TOPOGRAPHIC DIGITAL DATA COLLECTION AND REVISION BY PHOTOGRAMMETRIC METHODS FOR MAPPING END GIS

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ABSTRACT

The paper discusses the main aspects of photogrammetric methods and tools for digital topographic data collection and revision. Hardware and software are presented. Central Research Institute of Geodesy, Air Survey and Cartography (CNIIGAiK) by the order ROSCARTOGRAPHIJA has carried out and is designing now a few of modern photogrammetric instruments and technologies for topographic data collection and revision on air and space images. The main ways of these investigations are: 1) the improvement of the analytical photogrammetric methods for topographic data collection and revision by analytical plotters STEREOANAGRAPH and SD-20 (SD-2000 analog); 2) the investigation and designs of modern digital instruments (photogrammetric scanner, cost-efficient digital photogrammetric stations) for computation air and space images (mono and stereo) of central and panoramic projections; 3) the improvement of the technologies for digital topographic data collection and revision by analytical and digital workstations for mapping and geographic information systems.

1 INTRODUCTION

Geographic information systems and technologies evolution is linked with photogrammetric methods and tools for digital topographic data collection and revision. This methods are more operative and economic. A investigation and designs of modern instruments and technologies for topographic data acquisition and revision are realized at the Central Research Institute for geodesy, air survey and cartography (CNIIGAiK).

Last years mapping production enterprises of the Federal Service of Geodesy and Cartography of Russia (ROSCARTOGRAPHIJA) carried out large volume works for topographic maps digitizing. By this time the topographic maps digitizing at scales 1:1000000 and 1:200000 is finished on all territory of Russia; the digitizing of topographic maps and town planes at scale 1:10000 and 1:25000 is being carried out. As the result there is a problem of updating and maintenance of increasing volumes of digital cartographic data according to the requires. From the other side the new possibilities of high resolution space images (for example KVR-1000 at other) promote to use them for updating digital topographic maps and digital topographic data for GIS. The updating of digital topographic data is being carried out by using the photogrammetric methods. The photogrammetric methods are used also for production of the digital topographic planes at scale 1:500 - 1:5000.

Central Research Institute of Geodesy, Air Survey and Cartography (CNIIGAiK) by the order ROSCARTOGRAPHIJA has carried out and is designing now a few of modern photogrammetric instruments and technologies for topographic data collection and revision on air and space images. The main ways of these investigations are: 1) the improvement of the analytical photogrammetric methods for topographic data collection and revision by analytical plotters STEREOANAGRAPH and SD-20 (SD-2000 analog); 2) the investigation and designs of modern digital instruments (photogrammetric scanner, cost-efficient digital photogrammetric stations) for computation air and space images (mono and stereo) for central and panoramic projections; 3) the improvement of the technologies of digital topographic data collection and revision by analytical and digital workstations for mapping and geographic information systems.

The designed instruments and technologies provide the effective solution of practical tasks for digital topographic data collection and revision for mapping and GIS-technologies. They intend for using in production enterprises of ROSCARTOGRAPHIJA and other firms. They provide for technologic and information combination of the photogram-

metric scanner PS-30, the analytical plotters Stereoanagraph and SD-20, the digital photogrammetric workstations, the digital workstations for cartographic editing. Their possibilities are computing of digital topographic maps and planes at the other formats**,** and also at the format for exchange as branch standard of ROSCARTOGRAPHIJA. Designed technological procedures intend to combination of two processes - photogrammetric collection (revision) of digital topographic data by analytical and digital workstations and (it is necessary) cartographic editing this data in unite digital technology .

New fully digital systems are very economically priced and easy to use. Their software runs on ordinary personal computers, which may be networked with larger systems. Thus it offers an ideal entry into digital photogrammetric methods and it can also be integrated efficiently into photogrammetric organizations already operating the universal analytical stereo workstations specifically designed to achieve the highest precision.

Using of the digital photogrammetric workstations allows to except optic-mechanical tools, to automate the photogrammetric operations, to provide new treatment possibilities by using covering of vector and raster digital data, to give a new type of cartographic production, for example virtual reality scenes etc.

