.1. Location map of the study area

3.2. Data acquisition, software and materials

3.2.1. Data acquisition

For this research original digital spatial data that are digital orthophoto that have 15cm GSD, Digital line map and ortho rectified WorldView-1 satellite image that have 50cm GSD collected from Dire Dawa land management and development bureau.

3.2.2. Software and materials

In this study Arc GIS 10.4, Magnet office GPS data post processing software was used and SOKKIA GRX2 and SOKKIA Atlas/5 DGPS was used

3.3. Method

3.3.1. Sample selection

Due to dynamic nature of Urban area features are changed over time due to such factors spatial information such as orthophoto, satellite image and maps must updated. However the digital orthophoto and satellite image used in this study are long lasted. Therefore to solve feature absence problem on the ground, satellite image and orthophoto similar samples were selected carefully. The selected samples incorporate point, polygon and linear feature. Samples are selected based on FGDC, 1998, which are evenly distributed over the geographic extent of the image and well defined, easily identifiable features are selected. In fact, the guidelines of FGDC states that to evaluate the accuracy of spatial data, at least a minimum of 20 independent check points shall be tested.

Similarly, the American Society for Photogrammetry and Remote Sensing (ASPRS, 2013) recently developed new geo-location accuracy standards for digital geospatial data and recommend 20 clearly defined check points for a project area of ≤500 km$^{2.}$

Therefore to get better estimation of accuracy result 20 point features which are visible both on the ground and orthophoto which could be easily identifiable sharp edge of road junction and edge were selected.

Feature which represent polygon 28 similar parcels which found on orthophoto, digital line map (parcel) and satellite image that have sharp edge, clearly defined boundary and different geometry were selected.

For linear feature road which take number one (Millennium Park) to mesqlgna which has 1.4km length were selected from digital line map (road center line) and flood protection fences which constructed from gende gurage to shinile were selected from the orthophoto and satellite image. These fences were constructed both side of flow direction of the flood and has a length of 3.5 km and for this study left side(west direction) of the fence were selected.

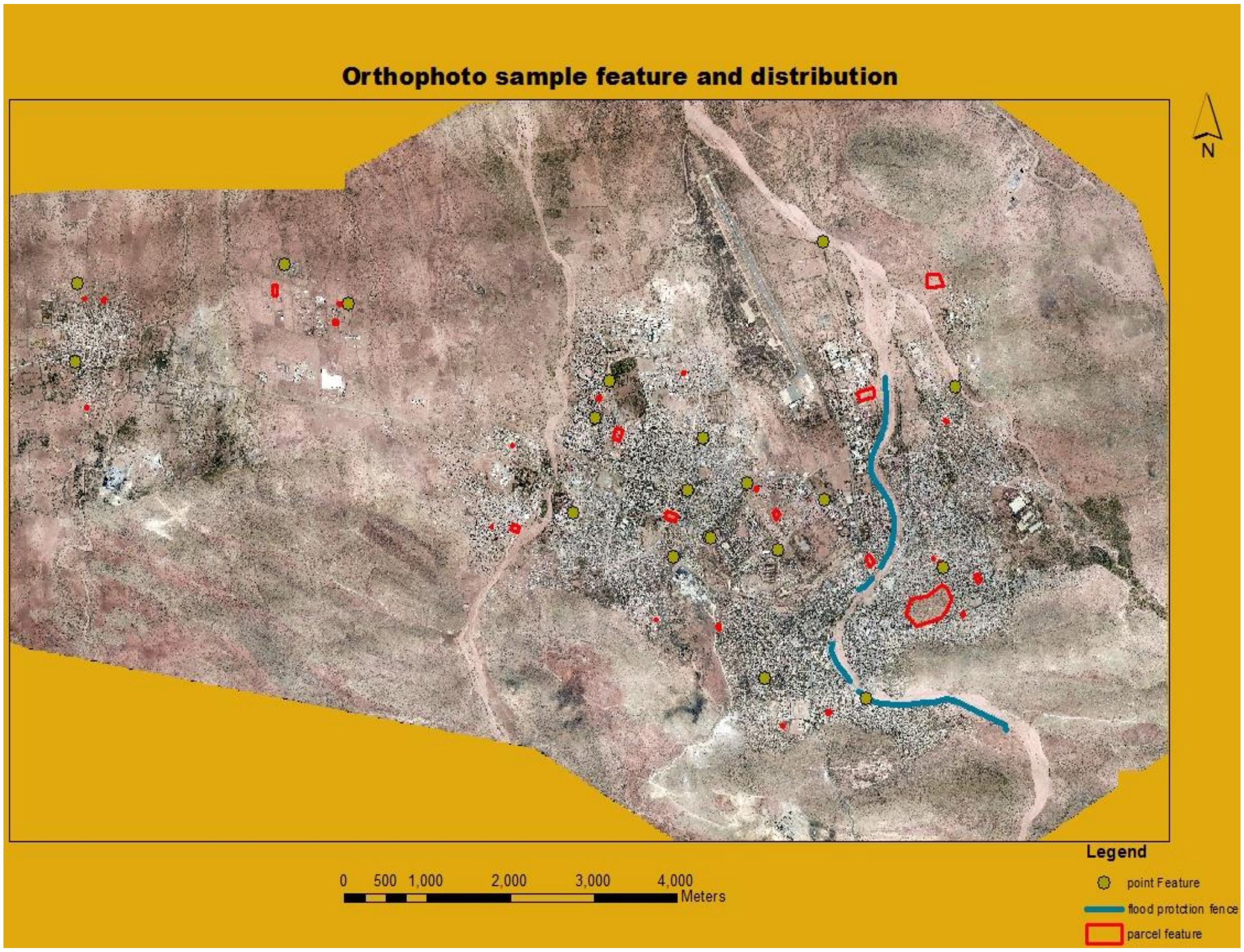


Figure 3.2. Selected sample feature distribution on the study area.

3.3.2. GPS survey

3.3.2.1. Survey instruments preparation

Before the field work could start all survey instruments were checked. This was done at the Bureau of Land development and management in Dire Dawa two days prior to the field work. 3 SOKKIA Atlas/ G5 DGPS for static GPS measurement and 2 SOKKIA GRX 2 were for RTK GPS measurement were checked all the accessories for each instrument. SOKKIA Atlas/ G5 DGPS take two batteries and each battery can be used 4 hours continuous observation furthermore one battery plug out without stopping the measurement for chagrining the battery.

I also tested that the radio signals from the base were received in the rover, and that the GPS obtained fix solution.

3.3.2.2. Static GPS Survey

The accuracy of ground based reference data or independent source used to validate the accuracy of spatial data shall be at least three times more accurate than the spatial data being assessed as Zinabu G. etal (2017) sited on works of (Congalton and Green, 2009). CORS station GPS data is preferable to process static GPS observation and for RTK GPS survey to use as a reference/base station during the establishment of independent source. Since CORS stations take measurement continuously for 24 hour throughout the year. However, in study area there is no CORS station.

Due to unavailability of CORS station nearby the study area two second order ground control points which was established by Ethiopian Geospatial information Agency in the study area and one first order GCP found in harar were selected and to assure the horizontal accuracy of these ground control point a 12 hour static measurement were carried out on these GCP at the same time using 3 SOKKIA Atlas/ G5 DGPS.

The GPS post processing technique were conducted by two way the first were observed static GPS data are processed by free online GPS data processing service provider (AUSPOS and OPUS) and the second technique using International GNSS Service (IGS) as a reference stations found in Addis Abeba. Static GPS data are processed with tie to IGS reference station found in Addis Abeba using licensed magnet office software which SOKKIA Company provides for post processing GPS data. Receiver Independent Exchange Format (RINEX) file were downloaded from those stations via

Internet (http://igs.bkg.bund.de/file/rinexsearch) and also to achieve higher accuracy precise satellite orbit data were downloaded for the processing.. This was done to check the positional accuracy of GCPs which used as a base station during RTK GPS data collection.

For accuracy comparison purpose all coordinates including online processed GPS data are transformed to local coordinate. To transform the measured WGS84 coordinate system to the local projection system a transformation parameter set given by E.G.I.A were used. The transformation parameters referenced to the WGS84 system are described in Table 3.1.

Table 3.1. Transformation parameters from WGS84 to local system, Adindan UTM.

Parameters	**Adindan UTM**
DX(m)	-162
DY(M)	-12
DZ(M)	206
R_X(s)	0
R_Y(s)	0
R_Z(s)	0

Figure 3.3. Static GPS field observation on GCP established by E.G.I.A.

3.3.2.3. RTK GPS survey

Prior to each day of surveying, a plan of which sample feature to survey was made. In the field printouts of the orthophto image overlaid with selected sample were used to make it easier to find and identify each sample feature.

During the RTK GPS measurement, the base station sends correction for GPS error sources in real-time via radio link to the rover over 1-4 km on average. According to the proximity of the selected sample feature to the base station two base stations are used for this RTK survey.

With the help of printed out location map of sample point RTK survey were conducted on each selected sample of point.

Due to coordinate discrepancy of GCP obtained from E.G.I.A and current computed coordinate from measured static GPS data on similar GCP. To compare planimetric accuracy of orthophot for the selected 20 sample points RTK GPS survey were collected twice by setting the reference base station coordinates obtained from E.G.I.A and current computed coordinate. Therefore the number of collected coordinated along the selected sample described below in detail on table 3.2.

Table 3.2. Number of collected RTK survey coordinates along the selected samples

NO	Sample type	No of collected coordinate by RTK survey
1	Flood protection fence	79
2	parcel	125
3	Road edge and	20 (two times with different horizontal coordinate reference)
4	Road center line	185

This RTK surveying data collection was carried out using 2 SOKKIA GRX 2 DGPS one GPS used as a rover and one as a base the rovers receive correction from the base station and horizontal accuracy was set to 1 cm of fixed solution during the data collection.

During field data collection each selected sample feature on the ground are measured carefully. After accomplishing the field survey measured coordinate value of each feature exported from the GPS data collector to external hard drive in MS-Excel format for statistical analysis.

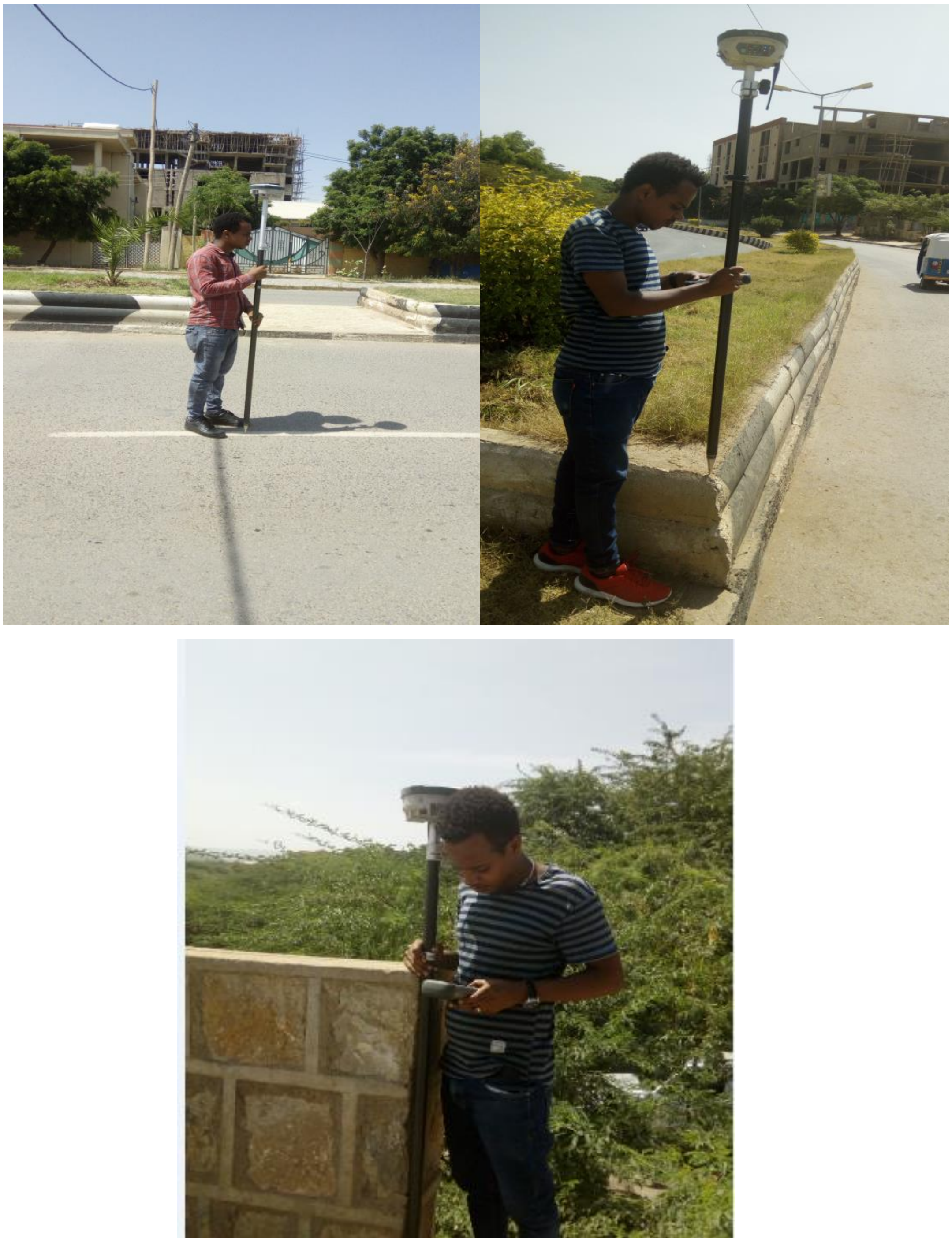


Figure 3.4. RTK GPS survey measurement on selected sample features

3.3.3. Feature and planimetric coordinate extraction

Feature extraction is a systematic collection of all details appearing on ground which are also visible on the imagery by digitization into vector form (Paul R. et al., 2014) i.e. conversion of data from raster to vector. In the science of photogrammetry there are two techniques of feature extraction (digitization) from digital image these are: - **a**, stereo digitization **b**, heads-up digitization. In stereo digitization technique features are digitized using stereo plotter instrument embedded with computer and in this technique one can see and extract 3 dimensional position of a feature while in heads-up digitization features displayed on a computer screen are digitized directly with a mouse. The human operator views the digital image simultaneously with the digitized features on the computer screen (Paul R. et al., 2014). In this study both techniques were tested only for orthophotho (parcel feature). Selected sample Parcel features were not digitized by sterio digitizing technique in photogrametry station by self rather Digital line map (parcel) were used as input to asses planimeteric accuracy of sterio digitization technique. This digital line map was prepared by INSA using sterio digitizing feature compilation technique from the orthophoto. Legal cadastre standard 03/2014 state that when using orthophoto as a data source for preparing cadastral map sterio compilation technique must be primarily used to extract parcel feature and as an option heads up feature compilation technique can be used.

Therefore coordinates of selected sample parcel corner (vertex) were extracted from digital line map (parcel) on Arc GIS 10.1 and using heads-up digitization technique planimetric coordinates of similar parcels corner are extracted from orthophoto and satellite image. This was done manually by creating a point vector layer using Arc GIS 10.1. In an effort to eliminate error, the sample point vectors were identified 5 different times independently from orthophoto and satellite image during manual digitization. The averages of the 5 coordinates for each point vector were used. The point vectors layer which are created along the parcel corners are digitized following points along the geometry of the feature.

Points (vertex) which are orthogonal to RTK survey point are extracted from digital base map (road center line). This were done by overlaying RTK survey point data over road center line on Arc GIS and planimetric coordinates are extracted by creating vertex point on points which are orthogonal to RTK survey data. Following similar techniques of heads up digitizing technique on the selected sharp edge, junction of road planimetric coordinates are extracted from orthophoto and satellite image by creating a point vector layer on Arc GIS 10.1. To clearly identify the selected sample features during the extraction of planimetric coordinate features are zoomed to at a visible extent.

Table 3.3 Number of planimetric coordinate extracted from the digital spatial data set

NO	Sample type	No of extracted planimetric coordinates
1	Flood protection fence from Orthophoto, and satellite image	90
2	Orthophoto, satellite image and digital line map (parcel)	125
3	Digital line map (parcel)	125
4	Road edge and junction(orthophoto)	20
5	Digital line map (Road center line)	28

3.3.4. Accuracy assessment

The accuracy of spatial data can be defined through measures of the difference between the location of the recorded feature and the true location (Goodchild and Hunter,1997).

In planimetric mapping process different kinds of features found on the earth according to their standard representation on a map can be extracted in terms of point, line and polygon from satellite image, orthophoto and other spatial source data (Tyner, 2010). Therefore in this study the palnimetric accuracy of orthophoto assessed on the selected points from road edge and junction, parcel (polygon feature) and flood protection fence (line feature). While for satellite image and digital line map polygon (parcel) and road center from line map and flood protection fence from satellite image was assessed.

Points are the simplest features to test. Points have only a location (coordinates), so the method would be to obtain the coordinates of the test point, then compare that to the planimetric coordinates of the same point as defined by a higher accuracy source (GPS). Thus in this study planimetric accuracy of points selected along edge of road and junction are assessed relative to coordinates obtained from RTK GPS survey.

Testing lines, for example, requires testing the accuracy of the intermediate and end points of the lines such as at road intersections, and the geometry of the line between the endpoints. The geometry is how the line behaves between the end points. This raises such questions as: Does it go in a straight line? Or, does it curve left or right? and so forth. Testing the end points of the lines is the same as testing a simple point. However, testing the accuracy of the geometry of the line requires obtaining a coordinate for some point or points along that geometry. Connection to this most researchers in this field have made a suitable but essentially arbitrary decision, for example, that the corresponding point on the true line can be found by drawing a line from the observed point that is perpendicular to the observed line as M. ANJI,2008 stated on the work of Keefer, smith, and Gregoire, 1988. Using this rule, we can measure the linear displacement error of any selected point, or compute the average displacement along the line.

Therefore in this study by overlaying road center line over collected RTK survey coordinates points that are perpendicular to RTK survey coordinates are selected similarly from the orthophoto planimetric coordinates extracted from on the bends and end points of flood protection fence are compared with similar coordinates obtained from RTK survey.

Testing the more complex geometry of a polygon requires finding discrete points on the edges of the polygon, such as vertices, which can be correlated to similar points of higher accuracy. If the polygon were a parcel boundary, for instance, one of the checks for spatial accuracy would be to test a corner of the parcel for accuracy.

An approach to assess the planimetric accuracy of orthophoto products is based on the use of geometric features (Vieira et al, 2002). Examples of geometric features are roads edges, and other boundaries. They should be easily located and represented as a set of sequential coordinates.

Errors in lines or polygon arise from the errors in the points that define those lines and polygon (REDDY, 2008). Therefore in this study the planimetric coordinates extracted from the orthophoto, satellite image and digital line map (parcel and road center line) planimetric accuracy were compared point wise independently with independent reference RTK GPS points in terms of x, y and horizontal root mean squared error (RMSEx, RMSEy and RMSEr, respectively) equations taken from FGDC (1998))

$$\mathrm{RMSE}_x = \frac{\sqrt{\sum(X_{\mathrm{datai}} - X_{\mathrm{checki}})^2}}{n}$$

$$\mathrm{RMSE}_y = \frac{\sqrt{\sum(y_{\mathrm{datai}} - y_{\mathrm{checki}})^2}}{n}$$

$$\mathrm{RMSE}_r = \sqrt{\mathrm{RMSEx}^2 + \mathrm{RMSEy}^2}$$

Where: - $X_{data,i}$, $Y_{data,i}$ are the coordinates of the ith point in the evaluated dataset,

$X_{check,i}$, $Y_{check,i}$ are the coordinates of the ith point in the independent reference dataset of higher accuracy,

n is the number of check points , and

i is an integer that ranges from 1 to n.

Computing Accuracy According to the NSSDA when $\mathrm{RMSE}_x = \mathrm{RMSE}_y$

If $\mathrm{RMSE}_x = \mathrm{RMSE}_y$

$\mathrm{RMSE}_r = \mathrm{sqrt}(2*\mathrm{RMSE}_x{}^2) = \mathrm{sqrt}(2*\mathrm{RMSE}_y{}^2)$

$= 1.4142*\mathrm{RMSE}_x = 1.4142*\mathrm{RMSE}_y$

It is assumed that systematic errors have been eliminated as best as possible. If error is normally distributed and independent in each the x- and y-component and error, the factor 2.4477 is used to compute horizontal accuracy at the 95% confidence level as FGDC 1998 stated on (Greenwalt and Schultz, 1968). When the preceding conditions apply, Accuracy, the accuracy value according to NSSDA, shall be computed by the formula:

$$\mathrm{Accuracy}_r = 2.4477 * \mathrm{RMSE}_x = 2.4477 * \mathrm{RMSE}_y$$

$$= 2.4477 * \mathrm{RMSE}_r / 1.4142$$

$$\mathrm{Accuracy} = 1.7308 * \mathrm{RMSE}_r$$

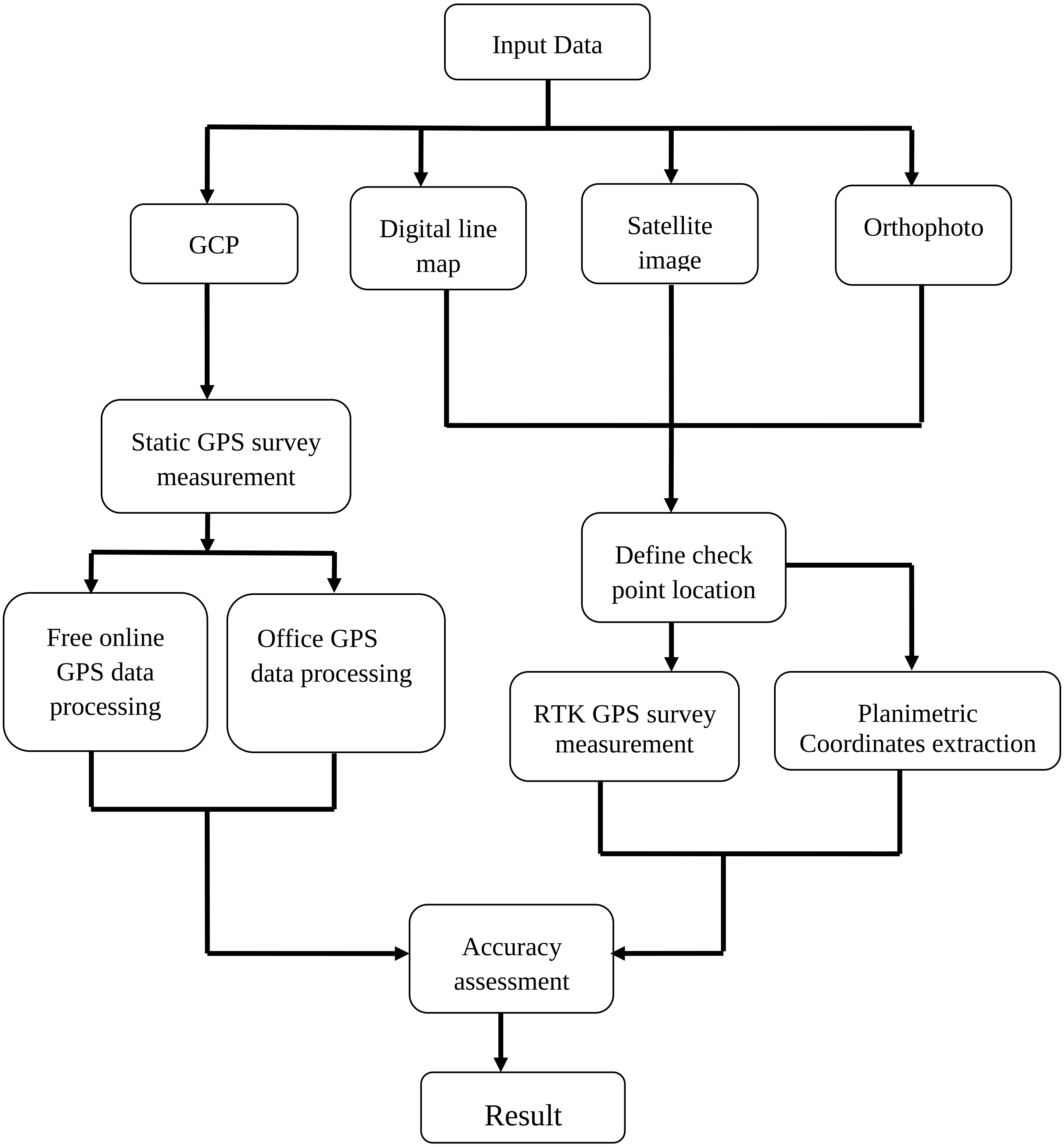


Figure 3.5. Schematic diagram of methodology

CHAPTER FOUR

4. Result and Discussion

4.1. Result

4.1.1. Static GPS survey result

To assure or check the accuracy of GCP which used as base during RTK survey a 12 hour static survey were conducted on the selected three ground control point which was established by Ethiopian Geospatial Information Agency. Observed GPS data were processed using magnet office tools and two online GPS data processing service providers, these are Australia positioning service (AUSPOS) and online positioning user service (OPUS). The processed result obtained from magnet office tools and online processed GPS data are presented below in table 4.1 projected WGS84 datum.

Table 4.1. Processed GPS observation coordinates result of GCPs on projected WGS84 datum

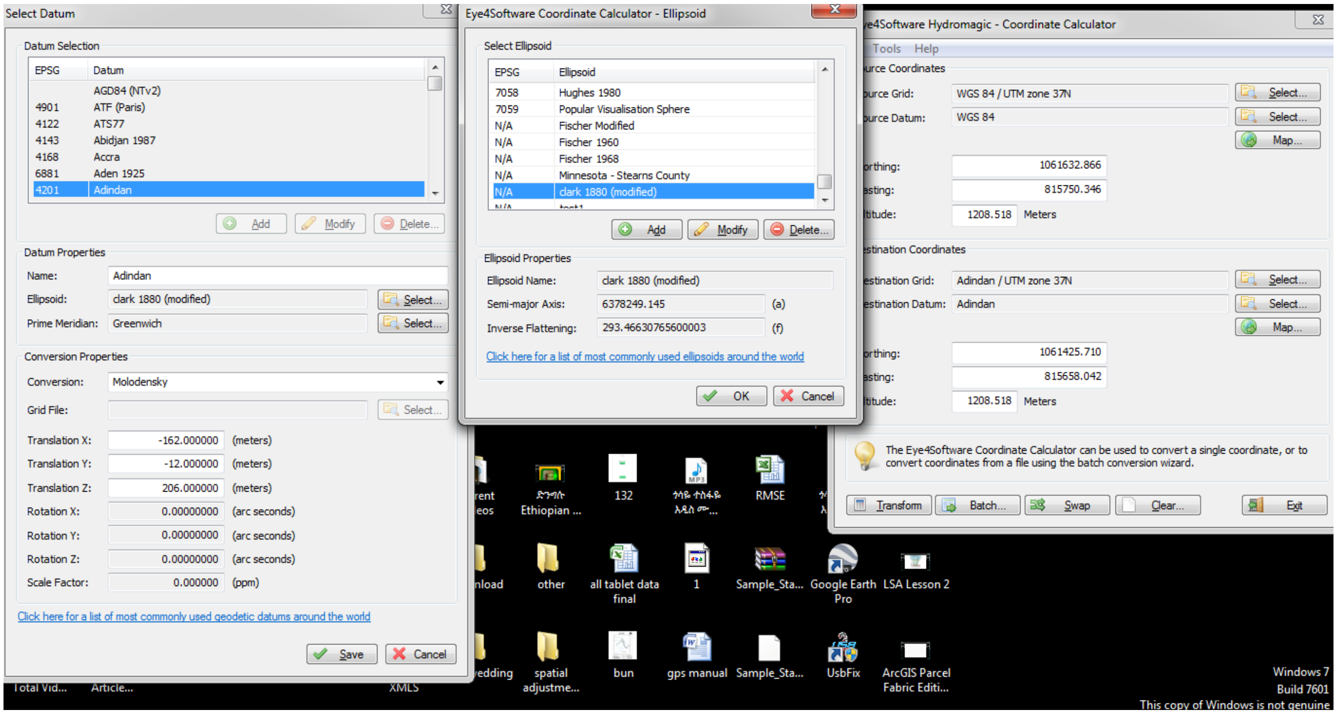
GCP Name	Magnet office tool		AUSPOS		OPUS		WGS84 UTM zone
	Easting	**Northing**	**Easting**	**Northing**	**Easting**	**Northing**	
Dire Dawa (GCP-38)	814154.658	1062671.709	814153.815	1062671.735	814153.826	1062671.742	37
Dire Dawa (GCP-62)	815751.176	1061632.836	815750.339	1061632.862	815750.346	1061632.866	37
Harar(GCP)	184274.078	1030640.009	184273.248	1030640.052	184273.250	1030640.054	38

GPS data computation results obtained from Magnet office tools, AUSPOS and OPUS are compared below in table 4.2 by differencing coordinates from one to another on WGS84 datum.

