NATIONAL REPORT OF TURKEY
BY
NATIONAL MAPPING AGENCY, GENERAL COMMAND OF MAPPING

Introduction

As a National Mapping Agency of Turkey, General Command of Mapping (GCM) is responsible for the establishment and maintenance of geodetic networks, collecting and structuring topographic data, geospatial information and producing standard topographic map series of Turkey.

The mission of GCM is to provide all users and community with all kind of adequate, consistent, up-to date geospatial products in a timely and economic manner.

Geospatial products are one of the vital elements of information infrastructure of a modern country, a component essential for the functioning of administration at all levels, for sustainable development of the country, and for development of information society. The particular role of spatial information results from the globality of its application, the richness of its content, the costs of acquiring and maintaining it, as well as the variety of aims which it serves. The fast growing needs concerning spatial information, coupled with the dynamic development of information and communication technologies have been the reason for taking various initiatives in Turkey, as well as government and self government projects, which aimed at modernization of systems and developing spatial information infrastructures.

Storms and floods are causing major problems in earth every year. This is just a few examples describing that almost everything that affects our lives is linked to some aspect of geography. The more we know about the area, the better. The more information we have, the more appropriately we can act, plan and allocate our resources, deal with damage, manage risks, implement preventative measures and make sure we are prepared.

Collection and the storage of the geospatial information is still problem of the mapping world today. The data is stored in different database systems, are based on different specifications or has undefined quality. It can also be difficult to find data of interest or to access to such data. Therefore, it is of vital interest to facilitate for the users to search, find and access to data needed.

The main aims of establishing a spatial information infrastructure is to:

- Maximize data quality and consistency,
- Minimize costs of collection and revision for data by avoiding duplication of work and establish efficient co-operation between data producers,
- Enable combination of data from different sources by achieving interoperability,
- Advance access to data, for example Web based services,
- Promote the development of e-governance and of business being established using spatial data.

In order to achieve those issues, GCM undertakes geodetic, photogrammetric and cartographical research and production activities.

1. Geodetic Networks and Earthquake:

Three different GNSS networks namely Turkish National Fundamental GPS Network (TUTGA), Turkish National Permanent GPS Network (TUSAGA) and Continuously Operating Reference Stations (TUSAGA-Active) serve as basis for geodetic positioning, mapping, navigational and geodynamical purposes in Turkey. TUTGA is the first fundamental geodetic network based on GPS technology in the country [1]. The network consists of about 600 stations (see Fig. 1) established through campaign type GPS surveys between 1997 and 1999. Some of the stations were re-surveyed due to the destructive earthquakes after mid-1999. For each station,

3 geocentric coordinate and their associated errors and velocities have been computed in ITRF2005 and transformed into ITRF-96, which is the initial reference frame chosen for TUTGA. Positional accuracies of the stations are about 1-3 cm and the relative accuracies are within the range of 0.1 - 0.01 ppm.

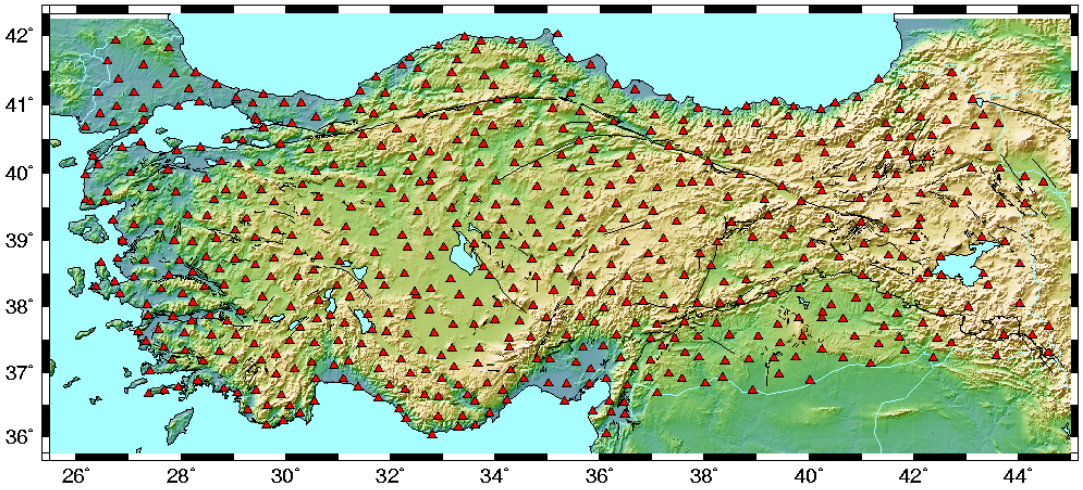


Fig. 1 Distribution of TUTGA stations.

