

# **MULTIPURPOSE USE OF ORTHOPHOTO MAPS FORMING BASIS TO DIGITAL CADASTRE DATA AND THE VISION OF THE GENERAL DIRECTORATE OF LAND REGISTRY AND CADASTRE**

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**KEY WORDS:** Aerial Photograph, Orthophoto, Photogrammetry, Decision-Support, Quality-Integrity Control, Geographic Information System

## **ABSTRACT**

The General Directorate of Land Registry and Cadastre (GDLRC) has started 1/5000 scale standard topographic map production by aerial image acquisition and photogrammetry in 1955 in order to complete initial cadastre within a short time in rural areas. Aerial photographs taken and 1/5000 scale standard topographic maps produced since 1955 have made a great contribution to the completion of Turkish Cadastre and have been used by public institutions and organizations at engineering services and applications.

The aerial photographs of approximately 480.000 km<sup>2</sup> out of 500.000 km<sup>2</sup> area, whose 1/5000 scale maps are intended to be produced with respect to the development plans, were taken between 1955–2007 and 1/5000 scale standard topographic map production was completed belonging to that area.

The aerial photographs located in the achieve of the General Directorate of Land Registry and Cadastre were taken in an approximate scale of 1/16.000 and with 60% forward & 30% side laps stereoscopically with the purpose of 1/5000 scale standard topographic map production and identification in order to complete initial cadastre rapidly. The aerial photographs covering this 480.000 km<sup>2</sup> area consist of about 1600 rolls and 150.000 photographs.

The GDLRC is an institution that produces, manages and improves the important parts of Turkish National Geographic Information System's main spatial basis such as geodesy, cadastre, metadata and orthophoto and provides services to another institutions and organizations. In this context, satellite images and aerial photographs forming one of the essential layers of spatial information systems, acquired by remote sensing instruments have a great importance taking the necessity of image base into consideration. The GDLRC, which conducts valuable projects in this area, has actualized the Orthophoto Information System.

The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000

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scale digital colored orthophoto map production of an area of approximately 310.000 km<sup>2</sup> was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

In this study, the use areas of orthophoto maps produced and the vision of GDLRC related to the production/use of the orthophoto are discussed.

## **1. INTRODUCTION**

The demand for geographic/spatial information in Turkey and World is increasing day by day. As a result, geographic information in various qualities is produced by different organizations and institutions using different sources with different methods

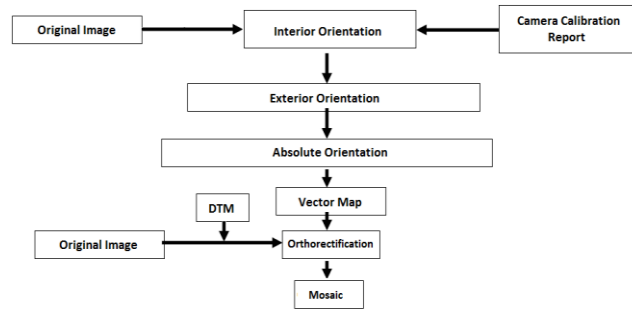
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The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000 scale digital colored orthophoto map production of an area of 305.700 km<sup>2</sup> was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

## **2. ORTHOPHOTO AND ORTHOPHOTO MAP**

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.

An orthophoto map can be defined as an orthophoto having cartographic information on it and produced with respect a certain map sheet system. An orthomosaic is obtained by combining more than one orthophoto on a single base.

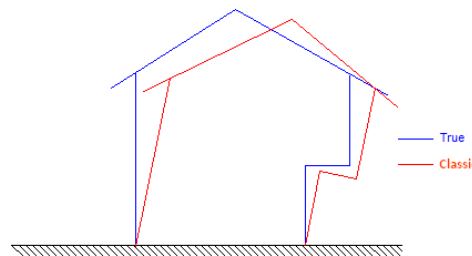


**Figure 1.** Orthophoto Flow Diagram

## 2.1 True Orthophoto

The term true orthophoto is generally used for an orthophoto where surface elements that are not included in the digital terrain model are also rectified to the orthogonal projection. Those elements are usually buildings and bridges.

Even though the GDLRC has the capability to produce true orthophoto, this kind of production is not performed with respect to the institution policy.