Table 4.2**.** horizontal coordinate difference between computed GPS data

GCP Name	**Magnet office tool - AUSPOS**		**Magnet office tool - OPUS**		**OPUS- AUSPOS**	
	DEasting(m)	**DNorthing(m)**	**DEasting(m)**	**DNorthing(m)**	**DEasting(m)**	**DNorthing(m)**
D. D (GCP-38)	0.843	-0.026	0.832	-0.033	-0.011	-0.007
D. D (GCP-62)	0.837	-0.026	0.83	-0.03	-0.007	-0.004
Harar(GCP)	0.83	-0.043	0.828	-0.045	-0.002	-0.002
Average difference	**0.84**	**-0.03**	**0.83**	**-0.036**	**-0.006**	**-0.004**

From the result obtained from Static GPS process the two online (**OPUS and AUSPOS)** processed GPS data result has small difference both on x and y direction on average it has 0.006m and 0.004m difference on x and y direction respectively . However result obtained from magnet office tool has large difference relative to online processed GPS data. Mainly on x direction the difference is larger than y direction which has an of average 0.84m difference. This is due to the reference station during data processing in magnet office software it used one reference IGS station found in Addis where as the two online GPS data process service provider used more than two nearby CORS station especially OPUS used Addis IGS CORS station found in Addis Abeba. Thus, results obtained from OPUS were used for accuracy comparison of GCP established by Ethiopian geospatial information agency. Therefore to check the accuracy of GCP coordinates obtained from OPUS were projected to local datum Adindan using parameters obtained from Ethiopian Geospatial information Agency that are DX(m) -162, DY(m) -12 and DZ(m) 206.



Select Datum

Datum Selection

EPSG	Datum
	AGD84 (NTv2)
4901	ATF (Paris)
4122	ATS77
4143	Abidjan 1987
4168	Accra
6881	Aden 1925
4201	Adindan

Datum Properties

Name: Adindan
Ellipsoid: clark 1880 (modified)
Prime Meridian: Greenwich

Conversion Properties

Conversion: Molodensky
Grid File:
Translation X: -162.000000 (meters)
Translation Y: -12.000000 (meters)
Translation Z: 206.000000 (meters)
Rotation X: 0.00000000 (arc seconds)
Rotation Y: 0.00000000 (arc seconds)
Rotation Z: 0.00000000 (arc seconds)
Scale Factor: 0.000000 (ppm)

Click here for a list of most commonly used geodetic datums around the world

Eye4Software Coordinate Calculator - Ellipsoid

Select Ellipsoid

EPSG	Ellipsoid
7058	Hughes 1980
7059	Popular Visualisation Sphere
N/A	Fischer Modified
N/A	Fischer 1960
N/A	Fischer 1968
N/A	Minnesota - Stearns County
N/A	clark 1880 (modified)

Ellipsoid Properties

Ellipsoid Name: clark 1880 (modified)
Semi-major Axis: 6378249.145 (a)
Inverse Flattening: 293.46630765600003 (f)

Click here for a list of most commonly used ellipsoids around the world

e4Software Hydromagic - Coordinate Calculator

urce Coordinates

urce Grid: WGS 84 / UTM zone 37N
urce Datum: WGS 84
orthing: 1061632.866
asting: 815750.346
ltitude: 1208.518 Meters

estination Coordinates

estination Grid: Adindan / UTM zone 37N
estination Datum: Adindan
orthing: 1061425.710
asting: 815658.042
ltitude: 1208.518 Meters

The Eye4Software Coordinate Calculator can be used to convert a single coordinate, or to convert coordinates from a file using the batch conversion wizard.

Figure 4.1. Datum transformation process

Table 4.3. Accuracy Comparisons of E.G.I.A GCPs coordinate

GCP name	Projected OPUS coordinate result		E.G.I.A coordinates of GCP		Error	
	Easting(m)	**Northing(m)**	**Easting(m)**	**Northing(m)**	**DEasting(m)**	**DNorthing(m)**
Diredawa(GCP-38, numeber one)	814061.502	1062464.567	814062.291	1062462.151	-0.789	2.416
Diredawa(GCP-62, leghare)	815658.042	1061425.710	815658.79	1061423.316	-0.748	2.394
Harar (GCP-Ras Lule Mekonene avenue)	184166.508	1030434.571	184167.289	1030432.13	-0.781	2.441
Mean error					**-0.77**	**2.42**

The positional accuracy of GCP's established by E.G.I.A has -0.77m and 2.42m mean error on x and y direction respectively. The accuracy was compared with coordinates obtained from OPUS online GPS data processing service provider on the same horizontal datum.

4.1.2. Planimetric accuracy assessment result

This study explicitly examined the planimetric accuracy of orthophoto, satellite image and digital line map (parcel and road center line). A point-based assessment technique was used to assess the planimetric (N, E) accuracy of these data sets. Each digital spatial data set was independently compared with RTK GPS survey result. Due discrepancy of coordinates obtained from E.G.I.A and computed coordinate tie to IGS on the same GCP RTK GPS survey were conducted twice only on selected 20 sample points. This was done by setting base station coordinate obtained from E.G.I.A and current computed coordinate. Therefore for 20 sample point from orthophoto accuracy compared with coordinate obtained from RTK survey with reference to two different bases/reference coordinate on the same base stations. Based on this the planimetric accuracy of orthophoto for the selected 20 points relative to coordinate computed from coordinate obtained from E.G.I.A GCP used as base station on RTK survey is much better than RTK survey coordinates computed from current derived coordinates from static survey result. Therefore, due to such result the remaining sample feature selected from the orthopho, line map and satellite image planimetric accuracy were tested reference to RTK survey coordinate result obtained from E.G.I.A coordinate as a base/reference station.

4.1.2.1. Orthophoto palanimetric accuracy assessment result

The planimetric accuracy (E, N) of orthophoto was assessed coordinates derived from different sample features from orthophoto with RTK GPS survey independently. These sample features are road edge, parcel corner and flood protection fence which has 3.5 km. Therefore from these sample 125 planimetric coordinate from 28 parcels, 20 coordinate value from road edge and intersection and 90 coordinate value along bends and end points the flood fence were extracted from the orthophoto using on screen digitization technique. Therefore the planimetric accuracy of orthophoto assessed relative to coordinate value obtained from RTK GPS survey result on similar sample features. Therefore similar coordinate value from similar sample feature 125 coordinate value extracted from orthophoto and coordinate collected from RTK survey 125 coordinate value for parcel, 28 similar coordinate value from orthophoto and RTK survey coordinate result on sharp bend point, end points and along the geometry of the flood protection fence and 20 coordinate similar with RTK survey coordinate value on road edge were computed there RMSE relative to RTK survey coordinate result on the same point(Appendix I,J and K).

in the ASPRS and NSSDA standards is suggested to calculate RMSE based on the $d_{\Delta N}$ and $d_{\Delta N}$ separately. Therefore the RMSE for each sample feature computed independently. Similarly $RMSE_r$ and 95% confidence levels according to NSSDA were computed. The result of this computation presented below on table 4.4.

Table 4.4. Summary of planimetric accuracy assessment result on orthophoto

NO	**Sample feature type**	**Mean error**		**RMSE(m)**		**$RMSE_r$(m)**	**NSSDA at 95 % confidence levels(m)**
		x	y	x	y		
1	Parcel feature	0.045	0.056	0.211	0.237	0.317	0.55
2	Point feature (road edge and junction)	0.019	0.025	0.138	0.159	0.210	0.36
3	Flood protection Fence	0.030	0.015	0.174	0.123	0.213	0.37

From the above result the RMSE of the difference between the orthophoto coordinates of all sample feature and in-situ RTK GPS coordinates of similar check points in x and y-directions lie between 0.13m-0.22m and 0.12 m – 0.24m respectively and 95% confidence level lie between 0.36m and 0.55m. Therefore according to ASPRS standard for large scale map planimetric accuracy which their RMSE laid with this range is applicable for the production of large scale planimetric map production. Similarly national standard for legal cadastre state that the overall planimetric RMSE of orthophoto should not exceeds to 0.40m at scale of 1:2000. Therefore the planimetric accuracy of orthophoth is liable for cadastral map production.

The above orthphoto planimetric accuracy assessment was conducted relative to independent GPS RTK surveys which E.G.I.A GCP used as a base station.

Due discrepancy between E.G.I.A coordinate and current computed coordinate with reference to computed OPUS coordinates as a reference station planimetric accuracy of orthophoto also assessed for 20 check points similar to orthophoto using RTK GPS survey (Appendix P). .

With reference to RTK GPS result computed from current derived coordinates as a base station the RMSE of orthophotho are -0.83m and 2.48m on X and Y direction respectively. The planimetric accuracy of orthophoto is better relative to E.G.I.A GCP than current derived coordinate from OPUS. Thus according to Zenabu G. etal, (2017) the accuracy of orthophoto depends on source data among this source data Control points are the major one error in control points can propagate to the final orthophoto thus, the planimetric accuracy of orthophoto used in this study is good relative to E.G.I.A GCP. Therefore according to this result the planimetric accuracy of orthophoto appropriate for large scale cadastral map production relative to E.G.I.A GCP.

Generally as we compared each features accuracy flood protection fence and points taken along the road edge and junction has good planimetric accuracy than parcel feature in RMSE sense. But all features planimetric accuracy lie on acceptable standard that demanded for the production of large scale planimetric maps.

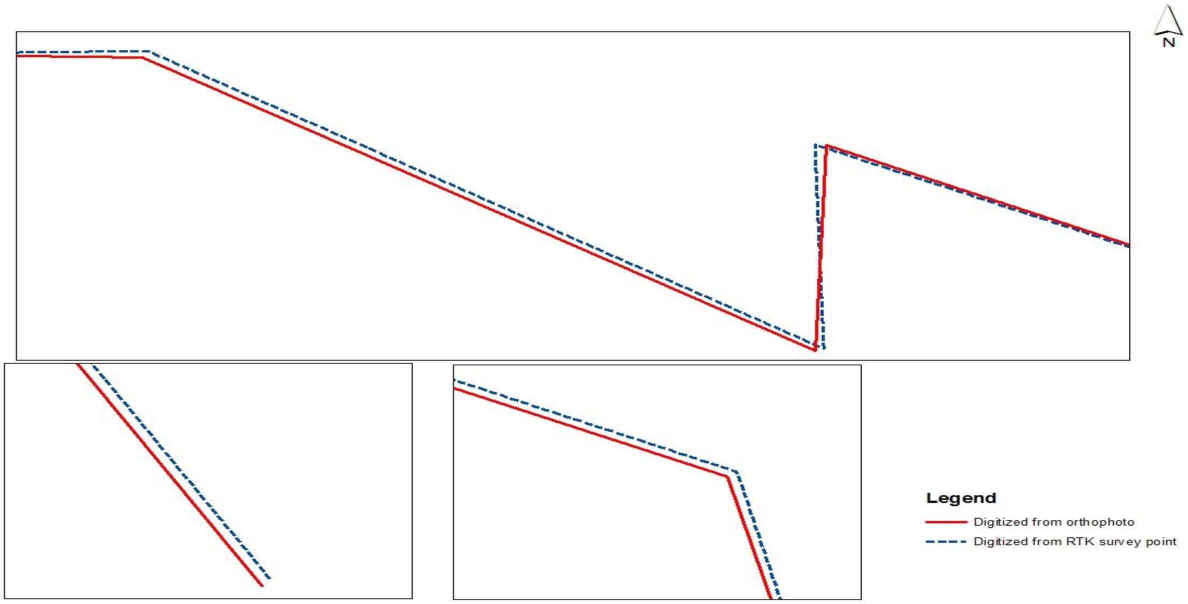


Figure 4.2 Comparative maps between digitized from orthophoto and RTK survey point for flood protection fence

4.1.2.2. Digital line map palanimetric accuracy assessment result

In this study the planimetric accuracy of digital line map are assessed on parcel and road center line feature. The planimetric accuracy of digital line (parcel) assessed on similar sample parcel feature with that of orthophoto. The planimetric coordinates of parcel was extracted on the vertex of each parcel and similar 125 vertexes with RTK GPS point are selected. The selected parcel vertex coordinates are generated on Arc GIS using Add xy tool. The planimetric coordinate extracted from selected parcel vertex were computed there difference relative on situ RTK GPS survey (Appendix N).

This digital line map (parcel) was prepared by INSA at a scale of 1:2000 for cadastral map production using sterio feature compilation technique. The planimetric accuracy of this feature compilation technique was compared to on screen digitization which was previously used for parcel feature extraction from orthophoto. Therefore as compared to on screen feature compilation technique the planimetric accuracy of sterio compilation has good accuracy relative to onscreen digitization. The RMSE which were obtained from orthophoto accuracy on parcel feature was 0.211m and 0.227 m on x and y direction respectively where as the RMSE of digital line map (parcel) are 0.183 m and 0.196 m on x and y respectively and 0.46m at 95% confidence level. Thus the RMSE on x has 0.038 m difference and 0.031m. Therefore it is better to use digital line map (parcel) than onscreen digitization feature compilation technique.

The planimetric accuracy of road center line assessed point wise relative to RTK GPS coordinate collected along the center of the road. Thus a total of 185 coordinates are collected along the center of the road starting from numberone (municipal office) to mesklgna (dawit garage) which has a length of 1.4 km then coordinates collected along the road centerline are overlaid on road center line and 28 point coordinates which are orthogonal to road center line are selected similarly from road center line 28 vertex are selected. Therefore the RMSE of 28 planimetric coordinates of digital line map (road center) were computed relative to RTK GPS surveying result.

Therefore based on the computation results (Appendix O) the accuracy of digital line map (road center line) as compared to the RTK GPS data is 0.151m and 0.195m in x and y-direction, respectively in RMSE sense and 0.426m at 95% confidence level. Therefore according to the national standard and FGDC (1998) the accuracy is laid on acceptable range for large scale map production.

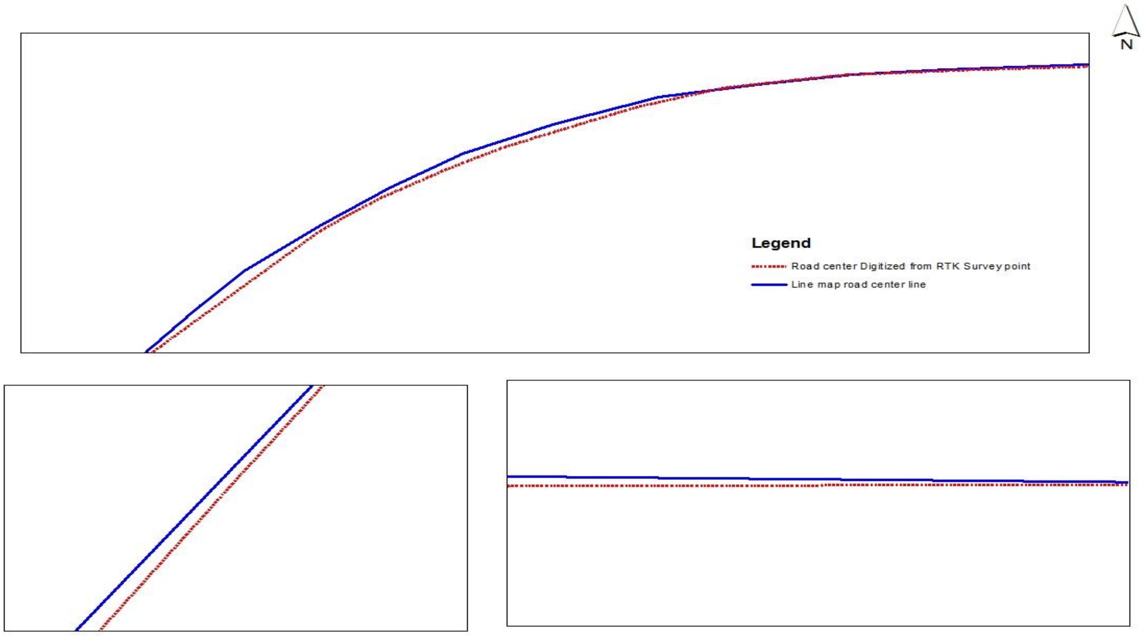


Figure 4.3. Digital line map (road center line) overlaid with digitized RTK survey point

4.1.2.3. Satellite image planimetric accuracy assessment result

The Satellite image used in this study was orthorectified Worldview-1 satellite image purchased by E.G.I.A (Ethiopian Geospatial Information Agency) from Digital Globe Company which has 50cm GSD and captured on July 2010/11. The main application of this satellite image in Dire Dawa is to identify buildings that are built before July 2010/11 and to legalize those plots of land. During the legalization process building that are seen on the satellite image are extracted by digitization process to include the buildings in the final cadastral maps. Therefore planimetric accuracy assessment were conducted on similar sample parcel and line feature (flood protection fence) with that of orthophoto. Therefore 128 planimetric coordinates extracted from satellite image parcel feature corners are computed there RMSE relative to RTK GPS survey which coordinates result obtained with reference to E.G.I.A GCP. Thus according this computation (Appendix L) RMSE of parcel are 1.735m and 2.07m on x and y direction respectively and according to NSSDA 95% confidence level is 4.6 m.

The planimetric accuracy of satellite image also assessed on selected line feature (flood protection fence). Thus from a total of 79 coordinate value obtained from RTK GPS survey 19 similar coordinate value (point) with that of points collected from satellite image were selected. Therefore RMSE of the difference between the satellite image coordinates and in-situ GPS coordinates of 19 similar points in x and y-directions are 1.89m and 2.25 m, respectively and 5.09 m with 95% confidence (Appendix M).

Table 4.5. summary of planimetric accuracy assessment result on satellite image

NO	**Sample feature type**	**Mean error**		**RMSE(m)**		**RMSE$_r$(m)**	**NSSDA at 95 % confidence levels (m)**
		x	y	x	y		
1	Parcel feature	3.012	4.292	1.73	2.07	2.70	4.6
2	Flood protection Fence	3.58	5.08	1.89	2.25	2.94	5.09

From table 4.4 as we compared planimetric accuracy of parcel features are better relative to flood protection fence however the accuracy result of both features is not appropriate for the demanded application for cadastre.

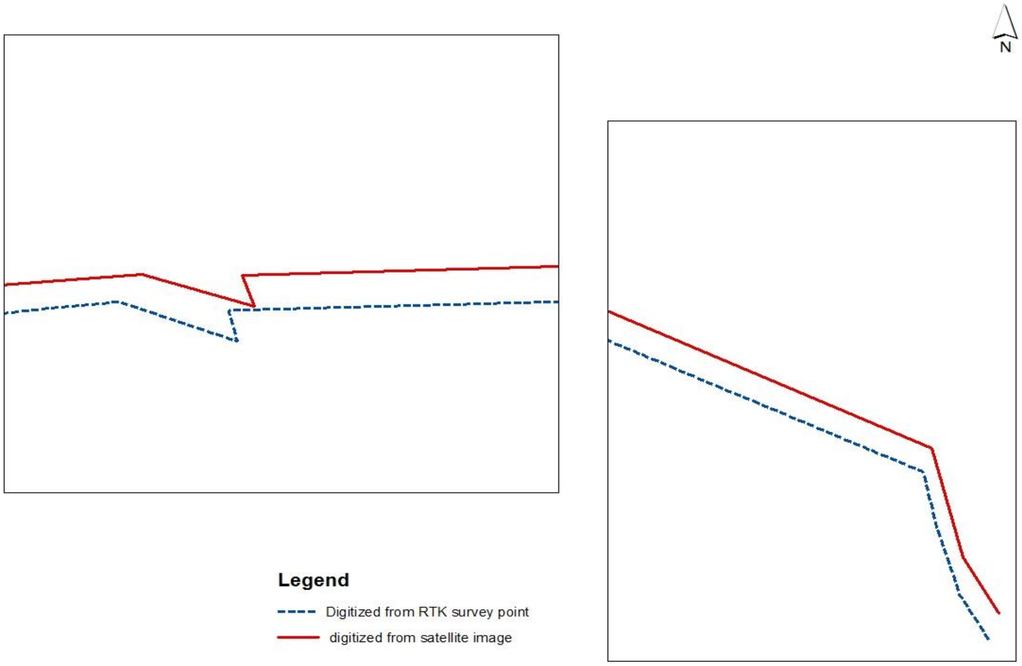


Figure 4.4. comparative maps between digitized from satellite image and RTK survey point for flood protection fence.

In figure 4.3 parcel feature digitized from orthophoto, satellite image, digital line map (parcel) feature and RTK GPS survey planimetric result are described in illustrative way from this figure we can clearly identify the deviation of each parcel feature from parcel obtained from RTK GPS result. Based on this orthophoto and digital line map is better accuracy than satellite image. The national standard for legal cadastre 03/2015 suggests using stereo feature compilation technique during the extraction of feature from the orthophoto. Therefore in this study to compare the accuracy of on screen digitization technique and sterio digitization technique digital line map (parcel) feature which was digitized by sterio digitization technique by INSA were used for comparison purpose. Based on this the digital line map (parcel) has better accuracy than digitized from orthophoto using onscreen digitization technique as illustrated in the figure 4.3.

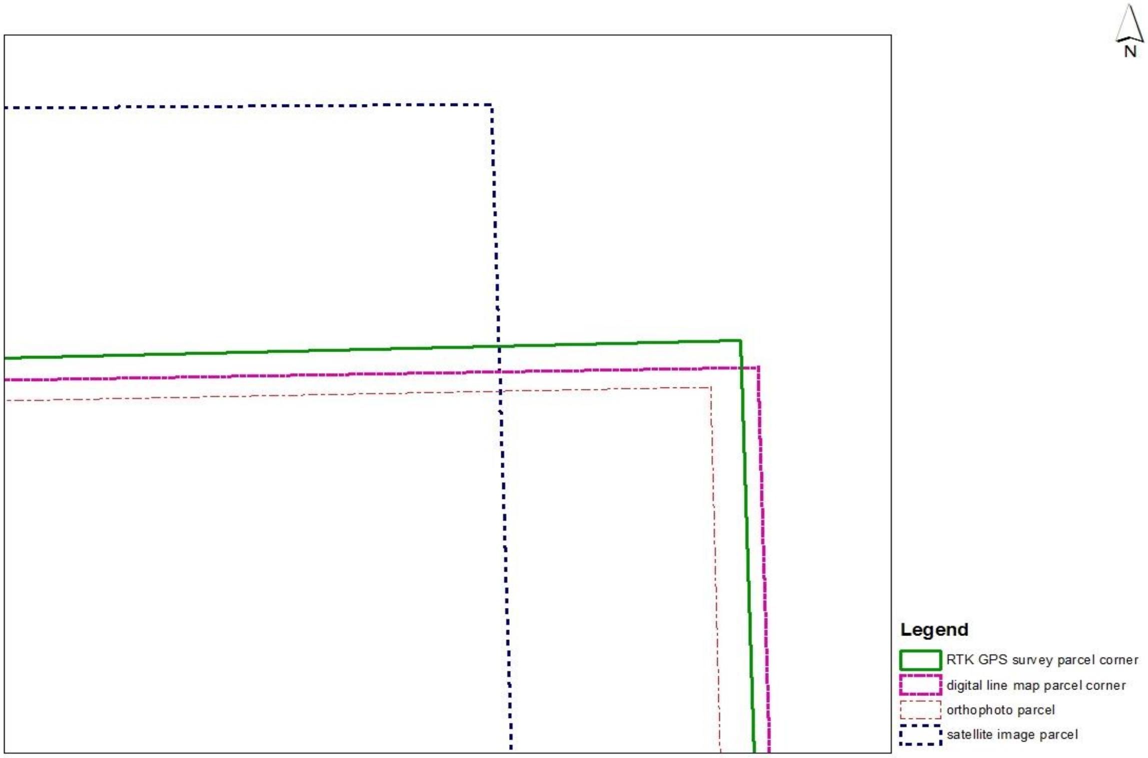


Figure 4.5. Comparative map show deviation between satellite image, digital line map (parcel), orthophoto and RTK GPS survey parcel corner.

4.2. Discussion

This thesis assessed the planimetric accuracy of digital spatial data sources used for the production of large scale planimetric maps in Dire Dawa. These digital spatial data sources are orthophoto, satellite image and digital line map (parcel and road center line). The study used point based accuracy assessment method in this method planimetric coordinate extracted from selected sample from digital spatial data sources are compared with RTK GPS survey coordinate collected from similar sample and the RMSE for each data set were computed.

The main challenges in this study were obtaining accurate reference base station which used for reference base during RTK GPS survey because in the study area there is no CORS station and finding similar check points for all data set because the spatial data used in this study mainly digital orthophoto and satellite image was taken in different time and long lasted image. Due to absence of CORS station nearby the study area thus two second order GCP which was established by E.G.I.A were used for the base station. Before using these GCP positional accuracy was assessed on two second order GCP found in Dire Dawa and one first order GCP found in Harar. The reason for positional accuracy test for first order GCP found in harar was to compare the accuracy first and second order GCP if better accuracy obtained on first GCP the rest of two second order control point would processed reference to first order GCP and to use as a base station during RTK survey.

Therefore 12 hour static GPS surveys were conducted on three GCP and measured static GPS data were processed reference to IGS CORS station found in Addis Abeba using Magnet Office tool software and free online GPS data processing service provider (AUSPOS and OPUS). Unfortunately the processed GPS result was large difference manly on y direction relative to previous coordinate of GCP obtained from E.G.I.A. Due to such large discrepancy between computed and previous coordinate planimetric accuracy of orthophoto only for 20 similar selected samples are assessed relative to RTK GPS survey coordinate result with reference to coordinate obtained from computed and previous E.G.I.A. coordinate on the same GCP. This were done to compare the planimetric accuracy of orthophoto relative to RTK survey coordinate obtained from two similar base station having different horizontal coordinates.

4.2.1. Digital Orthophoto and line map accuracy

The orthophoto and digital line map used in this study was prepared by Information Network Security Agency (INSA) in 2011/12. The digital line map also extracted from orthophoto using sterio feature compilation technique. The main purpose of these orthophoto and digital map are for the production of large scale cadastral map. Therefore this study also evaluated the potential of this digital spatial data set for the intended application.

The planimetric accuracy of orthophotho and digital line map (parcel) were assessed on similar parcel feature. Planimetric coordinate extracted from orthophoto using manual digitization and coordinates extracted from vertex of digital line map (parcel) compared with RTK GPS survey coordinate which used E.G.I.A. GCP as a reference. The main intention of assessing similar parcel feature was to compare the planimetric accuracy of digital line map parcel with that of manually digitized planimetric coordinate of parcel feature. Therefore based on the assessment result digital line map (parcel) was good accuracy than digitized planimetric coordinate but both planimetric coordinates that are extracted from orthophoto and line map (parcel) found on acceptable range of RMSE for the production of large scale cadastral map. However to increase accuracy of final cadastral map it is better to use digital line map (parcel). The planimetric accuracy of orthophoto also assessed on selected 20 points on road edge and junction and 28 planimetric coordinates collected along the flood protection fence. Thus RMSE of selected sample lies on acceptable range for cadastral application according to national urban legal cadastre standard 03/2015. This standard state that planimetric accuracy does not exceed 40cm at scale of 1:2000.

The accuracy of photogrammetric data is depend on GCP point used during rectification process. Thus the planimetric accuracy of orthophoto relative to E.G.I.A GCP is appropriate of the demanded application. However the planimetric accuracy of orthophoto relative to RTK GPS survey which were used current computed coordinate as a base station were inappropriate. This is because of the GCP point which used during the rectification process was not updated relative to CORS station.

4.2.2. Satellite image accuracy

Currently following the advancement technology in the field of remote sensing satellite image become an alternate source of spatial data. The advantage of using HRSI images is that they provide a temporal record of the areas that can be resurveyed in the future to observe the changes that have taken place. Old images can prove very useful in resolving the disputes regarding the existence of physical parcel boundaries (Dale, 1999).

However the accuracy of satellite image is affected during the acquisition of the image due to curvature of the earth and sensor distortion. To maintain image distortion rectification process were conducted this rectification processes also affected by the accuracy of GCPs and DEM accuracy thus for such reason assessing the accuracy of satellite image is required to determine its appropriateness for the demanded application.

