GIS «THE SOLAR SYSTEM PLANETS»
CASE STUDY OF THE ARCGIS PLANET DATA MODEL

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Abstract

The success of extraterrestrial territories exploration depends on not only launched missions and gathered data, but also on data processing and representation. Principles and methodology are discussed for GIS "The Solar System Planets" development. Actual works on the of Planets study field emphasize on just Data Base building. GIS "The Solar System Planets" allows integrating available information about planets and celestial bodies from different sources into powerful planetary database (Venus DB, Mars DB, etc.) with effective tools of spatial analyze and representation. The GIS in this case study was based on the data structure from "Atlas of the Terrestrial Planets and their Moons". The cartography-oriented approach in planetary data visualization makes this GIS useful for all kind of users: from experts to students.

GIS "Solar System Planets" is developed by researchers from Moscow State University of Geodesy and Cartography (MIIGAiK), who worked on the data model since 2003 and resulted in the first major draft of the Planetary Data Model (PDM). The PDM can be usefully for the cartography community because firstly it provides an example of application-specific spatial database structure for assembling, managing, storing and querying planetary data, secondly – it can work as template to meet the needs of a specific community of users, and finally it provides a better understanding of ESRI's new spatial database data structure.

At first stage GIS was tested on the example of the some planets to determine its adaptability in working with real data and performing analyses, as well as identify its strengths and weaknesses.

Next tasks are solved during the project realization:

- Data modeling and spatial database structure development.
- New mapping and updating of present data.
- GIS "Solar System Planets" development.
- WEB resource organization.

Originality of the objects (Planets) for GIS analyze and presentation further to new technologies of spatial modeling are made the subject of Planetary Cartography more familiar to anyone, not only for cartography community. This GIS will be supplied with Multilingual Gazetteer.

The successes on the studying extraterrestrial territories have resulted in reception of the large massive of the unique information about Solar system bodies. Period from 1989 on the present time is defined as newest in the history of planetary cartography, since after the long pause new missions have been launched to the objects of Solar System. Space remote sensing surveys occupied and they continue to occupy a significant place in the mission programs. The development of planetary cartography during this period can be indicated by several basic trends: (1) the missions' data processing with the use of the newest technologies, (2) creation of different cartographic works on their basis, (3) the development of mathematical basis for the bodies of substantially non spherical form.

Foundation of the Planetary Cartography Commission in the framework of International Cartographic Association (ICA) contributed to the realization of international cartographic projects and to use the planetary cartography achievements for the extraterrestrial territories geography. Space surveys of Venus on the Magellan project, Mars on Mars Global Surveyor, Mars Odyssey projects, the Moon on Clementine project, Galilean satellites of Jupiter on Galileo project, and also asteroids and comet of Halley explorations made it possible to create a number of unique cartographic works. The works on creating of the multilingual maps series of planets and their satellites, compiling of glossary on planetary cartography, and GIS developing are conducted under the aegis of ICA.

Researches from the Planetary Cartography Laboratory of Moscow State University for Geodesy and Cartography are carrying out works on the GIS for planetary cartography «The Solar system Planets» development [4]. GIS is based on the structure of the "Atlas of the Terrestrial Planets and their Moons" published in 1992 in Russia [1]. For the first time cartographic materials were represented in the atlas in the comparative-planetological aspect.

In the world there are some examples of planetary data storage system and database (DB) development. In Planetary Data System (PDS) DB describing different parameters of Solar system objects has to be the basic part of the System [6]. Today PDS became very complicate and unconvinient for every day use because of enormous volume of information in a lot of planetary science fields.

The project of creation the spatial DB for planetary cartography is intended for filling of information gaps in cartographical study of Solar system bodies. The access to the data is planned to use of GIS-technologies, which provides integration of the diverse information. There are some tasks:

- Development of the DB concept;
- Development of the DB structure (ordering of the all saved information on planets cartographical field);

-        Creation of electronic maps (input the data, their updating, geometrical transformations, check the data for completeness and quality, development of the conventional signs library and electronic catalogue);

-        Creation of the GIS of separate objects of Solar system ("Venus", "Mars" etc.): development of the inquiries system, system of navigation inside the separate project;

-        Creation of the GIS «The Solar system Planets» (development of the inquiries system, navigation system between the separate projects);

-        Creation of an information cartographical Internet-resource for organization of access to the spatial data on the basis of GIS-technologies.

