College of Engineering

Civil & Architectural Engineering Department

Surveying and Geomatics Engineering

Test and validation of orthophoto (2018) of WestBank used in Geomolg

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Signature of the project supervisor **Signature of the Head of the Department**

Name: ………………… **Name: ……………………..**

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الإهداء

إلى الرحمة المهداة في زمن الظلم والظلمات، **رسول ا□** (صلى الله عليه وسلم)

إلى الورثة الأنبياء بعلمهم، **علماؤنا الأجلاء**

إلى من عبدت لنا بحبها طريق الجنان، **نبع** الحنان أمنا الحبيبة

إلى الذي تناثرت قطرات العرق على جبينه كقطر الندى مجتهدا ليوفر لنا حياة كريمة، والدنا الحبيب

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إلى البيارق الخفاقة في سماء العزة والإباء، أسيراتنا و**أسرانا البواسل**

إلى اقصانا ومسرانا مهو القلوب وإلى كل **ذرة من ارض الرباط فلسط□ بأهلها وطهرها وقفارها**

إلى مسيرات العودة في شتى ربوع الوطن شماله
وجنوبه

إلى كل الأخوة والأخوات الذين ساهموا وعملوا
في هذا المشروع، بتشجيعهم ودعائهم
ا□تواصل، والذين كانوا لهم صدق مؤازرتنا
في تنفيذه

إلى من سار معنا الخطوة تلو الخطوة، إلى
مشرفنا الدكتور غادي زكارنة

الشكر والتقدير

إن الشكر وا□نة لا تليق إلا لواهب العقول
ومنير الدروب □ عز وجل.
كما ونتقدم بجزيل الشكر والامتنان
إلى بانية الجيل الواعد... جامعة
بوليتكنيك فلسط□.
إلى كلية الهندسة.
إلى دائرة الهندسة المدنية والمعمارية
بطاقمها التدريسي والإداري.

إلى الذين **مهدوا لنا** طريق الهداية **والعلم والمعرفة...**

إلى جميع أساتذتنا الأفاضل**...**

إلى مشرفنا العزيز، **الدكتور غادي زكارنة**

" **كن عالما،** فإن لم تستطع فكن **متعلما، فإن** لم تستطع فأحبب **العلماء،** فإن لم تستطع فلا تبغضهم"

كما ونشكر كل من ساهم في اتمام هذا **المشروع،** ونخص بالشكر المهندس ياسين احمد زعزع

لمساعدته في تزويدنا بنقاط ومخططات رصد في **منطقة جنين، والمهندسة** علياء الزير على تزويدنا بنقاط لمنطقة الخليل، **والمهندس معتصم** أيوب المشني لمساعدته في تزويدنا بنقاط ومخططات رصد جديدة في مناطق التسوية، والمهندس ايهاب شاهين من شركة جروما لمساعدته في الرصد.

ABSTRACT

Test and validation of orthophoto (2018) of WestBank used in Geomolg

Renad Halaika **Ali Zaazaa**

Supervisor

Dr. Ghadi Zakarneh

This project aims to apply field evaluation of the Orthophoto (2018), provided the Ministry of Local Government (Geomolg), including the test of accuracy and relief displacement.

To evaluation, the orthophoto, different study areas will be selected regarding different terrain situations, mountainous, hilly and flat areas. Tests will be carried out in both urban and rural areas, in the mountains of WestBank and Jordan valley. Points distributed on the ground, building, mountain and down valleys. The coordinates will be compared and analyzed statistically according to the standard methods of map accuracy assessment. Also, in comparison to the older solution (Orthophoto 2·16/2014) will be applied.

Finally, the accuracy in the different parts and areas will be tabulated, the proper best practice procedure will be discussed to make accurate mapping by the given Orthophoto.

الملخص

Test and validation of orthophoto (2018) of WestBank used in Geomolg

Renad Halaika **Ali Zaazaa**

Supervisor

Dr. Ghadi Zakarneh

يهدف المشروع الى تقييم الصور الجوية لعام 2018 المستخدمة في موقع وزارة الحكم المحلي Geomolg، واختبار والتحقق من دقتها ومقدار الازاحة الناتجة من الارتفاعات ميدانيا.

ليتم هذا التقييم، سيتم اختيار مناطق ذات تضاريس مختلفة مثل الجبال والتلال والمناطق السهلية، وسيجرى الاختبار على مناطق ريفية وحضرية بالإضافة لجبال الضفة الغربية وواد الأردن، ويتم ذلك من خلال توزيع النقاط على الأرض والبنايات والجبال والوديان.

بعد ذلك سيتم مقارنة الاحداثيات وتحليلها احصائيا وفقا للطرق المعيارية لتقييم دقة الخرائط وستقارن مع الصور الجوية السابقة لها كالصور الجوية لعام 2014/2016

وفي النهاية، سيتم جدولة الدقة الناتجة لمختلف المناطق التي تم اجراء الاختبار عليها، ومناقشتها.

// Acknowledge

We would like to express our endless gratitude for everyone who helped us during the graduation project, starting with the Palestine polytechnic university, college of engineering, civil and architectural engineering department for providing us with everything that we needed for the completion of the graduation project.

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INTRODUCTION

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1.1 Background

Geomolg was officially released in November 2014, and it’s a straightforward web mapping application that has helped Palestine's Ministry of Local Government collect data about land use and management and connect data with other government departments, nongovernmental organizations, and academic institutions.

It Provides all information relating to maps and charts at the national level, such as the structural plans of national and planned spatial maps settlement and maps of powers (according to the Oslo Agreement), in addition to providing aerial photography of all the territory of the West Bank with a resolution of about 25 cm until 2016.

In 2018, Aerial photographs of the West Bank were issued with a resolution of 10 cm and accuracy 30 cm, and this will be checked and verified in this project.

1.2 Objective

In this project, the object is to apply field evaluation of the Orthophoto (2018), provided the Ministry lo Local Government (Geomolg), including the test of accuracy and relief displacement.

1.3 Problem Statement

Ideal

The Orthophoto (2018) which used for the process of uploading the data, has resolution according to the Geomolg 10cm.

Reality

The accuracy is different than resolution, the resolution defined as the granularity, or fineness, of a display. Essentially, the resolution expresses the number of the smallest equal pieces used for a display.

Accuracy definition of how close a measurement is to the true value being measured.

Because of that, Can`t be relied upon in the field survey.

Solution

The process of assessing the level of accuracy to determine to what extent can be relied upon in the cadastral process, depending on the specifications international standards especially ASPRS (American Society for Photogrammetry and Remote Sensing).

1.4 Time Table

The time schedule in table (1.1) shows the stages of developing theoretical work and the process project that includes (literature review, organizing the scope, data collection, and the final presentation).

Table (1.1) Time Schedule for this semester.

Weeks Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project idea																
literature review																
organizing the scope																
Data collection																
Presentation																
Weeks Tasks	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
literature review																
organizing the scope																
Data collection																
Presentation																

1.5 Methodology

The Methodology of work in this project will be achieved by the following steps:

- Monitoring several points using the GNSS.
- Covering several areas in the West Bank and Jordan valley.
- Compared and analyzed coordinates statistically according to the standard methods of map accuracy assessment.

1.6 Study Area

Several areas in the WestBank and the Jordan Valley will be applied in this project, points were monitored using the GNSS device. The study areas selected to cover various types of topography like mountains, valleys, and flat areas, in both rural and urban areas, high buildings and buildings consisting of many floors.

1.7 Project Scope

This project consists of the fifth chapters as follows:

- Chapter One: A simple explanation about the project and an introduction to what will be done in this project.
- Chapter Two: Describes the Geomolg project and data types provided by it.
- Chapter Three: Introduces the principles and properties of Aerial Orthophoto.
- Chapter Four: Digital map accuracy standards by ASPRS.
- Chapter Five: Data collection and Analysis.
- Chapter Six: Conclusions and Recomendations.

Chapter Two

GEOMOLG

2.1 Introduction

2.2 Benefits of Geomolg

2.3 Components of Geomolg

2.4 The Spatial Data availability through Geomolg

2.5 GPS Technology to Double Check the Data

2.6 Facts make Geomolg distinct

2.7 Coordinate system supported by Geomolg

2.1 Introduction

The Ministry of Local Government (MOLG) is the ministry responsible for developing the capacity of local bodies in Palestine and the development of its resources to become more able to achieve the welfare of its citizens within the framework of local governance. [1]

It`s strategies:

- Enable local bodies to own institutional capacities of actors.
- Raise the efficiency of the ministry to enable planning, direction and supervision of the local government sector.
- Achieve greater democracy, transparency and community participation in the local government sector.
- Promote the concept of partnership between local authorities and the private and public sectors to contribute to the creation of local development and strengthening of the financial independence of local bodies.

Geomolg is the first-ever integrated spatial information system in Palestine, developed by The Palestine Ministry of Local Government (MOLG) in partnership with German International Cooperation (GIZ) through the Local Governance and Civil Society Development Programme (LGP), and it`s definition as a straightforward web mapping application that has helped Palestine's Ministry of Local Government to collect data about land use and management and connect data with other government departments, nongovernmental organizations, and academic institutions.

This project has started in December 2012. In May 2013, Geomolg was launched for the first time in its initial edition on the basis of the Application Developer Framework (ADF). The duration that preceded the launch included identifying functions and tools that should be available in the system, software and hardware deployment, collecting data and training. In November of the same year, the second generation of the system was launched that took advantage of Geocortex as a web mapping application. This forms a quantum leap in the way to reach the spatial data with the possibility to update it. Within this context, it should be mentioned that all MOLG directorates were linked to the system to be able to obtain the spatial information easily and to dispense gradually from the paper maps to digital.

Figure (2.1) Geomolg Website

2.2 Benefits of Geomolg

It has a lot of benefits that are innumerable, In addition to reducing the time, effort and costs in accessing spatial information, due to the development of methods and tools used across it, other benefits can be listed as follows:

- Work to increase the accuracy of the data and information level, due to be published over the internet and benefit from feedback from users nutrition.
- Allowed to read the spatial information from the official one source, rather than the multiplicity of sources and references, thus avoiding confusion at work, and easy to take a mature and informed decision.
- Provided the possibility of introducing all the updates that take place on maps and charts directly, which keeps them with the latest possible and constantly renewed formula.
- Within the system save data and information in a secure environment, it shall be safeguarded from damage and loss.
- The system introduced the public and private sector intelligent environment for data comparison and scrutiny, as being in (Real Time), and via the Internet directly (Online).

2.3 Components of Geomolg

Geomolg consists of two key selections, which are: Hardware and software selections.

Software Selection

Table (2.1) software Selection of Geomolg

Application	Product	Version
1. Engineering Drafting Application	**AutoCAD**	**2015**
2. Interoperability Application	**FME Desktop**	**2014**
3. Desktop Mapping Application	**ArcGIS Desktop**	**10.2.2**
4. Enterprise Spatial Database	**• Microsoft SQL Server • Oracle • ArcSDE License**	**2014 11g**
5. Spatial Data Publisher	**• ArcGIS Serve • Image Server Extension**	**10.2.2**
6. Web Mapping Application	**• Geocortex Essentials o The Geocortex Viewer for Silverlight o The Geocortex Viewer for HTML5 • Geocortex Optimizer**	**4.1.2**
7. Cloud Solution	**ArcGIS Online (Desktop, Server and Web application solution via clouds)**	
8. Mobile Solution	**Arc Pad (to dynamically capture data from the field)**	**10.2**

Hardware Selection

Table (2.2) Hardware Selection for Geomolg

Equipment	Specifications
1. Server Machine	**32 cores, 64 GB RAM**
2. Network	**CAT 7**
3. Switch	**10/100/100▪**
4. Editors Machine	**i7 32 GB or Xeon 3.5GH**
5. GPS Device (Rover)	**Tablet: Leica CS25 Antenna: Leica GG03 System: RTK (differential) Data line: Wataniya Software: Zeno field (ArcPad 10.2) Accuracy: 2cm**

2.4 The Spatial Data availability through Geomolg.

Geomolg provides the following set of spatial data:

<u>1. Urban Masters Plans (UMPs):</u>

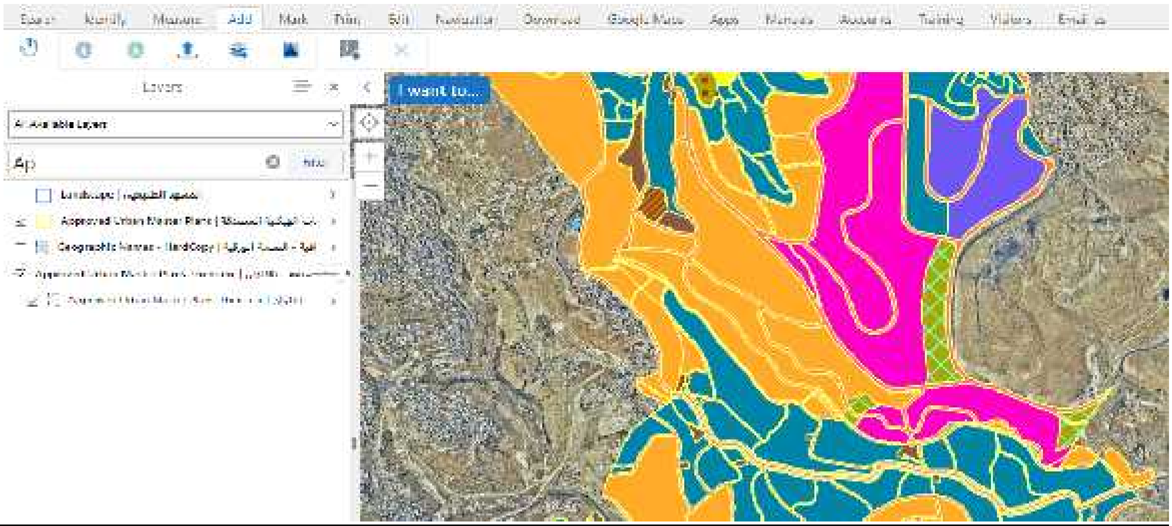

Figure (2.1) Urban Masters Plans

- Approved UMPs in Areas (A) and (B)
- UMPs in objection phase in Areas (A) and (B)
- Approved UMPs in Area (C)
- UMPs in objection phase in Area (C)
- Detailed UMPs

- Partial UMPs (developed at the era of Israeli occupation before 1992)
- Expansions of UMPs
- Modifications on UMPs

a. Modification of existing land use and/or road within the boundary of UMPs.

b. Detailing a particular area within the boundary of UMPs such as proposing new roads and/or land use.

2. Cadastral plans (blocks and parcels)

To identify the ownership boundaries,

3. Political classification of the West Bank in accordance with Oslo Accords: Borders of Areas (A), (B), and (C).

Figure (2.2) Political classification accordance to Oslo Accords

4. Land classification maps according to the agricultural value (high, medium, low).

Figure (2.3) Land classification according to the agricultural value

5. Biodiversity areas.

Biological diversity is defined as the interaction between all living organisms in an ecological medium, which begins with microorganisms and ends up in giant organisms such as whales, trees, etc. This includes all areas above the surface, including deserts, oceans, rivers, and forests.

6. Natural reserve areas.

A nature reserve (also known as a natural reserve, bio reserve, natural/nature preserve, or natural/nature conserve) is a protected area of importance for flora, fauna or features of geological or other special interest, which is reserved and managed for conservation and to provide special opportunities for study or research. Nature reserves may be designated by government institutions in some countries, or by private landowners, such as charities and research institutions, regardless of nationality.

7. Landscapes areas.

A landscape is the visible features of an area of land, its landforms, and how they integrate with natural or man-made features.