In this study ortho rectified worldview-1 panchromatic satellite image having 50cm GSD were used to assess its planimtric accuracy. This satellite image is used in Dire Dawa city to identify buildings built before July 2010 and to certify those owner whose there building are visible on the satellite image furthermore buildings which are extracted from the satellite image are used as input for the final cadastre map. However, according to the result obtained from this study the satellite image is not appropriate for such application. The RMSE of satellite image relative to RTK GPS survey which references to E.G.I.A GCP are 1.73m and 2.07m on X and Y direction respectively for parcel feature and line (flood protection fence) are 1.89m and 2.25m on X and Y direction respectively.

4.2.3. Potential of the digital spatial data for large scale mapping

The value of any geographic data set depends less on its cost, and more on its fitness for a particular purpose. A critical measure of that fitness is data quality. When used in GIS analysis, a data set's quality significantly affects confidence in the results. Unknown data quality leads to tentative decisions, increased liability and loss of productivity. Decisions based on data of known quality are made with greater confidence and are more easily explained and defended. Ultimately, users identify acceptable accuracies for their applications. Data and map producers must determine what accuracy exists or is achievable for their data and report it according to national and international accuracy standard. The accuracy of spatial data set depends on the application area. Different national and international standards were set to determine the application area of the spatial data. Among international standards The American Society for Photogrammetry and Remote Sensing (ASPRS) is the one which created standards in July of 1990 in a report titled "ASPRS Accuracy Standards for Large-Scale Maps". These standards were a response to the need for scale-independent accuracy standards. The ASPRS standards explicitly used the statistical term, Root Mean Square Error (RMSE) for reporting error. Similarly

Ethiopia by adopting this standard set standard for large scale legal urban cadastre standards called 03/2015 and this standard use RMSE to evaluate error on the spatial data set. The standard state that the total RMSE error of coordinates derived from orthophoto, line map and satellite image should not exceed 40cm in X or Y direction at 1:2000 scale of map.

Thus based on this national standard for urban cadastre the planimetric accuracy obtained from orthophoto and its line map is applicable for the production of large scale cadastral map and different utility maps at scale of 1:2000. However, the RMSE found on the satellite image is not appropriate for large scale cadastral map production.

In this study the planimetric accuracy of the digital spatial data set also evaluated according to ASPRS international standard for large scale maps. ASPRS accuracy standard for large scale maps described error in terms of RMSE in relation to the scale of map. For instance this standard categorized the digital spatial data which have 0.50m and 2.5m RMSE can be used for the production 1:2000 and 1:10,000 scale of map respectively. Therefore, according to this standard the planimetric accuracy obtained from the digital orthophoto and digital line map can be used for production of large scale maps starting from 1:2000 map scales. Although the planimetric accuracy obtained from Worldvie-1 satellite image is large relative to digital orthohoto and line map it can be used for the production of large scale maps starting from 1:10000 scale maps.

CHAPTER FIVE

5. Conclusion and recommendation

5.1. Conclusion

The planimetric accuracy is a much important element of the overall quality of a spatial data set. In contrast, spatial data is subject to a variety of quality issues, due to limitations in for instance data acquisition and maintenance. Assessing the quality of the data, in terms of for example its planimetric accuracy, can help to assure its suitability within a certain application area. In this study planimetric accuracy of the digital spatial data source used for different large scale map production in Dire Dawa City are assessed. These digital spatial data includes orthophoto and its digital line map (parcel and road center line) and worldview-1 satellite image

The planimetric (x,y) accuracy assessed using point based accuracy assessment method and the planimetric accuracy (horizontally) was evaluated mainly in terms of RMSE and 95 % confidence level and RMSE in x, y direction from the two datasets (RTK GPS survey checkpoints and derived coordinates of digital spatial data).

In this study due to absence of CORS station nearby the study area which used as a base or reference station during RTK GPS survey a 12 hour static observation was conducted on three GCP points established by E.G.I.A to cross check the accuracy and to use those GCP as a base station. Measured static GPS data were processed using Magnet office software and free online GPS data process service provider (AUSPOS AND OPUS); from processed GPS result OPUS result were used for accuracy comparison of E.G.I.A GCP. However the positional accuracy of these GCP relative to OPUS result was poor and it has a mean error of -0.77m and 2.42m difference on x and y direction respectively. Due to such discrepancy of coordinates obtained from E.G.I.A and current computed coordinate the planimetric accuracy of orthophoto assessed relative to both reference coordinates for 20 selected sample points. Therefore the planimetric accuracy of orthophoto for the selected 20 sample points relative to RTK GPS survey coordinate computed from current derived coordinate (base station) has poor accuracy which has RMSE of 0.82m on x direction and 2.41m on y direction and 4.3m at 95% confidence level however the planimetric accuracy on similar sample point relative to E.G.I.A GCP the planimetric accuracy has RMSE of 0.14m and 0.15m on x and y direction respectively and 0.36m at 95% confidence level. Due to such result the planimetric accuracy are assessed relative to E.G.I.A

GCP. Therefore the planimetric accuracy of orthophoto assessed coordinates extracted from sample feature relative to coordinates obtained from RTK GPS survey in terms of RMSE. Based on this the planimetric accuracy of point, polygon and line RMSE laid between 0.13m-0.21m and 0.12m-0.24m on x and y direction respectively. Thus based on this result national standard for urban legal cadastral 03/2015 state the final output of cadastre accuracy does not exceed 0.40m in horizontal RMSE at scale of 1:2000. Therefore according to this standard the orthophoto is applicable for the production of large scale cadastre maps.

In this study the planimetric accuracy of digital line map (parcel and road center line) was assessed. The planimetric accuracy of digital line map (parcel) was conducted on similar sample parcel feature with that of orthophoto. Based the assessment result the planimetric accuracy of digital line map (parcel) has RMSE of 0.18m and 0.196m on x and y direction respectively and 0.46m at 95% confidence level. Similarly digital line map (road center line) planimetric accuracy assessed on a series of 19 planimetric coordinates collected along the center of the road center line using RTK survey and coordinates extracted on similar points from digital line map (road center line). Based on this the planimetric accuracy has RMSE of 0.14m and 0.19m on x and y direction respectively and 0.43m at 95% confidence level. Thus the planimetric accuracy of the digital line map fulfill the national standard for large scale map and ASPRS accuracy standard for large scale maps starting from 1:2000 scale of maps.

Finally in this study planimetric accuracy of worldview-1 orthorectified satellite image were assessed. The assessment was undertaken on similar sample feature with that of orthophoto(parcel and flood protection fence) therefore planimetric coordinate extracted from satellite image on the selected sample features compared with RTK GPS survey coordinate result. The RMSE are 1.74m and 2.06m on x and y direction respectively for parcel feature and line (flood protection fence) has RMSE of 1.89m and 2.25m on x and y direction respectively. Therefore based on this result the satellite image does not satisfy national standard for large scale map especially for cadastral map purpose. However, based on ASPRS digital spatial accuracy standard for large scale maps the satellite image can be used for the production of large scale maps starting from 1:10,000 scales of maps.

5.2. Recommendations

Spatial data are the base for many engineering, land administration and planning application especially which needs high accuracy and used for decision making process should have uniform and fulfill the national and international accuracy standard. The accuracy of spatial data which are used for similar application should have similar accuracy or there accuracies must be on the acceptable error based on the standard. In Dire Dawa City the orthophoto and worldview-1 satellite image are used for cadastre application however based on the result obtained from this study the satellite image is not appropriate for large scale cadastral application and the planimetric accuracy is not fulfill national standard for the production of urban cadastral map. Therefore it is recommended that the office of Dire Dawa land administration use this satellite image for production of large scale maps starting from 1:10,000 and for identification of features.

In this study the accuracy of satellite image assessed on a orthorectified image purchased from Digital Globe company, thus it suggested that the planimetric accuracy of this satellite image can be further examined by rectifying the image again by self.

During spatial data acquisition or rectification process errors can be propagated from the source to the end (orthophoto, or satellite image). Among these GCP are major ones. The accuracy of orthophoto depends on positional accuracy of GCPs used in the rectification process. Thus the accuracy of GCPs should be checked before conducting any photogrammetric surveying and rectification process. Even though it is not the main objective of this study to assess positional accuracy GCP which was established by E.G.I.A three GCPs positional accuracy are assessed relative to coordinates obtained from IGS CORS however the accuracy of these GCP are poor mainly on y direction. Even if the accuracy of these GCPs are poor it fit to use relative to orthophoto. Thus it is suggested that the governmental organization that has a mandate to establishing GCP should check the accuracy of GCP and align with CORS station and also the government of Ethiopia should have to give more attention in building geospatial infrastructure across the city mainly establishing CORS station and up to date spatial data.

Generally it is recommend that the accuracy of spatial data which used for similar application should have uniform and the accuracy is acceptable for the demanded application based on either the national or international standards furthermore a responsible government body give due attention on spatial data accuracy.

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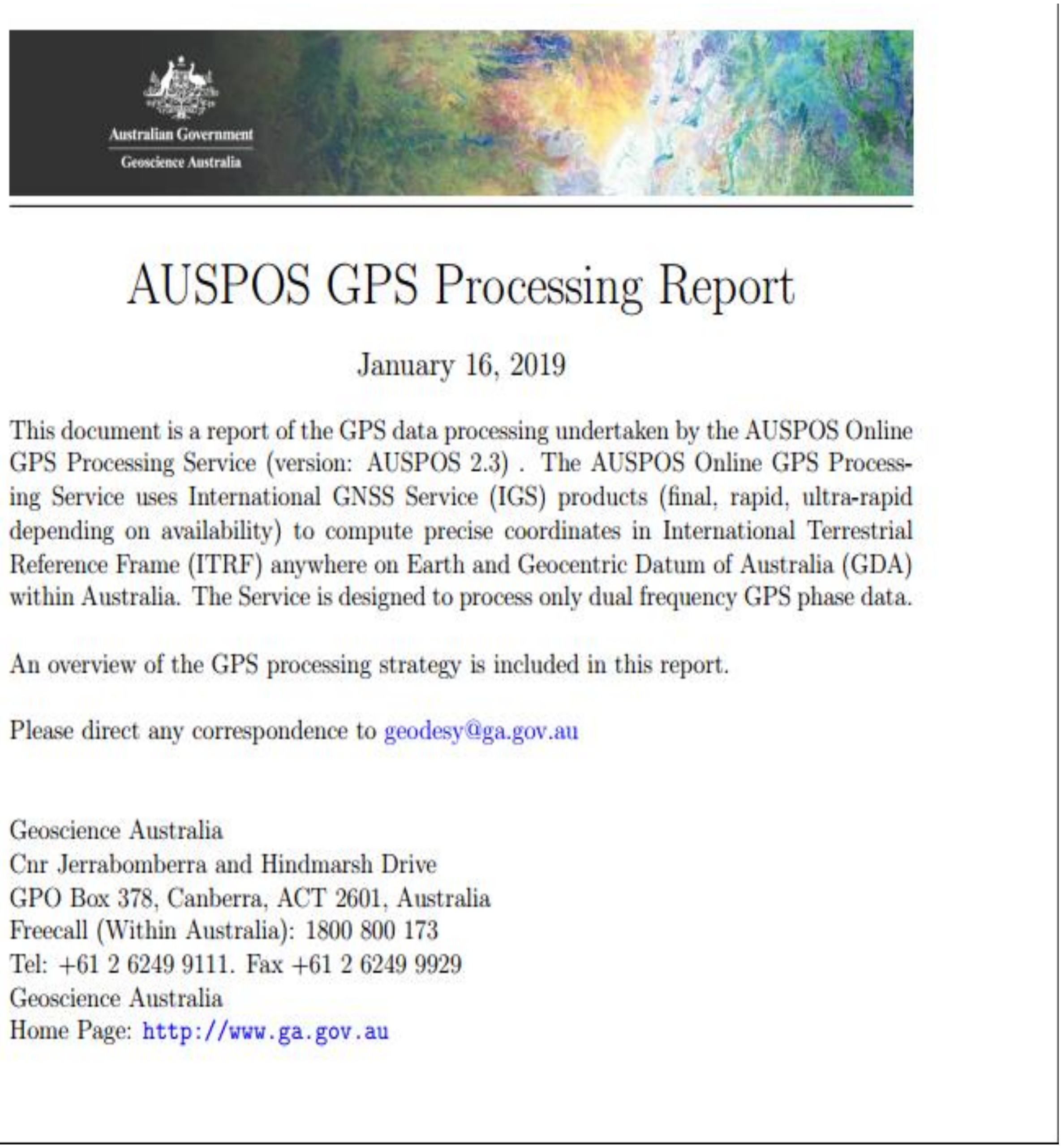
Appendix A. Online (AUSPOS) static GPS data report for Dire Dawa (GCP-38)



Australian Government
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AUSPOS GPS Processing Report

January 16, 2019

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 2.3) . The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is included in this report.

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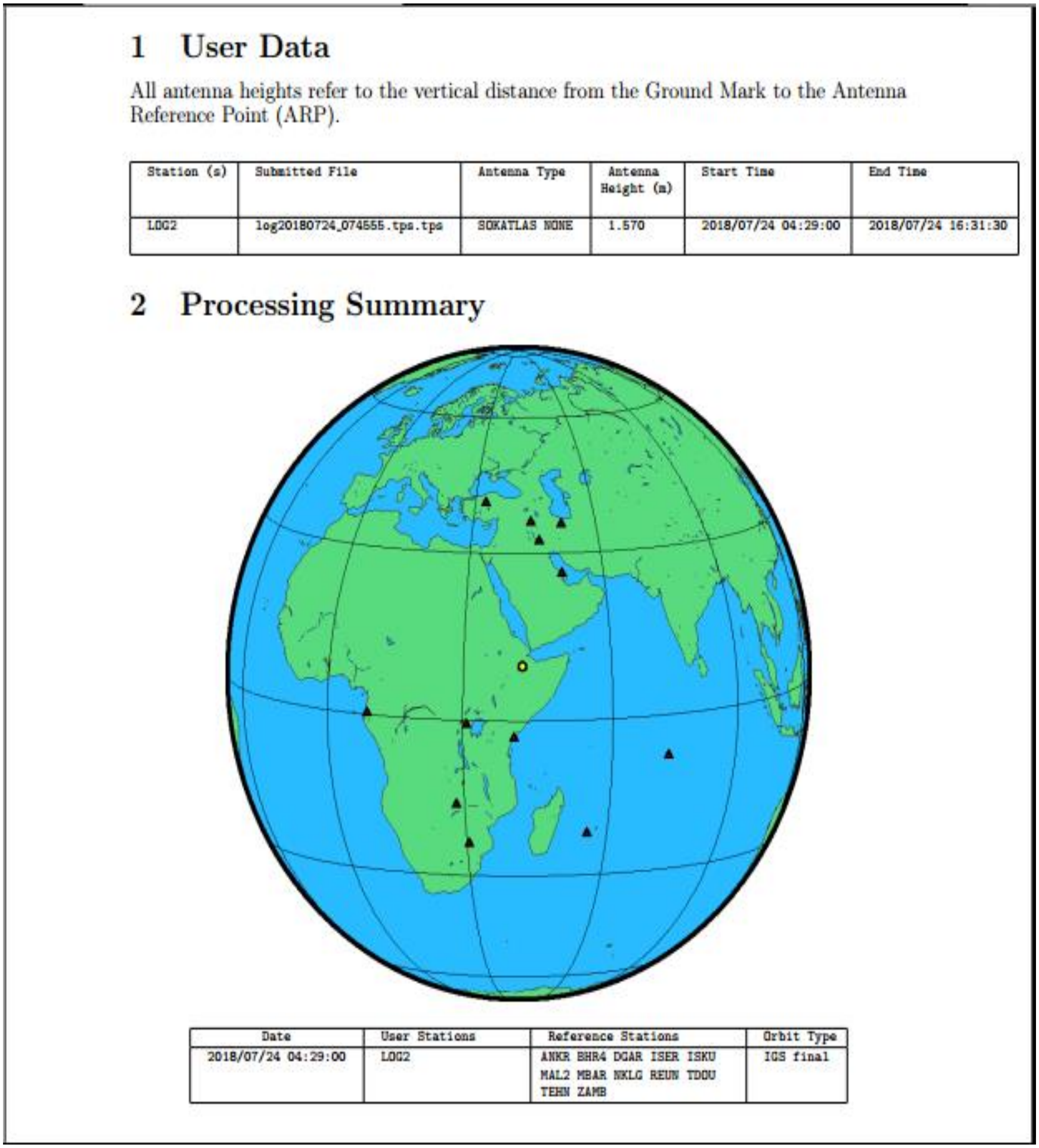


3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
LOG2	4684921.232	4197924.350	1057023.299	24/07/2018
ANKR	4121948.427	2652187.861	4069023.876	24/07/2018
BHR4	3633910.200	4425277.873	2799863.268	24/07/2018
DGAR	1916268.829	6029977.696	-801719.464	24/07/2018
ISER	3708160.822	3582297.980	3742781.675	24/07/2018
ISKU	3753237.899	3860668.679	3407514.545	24/07/2018
MAL2	4865385.463	4110717.454	-331137.401	24/07/2018
MBAR	5482951.145	3260442.835	-66519.639	24/07/2018
NKLG	6287385.712	1071574.827	39133.167	24/07/2018
REUN	3364098.938	4907944.638	-2293466.701	24/07/2018
TDOU	5064840.791	2969624.613	-2485109.873	24/07/2018
TEHN	3240498.925	4049740.442	3701663.287	24/07/2018
ZAMB	5415352.953	2917210.164	-1685888.628	24/07/2018

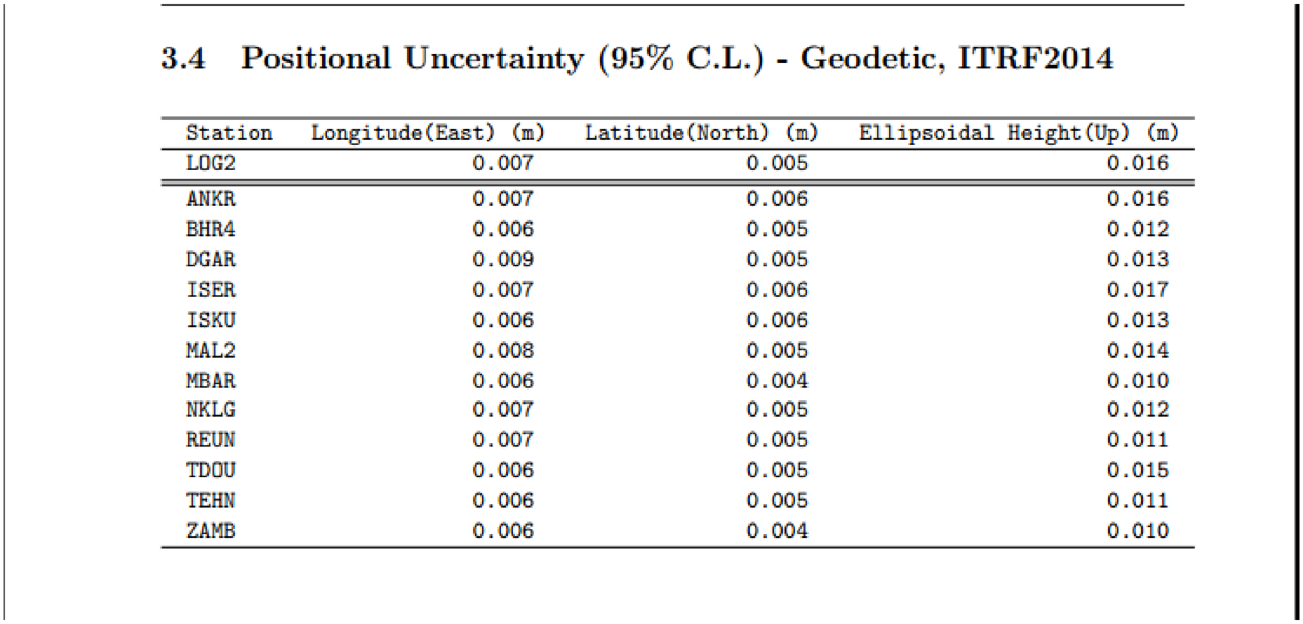
3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at `http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/`.

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
LOG2	9 36 05.68620	41 51 42.96057	1195.462	1208.373
ANKR	39 53 14.54143	32 45 30.49228	976.023	938.812
BHR4	26 12 32.92198	50 36 29.33907	-13.881	13.689
DGAR	-7 16 10.85265	72 22 12.88070	-64.939	8.942
ISER	36 09 35.48098	44 00 39.38786	431.288	420.105
ISKU	32 30 06.82452	45 48 30.16422	26.197	32.988
MAL2	-2 59 45.79180	40 11 38.92537	-20.924	9.491
MBAR	-0 36 05.28176	30 44 16.36366	1337.541	1349.488
NKLG	0 21 14.07190	9 40 19.65952	31.501	21.515
REUN	-21 12 29.60723	55 34 18.20012	1558.346	1552.113
TDOU	-23 04 47.66919	30 23 02.43253	630.210	617.361
TEHN	35 41 50.22401	51 20 02.74846	1194.572	1190.743
ZAMB	-15 25 31.93892	28 18 39.65276	1324.917	1324.489

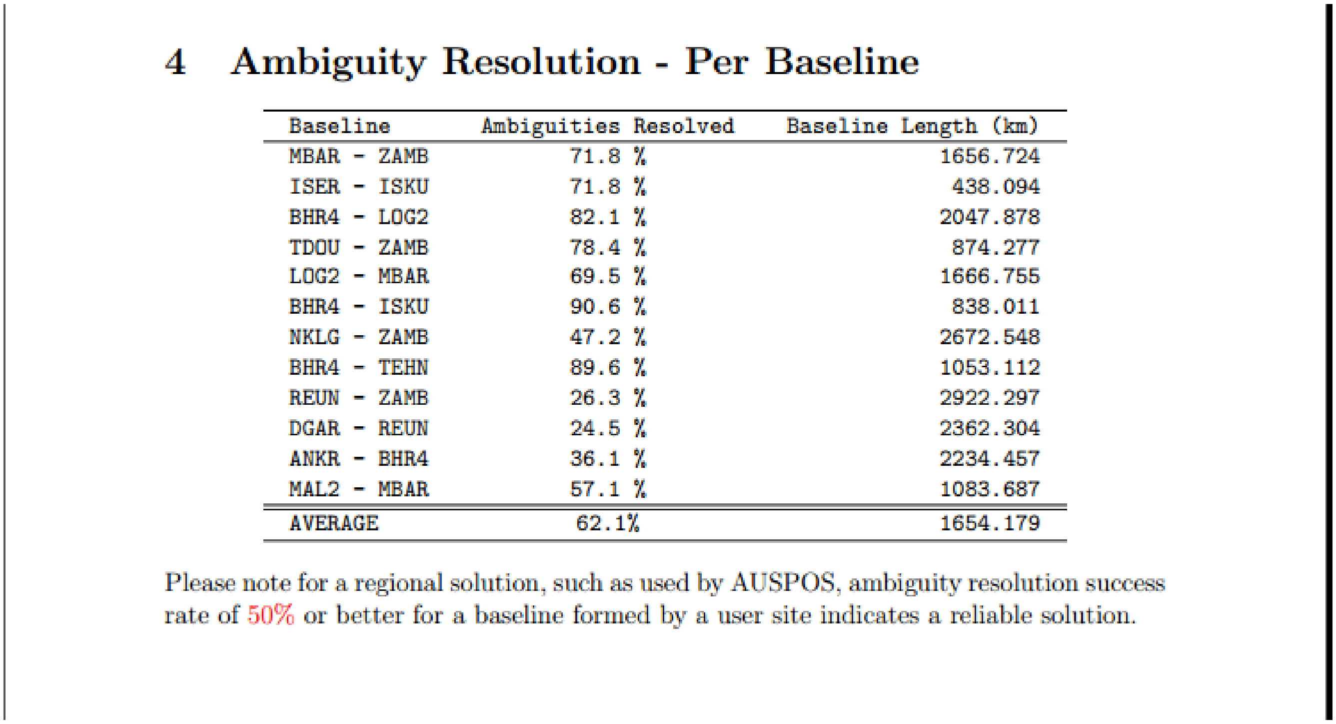
3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height (m)
LOG2	814153.821	1062671.735	37	1195.462	1208.373
ANKR	479349.235	14415284.716	36	976.023	938.812
BHR4	460854.053	12898904.780	39	-13.881	13.689
DGAR	209611.400	9195594.909	43	-64.939	8.942
ISER	411037.366	14002132.127	38	431.288	420.105
ISKU	575937.927	13596357.112	38	26.197	32.988
MAL2	632707.751	9668770.774	37	-20.924	9.491
MBAR	248230.479	9933467.589	36	1337.541	1349.488
NKLG	574791.288	10039120.277	32	31.501	21.515
REUN	351756.222	7654138.808	40	1558.346	1552.113
TDOU	232002.380	7445234.878	36	630.210	617.361
TEHN	530226.061	13950425.143	39	1194.572	1190.743
ZAMB	640671.875	8294178.535	35	1324.917	1324.489



3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
LOG2	0.007	0.005	0.016
ANKR	0.007	0.006	0.016
BHR4	0.006	0.005	0.012
DGAR	0.009	0.005	0.013
ISER	0.007	0.006	0.017
ISKU	0.006	0.006	0.013
MAL2	0.008	0.005	0.014
MBAR	0.006	0.004	0.010
NKLG	0.007	0.005	0.012
REUN	0.007	0.005	0.011
TDOU	0.006	0.005	0.015
TEHN	0.006	0.005	0.011
ZAMB	0.006	0.004	0.010



4 Ambiguity Resolution - Per Baseline

Baseline	Ambiguities Resolved	Baseline Length (km)
MBAR - ZAMB	71.8 %	1656.724
ISER - ISKU	71.8 %	438.094
BHR4 - LOG2	82.1 %	2047.878
TDOU - ZAMB	78.4 %	874.277
LOG2 - MBAR	69.5 %	1666.755
BHR4 - ISKU	90.6 %	838.011
NKLG - ZAMB	47.2 %	2672.548
BHR4 - TEHN	89.6 %	1053.112
REUN - ZAMB	26.3 %	2922.297
DGAR - REUN	24.5 %	2362.304
ANKR - BHR4	36.1 %	2234.457
MAL2 - MBAR	57.1 %	1083.687
AVERAGE	62.1%	1654.179

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of 50% or better for a baseline formed by a user site indicates a reliable solution.

5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.

5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(e)^2$ where e is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.