TUSAGA is the continuous but passive GPS network consisting of 25 stations (see Fig. 2) established particularly to monitor geodynamical activities in the country [3,4]. TUSAGA-Active, contrary to TUSAGA, is an RTK network consisting of 146 sites (see Fig. 2) to serve real-time positioning information for the variety of applications such as mapping, GIS and cadastral applications.

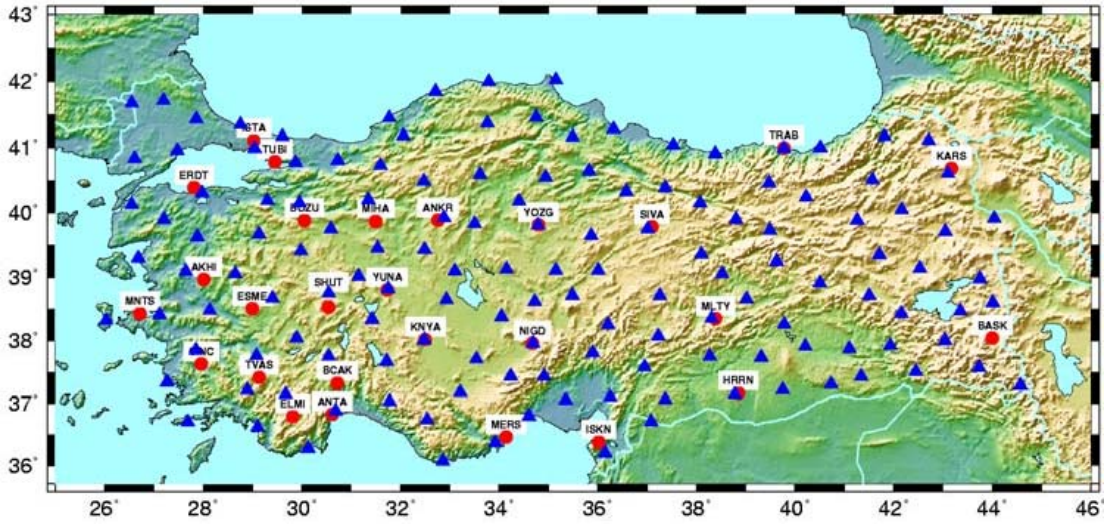


Fig. 2 Distribution of TUSAGA and TUSAGA-Active stations. Red circles: TUSAGA sites, blue triangles: TUSAGA-Active sites.

Turkish Vertical Control Network (Fig.3), namely leveling network was physically established based on spirit levelling measurements since 1940s, carried out along the main and collateral roads and even along the railroads throughout the country. It forms the infrastructure of the height system of the country along with the en-route gravity measurements. It gets its reference from Turkish National Sea Level Monitoring Network (TUDES) comprising of tide-gauge stations, where instantaneous sea-level measurements are carried out along the coasts of Turkey (Fig. 4). Besides geodetic objectives, the stations are also contributing to regional oceanography, meteorology and tsunami early warning.

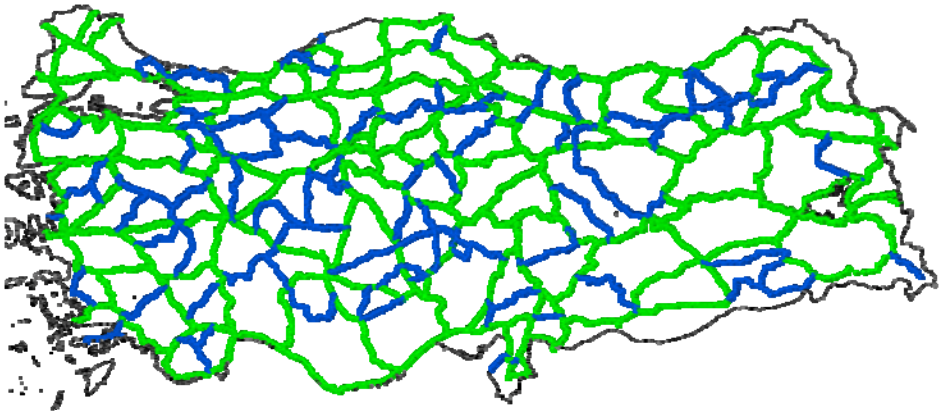


Fig. 3 Turkish Vertical Control Network. Green lines: first order, blue lines: second order network.

