

DATABASE DRIVEN CARTOGRAPHIC VISUALIZATION OF VMAP DATABASE

A. Torun, A. Ulubay

Harita Genel Komutanlığı (General Command of Mapping), 06100 Cebeci, Ankara
atorun@hgk.mil.tr, aulubay@hgk.mil.tr

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ABSTRACT:

Spatial databases contain feature classes that represent real world. Content of geographic database is mainly designed for GIS analysis. However, a spatial database for cartographic visualization should contain some more rules and information for visualization. Cartographic visualization of a spatial database is usually in map format. Being expressed in this study, Joint Operations Graphics (JOG) is cartographic visualization of Vector Smart Map Level 1 (VMAP L-1) spatial database. JOG Air and Ground series at scale 1:250000 are used for joint operations of allied forces. VMAP L-1 is a spatial database with a content of middle scale maps such as JOGs at scale 1:250000. JOG Air and Ground series are used for planning of short and long distance flight, air-ground tactical operations, helicopter operations, tactical and close-air support, visual navigation, and air-ground coordinated operations and strategic/operational planning purposes by ground units and civil aviation. First and second editions of JOG series are produced by General Command of Mapping (GCM) - (Harita Genel Komutanlığı-HGK) - between 1971-1973 and 1983-1987 respectively. Vector Smart Map Level 1 (VMAP L-1) database is presently used for the production of third edition by means of database driven cartographic visualization methods. Visualization based on database driven cartography allows not only producing different types of cartographic products, but also maintaining consistency of data within database. In this paper, Digital Landscape Model (DLM) and Digital Cartographic Model (DCM) of JOG charts are given. The JOG production workflow comprising data preparation, data processing, visualization and reproduction, which are based on database driven cartography is expressed.

1. INTRODUCTION

JOG air series are used for planning of short and long distance flight, navigation, air-ground tactical operations, helicopter operations, tactical and close-air support, visual navigation. These sheets are used by not only military purposes but also for visual and low-level navigation of civil aviation. JOG Ground series are used for air-ground coordinated operations and strategic/operational planning purposes to complement the 1:50000 and 1:100 000 scale map series by ground units.

JOGs contain reference system and projection information in addition to built-up areas such as cities, towns, transportation network such as airports, roads, railroads, ferries, infrastructure such as power lines, pipelines and landmarks and other cultural features besides natural features.

JOG air series are the basic data source of other air charts used for long-distance and high altitude navigation such as Special Aeronautical Chart (SAC), Tactical Pilotage Chart (TPC), Operational Navigational Chart (ONC), Jet Navigation Chart (JNC) and Global Navigation Chart (GNC).

VMAP L-1 database conveys information on location and descriptive specifications of thematic features. New edition of JOGs of Turkey are produced by using VMAP L-1 database built by collecting data from scanned JOG sheets, other rasterized topographic maps, remotely sensed images and by extracting data from other databases such as contour lines, populated places etc. Schema of VMAP L-1 database is extended to construct Digital Landscape Model (DLM) of JOGs. This extension comprises new relations (coverages and/or tables) and new attributes in existing relations and

population of these new attributes. VMAP L-1 being the DLM is visualized as JOG by means of Digital Cartographic Model (DCM) for this product. The DCM is formed by combination of JOG specifications by General Command of Mapping (GCM) and National Geospatial-Intelligence Agency (NGA), symbolization rules, symbols and colour models. The VMAP L-1 database is visualized as a digital map by using formed DCM. ESRI PLTS/MPS software, running on ArcInfo is used for data processing and for producing and editing map layout elements. Some of pre-press works are done with support of Adobe Illustrator. Final map layout file is colour-separated and pressed as hardcopy map and rasterized as softcopy map.

In the second chapter visualization model of VMAP L-1 database as a JOG chart, short description of VMAP L-1 database are given. Workflow to visualize VMAP L-1 as a hardcopy and softcopy map and tools for map editing are expressed in chapter 3. Results and experiences are presented in the last chapter.

2. JOG AS A VISUALIZATION MODEL OF VMAP SPATIAL DATABASE

Cartographic maps as a model of geographic framework have been widely used for geographic analysis and visual interpretation. Maps reduce our worlds of enquiry into assimilable proportions and cast them into shapes from which we can derive information (Visvalingam 1994). Design of visualization model of a spatial database as a map is a critical aspect, if these maps are employed in critical mission such as military operations.