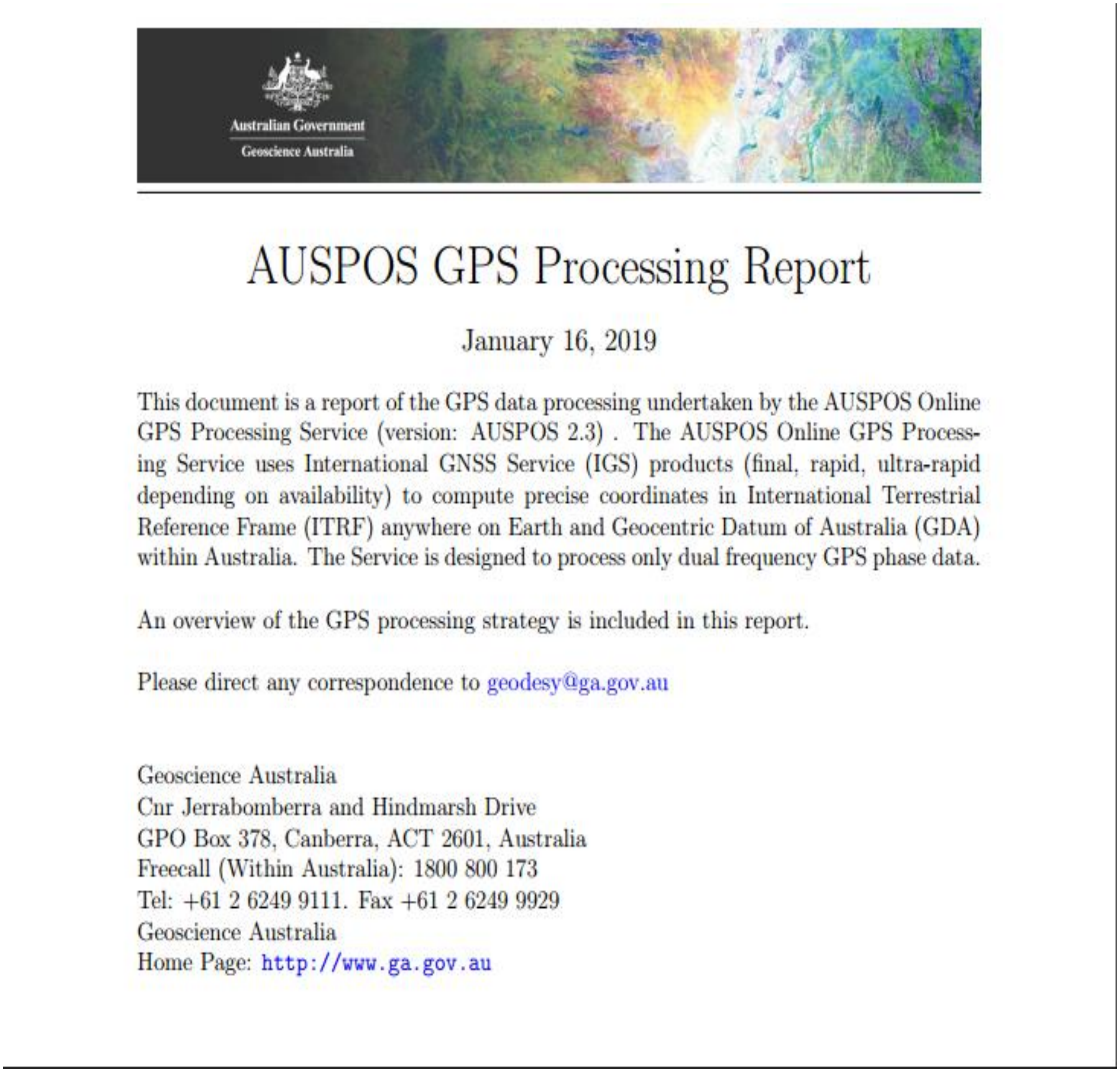
5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

Appendix B. Online (AUSPOS) static GPS data report for Dire Dawa (GCP-62)



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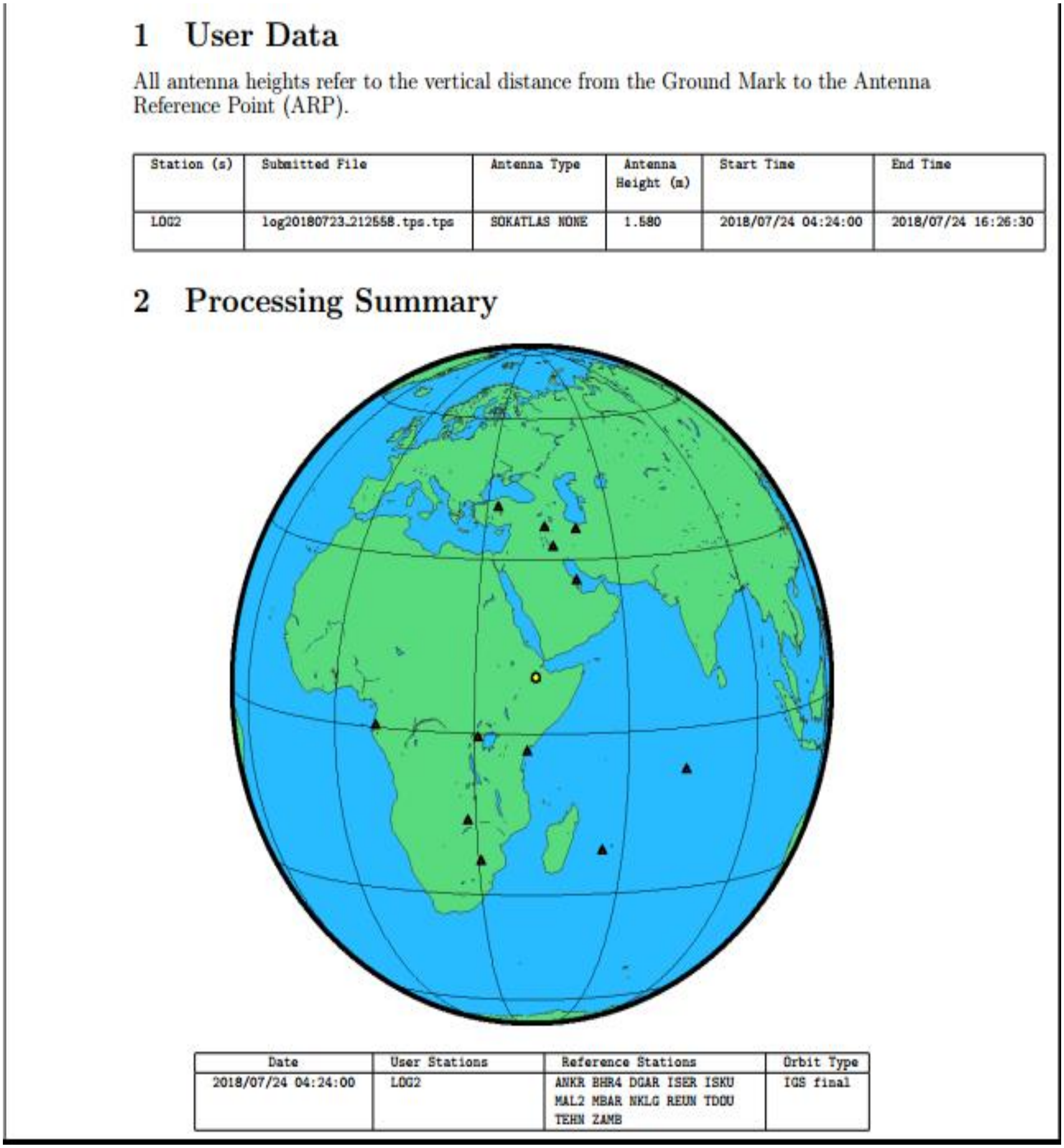


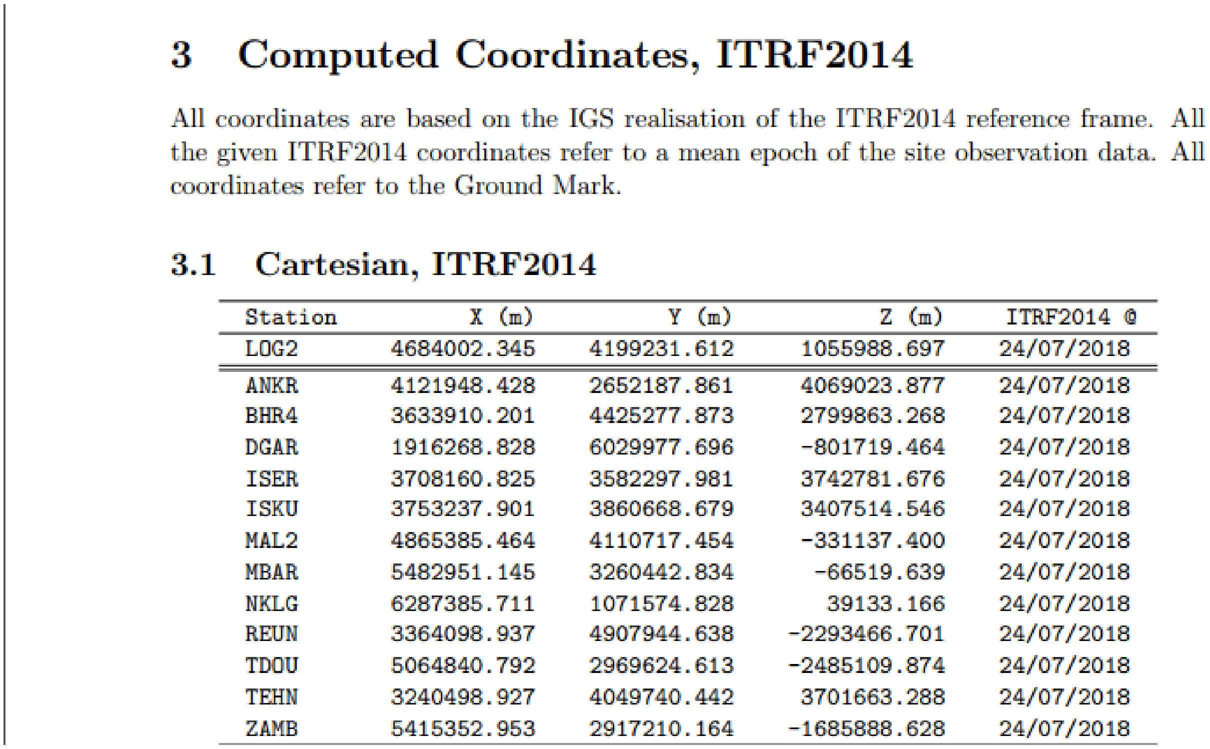
1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

Station (s)	Submitted File	Antenna Type	Antenna Height (m)	Start Time	End Time
LOG2	log20180723_212558.tps.tps	SOKATLAS NONE	1.580	2018/07/24 04:24:00	2018/07/24 16:26:30

2 Processing Summary

Date	User Stations	Reference Stations	Orbit Type
2018/07/24 04:24:00	LOG2	ANKR BHR4 DGAR ISER ISKU MAL2 MBAR NKLG REUN TDOU TEHN ZAMB	IGS final

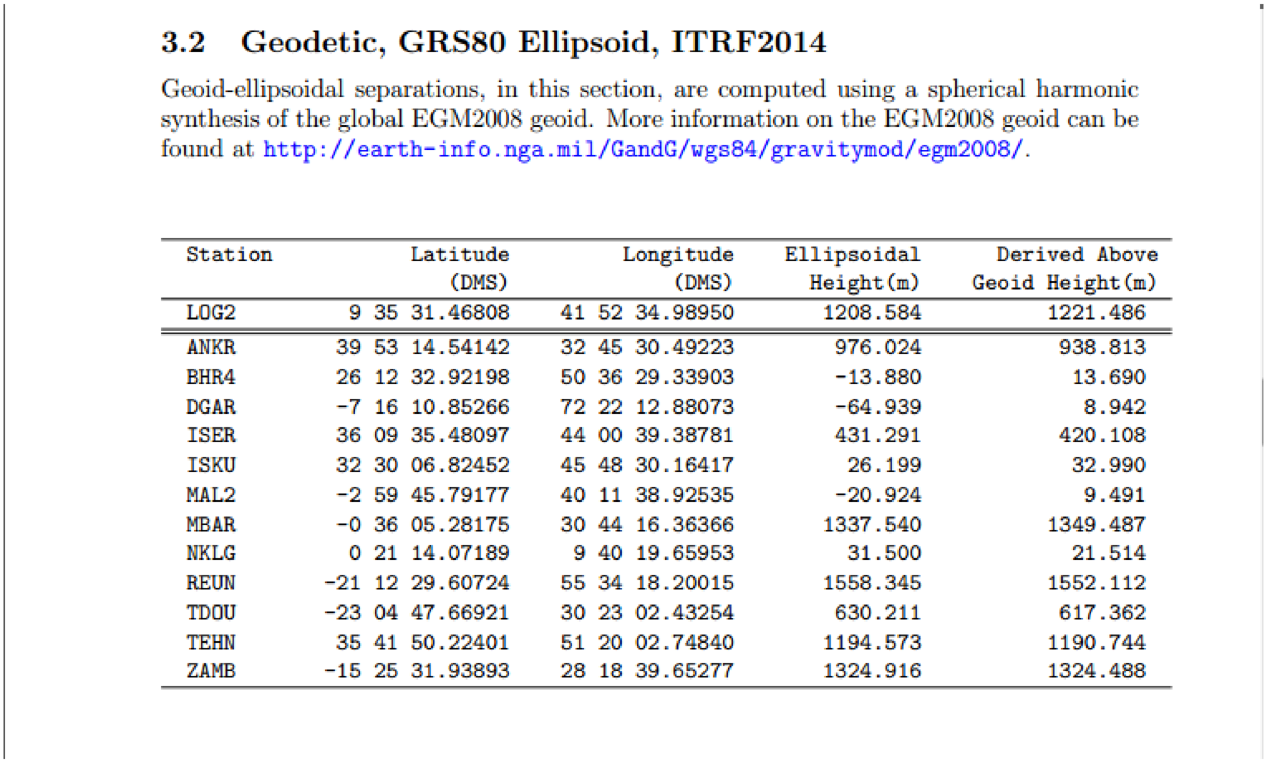


3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
LOG2	4684002.345	4199231.612	1055988.697	24/07/2018
ANKR	4121948.428	2652187.861	4069023.877	24/07/2018
BHR4	3633910.201	4425277.873	2799863.268	24/07/2018
DGAR	1916268.828	6029977.696	-801719.464	24/07/2018
ISER	3708160.825	3582297.981	3742781.676	24/07/2018
ISKU	3753237.901	3860668.679	3407514.546	24/07/2018
MAL2	4865385.464	4110717.454	-331137.400	24/07/2018
MBAR	5482951.145	3260442.834	-66519.639	24/07/2018
NKLG	6287385.711	1071574.828	39133.166	24/07/2018
REUN	3364098.937	4907944.638	-2293466.701	24/07/2018
TDOU	5064840.792	2969624.613	-2485109.874	24/07/2018
TEHN	3240498.927	4049740.442	3701663.288	24/07/2018
ZAMB	5415352.953	2917210.164	-1685888.628	24/07/2018



3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/.

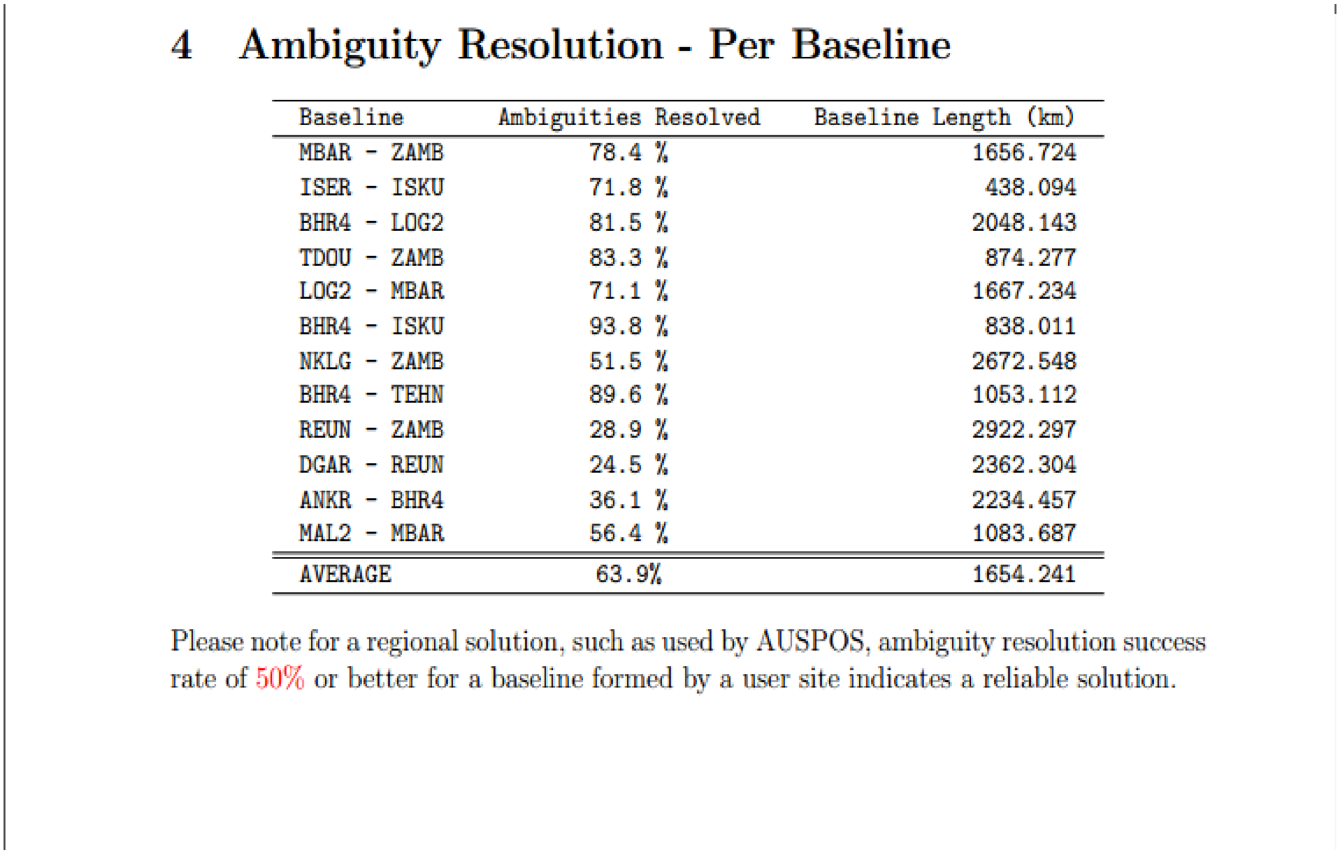
Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
LOG2	9 35 31.46808	41 52 34.98950	1208.584	1221.486
ANKR	39 53 14.54142	32 45 30.49223	976.024	938.813
BHR4	26 12 32.92198	50 36 29.33903	-13.880	13.690
DGAR	-7 16 10.85266	72 22 12.88073	-64.939	8.942
ISER	36 09 35.48097	44 00 39.38781	431.291	420.108
ISKU	32 30 06.82452	45 48 30.16417	26.199	32.990
MAL2	-2 59 45.79177	40 11 38.92535	-20.924	9.491
MBAR	-0 36 05.28175	30 44 16.36366	1337.540	1349.487
NKLG	0 21 14.07189	9 40 19.65953	31.500	21.514
REUN	-21 12 29.60724	55 34 18.20015	1558.345	1552.112
TDOU	-23 04 47.66921	30 23 02.43254	630.211	617.362
TEHN	35 41 50.22401	51 20 02.74840	1194.573	1190.744
ZAMB	-15 25 31.93893	28 18 39.65277	1324.916	1324.488

3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height (m)
LOG2	815750.345	1061632.862	37	1208.584	1221.486
ANKR	479349.234	14415284.715	36	976.024	938.813
BHR4	460854.052	12898904.780	39	-13.880	13.690
DGAR	209611.401	9195594.908	43	-64.939	8.942
ISER	411037.364	14002132.127	38	431.291	420.108
ISKU	575937.926	13596357.112	38	26.199	32.990
MAL2	632707.751	9668770.775	37	-20.924	9.491
MBAR	248230.479	9933467.589	36	1337.540	1349.487
NKLG	574791.289	10039120.277	32	31.500	21.514
REUN	351756.223	7654138.808	40	1558.345	1552.112
TDOU	232002.380	7445234.877	36	630.211	617.362
TEHN	530226.059	13950425.143	39	1194.573	1190.744
ZAMB	640671.876	8294178.535	35	1324.916	1324.488

3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014

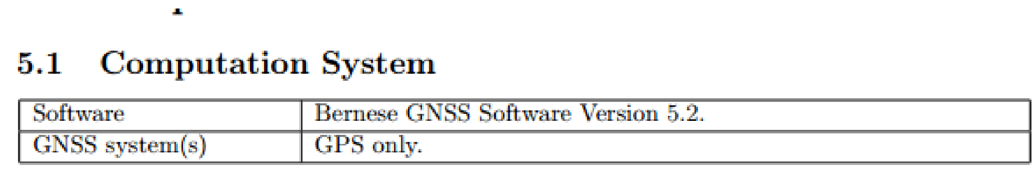
Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
LOG2	0.007	0.005	0.016
ANKR	0.007	0.006	0.016
BHR4	0.006	0.005	0.012
DGAR	0.009	0.005	0.013
ISER	0.007	0.006	0.018
ISKU	0.006	0.006	0.014
MAL2	0.009	0.005	0.014
MBAR	0.006	0.004	0.010
NKLG	0.007	0.005	0.012
REUN	0.007	0.005	0.011
TDOU	0.006	0.005	0.015
TEHN	0.006	0.005	0.011
ZAMB	0.006	0.004	0.010



4 Ambiguity Resolution - Per Baseline

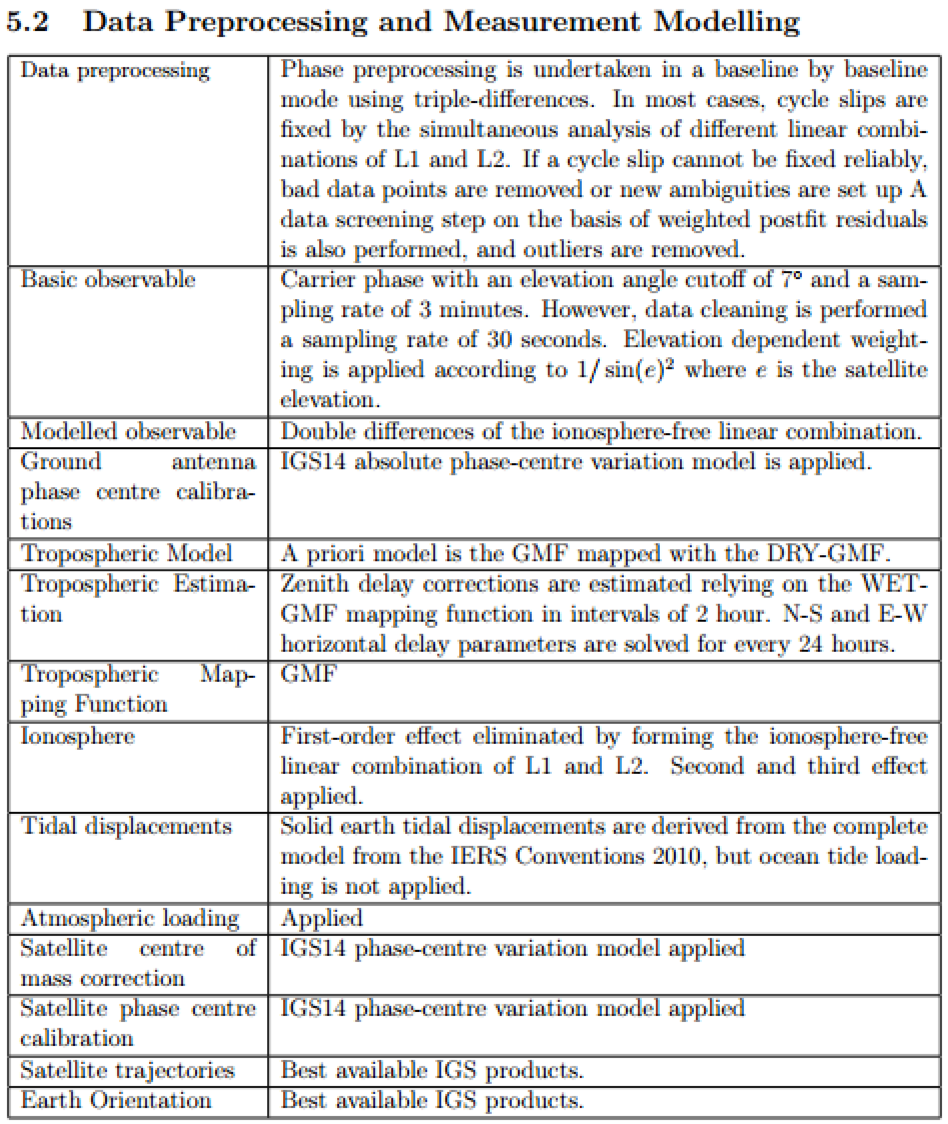
Baseline	Ambiguities Resolved	Baseline Length (km)
MBAR - ZAMB	78.4 %	1656.724
ISER - ISKU	71.8 %	438.094
BHR4 - LOG2	81.5 %	2048.143
TDOU - ZAMB	83.3 %	874.277
LOG2 - MBAR	71.1 %	1667.234
BHR4 - ISKU	93.8 %	838.011
NKLG - ZAMB	51.5 %	2672.548
BHR4 - TEHN	89.6 %	1053.112
REUN - ZAMB	28.9 %	2922.297
DGAR - REUN	24.5 %	2362.304
ANKR - BHR4	36.1 %	2234.457
MAL2 - MBAR	56.4 %	1083.687
AVERAGE	63.9%	1654.241

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of 50% or better for a baseline formed by a user site indicates a reliable solution.



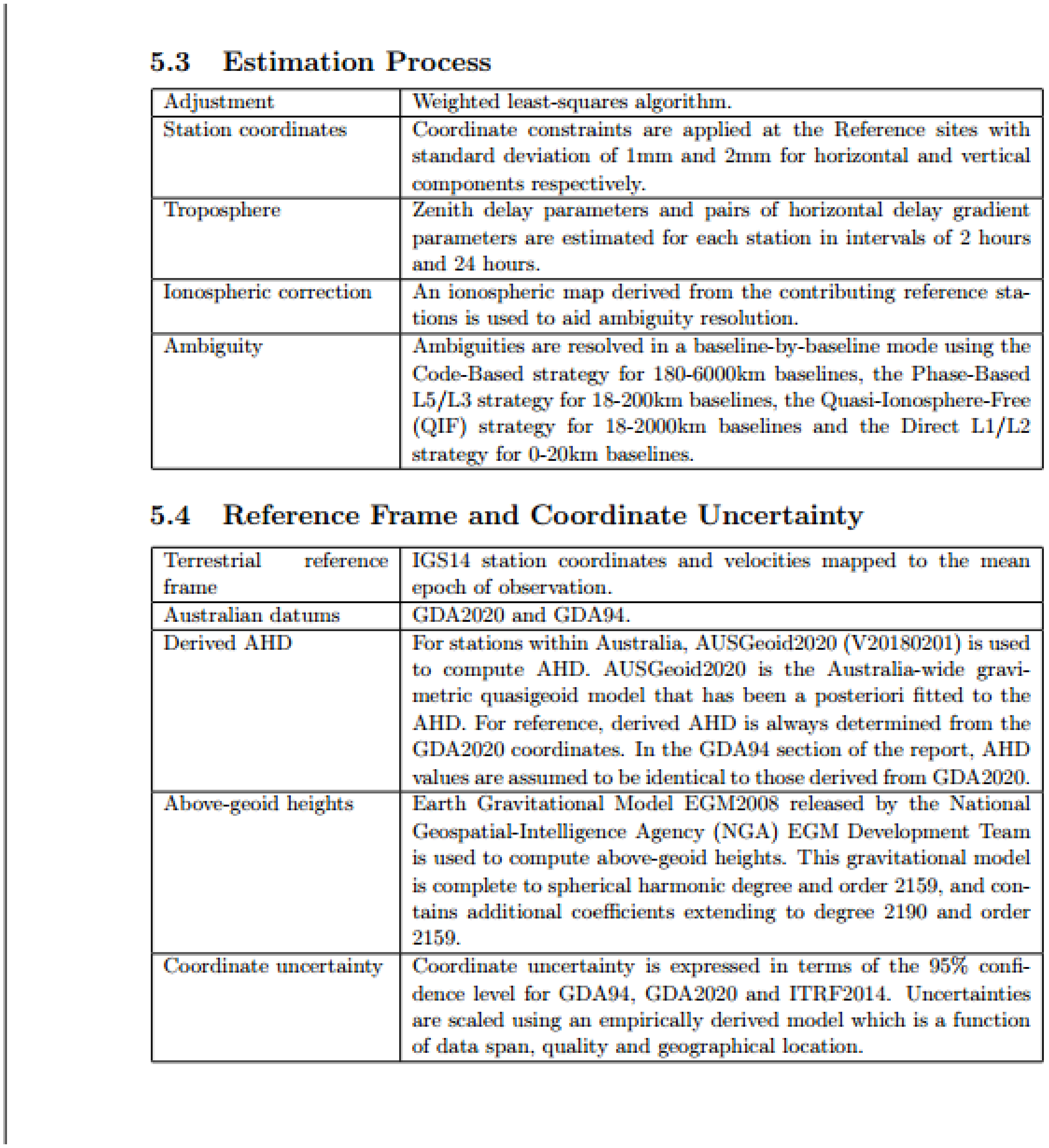
5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.



5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(\epsilon)^2$ where ϵ is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.