Fig. 4 Locations of the existing tide gauge stations of TUDES.

In order to understand the deriving forces of the earthquakes in Turkey, geophysical and geodynamical geodesy play an important role taken up by GCM. Inter-plate tectonic activity by Africa, Arabia and Eurasia major plates and its deformation process along the fault lines (East and north) in Anatolia are monitored through aforementioned geodetic networks TUTGA, TUSAGA and TUSAGA-Active. Utilizing the episodic GNSS measurements at the network stations, horizontal velocity solution over the interval 1992-2010 yields interseismic deformation and thus the tectonic nature of Anatolia and its surrounding regions (Figure-5). Eastern part of Anatolia escapes to north-east due to the compression along East Anatolian Fault where the two plates (Arabian and Anatolia) collide along Bitlis-Zagros thrust zone whereas, the bigger part of Anatolia moves westward (24 mm/yr) along the North Anatolian Fault and makes a counter-clock wise rotation (~35 mm/yr) with an Euler pole near Sina, Egypt. When an earthquake with a magnitude bigger than $M_w = 6.0$ occurs, GCM policy is to make a survey campaign to the affected region and re-survey the network points. GNSS observation campaigns initiated just after the earthquakes enable the precise determination of co-seismic displacements reaching up to a few meters.

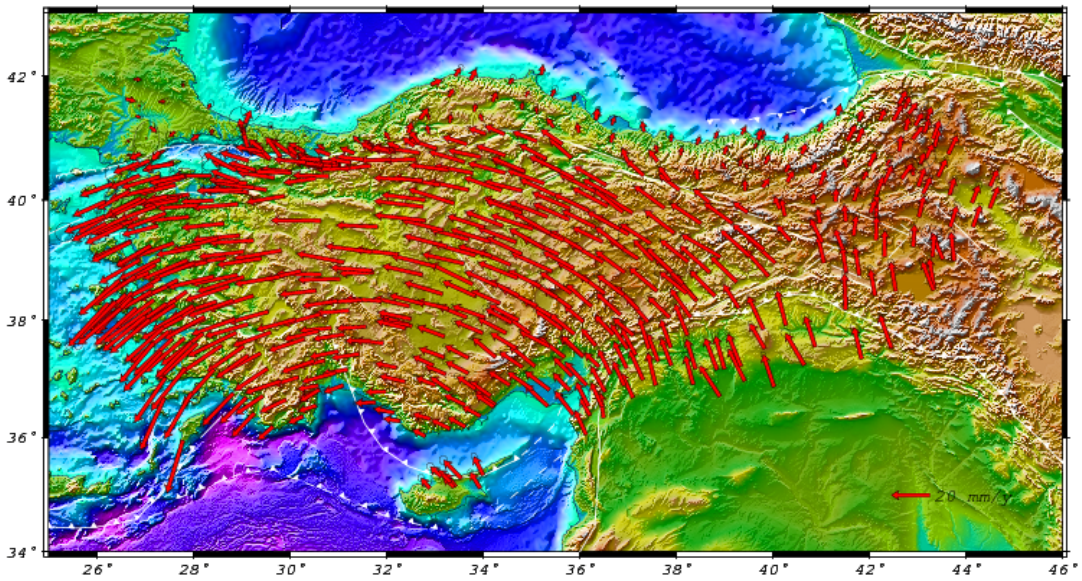


Figure 5 Horizontal velocity field of Turkey and surrounding regions in a Eurasia-fixed frame.

Turkish regional geoid models have been developed by employing a reference earth gravitational model, surface gravity observations and digital terrain models. The gravimetric geoid models provide a ready transformation from ellipsoidal heights to the orthometric heights through the use of GPS/leveling geoid heights determined through the national geodetic networks.

The recent gravimetric models for Turkish territory are computed depending on the Earth Gravitational Model 2008 (EGM08), new surface gravity observations (~266000), the advanced satellite altimetry-derived gravity anomalies over the sea (DNSC08), high resolution digital terrain model (90m) and a large number of GPS/leveling stations (~2700).