2 ANALYTICAL PHOTOGRAMMETRIC METHODS

2.1 Analytical instruments

Analytical photogrammetric methods use for topographic data collection and revision by analytical plotters STEREOANAGRAPH and SD-20 (SD-2000 analog). The analytical plotters are comprehensive automated systems for stereo plotting of air and space photographs:
- air triangulation data collection for independent models and bundle adjustment using digital point transfer and GPS data;
- geometric modeling of terrain on stereo pair photographs;
- digital terrain models and digital terrain data acquisition and revision on base stereo plotting and semantic data collection;
- superimposition of vector data on photo image (SD-20).

2.2 Digital point transfer for air triangulation by analytical plotter

Reliable and precision identification and marking of tie points are of great importance in photogrammetric bridging [3]. The technology, currently in practice in air triangulation, with artificial tie points marking and stereo comparators applied does not allow an efficiency increase of the process and prevents from introducing promising mapping technologies based on analytical plotters. In this connection the developed technology features are an exclusion of artificial tie point marking from photogrammetric bridging and substitution of it for digital points transfer. The new technology based on using of STEREOANAGRAPH and SD-20 analytical plotters permits to improve accuracy of photogrammetric measurements, to automate processes of block designing, point coordinate measuring on aerial photographs, and checking of results obtained from major procedures.

The technology involves using of the following software and hardware devices: analytical plotters (AP), software for the developed technology included as a part into loading modules; program package for block adjustment PHOTOCOM or PHOTOBLOK.

The above set actually forms a technological workstation of the on-line triangulation that makes it possible to accomplish at one working place and by one operator-photogrammetrist all the procedures needed for block adjustment including the formation of a catalogue of bridging point coordinates and parameters of orientation for each stereo pair.

Integrated solution of the problem providing for control of measurement results for each stereo pair, for elimination of defective points, and than their repeated measurements permits to increase reliability and precision of block adjustment, to reduce the number of forced additional measurements made by the results of adjustment. A graphical interface convenient for use reduces workload on an operator and increase his productivity.

2.3 Digital topographic data collection and revision

The analytical plotters STEREOANAGRAPH and SD-20 are intelligent and powerful data acquisition workstations for integration into the photogrammetric-cartographic program package. With its object-oriented data structure, the program package meets the most exacting demands and, especially in combination with COLORISS system, offers an optimum environment for data acquisition and revision on air and space images for mapping and GIS requirements [6].

Measuring operations proceed according to the menu instructions on the computer screen. Any necessary operations can be carried out efficiently and easily. The computer provides inner, relative and absolute orientation calculations necessary to obtain data as ground coordinates. The user measures several points in the stereo model in order to let the computer make the calculations. Upon completion of the above calculations, the 3-dimensional coordinates of any point in the stereo model can be measured. Measuring operations are very easy.

Collect features coded 3-D digital map data with real time graphical display. An exact photogrammetric solution is employed, with full allowance for space, aerial and terrestrial photographs. Support database management systems for cameras, ground control, feature codes and instrument calibration. The points can be simply measured and connected by lines, polygons or circle lines. User defined: layer style (polygon/polyline, polygon/polyline smoothed, spot height, symbol, frame and legend, table, DEM grid); layer state (editable, visible, selective, hidden); line attributes (style, color, width); brush attributes (style, color); font attributes (type, color, size); parameter style (real, word, integer, string, filename, fixed list); symbols types etc. User cods topographic objects with layers and by semantic classification (presented as text file and logical structure). Also rectangular correction for buildings is provided. The extracted data is simultaneously displayed superimposed on the stereo model (COLORISS for the SD-20).

Program package is available to transfer the collected data to graphic editing software, translating the AP data into formats compatible with several will-known GIS and CAD systems, such as MapInfo, AutoCAD, Micro Station.

Thus, the analytical plotters STEREOANAGRAPH and SD-20 can be used for GIS and topographic data collection and revision as well as for mapping at scales of 1:500 to 1:25000.