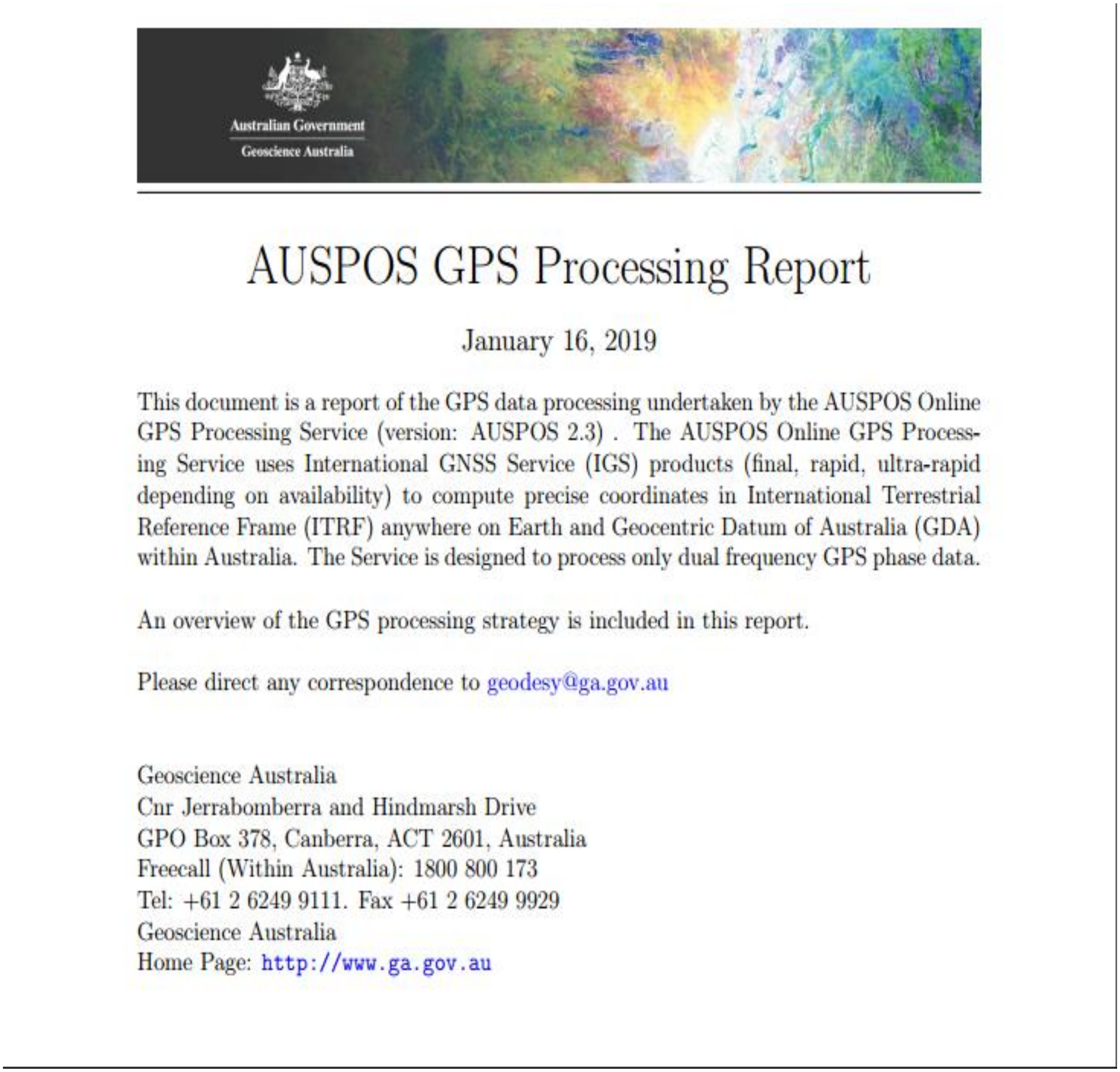
5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

Appendix C. Online (AUSPOS) static GPS data report for Harar (GCP-Ras Luel Mekonnen)



Australian Government
Geoscience Australia

AUSPOS GPS Processing Report

January 16, 2019

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 2.3) . The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is included in this report.

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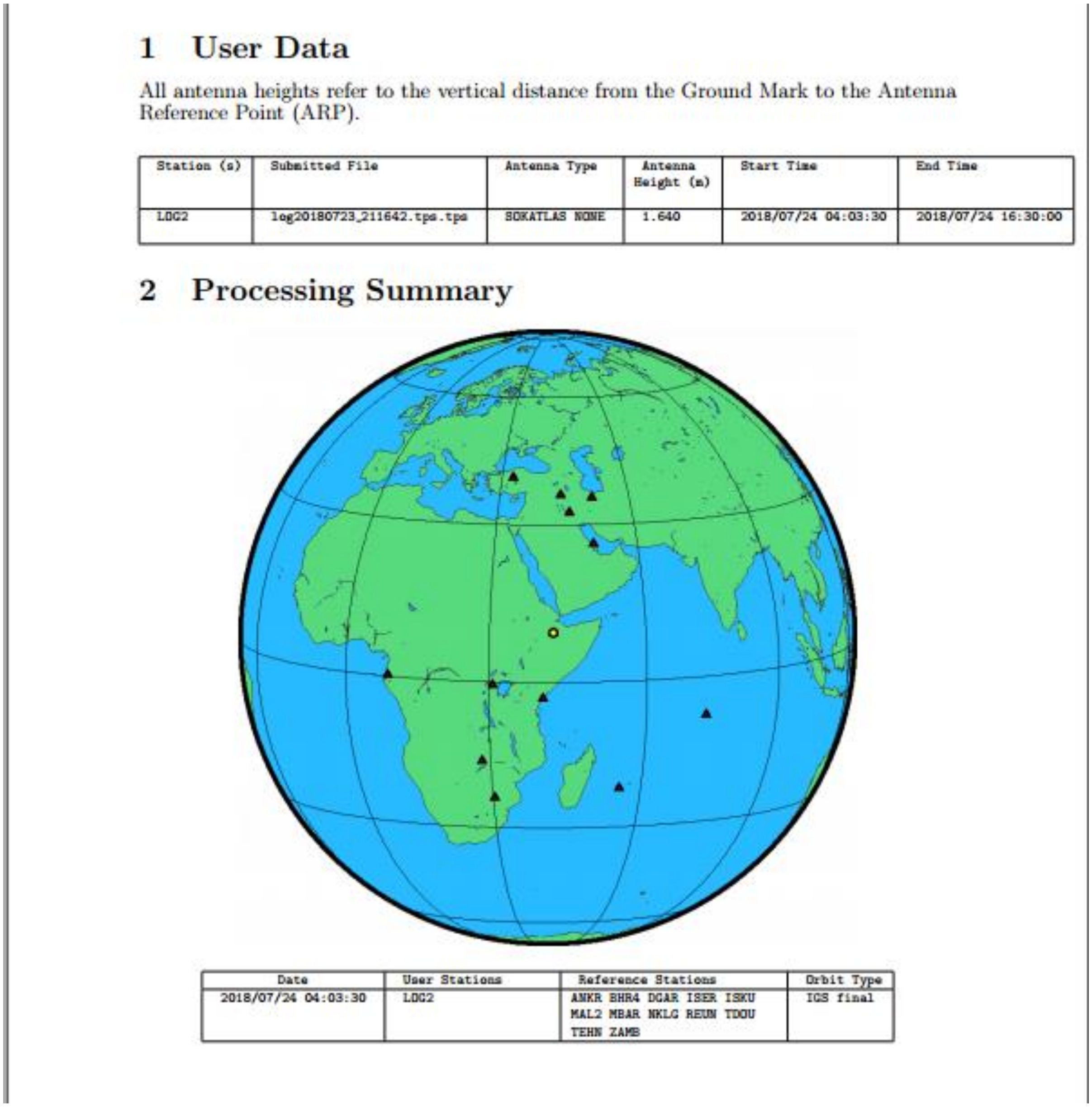


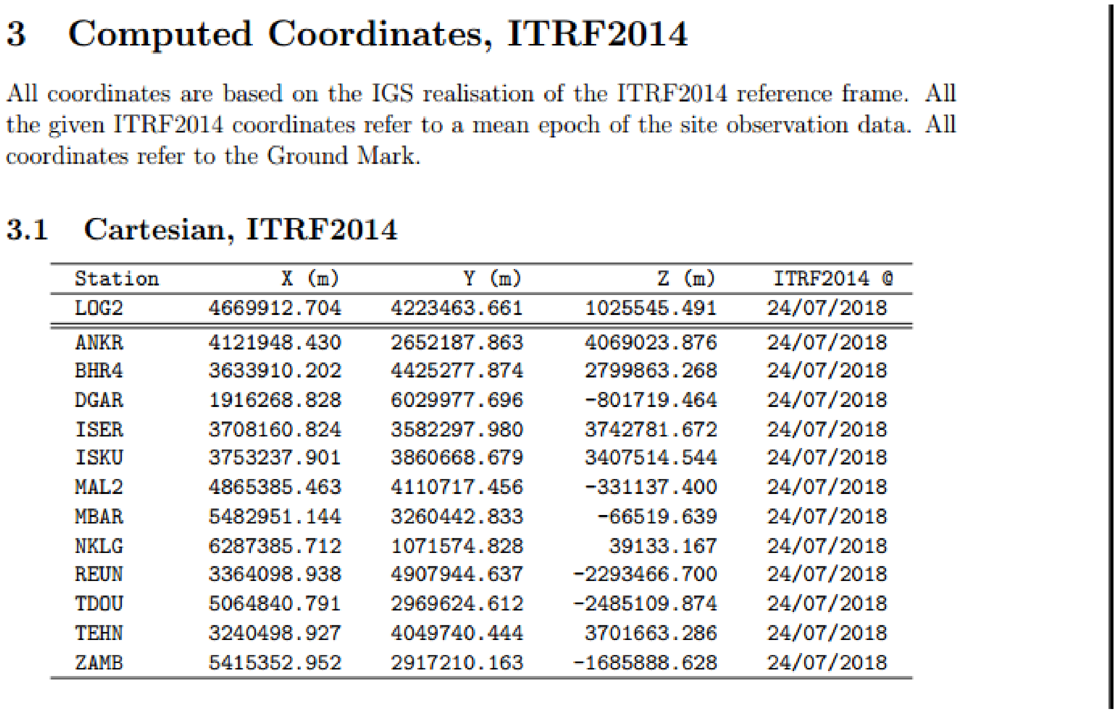
1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

Station (s)	Submitted File	Antenna Type	Antenna Height (m)	Start Time	End Time
LOG2	log20180723_211642.tps.tps	SOKATLAS NONE	1.640	2018/07/24 04:03:30	2018/07/24 16:30:00

2 Processing Summary

Date	User Stations	Reference Stations	Orbit Type
2018/07/24 04:03:30	LOG2	ANKR BHR4 DGAR ISER ISKU MAL2 MBAR NKLG REUN TDOU TEHN ZAMB	IGS final

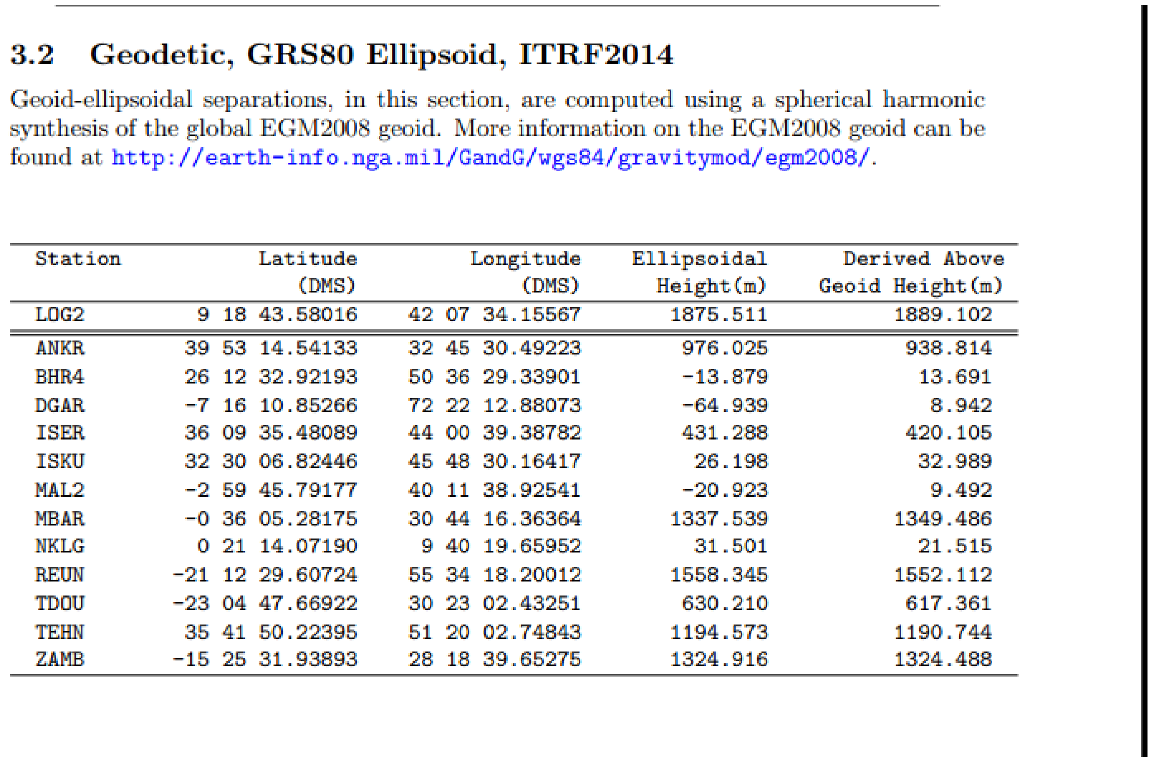


3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
LOG2	4669912.704	4223463.661	1025545.491	24/07/2018
ANKR	4121948.430	2652187.863	4069023.876	24/07/2018
BHR4	3633910.202	4425277.874	2799863.268	24/07/2018
DGAR	1916268.828	6029977.696	-801719.464	24/07/2018
ISER	3708160.824	3582297.980	3742781.672	24/07/2018
ISKU	3753237.901	3860668.679	3407514.544	24/07/2018
MAL2	4865385.463	4110717.456	-331137.400	24/07/2018
MBAR	5482951.144	3260442.833	-66519.639	24/07/2018
NKLG	6287385.712	1071574.828	39133.167	24/07/2018
REUN	3364098.938	4907944.637	-2293466.700	24/07/2018
TDOU	5064840.791	2969624.612	-2485109.874	24/07/2018
TEHN	3240498.927	4049740.444	3701663.286	24/07/2018
ZAMB	5415352.952	2917210.163	-1685888.628	24/07/2018

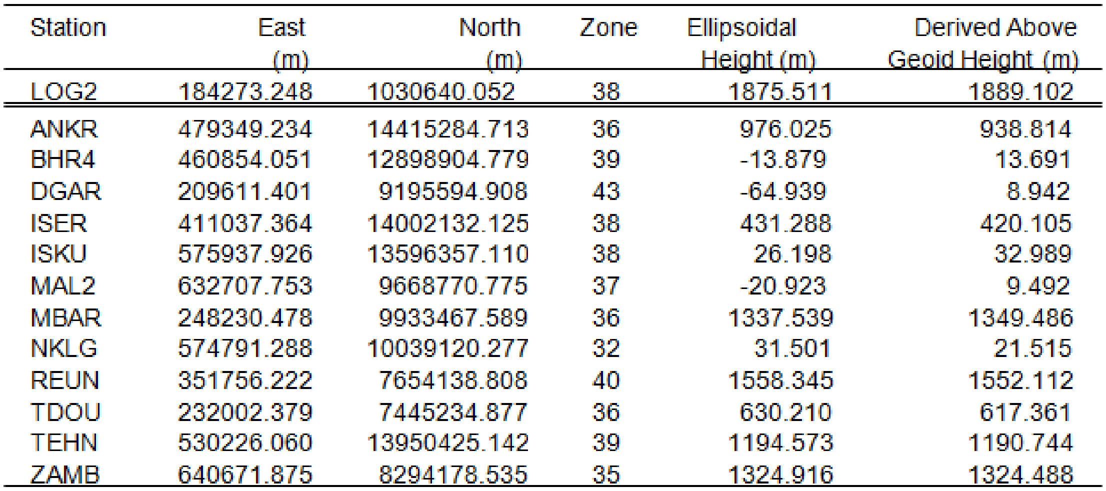


3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/.

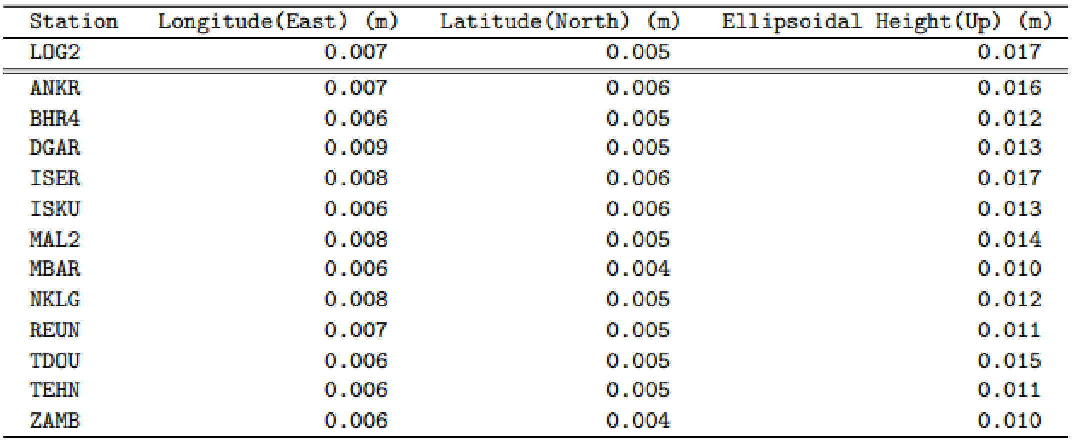
Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
LOG2	9 18 43.58016	42 07 34.15567	1875.511	1889.102
ANKR	39 53 14.54133	32 45 30.49223	976.025	938.814
BHR4	26 12 32.92193	50 36 29.33901	-13.879	13.691
DGAR	-7 16 10.85266	72 22 12.88073	-64.939	8.942
ISER	36 09 35.48089	44 00 39.38782	431.288	420.105
ISKU	32 30 06.82446	45 48 30.16417	26.198	32.989
MAL2	-2 59 45.79177	40 11 38.92541	-20.923	9.492
MBAR	-0 36 05.28175	30 44 16.36364	1337.539	1349.486
NKLG	0 21 14.07190	9 40 19.65952	31.501	21.515
REUN	-21 12 29.60724	55 34 18.20012	1558.345	1552.112
TDOU	-23 04 47.66922	30 23 02.43251	630.210	617.361
TEHN	35 41 50.22395	51 20 02.74843	1194.573	1190.744
ZAMB	-15 25 31.93893	28 18 39.65275	1324.916	1324.488

3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

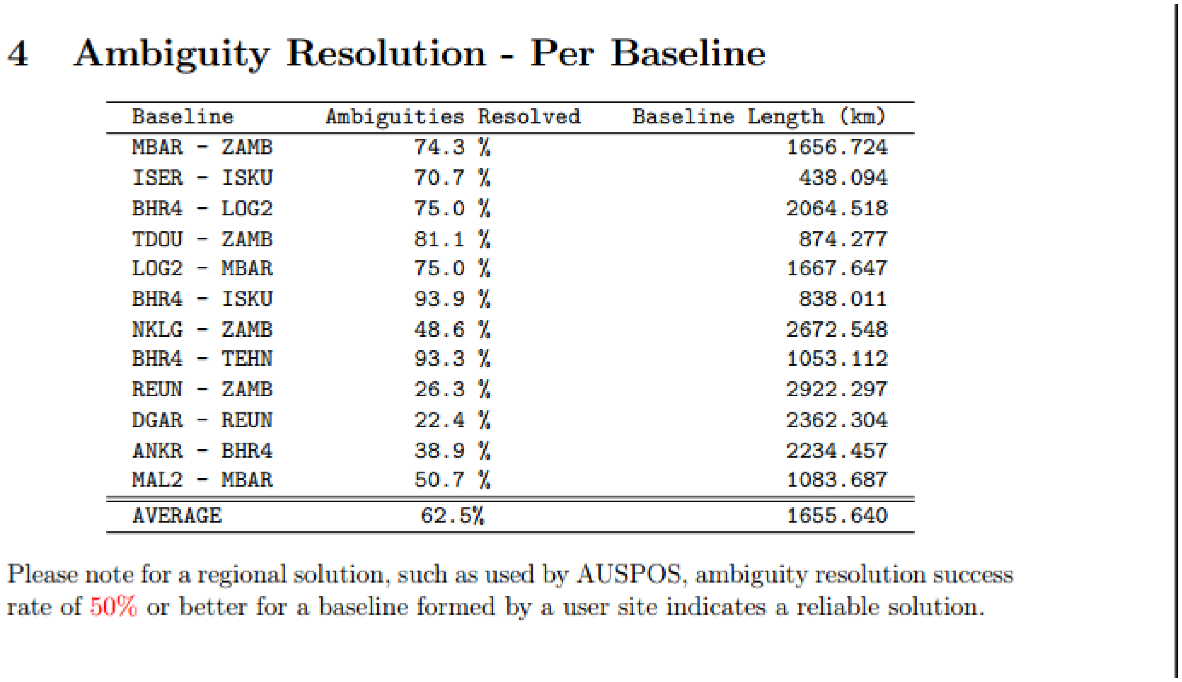


Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height (m)
LOG2	184273.248	1030640.052	38	1875.511	1889.102
ANKR	479349.234	14415284.713	36	976.025	938.814
BHR4	460854.051	12898904.779	39	-13.879	13.691
DGAR	209611.401	9195594.908	43	-64.939	8.942
ISER	411037.364	14002132.125	38	431.288	420.105
ISKU	575937.926	13596357.110	38	26.198	32.989
MAL2	632707.753	9668770.775	37	-20.923	9.492
MBAR	248230.478	9933467.589	36	1337.539	1349.486
NKLG	574791.288	10039120.277	32	31.501	21.515
REUN	351756.222	7654138.808	40	1558.345	1552.112
TDOU	232002.379	7445234.877	36	630.210	617.361
TEHN	530226.060	13950425.142	39	1194.573	1190.744
ZAMB	640671.875	8294178.535	35	1324.916	1324.488

3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014



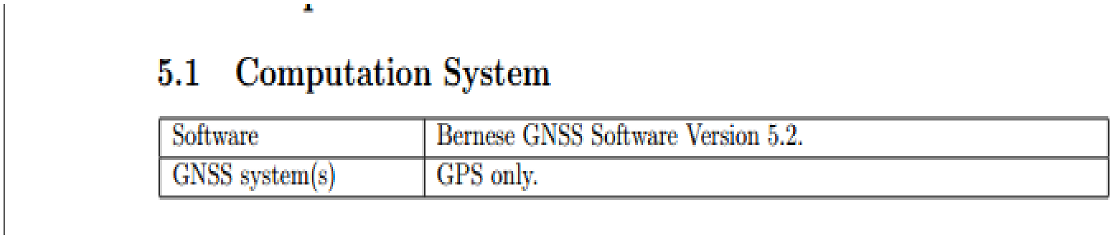
Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
LOG2	0.007	0.005	0.017
ANKR	0.007	0.006	0.016
BHR4	0.006	0.005	0.012
DGAR	0.009	0.005	0.013
ISER	0.008	0.006	0.017
ISKU	0.006	0.006	0.013
MAL2	0.008	0.005	0.014
MBAR	0.006	0.004	0.010
NKLG	0.008	0.005	0.012
REUN	0.007	0.005	0.011
TDOU	0.006	0.005	0.015
TEHN	0.006	0.005	0.011
ZAMB	0.006	0.004	0.010



4 Ambiguity Resolution - Per Baseline

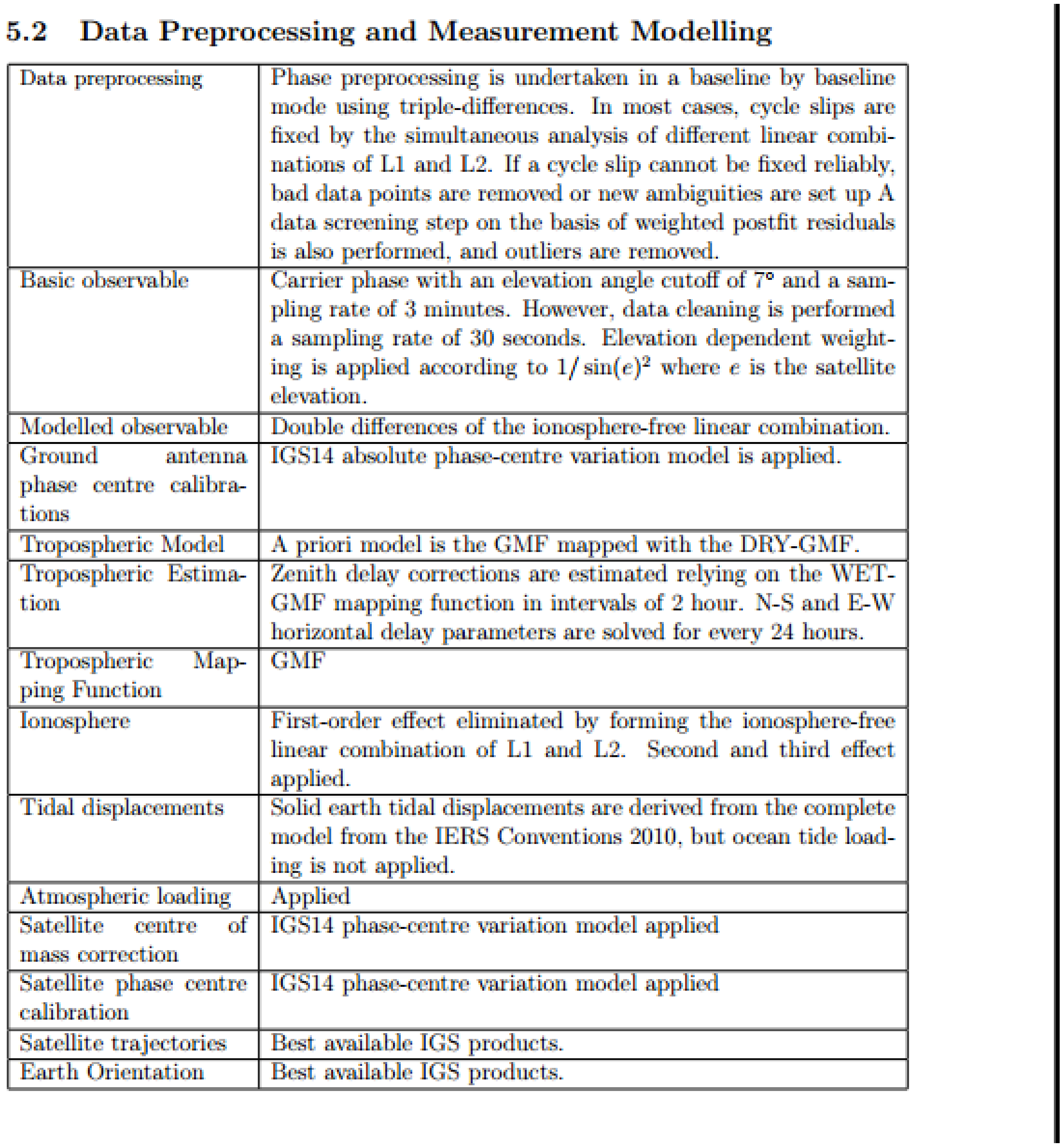
Baseline	Ambiguities Resolved	Baseline Length (km)
MBAR - ZAMB	74.3 %	1656.724
ISER - ISKU	70.7 %	438.094
BHR4 - LOG2	75.0 %	2064.518
TDOU - ZAMB	81.1 %	874.277
LOG2 - MBAR	75.0 %	1667.647
BHR4 - ISKU	93.9 %	838.011
NKLG - ZAMB	48.6 %	2672.548
BHR4 - TEHN	93.3 %	1053.112
REUN - ZAMB	26.3 %	2922.297
DGAR - REUN	22.4 %	2362.304
ANKR - BHR4	38.9 %	2234.457
MAL2 - MBAR	50.7 %	1083.687
AVERAGE	62.5%	1655.640

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of 50% or better for a baseline formed by a user site indicates a reliable solution.



5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.



5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(e)^2$ where e is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.