Gravimetric geoid model with GPS/leveling geoid heights are combined in order to obtain a hybrid geoid model (THG-09) (or a transformation surface) to be used in GPS positioning applications. The RMS of the post-fit residuals after the combination was found to be $\pm$ 0.95 cm, which represents the internal precision of the final combination. And finally, we tested the hybrid geoid model with GPS/leveling data, which were not used in the combination, to assess the external accuracy. Results show that the external accuracy of the THG-09 is $\pm$ 8.38 cm. which has not been achieved in Turkey until this study.

2. Topographic Mapping:

Base scale in the production of Turkey's topographic mapping is 1/25.000. Aerial triangulation technique is used in the production. Geographic Coordinate System was selected as the coordinate system of the Vector Database for providing the accurate continuity of the data. For map production, projection used is UTM for 1/25 000- through 1/250 000 and Lambert Conformal Conic for 1/500 000. Horizontal datum was ED50 until 2003, and after that time WGS84 datum is adopted. Vertical datum is Mean Sea Level (MSL).

Digital methods have been applied in the topographic map production since 1999. Standard GCM data model is used between 1/25 000 and 1/100 00 productions, while VMAP1 data model is used in 1/250 000 and 1/500 000 productions. Both data models are compliant with NATO standards.

In the production of 1/ 25 000 topographic maps, high resolution color stereo aerial photos (taken by Ultracam X and Eagle digital aerial cameras) are used. So far, the features have been compiled by using different kinds of software in CAD format. Then, CAD format is transformed into Geodatabase format in order to make some

topologic and semantic controls. Following the establishment of Topographic Vector Database, the data uploading process has started. After uploading the whole country's data into database, it's planned to delivering the data to the users.

GCM has participated in the Multinational Geospatial Co-Production Program (MGCP) under the Memorandum of Understanding signed by 28 countries. Participants may co-produce and share High-Resolution Vector Data over current high interest areas of the world. GCM began the production in 2007 by using the up-to-date satellite imagery as a main data source. Production is going on according to the standards defined by the MGCP team.

3. Remote Sensing, Photogrammetric Image Enhancement and Ortho-Imagery/Photo Works:

Remote sensing is used with panchromatic or colored satellite images for the topographic map productions for the areas of interest. GCM has been using Microsoft UltraCam X digital large format camera since 2008 (Also UltraCam Eagle by 2012). In the production of 1/ 25000 topographic maps, 45 cm GSD (Ground Sampling Distance) aerial photos are taken with %70 overlap and %30 sidelap. Kinematic GPS supported aerial triangulation is carried out by using GPS and IMU instruments. Three-dimensional topological vector data for 1/25 000 scale topographic maps are collected from stereo models using digital photogrammetric systems (Figure 6). These data are compiled in the field with complete GPS/GIS data collection sets and attributes collected in the field are appended to the vector data. All vector and tabular data are modified and edited for the Topographic Database. The 3D vector data collection for almost 80% of Turkey will be finished by the end of 2012. 30 % of this vector data has been gained by out-sourcing. Apart from the regular stereo plotting and revision of the 25K maps, some customized solutions have been developed in order to meet the user requirements. Among them, Digital Orthophoto Presentation System which contains orthophoto maps of the cities at various scales is the foremost one. Additionally, GCM carries out some research and development studies at national/international level on utilization of airborne SAR and satellite images.

