# COMPARISON OF THE RESULTS OBTAINED FROM THE AERIAL PHOTOGRAPHS AND SPOT STEREO IMAGES IN THE PRODUCTION OF 1:50.000 SCALED TOPOGRAPHICAL MAPS

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## ABSTRACT

Many countries need 1:50.000 or smaller scaled such as 1:100.000 and 1:250.000 topographical maps in order to use them in sivil and military activities. In the planning of land operations for military purposes, especially 1:50.000 scaled topographical maps are used. For that reason, it is of great importance to produce these maps accurate, up-to-date, reliable and on time.

As in all over the world, the main data sources used for the production of 1:50.000 scaled topographical maps are mostly up-to-date stereo aerial photographs or stereo satellite images in our country.

Because of several technical difficulties and some reasons explained in the paper, the production of 1:50.000 scaled maps directly from aerial photographs with an appropriate scale is not applied in our country 1:25.000 scaled analog or digital maps are firstly produced by using aerial photographs; and then, 1:50.000 scaled topographical maps are produced from the 1:25.000 scaled maps using the cartographic generalisation technique.

It is also possible to produce 1:50.000 scaled topographical maps directly from several mono or stereo satellite images having a good ground resolution (pixel size) and existing in the commercial markets.

In this research; it is investigated that the production methods of 1:50.000 scaled topographical maps indirectly produced from up-to-date aerial photographs with an appropriate scale and directly by using SPOT-Panchromatic stereo satellite images in detail; it is determined the final accuracies, the approximate production times and speeds, the main components concerning the cost, the detection and interpretation capabilities of 330 different features existing in the 1:25.000-1:50.000 Scaled Map Standardisation Specification and, the need of the topographical map completion in the field in two methods; the results obtained from two different methods are compared in terms of some criterias such as accuracy, cost, economy, production time and velocity, feature interpretibility and completness.

# 1 INTRODUCTION

Some countries use 1:25.000 scaled maps and, some use 1:50.000 scaled maps as the base map series in civil and military applications. Although 1:25.000 scaled topographical maps are commonly used in many development projects and civilian services, they are usually incapable and insufficient for military applications. For that reason, there is generally a need of 1:50.000 scaled topographical maps for military activities.

For the production of 1:50.000 scaled topographical maps, two different methods are applied in our country. In the first method; first, 1:25.000 scaled analog or digital maps are produced from up-of-date aerial photographs with an appropriate scale; then, the production of 1:50.000 or smaller scaled topographical maps are carried out by the way of the cartographic generalisation technique. In the second method; the production of 1:50.000 scaled maps is directly fulfilled by using SPOT stereo satellite images. But, the second technique is rarely used and a complementary technique for the map production in Turkey.

# 2 THE PRODUCTION METHOD OF THE 1:25.000 SCALED TOPOGRAPHICAL MAPS USING AERIAL PHOTOGRAPHS

## 2.1 General Information

It is necessary to produce first 1:25.000 scaled topographical maps using photogrammetric instruments and techniques in order to perform the production of 1:50.000 scaled maps. Because of the technical and administrative constraints, the production of 1:50.000 scaled maps directly by using aerial photographs are not generally applied in our country. According the economy, time and cost criterias, it is necessary to take aerial photographs between 1:60.000-1:70.000 scales in order to produce 1:50.000 scaled maps directly from the aerial photographs. For taking aerial photographs, if the photogrammetric aerial camera which has 153 mm focal length is used, the aircraft should fly at about 10-12 kilometers altitude from the average ground elevation level, by taking care of the height differences and roughness of the ground. Such a flight height is the maximum limit for most aircraft used for taking aerial photographs today and, seems impossible to carry out this flight. In addition to these technical constraints, it is rather difficult to see and interprete all features in the 1:60.000-1:70.000 scaled aerial photographs, which are existing on the 1:50.000 scaled topographical maps.