2.1 Conceptual View of VMAP Database for Visualization of JOG

Aircrew needs to know all kind of information about every phase of a mission, before they fly. Those information are weight and balance, weather conditions, performance figures, flight characteristics and navigation data. Aeronautical charts are one way of providing the navigational information to the pilot. Each different type of flying can require a different type of chart: high-altitude or low, visual (VFR) or instrumental (IFR) navigation, departure, cross-country or approaching for landing. Instrument Flight Rules (IFR) products are FLIP Enroute Charts. Visual Flight Rules (VFR) products used for visual flight are JNC at scale 1:2000000, ONC at scale 1:1000000, TPC at scale 1:500000, JOG Air at scale 1:250000, SAC at scale 1:500000 and at 1:250000 (DMS 2002). Visual flight refers to flight operations in fair weather, under VFR, where the pilot is able to see the ground well enough to navigate and to see and to avoid other aircraft.

Visual aeronautical charts, such as JOG Air, portray aeronautical data on a basemap of the charted area. This basemap includes the relief (mountains and valleys), drainage (streams and shorelines, and cultural (man made) features of the area, drawn and symbolized so that the pilot can easily spot the mapped landmarks and compare them to the features seen from the cockpit.

In JOG series, in addition to reference system and projection information, information about hydrography, populated places, transportation, physiography, relief, administrative boundaries, industry and utilities are presented. Relief is shown by means of contour, spot heights, elevation tints and shaded relief. Contours are generalized in JOGS. Elevation tints and relief shading help the pilot locate the main ridges and valleys in JOG air. Streams and roads are portrayed for their landmark value. Drainage is extremely detailed. Vegetation is symbolized in all areas.

There are some differences between ground and air series due to their functionality. In air charts, other than ground maps, information about Maximum Elevation Figures (MEF) in every 15'x15' graticules, magnetic isogons, aerodromes, heliports, radio navigation aids, vertical obstructions, power lines and air-defence identification zones (ADIZ) are portrayed in the first order of visual hierarchy with respect to other feature types. Height information is expressed in meters in ground version and in air version they are marked in feet for pilots.

Accuracy of JOGs are in category 2 standards of NATO. Horizontal and vertical accuracies of JOGs are 125 meters and 50 (half the contour interval) meters respectively (NGA 19951, NGA 1995-2).

2.2 Data sources of JOG maps (Extended VMAP L-1 database)

Geographic extent of VMAP L-1 database is global. Data is continuous and seamless. VMAP database is a vector-based product implemented in VPF. Each layer contains thematically consistent data. The VMAP thematic layers are organized into ESRI ArcInfo coverages contained in VPF (Vector Product Format) libraries. VPF is a subset of DIGEST (Digital Geographic Information Exchange Standard) FACC (feature attribute Coding Catalogue) (NGA, 1995-1, Ohlhof, et.al. 2000).

VMAP family of databases is used to extract digital geographic information, to produce analogue and digital maps for military purposes. In Table 1, types of VMAP products, their scale and date of availability are given (Ohlhof et.al., 2000). Data source of VMAP L-1 is JOG series which has a density of detail of medium scale maps in NATO Standardization Agreements (STANAG). This product is designed to support GIS applications with geographic data at medium resolution. Based on this collection density, the scale of hard-copy product is 1:250 000. According to this compatibility, VMAP L-1 is a model of small world containing the phenomenon such as boundaries, data quality, elevation, hydrography, industry, physiography, population, transportation, utilities, and vegetation as separate ten feature classes in medium scale maps (NGA 1995-2). Feature class is a group of features sharing a homogenous set of attributes. There are five feature class types in VMAP L-1 namely point, node, line, area and text. Rules and minimum size of features collected from source materials are defined in NGA 1995-1.