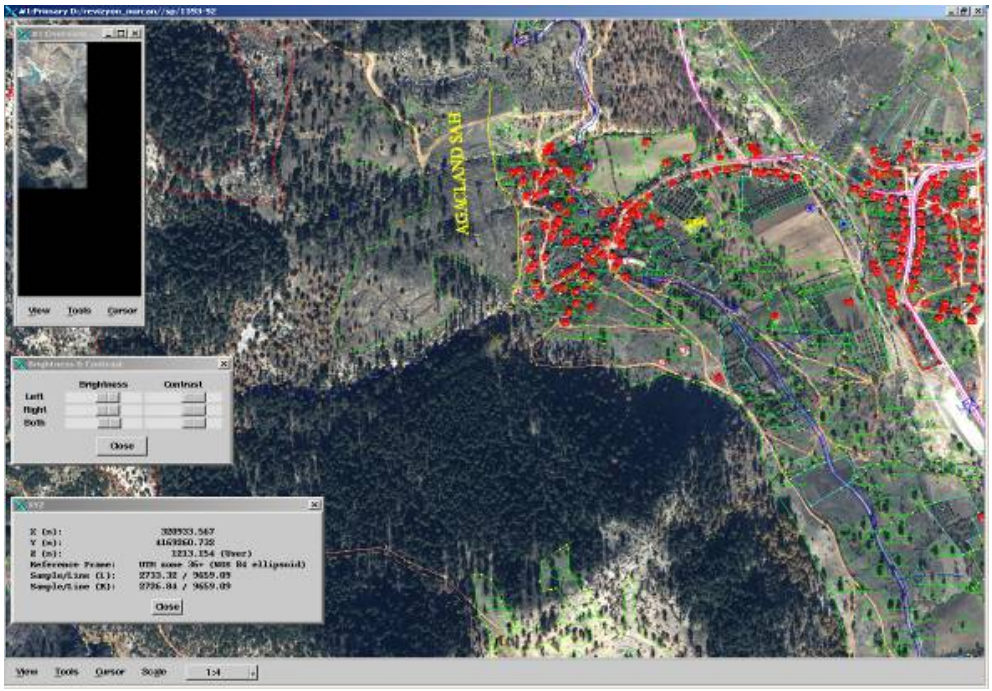


Figure 6. Stereo vector data capturing

Ortho-rectified imagery/photo is produced as succeeding work after aerial photography for revision. GCM DEM, NASA-SRTM 1/2 and ASTER DEM2 are being used for ortho-rectification. Several image processing software

such as ERDAS, Lieca Photogrammetry Suite (LPS) and PCI are used for image enhancement and ortho-imagery works. Following activities are the main ones in this context;

- Performing aerial triangulation (adjustment) of aerial-photos,
- Orthorectification of aerial photos and remotely sensed imagery,
- Mosaicing and clipping due to required frames or grids,
- Enhancing ortho-imagery/photo for photo interpretation and information extraction,
- Pan-sharpening.

Digital Ortho-photo Presentation System which contains orthophoto maps of the cities at various scales is one of the particular product for the community (Figure 7). Additionally, GCM carries out some research and development studies at national/international level on utilization of airborne SAR and satellite images.

Figure 7. Screenshot of Digital Ortho-photo Presentation System

4. Creation and/or Development of Geo-Databases:

Turkey has established a 1:25000 scaled Topographic Vector Database (TOPO25) for storing the vector data. The main properties of the developed Geodatabase are as follows.

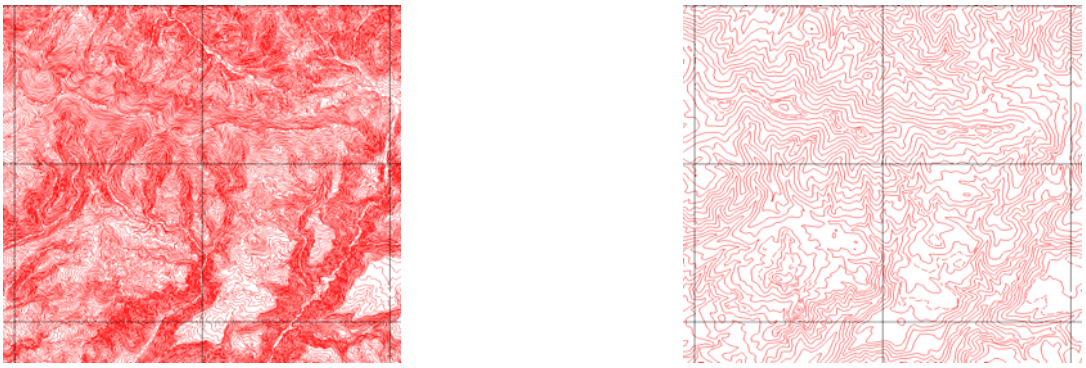
- The real world features are represented by 128 feature classes and 352 feature sub-types in the database,
- Several attributes are defined for each feature class,
- Attribute Domains are defined for the required attributes,
- There are 208 topological rules in the database. All data in the database must be consistent with these rules,
- The database stores the data in a continuous structure for the whole country. It is independent from any map sheet or border,
- The data is stored in 3D structure in WGS84 Datum and in ORACLE/ArcSDE Enterprise Geodatabase.