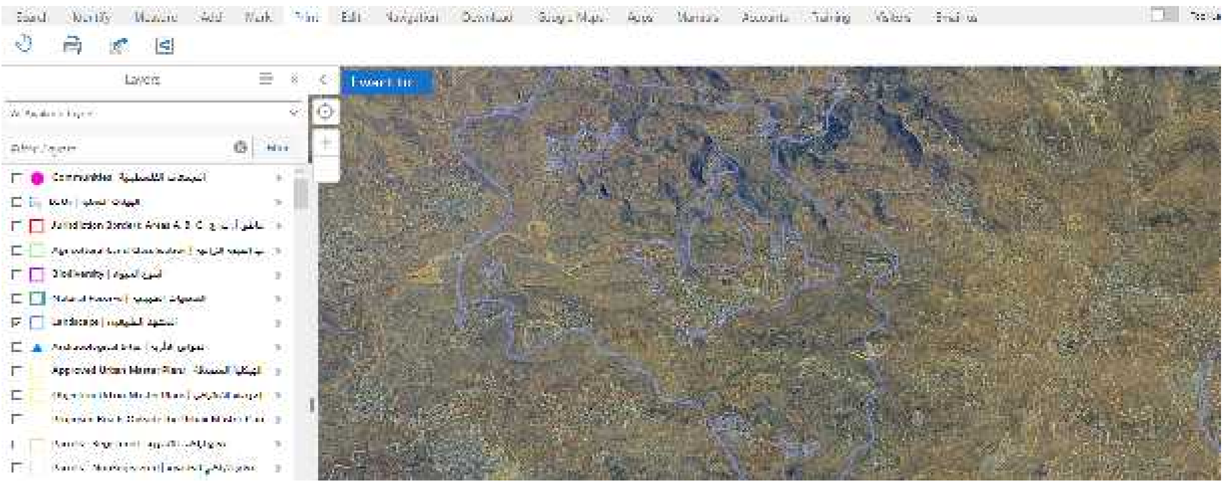

Figure (2.4) Landscape Areas

8. Archeological sites.

An archaeological site is a place (or group of physical sites) in which evidence of past activity is preserved (either prehistoric or historic or contemporary), and which has been, or maybe, investigated using the discipline of archaeology and represents a part of the archaeological record. Sites may range from those with few or no remains visible above ground, to buildings and other structures still in use.

9. Streams and rivers.

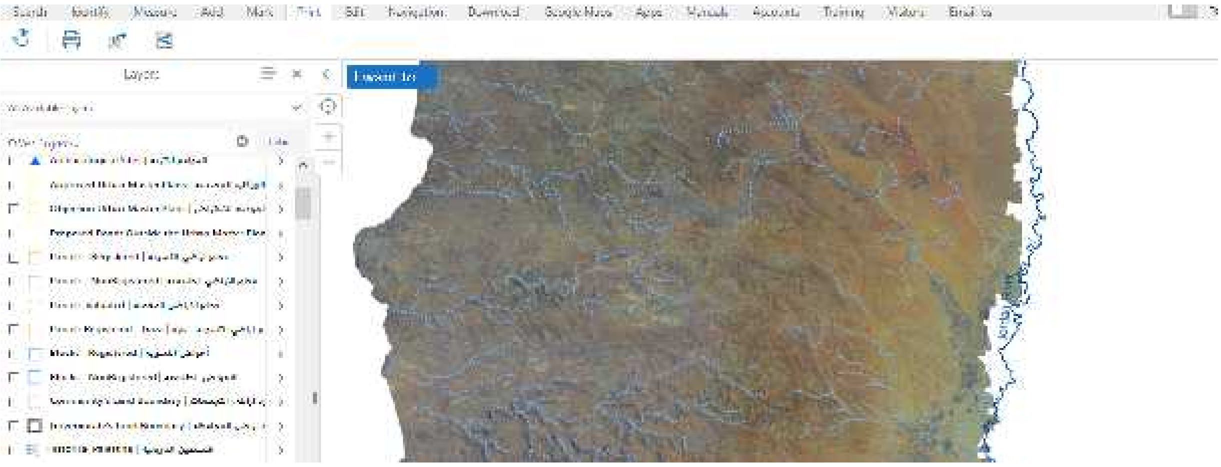

Figure (2.5) Stream and Rivers

10. Contours.

Shown contour interval 10 m, 2m or 5m, 1m.

11. State lands (registered, announced, surveyed).

12. Communities (Attributes: population, LGU classification, services, UMP status, etc.).

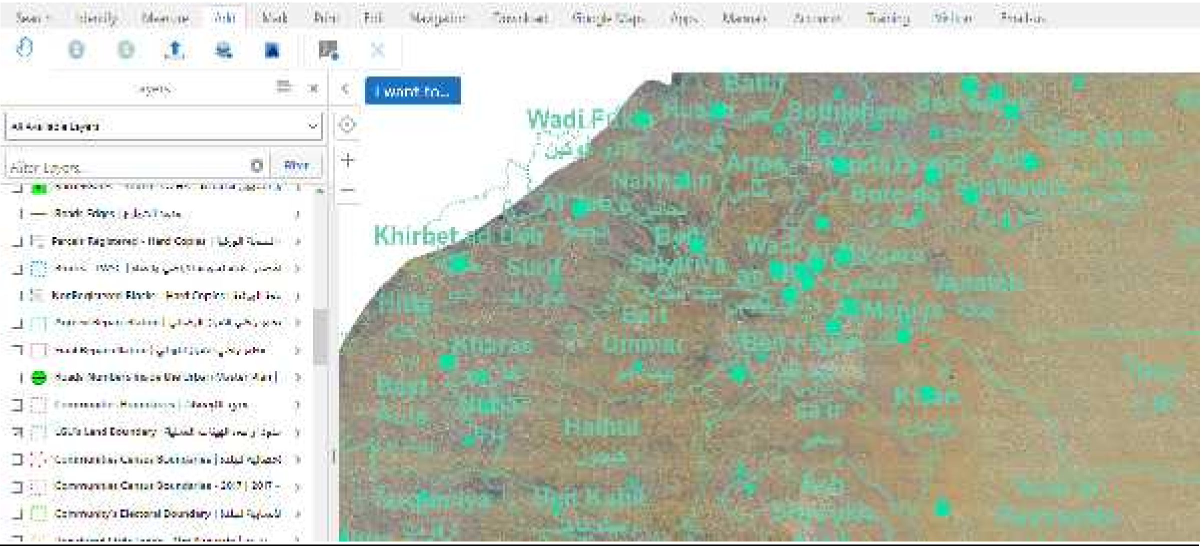

Figure (2.6) LGU classification

13. Facilities and services locations.

14. Trigs and GPS points

Shown the position of trigs and control points

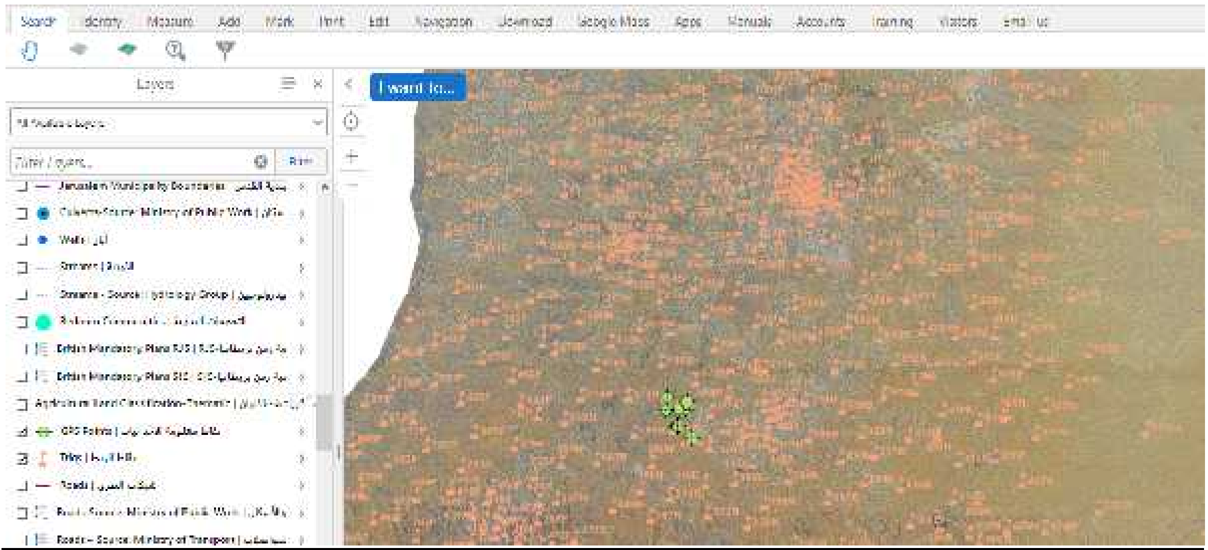

Figure (2.7) Trigs and GPS points

15. Administrative boundaries of local communities.

16. Administrative boundaries of governorates.

17. Updated Orthophoto (2018) with a spatial resolution (pixel size) of 10 cm and a spatial accuracy (locational error) of 30 cm.

Year	Spatial Resolution	Spatial Accuracy
2010	50 cm	70cm
2011	50 cm	70cm
2012	50 cm	70cm
2013	50 cm	70cm
2014	25 cm	70cm
2015	25 cm	70cm
2016	10 cm	50cm
2018	10 cm	30 cm

In addition of that, Geomolg contain coordinate and scale, and you can add any point with its coordinate, whether it`s Palestinian, Israel, lat/long or DDM (decimal/degree/minute)

And it has scaled from 1: 250 to scale 1: 2000000, else you can print from it, or save points, or input AutoCAD to it.

2.5 GPS Technology to Double Check the Data:

In principle, the major inputs to commence developments of UMPs are the spatial entities on the ground for the area of interest. Therefore, more accurate data produces better UMPs. Generally, the spatial entities of the area of interest are represented in CAD formats. The process can be described as follows:

- Aerial Photos are captured with a particular scale, resolution, and accuracy.
- Aerial Photos are processed to ensure the best output possible in all terms.
- Spatial entities are digitized to provide them in CAD format.

However, it is very common to find that the spatial accuracy of CAD format entities is low.

For that purpose, MOLG is employing the GPS technology to double-check that the spatial location of the CAD formats entities (mainly provided by the private sector) match their correct location in reality. Therefore, the XY coordinates of a particular CAD object obtained from the digitized version are compared with their corresponding XY coordinates captured by the GPS. The error is calculated at this level and remarks are supplied. In this regard, it should be indicated that the specification of the aerial photo plays a major role in specifying the level of accuracy of the output. The most critical specifications of aerial photos are:

- Spatial accuracy (XYZ coordinates with respect to the correct values).
- Spatial Resolution (pixel or cell size).
- Image scale.
- Radiometric resolution (in bits).
- Spectral resolution (number of bands).
- Temporal resolution (date of capturing).
- Time of capturing.
- Coordinate system.
- Image format (ecw, jpg, tiff, etc.).

In practice, the resolution of an image (R) can be derived from the image scale according to the equation (1.1) below:

$$R = \frac{(0.2/1000)}{(1/x)} \quad (1.1)$$

Where x is the scale.

Originally, the scale of an aerial photo can be determined based on the flying height of the aircraft (H) and the focal length of the camera lens (f) as shown in the equation (1.2) below:

$$S = (1/f) * H \quad (1.2)$$

2.6 Facts make Geomolg distinct

Developing a GIS-based system is not the first attempt of its kind either at the local or at the national level. However, Geomolg is considered distinct due to the following facts:

1. Geomolg is the most comprehensive GIS-based system at the national scale where major amounts of the national spatial data are made accessible.
2. Geomolg is featured by the most powerful web mapping application (Geocortex). The application starts with a browser and, thus, no sophisticated expertise is required to get familiar with its functionalities and capabilities.
3. Geomolg database is built on Microsoft SQL Server and enabled with the ArcSDE technology which allows simultaneous multi-editing either with the desktop or the web application.
4. Geomolg is entirely developed in-house to invest in available staff, thus, ensuring a high level of sustainability of the system.
5. Geomolg is the nucleus for an integrated spatial information system for Palestine that takes care of all spatial data streamed from multiple official channels where this data is edited, validated, and maintained by its owner and source.

٢.٧ Coordinate system supported by Geomolg

Israel TM Grid

Israel 1993 / Israeli TM Grid is a projected CRS last revised on May 7, 2019, and is suitable for use in Israel - onshore; Palestine Territory - onshore. **Israel 1993 / Israeli TM Grid** uses the Israel 1993 geographic 2D CRS as its base CRS and the Israeli TM (Transverse Mercator) as its projection. **Israel 1993 / Israeli TM Grid** is a CRS for Large and medium scale topographic mapping, cadastre and engineering survey. It was defined by information from the Survey of Israel. Replaces Israeli CS Grid (EPSG code 28193) from June 1998. Replaced by Israeli Grid 05 (IG05) (CRS code 6984) for precise applications.

Area Of Use: Asia - Middle East - Israel and Palestine Territory onshore

Scope: Large and medium scale topographic mapping and engineering survey

Conversion Parameter:

- Scale: 1.0000067
- Latitude of natural origin: 31° 44' 03.817'' N
- Longitude of natural origin: 35° 12' 16.261'' E
- False easting: 219529.584 meter
- False northing: 626907.39 meter

Palestine 1923 Grid

Palestine 1923 / Palestine Grid is a projected CRS last revised on May 7, 2019, and is suitable for use in Israel - onshore; Jordan; Palestine Territory - onshore. **Palestine 1923 / Palestine Grid** uses the Palestine 1923 geographic 2D CRS as its base CRS and the Palestine Grid (Cassini-Soldner) as its projection. **Palestine 1923 / Palestine Grid** is a CRS for Large and medium scale topographic mapping and engineering survey. It was defined by information from UK General Staff Geographic Service.. Replaced by CRS 28192 (AMS use) and 28193 (in Israel).

Area Of Use: Asia - Middle East - Israel and Palestine Territory onshore

Scope: Large and medium scale topographic mapping and engineering survey

Conversion Parameter:

- Scale: 1.0000000
- Latitude of natural origin: 31° 44' 02.749" N
- Longitude of natural origin: 35° 12' 43.490" E
- False easting:170251.555 meter
- False northing: 126867.909 meter

Chapter Three

Orthophoto Generation

3.1 Introduction

3.2 Orthophoto Generation Procedure

3.3 Orthophoto and Mosaic Production

3.1 Introduction

The photogrammetric central projection of a point of the terrain on the photographic negative plane is carried out by means of a projective line starting at terrain point, passing through de projection Centre O and intersecting the negative plane. To know the plane position of the point P on the terrain surface having only one photograph, it is necessary to reconstruct the corresponding projective line from the coordinates of the image point p and the projection Centre. The length of the line L is determined from planialtimetric information of the point on the ground. The projective line is represented by the colinearity equations.

The planialtimetric information of the terrain necessary to found the intersection point P is represented by a Digital Elevation Model (DEM). A DEM is determined from known characteristic points and interpolation algorithms to obtain the elevations of each unknown point.

There are to different approaches to finding the correspondence between image point and terrain point:

1. Transforming the position of each image point to its terrain position (DEM).
2. Transforming the position of each terrain (DEM) point to its image point.

There are important differences in the manner in which the process is carried out. In the first case, the georeferenciation of each image point on the DEM implies to determine iteratively its coordinates on the DEM to identify the cell that contains the point (Doysther and Hall, 1995). In the second case, the DEM cell is already referenced, remaining only to find its Position on the image and determine its grey value, which is simpler than to determine the Z value. In this paper is presented a procedure for the digital orthorectification based on the projection of the DEM on the image.

3.2 Orthophoto Generation Procedure

The procedure is based on the determination of the six parameters of the colinearity equations, i.e., the spatial position of the projection centre (X_O, Y_O, Z_O) and the camera orientation angles (ω, ϕ, κ) simultaneously, which permits to project the DEM points on the image. The process is developed in six stages

- Determination of the correspondence relation between the scanner system (reference system of the device used to digitize the photographed image) and the fiducial system.
- Determination of the correspondence relation between the terrain system and the fiducial system.
- Transformation of the DEM points to the fiducial system.
- Transformation of the DEM from the fiducial system to the scanner system.
- Projective transformation of the densified DEM to scanner system and.
- Determination of the grey value for each rectified point.

