AN INVESTIGATION ON HIGH RESOLUTION IKONOS SATELLITE IMAGES FOR CADASTRAL APPLICATIONS

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ABSTRACT:

In Turkey cadastral works and registrations in the means of establishment of determination parcel boundaries and owners have been completed as 99 % for urban area and 88% for rural area by General Directorate of Land Registry and Cadastre of Turkey (GDLRC). Rural areas which are mostly mountainous and forestry are remaining. In most of the cadastral works completed areas are expected to be renovating in cadastral means.

Currently many projects are started with related to cadastral works and land registration. One of them is MERLIS (Marmara Earthquake Region Land Information System). Cadastre Renovation and Land Management (A4 Component of MERLIS) financed by the World Bank in Marmara Earthquake Region. Another one is ARIP (Agricultural Reform Implementation Project). The aim of project is to design and form the NRF (National Registry of Farmers) system under the Direct Income Support (DIS). This sub-component of the DIS is aimed supporting GDLRC to increase the inclusion of agricultural areas that are not yet in computerized part of the cadastre. For the realization of this aim, true and reliable Cadastre and Land Registry information is needed in 20 provinces, especially in Eastern Anatolia and Southeastern Anatolia. These projects are required land information such as parcel boundary, owner, area etc. To get such information cadastre and land registry must be completed and served in digital medium.

These paper presents an investigation on comparison to 1/5000 scale digital photogrammetric measurements and satellite image measurements of the same cadastral boundary points. Initial aim was to compare with real time GPS measurements, unfortunately winter conditions in the test area are prevented us doing GPS measurements. Before the Congress GPS and total station measurements probably will be carried out. Results of the tests have been evaluated as accuracy, time and costs.

1. TEST AREA SPECIFICATION

Test area is SIVAS-Şarkışla region which is located on eastern part of Turkey have been chosen. Size of test area is 10*10 km and has same characteristic of areas which is uncompleted initial cadastre. Main characteristics specifications of test area are;

- Some part of the area flat, plain and somehow mountainous, undulating and rural areas,
- Some part of area open and somehow forestry,
- Very dense parcel, infrequent parcel distribution and in the rural area forestry related parcels available
- Test area also reflects typical characteristics of uncompleted cadastral areas.

After densification of geodetic points in test area, aerial photographs have been taken in year 2000. Photogrammetric standard map production has been completed in 1/5000 scale. Terrestrial map verification has not been completed yet. As comparison critters unverified photogrammetric data and satellite based data were used. In addition terrestrial based data measured by RTK GPS were planned to use a comparison but it is not completed because of winter season.

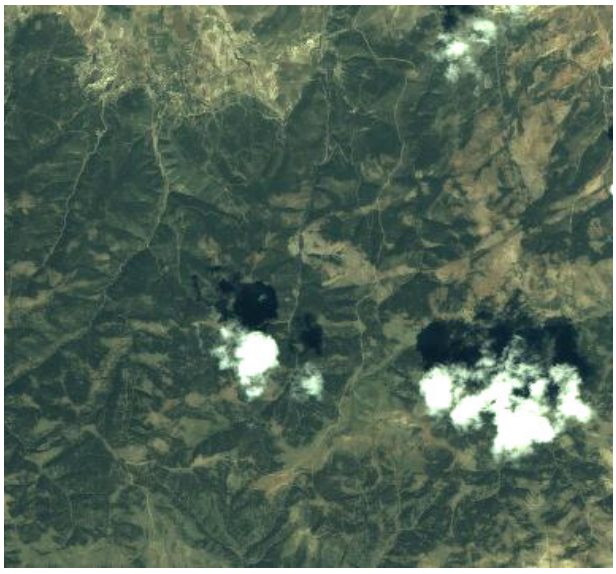


Image.1 . IKONOS Space image of all test area

Image.2 . IKONOS Space image of one part of test area

2. GROUND CONTROL POINTS

Ground control points were established in order to produce 1/5000 scale standard maps by photogrammetric mapping method. All control points are signalized and measured by GPS. In the project area there are14 signalized ground control points. After adjustment of GPS measurements accuracy of ground control points less then 10 cm. All control points in test area re-signalized for the satellite imaging. Signalization dimensions are shown below figure. After signalization of that control points satellite images were provided from INTA Company.