5. Cartographic Activities

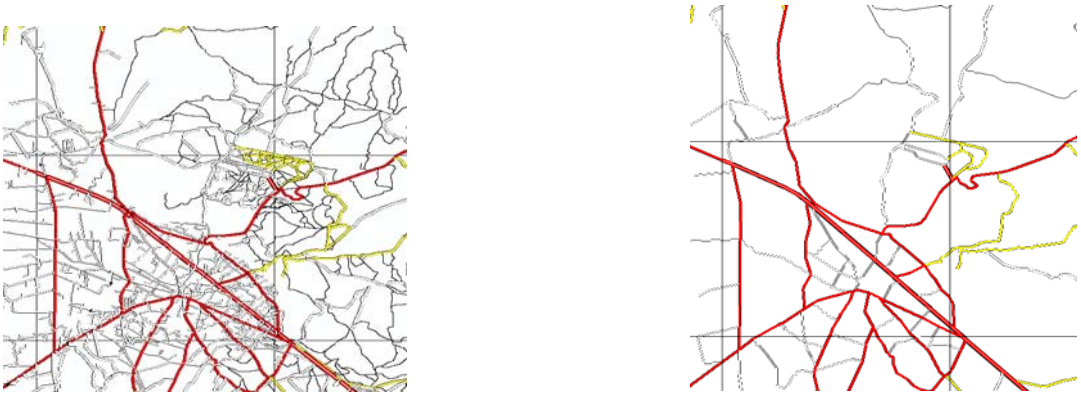
All map series (1:50 000 and 1:100 000)other than base map 1/25 000 are produced by means of cartographic generalization from larger scale map series except JOG series. Mid-scale air and ground series such as JOG A/G, 1404 series of 1:500.000 are handled by GCM. JOG Air/Ground maps are produced from VMAP L1 database. In addition to standard work flows, GCM is also carrying out production of small-scale thematic maps, city plans and plastic relief maps.

Base map consists of more than 5500 sheets. The first and second editions are completed between 1951-1972 and 1957-1996, respectively. Moreover, maps of some regions which are developed rapidly are published for several times - edition 5, for some regions - since 1977. The third edition of base map series is being produced

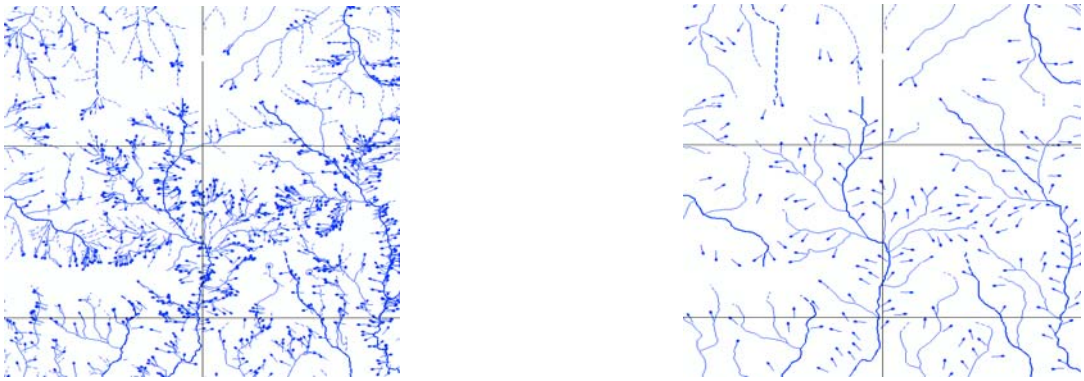
by means of digital techniques. Almost 4269 sheets have been produced since the end of 1999. The resultant raster and vector maps are being stored in digital media. Conventional cartographic productions at these scales were stopped in 2000. GCM has initiated a new project called "Computer Assisted Generalization Project" in 2002 to develop digital cartographic generalization production lines. At the end of 2005, the project has succeeded to establish a new map production line that produces 1/100.000 scale maps through generalization using 1/25.000 scale master data. Following the same procedures, similar map production line for producing 1/50.000 scale map series through generalizing 1:25.000 scale master data has been realized by the end of 2006 (Figure 8). According to the statistics, 75 % of cartographic processes are carried out automatically and the rest are made interactively.