Table 1. VMAP databases and maps produced from these databases

Product Name	Paper Product Scale	Availability
VMAP L0	1:1000000	Digital Chart of the World (DCW-2001)
VMAP L1	1:250000	2004
VMAP L2	1:50000	On demand
Urban VMAP	City Map	On demand

Being produced by several NATO countries as a co-production, the VMAP L1 database is going to be finalized in 2004. VMAP L-1 database is generated by collecting data from scanned JOG sheets, rasterized topographic maps, thematic maps, remotely sensed images, contour lines in digital format and sources from other databases. Graphic data –geometric models of features- is mainly extracted from panchromatic mono SPOT images with 10 meters pixel size. However stereo images are used in case of uncertainty in image interpretation as a control of data collection. Thematic information is collected from JOGs and large scale topo-maps. And, aeronautical information is taken from AAFIF, DVOF and documents for aero-navigation of State Airport Authority (SAA) and Turkish Air Force (TAF). AAFIF (Automated Air Facility Information File) contains information about physical characteristics of airfields and DVOF (Digital Vertical Obstruction File) comprises a list of man-made vertical obstructions such as towers, buildings, radio masts and power lines. Toponymy are collected from topo-maps, former JOG editions, PPDB_T (Populated Places Database of Turkey) which stores information about populated places, their population and location.

2.3 Production of JOG Series by Using VMAP L-1 Database

Former editions of JOG series (firs edition 1971-1973 and second edition 1983-1987) are produced by means of cartographic generalization of topographic maps at scale 1:100000 which are extracted from base topographic maps at scale 1:25000 and addition of aero-information. Vector Smart Map Level 1 (VMAP L-1) database is presently used production of air and ground series of third edition. The source of VMAP L-1 is the basic data of JOG series, density of which is appropriate for density defined for middle-scale. This

compatibility enables to use VMAP L-1 for JOG production. JOGs are used as a basic data source for other air and topographic maps at smaller scales.

The third edition of JOG series are produced by means of database driven cartographic visualization methods. Visualization based on database driven cartography allows not only produce to different types of cartographic products, but also maintains consistency of data within database.

Visualization is done in a semi-automated manner such that;

- some of the processes are done by computer,
- some are firstly done by computer than edited by cartographer,
- some are done interactively by cartographers.

Because of diversity of information on JOGs, the cartographers in JOG production are trained on aeronautical cartography. The training is provided by Mobile Training Team of Defence Mapping School of NGA. Computer skills of cartographers on the software for map production work flow are enhanced several times before and during the period of process.

2.4 Digital Terrain Model and Digital Cartographic Model for JOG

Digital Landscape Model (DLM) consists of data model, data dictionary, rules, condition, constraints and relationships (Kraak and Ormeling 1996). DLM is a subset of conceptual schema of VMAP L-1 database. However, this schema is extended with necessary dimensions (attributes) for the need of cartographic visualization. In addition to extended VMAP L-1 database, aeronautical information, magnetic and normal magnetic models, digital depth model of the seas surrounding Turkey and Populated Places Database of Turkey (PPDB_T) are the data content supporting JOG.

Data dictionary and rules for data collection are strictly defined in MIL-J-80100 (DMA) of NGA (NGA 1995-2). The feature classes and features are coded by means of DIGEST FACC of NATO.

The content, accuracy, density and symbolization rules of spatial/non-spatial data are defined in Digital Cartographic Model (DCM) (Kraak and Ormeling 1996). DCM is implemented in the conceptual model of extended VMAP L1 database for visualizing JOG. The rules and knowledge are stored in a logical model of extended VMAP L1 database. The DCM is constructed by combination of former editions of JOGs by GCM, JOG specifications by GCM and NGA, STANAGs, symbolization rules and rules defined in ESRI PLTS/MPS. Previous editions of JOGs, JOG specifications and STANAGs are used for generating and compiling surrounding information and graphics (NGA 1995-2, NGA 1995-3, STANAG-3675 2000).

There are two main approaches to construct spatial databases for cartographic visualization. First one is preparing a database for cartographic use only. The database is transferred into a visual model by means of batch or manual editing processes and adding cartographic features prepared for certain type of maps. The second approach enables the user to generate multiple views of the database based on a DCM. This method is more generic and flexible providing definition of map composition, colours, symbols, representation rules, sequence of processes

etc (Frye, C. et.al, 2003). Integrity and visualization rules of DCM are introduced in rule-bases. And, constraints are modelled as processes in the software. Definitions expressed in knowledge base are utilized as a process during implementation. All the map elements except data frame (basemap) are encapsulated in data and map processing functions. Map elements are located due to product type (air/ground) and size of graphic elements created based on information for each map. Therefore, the user doesn't need to re-arrange them. The tools and models customized and extended MPS software are employed producing cartographic visualization of VMAP L1 database.