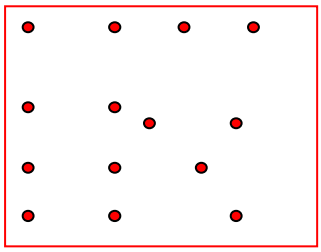


Figure 1- Ground Control Points

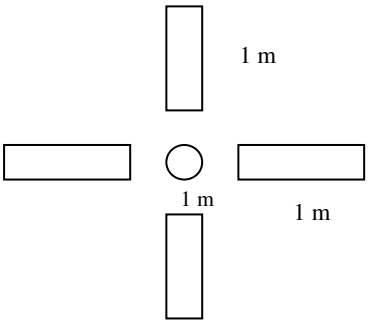


Figure 2- Signalization of GCP's

3. SATELLITE IMAGES SPECIFICATIONS

A pair of stereo images provided free of charge by INTA Space Company in order to use test works. Image overlaps is %100 and time interval between two image around 1 minutes. Ground resolution of first image is on cross track 0.88 m and on track 0.85 m. Scanning azimuth 179.96 degrees, nominal data collection azimuth 78.6370 degrees, nominal data collection elevation is 74.57693 degrees. Azimuth of sun is 134.9709 degrees and sun elevation 68.83922 degrees during scanning. Ground resolution of second image is on cross track 0.92 m and on track 1.02 m. Scanning azimuth 179.96 degrees, nominal data collection azimuth 163.4890 degrees, nominal data collection elevation is 62.21244 degrees. Azimuth of sun is 135.4087 degrees and sun elevation 68.95507 degrees during scanning.

Pan Sharpened stereo images covered whole test area. Geometric resolution is 1 meter and spectral resolution is 4 m of those images. More information about Ikonos images please visit; http://www.spaceturk.com.tr

4. TEST PHASES

4.1 ACCURACY INVESTIGATION

Inside the test area, two different sub areas have been chosen for accuracy investigation. One of the regions has very dense parcels, flat area, definition and identification of boundaries, details would be easier and will be called 4B area. Second region has mountainous, forestry related parcels, definition and identification of boundaries, details would be harder and will be called 9B area.

4.1.1 Preliminary Investigation Of Images

SOCET SET V.4.4.2, ERDAS IMAGINE V8.5, V8.6 and PCI GEOMATIC V7.2 software were used for different purposes during test phase.
Before starting test phase, satellite images investigated detailed and realized following findings;

- Size of each part of Pan-Sharpened stereo images with 1 meter ground resolution is around 400 MB,
- There is a specific file called RPC contains sensor parameters, meta data and other information,
- Images covered whole test area,
- All signalized ground control points are identified and defined,
- Some part of test area covered by clouds and there is no information about terrain on the cloudy area,
- Some milky areas has a little terrain information which can interpretable,
- There is sun light reflection on the building roof surface on settlement area., so it is not possible to collect data about these buildings,
- Linear features such as parcel boundaries can interpretable but attributes of linear features can not be defined such as fence, hedge and so on,
- Some of linear features presents is around 3-4 pixels. It seems a gap between linear features. So, It needs a special experience to identity if is it patches or drainages and so on,
- Some details for example fountain, communication line pillar, power line pillar in the settlement area can not be seen on the satellite images,
- Main power line and its pillar can be seen easily and identified very well,
- In very dense agricultural area parcel boundaries can be identified exactly,
- In mountainous and forestry related area, definition and identification of parcel boundaries and its details can be very hard.