**Figure 2.** True vs. Classic Orthophoto

## 2.2 Near Infrared (NIR) Orthophoto

Color contrast is quite high in infrared orthophotos. Therefore, they are used effectively in vegetation classification, tree classification and health status determination.



**Figure 3.** RGB & NIR Orthophoto

### **3. IMAGE BASE REQUIREMENT FOR NATIONAL SPATIAL DATABASE**

One of the main components of spatial information systems is image layer, which includes satellite images and aerial photographs obtained by remote sensing instruments. According to the researches done for determining the usability of aerial photographs against satellite images, it was found out that aerial photographs are fast and reliable source for establishing image basis. Besides, their production cost is lower than satellite data.

Moreover, the investigations done for meeting the requirements of different organizations and institutions showed that aerial photographs are the most reliable source since they provide more accurate, up-to-date and cloudless information.

### **4. ORTHOPHOTO PRODUCTION IN THE GDLRC**

In order to complete first cadastre within a short time, 1/5000 scaled base map production has been carried out over 480.000 km<sup>2</sup> area since 1955 by photogrammetric method meaning map production from aerial photography, and digital colored orthophoto production has been carried out since 2009 for the purposes of decision-support, quality control and establishing legal basis within the context of renewal and update Works.

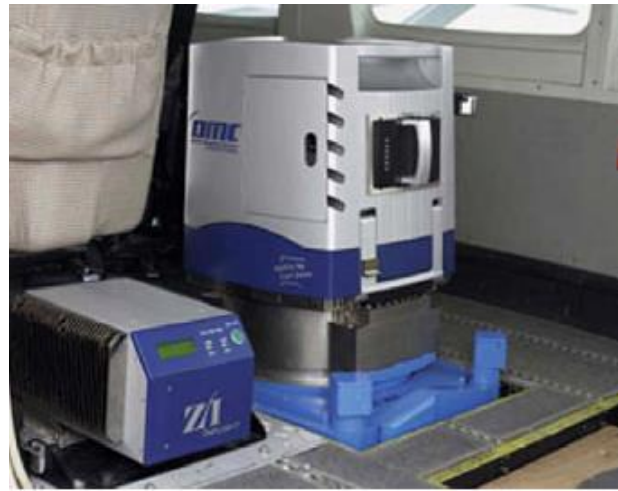
#### **4.1 Hardware and Technology**

Flight services for aerial image acquisition are provided by 1 airplane with special equipment in the institution. Apart from institution's own need, service for map production is given to private sector as well against remuneration set by Circulating Capital Enterprise.



**Figure 4.** Airplane of GDLRC

In 2009, ZI/DMC Digital Aerial Camera was purchased for the purpose of digital orthophoto production.



**Figure 5.** DMC Digital Aerial Camera

Digital aerial camera was mounted on the institution's ISLANDER BN-2T airplane. It performs aerial image acquisition of approximately 60.000 – 70.000 km<sup>2</sup> area per year.

With this system, photogrammetric map production costs have been decreased 26% and the opportunity of high quality digital service has been provided.

In the institution, there are two storage units to store the raw flight data and orthophotos. Besides, hardware and software for flight planning, GPS/IMU calculations, digital image processing, stereo assessment and orthophoto production are present.



**Figure 6.** Photogrammetric Hardware and Software

#### 4.2 Digital Colored Orthophoto Production Studies in the GDLRC

The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera taken in 2009, 1/5000 scale digital colored orthophoto map production of an area of approximately 310.000 km<sup>2</sup> was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.



**Figure 7.** 1/5000 Scale Digital Colored Orthophoto Production Areas

#### 4.3 Products and Quality Works

The Digital Mapping Camera (DMC) has eight cameras. There are four panchromatic cameras with a 7.000 x 4.000 pixel array and four multi-spectral cameras with a 3.000 x 2.000 pixel array. The raw data for each of the cameras is stored in separate partitions on the FDS units. The final output from the post processing are high resolution panchromatic, color, and color infrared images with a 12 micron resolution and an image size of 7.680 x 13.824 pixels.

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The spectral sensitivity in images is 400-580 nm for blue band, 500-650 nm for green band and 675-850 nm for red band. The radiometric resolution is 12 bits.

The Ground Sampling Distance (GSD) of the images is 30 cm, which means the image acquisition is performed from 3.000 m above the terrain. The images are 99,9% cloudless, which are gathered between May and October.