Taking into account of all these matters, it is considered appropriate, producing initially the 1:25.000 scaled topographical maps using between 1:25.000-1:40.000 scaled aerial photographs; then, the production of 1:50.000 scaled topographical maps by the cartographic generalisation technique. This technique is applied in our country, too.

## 2.2 The Production Method

The production of the first original copies of the 1:25.000 scaled base maps had been carried out with 1:25.000-1:30.000 scaled aerial photographs and; the revision of these map series have been made by using 1:35.000-1:40.000 scaled aerial photographs. The first original copies of the 1:25.000 scaled map series which consist of 5547 map sheets, had been

produced in analog form between 1947-1972, following stereo photogrammetric technique with analog instruments.

From 1969 until today, the first photogrammetric and topographic revisions of all 1:25.000 scaled maps have been completed and, the second and third revisions of some regions where changes and developments occured very rapidly, had been carried out in this period. Additionally, approximately 700 map sheets of 1:25.000 scaled maps, including some errors and which didn' t meet the basic standards, had been produced newly. In the recent years, as a result of the rapid developments in the computer-supported photogrammetric instruments and methods, we have also started to produce these maps in digital form. At present, the production and revision of the 1:25.000 scaled maps both in analog and in digital form are being continued using the computer-supported semi analog-semi analytical, analytical and digital photogrammetric systems.

In the production of the first original map sheets at 1:25.000 scale; all natural and artificial features which could be seen in the stereo models and contour lines defined in the 1:25.000-1:50.000 Scaled Map Standardisation Specification, had been captured in 3-dimensional.

In the analog revision of 1:25.000 scaled maps; all natural and artificial features changed and could be seen in the stereo models are compiled in 3-dimensional by looking at the original base maps (aliminum based); some topographical and relief features such as rocks, stony places, swamps, dry streams and unchanged ground surface elements (karsts, lavas, loess etc.), are taken exactly the same as in the base maps if they were not changed. The precision of the contour lines in the base maps is controlled in the stereo models and then, some corrections are done, if necessary.

In the revisions of 1:25.000 scaled maps with the computer-supported stereo photogrammetric instruments, all natural and artificial features which can be seen in the stereo models are drawn in 3-dimension; the contour lines produced before in digital form in 3-dimension for the whole country are controlled and, necessary corrections are applied to the wrong contours.

The 1:25.000 scaled maps produced both analogically and analytically are controlled in the field and, non-existing and incomplete features and contour lines are completed by the topographical map revision process.

In the recent years, the revision of the digital map data produced from available map sheets and updated revision plates (on astrolon bases) with the cartographic techniques have been started with the computer-supported photogrammetric instruments by using up-to-date aerial photographs.

1:50.000 scaled maps are produced by combining the 1:25.000 scaled maps produced in analog form using traditional cartographic generalisation. Works for the production of 1:50.000 scaled digital map data from the 1:25.000 scaled digital maps by the automatic generalisation method have been continued.

## 2.3 The Production Time and Speed

The production and revision are fulfilled in 5 steps for 1:25.000 scaled maps and, in 6 steps for 1:50.000 scaled maps.

- First step : Building, signalising, measurement and coordinate calculation of the ground control points.
- Second step : Taking the aerial photographs.
- Third step : Production of 1:25.000 scaled maps with the photogrammetric method.
- Fourth step : Performing topographical map completion and revision of the maps in the field.
- Fifth step : Cartographic applications and printing of the maps.
- Sixth step : The production of 1:50.000 scaled maps with the cartographic generalisation.

In connection with the width of the working area, the production project of up-to-date 1:25.000 scaled maps by using aerial photographs takes approximately 3 years supposing 0.5 year for the establishment of the ground control points in the field and taking aerial photographs; 1 year for the production of 1:25.000 scaled maps with the photogrammetric stereo map compilation technique; 0.5 year for performing topographical map completion and revision of the maps; 1 year for the cartographic applications and printing of the maps. The production project of up-to-date 1:50.000 scaled maps takes nearly 4 years, by adding 1 year period for the cartographic generalisation process.