4.1.2Orientation Of Images By GCP' s

There are 14 ground control points in the test area. Ground control points datum is European Datum 1950 (ED50). All control points measured on images. We used DLT (Direct Linear Transformation) for image orientation. Orientation results are shown below;

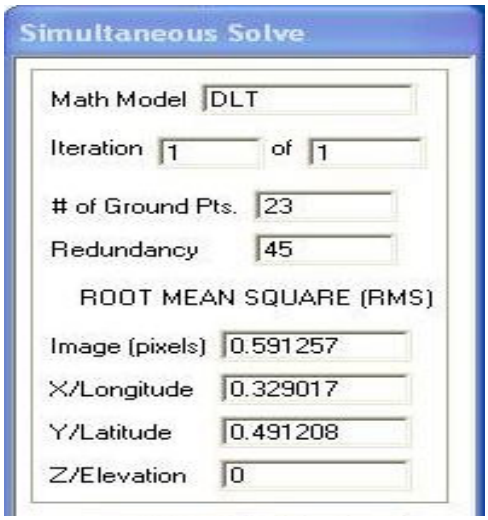


Figure 3- Orientation results of Right image

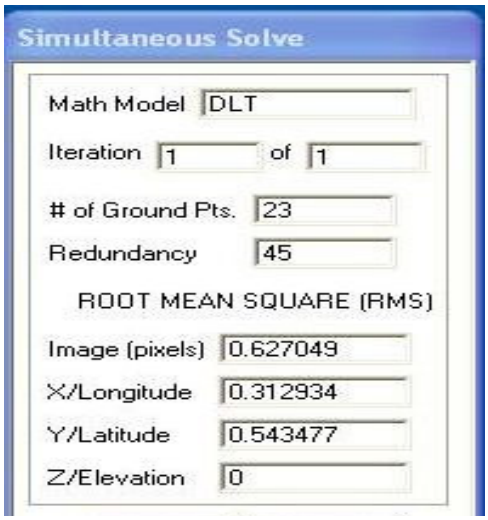


Figure 4- Orientation results of Left image

As a shown on figure Root mean square error of Right image is RMS Y=0.329m, RMS X=0.491m ,RMS XY= 0.591m and for left image is RMS Y=0.313 m, RMS X=0.543 m, RMS XY= 0.627 m. Residuals of ground control points for both images is founded minimum 0.02 m and maximum 0.90m.

In test some GCP' s used as check point, results are;

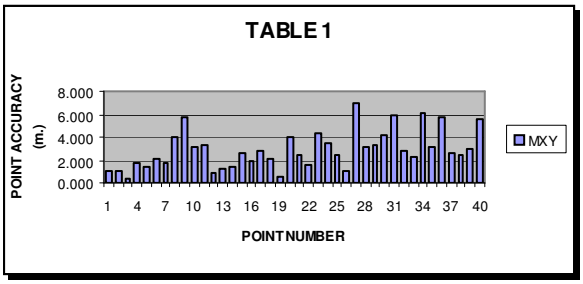
CHECK POINTS	RIGHT IMAGE MEAN RMS(XY)	LEFT IMAGE MEAN RMS(XY)
432 174	0.63 m.	0.63 m.
433 439	0.44 m.	0.59 m.
437 173	0.61 m.	0.58 m.
MEAN	**0.56 m.**	**0.60 m.**

Figure 4 – Orientation results in case of check points

4.1.3Comparison of Results

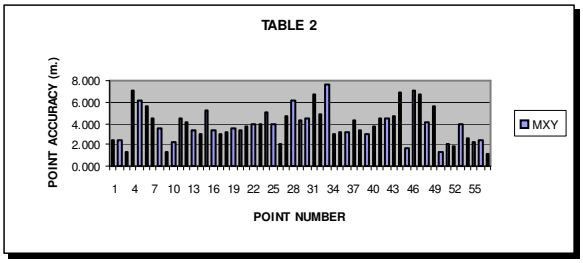
After DLT stereo restitution of images and orthophoto production with two different DEM has been carried out by Digital Photogrammetric Systems in GDLRC. Comparative results between coordinate differences of photogrammetric restituted and digitized from satellite images feature points are shown below. For comparison well identified feature points are chosen and blunders were eliminated.