3 DIGITAL PHOTOGRAMMETRIC METHODS

3.1 Digital instruments

Digital photogrammetric methods for topographic data collection and revision use a photogrammetric scanner and cost-efficient digital photogrammetric workstations for computation air and space images (mono and stereo) for central and panoramic projections. Performing similar functions to an analytical plotters, the digital photogrammetric station uses digitized photos instead of the original negatives or positives. A digital photogrammetric workstation is designed to perform measurement functions of the analytical plotter, plus it may allow the operator to

- integrate raster image and vector map data;
- digital stereocorrelation for procedures of inner, relative, absolute orientation;
- implement image processing procedures such as contrast enhancement, edge sharpening, vector on raster overlay;
- automatically generate digital elevation models (DEMs);
- produce digital ortophotos and ortophoto maps;
- produce new type of cartographic production, for example virtual reality scenes etc.

3.2 Photogrammetric scanner

A photogrammetric scanner is tools for presentation of photo images in digital form. Central Research Institute of Geodesy, Air Survey and Cartography (CNIIGAiK) and State Enterprise Experimental Optic-Mekhanical Factory are designing the PS-30 photogrammetric scanner for digitizing half-tone photos (b/w) with a high geometric and radiometric accuracy [4]. Scanner module has CCD line sensor (2048 pixels) for photo sizes up to 300 mm x 300 mm; geometric resolution 1 μm, radiometric resolution 256 gray levels; pixel size 11, 22, 44, 88 μm. Scanning time for a 180 mm x 180 mm monochrome photo is less then 20 min, with 11 μm pixel resolution. Computer: IBM PC Pentium. Software package provides with scanner calibration, interior orientation, digitization in accordance with the image format specifications, storage on disk and display of the image data on the graphics monitor.

3.3 Structure and assignment of the digital photogrammetric system

Digital photogrammetric system is intended for the decision of the following tasks:
- production and updating of the digital topographic planes and maps at scales 1:500 - 1:50 000 on aerial photographs;
- updating of the digital topographic maps at scales 1:50 000 - 1:200 000 on space images of the central and panoramic projections;
- production of the orthophotos and orthomaps on aerial both space photographs of the central and panoramic projections;
- preparation of the graphically made out sheets of the maps and orthomaps for input them on jet plotter.

Digital photogrammetric system except for traditional component (system computing block, monitor and network equipment) includes in additional optic-mechanical and electronic units (stereoscope mounted in front of the monitor or active shutter equipped eyewear, XY hand wheels, Z foot disk, three foot pedals, build in PC controller, interfaces).

Stereo display in digital formats is realized by two ways:
1) Optical (splitting the screen to display the left and right images of a stereopair for viewing by means of a stereoscope in front of the monitor);
2) Electronic (employing active shutter equipped eyewear).

The following digital workstations (DWS) or automated workplaces can be generated on the basis of digital photogrammetric system:
1. DWS-vector.
2. DWS-mono.
3. DWS-mono plus.
4. DWS-stereo.
5. DWS-orthophoto.
6. DWS-map.

DWS-vector is intended for orientation of the raster images (or its fragments) of the graphic maps and digitizing it to vector format.

DWS-mono and technology, developed for it, are intended for two-dimensional updating of the digital maps and planes on single air and space images [1 , 6] central and panoramic projections. Thus the coordinates Z for points of objects on a updated maps are calculated on the basis of available contour lines. The accuracy of object XY-coordinates is connected with their displacement on account of relief. For digital topographic maps and planes on city with multi-storey buildings, on mountain territories is required use DWS-stereo.

DWS-mono plus is intended for three-dimensional data collection on stereo images with automatic definition of heights by stereo correlation of points. This variant is intermediate between mono and stereo modes and allows to open the right photo (or anyone another raster image) in a separate window. The window automatically scrolling at the cursor moving on the basic left image. It makes possible the collection of the digital data on stereopair images without use stereoscope at rather flat relief and non-urban territories.

DWS-stereo and appropriate technology are intended for three-dimensional data collection on stereo images (air and space). This variant is used for collection and updating of digital maps and planes on urban territory, territory areas with hard relief. Stereo correlation of the digital images is used for image orientations, collection of digital data for plane and high coordinates.