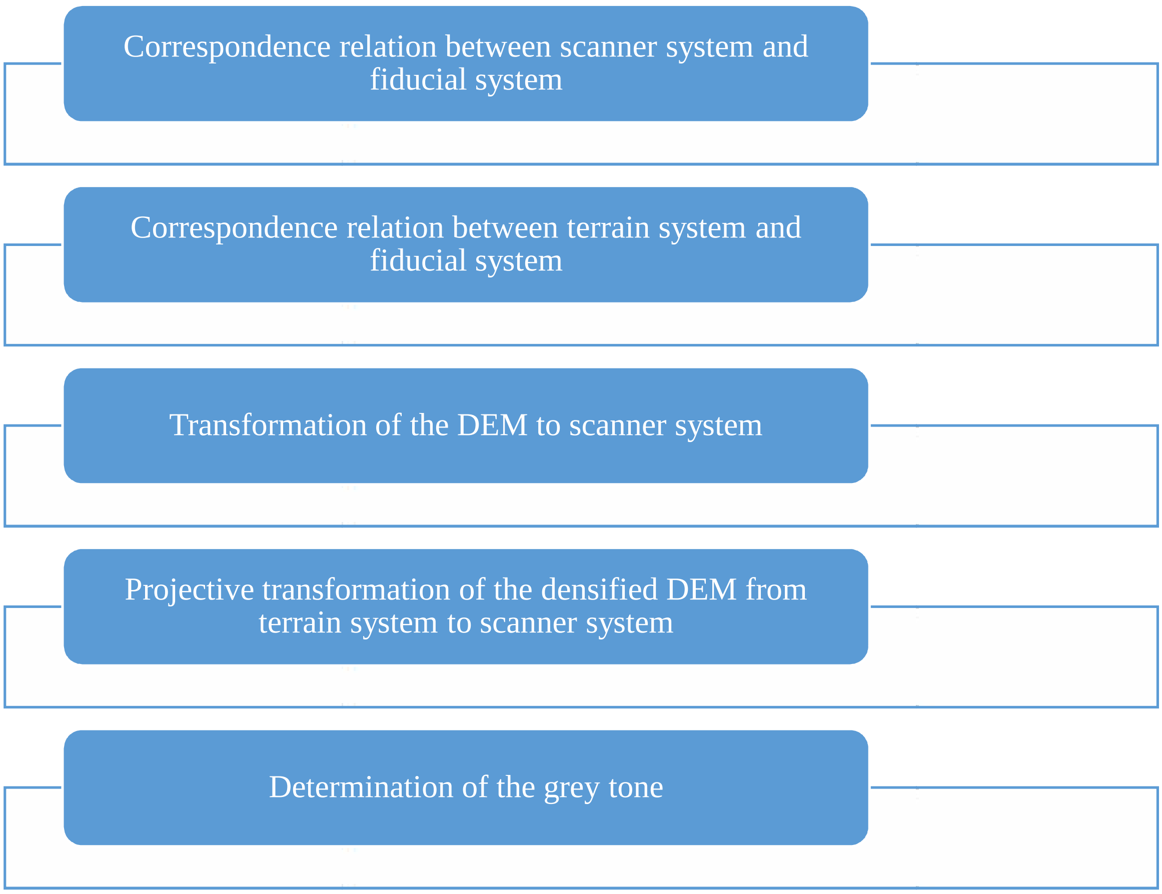

Figure (3.1) Scheme of the procedure

3.2.1 Determination of the correspondence relation between the scanner system and the fiducial system

Figure 3.2 shows the location of the photograph respect to the reference system x, y of a digitizer device (scanner system)، the relation between the scanner system and the fiducial system is established through an Affine transformation. The fiducial marks of the image are used to obtain the parameters of the Affine transformation because of its coordinates are known both the scanner system and the fiducial system (in the event that they are unknown, they can be determined). Then, the control points are transformed to a fiducial system using the following expression:

$$X = a_1 x + a_2 y + a_3$$
$$Y = a_4 x + a_5 y + a_6 \qquad (3.1)$$

Where,

X, Y: are the coordinates in the fiducial system.

x, y: are the coordinates in the scanner system.

$a_1, a_2, a_3, a_4, a_5, a_6$: are the transformation parameters from the scanner system to the fiducial system.

Analogously, the parameters to transform from the fiducial system and scanner system are computed using Equations 1, to convert later the corners of the DEM cells to the scanner system.

3.2.2 Determination of the correspondence between terrain system and the fiducial system

In the figure 3.3 can be observed that the terrain system X, Y, Z has been moved parallel from G to O a distance X_O, Y_O, Z_O, defining the system X´, Y´, Z´, which is rotated the angles ω, ϕ , κ respect to x,y,z. The determination of the parameters between the terrain system and the fiducial system requires the control points and collinearity equations. In general, the colinearity equations are expressed as:

$$\begin{matrix} x \\ y \\ -c \end{matrix} = K * A^T * \begin{matrix} X - X_0 \\ Y - Y_0 \\ Z - Z_0 \end{matrix} \qquad (3.2)$$

Where:

$x, y, -c$: are the image point coordinates referenced to the fiducial system.

c: is the principal distance of the camera.

X, Y, Z: are the control point coordinates in the terrain system.

X_0, Y_0, Z_0: are the projection centre coordinates O in the terrain system.

k: the scale module between the vector l and the vector L for each point.

A: orthogonal rotation matrix defined by the rotation of the photograph.

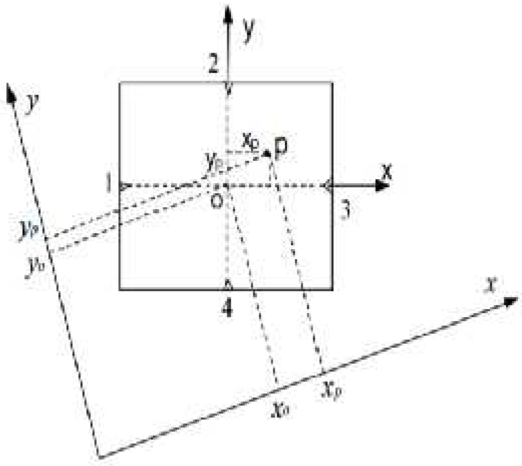

Figure (3.2) Relation between the projection of the fiducial system of the photograph and the scanner system.

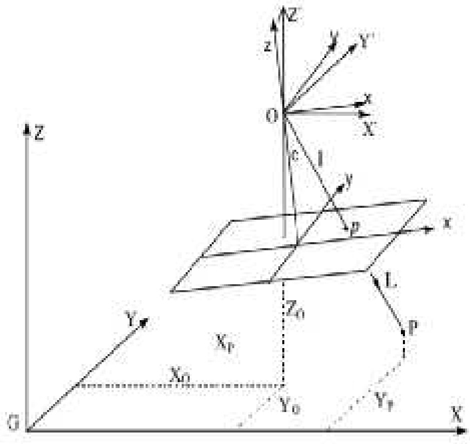

Figure (3.3) Relation between the fiducial system and the terrain system.

The Equations 3.2 can be written as follows:

$$\begin{array}{c} x \\ y \\ -c \end{array} = K * \begin{array}{c} a_{11}\ X - X_0\ + a_{21}\ Y - Y_0\ + a_{31}\ Z - Z_0 \\ a_{12}\ X - X_0\ + a_{22}\ Y - Y_0\ + a_{32}\ Z - Z_0 \\ a_{13}\ X - X_0\ + a_{23}\ Y - Y_0\ + a_{33}\ Z - Z_0 \end{array} \tag{3.3}$$

Such as is showed in Figure 3.3, the vector l, defined from projection centre O to the point p on the photograph, and the vector L, defined from the projection centre O to the point P on the terrain, are collinear (i.e. l = k * L). Usually, the value k of each point is not known and can be eliminated dividing the first equations in the third of the equations 3.3, obtaining:

$$\frac{x}{-c} = \frac{a_{11}\ X - X_0\ + a_{21}\ Y - Y_0\ + a_{31}\ Z - Z_0}{a_{13}\ X - X_0\ + a_{23}\ Y - Y_0\ + a_{33}\ Z - Z_0} \tag{3.4}$$

$$\frac{y}{-c} = \frac{a_{12}\ X - X_0\ + a_{22}\ Y - Y_0\ + a_{32}\ Z - Z_0}{a_{13}\ X - X_0\ + a_{23}\ Y - Y_0\ + a_{33}\ Z - Z_0} \tag{3.5}$$

The Equations 3.4 and 3.5 are rigorous and not linear in terms of the six parameter unknowns X_O, Y_O, Z_O,ω,ϕ ,κ.

3.2.3 Transformation of the DEM to the imaging system

The transformation DEM to scanner system requires previously projecting the DEM, referenced in the terrain system, to the fiducial system by using the Equations 3.4 and 3.5:

$$x = -c\frac{a_{11}\ X - X_0\ + a_{21}\ Y - Y_0\ + a_{31}\ Z - Z_0}{a_{13}\ X - X_0\ + a_{23}\ Y - Y_0\ + a_{33}\ Z - Z_0} \tag{3.6}$$

$$y = -c\frac{a_{12}\ X - X_0\ + a_{22}\ Y - Y_0\ + a_{32}\ Z - Z_0}{a_{13}\ X - X_0\ + a_{23}\ Y - Y_0\ + a_{33}\ Z - Z_0} \tag{3.7}$$

Where,

X, Y, Z: are the coordinates of the DEM nodes in the terrain system.

X_0, Y_0, Z_0: are the coordinates of the projection centre in the terrain system.

x, y : are the image coordinates of DEM nodes in the fiducial system.

c: is the principal distance of the camera.

Then, the DEM nodes are transformed from the fiducial system to the scanner system, using the parameters of the Affine transformation, computed in step 3.2.1 (Figure 3.4).

3.2.4 Projective transformation of the densified DEM from the terrain system to the scanner system

Until now, it has been only projected in the scanner system the cell corners of the DEM. Since the DEM has a resolution lower than the digitized image, each DEM cell must be divided into sub-cells whose size is the same that the image cells (or image pixels). If the sub-cell size is greater than the cell size of the digitized image, it is lost information; if the sub-cell size is lower than the cell size of the digitized image, it is not obtained new details.

The geometric relation between each DEM sub-cell and the photograph can be determined in two ways: 1) using collinearity equations or 2) using projective transformation. In the first way, it is necessary to know the coordinate Z of each sub-cell, and it is only available in the cell corners of the DEM (i.e., the DEM might be generated to the same resolution that the photographed image). This involves a lot of computations and storing information. In a second way, it is not required the coordinate Z because of the sub-cell is projected directly on the digitized image, considering each DEM cell a plane (Figure 3.5). This reduces the computing process.

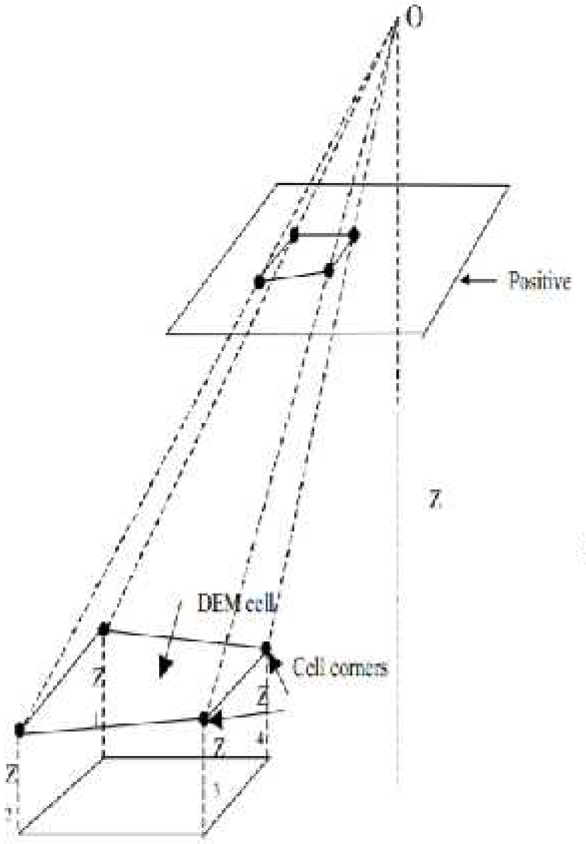

Figure (3.4) Projection of the DEM cell corners to the photographed image using collinearity equations

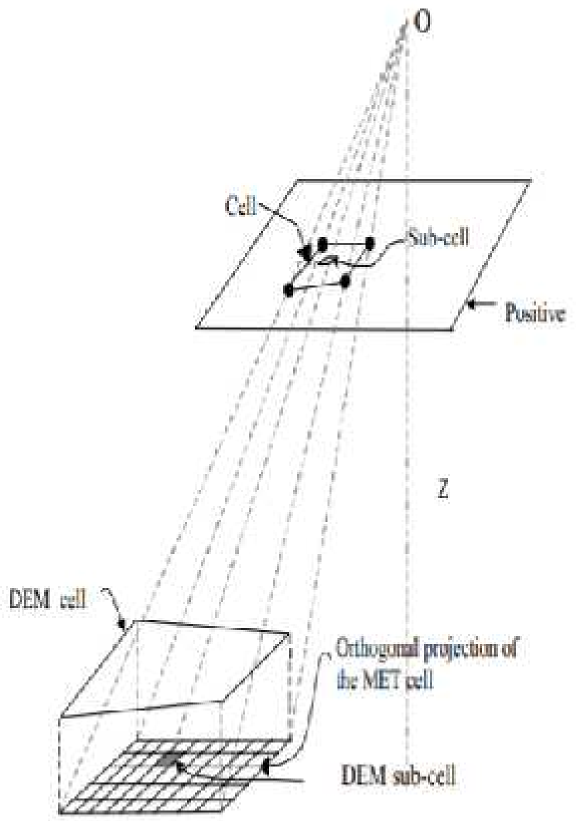

Figure (3.5) Projection of a DEM sub-cell to the photographed image using projective transformation. Previously, the cell corners were projected using collinearity equations.

Each sub-cell might project on the digitized image through a projective transformation whose equations are as follows:

$$x = a_0 + a_1X + a_2Y + a_3XY$$
$$y = b_0 + b_1X + b_2Y + b_3XY \qquad (3.8)$$

Where,

x, y : are the coordinates of the sub-cells in the scanner system.

X, Y: are the coordinates of the sub-cells in the terrain system.

a_0, a_1, a_2, a_3, b_0, b_1, b_2, b_3: are the parameters of the projective transformation.

To solve the Equations 3.8 it is required at least four points in both systems, this is, the four-cell corners of the DEM. Knowing the parameters of projective transformation, the coordinates X, Y of each sub-cell corner are transformed into the scanner system.

3.2.5 Determination of the grey tone.

In this stage a grey tone is assigned to the cells of the rectified photograph image, i.e., each DEM sub-cell projected on the digitized photograph image. Commonly, there is a partial overlapping of a sub-cell on the several pixels of digitized photograph image (Figure 3.6). Therefore, it is necessary to interpolate the grey tone of each DEM sub-cell from the grey tone of the pixels of the photographed image overlapping. Nearest neighbor, proportional areas, significant areas are the methods usually used to interpolate. [2]

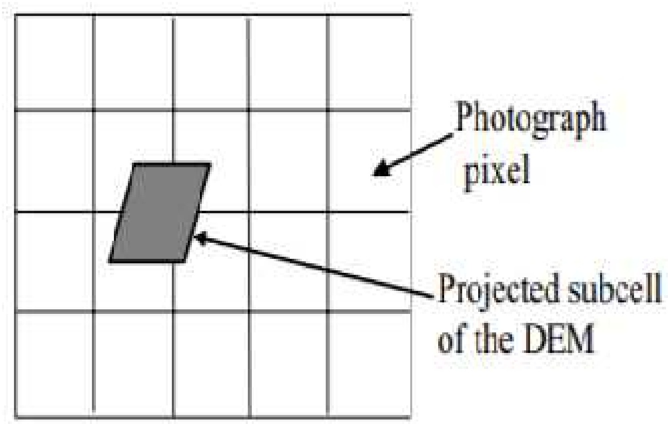

Figure (3.6). Projection of a DEM sub-cell on the digitized photograph.