However, the DCM of the software used is based on FACS of NGA. The database schema is extended for cartographic visualization with necessary attributes. These attribute values are calculated and populated as a function of other attribute values in the same feature class for visualization model.

3. APPLICATION

Visualization of VMAP database is done by enriching the visualization model of ESRI PLTS/MPS in two ways: first customizing the open source tools for the needs and national mapping requirements in the frame of NATO STANAGs; second, generating new tools and methods. The visualization system, analogue map production workflow, data content, visualization model and brief explanation of implementation are expressed in this chapter.

3.1 Workflow of JOG Production

Digital JOG production workflow from VMAP L-1 database is given in Figure 1. Firstly, data with extent of a sheet are cut and extracted from VMAP L-1 data library. Errors due to cut are corrected and data is transformed into UTM projection from geographic coordinates. Then, descriptive information of the sheet such as name of the sheet, country, vertical unit, producing company, copyright etc. are defined for a project

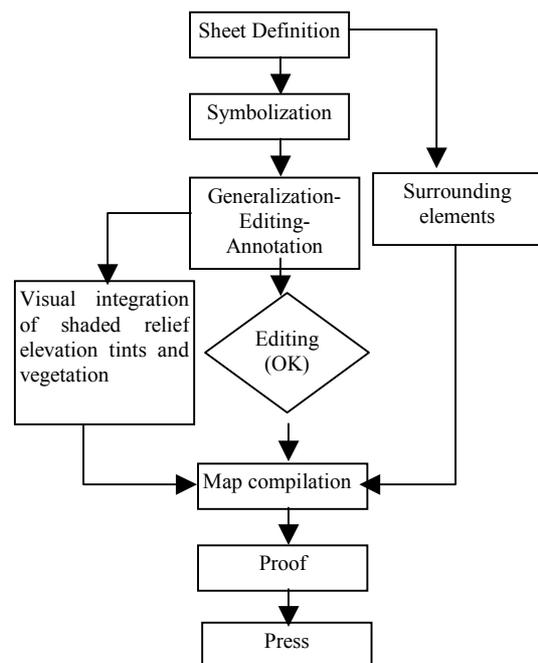


Figure 1. Workflow for Analogue JOG production

space for the sheet. Since DLM required by MPS is not equivalent to data model of VMAP L-1, the database schema of VMAP L-1 is adapted to make it an input to the software. Data is symbolized regarding DCM. Model errors, cases contrary to DCM and incompleteness in database schema are determined and removed to finalize editing on database.

As graphic detail and density of data in VMAP L-1 is more than the geometric and thematic content of JOG series, cartographic generalization is necessary to visualize the data as JOG. In order to improve graphic readability and produce a map according to JOG specifications, VMAP L-1 data is generalized by using conceptual and particularly cartographic (graphic) generalization operations such as simplification, exaggeration, replacement, classification, and aggregation.

Initially both ED50 and WGS84 datum information has been shown on the sheets by means of depicting ED50 grid as a secondary grid with tick marks along the border of sheet. In order to prevent the confusion of reference information, it has been provided a coordinate conversion note between datum ED50 and WGS84 in the marginalia (surrounding elements). Datum transformation information for each JOG sheet among ED50 and WGS84 are provided by Geodesy Department (GCM). And magnetic declination at epoch 2000 which are calculated from magnetic observations done on field by Geodesy Department of GCM.

Contour intervals are determined due to the steepness of the region and availability of contour. Selected standard contour intervals for index contours are [100-500-1000-1500-2000 ...], contours not in standard interval are [40-200-400-600-800-1000 ...]. Visual air charts have a variety of terrain elevation cues, both for navigation and for alerting the pilot to danger. Contours and spot elevations give accurate values; elevation tints point out the highs and lows; shaded relief emphasizes every ridge and valley, helping the chart mimics the view out of the cockpit.

MEFs are calculated based on relief, and information about vertical obstacles from SAA, NGA, AirForce. MEFs give the disoriented or smoke-blinded pilot an instant target to climb out of trouble (NGA 1995-2, DMS 2002). MEFs are shown in each quadrangle bounded by the projection's lines of latitude and longitude (on JOGs 15-minute quadrangle). MEFs are based on the highest known feature in the quadrangle, including terrain (ridges, mountains, hilltops) and obstructions (trees, towers, buildings, antennas etc.). After transforming labels coded in ASCII into Turkish, the base map is formed. This process is done due to the graphic representation of Populated Places DB of Turkey (PPDB_T) (Torun, 2002). Names and other descriptive information are labelled due to typography model which is developed based on FACS feature code (Figure 2).