DWS-orthophoto is intended for generation of digital orthophoto mosaic and orthophoto maps as specific mode of production. The data on Z-coordinates for image orthotransformation can be collected on stereopair as DTM or on available contour lines or other topographic objects.

DWS-map is intended for graphical preparation of digital map, plan or orthophoto sheets. The purpose of these works is the design of improved quality copy of the print original for output of them on jet plotter.

3.4 Features of digital photogrammetric system

Main feature of the theoretical approach in development of algorithms and software of the DPS is the collection and updating of the digital vector data on the original not transformed images. I.e. vector digital map is carried out transform to a digital images (stereopair or single) central or panoramic projection. This method excludes photo image trans-

formation and consequently computer time for transforming and storage of this data. At digital map updating each point 2D-vector information receives third coordinate Z, that especially essentially for large-scale mapping and GIS-applications.

Other main feature of the DPS is the formation of the digital vector data in database for mapping area and monitoring of the data. The special possibilities of the DPS (on the basis of patterns: layers, object characteristics, symbols types etc.) allow to receive from its database only that information, which is necessary for the different users: mapping, land inventory, urbanism, ecology, etc.). Thus, digital maps, formed for user, can have both increased and lowered database. For increase database of digital maps and planes there is possibility to include in its orthophoto images.

The third main feature of the digital system are its possibilities of cartographic preparation for collected on DWS of digital vector data. At collection from zero in DWS database already there are identifiers of topographic objects, their characteristics, models of relation of objects and characteristics, attributes of lines, areas, symbols types, etc. descriptions set with the help of patterns for required scale of mapping. It allows essentially to increase of collection productivity on the DWS and to facilitates work of the operator. After a choice from the list of the patterns such as useful object and fixation of its geometry on a image all its attributes are brought in to a database automatically. Thus, the routine work on graphic preparation of digital original disappears.

The software of digital photogrammetric system represents the 32-digit MDI-appendix in language Delphi, intended for functioning in operation systems Windows 95/98/NT and realized on personal computers Intel such as Pentium-II and is higher. The possibilities of image processing automation are:
- automatic stereo identification of points for procedures of inner, relative and absolute orientation of stereopair images;
- automatic construction of regular digital elevation models with the given step of a grid;
- automatic construction of contour lines with the given height interval;
- automatic construction of intermediate contour lines;
- automatic digital elevation models construction with the given step of a grid on available contour lines;
- three-dimensional collection of topographic objects in a mode automatic stereo identification of image points.

4 TECHNOLOGY

On the basis of developed hardware and software for the enterprises of branch the basic technology circuits of production and updating of digital topographical maps and plans are offered.

The technology № 1 is focused on production of the digital topographic planes at scales 1:500 - 1:5000 and topographic maps at scale 1:10000 on aerial stereo photographs. The collection of the digital information about a contour lines and topographic objects is carried out by DWS-stereo, analytical plotters Stereoanagraph or SD-20 in DWS (Windows and DOS) 3D-format. The data can be transferred (if necessary) to other widespread formats (DXF/DBF, MID/MIF).

The technology № 2 is focused on updating of the digital topographic planes at scales 1:500 - 1:5000 on cities with high buildings and topographic maps at scale 1:10000 on territory with a hard relief. The digital data on a relief is used without correction. Updating of the digital data on a topographic objects is carried out. (Can be if necessary updated and information on a relief). Updating initial data can be submitted in DWS (Windows, DOS), DXF/DBF, MID/MIF formats, exchange format of the ROSCARTOGRAPHIJA. The processing of the digital data on DWS-stereo or analytical plotter is carried out in internal format of DWS. Updated data can be transferred to DWS (Windows and DOS), DXF/DBF, MID/MIF formats, exchange format. If necessary this technology can be applied for new collection of digital maps at scale 1:25000 without use or with partial use of the digital updating data.