3.4 Orthophoto and Mosaic production

1. Orthophotography

An orthophoto, orthophotograph or orthoimage is an aerial photograph geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt. [3]

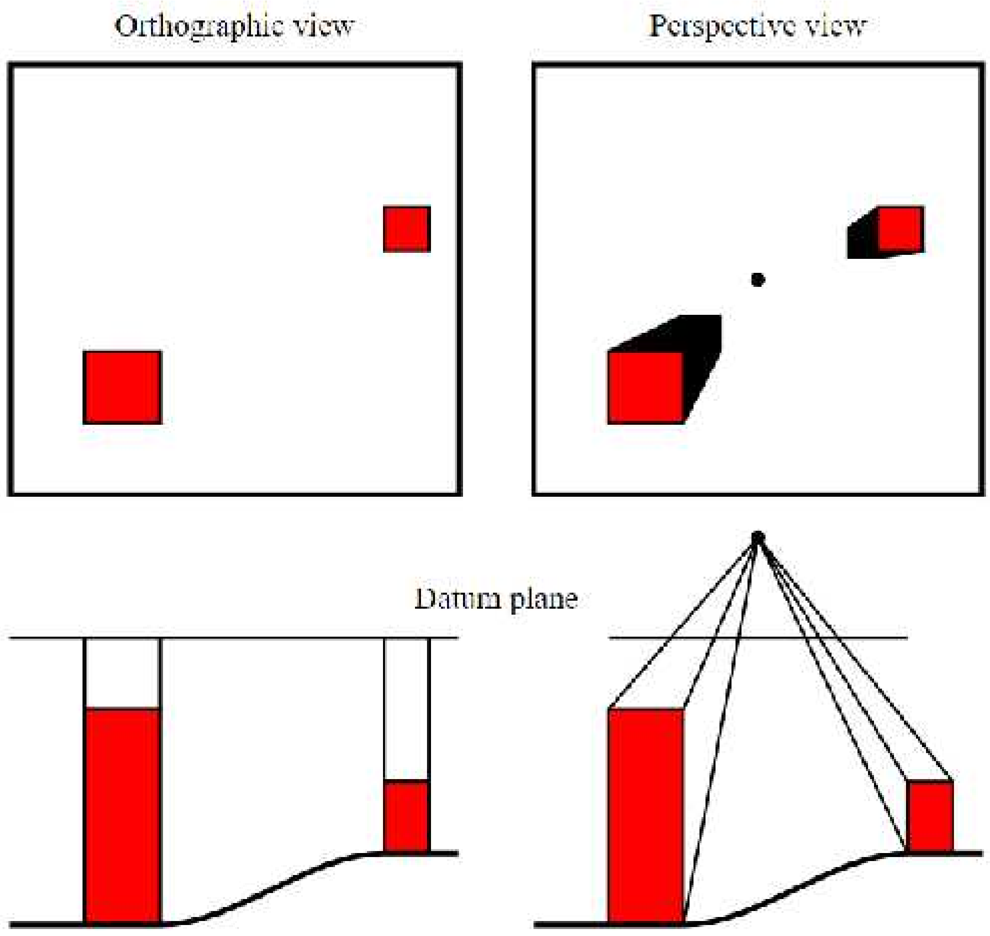

Figure (3.7) Orthographic views

Orthophotographs are commonly used in the creation of a Geographic Information System (GIS). The software can display the orthophoto and allow an operator to digitize or place linework, text annotations or geographic symbols (such as hospitals, schools, and fire stations). Some software can process the orthophoto and produce the linework automatically. Production of orthophotos was historically achieved using mechanical devices.

2. Orthorectification

The topographical variations in the surface of the earth and the tilt of the camera affect the distance with which features on the aerial image display. The more topographically diverse the landscape, the more distortion inherent in the photograph. Thus an aerial photograph taken over a field in Nebraska would contain little or no distortion, while an image of the Cascades would contain a high amount of distortion. As a result, real-world distances are not represented uniformly on the photograph. For example, an inch measured in a steep area would relate to a much longer distance than an inch measured over a flat surface such as a plain. Orthorectification is the name of the process used to remove these sources of distortion to equilibrate photo units with real-life distances. Once an aerial photo has been orthorectified, it is commonly referred to as an orthophoto.

An interesting side note is while orthorectification removes horizontal distortion, vertical relief displacement is still maintained. For example, the sides of a building would still contain distortion.

3.3 Orthorectification Process

A simple rectification process like removing the effects of the tilt of the camera may be all that is necessary. This is very rare and in most cases, a more involved process is required. After removing the effect of the camera tilt, removing the effects of relief must be accomplished by knowing the elevation of the terrain above (or below) the mapping plane must be known.

The digital orthophoto is gained from the original photo. During the orthorectification, we eliminate the perspective and height distortions at each image point. The reason for perspective distortion is that the image plane and the terrain is not parallel, the height distortion is caused by the differences in height on the terrain. After eliminating these distortions in the resulted image, the orthophoto can be used for mapping purposes directly. We can print it out on a certain scale; we can draw on it all the content which usually can be seen on a normal cartographic map. For the elimination of these distortions, we need to know the orientation elements and the DTM covering the image area.

If the target area is larger than one photo, we need to produce an orthophoto mosaic image. From this mosaic an orthophoto map is produced, when we add to it the coordinate grid, the scale, and other necessary mapping elements.

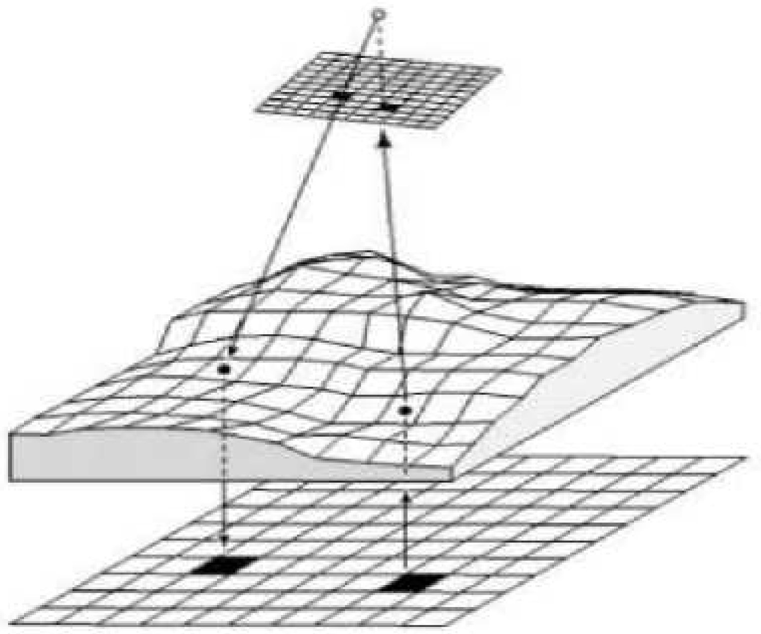

Figure (3.8) Orthorectification Process

4. Methods

There are two methods by which rectification of an aerial photograph can occur. In the first case, Ground Control Points (GCP) are determined either conventional ground surveys, from published maps, by Global Positioning System (GPS) surveys, or by aerotriangulation. These points are taken at visible physical features on the landscape. On the corresponding image, the x, y photo coordinates are then determined for each corresponding GCP. Depending on the type of algorithmic correction to be used, a minimum of 3 to 5 GCP must be established. The relationship of the x, y photo coordinates to the real world GCP is then used to determine the algorithm for resampling the image.

The second method of orthorectification is to use DEMs. These elevations are collected from stereoscopic models by photogrammetric methods to form a digital elevation model (DEM). As with using GCPs, the mathematical relationship between the real world coordinates and the scanned aerial photograph is determined and the digital image is resampled to create the rectified image. For both cases, the resampling of the digital image involves warping the image so that distance and area are uniforms in relationship to real-world measurements. This means that with the resampled photo, an inch on the image now measures the same distance on steep terrain as it does in a field

Depending on the needs of the aerial imagery in the GIS system, there are advantages and disadvantages to using either method. GCP orthorectification is a faster process and can be accomplished using existing paper maps to establish the GCPs. Using DEMs for orthorectification is a more accurate process by which to geocode digital imagery but require an existing DEM or DTM for processing.

Once an image has been orthorectified it can be used with vector and raster data of the same coordinate system. This image can now have road outlines and street names overlayed onto it. As mentioned before, spatial data can also now be accurately measured in terms of distances and areas, allowing for more complex spatial analysis.

1. **Levels of rectification**
   a. Level 1: raw image
   b. Level 2: rectified image with the exclusive use of image acquisition parameters, but without information on the relief. Such a product will be accessible when one obtains the digital images with their orientation and localization parameters.
   c. Level 3: image rectified by using image acquisition parameters and a DTM. The result will be therefore orthophotography.

5. Steps of orthophotography

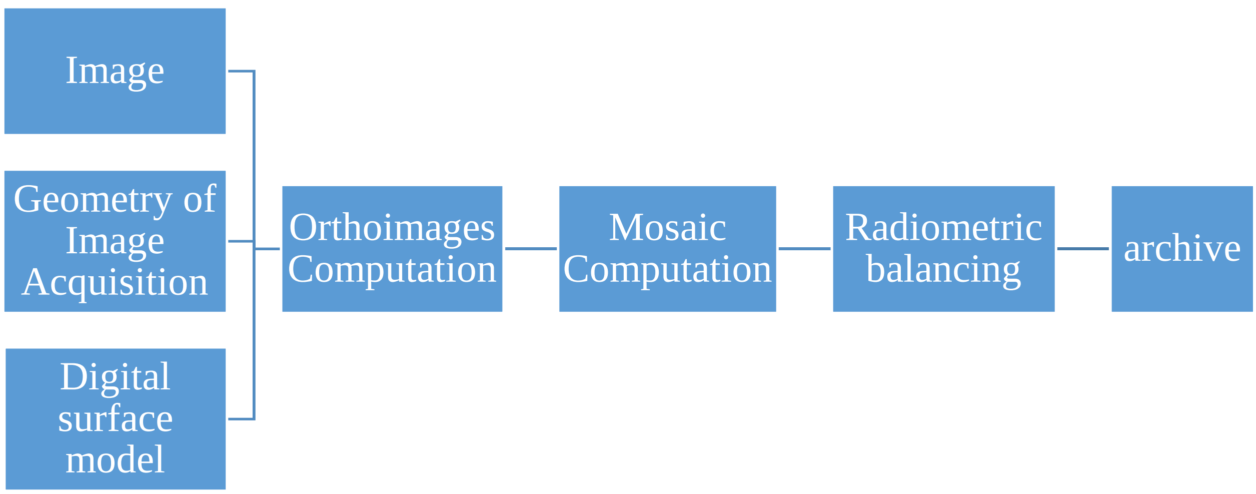

Figure (3.9) Steps of orthophotography

1. Images acquisition
2. The geometry of images is done by calculating the image orientation parameters: omega, phi, kappa, XL, YL, and ZL.
3. Collecting DTM direct by the photogrammetry, or the use of existing DTMs.
4. Orthophoto computation: this can be done using the DTM and the image orientation parameters. From the DTM the X Y and Z coordinates are measured and using the collinearity equations the xy-image coordinates are calculated to get the color (grey values). The calculated values of xy-image are in sub-pixels. resampling methods have to be used to interpolate the grey level values.

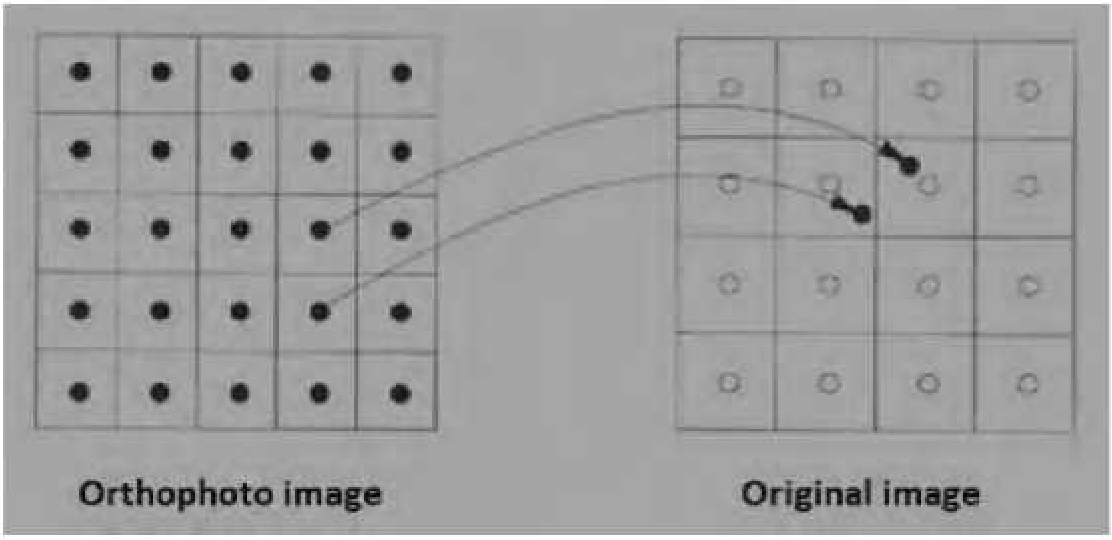

Figure (3.10) Orthophoto computation

1. Mosaic: the integration of a group of images (orthoimages) in an image. This requires two steps

    a. Defining the line of join up, this defines a path that joins the two images in common zone. This line must not be as visible as possible. This can be automatically done by defining the path as a line with minimum differences between the pixel's gray values in the line.

b. Radiometric balancing, both images have different grey levels for each pixel; this means that the resulting image will have different color distribution. This problem can be solved by image enhancement techniques like point operators and spatial filters.

Chapter Four

ASPRS Accuracy Standards for Digital Geospatial Data

4.1 Objective

4.2 Digital Imagery

4.3 Methodology

4.4 Accuracy Standards for Aerial Triangulation or INS-based Sensor Orientation

4.5 Horizontal Accuracy Standards for Digital Orthophotos

4.6 Horizontal Accuracy Standards for Planimetric Maps

4.7 Vertical Accuracy Standards

4.8 Appendix A — Background

4.9 Appendix B — Data Accuracy and Quality Examples

4.10 Elevation Data Accuracy vs. Elevation Data Quality

4.11 Appendix C — Accuracy Testing and Reporting Guidelines

4.12 Number of Checkpoints

4.13 Appendix D — Accuracy Statistics and Example

4.1 Objective

The objective of the ASPRS Accuracy Standards for Digital Geospatial Data is to replace the existing ASPRS Accuracy Standards for Large-Scale Maps, 1990, and the ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, 2004, with new accuracy standards that better address digital orthophotos and digital elevation data. The new standard includes accuracy thresholds for digital orthophotos and digital elevation data, independent of published map scale or contour interval, whereas the new standard for planimetric data, while still linked to map scale factor, tightens the planimetric mapping standard published in ASPRS, 1990. The new standard addresses geolocation accuracies of geospatial products and they are not meant for regulating classification accuracy of thematic maps.

To supplement these standards, Appendix A provides a background summary of other standards, specifications and/or guidelines relevant to ASPRS but which do not satisfy current requirements for digital geospatial data. Appendix B provides horizontal accuracy/quality examples for digital orthophotos based on ten common pixel sizes, horizontal accuracy/ quality examples for planimetric maps with ten common map scales, plus vertical accuracy/quality examples for ten common vertical data accuracy classes. Appendix C provides accuracy testing and reporting guidelines, and Appendix D provides relevant accuracy statistics and an example for computing vertical accuracy in vegetated and non-vegetated terrain consistent with these ASPRS Accuracy Standards for Digital Geospatial Data. All accuracies are assumed to be network accuracies unless specified to the contrary for projects requiring local accuracies only.

4.2 Digital Imagery

Whereas film photographs are commonly qualified by photo scale, a digital image file does not have a scale per se and can be displayed and printed at many different scales. Ground sample distance (GSD) provides a better metric for digital imagery. However, as explained in the "Talking Digital" highlight article in the December 1998 issue of Photogrammetric Engineering and Remote Sensing (PE&RS), collection GSD, display GSD, and product GSD, from the same source digital imagery, can be very different. For this ASPRS Accuracy Standard for Digital Geospatial Data, it is assumed that "GSD" refers to the collection GSD unless the ortho imagery is re-sampled to a coarser resolution in which case the GSD will be equivalent to the product GSD. For this document's purposes, the GSD is the linear dimension of a sample pixel's footprint on the ground in the source image; and it is assumed that "pixel size" is the real-world's ground size of a pixel in a digital orthophoto product after all rectifications and resampling procedures have occurred. Furthermore, in these standards, GSD is intended to pertain to near-vertical imagery and not too oblique imagery, also recognizing that GSD values can vary greatly in cities and mountainous areas.

4.3 Methodology

As indicated in the National Standard for Spatial Data Accuracy (NSSDA): "Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with coordinates of the same points from an independent source of higher accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy. A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points." In these ASPRS standards, the independent source of higher accuracy for QA/QC checkpoints should be at least three times more accurate than the required accuracy of the geospatial dataset being tested.

Elevation datasets rarely include clearly-defined point features, and it is extremely difficult and expensive to acquire surveyed vertical checkpoints at the exact same horizontal coordinates as lidar mass points. Consistent with best practices, Triangulated Irregular Networks (TINs) of elevation datasets are interpolated at the horizontal coordinates of vertical checkpoints in order to interpolate elevations at those coordinates for the dataset being tested. This is one reason why it is advantageous to utilize high-density elevation datasets so that interpolated elevation errors are minimized. When the terrain is flat or has a uniform slope, interpolation errors are significantly reduced; this is the reason why vertical checkpoints should be surveyed on flat or uniformly-sloped terrain, with slopes of 10 percent or less.