Control of data editing process is done by taking print-outputs of layer which are closely related to each other. Consistency of all thematic layers is maintained by checking cross-layer compatibility such as relief-hydrography, population-hydrography-vegetation and transportation-hydrography-physiography.

The map face (basemap) is created by using the tools regarding rules, constraints, definitions and models. The map face contains all the graphic and text information with reference. Different parameters and procedures are used for ground and air versions. Tools for visualizing VMAP L1 as a ground map are all implemented by our team by obeying the structure of MPS

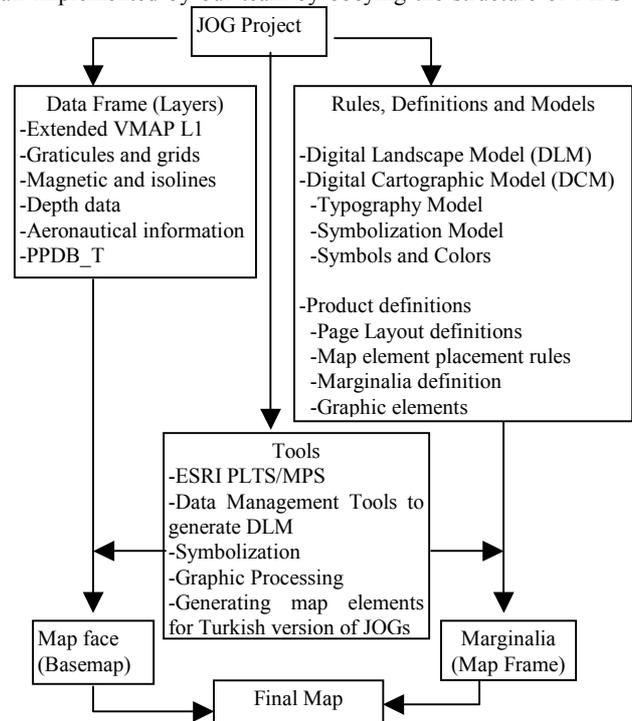


Figure 2. Process Model of Cartographic Visualization

software. The sequence of visualization is area, line, point and labels. If the lines are visualized with case, those are visualized with respect to defined rules which yields cartographic aesthetic. These tools are running with the core software in a friendly manner.

After graphic operations, surrounding information (marginalia) are created. These are descriptive information about sheet, symbol legend, aeronautical symbol legend, location diagram, conversion table for units, referencing information about military grid, bar scale, diagram for horizontal and vertical reliability, colours of elevation tints, glossary, caution and disclaimer notes, georef index, copyright and producer notes. Location Diagram is a graphic element depicting location of a sheet on a reference map and neighbouring sheets and the charts containing this particular JOG at lower scales. In Figure 3, Location Diagram created by using a customized tool with descriptive text. Graphic and surrounding graphics are compiled to generate Postscript graphic file for reproduction. The compilation is employed according to rule base for compilation for different cartographic visualizations; such as air or ground chart, Turkish or English as primary language etc. Almost all of the rules, models and definitions in DCM of MPS for map layout and marginalia are customized due to specifications of GCM. The tools creating graphic elements in marginalia are all re-designed, implemented and embedded in MPS software.

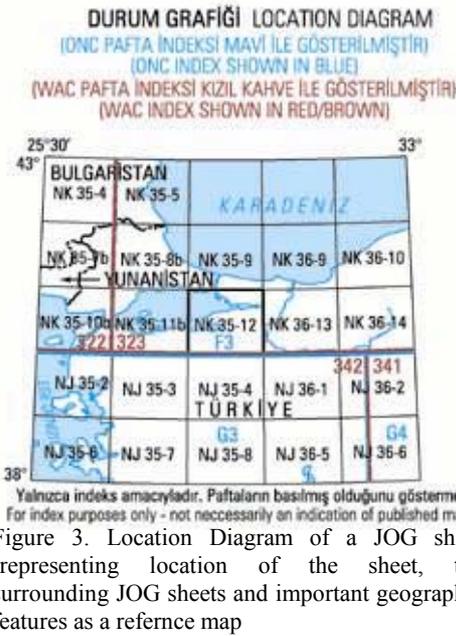


Figure 3. Location Diagram of a JOG sheet (representing location of the sheet, the surrounding JOG sheets and important geographic features as a reference map)