The technology № 3 is focused on updating of the digital topographic maps at scales 1:10 000 - 1:50000 (it is supposed, that for maps at scale 1:10000 the buildings should not have too high) by DWS-mono or DWS-mono plus on aerial photographs. The updating will carry out basically on flat and hilly areas, when it is not required to correct a relief, and updating of digital data about topographic objects is necessary. Old and updated digital maps can be presented in DWS (Windows and DOS) formats and exchange format.

The technology № 4 assumes updating of digital topographic maps at scales 1:25000-1:1000000 by DWS-mono on single space photographs of the central and panoramic projections. DWS-mono is used for updating the XY-information about topographic objects. Old and updated digital maps can be presented in DWS (Windows and DOS) formats and exchange format.

The technologies of production and updating of digital topographic maps and planes on digital and analytical workstations are submitted as the block diagram in a fig. 1 and 2. The basic processes of technologies are the following:
- development of the technical project;
- air (space) photo survey;
- preparatory procedures;
- field geodetic works;
- photogrammetric bridging;
- scanning of photos on photogrammetric scanner;
- photogrammetric model computation on single or stereo images;
- converting digital map (plan) from a storage format to photogrammetric format;
- image interpretation;
- updating of the digital data (geometry, features, characteristics) on photogrammetric model and semantic coding;
- cartographic editing of the collected digital topographic data;
- field inspection and image interpretation, field survey of the objects non presented on the image;
- final editing of the digital map (plan);
- test quality of the digital map (plan) and formation of digital production in the formats, given by the technical project;
- digital map (plan) archiving, transfer to the users or distribution of hard copies.

5 CONCLUSIONS

The works on collection and updating of digital topographic maps and large-scale planes are carried out now in production enterprises of ROSCARTOGRAPHIJA. A technical basis of the developed technologies is the analytical plotters Stereoanagraph and SD-20 for photogrammetric bridging, photogrammetric scanner PS-30 for digitizing of photos, a few digital work stations for acquisition end editing of the digital data and jet plotter for graphic presentation of the digital information. The important feature of offered technology is the opportunity of its expansion both in the large enterprises of ROSCARTOGRAPHIJA, and in their divisions (expeditions) or in again formed small enterprises.

Thus, the works carried out in CNIIGAiK are focused on the decision of the basic theoretical and practical tasks of development instruments, software and technology for collection and updating digital maps and planes on air and space photos by analytical and digital photogrammetric methods. The decision of these tasks in conditions of computerization of enterprises open a way of the further perfection of domestic methods of digital photogrammetry and cartography and effective technologies, suitable for introduction in the enterprises.

REFERENCES

1. Агапов С.В. Фотограмметрия сканерных снимков. М., Картгеоцентр Геодезиздат, 1996, 176 с.

2. Нехин С.С. Об оптимальном геометрическом разрешении изображений, обрабатываемых на цифровой фотограмметрической системе. Геодезия и картография. 1996, № 6, с. 34 - 39.

3. Zotov G.A., Ilyin L.B., Nekhin S.S., Oleinik S.V. Digital points transfer for aerotriangulation by analytical plotter. In IAPRS Vol. 31, Part 1, Commission II, pp. 437-442, Vena, Austria, 1996.

4. Зотов Г.А., Блюдусов А.П., Нехин С.С., Фельдман Г.А. Разработка фотограмметрического сканера. Материалы юбилейной научно-технической конференции ЦНИИГАиК, посвященной 850-летию г. Москвы, 1997, ч. 2, стр. 17-21.

5. Нехин С.С., Зотов Г.А. Создание и обновление топокарт и планов на ЦФС. Материалы юбилейной научно-технической конференции ЦНИИГАиК, посвященной 850-летию г. Москвы, 1997, ч. 2, стр. 21-30.

6. Нехин С.С., Зотов Г.А., Бирюков В.С. и др. Разработка цифровой фотограмметрической станции и методов создания и обновления топографических карт и планов. Геодезия и картография. 1997, № 9, с. 34 - 39.

7. Nekhin S.S., Zotov G.A. Photogrammetric methods and tools for GIS digital data acquisition and revision. Presented Paper to Third Turkish-German Joint Geodetic Days. Istanbul, June 1-4, 1999, Vol. 1, pp. 495-502.