5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

Appendix D. Online (OPUS) static GPS data report for Dire Dawa (GCP-38)

OPUS SOLUTION REPORT
========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

```
USER: fggreat@gmail.com                DATE: August 17, 2018
RINEX FILE: ddad205e.18o                    TIME: 11:15:33 UTC

SOFTWARE: page5 1603.24 master58.pl 160321
START: 2018/07/24 04:28:00  STOP: 2018/07/24  16:31:00
EPHEMERIS: igs20112.eph [precise]
NAV FILE: brdc2050.18n
OBS USED: 28523 / 28885   :  99%
ANT NAME: SOKATLAS
ARP HEIGHT: 1.5700m
FIXED AMB:    79 /    87   :  91%
OVERALL RMS: 0.012(m)
```

REF FRAME: IGS08 (EPOCH:2018.5601)

```
    X:     4684921.339(m)   0.036(m)
    Y:     4197924.453(m)   0.029(m)
    Z:     1057023.331(m)   0.010(m)

LAT:    9 36  5.68645      0.017(m)
E LON:   41 51 42.96074      0.014(m)
W LON:  318  8 17.03926      0.014(m)
EL HGT:         1195.614(m)   0.041(m)
```

WGS84 UTM COORDINATES

UTM (Zone 37)

Northing (Y) [meters]	1062671.742
Easting (X) [meters]	814153.826
Convergence [degrees]	0.47775278
Point Scale	1.00082148
Combined Factor	1.00063331

BASE STATIONS USED

DESIGNATION	DISTANCE (m)
ADIS	345864.5
MBAR	1666755.0
BHR4	2047878.2

Appendix E. Online (OPUS) static GPS data report for Dire Dawa (GCP-62)

OPUS SOLUTION REPORT

========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: fggreat@gmail.com DATE: December 14, 2018

RINEX FILE: log2205e.18o TIME: 08:33:26 UTC

SOFTWARE: page5 1603.24 master73.pl 160321

START: 2018/07/24 04: 23:00 STOP: 2018/07/24 16:26:00

EPHEMERIS: igs20112.eph [precise]

NAV FILE: brdc2050.18n

OBS USED: 28503 / 28873 : 99%
ANT NAME: SOKATLAS

ARP HEIGHT: 1.5800

FIXED AMB: 79 / 91 : 87%

OVERALL RMS: 0.012(m)

REF FRAME: IGS08 (EPOCH:2018.5601)

X:	4684002.295(m)	0.036(m)
Y:	4199231.568(m)	0.032(m)
Z:	1055988.689(m)	0.011(m)

LAT:	9 35 31.46820	0.017(m)
E LON:	41 52 34.98953	0.015(m)
W LON:	318 7 25.01047	0.015(m)
EL HGT:	1208.518(m)	0.042(m)

WGS84 UTM COORDINATES

UTM (Zone 37)

Northing (Y) [meters]	1061632.866
Easting (X) [meters]	815750.346
Convergence [degrees]	0.47969722
Point Scale	1.00083393
Combined Factor	1.00064373

BASE STATIONS USED

DESIGNATION	**DISTANCE(m)**
ADIS	347242.8
MBAR	1667233.8
BHR4	2048142.8

Appendix F. Online (OPUS) static GPS data report for Harar (GCP-Ras Luel Mekonnen)

```
                       OPUS SOLUTION REPORT
                       ========================

 All computed coordinate accuracies are listed as peak-to-peak values.
 For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

 USER: fggreat@gmail.com                    DATE: December 13, 2018
 RINEX FILE: log2205e.18o                   TIME: 08:53:15 UTC
 SOFTWARE: page5  1603.24 master53.pl 160321
 START: 2018/07/24  04:03:00    STOP: 2018/07/24  16:30:00
  EPHEMERIS: igs20112.eph [precise]
  NAV FILE: brdc2050.18n
 OBS USED: 28567 / 29093   :  98%
  ANT NAME: SOKATLAS
 ARP HEIGHT: 1.6400
 FIXED AMB:    97 /   106   :  92%
 OVERALL RMS: 0.014(m)

  REF FRAME: IGS08 (EPOCH:2018.5601)

         X:      4669912.743(m)   0.054(m)
         Y:      4223463.699(m)   0.045(m)
         Z:      1025545.503(m)   0.006(m)

       LAT:    9 18 43.58023       0.016(m)
     E LON:   42  7 34.15573       0.016(m)
     W LON:  317 52 25.84427       0.016(m)
    EL HGT:         1875.566(m)   0.063(m)

              WGS84UTM COORDINATES
                     UTM (Zone 38)
 Northing (Y) [meters]     1030640.054
 Easting (X)  [meters]      184273.250
 Convergence  [degrees]    -0.46541111
 Point Scale            1.00083377
 Combined Factor           1.00053861

                       BASE STATIONS USED
   DESIGNATION                             DISTANCE(m)
     MBAR                                     1667647.1
     ADIS                                     370604.7
     BHR4                                     2064517.8
```

Appendix G : Mangnet office static GPS data processing Result of GCP 38 and 62 (Dire Dawa)

Project name: MSc
Linear unit: Meters
Angular unit: DMS
Projection: UTMNorth-Zone_37 : 36E to 42E
Datum: WGS84

Control Points					
Name	**Control**	**Grid Northing (m)**	**Grid Easting (m)**	**Elevation (m)**	**Code**
ADIS	Both	998745.053	474317.028	2440.42	

GPS Observations									
Name	**SigmaX (m)**	**SigmaY (m)**	**SigmaZ (m)**	**Horz RMS (m)**	**Vert RMS (m)**	**Duration**	**Solution Type**	**Orbit**	**Distance (m)**
ADIS–GCP-38	0.063	0.055	0.028	0.022	0.078	12:03:20	Fixed	Precise	345864.588
ADIS–GCP-62	0.063	0.056	0.028	0.012	0.078	12:02:15	Fixed	Precise	347242.865
GCP-38–GCP-62	0.001	0.001	0.001	0.001	0.001	11:57:20	Fixed	Precise	1903.592

Adjusted Points			
Name	**Grid Northing (m)**	**Grid Easting (m)**	**Elevation (m)**
GCP-38	1062671.709	814154.658	1197.092
GCP-62	1061632.836	815751.176	1209.979

Appendix H: Mangnet office static GPS data processing Result of Harar GCP

Project name: MSc
Linear unit: Meters
Angular unit: DMS
Projection: UTMNorth-Zone_38 : 42E to 48E
Datum: WGS84

Control Points					
Name	**Control**	**Grid Northing (m)**	**Grid Easting (m)**	**Elevation (m)**	**Code**
ADIS	Both	998745.053	474317.028	2440.42	

GPS Observations									
Name	**SigmaX (m)**	**SigmaY (m)**	**SigmaZ (m)**	**Horz RMS (m)**	**Vert RMS (m)**	**Duration**	**Solution Type**	**Orbit**	**Distance (m)**
ADIS–harar GCP	0.034	0.027	0.032	0.033	0.061	12:26:55	Fixed	Precise	370604.7

Adjusted Points			
Name	**Grid Northing (m)**	**Grid Easting (m)**	**Elevation (m)**
harar GCP	1030640.009	184274.078	1877.056

Appendix I orthophoto parcel planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

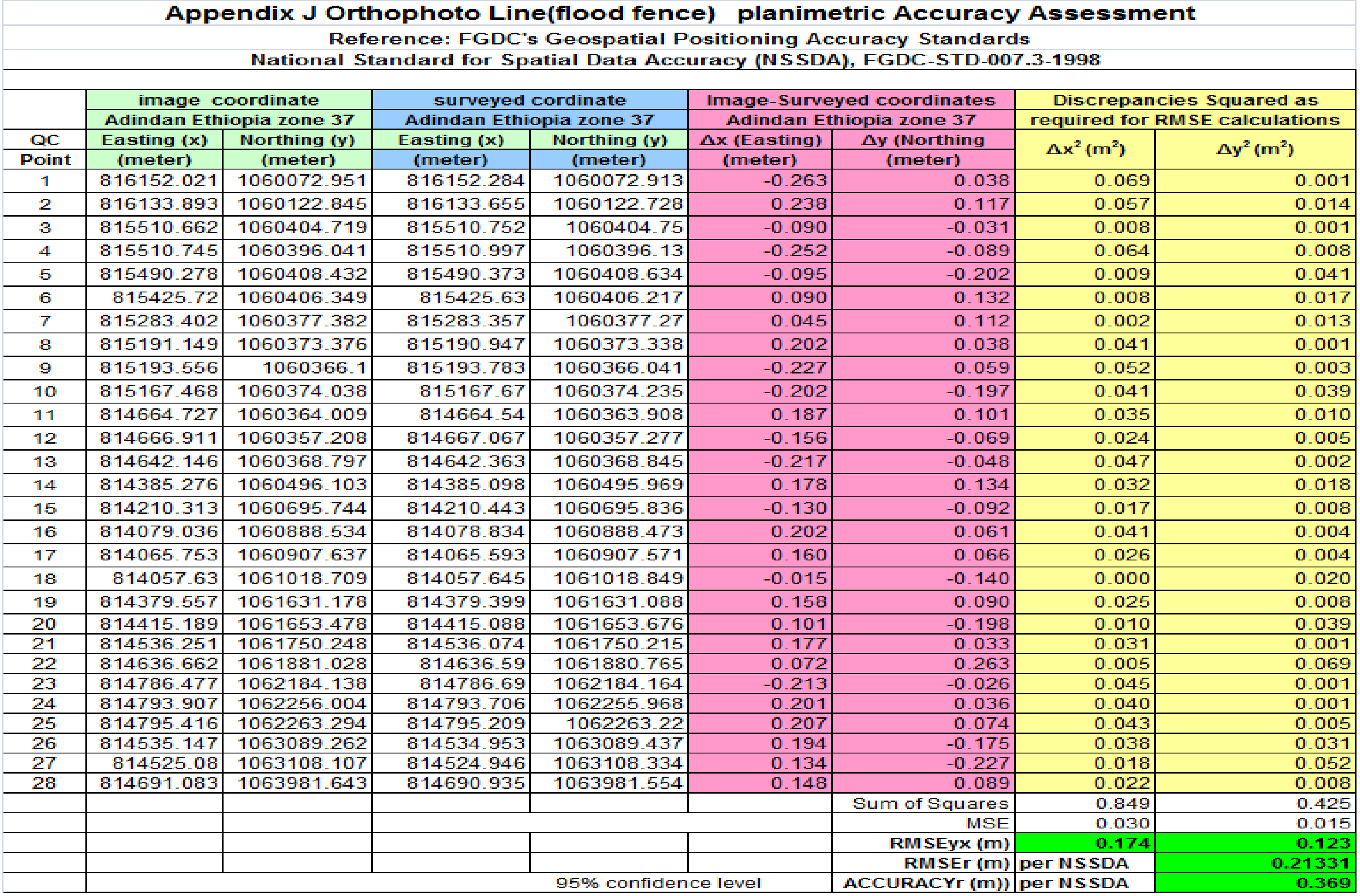
National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	image coordinate		surveyed cordinate		Image-Surveyed coordinates		Discrepancies Squared as	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	$\Delta x^2 (m^2)$	$\Delta y^2 (m^2)$
1	814041.219	1060286.671	814041.19	1060286.808	0.029	-0.137	0.001	0.019
2	814048.885	1060251.311	814048.94	1060251.19	-0.055	0.121	0.003	0.015
3	814007.199	1060242.451	814007.246	1060242.305	-0.047	0.146	0.002	0.021
4	814001.059	1060243.476	814000.767	1060243.333	0.292	0.143	0.085	0.020
5	813993.531	1060276.423	813993.482	1060276.65	0.049	-0.227	0.002	0.052
6	813388.934	1062405.719	813388.959	1062405.706	-0.025	0.013	0.001	0.000
7	813353.544	1062487.033	813353.292	1062486.94	0.252	0.093	0.064	0.009
8	813386.312	1062518.723	813386.194	1062518.589	0.118	0.134	0.014	0.018
9	813434.268	1062469.39	813434.508	1062469.276	-0.240	0.114	0.058	0.013
10	813142.967	1062723.501	813143.105	1062723.962	-0.138	-0.461	0.019	0.213
11	813138.786	1062771.144	813138.728	1062771.135	0.058	0.009	0.003	0.000
12	813163.271	1062776.494	813163.335	1062777.086	-0.064	-0.592	0.004	0.350
13	813168.369	1062727.998	813168.558	1062727.864	-0.189	0.134	0.036	0.018
14	813480.949	1060094.169	813481.154	1060093.959	-0.205	0.210	0.042	0.044
15	813443.185	1060125.273	813443.085	1060125.27	0.100	0.003	0.010	0.000
16	813444.785	1060131.938	813443.393	1060132.01	1.392	-0.072	1.938	0.005
17	813480.976	1060129.386	813481.077	1060129.385	-0.101	0.001	0.010	0.000
18	815340.252	1061919.612	815340.206	1061919.829	0.046	-0.217	0.002	0.047
19	815332.168	1061933.26	815332.325	1061933.354	-0.157	-0.094	0.025	0.009
20	815352.982	1061945.799	815352.861	1061945.76	0.121	0.039	0.015	0.002
21	815358.302	1061930.597	815358.282	1061930.652	0.020	-0.055	0.000	0.003
22	815286.038	1061974.412	815286.212	1061974.631	-0.174	-0.219	0.030	0.048
23	815271.201	1061964.295	815271.55	1061964.416	-0.349	-0.121	0.122	0.015
24	815259.93	1061978.449	815259.91	1061978.597	0.020	-0.148	0.000	0.022
25	815269.929	1061991.949	815270.019	1061992.111	-0.090	-0.162	0.008	0.026
26	815274.487	1061991.903	815274.53	1061992.176	-0.043	-0.273	0.002	0.075
27	814390.38	1063725.869	814390.503	1063725.558	-0.123	0.311	0.015	0.097
28	814363.03	1063829.457	814362.581	1063829.615	0.449	-0.158	0.202	0.025

29	814550.791	1063879.633	814551.177	1063879.783	-0.386	-0.150	0.149	0.023
30	814568.885	1063773.187	814569.028	1063772.68	-0.143	0.507	0.020	0.257
31	812719.097	1061184.434	812719.259	1061184.772	-0.162	-0.338	0.026	0.114
32	812688.6	1061187.217	812688.792	1061187.548	-0.192	-0.331	0.037	0.110
33	812678.658	1061243.096	812678.77	1061243.318	-0.112	-0.222	0.013	0.049
34	812681.03	1061246.348	812680.861	1061246.684	0.169	-0.336	0.029	0.113
35	812701.846	1061248.887	812701.626	1061249.103	0.220	-0.216	0.048	0.047
36	812717.786	1061236.581	812717.867	1061236.76	-0.081	-0.179	0.007	0.032
37	815843.985	1061732.188	815844.116	1061732.19	-0.131	-0.002	0.017	0.000
38	815795.707	1061715.092	815795.676	1061714.919	0.031	0.173	0.001	0.030
39	815771.698	1061785.436	815771.466	1061785.413	0.232	0.023	0.054	0.001
40	815774.931	1061794.153	815774.639	1061793.822	0.292	0.331	0.085	0.110
41	815816.814	1061809.267	815817.051	1061809.552	-0.237	-0.285	0.056	0.081
42	814514.619	1061890.729	814514.642	1061890.376	-0.023	0.353	0.001	0.125
43	814465.517	1061971.635	814465.314	1061971.905	0.203	-0.270	0.041	0.073
44	814467.835	1061985.962	814467.711	1061986.011	0.124	-0.049	0.015	0.002
45	814504.905	1062019.55	814504.893	1062019.633	0.012	-0.083	0.000	0.007
46	814568.371	1061927.961	814568.761	1061927.801	-0.390	0.160	0.152	0.026
47	815617.677	1061329.338	815617.695	1061329.029	-0.018	0.309	0.000	0.095
48	815615.923	1061376.561	815615.908	1061376.397	0.015	0.164	0.000	0.027
49	815639.456	1061384.423	815639.565	1061384.743	-0.109	-0.320	0.012	0.102
50	815653.887	1061341.894	815654.118	1061341.872	-0.231	0.022	0.053	0.000
51	808127.721	1064622.711	808128.101	1064622.591	-0.380	0.120	0.144	0.014
52	808131.357	1064579.894	808131.611	1064580	-0.254	-0.106	0.065	0.011
53	808072.152	1064576.811	808072.011	1064577	0.141	-0.189	0.020	0.036
54	808068.687	1064618.559	808068.629	1064618.471	0.058	0.088	0.003	0.008
55	811543.903	1063407.571	811543.965	1063407.425	-0.062	0.146	0.004	0.021
56	811505.141	1063290.881	811504.975	1063290.737	0.166	0.144	0.028	0.021
57	811436.782	1063313.741	811436.792	1063313.553	-0.010	0.188	0.000	0.035
58	811475.322	1063431.451	811475.414	1063431.581	-0.092	-0.130	0.008	0.017
59	811267.767	1063740.582	811267.793	1063740.657	-0.026	-0.075	0.001	0.006
60	811236.677	1063750.545	811236.668	1063750.493	0.009	0.052	0.000	0.003
61	811243.102	1063768.923	811243.29	1063768.973	-0.188	-0.050	0.035	0.003
62	811280.097	1063778.095	811280.125	1063778.211	-0.028	-0.116	0.001	0.013
63	815395.763	1065001.385	815395.927	1065001.595	-0.164	-0.210	0.027	0.044
64	815205.872	1064992.137	815205.672	1064992.251	0.200	-0.114	0.040	0.013
65	815197.489	1065134.153	815197.404	1065133.748	0.085	0.405	0.007	0.164
66	815346.948	1065141.307	815347.183	1065141.364	-0.235	-0.057	0.055	0.003

67	810227.916	1062356.684	810227.864	1062356.671	0.052	0.013	0.003	0.000
68	810312.144	1062328.087	810312.262	1062328.021	-0.118	0.066	0.014	0.004
69	810292.383	1062270.711	810292.185	1062269.694	0.198	1.017	0.039	1.034
70	810207.852	1062298.101	810207.604	1062298.209	0.248	-0.108	0.062	0.012
71	815367.053	1061314.938	815367.352	1061314.902	-0.299	0.036	0.089	0.001
72	815070.169	1061219.012	815070.17	1061218.835	-0.001	0.177	0.000	0.031
73	814951.294	1061355.353	814951.152	1061354.332	0.142	1.021	0.020	1.042
74	815004.641	1061526.274	815004.792	1061526.424	-0.151	-0.150	0.023	0.023
75	815204.269	1061558.024	815204.346	1061557.861	-0.077	0.163	0.006	0.027
76	815390.007	1061679.468	815390.139	1061679.086	-0.132	0.382	0.017	0.146
77	815414.613	1061672.324	815414.743	1061672.389	-0.130	-0.065	0.017	0.004
78	815437.797	1061647.21	815437.874	1061647.26	-0.077	-0.050	0.006	0.003
79	815481.288	1061571.121	815481.27	1061571.265	0.018	-0.144	0.000	0.021
80	815486.845	1061517.94	815487.122	1061517.882	-0.277	0.058	0.077	0.003
81	812204.03	1062461.718	812204.238	1062461.539	-0.208	0.179	0.043	0.032
82	812179.463	1062384.321	812179.203	1062384.266	0.260	0.055	0.068	0.003
83	812048.944	1062429.988	812049.128	1062429.551	-0.184	0.437	0.034	0.191
84	812075.27	1062506.717	812075.49	1062506.589	-0.220	0.128	0.048	0.016
85	811966.221	1061305.159	811966.312	1061305.262	-0.091	-0.103	0.008	0.011
86	811965.968	1061291.971	811966.208	1061291.976	-0.240	-0.005	0.058	0.000
87	811938.515	1061293.354	811938.414	1061293.236	0.101	0.118	0.010	0.014
88	811938.945	1061303.886	811938.867	1061304.012	0.078	-0.126	0.006	0.016
89	809971.078	1062344.809	809971.298	1062344.715	-0.220	0.094	0.048	0.009
90	809982.662	1062341.129	809982.359	1062340.954	0.303	0.175	0.092	0.031
91	809976.047	1062322.343	809976.158	1062322.162	-0.111	0.181	0.012	0.033
92	809964.391	1062326.385	809964.407	1062326.153	-0.016	0.232	0.000	0.054
93	808255.835	1064801.93	808256.111	1064802.111	-0.276	-0.181	0.076	0.033
94	808132.956	1064791.877	808132.901	1064792	0.055	-0.123	0.003	0.015
95	808130.444	1064824.446	808130.412	1064825	0.032	-0.554	0.001	0.307
96	808253.502	1064832.983	808253.601	1064833	-0.099	-0.017	0.010	0.000
97	805097.574	1063665.023	805097.448	1063665.117	0.126	-0.094	0.016	0.009
98	805098.161	1063644.744	805097.991	1063644.595	0.170	0.149	0.029	0.022
99	805122.916	1063665.592	805123.067	1063665.594	-0.151	-0.002	0.023	0.000
100	805123.532	1063645.763	805123.65	1063645.666	-0.118	0.097	0.014	0.009
101	805098.022	1064872.554	805098.149	1064872.599	-0.127	-0.045	0.016	0.002
102	805098.396	1064852.773	805098.478	1064852.666	-0.082	0.107	0.007	0.011
103	805075.338	1064853.528	805075.205	1064853.568	0.133	-0.040	0.018	0.002
104	805074.804	1064870.118	805074.887	1064870.236	-0.083	-0.118	0.007	0.014

105	805330.703	1064869.338	805330.683	1064869.062	0.020	0.276	0.000	0.076
106	805324.348	1064831.734	805324.491	1064831.565	-0.143	0.169	0.020	0.029
107	805299.13	1064835.61	805298.985	1064835.57	0.145	0.040	0.021	0.002
108	805305.077	1064873.014	805305.018	1064873.088	0.059	-0.074	0.003	0.005
109	810223.014	1063221.675	810223.202	1063221.262	-0.188	0.413	0.035	0.171
110	810211.979	1063226.205	810211.802	1063226.093	0.177	0.112	0.031	0.013
111	810219	1063244.349	810218.898	1063244.48	0.102	-0.131	0.010	0.017
112	810230.408	1063239.823	810230.544	1063239.742	-0.136	0.081	0.018	0.007
113	812289.259	1064052.608	812289.583	1064052.74	-0.324	-0.132	0.105	0.017
114	812286.426	1064028.188	812286.46	1064027.966	-0.034	0.222	0.001	0.049
115	812258.547	1064031.376	812258.457	1064031.035	0.090	0.341	0.008	0.116
116	812261.415	1064055.838	812261.246	1064055.779	0.169	0.059	0.029	0.003
117	815450.985	1063506.111	815450.878	1063506.292	0.107	-0.181	0.011	0.033
118	815433.309	1063477.598	815433.179	1063477.574	0.130	0.024	0.017	0.001
119	815391.038	1063505.767	815390.955	1063505.842	0.083	-0.075	0.007	0.006
120	815415.309	1063528.356	815415.205	1063528.589	0.104	-0.233	0.011	0.054
121	812702.315	1061236.549	812702.411	1061236.592	-0.096	-0.043	0.009	0.002
122	807350.715	1064901.207	807350.901	1064901.011	-0.186	0.196	0.035	0.038
123	807346.527	1065011.823	807346.701	1065012.112	-0.174	-0.289	0.030	0.084
124	807398.167	1064904.042	807398.1	1064904.011	0.067	0.031	0.004	0.001
125	807393.179	1065013.641	807393.601	1065014.001	-0.422	-0.360	0.178	0.130
						Sum of Squares	5.574	7.037
						MSE	0.045	0.056
						RMSEyx (m)	**0.211**	**0.237**
						RMSEr (m)	**per NSSDA**	**0.31763**
				95% confidence level		**ACCURACYr (m))**	**per NSSDA**	**0.550**

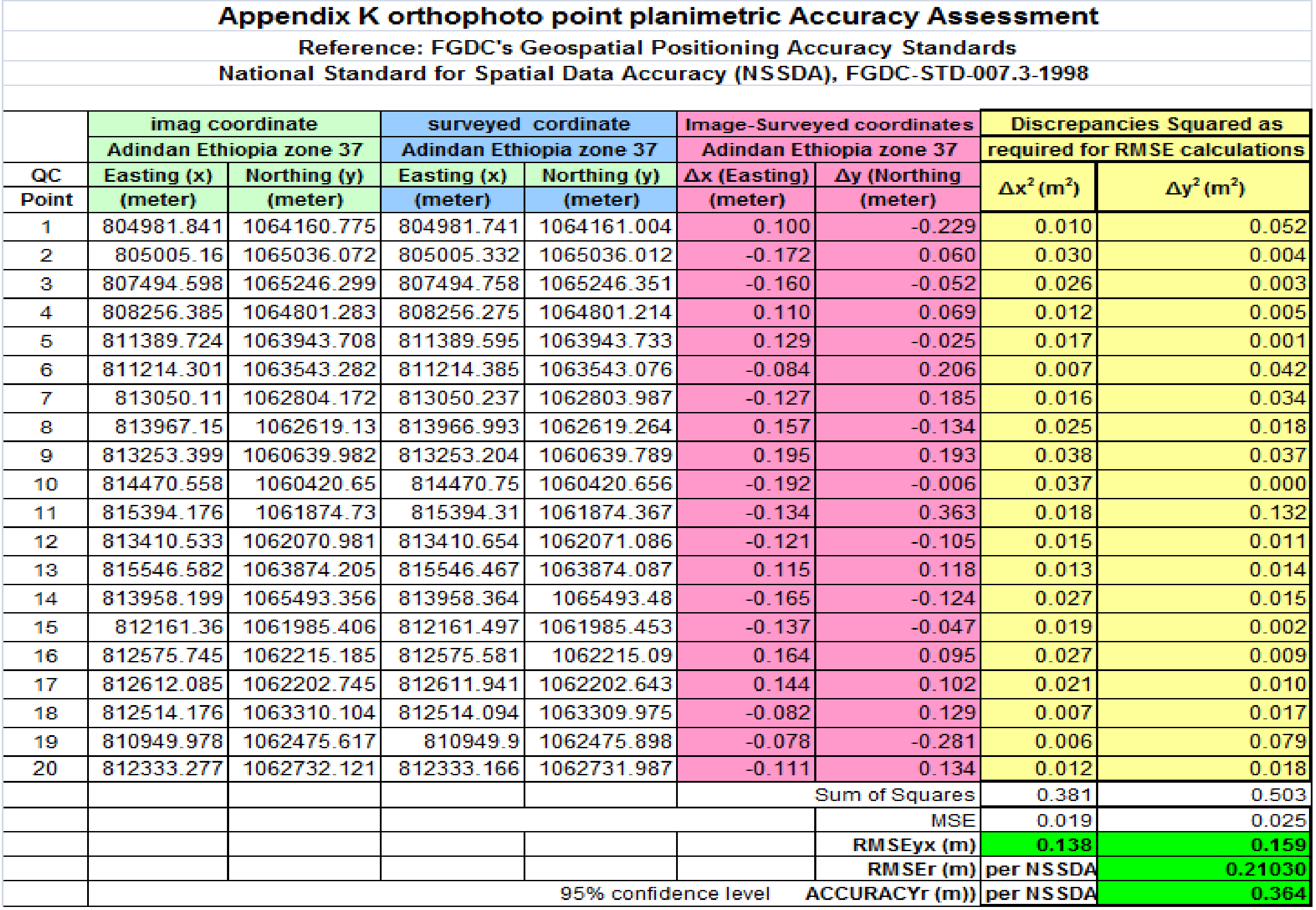


Appendix J Orthophoto Line(flood fence) planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	image coordinate Adindan Ethiopia zone 37		surveyed cordinate Adindan Ethiopia zone 37		Image-Surveyed coordinates Adindan Ethiopia zone 37		Discrepancies Squared as required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	816152.021	1060072.951	816152.284	1060072.913	-0.263	0.038	0.069	0.001
2	816133.893	1060122.845	816133.655	1060122.728	0.238	0.117	0.057	0.014
3	815510.662	1060404.719	815510.752	1060404.75	-0.090	-0.031	0.008	0.001
4	815510.745	1060396.041	815510.997	1060396.13	-0.252	-0.089	0.064	0.008
5	815490.278	1060408.432	815490.373	1060408.634	-0.095	-0.202	0.009	0.041
6	815425.72	1060406.349	815425.63	1060406.217	0.090	0.132	0.008	0.017
7	815283.402	1060377.382	815283.357	1060377.27	0.045	0.112	0.002	0.013
8	815191.149	1060373.376	815190.947	1060373.338	0.202	0.038	0.041	0.001
9	815193.556	1060366.1	815193.783	1060366.041	-0.227	0.059	0.052	0.003
10	815167.468	1060374.038	815167.67	1060374.235	-0.202	-0.197	0.041	0.039
11	814664.727	1060364.009	814664.54	1060363.908	0.187	0.101	0.035	0.010
12	814666.911	1060357.208	814667.067	1060357.277	-0.156	-0.069	0.024	0.005
13	814642.146	1060368.797	814642.363	1060368.845	-0.217	-0.048	0.047	0.002
14	814385.276	1060496.103	814385.098	1060495.969	0.178	0.134	0.032	0.018
15	814210.313	1060695.744	814210.443	1060695.836	-0.130	-0.092	0.017	0.008
16	814079.036	1060888.534	814078.834	1060888.473	0.202	0.061	0.041	0.004
17	814065.753	1060907.637	814065.593	1060907.571	0.160	0.066	0.026	0.004
18	814057.63	1061018.709	814057.645	1061018.849	-0.015	-0.140	0.000	0.020
19	814379.557	1061631.178	814379.399	1061631.088	0.158	0.090	0.025	0.008
20	814415.189	1061653.478	814415.088	1061653.676	0.101	-0.198	0.010	0.039
21	814536.251	1061750.248	814536.074	1061750.215	0.177	0.033	0.031	0.001
22	814636.662	1061881.028	814636.59	1061880.765	0.072	0.263	0.005	0.069
23	814786.477	1062184.138	814786.69	1062184.164	-0.213	-0.026	0.045	0.001
24	814793.907	1062256.004	814793.706	1062255.968	0.201	0.036	0.040	0.001
25	814795.416	1062263.294	814795.209	1062263.22	0.207	0.074	0.043	0.005
26	814535.147	1063089.262	814534.953	1063089.437	0.194	-0.175	0.038	0.031
27	814525.08	1063108.107	814524.946	1063108.334	0.134	-0.227	0.018	0.052
28	814691.083	1063981.643	814690.935	1063981.554	0.148	0.089	0.022	0.008
						Sum of Squares	0.849	0.425
						MSE	0.030	0.015
						RMSEyx (m)	0.174	0.123
						RMSEr (m)	per NSSDA	0.21331
	95% confidence level					ACCURACYr (m))	per NSSDA	0.369