The analog or digital compilation by the photogrammetric method of one 1:25.000 scaled map sheet with an average feature density takes 4 weeks; and, the revision of this map takes only 2 weeks. Therefore, in the production of one 1:50.000 scaled map sheet, the photogrammetric map compilation lasts nearly 4 months; the photogrammetric map revision 2 months; the topographical map completion 2 months; the cartographic operations and generalisation activities 2 months. Finally, the production of one up-to-date 1:50.000 scaled map by using aerial photographs may be able to be completed in 8 months; the revision of this map in 6 months.

The topographical map completion and revision of one 1:25.000 scaled map obtained by the photogrammetric production and revision takes 2 weeks. So, the topographical map completion of 1:50.000 scaled maps lasts nearly 2 months.

## 2.4 The Basic Components of the Cost

1:25.000 scaled aerial photographs are generally used for the new production of 1:25.000 scaled topographical maps and, one 1:25.000 scaled map sheet may be covered approximately with 18-20 photos; one 1:50.000 scaled map sheet with 75-80 photos. 1:35.000 scaled aerial photographs are generally used for the revision of 1:25.000 scaled topographical maps and, one 1:25.000 scaled map sheet may be covered approximately with 10-12 photos; one 1:50.000 scaled map sheet with 40-45 photos. The periods of the map production and revision by the photogrammetric map compilation technique and topographical map completion in the field, have been explained in detail in the previous section. The expenses of the instruments used in the photogrammetric map compilation, topographical map completion and revision and cartographic generalisation; personnel expenses are the main components effect on the total cost.

### 2.5 The Visibility and Interpretibility of the Features

The productions of 1:25.000 and 1:50.000 scaled topographical maps are carried out in accordance with the 1:25.000-1:50.000 Scaled Map Standardisation Specification. There are 330 different features in this Specification. But, the number of the features increases to approximately 550 with additional 220 features determined with their attibutes.

Related to the production and revision of the 1:25.000 scaled maps by using aerial photographs and the production of 1:50.000 scaled maps from the 1:25.000 scaled maps by cartographic methods; it was understood that, 280 of 330 different features existing in the specification could be directly seen and determined with their types; 18 features could be seen, but couldn' t be determined with their types; only 2 features couldn' t be seen, but could be determined with their types by interpretation; 30 features couldn' t be seen and interpreted in any way.

According to these results, it has been pointed out that, % 90 of the feature types existing in the 1:50.000 scaled maps can be seen in the aerial photographs and can be drawn onto the maps at the end of the photogrammetric map compilation; % 10 of the feature types cannot be seen in the aerial photographs and cannot be drawn onto the maps. The non-existing and uninterpreted features in the 1:25.000 scaled maps produced by using aerial photographs are completed in the field by the topographical map completion and revision.

### 2.6 The Accuracy of the Method

The compilation accuracy of the maps produced by the photogrammetric method is determined with the equations for the planimetry and height individually. Since Turkey is a member of NATO organisation, the production results of the middle scaled topographical maps should be compatible with the map production standards declared by this organisation. The accuracy estimation for the 1:25.000 scaled analog maps (paper map sheets) is about ±12.5m, and for the 1:50.000 scaled analog maps is about ± 25m. According to various researches, it has been understood that the planimetric accuracy of the analog 1:25.000 scaled maps is about ± 5-6m, while the height accuracy is about ± 2-3m; the planimetric and height accuracy of the digital maps produced by the photogrammetric method is about ± 1.5-2m. According to these results, it was determined that the planimetric accuracy of the analog 1:50.000 scaled maps produced from the aerial photographs is about ± 10-12m, the height accuracy is about ± 4-5m; the planimetric and height accuracies of the digital maps are about ± 3-4m.