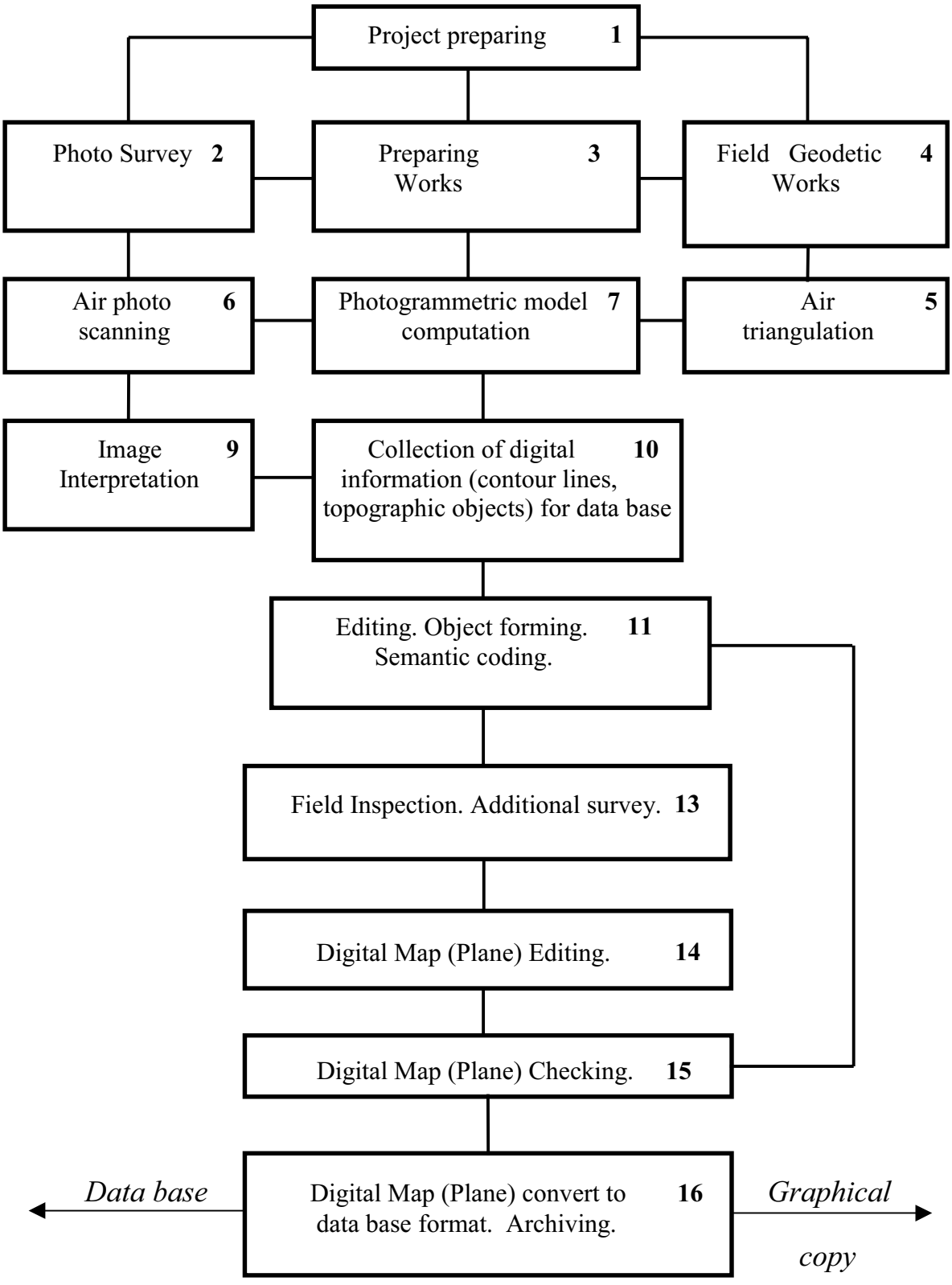

Fig. 1. Technological Block-Scheme of digital maps and planes production