1) Coordinate differences between feature points from orthophoto which is produced by DTM via stereo images, from satellite images and photogrammetric restitution for 4b area.



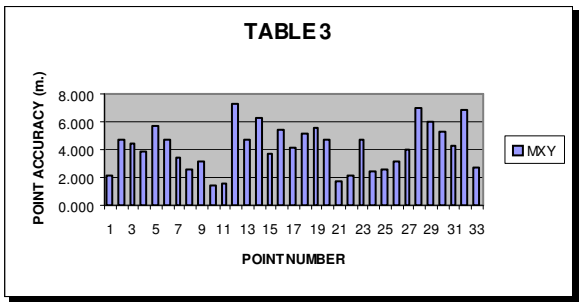
MEAN MXY= 2.889 m.

2) Coordinate differences between feature points from orthophoto which is produced by DTM via YUKPAF (Digitized 1/25000 contour lines) and photogrammetric restitution for 4b area .



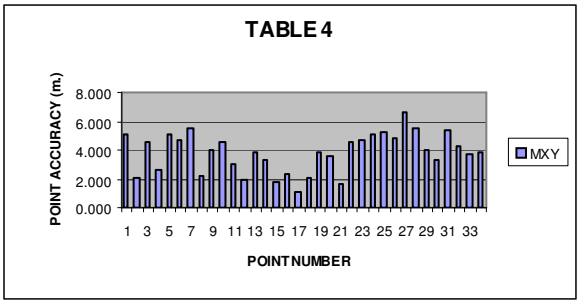
MEAN MXY= 3.870 m.

3) Coordinate differences between feature points from orthophoto which is produced by DTM via stereo images from satellite images and photogrammetric restitution for 9b area .



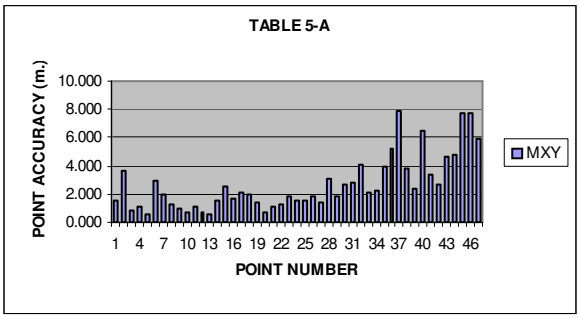
MEAN MXY= 4.147 m.

4) Coordinate differences between feature points from orthophoto which is produced by DTM via YUKPAF (Digitized 1/25000 contour lines) and photogrammetric restitution for 9b area.

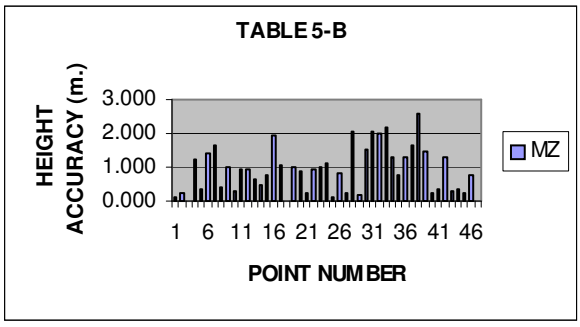


MEAN MXY= 3.82 m.

5) Coordinate differences between feature points from stereo restitution of satellite images and photogrammetric restitution for both area.

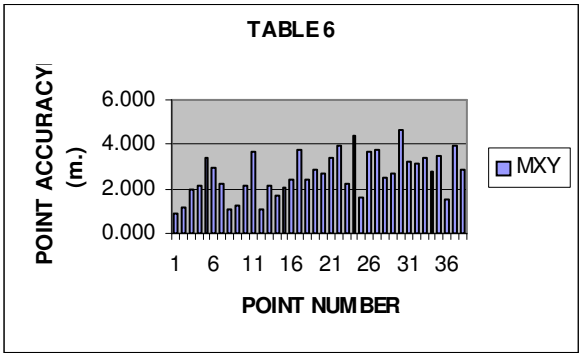


MEAN MXY= 2.689 m.