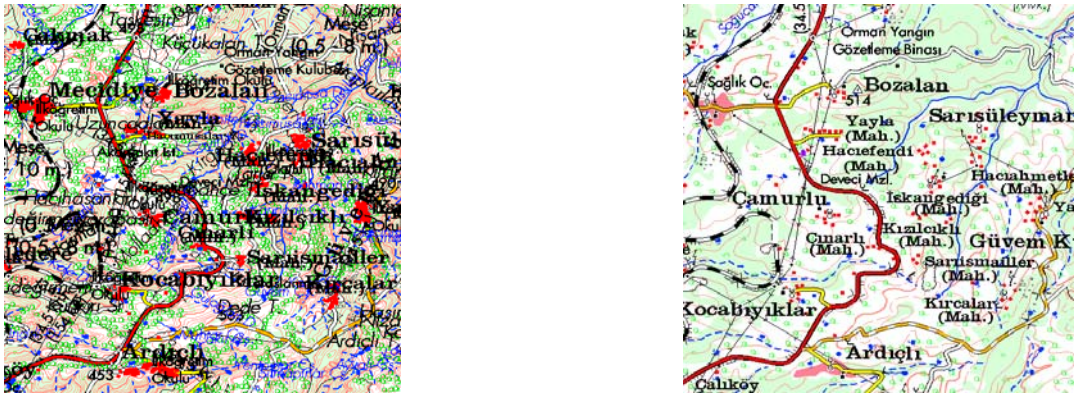
(a) Elevation



(b) Transportation



(c) Hydrography



(d) All feature classes

Figure 8: Samples of different feature classes before (left column) and after (right column) generalization process.

Several types of thematic maps are printed at different scales. Some of them are produced as 3D plastic relief models. Physical and Administrative Units of Turkey, Plastic Relief Map of Turkey, Political and Physical Maps of the World, Europe, Turkey and Surroundings are some of the sample thematic maps that have been produced. Also, gazetteers and Populated Places Databases and Standardization of Geographical Names are the examples of cartographic production line.

6. Spatial Data Infrastructure (SDI):

Ministry of Environment and Urban Planning has been the coordinator related with NSDI since 2003. General Directorate of GIS is established under this ministry. GCM that is the National Mapping Organization and other public organizations that produce GIS data have an active role in this action. One of the other public organization responsible for the production large scale mapping (eg: 1/5000 and larger) is General Directorate of Land Registery and Cadastre. This institution is also the major contributor for NSDI activity in Turkey. However, country-wide efforts to establish NSDI are still going on.

7. Non-Governmental Organization (NGO) Activities:

Union of Chambers of Turkish Engineers and Architects, Chamber of Survey and Cadastre Engineers is one of the NGO giving administrative and technical support to the mapping and geospatial activities of Turkey as well as its indispensible guidance role to its members in the same field of interest. Private sector is active in the production of geospatial elements in the country. Collaboration between private sector and academic organizations on some governmental projects are increasingly becoming outstanding in the country. National and EU funded collaborative academic projects are ascending rapidly.

As mentioned above, large scale maps are produced by other governmental organizations. These organizations share some part of their responsibilities with the mapping and surveying companies. This is very common and popular in Turkey.

Private sector not only gets the routine mapping works but also contributes to the reseach and development activities in Turkey. For example, a private company has taken up the industrial supportthe geodetic RTK network TUSAGA-Active financed by Scientific and Technological Research Council of Turkey.

8. Hydrographic Activities:

Hydrographic activities in Turkey are carried and coordinated by a Board named “Navigation, Hydrography and Oceanography Services Planning and Coordination Board”. “Office of Navigation, Hydrography and

Oceanography" under Naval Forces holds the presidency of this Board. All naval products are produced by the members of this Board.

"Office of Navigation, Hydrography and Oceanography" produces navigation maps ranging from 1/25 000 to 2M scales and electronic charts at S57 standard.

GCM is also a member of this Board. Operating Turkish National Sea Level Monitoring System (TUDES) with 20 stations, we provide sea level data and other meteorological data.

9. Research , Training Activity and Adhering Organizations.

Four year geodesy and photogrammetry education is given at various universities in Turkey. GCM is in close contact with these universities. Besides, two year surveying technician education is given at various vocational high schools.

GCM has a High Technical School of Surveying. This school gives bachelors degree education to the students coming from Army Academy and technician education to the NCOs. Also some short period specific courses are organized for personnel from armed forces to introduce new technologies for their mapping requirements.

Cooperating with universities, GCM gives on the job training and provides internship program for the civilian students from universities annually. GCM is also the adhering organization of International Union of Geodesy and Geophysics (IUGG), International Society of Photogrammetry and Remote Sensing (ISPRS) through national bodies with participating members from national universities and related governmental institutions. Also, it is contributing International Cartographic Association (ICA) and other multinational and European geospatial associations.

References

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