## 3 THE PRODUCTION METHOD OF THE 1:50.000 SCALED TOPOGRAPHICAL MAPS BY USING SPOT STEREO SATELLITE IMAGES

### 3.1 General Information

Various mono or stereo satellite images have also been used for the production of the recent 1:50.000 scaled topographical maps for many years. Especially SPOT-P (France, ± 10m.) IRS-1C (India, ± 5.8m.) and MOMS-01/02 (Germany, ± 4.5m.) stereo satellite images are widely used for that purpose (Fukushima, 1998).

It is thought that, the high precision (± 1m pixel size in Panchromatic (P), ± 4m in Multispectral (MS) bands) mono and stereo satellite images would be available in close feature and the production of 1:50.000 and 1:25.000 scaled topographical maps may be able to be produced without any problems using these satellite images Besides, the production of 1:10.000 and 1:5.000 scaled standart topographical maps would also be possible in the near feature. Some important developments in the high precision satellite imagery (such as CRRS, Space Imagine, EarthWatch, OrbView, WorldView, EarlyBird, QuikBird etc.) expected to offer great opportunities in the production of 1:50.000 or smaller scaled maps, are seriously followed by the national mapping agencies (Fritz, 1995).

However these large improvements and developments in the satellite imagery, according to some researches done; it is understood that the most usable stereo satellite images for the production and revision of 1:50.000 scaled topographical maps are still SPOT stereo satellite images in many countries (Priebbenow, 1998).

The SPOT stereo satellite images at 1AP processing level in diapositive form are used in the analytical instruments, the images at 1A processing level in digital format are used in the digital photogrammetric instruments. 1:50.000 scaled maps are directly produced by using these diapositives or digital images (Boudoin,1995).

### 3.2 The Production Method

In the production of 1:50.000 scaled topographical maps from SPOT stereo images; there is a need of having the SPOT-Panchromatic stereo pairs, the orientation parameters of each satellite image scene and the ground control points with enough number and density for orientation of the stereo images, building a photogrammetric block and stereo models and 3-dimensional map compilation (Maybon, 1997).

Satellite images together with their orientation parameters are supplied by purchase. Necessary ground control points for doing the orientations of SPOT stereo pairs are often taken from the 1:25.000 scaled base maps (rarely from the 1:50.000 scaled maps) by measuring the coordinates (X, Y, Z) of specific feature points selected.

In analytical instruments, interior orientation of each satellite image related to SPOT stereo pairs is performed separately. Then, the image coordinates of the ground control and parallax points are measured in the relative orientation. After that, UTM coordinates (X, Y, Z) of the specific feature points selected as ground control points are measured from the paper map sheets. Image and ground coordinates of the control points, image coordinates of the parallax points and, satellite orbit parameters are adjusted together by using Zeiss-BİNGO SPOT software and finally, a stereo model is built upon and presented continuosly to the human eyes. All natural and artifical features which can be seen in the stereo model area and, all contour lines at 20m intervals are digitised separately. The digital map data obtained by 3-dimensional digital map compilation are edited and corrected. If necessary, it is possible to plot the results of these digital map data (OEEPE, 1990).

In digital instruments, interior orientation of each satellite image of SPOT stereo pairs in the block is performed separately. Then, image coordinates of the ground control points with enough number and density, selected from the paper maps and image coordinates of tie points used for the connection of the consecutive models and stripts are measured in sequence. UTM coordinates (X, Y, Z) of the ground control points are measured from the maps.The

measurements of all image coordinates, the coordinates of the ground control points and available satellite orbit parameters are adjusted together by using Vision-SOFTPLOTTER software and, as a result, a photogrammetric block is built upon. Stereo models are individually calculated using the estimated block parameters. Finally, digital map data produced by applying the stereo map compilation technique like in the analytical instruments.

### 3.3 The Production Time and Speed

The production and revision of 1:50.000 scaled maps in digital form directly by using SPOT stereo satellite images are fulfilled in 4 steps:

- First step : Purchasing SPOT stereo images.
- Second step : The production of 1:50.000 scaled maps with the stereo photogrammetric map compilation technique.
- Third step : Topographical map completion and revision in the field if necessary.
- Fourh step : Cartographic applications and printing (Priebbenow, 1998).