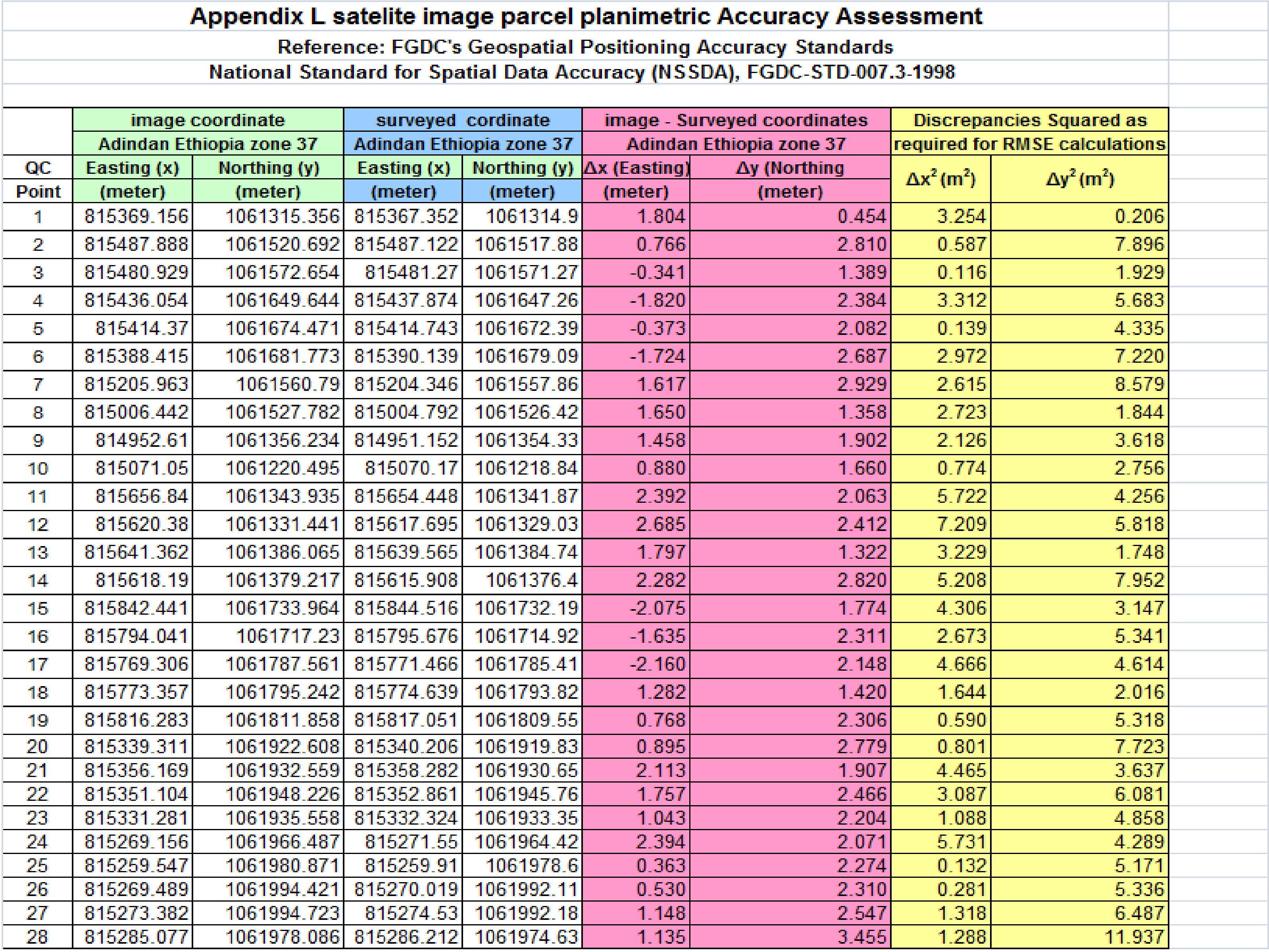


Appendix K orthophoto point planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	imag coordinate		surveyed cordinate		Image-Surveyed coordinates		Discrepancies Squared as	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	804981.841	1064160.775	804981.741	1064161.004	0.100	-0.229	0.010	0.052
2	805005.16	1065036.072	805005.332	1065036.012	-0.172	0.060	0.030	0.004
3	807494.598	1065246.299	807494.758	1065246.351	-0.160	-0.052	0.026	0.003
4	808256.385	1064801.283	808256.275	1064801.214	0.110	0.069	0.012	0.005
5	811389.724	1063943.708	811389.595	1063943.733	0.129	-0.025	0.017	0.001
6	811214.301	1063543.282	811214.385	1063543.076	-0.084	0.206	0.007	0.042
7	813050.11	1062804.172	813050.237	1062803.987	-0.127	0.185	0.016	0.034
8	813967.15	1062619.13	813966.993	1062619.264	0.157	-0.134	0.025	0.018
9	813253.399	1060639.982	813253.204	1060639.789	0.195	0.193	0.038	0.037
10	814470.558	1060420.65	814470.75	1060420.656	-0.192	-0.006	0.037	0.000
11	815394.176	1061874.73	815394.31	1061874.367	-0.134	0.363	0.018	0.132
12	813410.533	1062070.981	813410.654	1062071.086	-0.121	-0.105	0.015	0.011
13	815546.582	1063874.205	815546.467	1063874.087	0.115	0.118	0.013	0.014
14	813958.199	1065493.356	813958.364	1065493.48	-0.165	-0.124	0.027	0.015
15	812161.36	1061985.406	812161.497	1061985.453	-0.137	-0.047	0.019	0.002
16	812575.745	1062215.185	812575.581	1062215.09	0.164	0.095	0.027	0.009
17	812612.085	1062202.745	812611.941	1062202.643	0.144	0.102	0.021	0.010
18	812514.176	1063310.104	812514.094	1063309.975	-0.082	0.129	0.007	0.017
19	810949.978	1062475.617	810949.9	1062475.898	-0.078	-0.281	0.006	0.079
20	812333.277	1062732.121	812333.166	1062731.987	-0.111	0.134	0.012	0.018
						Sum of Squares	0.381	0.503
						MSE	0.019	0.025
						RMSEyx (m)	0.138	0.159
						RMSEr (m)	per NSSDA	0.21030
			95% confidence level			ACCURACYr (m))	per NSSDA	0.364



Appendix L satelite image parcel planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

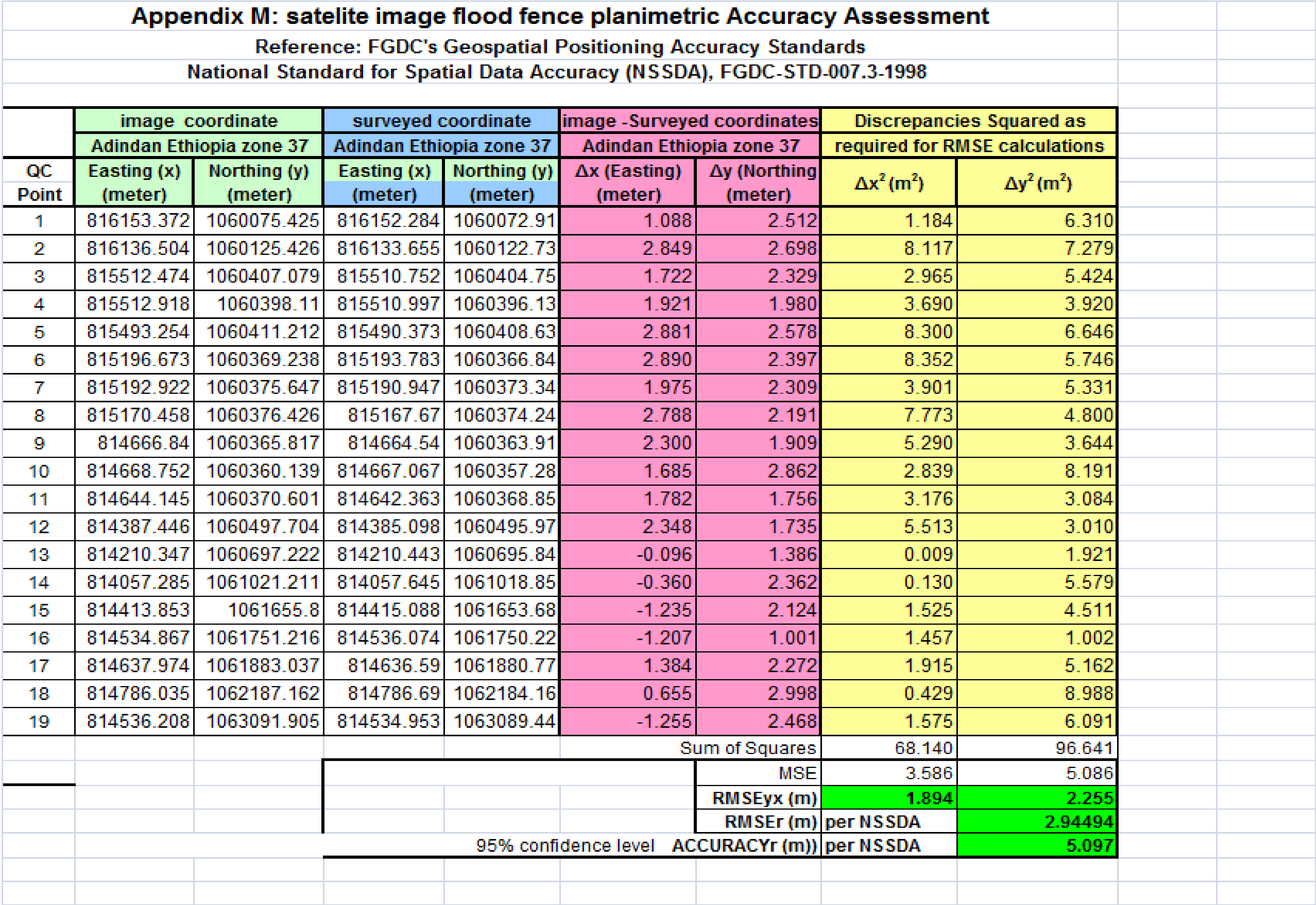
National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	image coordinate Adindan Ethiopia zone 37		surveyed cordinate Adindan Ethiopia zone 37		image - Surveyed coordinates Adindan Ethiopia zone 37		Discrepancies Squared as required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	815369.156	1061315.356	815367.352	1061314.9	1.804	0.454	3.254	0.206
2	815487.888	1061520.692	815487.122	1061517.88	0.766	2.810	0.587	7.896
3	815480.929	1061572.654	815481.27	1061571.27	-0.341	1.389	0.116	1.929
4	815436.054	1061649.644	815437.874	1061647.26	-1.820	2.384	3.312	5.683
5	815414.37	1061674.471	815414.743	1061672.39	-0.373	2.082	0.139	4.335
6	815388.415	1061681.773	815390.139	1061679.09	-1.724	2.687	2.972	7.220
7	815205.963	1061560.79	815204.346	1061557.86	1.617	2.929	2.615	8.579
8	815006.442	1061527.782	815004.792	1061526.42	1.650	1.358	2.723	1.844
9	814952.61	1061356.234	814951.152	1061354.33	1.458	1.902	2.126	3.618
10	815071.05	1061220.495	815070.17	1061218.84	0.880	1.660	0.774	2.756
11	815656.84	1061343.935	815654.448	1061341.87	2.392	2.063	5.722	4.256
12	815620.38	1061331.441	815617.695	1061329.03	2.685	2.412	7.209	5.818
13	815641.362	1061386.065	815639.565	1061384.74	1.797	1.322	3.229	1.748
14	815618.19	1061379.217	815615.908	1061376.4	2.282	2.820	5.208	7.952
15	815842.441	1061733.964	815844.516	1061732.19	-2.075	1.774	4.306	3.147
16	815794.041	1061717.23	815795.676	1061714.92	-1.635	2.311	2.673	5.341
17	815769.306	1061787.561	815771.466	1061785.41	-2.160	2.148	4.666	4.614
18	815773.357	1061795.242	815774.639	1061793.82	1.282	1.420	1.644	2.016
19	815816.283	1061811.858	815817.051	1061809.55	0.768	2.306	0.590	5.318
20	815339.311	1061922.608	815340.206	1061919.83	0.895	2.779	0.801	7.723
21	815356.169	1061932.559	815358.282	1061930.65	2.113	1.907	4.465	3.637
22	815351.104	1061948.226	815352.861	1061945.76	1.757	2.466	3.087	6.081
23	815331.281	1061935.558	815332.324	1061933.35	1.043	2.204	1.088	4.858
24	815269.156	1061966.487	815271.55	1061964.42	2.394	2.071	5.731	4.289
25	815259.547	1061980.871	815259.91	1061978.6	0.363	2.274	0.132	5.171
26	815269.489	1061994.421	815270.019	1061992.11	0.530	2.310	0.281	5.336
27	815273.382	1061994.723	815274.53	1061992.18	1.148	2.547	1.318	6.487
28	815285.077	1061978.086	815286.212	1061974.63	1.135	3.455	1.288	11.937

29	815415.143	1063531.321	815415.205	1063528.59	0.062	2.732	0.004	7.464
30	815448.267	1063508.697	815450.878	1063506.29	2.611	2.405	6.817	5.784
31	815431.759	1063479.23	815433.179	1063477.57	1.420	1.656	2.016	2.742
32	815391.301	1063509.118	815390.955	1063505.84	-0.346	3.276	0.120	10.732
33	814566.674	1063774.572	814569.328	1063772.68	2.654	1.892	7.044	3.580
34	814549.003	1063880.706	814551.177	1063879.78	2.174	0.923	4.726	0.852
35	814361.536	1063832.379	814362.581	1063829.62	1.045	2.764	1.092	7.640
36	814388.908	1063728.453	814390.503	1063725.56	1.595	2.895	2.544	8.381
37	813277.299	1062733.497	813279.12	1062731.43	1.821	2.072	3.316	4.293
38	813305.029	1062735.58	813307.116	1062735.37	2.087	0.211	4.356	0.045
39	813309.867	1062696.497	813312.292	1062694.55	2.425	1.944	5.881	3.779
40	813386.859	1062408.222	813388.959	1062405.71	2.100	2.516	4.410	6.330
41	813431.6	1062471.125	813434.508	1062469.28	2.908	1.849	8.456	3.419
42	813384.275	1062520.313	813386.194	1062518.59	1.919	1.724	3.683	2.972
43	813351.619	1062488.932	813353.292	1062486.94	1.673	1.992	2.799	3.968
44	811871.851	1061353.135	811869.863	1061350.05	-1.988	3.086	3.952	9.523
45	811879.765	1061375.741	811877.428	1061373.27	-2.337	2.469	5.462	6.096
46	811870.546	1061374.391	811868.418	1061372.25	-2.128	2.140	4.528	4.580
47	811882.707	1061352.932	811880.984	1061350.9	-1.723	2.029	2.969	4.117
48	812202.724	1062462.093	812204.238	1062461.54	1.514	0.554	2.292	0.307
49	812177.41	1062386.374	812179.203	1062384.27	1.793	2.108	3.215	4.444
50	812048.158	1062432.634	812049.127	1062429.55	0.969	3.083	0.939	9.505
51	812073.234	1062507.802	812075.49	1062506.59	2.256	1.213	5.090	1.471
52	811541.46	1063409.591	811543.965	1063407.43	2.505	2.166	6.275	4.692
53	811475.169	1063433.803	811475.414	1063431.58	0.245	2.222	0.060	4.937
54	811437.205	1063315.35	811436.792	1063313.55	-0.413	1.797	0.171	3.229
55	811503.605	1063292.571	811504.975	1063290.74	1.370	1.834	1.877	3.364
56	811278.584	1063780.661	811280.125	1063778.21	1.541	2.450	2.375	6.003
57	811266.198	1063742.798	811267.793	1063740.66	1.595	2.141	2.544	4.584
58	811235.623	1063752.874	811236.668	1063750.49	1.045	2.380	1.092	5.664
59	811242.113	1063771.525	811243.29	1063768.97	1.177	2.552	1.385	6.513
60	810290.73	1062271.868	810292.185	1062269.69	1.455	2.174	2.117	4.726
61	810312.021	1062330.708	810312.262	1062328.02	0.241	2.687	0.058	7.220
62	810226.933	1062359.367	810227.864	1062356.67	0.931	2.696	0.867	7.268
63	810207.878	1062296.209	810207.604	1062298.21	-0.274	-2.000	0.075	4.000
64	807690.223	1064637.085	807692.646	1064635.16	2.423	1.924	5.871	3.702
65	807693.742	1064587.317	807695.477	1064585.96	1.735	1.362	3.010	1.855
66	807642.039	1064633.963	807643.588	1064631.87	1.549	2.090	2.399	4.368
67	807644.975	1064585.065	807646.909	1064582.97	1.934	2.097	3.740	4.397
68	808068.729	1064588.473	808071.341	1064586.98	2.612	1.495	6.823	2.235

69	808009.661	1064584.048	808012.257	1064583.24	2.596	0.804	6.739	0.646
70	808007.2	1064626.847	808009.037	1064624.78	1.837	2.069	3.375	4.281
71	808066.209	1064630.498	808068.1	1064629.05	1.891	1.444	3.576	2.085
72	807344.484	1065013.587	807346.7	1065012	2.216	1.587	4.911	2.519
73	807391.606	1065015.833	807393.6	1065014	1.994	1.833	3.976	3.360
74	807349.206	1064903.266	807350.9	1064901	1.694	2.266	2.870	5.135
75	807395.896	1064905.214	807398.1	1064904	2.204	1.214	4.858	1.474
76	805328.956	1064870.809	805330.683	1064869.06	1.727	1.747	2.983	3.052
77	805303.45	1064874.492	805305.018	1064873.09	1.568	1.404	2.459	1.971
78	805322.45	1064834.085	805324.491	1064831.57	2.041	2.520	4.166	6.350
79	805297.498	1064837.328	805298.985	1064835.57	1.487	1.758	2.211	3.091
80	805096.75	1064854.804	805098.478	1064852.67	1.728	2.138	2.986	4.571
81	805073.625	1064855.201	805075.205	1064853.57	1.580	1.633	2.496	2.667
82	805096.181	1064874.605	805098.149	1064872.6	1.968	2.006	3.873	4.024
83	805073.173	1064872.573	805074.887	1064870.24	1.714	2.337	2.938	5.462
84	805096.534	1063667.143	805097.448	1063665.12	0.914	2.026	0.835	4.105
85	805095.948	1063646.158	805097.991	1063644.6	2.043	1.563	4.174	2.443
86	805121.393	1063667.365	805123.067	1063665.59	1.674	1.771	2.802	3.136
87	805121.972	1063647.981	805123.65	1063645.67	1.678	2.315	2.816	5.359
88	810228.53	1063241.146	810230.544	1063239.74	2.014	1.404	4.056	1.971
89	810216.505	1063245.406	810218.898	1063244.48	2.393	0.926	5.726	0.857
90	810209.538	1063227.049	810211.801	1063226.09	2.263	0.956	5.121	0.914
91	810220.923	1063222.567	810223.202	1063221.26	2.279	1.305	5.194	1.703
92	809964.929	1062327.148	809964.407	1062326.15	-0.522	0.995	0.272	0.990
93	809976.137	1062323.756	809976.159	1062322.16	0.022	1.594	0.000	2.541
94	809970.673	1062346.928	809971.298	1062344.72	0.625	2.213	0.391	4.897
95	809982.368	1062343.681	809982.359	1062340.95	-0.009	2.727	0.000	7.437
96	812259.51	1064058.298	812261.246	1064055.78	1.736	2.519	3.014	6.345
97	812287.46	1064054.672	812289.583	1064052.74	2.123	1.932	4.507	3.733
98	812284.724	1064031.007	812286.46	1064027.97	1.736	3.041	3.014	9.248
99	812257.257	1064032.308	812258.456	1064031.04	1.199	1.272	1.438	1.618
100	815393.784	1065004.138	815395.926	1065001.6	2.142	2.542	4.588	6.462
101	815202.532	1064994.555	815204.672	1064992.25	2.140	2.304	4.580	5.308
102	815196.23	1065136.155	815197.404	1065133.75	1.174	2.407	1.378	5.794
103	815345.887	1065143.704	815347.183	1065141.36	1.296	2.340	1.680	5.476
104	813280.995	1062692.599	813282.637	1062690.28	1.642	2.321	2.696	5.387
105	814042.772	1060288.954	814041.19	1060286.81	-1.582	2.146	2.503	4.605
106	814047.772	1060252.271	814048.94	1060251.19	1.168	1.081	1.364	1.169
107	814008.375	1060243.803	814007.246	1060242.31	-1.129	1.498	1.275	2.244
108	814002.085	1060245.361	814000.767	1060243.33	-1.318	2.028	1.737	4.113

109	813993.992	1060278.862	813993.482	1060276.65	-0.510	2.212	0.260	4.893
110	812687.174	1061190.15	812688.792	1061187.55	1.618	2.602	2.618	6.770
111	812719.519	1061186.901	812719.259	1061184.77	-0.260	2.129	0.068	4.533
112	812715.873	1061238.558	812717.867	1061236.76	1.994	1.798	3.976	3.233
113	812701.361	1061238.6	812702.411	1061236.59	1.050	2.008	1.102	4.032
114	812677.509	1061245.508	812678.77	1061243.32	1.261	2.191	1.590	4.800
115	812679.781	1061248.676	812680.861	1061246.68	1.080	1.992	1.166	3.968
116	812699.58	1061249.845	812701.626	1061249.1	2.046	0.742	4.186	0.551
117	813482.964	1060095.574	813481.154	1060093.96	-1.810	1.615	3.276	2.608
118	813482.496	1060131.933	813481.077	1060129.39	-1.419	2.548	2.014	6.492
119	813446.218	1060133.643	813443.393	1060132.01	-2.825	1.633	7.981	2.667
120	813444.3	1060126.276	813443.085	1060125.27	-1.215	1.006	1.476	1.012
121	814502.239	1062021.015	814504.893	1062019.63	2.654	1.382	7.044	1.910
122	814565.88	1061929.837	814568.761	1061927.8	2.881	2.036	8.300	4.145
123	814511.836	1061892.716	814514.642	1061890.38	2.806	2.340	7.874	5.476
124	814463.768	1061971.595	814465.314	1061971.91	1.546	-0.310	2.390	0.096
125	814465.966	1061986.457	814467.711	1061986.01	1.745	0.446	3.045	0.199
						Sum of Squares	376.445	536.501
						MSE	3.012	4.292
						RMSEyx (m)	**1.735**	**2.072**
						RMSEr (m)	**per NSSDA**	**2.70251**
	95% confidence level					**ACCURACYr (m))**	**per NSSDA**	**4.678**

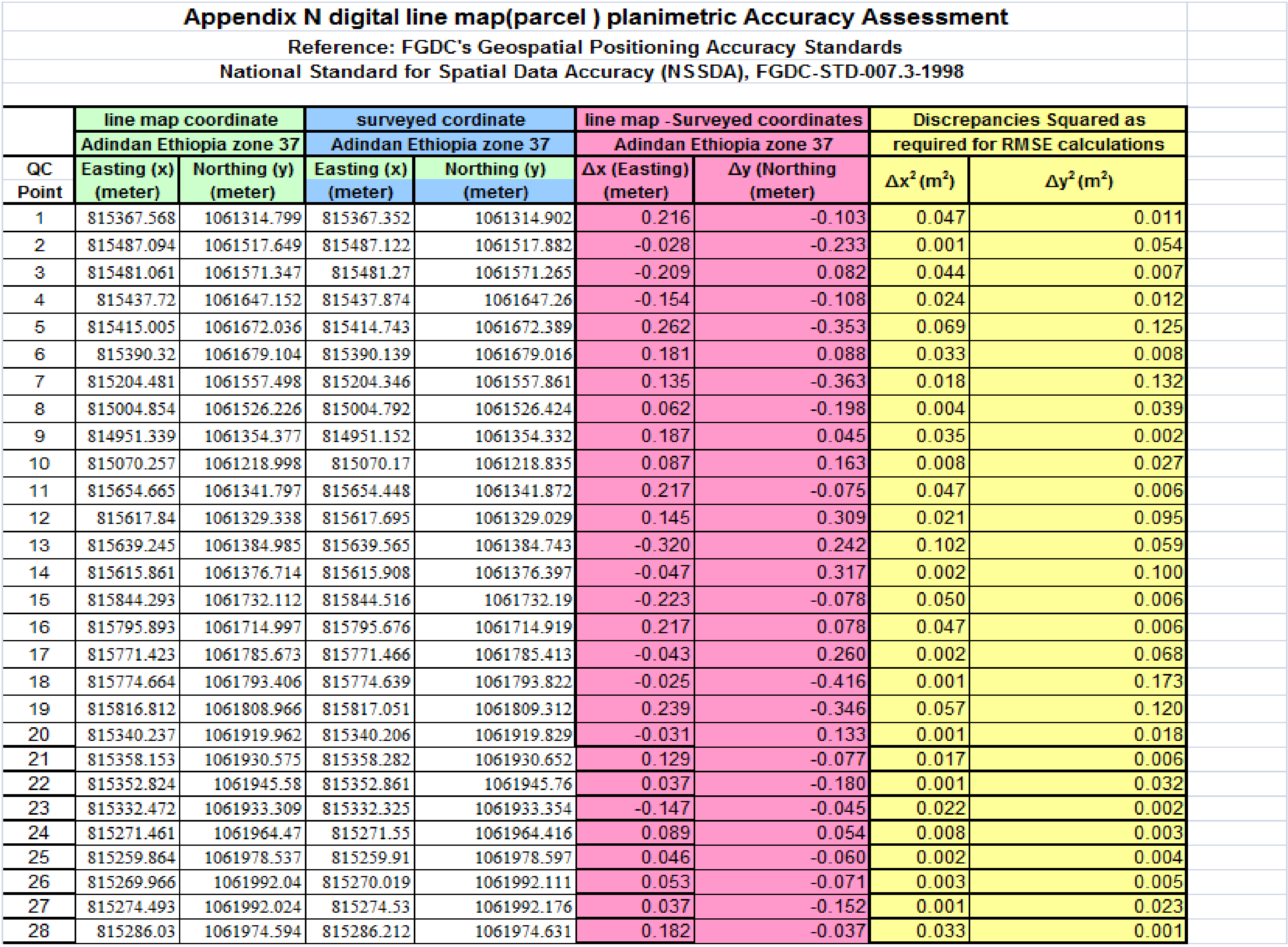


Appendix M: satelite image flood fence planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	image coordinate		surveyed coordinate		image -Surveyed coordinates		Discrepancies Squared as	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	816153.372	1060075.425	816152.284	1060072.91	1.088	2.512	1.184	6.310
2	816136.504	1060125.426	816133.655	1060122.73	2.849	2.698	8.117	7.279
3	815512.474	1060407.079	815510.752	1060404.75	1.722	2.329	2.965	5.424
4	815512.918	1060398.11	815510.997	1060396.13	1.921	1.980	3.690	3.920
5	815493.254	1060411.212	815490.373	1060408.63	2.881	2.578	8.300	6.646
6	815196.673	1060369.238	815193.783	1060366.84	2.890	2.397	8.352	5.746
7	815192.922	1060375.647	815190.947	1060373.34	1.975	2.309	3.901	5.331
8	815170.458	1060376.426	815167.67	1060374.24	2.788	2.191	7.773	4.800
9	814666.84	1060365.817	814664.54	1060363.91	2.300	1.909	5.290	3.644
10	814668.752	1060360.139	814667.067	1060357.28	1.685	2.862	2.839	8.191
11	814644.145	1060370.601	814642.363	1060368.85	1.782	1.756	3.176	3.084
12	814387.446	1060497.704	814385.098	1060495.97	2.348	1.735	5.513	3.010
13	814210.347	1060697.222	814210.443	1060695.84	-0.096	1.386	0.009	1.921
14	814057.285	1061021.211	814057.645	1061018.85	-0.360	2.362	0.130	5.579
15	814413.853	1061655.8	814415.088	1061653.68	-1.235	2.124	1.525	4.511
16	814534.867	1061751.216	814536.074	1061750.22	-1.207	1.001	1.457	1.002
17	814637.974	1061883.037	814636.59	1061880.77	1.384	2.272	1.915	5.162
18	814786.035	1062187.162	814786.69	1062184.16	0.655	2.998	0.429	8.988
19	814536.208	1063091.905	814534.953	1063089.44	-1.255	2.468	1.575	6.091
						Sum of Squares	68.140	96.641
						MSE	3.586	5.086
						RMSEyx (m)	1.894	2.255
						RMSEr (m)	per NSSDA	2.94494
					95% confidence level	ACCURACYr (m))	per NSSDA	5.097