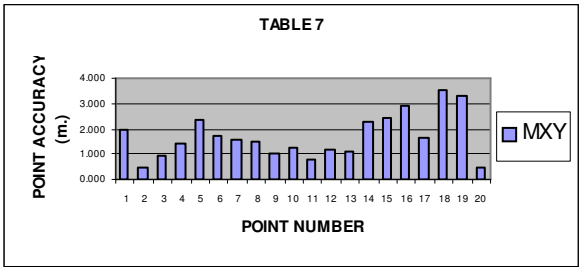
MEAN MZ= 0.904 m.

6) Coordinate differences between feature points from orthophoto which is produced by YUKPAF dtm and stereo dtm for 4b area.



MEAN MXY= 2.664 m.

7) Coordinate differences between feature points from orthophoto which is produced by YUKPAF dtm and stereo dtm for 9b area.



MEAN MXY= 1.689 m.

COMPARISON	4B - AREA NP	4B - AREA MXY	9B- AREA NP	9B- AREA MXY
SI ORTHOPHOTO FROM STEREO - DTM via 1/5000 PHOTOGRAMMETRIC MAPS	40	2.889	33	4.147
SI ORTHOPHOTO FROM YUKPAF - DTM via 1/5000 PHOTOGRAMMETRIC MAPS	57	3.870	34	3.820
SI ORTHOPHOTO FROM STEREO - DTM via SI ORTHOPHOTO FROM YUKPAF - DTM	38	2.664	20	1.689
SI STEREO RESTITUTION via 1/5000 PHOTOGRAMMETRIC MAPS	47	2.689		

Table 8 - Summary of comparison results

4.2 COSTS

Photogrammetric mapping procedure is the same for using both aerial images and satellite images. But to procurement of images are different in aerial photogrammetic mapping from use satellite images. Satellite imagery does not need flight mission, photo laboratory processes, scanning and requires less ground works.

Before providing images it is necessary to do ground control points establishment and signalization which are required 9-10 GCP for same area for aerial photogrammetry and satellite photogrammetry. In this case cost of aerial photogrammetry and satellite image must be compared.

4.3 TIME

A Ikonos satellite image cover approximately 100 km2 on the ground. Same area covered approximately 30 pieces aerial images in 1/16000 scale and 20 map sheets in 1/5000 map scale. There are huge differences to process to do orthophoto between one satellite images and 30 pieces aerial images. On the other hand to provide satellite images very faster than aerial images. May be one week later it can be provided after ordering.

5. RESULTS

Interpretation of comparison results;

- Orientation of satellite images achieved RMS +/- 0.6 m using signalized ground control points.
- If we use some control points as check points this means (we also change point distribution), RMS of orientation reached as value between around +/- 0.6m.
- If we use parcel boundary features this means features points may have IDENDIFICATION and DEFINATION problems, RMS of orientation of satellite images achieved as average value between +/- 1.50m and +/- 2m.
- Results of comparison data between orthophoto produced by stereo DTM from satellite images and aerial photogrammetric data we reached a value between +/- 2m and +/-3 m RMS depends on selected feature, which identification and definition problem has it or not.
- Results of comparison data between orthophoto produced by YUKPAF and aerial photogrammetric data we reached a value around +/-3m RMS in depended from selected feature identification and definition problem has it or not.
- Results of comparison data between two orthophotos one of produced by YUKPAF and other produced by STEREO-DTM we reached RMS around +/- 1-2m .
- Results of comparison data between aerial based photogrametric data and satellite based photogrammetric data we reached RMS around +/- 2m.
- After realization of GPS and total station measurements more clear results will be achieved.