CORS-TR data is used at geodetic works and GPS/INS assessments. The ground control points have 1-2 cm positional accuracy. Within this context, the positional accuracy in photogrammetric triangulation is approximately 1/4 of the pixel size, whereas height accuracy is about 1/3 of the pixel size. The positional accuracy of orthophotos is around 1 - 1,5 pixel size.

From the sectoral priorities point of view, the maps produced are infrastructure investment service for developing agriculture, education, health, technological research, transportation, irrigation, e-state and information & communication technologies. From the regional priorities point of view, the maps produced are used as an effective tool for reducing interregional development levels.

## **5. GEO-METADATA WEB PORTAL**

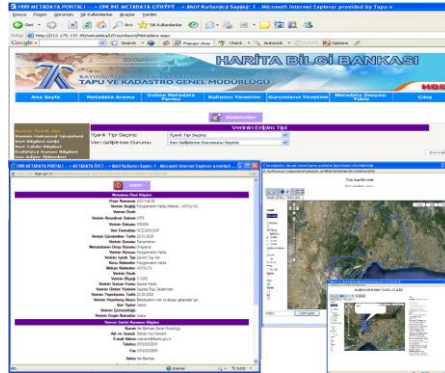
The purpose of establishing Geo-Metadata Web Portal is collecting all kind of map information from different sources under a single roof, combining it in a portal structure and presenting this information to users.

After completing the project in 07.07.2008, announcing it to the related public institutions and organizations and providing online service from the website of <http://hbb.tkgm.gov.tr/metadata/>;

- Producing duplicate maps by different public institutions and organizations is prevented.
- Final numbers for ground control points are started to be given from a single center. So, duplicate numbering and duplicate geodetic point establishment are prevented.
- Geodetic point analyze can be done before going to field, approximate coordinates can be seen and planning can be done accordingly.
- Existence of any 1/5000 scale maps can be queried. If a 1/5000 scale map has been produced, the producing institution can be identified.
- Queries can be performed such as when, where and what kind of maps were produced by any institution and detailed information can be reached.
- Since it is not necessary to come to the institution to get information and learn all these things, time and cost saving is provided.



It is a Spatial Information System in portal structure developed for enabling relevant institutions to access online, update and present metadata relating to information and documents of maps produced by mapping agencies and institutions and preventing waste of resources caused by duplicate map production as a result.

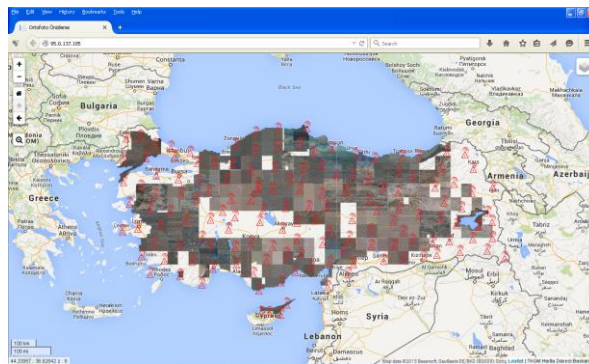


**Figure 8.** Geo-metadata Web Portal

## 6. ARCHIVING AND WEB SERVICES

The General Directorate of Land Registry and Cadastre has started a test project in 2010 in order to share digital orthophoto maps on web, which are produced regarding to the institutional requirements and taken from other institutions with the protocols done.

The test project for presentation of 1/5000 scale orthophoto/base maps on <http://www.tucbs.gov.tr> still continues, which are produced to be used in decision-making processes, quality-integrity controls and base for legal aspects in digital cadastre works and other institutions' large scale engineering projects.



**Figure 9.** Orthophoto WEB Services

Besides, existing orthophotos produced by other institutions are taken as services and in magnetic environments. The obtained orthophoto maps and services are presented as WMS/TMS/WMTS.