In connection with of the working area, the production project of updated 1:50.000 scaled maps by using SPOT stereo images takes approximately 2.5 years; considering 1 year for purchasing SPOT stereo images an, producing 1:50.000 scaled maps by the photogrammetric method; 0.5 year for perfoming topographical map completion and revision of the maps in the field (if necessery) and; 1 year for the cartographic applications and printing of the maps. Therefore, it can be said that the most updated map with 1:50.000 scale is 2.5 years old. The topographical map completion and revision in the field of the 1:50.000 scaled maps produced from SPOT stereo images are not generally performed.

Digital stereo map compilation by the photogrammetric method of one 1:50.000 scaled map sheet with the use of an analytical or digital instrument (including all features and contour lines) takes 6 weeks; the revision of this map lasts only 4 weeks. The topographical map completion and revision of one map sheet takes 2 months and cartographic applications only 1 month. Finally, it has been evaluated that the production of one 1:50.000 scaled map by using SPOT stereo images may be completed approximately in 4.5 months and, the revision of a map may be performed in 4 months.

### 3.4 The Basic Components of the Cost

One SPOT stereo pair which has nearly % 70-95 forward overlap covers approximately 4 (four) 1:50.000 scaled full-maps. So, one 1:50.000 scaled map may be able to be covered 1/4 SPOT stereo pairs. In addition to the satellite images, depending on the photogrammetric, topographic and cartographic production times explained in the previous section; personnel and instrumental expenses have to be taken into account in the calculation of the total cost.

### 3.5 The Visibility and Interpretibility Conditions of the Features

The applications performed in the stereo models formed by SPOT satellite images in the analytical or digital instruments resulted in that 100 of 330 different features existing in the Specification could be seen directly and determined with their types; 110 features could be seen, but couldn’ t be determined with their types; only 10 features couldn’ t be seen, but could be determined with their types by interpretation; 110 features couldn’ t be seen and interpreted in any way.

It has been determined from these results that, in the production of 1:50.000 scaled maps using SPOT stereo satellite images, % 65 of the feature types defined in the Specification could be seen directly and drawn onto the maps at the photogrammetric map compilation; % 35 of the feature types couldn' t be seen and drawn onto the maps. The non-existing and erronous features in the 1:50.000 scaled maps produced from SPOT stereo satellite images are completed in the field by the topographical map completion and revision. The need of topographical map complation and revision is extremely high.

### 3.6 The Accuracy of the Method

The estimated accuracies for planimetry and height components of digital map data produced from SPOT stereo images mainly depend upon the ground resolution (pixel size ±10 m.) of SPOT- Panchromatic (P) satellite images, the scale and precision of the base maps used in the selection of the ground control points, the precision of the measurements of image coordinates the ground control and parallax points, the precision of the satellite orbit parameters. The accuracy of the digital map data are changeable depending on these factors. The scale of the base map used for the identification of the control points, in the production and revision of the 1:50.000 scaled maps by SPOT images, should be ideally 1:25.000. In some cases, 1:50.000 scaled base maps may be able to be used for this purpose (Fukushima, 1998).

By considesing all these negative and positive factors, it can be said that, the planimetric accuracy of all features existing in the 1:50.000 scaled analog or digital maps is about ±20-25 m., the height accuracy is about ±10 m.

## 4 APPLICATIONS

Two different SPOT panchromatic stereo pairs (1994-1995 dated) covering Çeşme and Ayval k regions in Turkey have been used in the applications. In the SPOT stereo models formed in Zeiss-Planicomp P2 analytical and Vision-Softplotter digital photogrammetric instruments; the visibility and interpretibility of all features defined in the 1:50.000 Scaled Map Standardisation Specification has been investigated; additionally, all features and contour lines have been captured in 3-dimension in the 1:50.000 scaled maps covered the stereo models. In these applications, BINGO software has been used in the analytical instrument, SOFTPLOTTER software in the digital instruments. And then, the digital vector data have been edited and corrected in the PC-based work/stations. The topographical map completion of this data was not performed, the necessary information related to the cartographic and topographic applications have been taken from the results obtained from the previous applications.