The ASPRS horizontal accuracy standard is based on accuracy classes using root-mean-square-error (RMSE) statistics, whereas the ASPRS vertical accuracy standard is based on accuracy classes using RMSE statistics in non-vegetated terrain, and 95th percentile statistics in vegetated terrain. Horizontal Class I products refer to highest-accuracy survey-grade geospatial data for more-demanding engineering applications, Class II products refer to a standard, high accuracy mapping-grade geospatial data, and Class III and larger class products refer to lower-accuracy visualization-grade geospatial data suitable for less-demanding user applications.

It is the responsibility of the data provider to do whatever it takes for the data to meet accuracy standards. This includes, but is not limited to, the bias removal (removal of the mean errors in x, y or z by what is commonly called an “x-bump”, “y-bump” and/or “z-bump”) prior to delivery. The client may also add a post-delivery requirement that the mean error in any direction should not exceed the target RMSE by more than 25%, for example, even if the RMSE accuracy standards are satisfied. Data providers may agree to do this voluntarily and should do so voluntarily if a systematic error can be identified in their data. However, it could be a costly and contentious issue if there is concern that the QA/ QC check points may be less accurate than the control points used by the data provider. Ultimately, it is the client (end user) who must decide whether remaining biases, identified post-delivery, should be removed, or whether they want to avoid the delays and extra cost of removing them. Regardless, mean errors that exceed 25% of the target RMSE, whether identified pre-delivery or post-delivery, should be investigated to determine what actions, if any, should be taken.

4.4 Accuracy Standards for Aerial Triangulation or INS-based Sensor Orientation

The results of the aerial triangulation (if performed) or the INS-based sensor orientation plays the main role in determining the accuracy of the final mapping products. Therefore, Table (4.1) provides the required 3-dimensional accuracy of aerial triangulation or the INS-based sensor orientation as measured on the ground using stereophotogrammetric measurements and ground checkpoints. Ground controls points used for aerial triangulation should be at least three times better than the expected accuracy of aerial triangulation. For example, in order to produce a 15 cm orthophoto with Class I accuracy, the ground control to be used for the aerial triangulation should have RMSExyz of 2.5 cm considering the required aerial triangulation RMSExyz of 7.5 cm (1/2 the orthophoto's pixel size). [6]

4.5 Horizontal Accuracy Standards for Digital Orthophotos

Table 4.1 includes three standard ASPRS horizontal accuracy classes (I, II, III) applicable to digital orthophotos produced from digital imagery with any ground sample distance (GSD), as well as variable lower accuracy classes for ortho imagery. It is the pixel size of the final digital orthophoto being tested that is used to establish horizontal accuracy classes for digital orthophotos.

Table (4.1) Horizontal Accuracy Standards for Orthophotos

Horizontal Data Accuracy Class	RMSEx and RMSEy	Orthophoto Mosaic Seamline Maximum Mismatch	Aerial Triangulation or INS-based RMSEx RMSEy and RMSEz
I	Pixel size x 1.0	Pixel size x 2.0	Pixel size x 0.5
II	Pixel size x 2.0	Pixel size x 4.0	Pixel size x 1.0
III	Pixel size x 3.0	Pixel size x 6.0	Pixel size x 1.5
…			
N	Pixel size x N	Pixel size x 2N	Pixel size x 0.5N

When producing digital orthophotos, the pixel size should never be less than 95% of the GSD of the raw imagery acquired by the sensor; however, so long as proper low-pass filtering is performed prior to decimation, orthophotos can be down-sampled from the GSD to any ratio that is agreed upon between the data provider and the data user, such as when imagery with 15-cm GSD is used to produce orthophotos with 30-cm pixels.

4.6 Horizontal Accuracy Standards for Planimetric Maps

Table 4.2 includes three ASPRS horizontal accuracy classes (I, II and III) applicable to planimetric maps compiled at any map scale. The Class I accuracy formula is based on the map's Scale Factor, which is the reciprocal of the ratio used to specify the map scale. The derivation of the number 0.0125 in Table 2 is 1.25% of the Map Scale Factor. For example, if a map was compiled for use or analysis at a scale of 1:1,200 or 1/1,200, the Scale Factor is 1,200. Then the RMSE in X or Y (cm) = 0.0125 times the Scale Factor. In this example: the Class I RMSEx and RMSEy standard would be 1,200 x 0.0125 = 15 cm. [7]

Table (4.2) Horizontal Accuracy Standards for Digital Planimetric Data

Horizontal Data Accuracy Class	RMSEx and RMSEy (cm)
I	1.25% of the Map Scale Factor (0.0125 x Map Scale Factor)
II	2.0 x Class I Accuracy (0.025 x Map Scale Factor)
III	3.0 x Class I Accuracy (0.0375 x Map Scale Factor)
.....	
N	N x Class I Accuracy

The 0.0125, 0.025 and 0.0375 multipliers in Table 4.2 are not unit-less; they apply only to RMSE values computed in centimeters. Appropriate conversions must be applied to compute RMSE values in other units. The source imagery, control, and data compilation methodology will determine the level of map scale detail and accuracy that can be achieved. Factors will include sensor type, imagery GSD, control, and aero triangulation methodologies. Multiple classes are provided for situations where a high level of detail can be resolved at a given GSD, but the sensor and/or control utilized will only support a lower level of accuracy.

4.7 Vertical Accuracy Standards

Table 4.3 includes vertical accuracy classes for ten accuracy levels relevant to elevation technologies, including mobile mapping systems, unmanned aerial systems, airborne or satellite stereo imagery, lidar or IFSAR.

The Non-vegetated Vertical Accuracy (NVA), i.e., vertical accuracy at the 95% confidence level in non-vegetated terrain, is approximated by multiplying the RMSEz (in non-vegetated land cover categories only) by 1.96. This includes survey checkpoints located in traditional open terrain (bare soil, sand, rocks, and short grass) and urban terrain (asphalt and concrete surfaces). The NVA, based on an RMSEz multiplier, should be used in non-vegetated terrain where elevation errors typically follow a normal error distribution. RMSEz-based statistics should not be used to estimate vertical accuracy in vegetated terrain where elevation errors often do not follow a normal distribution for unavoidable reasons.

The Vegetated Vertical Accuracy (VVA), an estimate of vertical accuracy at the 95% confidence level in vegetated terrain, is computed as the 95th percentile of the absolute value of vertical errors in all vegetated land cover categories combined, to include tall weeds and crops, brushlands, and fully forested. For all vertical accuracy classes, the VVA is 1.5 times larger than the NVA. If this VVA standard cannot be met in impenetrable vegetation such as dense cornfields or mangrove, low confidence area polygons should be developed and explained in the metadata as the digital equivalent to dashed contours used in the past when photogrammetrists could not measure the bare-earth terrain in forested areas. See Appendix C for low confidence area details.

Relative accuracy between lidar and IFSAR swaths in overlap areas is a measure of the quality of the system calibration and bore-sighting. A dataset, overall, cannot be any more accurate absolutely than its component parts (swaths) are accurate relative to each other. The requirements for relative accuracy are therefore more stringent than those for absolute accuracy.

- Relative accuracy swath-to-swath is computed as a root-mean square-difference (RMSDz) because neither swath represents an independent source of higher accuracy as used in root-mean square-error (RMSEz) calculations for tested data compared with QA/QC checkpoints of higher accuracy. In comparing overlapping swaths, users are comparing RMS differences rather than RMS errors.
- To the greatest degree possible, relative accuracy testing locations should include all overlap areas (sidelap, endlap, and cross flights), be evenly distributed throughout the full width and length of each overlap area, be located in non-vegetated areas (clear and open terrain and urban areas) at least 3 meters away from any vertical artifact or abrupt change in elevation, on slopes less than 20 percent, and within the geometrically reliable portion of both swaths (excluding the extreme edge points of the swaths). For lidar sensors with zig-zag scanning patterns from oscillating mirrors, the geometrically reliable portion excludes about 5% (2½% on either side); lidar sensors with circular or elliptical scanning patterns are generally reliable throughout.

Table (4.3) Vertical Accuracy Standards for Digital Elevation Data

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy3 (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy4 (VVA) at 95th Percentile (cm)	Relative Accuracy Swath-to-Swath in Non-Vegetated Terrain5 (RMSDz/Max Diff) (cm)
I	1.0	2.0	2.9	0.8/1.6
II	2.5	4.9	7.4	2.0/4.0
III	5.0	9.8	14.7	4.0/8.0
IV	10.0	19.6	29.4	8.0/16.0
V	12.5	24.5	36.8	10.0/20.0
VI	20.0	39.2	58.8	16.0/32.0
VII	33.3	65.3	98.0	26.7/53.3
VIII	66.7	130.7	196.0	53.3/106.6
IX	100.0	196.0	294.0	80.0/160.0
X	333.3	653.3	980.0	266.6/533.4

While the RMSDz value may be calculated from a set of specific test location points, the Maximum Difference requirement is not limited to these check locations; it applies to all locations within the entire dataset that meet the above criteria.

4.8 Appendix A — Background

Accuracy standards for geospatial data have broad applications nationally and/or internationally, whereas specifications provide technical requirements/acceptance criteria that a geospatial product must conform to in order to be considered acceptable for a specific intended use. Guidelines provide recommendations for acquiring, processing and/or analyzing geospatial data, normally intended to promote consistency and industry best practices.

4.9 Appendix B — Data Accuracy and Quality Examples

For Classes, I, II and III, Table 4.4 provides horizontal accuracy examples and other quality criteria for digital orthophotos produced from imagery having ten common pixel sizes. For other accuracy classes, use the formula for Class N in Table 4.1.

RMSEr equals the horizontal radial RMSE, i.e. $\overline{(RMSEx^2 + RMSEy^2)}$. All RMSE values and other accuracy parameters are in the same units as the pixel size. For example, if the pixel size is in cm, then RMSEx, RMSEy, RMSEr, horizontal accuracy at the 95% confidence level, and seamline mismatch are also in centimeters.

Table 4.5 provides horizontal accuracy examples and other quality criteria for planimetric maps intended for use at ten common map scales.

Source imagery GSD cannot be universally equated to image resolution or supported accuracy. This will vary widely with different sensors. The GSD values shown in Table 4.5 are typical of the GSD required to achieve the level of detail required for the stated map scales. Achievable accuracies, and the resulting map accuracy class, for a given GSD, will depend upon the sensor capabilities, control, adjustment, and compilation methodologies. [5]

Table 4.6 provides vertical accuracy examples and other quality criteria for ten vertical accuracy classes, each with an appropriate contour interval supported by the RMSEz values for users that may require contours to be plotted or displayed.

These vertical data accuracy classes were chosen for the following reasons:

Class I, the highest vertical accuracy class, is most appropriate for local accuracy determinations and tested relative to a local coordinate system, rather than network accuracy relative to a national geodetic network.

Class II, the second-highest vertical accuracy class could pertain to either local accuracy or network accuracy.

Class III elevation data, equivalent to 15-cm (~6-inch) contour accuracy, approximates the accuracy class most commonly used for high accuracy engineering applications of fixed-wing airborne remote sensing data.

Class IV elevation data, equivalent to 1-foot contour accuracy, approximates Quality Level 2 (QL2) from the National Enhanced Elevation Assessment (NEEA) when using airborne lidar point density of 2 points per square meter, and Class IV also serves as the basis for USGS' 3D Elevation Program (3DEP). The NEEA's Quality Level 1 (QL1) has the same vertical accuracy as QL2 but with a point density of 8 points per square meter. QL2 lidar specifications are found in the USGS Lidar Base Specification, Version 1.1

Class V elevation data are equivalent to that specified in the USGS Lidar Base Specification, Version 1.0

Class VI elevation data, equivalent to 2-foot contour accuracy, approximates Quality Level 3 (QL3) from the NEEA and covers the majority of legacy lidar data previously acquired for federal, state and local clients.

Class VII elevation data, equivalent to 1-meter contour accuracy, approximates Quality Level 4 (QL4) from the NEEA.

Class VIII elevation data are equivalent to 2-meter contour accuracy.

Class IX elevation data, equivalent to 3-meter contour accuracy, approximates Quality Level 5 (QL5) from the NEEA and represents the approximate accuracy of airborne IFSAR

Class X elevation data, equivalent to 10-meter contour accuracy, represents the approximate accuracy of elevation datasets produced from some satellite-based sensors

Table (4.4) Horizontal Accuracy/Quality Examples for Digital Orthophotos

Orthophoto Pixel Size	Horizontal Data Accuracy Class	RMSEx or RMSEy (cm)	RMSEr (cm)	Orthophoto Mosaic Seamline Maximum Mismatch (cm)	Horizontal Accuracy at the 95% Confidence Level6 (cm)
2.5-cm (~1 in)	I	2.5	3.5	5.0	6.1
	II	5	7.1	10.0	12.2
	III	7.5	10.6	15.0	18.4
5-cm (~2 in)	I	5.0	7.1	10.0	12.2
	II	10.0	14.1	20.0	24.5
	III	15.0	21.2	30.0	36.7
7.5-cm (~3 in)	I	7.5	10.6	15.0	18.4
	II	15.0	21.2	30.0	36.7
	III	22.5	31.8	45.0	55.1
15-cm (~6 in)	I	15.0	21.2	30.0	36.7
	II	30.0	42.4	60.0	73.4
	III	45.0	63.6	90.0	110.1
30-cm (~12 in)	I	30.0	42.4	60.0	73.4
	II	60.0	84.9	120.0	146.9
	III	90.0	127.3	180.0	220.3
60-cm (~24 in)	I	60.0	84.9	120.0	146.8
	II	120.0	169.7	240.0	293.7
	III	180.0	254.6	360.0	440.6
1-meter	I	100.0	141.4	200.0	244.7
	II	200.0	282.8	400.0	489.5
	III	300.0	424.3	600.0	734.3
2-meter	I	200.0	282.8	400.0	489.5
	II	400.0	565.7	800.0	979.1
	III	600.0	848.5	1200.0	1468.6
5-meter	I	500.0	707.1	1000.0	1224.0
	II	1000.0	1414.2	2000.0	2447.7
	III	1500.0	2121.3	3000.0	3671.5
10-meter	I	1000.0	1414.2	2000.0	2448.0
	II	2000.0	2828.4	4000.0	4895.4
	III	3000.0	4242.6	6000.0	7343.1

Table (4.5) Horizontal Accuracy/Quality Examples for Digital Planimetric Data

Map Scale	Horizontal Data Accuracy Class	Approximate Source Imagery GSD	RMSEx or RMSEy (cm)	RMSEr (cm)	Horizontal Accuracy at the 95% Confidence Level (cm)
1:100	1-2 cm	I	1.3	1.8	3.1
		II	2.5	3.5	6.1
		III	3.8	5.3	9.2
1:200	2-3 cm	I	2.5	3.5	6.1
		II	5.0	7.1	12.2
		III	7.5	10.6	18.4
1:250	3-4 cm	I	3.1	4.4	7.6
		II	6.3	8.8	15.3
		III	9.4	13.3	22.9
1:500	4-10 cm	I	6.3	8.8	15.3
		II	12.5	17.7	30.6
		III	18.8	26.5	45.9
1:1,000	10-20 cm	I	12.5	17.7	30.6
		II	25.0	35.4	61.2
		III	37.5	53.0	91.9
1:2,000	20-30 cm	I	25.0	35.4	61.2
		II	50.0	70.7	122.4
		III	75.0	106.1	183.6
1:2,500	30-40 cm	I	31.3	44.2	76.5
		II	62.5	88.4	153.0
		III	93.8	132.6	229.5
1:5,000	40-100 cm	I	62.5	88.4	153.0
		II	125.0	176.8	306.0
		III	187.5	265.2	458.9
1:10,000	1-2 m	I	125.0	176.8	306.0
		II	250.0	353.6	611.9
		III	375.0	530.3	917.9
1:25,000	3-4 m	I	312.5	441.9	764.9
		II	625.0	883.9	1529.8
		III	937.5	1325.8	2294.7

Table (4.6) Vertical Accuracy/Quality Examples for Digital Elevation Data

Vertical Data Accuracy Class	RMSEz in NonVegetated Terrain (cm)	NonVegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)	Appropriate Contour Interval supported by the RMSEz value	Recommended Minimum Nominal Pulse Density7 (pts/ m2)/ Maximum Nominal Pulse Spacing (meters)
I	1.0	2.0	2.9	3 cm	≥20/0.224
II	2.5	4.9	7.4	7.5 cm	16/0.250
III	5.0	9.8	14.7	15 cm (~6”)	8/0.354
IV	10.0	19.6	29.4	30 cm	(~1’) 2/0.707
V	12.5	24.5	36.8	37.5 cm	1/1.000
VI	20.0	39.2	58.8	60 cm	(~2’) 0.5/1.414
VII	33.3	65.3	98.0	1-meter	0.25/2.000
VIII	66.7	130.7	196.0	2-meter	0.1/3.162
IX	100.0	196.0	294.0	3-meter	0.05/4.472
X	٣٣٣.٣	653.3	980.0	10-meter	0.01/10.000

4.10 Elevation Data Accuracy vs. Elevation Data Quality

In aerial photography and photogrammetry, the accuracy of the individual points in a dataset is largely dependent on the scale and resolution of the source imagery. Larger scale imagery, flown at a lower altitude, produces smaller GSDs and higher measurement accuracies (both vertical and horizontal). Users have quite naturally come to equate higher density imagery (smaller GSD or smaller pixel sizes) with higher accuracies and higher quality.