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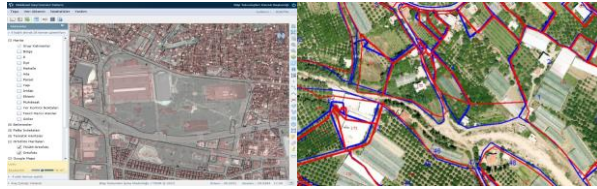
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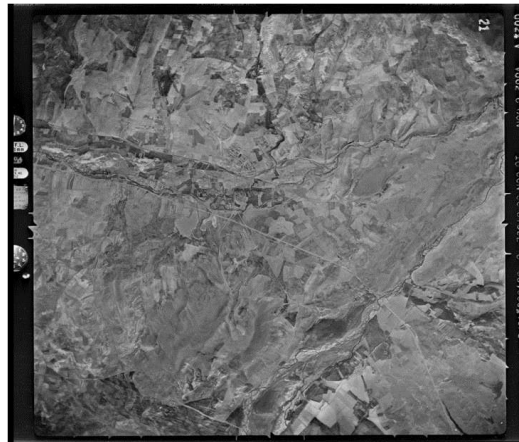


**Figure 10.** a) Orthophoto Web Service b) Superimposition of Parcel Data on Orthophoto

Produced and provided orthophoto maps are opened to the use of our directorates by giving services to the one of the most important projects of our institution namely Land Registry and Cadastre Information System (TAKBİS). In this context, web services of orthophoto maps produced by both our institution and other institutions were created. Web services are also provided to the use of institutional users outside the General Directorate of Land Registry and Cadastre.

## **7. PROJECT OF ORTHOPHOTO PRODUCTION WITH APPROXIMATE ACCURACY FROM OLD-DATED AERIAL PHOTOGRAPHS**

Production of Digital Orthophoto with approximate accuracy from old-dated aerial photographs in order to establish basis for decision support processes before and during renewal; accuracy & integrity checks after renewal; and legal aspect of renewal at works of renewal and update of cadastral maps.

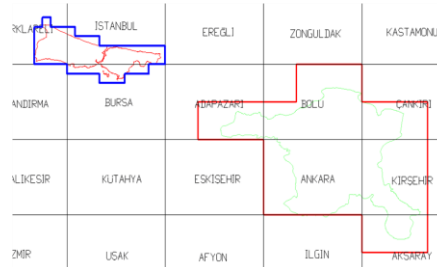


**Figure 11.** Scanned Aerial Photograph

Old-dated aerial photographs within the archive of the GDLRC and the General Command of Mapping (GCM), whose orthophotos were not produced, are demanded and used by Cadastre Directorates at renewal and update of cadastral maps.

It is quite hard to use these images at cadastral works, which are not in orthophoto format, having no coordinates & scale and including errors arising from field slope.

Black/white orthophoto map production with approximate accuracy from old-dated aerial photographs of total 55.000 km<sup>2</sup> area including the city borders of Istanbul (5.000 km<sup>2</sup>) and Ankara (50.000 km<sup>2</sup>) was carried out by service procurement in 2012 and delivered to Cadastre Directorates.



**Figure 12.** Pilot Projects

## 8. TURKISH NATIONAL GEOGRAPHIC INFORMATION SYSTEM (TUCBS)

The Feasibility Etude Report of Geographic Information System Infrastructure Establishment operated under the responsibility of the General Directorate of Land Registry and Cadastre was prepared and submitted to the Ministry of Development (Secretariat of the State Planning Organization) in 27.01.2011.

Since the mission of establishment and improvement of National Geographic Information System was given to the General Directorate of Geographic Information Systems, which was founded regarding to the statutory decree numbered 644, the related studies are carried out by the General Directorate of Geographic Information Systems.

"Geographic Information Infrastructure Establishment Project" was performed under the responsibility of the General Directorate of Land Registry and Cadastre with respect to the action no 75 in action plan under the topic of Modernization of Information Society Strategy in Public Administration, published in official gazette dated 28/07/2006 & numbered 26242 proposing the presentation of information from the place where it is produced.

Turkish National Geographic Information System is an e-state project that aims to establish Geographic Information System infrastructure complying with national level technological advancements and INSPIRE Directive, to create web portal with the purpose of presenting geographic information under the responsibility of public institutions and organizations to the users through a joint infrastructure and to define the standards of content for geographic information as meeting the requirements of all user institutions.

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## 9. RESULTS

In order to complete first cadastre within a short time, 1/5000 scaled base map production has been carried out over 480.000 km<sup>2</sup> area since 1955 by photogrammetric method meaning map production from aerial photography.

The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000 scale digital colored orthophoto map production of an area of approximately 310.000 km<sup>2</sup> was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

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