ESRI ArcInfo is originally a GIS software which is weak in colour separation and graphic processes. These disabilities in pre-press and pressing with process colours (CMYK) are solved with support of Adobe Illustrator software which is designed for graphic processing. Overlapping polygon layers such as shaded relief, elevation tints and vegetation hide the layers underneath within abilities of ArcInfo. However, Illustrator enabled to compile those three layers without loss and hiding. As pressing system of GCM is based on process colours (4 colours-CMYK), the postscript graphic file is colour separated into CMYK and plotted on films by using Dolev 800 laser film plotter. The films are developed automatically and plotted on plates for reproduction in 4 colour Heidelberg pressing system.

3.2 Using PLTS/MPS Software for JOG Production of Turkey

MPS provides tools necessary for data processing and tools to produce and edit map layout elements such as location diagram, GEOREF guide, glossary, scale bar and so forth. MPS also includes tools to generate the sophisticated graticule and grids required for the JOG A product. WYSIWYG editing tools are included to cartographically modify both the database and graphic layout elements. Templates are provided for the different legends and notes, reliability diagram and conversion graph. Each of these can be customized to the individual requirements and editors. All symbology and map elements meet NGA's current JOG Air specifications. The final map layout can be colour separated using custom tools provided in MPS and the resulting PostScript files can be used to generate film negatives of TIFF files (ESRI 2000).

The process model of a cartographic visualization of JOGs is given in Figure 2. The model consists of three basic elements namely data frame, tools and rules, definitions and models. The data frame is a combination of extended VMAP L-1 in which cartographic attributes are populated and other data sources such as military grids and graticules, magnetic isolines, depth data around Turkey at seas, aeronautical information in Turkey and abroad and information about populated places. Being an



Figure 4. Aeronautical information for attention of pilot

indispensable graphic element of marginalia, caution information depicted in Figure 4 are drawing attention of pilots to them that are created in both Turkish and English. There are tools for data management, cartographic editing, symbolization and graphic processing. Most of the tools are provided in MPS. However, there are some tools customized in the software and some new tools implemented and added to the system. The rules, definitions and models are based on specifications of GCM, NGA and NATO STANAGs.

Since MPS is produced for the requirements of NGA, it does not provide handy and direct solutions for the other countries other than USA. The JOG production of GCM differs than NGA, thus MPS is corrected, changed, customized, adapted and some new modules are added to MPS based on demands of GCM.

Feature requirements are stated in terms of NGA's FACS, to maintain consistency between various production methods. However the software transforms NGA FACS to NATO-FACC. NATO, DIGEST-FACC is the approved coding standard for the exchange of digital geographic data.

Some of the customizations on MPS are as follows; adding rules due to the features in territory of Turkey to the rule base of DCM, representing two grid networks in different datum on a single sheet, defining rules, visualization model and symbols for JOG Ground series, generating bilingual (Turkish and English) surrounding elements (Figure 5).



Figure 5. Cartographic visualization of VMAP L-1 database based on JOG specifications (this graphic is used for production of analogue map)

4. CONCLUSION

The JOG series produced by GCM are analyzed by comparing the maps with each other within the same edition and with other editions with respect to specifications. The differences are determined within each other and deviations among the specifications. The new data sources, availability of current data such as remotely sensed images and new technologies in visualization software are considered in design of visualization model for VMAP L1 database. Thus, the new series of JOGs have difference from previous reproductions according to new requirements and needs of current users. The third series of JOGs of Turkey are being produced based on database driven cartographic visualization methods. Territory of Turkey is covered with 66 JOGs, 29 of which are going to be accomplished by 2004 and the rest will be produced in close future. The JOG production system of Turkey is designed and implemented on top of PLTS/MPS software by ESRI. This system enables the producer to generate different views of VMAP L-1 database by means of a different DCM. After producing the JOG series, the topographic maps series of 1404 at scale 1:500 000 are planned to be produced.

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