In airborne topographic lidar, this is not entirely the case. While it is true that lidar flown at very high altitudes is not as accurate as lidar flown at low altitudes, and it is also true that lidar collected at lower altitudes tends to be denser than that flying at high altitudes and therefore have better definition for the terrain surface (better quality), there is no causal relationship between lidar point density and the vertical accuracy of the points being collected. It is known, however, that at high flying heights above ground level, IMU angular error dominates, particularly in wide collection swath modalities, whereas at low flying heights above ground level, GPS error tends to dominate.

For many typical lidar collections, the maximum accuracy attainable, theoretically, is now limited by physical error budgets of the different components of the lidar system such as laser ranging, the GPS, the IMU, and the encoder systems. Increasing the density of points does not change those factors. Beyond the physical error budget limitations, all data must also be properly controlled, calibrated, bore-sighted, and processed. Errors introduced during any of these steps will affect the accuracy of the data, regardless of how dense the data are. That said, high-density lidar data are usually of higher quality than low-density data, and the increased quality can manifest as apparently higher accuracy.

In order to accurately represent a complex surface, denser data are necessary to capture the surface details for accurate mapping of small linear features such as curbs and micro drainage features, for example. This does not make the individual lidar measurements any more accurate but does improve the accuracy of the derived surface at locations between the lidar measurements (as each reach between points is shorter). The accuracy of a lidar dataset is rarely (if ever) assessed by measuring the accuracy of discrete lidar points, and so assessments of a lidar dataset are accepted through a surrogate surface (TIN or DEM) made from the points. It is nearly impossible to establish QA/QC checkpoints at the exact coordinates of individual lidar mass points; that is why TINs are interpolated at the horizontal coordinates of QA/ QC checkpoints to determine elevation differences at those coordinates. The higher the point density, the smaller the TIN triangles subject to interpolation errors.

In vegetated areas, where many lidar pulses are fully reflected before reaching the ground, a higher density dataset tends to be more accurate because more points will penetrate through vegetation to the ground. More ground points will result in less interpolation between points and improved surface definition because more characteristics of the actual ground surface are being measured, not interpolated. This is more critical in variable or complex surfaces, such as mountainous terrain, where generalized interpolation between points would not accurately model all of the changes in the surface.

Increased density may not improve the accuracy in flat, open terrain where interpolation between points would still adequately represent the ground surface. However, in areas where denser data may not be necessary to improve the vertical accuracy of data, a higher density dataset may still improve the quality of the data by adding additional detail to the final surface model, by better detection of edges for break lines, and by increasing the confidence of the relative accuracy in swath overlap areas through the reduction of interpolation existing within the dataset. When lidar intensity is to be used in product derivation or algorithms, high collection density is always useful.

4.11 Appendix C — Accuracy Testing and Reporting Guidelines

Since 1990, ASPRS has used accuracy standards based on RMSE statistics. Since 1998, the NSSDA has advocated the use of RMSE statistics converted into horizontal and/or vertical accuracies at the 95% confidence levels by assuming errors follow a normal distribution and sample sizes are sufficiently large --allowing RMSE values to substitute for standard deviations as mean errors approach zero. Since 2004, the NDEP and ASPRS have both advocated the use of the 95th percentile to estimate vertical accuracy at the 95% confidence level for lidar data in vegetated land cover categories where errors do not necessarily follow a normal distribution.

When errors are normally distributed, accuracy testing can be performed with RMSE values, standard deviations, mean errors, maximum and minimum errors, and unit-less skew and kurtosis values. When errors are not normally distributed, alternative methods must be used. If the number of test points (checkpoints) is sufficient, testing and reporting can be performed using 95th percentile errors. A percentile rank is the percentage of errors that fall at or below a given value. Errors are visualized with histograms that show the pattern of errors relative to a normal error distribution. Standard deviation is a measure of precision around the mean whereas RMSE is a measure of accuracy relative to the referenced datum. As mean errors approach zero, RMSE and standard deviation values tend to converge. It is not mandatory that mean errors equal zero so long as required accuracies at the 95% confidence levels or 95th percentiles are satisfied.

The spatial distribution of ground control and checkpoints plays an important role in the accurate evaluation of any geospatial data. First, the strength of the geometry during the orientation reconstruction largely depends on the number of control points and their distribution in the project area. Second, the checkpoint evaluation provides error characterization around the checkpoints, and thus the distribution of checkpoints is essential for obtaining an adequate representation of the entire project area. In both cases, the recommendation is to use as many points as possible (affordable) and try to evenly space the points in the project area. Obviously, it is hard to assure the ideal case, as object space constraints (e.g., limited access, size and location of land cover categories) and, more importantly, economics defines the number of points surveyed in a project.

Past guidelines and accuracy standards have typically specified the required number of checkpoints and, in some cases, the land-cover types, but there was no requirement for defining and/or characterizing the spatial distribution of the points. Clearly, it is not simple and/or even feasible at this time, but characterizing the point distribution by some measure and, consequently, providing a quality number is undoubtedly both realistic and necessary. ASPRS encourages research into this topic, peer-reviewed and published in Photogrammetric Engineering and Remote Sensing for public testing and comment.

In the interim, the following guidelines for the number, distribution across land cover types, and spatial distribution within a project, of elevation data vertical checkpoints are recommended.

4.12 Number of Checkpoints

The 2001-2005 North Carolina Floodplain Mapping Program (NCFMP) required 100 checkpoints in each county, regardless of size. The average area of each county in North Carolina is approximately 500 square miles.

Based in part on the NCFPM experience, FEMA’s 2003 Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying specified 60-100 vertical checkpoints within the project area (assumed to be, typically, a county), depending on the number of land cover types within the project area. FEMA’s current Procedure Memorandum 61 – Standards for Lidar and Other High-Quality Topographic Data requires the same 60-100 checkpoints, but additionally links this quantity to each 2000 square mile area, or partial area, within the project.

Using metric units, ASPRS recommends 100 static vertical checkpoints for each 2500 square kilometer area, or partial area, within the project, consistent with Table 4.7. This provides a statistically defensible number of samples on which to base a valid vertical accuracy assessment. Vertical checkpoints are not clearly-defined point features. Table 4.7 also lists the number of static horizontal checkpoints recommended by ASPRS; horizontal checkpoints must be clearly-defined point features, clearly visible on the digital orthophotos or planimetric maps being tested.

Kinematic checkpoints, which are less accurate than static checkpoints, can be used in any quantity as supplemental data, but the core accuracy assessment must be based on static surveys, consistent with NOAA Technical Memorandum NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 cm and 5 cm), or equivalent. NGS-58 establishes ellipsoid height network accuracies of 5 cm at the 95% confidence level, as well as ellipsoid height local accuracies of 2 cm and 5 cm at the 95% confidence level.

Table (4.7) Recommended Number of Check Points Based on Area

Project Area (Square Kilometers)	Horizontal Testing	Vertical Testing (not clearly-defined points)		
	Total Number of Static Horizontal Check Points (clearly-defined points)	Number of Static Vertical Check Points in NVA	Number of Static Vertical Check Points in VVA	Total Number of Static Vertical Check Points
≤500	20	20	0	20
501-750	25	20	10	30
751-1000	30	25	15	40
1001-1250	35	30	20	50
1251-1500	40	35	25	60
1501-1750	45	40	30	70
1751-2000	50	45	35	80
2001-2250	55	50	40	90
2251-2500	60	55	45	100

The recommended number and distribution of NVA and VVA checkpoints may vary depending on the importance of different land cover categories and client requirements.

4.13 Appendix D — Accuracy Statistics and Example

- **NSSDA Horizontal Accuracy**

Let: $RMSE_x = \sqrt{\frac{\sum_{I=1}^{n}({}^{x}(data\ I - {}^{x}\text{check I})^{2}}{n}}$

and $RMSE_y = \sqrt{\frac{\sum_{I=1}^{n}({}^{y}data\ I - {}^{y}\text{check I})^{2}}{n}}$ (4.1)

Where:

${}^{x}data\ I$, ${}^{x}data\ I$, are the coordinates of the Ith checkpoint in the dataset,

${}^{y}check\ I$, ${}^{y}check\ I$, are the coordinates of the Ith checkpoint in the independent source of higher accuracy, n is the number of checkpoints tested,

I, is an integer ranging from 1 to n.

If a horizontal error at the point I is defined as:

$$ERROR_{r\,I} = \sqrt{({}^{x}(data\ I - {}^{x}\text{check I})^{2} + ({}^{y}(data\ I - {}^{y}\text{check I})^{2}} \qquad (4.2)$$

then horizontal RMSE is:

$$\text{RMSE}_r = \sqrt{\frac{\sum_{I=1}^{n}({}^{x}(data\ I - {}^{x}\text{check I})^{2} + ({}^{y}(data\ I - {}^{y}\text{check I})^{2}}{n}} = \sqrt{(\text{RMSE}_x^2 + \text{RMSE}_y^2)} \qquad (4.3)$$

Computing Accuracy according to the NSSDA, where: $RMSE_x = RMSE_y$:

$$RMSE_r = \sqrt{2\ \text{RMSE}_x^2} = \sqrt{2\ \text{RMSE}_y^2} = 1.4142(RMSE_x) = 1.4142(RMSE_y) \qquad (4.4)$$

The NSSDA assumes that systematic errors have been eliminated as best as possible. If horizontal errors are normally distributed and independent in each of the x- and y-components and error for the x-component is equal to and independent of error for the y-component, the factor 2.4477 is used to compute horizontal accuracy at the 95% confidence level. When the preceding conditions apply, the accuracy value according to NSSDA, shall be computed by the formula:

$$\text{Accuracy}_r = 2.4477\ RMSE_x = 2.4477\ RMSE_y = 2.4477\ \frac{RMSE_r}{1.4142} \qquad (4.5)$$

$= 1.7308\ RMSE_r$ where:

Accuracy_r is the horizontal (radial) accuracy at the 95% confidence level

- **NSSDA Vertical Accuracy**

Let: $$RMSE_z = \sqrt{\frac{\sum_{I=1}^{n}({}^{z}data\ I - {}^{z}\text{check I})^{2}}{n}} \qquad (4.6)$$

where:

${}^{z}\,data\ I$, is the vertical coordinate of the Ith checkpoint in the dataset,

$z_{check\ I}$,is the vertical coordinate of the Ith checkpoint in the independent source of higher accuracy,

n , is the number of checkpoints tested,

I , is an integer ranging from 1 to n.

The NSSDA assumes that systematic errors have been eliminated as best as possible. If vertical errors are normally distributed, the factor 1.9600 is applied to compute linear error at the 95% confidence level. Therefore, vertical accuracy, $Accuracy_z$ reported according to the NSSDA shall be computed by the following formula:

$$Accuracy_z = 1.9600\,(RMSE_z) \quad (4.7)$$

where:

$Accuracy_z$ is the vertical accuracy at the 95% confidence level.

- **Comparison of NSSDA and NMAS**

Per Appendix 3-D of the NSSDA (FGDC, 1998), the relationship between NSSDA and NMAS are defined as follows:

Relationship between NSSDA and NMAS (horizontal):

$$CMAS = 2.1460\ RMSE_x = 2.1460\ RMSE_y = 2.1460\ \frac{RMSE_r}{1.4142} = 1.5175\,(RMSE_r) \quad (4.8)$$

$$Accuracy_r = \frac{2.4477}{1.4142}\ CMAS = 1.1406(CMAS) \quad (4.9)$$

Relationship between NSSDA and NMAS (vertical):

$$VMAS = 1.6449(RMSE_z) \quad (4.10)$$

$$Accuracy_z = \frac{2.4477}{1.4142}\ VMAS = 1.1916\ (VMAS) \quad (4.11)$$

Therefore, vertical accuracy reported according to the NSSDA is:

$$\frac{2.4477}{1.4142} CI = 0.5958\ (CI)$$

Where:

CI is the contour interval, and

$$CI = \frac{Accuracy_z}{0.5958} = \frac{1.9600(RMSE_z)}{0.5958} = 3.2898\ (RMSE_z)^9 \quad (4.12)$$

Chapter Five

Data Collection and Analysis

5.1 Introduction

٥.٢ Test and validation of Accuracy

5.٣ Test of Relief Displacement

5.4 Test of accuracy in Palestine Explorer

5.1 Introduction

In this chapter the results will be present, tabulate, analyze, and the proper best practice procedure will be discussed to make accurate mapping by the given Orthophoto.

These results obtained after several tests were carried out on Flat Lands, Low Lands, High Lands, and Buildings contain one floor or more.

Two Tests were conducted, the first one is Test and Validation of accuracy, the second one is for Relief Displacement, the tests were carried out on several areas like Al-Shyouk, Jenin, Jericho, Doma, Hebron, and Ramallah, these were conducted by monitoring points by the GNSS/GPS system in RTK (Real-Time Kinematic) mode, and distributed to the areas which mentioned previously, and using the Geomolg site and Palestine Explorer.

5.2 Test and Validation of accuracy

This test aims to test and validate the accuracy of the orthophoto 2018 which using in Geomolg, and to check if it a rounding 30 cm or not.

This was done by monitored points distributed in flatlands, low lands, and high lands, in addition to the monitoring of one-story buildings, and high buildings such as villas, this was done in Al-shyouk, Jenin, Doma, Hebron, and Jericho, then the same coordinates that were monitored were taken from the Geomolg, and the difference between the coordinates was calculated.

5.2.1 AL-SHYOUK

A Palestinian village follows the governorate of Hebron, located in the north-east of Hebron, lies 880 m above sea level, located in 35.15º Easting and 31.58º Northing, the result of the test of accuracy on the lands and buildings in Al-shyouk shown in tables (5.1), (5.2).

Table (5.1) Accuracy Test on the lands In Al-shyouk

	#P	E	N	Z	X	Y	ΔX	ΔY
high land	1	163962.27	108560.95	987.108	163962.34	108561.12	0.07	0.17
	2	163993.85	108581.77	989.407	163993.95	108582.025	0.1	0.255
	3	163973.15	108590.14	988.973	163973.12	108590.56	0.03	0.42
Flatland	4	164090.74	108690.32	976.458	164090.9	108690.21	0.16	0.11
	5	164045.49	108692.47	975.835	164045.47	108692.56	0.02	0.09
	6	164046.64	108664.63	977.269	164046.75	108664.75	0.11	0.12
	7	164090.14	108663.9	974.704	164090	108664.51	0.14	0.61
low land	8	168644.69	107446.83	842.511	168644.42	107446.48	0.27	0.35
	9	168631.3	107460.6	846.902	168631.26	107459.91	0.04	0.69
	10	168628.06	107412.03	843.069	168628.35	107412.35	0.29	0.32
	11	168617.73	107424.99	844.749	168618.03	107425.08	0.3	0.09
						maximum	0.3	0.69
						minimum	0.02	0.09
						RMSE	0.1795	0.3723
						RMSEr	0.4133	

The Results of the Table for the lands in Al-Shyouk show that the accuracy of Δx is18 cm, in Δy the accuracy is a rounding 30 cm, but in some lands, and show that the flat land is more accurate than high and low land, in general, the accuracy of lands in Al-shyouk reach to 41 cm.