Appendix N digital line map(parcel) planimetric Accuracy Assessment

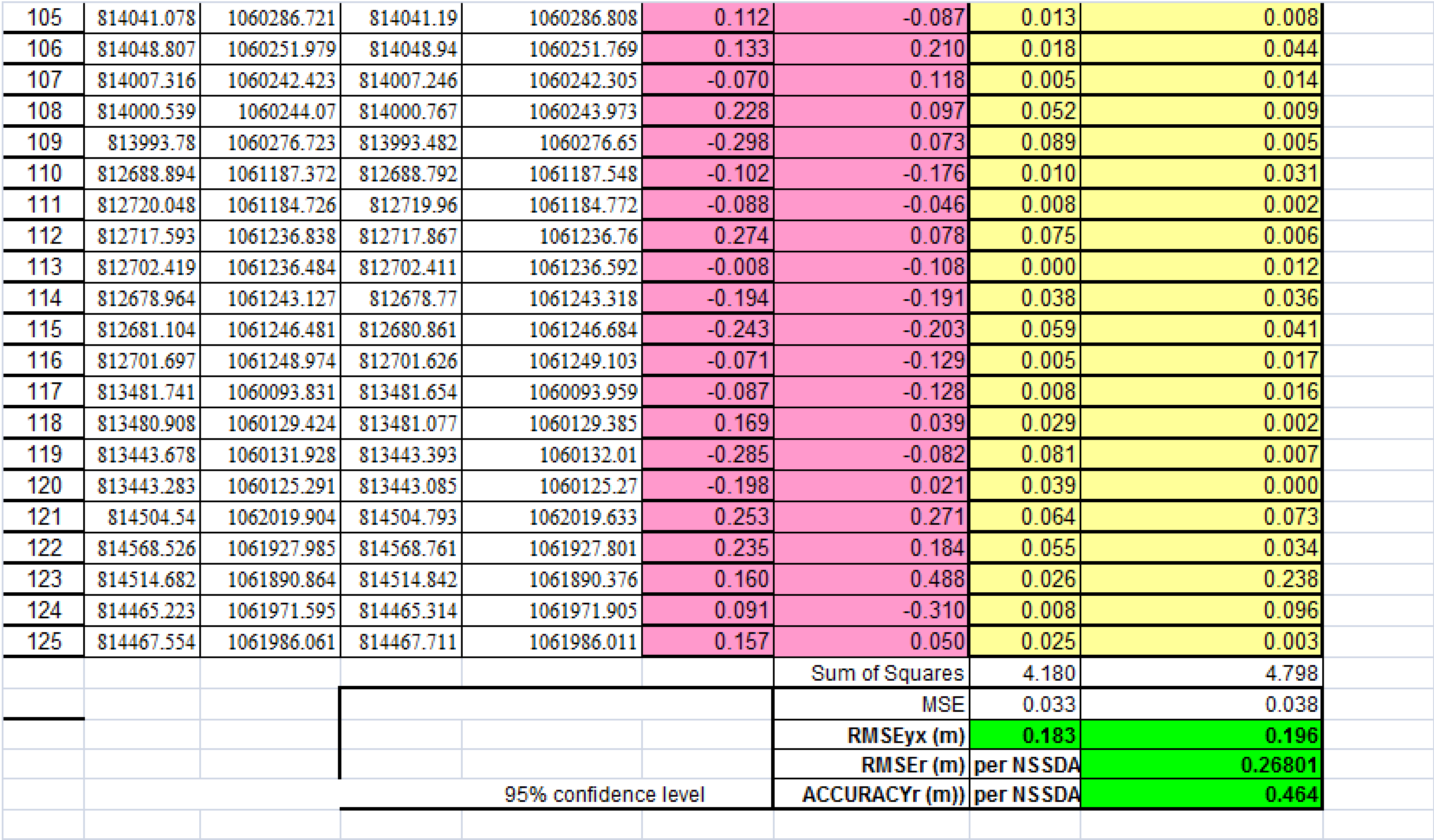
Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	line map coordinate		surveyed cordinate		line map -Surveyed coordinates		Discrepancies Squared as	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	815367.568	1061314.799	815367.352	1061314.902	0.216	-0.103	0.047	0.011
2	815487.094	1061517.649	815487.122	1061517.882	-0.028	-0.233	0.001	0.054
3	815481.061	1061571.347	815481.27	1061571.265	-0.209	0.082	0.044	0.007
4	815437.72	1061647.152	815437.874	1061647.26	-0.154	-0.108	0.024	0.012
5	815415.005	1061672.036	815414.743	1061672.389	0.262	-0.353	0.069	0.125
6	815390.32	1061679.104	815390.139	1061679.016	0.181	0.088	0.033	0.008
7	815204.481	1061557.498	815204.346	1061557.861	0.135	-0.363	0.018	0.132
8	815004.854	1061526.226	815004.792	1061526.424	0.062	-0.198	0.004	0.039
9	814951.339	1061354.377	814951.152	1061354.332	0.187	0.045	0.035	0.002
10	815070.257	1061218.998	815070.17	1061218.835	0.087	0.163	0.008	0.027
11	815654.665	1061341.797	815654.448	1061341.872	0.217	-0.075	0.047	0.006
12	815617.84	1061329.338	815617.695	1061329.029	0.145	0.309	0.021	0.095
13	815639.245	1061384.985	815639.565	1061384.743	-0.320	0.242	0.102	0.059
14	815615.861	1061376.714	815615.908	1061376.397	-0.047	0.317	0.002	0.100
15	815844.293	1061732.112	815844.516	1061732.19	-0.223	-0.078	0.050	0.006
16	815795.893	1061714.997	815795.676	1061714.919	0.217	0.078	0.047	0.006
17	815771.423	1061785.673	815771.466	1061785.413	-0.043	0.260	0.002	0.068
18	815774.664	1061793.406	815774.639	1061793.822	-0.025	-0.416	0.001	0.173
19	815816.812	1061808.966	815817.051	1061809.312	0.239	-0.346	0.057	0.120
20	815340.237	1061919.962	815340.206	1061919.829	-0.031	0.133	0.001	0.018
21	815358.153	1061930.575	815358.282	1061930.652	0.129	-0.077	0.017	0.006
22	815352.824	1061945.58	815352.861	1061945.76	0.037	-0.180	0.001	0.032
23	815332.472	1061933.309	815332.325	1061933.354	-0.147	-0.045	0.022	0.002
24	815271.461	1061964.47	815271.55	1061964.416	0.089	0.054	0.008	0.003
25	815259.864	1061978.537	815259.91	1061978.597	0.046	-0.060	0.002	0.004
26	815269.966	1061992.04	815270.019	1061992.111	0.053	-0.071	0.003	0.005
27	815274.493	1061992.024	815274.53	1061992.176	0.037	-0.152	0.001	0.023
28	815286.03	1061974.594	815286.212	1061974.631	0.182	-0.037	0.033	0.001

29	815415.407	1063528.411	815415.205	1063528.589	-0.202	-0.178	0.041	0.032
30	815450.649	1063506.052	815450.878	1063506.292	0.229	-0.240	0.052	0.058
31	815433.347	1063477.468	815433.179	1063477.574	-0.168	-0.106	0.028	0.011
32	815391.037	1063505.679	815390.955	1063505.842	-0.082	-0.163	0.007	0.027
33	814569.214	1063772.667	814569.328	1063772.68	0.114	-0.013	0.013	0.000
34	814550.908	1063879.436	814551.177	1063879.783	0.269	-0.347	0.072	0.120
35	814363.718	1063829.504	814363.581	1063829.615	-0.137	-0.111	0.019	0.012
36	814390.601	1063725.489	814390.503	1063725.558	-0.098	-0.069	0.010	0.005
37	813163.263	1062777.153	813163.335	1062777.086	0.072	0.067	0.005	0.004
38	813138.606	1062771.034	813138.728	1062771.135	0.122	-0.101	0.015	0.010
39	813142.65	1062723.749	813143.105	1062723.962	0.455	-0.213	0.207	0.045
40	813388.975	1062406.318	813388.959	1062405.906	-0.016	0.412	0.000	0.170
41	813433.985	1062469.855	813434.108	1062469.876	0.123	-0.021	0.015	0.000
42	813386.259	1062518.725	813386.194	1062518.589	-0.065	0.136	0.004	0.018
43	813353.313	1062487.027	813353.292	1062486.94	-0.021	0.087	0.000	0.008
44	811939.002	1061304.018	811938.867	1061304.012	-0.135	0.006	0.018	0.000
45	811938.661	1061293.334	811938.414	1061293.236	-0.247	0.098	0.061	0.010
46	811965.902	1061292.19	811966.208	1061291.976	0.306	0.214	0.094	0.046
47	811966.21	1061305.079	811966.312	1061305.262	0.102	-0.183	0.010	0.033
48	812203.994	1062461.299	812204.238	1062461.539	0.244	-0.240	0.060	0.058
49	812178.997	1062384.469	812179.203	1062384.266	0.206	0.203	0.042	0.041
50	812049.34	1062429.67	812049.128	1062429.551	-0.212	0.119	0.045	0.014
51	812075.457	1062506.373	812075.49	1062506.589	0.033	-0.216	0.001	0.047
52	811543.841	1063407.474	811543.965	1063407.425	0.124	0.049	0.015	0.002
53	811475.645	1063431.581	811475.414	1063431.381	-0.231	0.200	0.053	0.040
54	811436.941	1063313.646	811436.792	1063313.553	-0.149	0.093	0.022	0.009
55	811505.193	1063290.719	811504.975	1063290.737	-0.218	-0.018	0.048	0.000
56	811279.959	1063778.015	811280.125	1063778.211	0.166	-0.196	0.028	0.038
57	811267.838	1063740.535	811267.793	1063740.657	-0.045	-0.122	0.002	0.015
58	811236.615	1063750.559	811236.668	1063750.493	0.053	0.066	0.003	0.004
59	811243.277	1063768.76	811243.29	1063768.973	0.013	-0.213	0.000	0.045
60	810291.722	1062269.899	810292.185	1062269.694	0.463	0.205	0.214	0.042
61	810312.021	1062328.063	810312.262	1062328.021	0.241	0.042	0.058	0.002
62	810227.925	1062356.721	810227.864	1062356.671	-0.061	0.050	0.004	0.002
63	810207.548	1062297.915	810207.604	1062298.209	0.056	-0.294	0.003	0.086
64	808130.438	1064825.384	808130.4	1064825.22	-0.038	0.164	0.001	0.027
65	808133.031	1064791.629	808132.9	1064792	-0.131	-0.371	0.017	0.138
66	808255.821	1064802.339	808256.1	1064802	0.279	0.339	0.078	0.115

67	808253.668	1064833.192	808253.6	1064833	-0.068	0.192	0.005	0.037
68	808131.568	1064579.543	808131.6	1064580	0.032	-0.457	0.001	0.209
69	808072.168	1064576.771	808072	1064577.12	-0.168	-0.349	0.028	0.122
70	808128.247	1064621.555	808128.1	1064622	-0.147	-0.445	0.022	0.198
71	808068.921	1064618.393	808068.629	1064618.471	-0.292	-0.078	0.085	0.006
72	807346.556	1065011.973	807346.7	1065012	0.144	-0.027	0.021	0.001
73	807393.488	1065014.14	807393.6	1065014	0.112	0.140	0.013	0.020
74	807350.87	1064901.149	807350.9	1064901	0.030	0.149	0.001	0.022
75	807398.377	1064903.732	807398.1	1064904	-0.277	-0.268	0.077	0.072
76	805330.702	1064868.745	805330.683	1064869.062	-0.019	-0.317	0.000	0.100
77	805305.196	1064872.904	805305.018	1064873.088	-0.178	-0.184	0.032	0.034
78	805324.355	1064831.386	805324.491	1064831.565	0.136	-0.179	0.018	0.032
79	805299.085	1064835.423	805298.985	1064835.57	-0.100	-0.147	0.010	0.022
80	805098.602	1064852.555	805098.478	1064852.666	-0.124	-0.111	0.015	0.012
81	805075.345	1064853.349	805075.205	1064853.568	-0.140	-0.219	0.020	0.048
82	805098.033	1064872.356	805098.149	1064872.599	0.116	-0.243	0.013	0.059
83	805074.628	1064870.192	805074.887	1064870.236	0.259	-0.044	0.067	0.002
84	805097.381	1063664.921	805097.448	1063665.117	0.067	-0.196	0.004	0.038
85	805097.747	1063644.771	805097.991	1063644.595	0.244	0.176	0.060	0.031
86	805122.769	1063665.46	805123.067	1063665.594	0.298	-0.134	0.089	0.018
87	805123.442	1063645.758	805123.65	1063645.666	0.208	0.092	0.043	0.008
88	810230.647	1063239.955	810230.544	1063239.742	-0.103	0.213	0.011	0.045
89	810219.084	1063244.744	810218.898	1063244.48	-0.186	0.264	0.035	0.070
90	810211.919	1063226.388	810211.802	1063226.093	-0.117	0.295	0.014	0.087
91	810223.302	1063221.341	810223.202	1063221.262	-0.100	0.079	0.010	0.006
92	809964.218	1062325.914	809964.407	1062326.153	0.189	-0.239	0.036	0.057
93	809975.925	1062321.946	809976.158	1062322.162	0.233	-0.216	0.054	0.047
94	809970.973	1062344.753	809971.298	1062344.715	0.325	0.038	0.106	0.001
95	809982.591	1062340.929	809982.359	1062340.954	-0.232	-0.025	0.054	0.001
96	812261.415	1064055.6	812261.246	1064055.779	-0.169	-0.179	0.029	0.032
97	812289.365	1064052.925	812289.583	1064052.74	0.218	0.185	0.048	0.034
98	812286.629	1064028.149	812286.46	1064027.966	-0.169	0.183	0.029	0.033
99	812258.845	1064031.133	812258.457	1064031.035	-0.388	0.098	0.151	0.010
100	815395.689	1065001.598	815395.927	1065001.595	0.238	0.003	0.057	0.000
101	815204.861	1064992.227	815204.672	1064992.251	-0.189	-0.024	0.036	0.001
102	815198.025	1065133.932	815197.904	1065133.748	-0.121	0.184	0.015	0.034
103	815347.012	1065141.125	815347.183	1065141.364	0.171	-0.239	0.029	0.057
104	813168.282	1062727.724	813168.558	1062727.864	0.276	-0.140	0.076	0.020



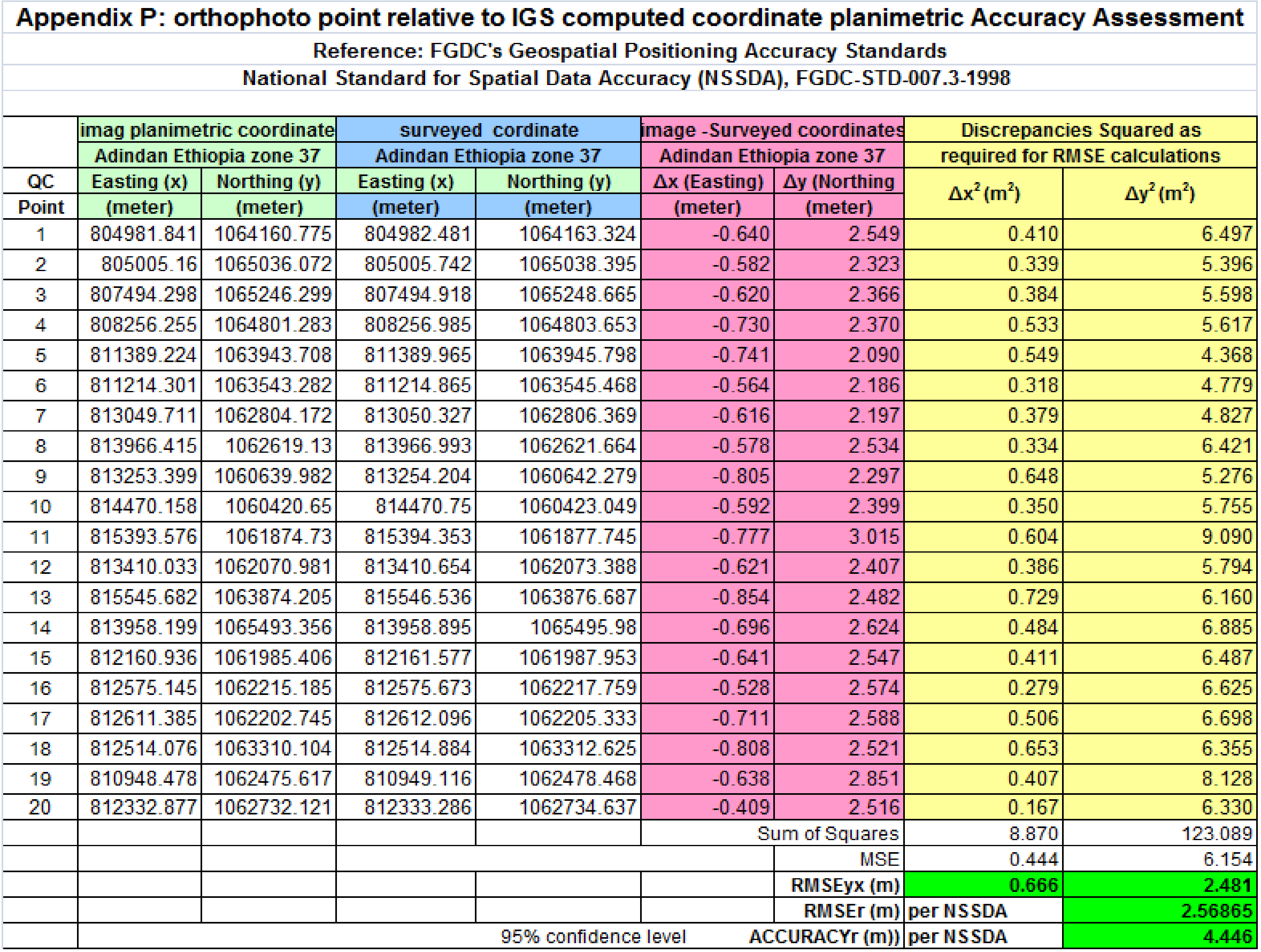
105	814041.078	1060286.721	814041.19	1060286.808	0.112	-0.087	0.013	0.008
106	814048.807	1060251.979	814048.94	1060251.769	0.133	0.210	0.018	0.044
107	814007.316	1060242.423	814007.246	1060242.305	-0.070	0.118	0.005	0.014
108	814000.539	1060244.07	814000.767	1060243.973	0.228	0.097	0.052	0.009
109	813993.78	1060276.723	813993.482	1060276.65	-0.298	0.073	0.089	0.005
110	812688.894	1061187.372	812688.792	1061187.548	-0.102	-0.176	0.010	0.031
111	812720.048	1061184.726	812719.96	1061184.772	-0.088	-0.046	0.008	0.002
112	812717.593	1061236.838	812717.867	1061236.76	0.274	0.078	0.075	0.006
113	812702.419	1061236.484	812702.411	1061236.592	-0.008	-0.108	0.000	0.012
114	812678.964	1061243.127	812678.77	1061243.318	-0.194	-0.191	0.038	0.036
115	812681.104	1061246.481	812680.861	1061246.684	-0.243	-0.203	0.059	0.041
116	812701.697	1061248.974	812701.626	1061249.103	-0.071	-0.129	0.005	0.017
117	813481.741	1060093.831	813481.654	1060093.959	-0.087	-0.128	0.008	0.016
118	813480.908	1060129.424	813481.077	1060129.385	0.169	0.039	0.029	0.002
119	813443.678	1060131.928	813443.393	1060132.01	-0.285	-0.082	0.081	0.007
120	813443.283	1060125.291	813443.085	1060125.27	-0.198	0.021	0.039	0.000
121	814504.54	1062019.904	814504.793	1062019.633	0.253	0.271	0.064	0.073
122	814568.526	1061927.985	814568.761	1061927.801	0.235	0.184	0.055	0.034
123	814514.682	1061890.864	814514.842	1061890.376	0.160	0.488	0.026	0.238
124	814465.223	1061971.595	814465.314	1061971.905	0.091	-0.310	0.008	0.096
125	814467.554	1061986.061	814467.711	1061986.011	0.157	0.050	0.025	0.003
						Sum of Squares	4.180	4.798
						MSE	0.033	0.038
						RMSEyx (m)	**0.183**	**0.196**
						RMSEr (m)	**per NSSDA**	**0.26801**
				95% confidence level		**ACCURACYr (m))**	**per NSSDA**	**0.464**

Appendix O: digital line map(road center line)planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	line map coordinate		surveyed cordinate		line map -Surveyed coordinates		Discrepancies Squared as required for RMSE calculations	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37			
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	Δx^2 (m^2)	Δy^2 (m^2)
1	814151.307	1062512.918	814151.3781	1062512.989	-0.071	-0.071	0.005	0.005
2	814109.0736	1062540.809	814109.3145	1062541.027	-0.241	-0.218	0.058	0.047
3	814053.8616	1062578.189	814053.7927	1062578.103	0.069	0.086	0.005	0.007
4	814014.16	1062604.543	814014.195	1062604.569	-0.035	-0.026	0.001	0.001
5	813989.9698	1062621.027	813989.8174	1062620.798	0.152	0.229	0.023	0.052
6	813959.1815	1062641.446	813959.0633	1062641.283	0.118	0.163	0.014	0.027
7	813925.9342	1062663.479	813925.9076	1062663.435	0.027	0.044	0.001	0.002
8	813885.8297	1062690.406	813885.6357	1062690.276	0.194	0.130	0.038	0.017
9	813834.4642	1062724.829	813834.1824	1062724.568	0.282	0.261	0.079	0.068
10	813804.4273	1062744.737	813804.3116	1062744.548	0.116	0.189	0.013	0.036
11	813767.1493	1062769.547	813767.0258	1062769.354	0.124	0.193	0.015	0.037
12	813721.8033	1062799.942	813721.5966	1062799.697	0.207	0.246	0.043	0.060
13	813657.5352	1062842.664	813657.3147	1062842.327	0.221	0.337	0.049	0.113
14	813589.6714	1062883.631	813589.4217	1062883.417	0.250	0.215	0.062	0.046
15	813563.1034	1062889.231	813563.0522	1062889.041	0.051	0.191	0.003	0.036
16	813506.0514	1062890.011	813506.0422	1062889.774	0.009	0.237	0.000	0.056
17	813443.247	1062890.243	813443.2635	1062890.097	-0.017	0.146	0.000	0.021
18	813282.4939	1062888.001	813282.6874	1062887.849	0.194	0.152	0.037	0.023
19	813262.6293	1062878.081	813262.8549	1062878.128	0.226	-0.047	0.051	0.002
20	813251.1067	1062867.742	813251.2387	1062867.662	0.132	0.080	0.017	0.006
21	813234.8347	1062845.149	813234.8461	1062845.142	0.011	0.008	0.000	0.000
22	813223.5508	1062829.9	813223.7657	1062829.731	0.215	0.169	0.046	0.029
23	813214.962	1062820.622	813215.1788	1062820.512	0.217	0.110	0.047	0.012
24	813185.7153	1062806.255	813185.8427	1062805.959	0.127	0.297	0.016	0.088
25	813155.4044	1062795.264	813155.4963	1062795.004	0.092	0.260	0.008	0.068
26	813141.707	1062791.327	813141.7338	1062791.191	0.027	0.136	0.001	0.018
27	813132.5818	1062790.72	813132.5855	1062790.481	0.004	0.239	0.000	0.057
28	813123.0834	1062791.557	813123.038	1062791.206	-0.045	0.350	0.002	0.123
						Sum of Squares	0.636	1.059
						MSE	0.023	0.038
						RMSEyx (m)	0.151	0.195
						RMSEr (m)	per NSSDA	0.24606
			95% confidence level			ACCURACYr (m))	per NSSDA	0.426



Appendix P: orthophoto point relative to IGS computed coordinate planimetric Accuracy Assessment

Reference: FGDC's Geospatial Positioning Accuracy Standards

National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

	imag planimetric coordinate		surveyed cordinate		image -Surveyed coordinates		Discrepancies Squared as	
	Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		Adindan Ethiopia zone 37		required for RMSE calculations	
QC Point	Easting (x) (meter)	Northing (y) (meter)	Easting (x) (meter)	Northing (y) (meter)	Δx (Easting) (meter)	Δy (Northing (meter)	$\Delta x^2 (m^2)$	$\Delta y^2 (m^2)$
1	804981.841	1064160.775	804982.481	1064163.324	-0.640	2.549	0.410	6.497
2	805005.16	1065036.072	805005.742	1065038.395	-0.582	2.323	0.339	5.396
3	807494.298	1065246.299	807494.918	1065248.665	-0.620	2.366	0.384	5.598
4	808256.255	1064801.283	808256.985	1064803.653	-0.730	2.370	0.533	5.617
5	811389.224	1063943.708	811389.965	1063945.798	-0.741	2.090	0.549	4.368
6	811214.301	1063543.282	811214.865	1063545.468	-0.564	2.186	0.318	4.779
7	813049.711	1062804.172	813050.327	1062806.369	-0.616	2.197	0.379	4.827
8	813966.415	1062619.13	813966.993	1062621.664	-0.578	2.534	0.334	6.421
9	813253.399	1060639.982	813254.204	1060642.279	-0.805	2.297	0.648	5.276
10	814470.158	1060420.65	814470.75	1060423.049	-0.592	2.399	0.350	5.755
11	815393.576	1061874.73	815394.353	1061877.745	-0.777	3.015	0.604	9.090
12	813410.033	1062070.981	813410.654	1062073.388	-0.621	2.407	0.386	5.794
13	815545.682	1063874.205	815546.536	1063876.687	-0.854	2.482	0.729	6.160
14	813958.199	1065493.356	813958.895	1065495.98	-0.696	2.624	0.484	6.885
15	812160.936	1061985.406	812161.577	1061987.953	-0.641	2.547	0.411	6.487
16	812575.145	1062215.185	812575.673	1062217.759	-0.528	2.574	0.279	6.625
17	812611.385	1062202.745	812612.096	1062205.333	-0.711	2.588	0.506	6.698
18	812514.076	1063310.104	812514.884	1063312.625	-0.808	2.521	0.653	6.355
19	810948.478	1062475.617	810949.116	1062478.468	-0.638	2.851	0.407	8.128
20	812332.877	1062732.121	812333.286	1062734.637	-0.409	2.516	0.167	6.330
						Sum of Squares	8.870	123.089
						MSE	0.444	6.154
						RMSEyx (m)	**0.666**	**2.481**
						RMSEr (m)	**per NSSDA**	**2.56865**
				95% confidence level		**ACCURACYr (m))**	**per NSSDA**	**4.446**