## 5 COMPARISON OF THE 1:50.000 SCALED MAP PRODUCTION METHODS

| **a. THE PRODUCTION OF 1:50.000 SCALED MAPS WITH AERIAL PHOTOGRAPHS** | **b. THE PRODUCTION OF 1:50.000 SCALED MAPS WITH SPOT STEREO IMAGES** |
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| They are produced with up-to-date aerial photographs. | They are produced with archieved or programmed SPOT stereo images. |

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| The scale of are aerial photographs changes between 1:25.000-1:40.000. | The scale of SPOT satellite images is approximately 1:400.000. |
| The precision of the aerial photographs is extremely high. | The ground resolution of SPOT-P satellite images is ±10 m. |
| At the first step, 1:25.000 scaled maps are produced. At the second step, 1:50.000 scaled maps are produced by the cartographic generalisation. | 1:50.000 scaled maps are directly produced in one step. |
| The number and contribution of the necessary ground control points are determined by the kinematic GPS-supported aerial triangulation technique. The precisions of the geodetic control and photogrammetric tie points are about ±50-60 cm. | The necessary ground control points are measured from the paper maps. The accuracy of the control points taken from the 1:25.000 scaled maps is about ±5 m.; the accuracy of the control points taken from the 1:50.000 scaled maps is about ±10 m. |
| They are produced in analog or digital form by using analog, computer-supported analog (semi-analog), analytical and digital photogrammetric instruments. | They are produced only in digital form by using analytic and digital instruments. |
| The main problems related to the automatic generalisation used for the production of 1:50.000 scaled digital maps from the 1:25.000 scaled digital maps couldn' t be still solved. | 1:50.000 scaled digital maps are directly produced. For that reason, there is no any generalisation problem. |
| % 90 of 330 different features existing in the Specification can be seen and compiled in 3-dimension by using aerial photographs. | Only % 65 of 330 different features existing in the Specification can be seen and compiled in 3-dimension by using the best quality SPOT images. |
| The need for topographical map revision and completion is about %ö10-15 (minimum degree) | The need for topographical map revision and completion is about %35-40 (extremely high degree). |
| The visibility and interpretibility rates of the features are very high. | The visibility and interpretibility rates of the features are too low. |
| The production period is nearly 3 years. The most updated map is nearly 3-4 years old. | The production period is nearly 1.5-2 years. The most updated map is nearly 2 years old. |
| It is not necessary to use the base maps for the photogrammetric map compilation.<br><br>This method is very time-consuming. It is appropriate to use this method especially for the production of the 1:50.000 scaled map | It is compulsory to use the base maps for the photogrammetric map compilation.<br><br>This method is very fast. It is appropriate to use this method especially for the revision of the 1:50.000 scaled maps rapidly and for the |

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| originals and the revision of these maps. | visualisation and mapping of the big and rapid changes in a short time. |
| The production of one new map takes 8 months, the revision of it takes 6 months included all operations. | The production of one new map takes nearly 4.5 months, the revision of it takes 4 months included all operations. |
| This is the main method used for the production of the 1:50.000 scaled base maps. | This is a complementary method used for the production. It is generally used to see and map the rapid and huge changes on the ground surface. |

## 6 CONCLUSION

It is considered appropriate that the production of the 1:50.000 scaled base map originals should be performed by the cartographic generalisation of the 1:25.000 scaled base maps produced from the aerial photographs and, SPOT stereo satellite images should be used to see and map the regions occured many changes, new and big developments and to revise the 1:50.000 scaled maps very rapidly and at the ratherly low precision.

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