Table (5.2) Accuracy Test on the Buildings in Al-shyouk

	#P	E	N	Z	X	Y	ΔX	ΔY
building "one floor"	12	163977.88	108584.93	992.674	163977.95	108585.13	0.07	0.2
	13	163988.74	108580.38	992.9	163988.4	108580.93	0.34	0.55
	14	163984.66	108570.8	992.778	163984.56	108571.91	0.1	1.11
	15	163974.44	108576.96	995.139	163974.44	108577.85	0	0.89
building "many floors"	16	165176.99	109383.83	""	165176.59	109382.18	0.4	1.65
	17	165185.05	109383.27	""	165184.93	109381.58	0.12	1.69
	18	165186.2	109398.68	""	165186.12	109397.13	0.08	1.55
	19	165173.62	109399.12	""	165173.48	109398.26	0.14	0.86
	20	165172.99	109391.06	""	165172.91	109389.15	0.08	1.91
	٢١	164399.75	109404.08	""	164399.64	109403.34	0.11	0.74
	٢٢	164407.35	109395.66	""	164407.15	109397.26	0.20	1.60
	٢٣	164392.14	109394.38	""	164392.00	109394.10	0.14	0.28
	٢٤	164400.25	109387.13	""	164400.15	109387.63	0.10	0.50
						maximum	0.4	1.91
						minimum	0	0.2
						RMSE	0.1869	1.231
						RMSEr	1.245	

Results of the Table for the buildings in Al-Shyouk show that the accuracy of Δx is 19 cm and in Δy a rounding 123cm in general, the accuracy of buildings in Al-shyouk reaches to 124.5cm.

5.2.2 JENIN

Located in the northern West Bank, an area of 583 km2, and constitute a gain of 9.7% of the total West Bank area, lies 250 m above sea level, located in 35.30 º Easting and 32.47 º Northing, the result of the test of accuracy on the lands and buildings in Jenin shown in tables (5.3), (5.4).

Table (5.3) Accuracy Test on the lands In Jenin

	#P	E	N	Z	X	Y	ΔX	ΔY
high land	1	170451.02	206774.11	424.32	170451.52	206775.36	0.5	1.25
	2	170601.92	206644.35	401.36	170601.43	206644.2	0.49	0.15
	3	170373.55	206562.72	421.43	170373.78	206563.09	0.23	0.37
Flat land	4	170431.68	206373.97	379.83	170431.85	206374.12	0.17	0.15
	5	170468.19	206377.78	374.69	170468.49	206377.62	0.3	0.16
	6	170529.67	206394.77	370.27	170529.87	206394.83	0.2	0.06
	7	170473.21	206390.78	374.66	170473.36	206390.67	0.15	0.11
low land	8	179112.73	207146.49	180.7	179112.8	207146.56	0.07	0.07
	9	179105.18	207168.1	179.18	179105.26	207167.99	0.08	0.11
	10	179093.03	207203.51	177.63	179093.22	207203.58	0.19	0.07
	11	179087.52	207218.12	176.99	179087.66	207218.2	0.14	0.08
						maximum	0.5	1.25
						minimum	0.07	0.06
						RMSE	0.2813	0.426
						RMSEr	0.5104	

The Results of the Table for the lands in Jenin show that the accuracy of Δx 28 cm and Δy 43 cm in general, the accuracy of lands in Jenin reaches to 51 cm.

Table (5.4) Accuracy Test on the Buildings in Jenin

	#P	E	N	Z	X	Y	ΔX	ΔY
Building	12	178128.98	206243.78	224.62	178129.05	206243.51	0.07	0.27
	13	178116.33	206243.55	224.66	178116.02	206244.3	0.31	0.75
	14	178115.82	206251.98	224.59	178115.97	206251.75	0.15	0.23
	15	178128.28	206265.51	224.75	178128.67	206264.78	0.39	0.73
	16	178117.41	206264.81	224.66	178117.43	206264.45	0.02	0.36
	١٧	١٧٧٥٢١.١٠	١٩٩٥٦٤.٣٧	""	١٧٧٥٢١.٠٠	١٩٩٥٦٤.١٠	٠.١٠	٠.٢٧
	١٨	١٧٧٥٣٢.٥٤	١٩٩٥٦٠.٦٦	""	١٧٧٥٣٢.٦١	١٩٩٥٦٠.٩٧	٠.٠٧	٠.٣١
	١٩	١٧٧٥٢٧.٠٦	١٩٩٥٥١.١٦	""	١٧٧٥٢٦.٨٢	١٩٩٥٥٠.٨٠	٠.٢٤	٠.٣٦
	٢٠	١٧٧٥١٦.٨٤	١٩٩٥٥٤.٨٠	""	١٧٧٥١٦.٨٤	١٩٩٥٥٤.١٨	٠.٥	٠.٦٢
						maximum	0.39	0.75
						minimum	0	0.23
						RMSE	0.209	0.504
						RMSEr	0.546	

The Results of the Table for the Buildings in Jenin show that the accuracy of Δx is approximately 30 cm reach to 21 cm, and in Δy the accuracy becomes less to reach 5 cm, in general, the accuracy of buildings in Jenin reaches to 55cm.

5.2.3DOMA/NABLUS

A village located in the center of Palestine, in the northeastern part of the West Bank, about 25 km south of Nablus city center, lies ٦٢٠ m above sea level, located in 35.٣٧٦ ° Easting and 32.٠٥٥ ° Northing, the result of the test of accuracy on the lands and buildings in Doma shown in tables (5.5), (5.6).

Table (5.٥) Accuracy Test on the lands in Doma

	#P	E	N	Z	X	Y	ΔX	ΔY
high land	1	183134.66	163585.67	795.057	183134.51	163585.65	0.15	0.02
	2	183239.06	163619.81	743.495	183239.22	163619.78	0.16	0.03
	3	183156.41	163320.33	802.638	183156.21	163320.23	0.2	0.1
	4	183235.38	163336.06	763.927	183235.26	163335.84	0.12	0.22
flat land	5	183935.08	163670.7	641.535	183934.83	163670.6	0.25	0.1
	6	184159.96	163678.63	634.967	184159.82	163678.68	0.14	0.05
	7	183967.23	163615.22	641.31	183966.98	163615.11	0.25	0.11
	8	184158.82	163613.16	632.966	184158.04	163613.66	0.78	0.5
low land	9	184112.85	164139.6	537.899	184112.33	164139.35	0.52	0.25
	10	184159.07	164174.02	502.492	184158.94	164174.46	0.13	0.44
	11	184193.67	163993.69	547.399	184194.75	163993.76	1.08	0.07
	12	184264.6	164050.85	496.415	184264.7	164050.5	0.1	0.35
						maximum	1.08	0.5
						minimum	0	0.1
						RMSE	0.459	0.255
						RMSEr	0.525	

The Results of the Table for the lands in Doma show that the accuracy of Δx 46 cm and Δy a rounding 30 cm to reach 25.5 cm and show that the high land more accurate than flat and low land, in general, the accuracy of lands in Doma reaches to 52.5cm.

Table (5.٦) Accuracy Test on the Buildings in Doma

	#P	E	N	Z	X	Y	ΔX	ΔY
building "one floor"	13	١٨٤٩٤٦.٤٥	١٦٢٤٣٥.١٢	""	١٨٤٩٤٦.٥٧	١٦٢٤٣٤.٩٧	٠.١٢	٠.١٥
	14	١٨٤٩٤٨.٦٠	١٦٢٤٢٦.٦٠	""	١٨٤٩٤٨.٣٥	١٦٢٤٢٦.٤٠	٠.٢٥	٠.٢
	15	١٨٤٩٥٨.٤٧	١٦٢٤٢١.١٢	""	١٨٤٩٥٨.٣٧	١٦٢٤٢١.١٢	٠.١	٠
	16	١٨٤٩٦٠.٠١	١٦٢٤٣٣.٩٢	""	١٨٤٩٥٩.٨٧	١٦٢٤٣٣.٦٠	٠.١٤	٠.٣٢
building "many floors"	17	١٨٤٩٧٤.٦٦	١٦٢٤٧٤.٩٧	""	١٨٤٩٧٤.٥٥	١٦٢٤٧٤.٣٤	٠.١١	٠.٦٣
	18	١٨٤٩٧٣.٨٥	١٦٢٤٦٦.٦٨	""	١٨٤٩٧٣.٩٢	١٦٢٤٦٦.٤٠	٠.٠٧	٠.٢٨
	19	١٨٤٩٨٥.٢٥	١٦٢٤٧٤.٩١	""	١٨٤٩٨٤.٤٣	١٦٢٤٧٣.٣٥	٠.٨٢	١.٥٦
	20	١٨٤٩٨٤.٠٧	١٦٢٤٦٥.٨٩	""	١٨٤٩٨٣.٦٨	١٦٢٤٦٥.١٥	٠.٣٩	٠.٧٤
	٢١	١٨٥٠١٨.٤٧	١٦٢٤٥٧.٩١	""	١٨٥٠١٨.٣٠	١٦٢٤٥٦.٨٨	٠.١٧	١.٠٣
	٢٢	١٨٥٠١٦.٢٨	١٦٢٤٦٦.٨٧	""	١٨٥٠١٥.٧٥	١٦٢٤٦٥.٦٩	٠.٥٣	١.١٨
	٢٣	١٨٥٠٠٧.١٦	١٦٢٤٦٣.٠٥	""	١٨٥٠٠٦.٧٦	١٦٢٤٦٢.٧٨	٠.٤٠	٠.٢٧
	٢٤	١٨٥٠٠٨.٥٧	١٦٢٤٥٤.٥٦	""	١٨٥٠٠٨.٥٥	١٦٢٤٥٤.٤٧	٠.٠٢	٠.٠٩
						maximum	0.82	1.56
						minimum	0.02	0
						RMSE	0.359	0.748
						RMSEr	0.829	

The Results of the Table for the Buildings in Doma shows that the accuracy in Δx a rounding 30 cm reach to 36 cm, in Δy the table shows that accuracy becomes less than Δx to reach 75 cm, in general, the accuracy of buildings in Doma reaches to 83 cm.

٥.٢.٤ JERICHO

It is a Palestinian city in the West Bank, located in the Jordan valley, with the Jordan River to the east and Jerusalem to the west, lies ٢٧٥ m below sea level, located in 35.٤٥° Easting and 31.٨٦° Northing, the result of the test of accuracy on the lands and buildings in Jericho shown in tables (5.7), (5.8).

Table (5.7) Accuracy Test on the lands in Jericho

	#P	E	N	Z	X	Y	ΔX	ΔY
high land	1	191179.82	144235.12	""	191180.32	144235.09	0.50	0.03
	2	191192.87	144193.58	""	191192.95	144192.98	0.08	0.6
	3	191145.69	144184.64	""	191146.44	144185.95	0.75	1.31
	4	191134.49	144234.53	-94.2	191134.86	144234.16	0.41	0.37
flat land	5	191783.09	143174.99	-156.84	191782.88	143175.13	0.21	0.14
	6	191771.55	143192.44	-161.69	191771.42	143192.64	0.13	0.20
	7	191809.33	143222.99	-164.42	191809.36	143223.21	0.03	0.22
	8	191820.52	143213.83	-158.70	191820.42	143214.02	0.10	0.19
low land	9	193755.90	139717.08	""	193755.53	139716.96	0.37	0.12
	10	193733.92	139717.38	""	193733.22	139717.29	0.70	0.09
	11	193729.90	139688.69	-258	193729.58	139688.23	0.32	0.46
	12	193754.32	139687.15	""	193753.70	139687.02	0.62	0.13
						maximum	0.75	1.31
						minimum	0.٠٣	0.٠٣
						RMSE	0.444	0.487
						RMSEr	0.659	

The Results of the Table for the lands in Jericho show that the accuracy of Δx and Δy is a rounding ٤4, 49cm, and shows that the flat land more accurate than high and low land, in general, the accuracy of lands in Jericho reaches to 66cm.

Table (5.8) Accuracy Test on the Buildings in Jericho

	#P	E	N	Z	X	Y	ΔX	ΔY
building "one floor"	13	192461.69	142732.86	""	192461.58	142732.71	٠.١1	٠.١٥
	14	192464.64	142734.94	""	192464.37	142734.74	٠.٢7	٠.٢
	15	192473.87	142732.62	""	192473.77	142731.73	٠.١	٠.89
	16	192468.21	142724.33	""	192468.07	142724.01	٠.١٤	٠.٣٢
building "many floors"	17	192333.78	142735.54	""	192333.67	142734.63	٠.١١	٠.91
	18	192346.32	142728.37	""	192346.25	142728.09	٠.٠٧	٠.٢٨
	19	192342.72	142719.60	""	192341.96	142718.10	٠.76	١.50
	20	192331.19	142724.63	""	192330.78	142723.89	٠.41	٠.٧٤
	٢١	192230.05	142237.07	""	192229.88	142236.04	٠.١٧	١.٠٣
	٢٢	192245.90	142231.64	""	192245.37	142230.39	٠.٥٣	١.25
	٢٣	192240.75	142217.26	""	192240.38	142216.99	٠.37	٠.٢٧

	٢٤	192224.98	142222.36	""	192224.96	142222.27	٠.٠٢	٠.٠٩
						maximum	0.76	1.5
						minimum	0.02	0.09
						RMSE	0.347	0.818
						RMSEr	0.888	

The Results of the Table for the Buildings in Jericho shows that the accuracy in Δx a rounding 30 cm to reach 35 cm, but in some building that contains more than one floor the accuracy becomes less, in Δy the table shows that accuracy becomes less than Δx, to reach 82 cm, in general, the accuracy of buildings in Jericho reaches to 89 cm.

5.2.5 HEBRON

It is a Palestinian city in the southern West Bank, 30 km south of Jerusalem, it lies 930 meters above sea level, The largest city in the West Bank, located in 35.095º Easting and 3١.53º Northing**,** the result of the test of accuracy on the lands and buildings in Hebron shown in tables (5.9), (5.10).

Table (5.9) Accuracy Test on the lands in Hebron

	#P	E	N	Z	X	Y	ΔX	ΔY
high land	1	158851.99	103793.97	""	158851.89	103794.09	0.10	0.12
	2	158833.13	103790.94	""	158832.73	103790.44	0.4	0.5
	3	158814.22	103817.98	""	158813.70	103817.21	0.52	0.77
	4	158825.31	103833.55	""	158825.06	103833.16	0.25	0.39
flat land	5	155299.71	103397.93	""	155299.20	103397.43	0.38	0.50
	6	155265.21	103409.77	""	155265.46	103409.51	0.25	0.26
	7	155284.62	103358.26	""	155284.84	103357.46	0.22	0.80
	8	155223.84	103341.25	""	155224.19	103341.37	0.35	0.12
low land	9	158857.02	101654.66	""	158856.37	101654.40	0.65	0.26
	10	158819.94	101651.40	""	158819.43	101651.15	0.51	0.25
	11	158821.70	101632.89	""	158822.40	101632.63	0.7	0.26
	12	158867.69	101631.91	""	158867.56	101631.83	0.13	0.08
						maximum	0.70	0.80
						minimum	0.1	0.08
						RMSE	0.438	0.446
						RMSEr	0.625	

The Results of the Table for the lands in Hebron show that the accuracy of Δx and Δy is a rounding 45 cm, and shows that the high land more accurate than flat and low land, in general, the accuracy of lands in Hebron reaches to 63cm.

Table (5.10) Accuracy Test on the Buildings in Hebron

	#P	E	N	Z	X	Y	ΔX	ΔY
building "one floor"	1	159077.03	101975.77	""	159076.82	101975.62	٠.21	٠.١٥
	2	159073.64	101967.58	""	159073.37	101967.38	٠.٢7	٠.٢
	3	159088.08	101961.66	""	159088.02	101961.28	٠.06	٠.38
	4	159092.16	101969.59	""	159091.72	101969.27	٠.44	٠.٣٢
building "many floors"	5	159056.29	101946.64	""	159056.14	101945.80	٠.١5	٠.84
	6	159074.02	101937.95	""	159072.70	101937.67	1.32	٠.٢٨
	7	159083.91	101958.10	""	159083.29	101956.68	٠.62	١.50
	8	159067.40	101965.29	""	159066.99	101964.55	٠.41	٠.٧٤
	9	158966.36	101970.19	""	158966.19	101969.16	٠.١٧	١.٠٣
	10	158973.21	101960.27	""	158972.68	101959.02	٠.٥٣	١.25
	11	158961.56	101949.16	""	158960.56	101948.89	1.00	٠.٢٧
	12	158953.01	101958.37	""	158952.93	101958.28	٠.٠8	٠.٠٩
						maximum	1.32	1.5
						minimum	0.06	0.09
						RMSE	0.599	0.774
						RMSEr	0.979	

The Results of the Table for the Buildings in Hebron shows that the accuracy in Δx 60 cm, in Δy the accuracy becomes less than Δx, to reach 77cm, and shows that the accuracy in building which contains one floor more accurate than others, in general, the accuracy of buildings in Hebron reaches to 98 cm.