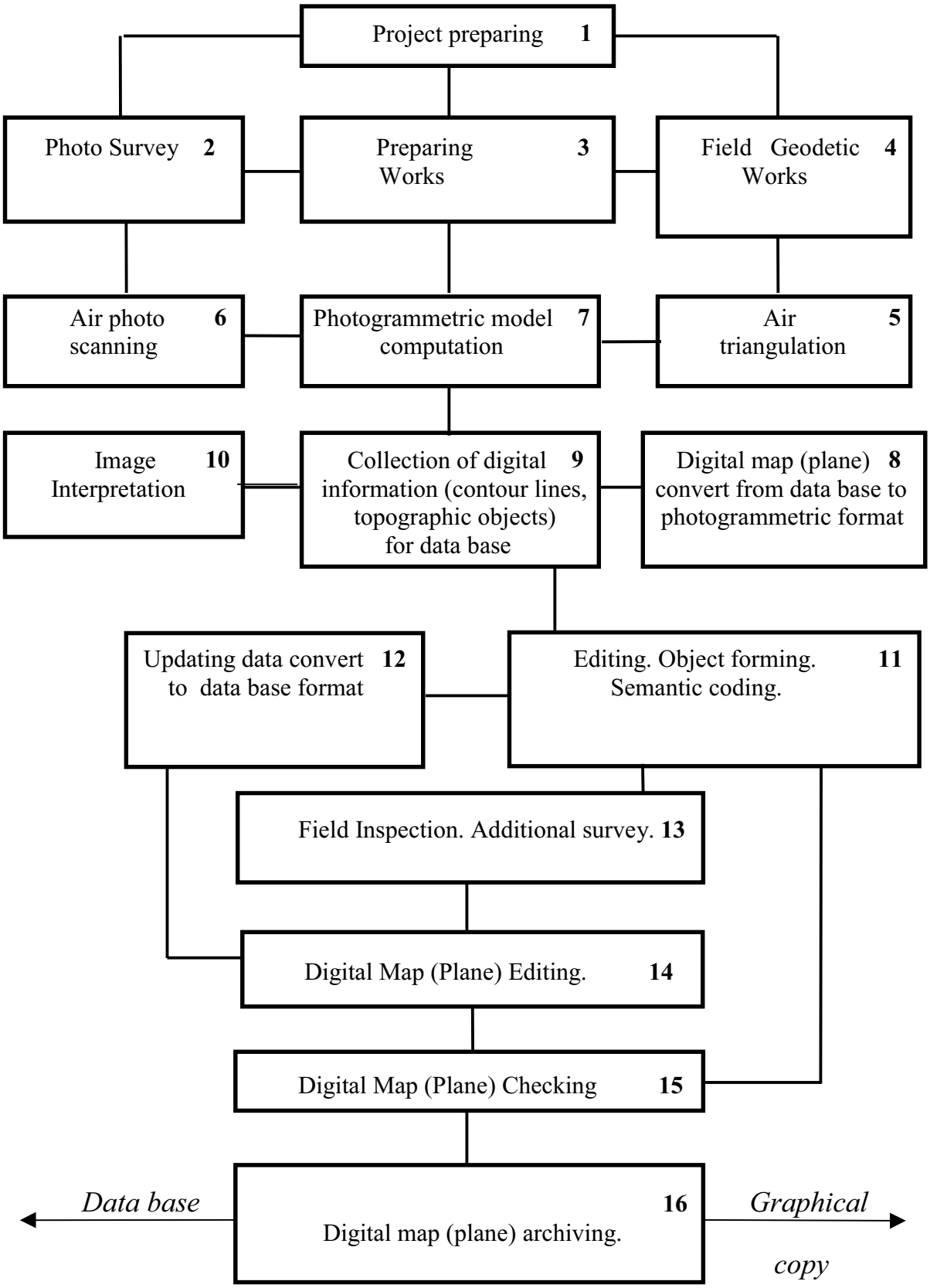

Fig. 2. Technological Block-Scheme of digital maps and planes updating