5.2.6 Results and Analysis of Test and Validation Tables

In the accuracy tests which conducted on many areas specifically on the high, flat and low land in these areas, every table has shown that the Geomolg have different accuracy, it reached to 41 cm in Al-shyouk, 51 in Jenin, 52.5 in Doma, 66 in Jericho, 62.5 in Hebron, but most tables showed that the flat land is more accurate than high and low land.

Inaccuracy tests conducted on the buildings, all tables showed that the accuracy in the building is less than lands, and increasing in buildings that contain on the floor, but the values of accuracy different from table to other, it reached to 124.5 cm in Al-shyouk, 55 in Jenin, 83 in Doma, 89 in Jericho, 98 in Hebron.

5.3 Test of Relief Displacement

Relief is the difference in elevation between the high and low points of a feature or object. Due to central perspective projection system used in aerial photography, vertical objects standing above datum (average elevation) other than principal point lean outward and objects standing below the datum (average elevation) lean inward in an aerial photograph. This distortion is called relief displacement.

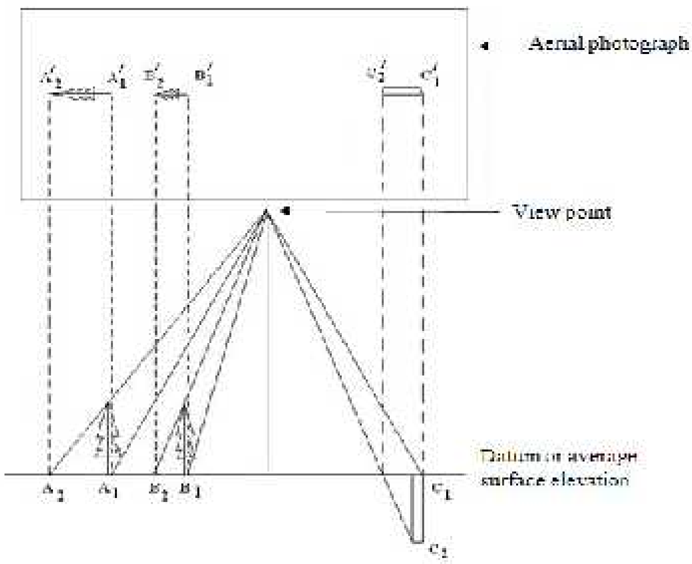

Figure (٥.١) Relief Displacement in Aerial photography

The main causes of relief displacement are the height of the object, focal length, flying height or altitude, the height of objects in relation to datum plane and effect of the field of view.

This test aims to test the relief displacement of the orthophoto 2018 which using in Geomolg, this was done by used Geomolg and measured approximately 5 points on the top and on the ground of the buildings, it was carried out on one, two and three-floor buildings in several √areas like Jericho, Jenin, Hebron, and Ramallah, then the difference between coordinates and RMSE was calculated.

RMSE (Root Mean Square Error) is the standard deviation of the residuals (prediction errors). Residuals are a measure of how far from the regression line data points are; RMSE is a measure of how to spread out these residuals are. In other words, it tells you how concentrated the data is around the line of best fit. Root mean square error in equation (5.1) is commonly used in climatology, forecasting, and regression analysis to verify experimental results.

$$\sqrt{\sum \Delta X^2 / n-1}, \sqrt{\sum \Delta Y^2 / n-1} \qquad (5.1)$$

5.3.1 Buildings of one floor

In this test, the top and the ground of the buildings of one floor were measured, and then the difference between coordinates and RMSE was calculated in several areas.

The result of the test of Relief displacement on the buildings of one-floor is shown in the table (5.11).

Table (5.11) Test of Relief Displacement for one floor's buildings

#point	Area	X top	Y top	X ground	Y ground	ΔX	ΔY
١	Jenin	178848.99	207358.35	178849.39	207357.36	٠.٤	٠.٩٩
٢	Jenin	178906.46	207302.25	178906.72	207300.53	٠.٢65	١.٧٢
٣	Jenin	178878.9	207286.15	178878.9	207284.89	٠	١.٢٦
٤	Jenin	178863.82	207297.86	178864.02	207296.73	٠.٢	١.١٣
٥	Jenin	179108.55	207491.94	179108.42	207490.55	٠.١٣	١.٣٩
٦	Jericho	194259.56	141220.78	194259.56	141219.2	٠	١.٥٨
٧	Jericho	194963.21	141311.39	194963.34	141310.13	٠.١٣	١.٢٦
٨	Jericho	193263.63	141694.15	193263.37	141693.56	٠.٢٦	٠.٥٩
٩	Jericho	193455.74	141871.99	193455.87	141871.27	٠.١٣	٠.٧٢
١٠	Jericho	194048.11	140390.58	194048.05	140389.46	٠.٠٦	١.١٢
١١	Hebron	158609.37	106206.37	158608.57	106205.44	٠.٨	٠.٩٣
١٢	Hebron	158531.98	106206.64	158532.64	106206.04	٠.٦٦	٠.٦
١٣	Hebron	159872.06	105625.5	159871.8	105624.17	٠.٢٦	١.٣٣
١٤	Hebron	159252.87	105721.65	159252.81	105722.97	٠.٠٦	١.٣٢
١٥	Hebron	158685.49	104938.05	158684.93	104937.59	٠.٥٦	٠.٤٦
١٦	Ramallah	169965.74	151015.86	169965.74	151015.33	٠	٠.٥٣
١٧	Ramallah	170074.96	151109.94	170075.09	151108.81	٠.١٣	١.١٣
١٨	Ramallah	169858.85	150932.65	169858.72	150931.66	٠.١٣	٠.٩٩
١٩	Ramallah	170195.18	151105	170194.78	151104.34	٠.٤	٠.٦٦
٢٠	Ramallah	170277.92	150956.31	170277.65	150955.58	٠.٢٧	٠.٧٣
				maximum		0.27	1.72
				minimum		0	0.46
				RMSE		0.334	1.11
				RMSEr		1.1592	

The table shows that the relief displacement is the difference between different areas, whether in ΔX and ΔY, but in general, the displacement in ΔX is smaller than ΔY to reach 0 cm, and in ΔY the values reach 172cm and shows that the relief displacement in Ramallah less than Hebron less than Jericho less than Jenin.

٥.3.2 Buildings of two floors

In this test, the top and the ground of the buildings of two floors were measured, and then the difference between coordinates and RMSE was calculated in several areas.

The result of the test of Relief displacement on the buildings of two-floor is shown in the table (5.12).

Table (5.12) Test of Relief Displacement for two floor's buildings

#point	Area	X top	Y top	X ground	Y ground	ΔX	ΔY
١	Jenin	179115.78	207126.23	179115.12	207124.77	0.66	1.46
٢	Jenin	178889.49	207257.84	178889.55	207257.05	0.06	0.79
٣	Jenin	178889.09	207478.05	178889.42	207476.06	0.33	1.99
٤	Jenin	178884.06	207586.06	178884.06	207584.15	0	1.91
٥	Jenin	178953.58	207592.48	178953.72	207591.49	0.14	0.99
٦	Jericho	194207.96	141145.87	194207.83	141146.4	0.13	0.53
٧	Jericho	194200.09	141148.69	194201.22	141147.89	1.13	0.8
٨	Jericho	194102.28	141142.12	194103.53	141141.26	1.25	0.86
٩	Jericho	193557.3	141046.52	193558.1	141046.12	0.8	0.4
١٠	Jericho	192745.69	141723.61	192745.69	141722.15	0	1.46
١١	Hebron	159802.04	103714.08	159802.18	103711.17	0.135	2.915
١٢	Hebron	159753.5	103838.57	159753.77	103836.79	0.27	1.78
١٣	Hebron	159665.53	103812.51	159666.26	103810.39	0.73	2.12
١٤	Hebron	159413.76	103816.55	159413.96	103815.29	0.2	1.26
١٥	Hebron	159265.19	103733.66	159265.79	103731.01	0.6	2.65
١٦	Ramallah	169749.57	150773.12	169750.43	150771.53	0.86	1.59
١٧	Ramallah	170020.98	151156.79	170020.64	151154.74	0.34	2.05
١٨	Ramallah	170343.11	151075.91	170342.85	151073.86	0.26	2.05
١٩	Ramallah	170422.44	151086.98	170421.78	151085.19	0.66	1.79
٢٠	Ramallah	170447.05	151104.45	170446.72	151102.93	0.33	1.52
				maximum		1.25	2.915
				minimum		0	0.4
				RMSE		0.587	1.725
				RMSEr		1.822	

The table shows that the relief displacement is the difference between different areas, whether in ΔX and ΔY, but in general, the displacement in ΔX is smaller than ΔY to reach 0 cm, and in ΔY the values reach 291.5cm and shows that the relief displacement in Jericho less than Jenin less than Ramallah less than Hebron.

0.3.3 Buildings of three floors

In this test, the top and the ground of the buildings of three floors were measured, and then the difference between coordinates and RMSE was calculated in several areas.

The result of the test of Relief displacement on the buildings of three-floors is shown in the table (5.13).

Table (5.13) Test of Relief Displacement for three floor's buildings

#point	Area	X top	Y top	X ground	Y ground	ΔX	ΔY
1	Jenin	179376.56	207144.8	179377.15	207143.28	0.59	1.52
2	Jenin	177700.78	206950.67	177699.06	206950.34	1.72	0.33
3	Jenin	177309.2	206742.76	177310.52	206743.42	1.323	0.66
4	Jenin	177114.45	206244.7	177114.45	206246.62	0	1.92
5	Jenin	177138.38	206469.83	177138.84	206471.02	0.46	1.19
6	Jericho	194402.91	140368.36	194402.71	140366.11	0.2	2.25
7	Jericho	194448.78	140407.06	194448.58	140405.54	0.2	1.52
8	Jericho	194371.49	140417.12	194371.49	140415.14	0	1.98
9	Jericho	193442.54	140458.05	193442.01	140455.27	0.53	2.78
10	Jericho	194120.35	140891.99	194120.15	140891.99	0.2	0
11	Hebron	158991.93	104098.96	158992.19	104096.05	0.264	2.91
12	Hebron	159030.18	104070.45	159030.57	104067.01	0.39	3.44
13	Hebron	159080.98	104105.57	159080.38	104103.66	0.6	1.91
14	Hebron	159011.14	104132.39	159010.08	104134.11	1.06	1.72
15	Hebron	159148.75	104130.67	159149.08	104132.66	0.33	1.99
16	Ramallah	170272.98	150291.97	170272.12	150290.45	0.86	1.52
17	Ramallah	170466.73	151167.36	170466.2	151165.11	0.529	2.25
18	Ramallah	170434.71	151276.17	170434.25	151273.19	0.46	2.98
19	Ramallah	170465.34	151216.17	170465.27	151215.11	0.07	1.06
20	Ramallah	170547.09	151212.53	170547.49	151211.08	0.4	1.45
				maximum		1.72	3.44
				minimum		0	0
				RMSE		0.684	2.017
				RMSEr		2.129	

The table shows that the relief displacement is the difference between different areas, whether in ΔX and ΔY, but in general, the displacement in ΔX is smaller than ΔY to reach 0 cm, and in ΔY the values reach to 344cm and shows that the relief displacement in Jenin less than Jericho less than Ramallah less than Hebron.

5.3.4 Results and Analysis of Test and Validation Tables

In the Relief displacement tests which conducted on many areas like Jenin, Jericho, Hebron, and Ramallah all tables shown that the Geomolg have relief displacement specifically in buildings, it`s values and RMSE values difference according to the height of the object, where the relief displacement and RMSE increase as the height of the object increase.

In Buildings of one floor the values of RMSEr 1.159 cm, In Buildings of two floors 1.822, In Buildings of three floors 2.129.



Figure (٥.٢) Relief Displacement in Buildings

5.4 Test of accuracy in Palestine Explorer

Palestine Explorer: It is a site to search for landmarks and lands in Palestine, which is characterized by ease in dealing, in addition to it contains measurement tools, drawing tools and a feature of knowing my location "go-to".

The test was done by used Palestine Explorer This was done by monitored points distributed in flatlands, low lands, and high lands, this was done in Al-shyouk, Jenin, Doma, Hebron, and Jericho, then the same coordinates that were monitored were taken from the Palestine explorer, and the difference between the coordinates was calculated, and the result of test is shown in the table (5.14).

Table (5.14) Accuracy Test on the Palestine Explorer

	#P	E	N	Z	X	Y	ΔX	ΔY
Jericho	1	194278.89	140491.93	""	194278.51	140492.82	0.38	0.89
	2	194253.66	140480.63	""	194251.12	140482.65	2.54	2.02
	3	194263.88	140453.25	""	194263.24	140455.01	0.64	1.76
	4	194288.61	140462.27	""	194288.75	140464.42	0.14	2.15
Hebron	5	158803.16	103755.09	""	158802.14	103754.84	1.02	0.25
	6	158810.77	103724.79	""	158810.51	103723.78	0.26	1.01
	7	158859.56	103732.09	""	158857.65	103732.98	1.91	0.89
	8	158850.78	103745.16	""	158849.38	103745.16	1.4	0
Jenin	9	178355.81	207092.57	""	178353.92	207091.07	1.89	1.5
	10	178331.60	207095.06	""	178331.35	207094.31	0.25	0.75
	11	178326.96	207064.44	""	178326.08	207063.06	0.88	1.38
	12	178353.06	207063.21	""	178350.04	207063.20	3.02	0.01
						maximum	3.02	2.15
						minimum	0.14	0
						RMSE	1.574	1.321
						RMSEr	2.055	

The table shows that Palestine explorer has less accuracy than Geomolg. Where the Δx values reach 157 cm, and the Δy values reach 132cm, in general, the accuracy of Palestine explorer reached 205.5cm.

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

6.2 Recommendations

6.1 Conclusions

The online orthophoto provided by the ministry of local government, with a claimed accuracy of 30 cm was tested using ground control points measured by GNSS, the control points were observed on different topographic conditions and in urban and rural areas, and the summary of results at 90% probability is introduced in tables to discuss it.

6.1.1 Lands

It contains High, flat, low, rural and urban lands in different areas like Al-shyouk, Jenin, Doma, Jericho, and Hebron, and the accuracy calculated at 90% probability as shown in table (6.1).

Table (6.1) Accuracy Test on the lands at 90% probability

Areas	RMSEr	Minimum		Maximum		Δr
Al-shyouk	٠.37	0.٠2	0.٠9	٠.30	٠.61	2.94
Jenin	٠.30	0.٠7	0.٠6	٠.49	٠.37	2.4٢
Doma	٠.43	٠.10	0.٠2	٠.78	٠.44	3.54
Jericho	0.50	٠.٠٣	٠.٠٣	0.70	0.60	4.306
Hebron	0.58	٠.١	0.08	0.7	0.80	5.33

The Results of the Table for the lands at 90% probability show that the accuracy in Al-shyouk, Jenin and Doma aa rounding 30 cm, but in Jericho and Hebron it is decreasing to reach around 50, 58cm, but in general, the accuracy is better than ortho photo 2016, 2014 which reached to 50 cm.

On the other hand, the results for accuracy at 90% probability are more accurate than the results mentioned in chapter 5, for example, Jericho had accuracy reached 65 cm, at 90% probability the accuracy reached 50 cm.

6.1.2 Buildings

It contains buildings of one floor, villas in different areas like Al-shyouk, Jenin, Doma, Jericho, and Hebron, and the accuracy calculated at 90% probability as shown in table (6.2).

Table (6.2) Accuracy Test on the buildings at 90% probability

Areas	RMSEr	Minimum		Maximum		Δr
Al-shyouk	1.165	0	0.2	0.4	1.69	11.75
Jenin	0.492	0	0.23	0.31	0.75	3.312
Doma	0.668	0	0.·2	0.53	1.18	5.404
Jericho	0.766	0.02	0.09	0.53	1.25	6.547
Hebron	0.889	0.06	0.09	1.32	1.25	7.234

The Results of the Table for the buildings at 90% probability show that the accuracy is decreasing than 30 cm to reach 116.5 cm in Al-shyouk, 49.2 cm in Jenin, 67 cm in Doma, 77cm in Jericho and 89 cm in Hebron.

On the other hand, the results for accuracy at 90% probability are more accurate than the results mentioned in chapter 5, for example, Doma had accuracy reached 83 cm, at 90% probability the accuracy reached 67 cm, in generall the accuracy tests of lands is more accurate than buildings.

6.2 Recommendations

Depending on the results were shown, the recommendations will be as followings:

1. Reducing the displacement by making vertical photography as possible, and using the Ortho Photo Scop devices.
2. Checking the characteristics of the aerial photos that will be processed.
3. Ensuring and improving the methods of processing for aerial photos.

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