The development of principles of DB building is one of the first tasks. The system approach in the structure DB development is necessary which allow considering all variety of the cartographical information. Mapping of the Solar system bodies essentially differs from traditional (terrestrial) cartography because of a number of specific features of the objects. Therefore classification of cartographical products should be carried out for each planet and body features. At the same time, for obtaining information of Solar system bodies without changes in time and spatial resolution, it is possible to use general classification of the maps of extraterrestrial territories constructed on traditional principles and reflecting such parameters as the contents and purpose of maps, scales, scope of territory. Such classification used for the Moon is represented below (Fig. 1) [2].
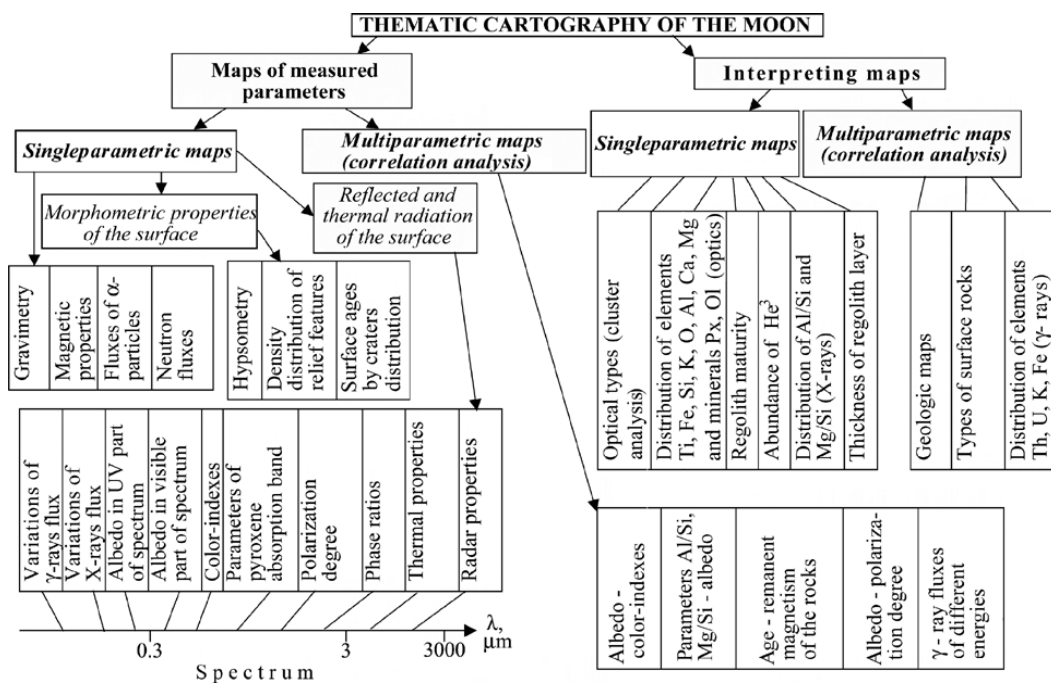

Fig. 1. The scheme representing the modern lunar thematic mapping.

The purpose of cartographical classification - grouping of maps on the basis of the accepted model, maps inventory, and also realization of search and metadata maps receiving. Nowadays the role of knowledgeable maps is not only for inventory and cartographical modeling, but also on their basis could be filled gaps in the digital spatial data. Besides the traditional approaches to classification which is mentioned above, it is necessary to take into account conditions, characteristic for digital environment of creation and maps applications [3]:

- Models of the spatial data.
- Properties and functionalities of program environments;
- Design: the cartographical and graphic interface;
- Structure organization of the information.

The basic principles of classification and spatial data organization were used as a basis of developed database structure of GIS «The Solar system Planets». Due to special models of the data and various methods of the analysis GIS «The Solar system Planets» is intended not only for mapping of the planets, but also for the analysis tasks (choice of landing sites for new missions, data processing of remote sensing etc.). Prospective volume and structure of the data is rather significant, as it will include thematic maps, relief models of planets, illustrations, and extensive support data and help items.
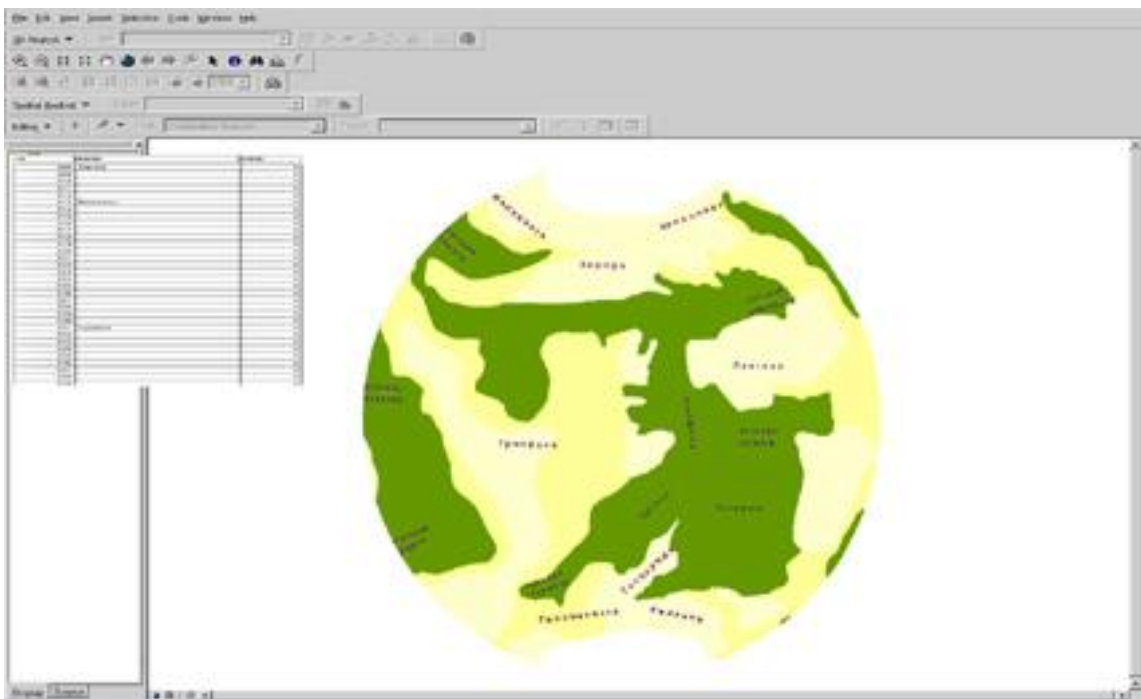

Fig. 2. Thematic mapping within ArcGIS. The map of Mercury Albedo

Detailed processing of this information needs the software with a high level functionality (support of various models of the data, performance of operations of the spatial analysis advanced means of registration, access to the diverse information). The new line of software from ESRI - ArcGIS satisfies to these requirements. On the ArcGIS basis is possible to carry out a complex data processing within the unified technology. Full-function ArcGIS 8.3/9.0 and additional modules (ArcGIS Spatial Analyst, ArcGIS 3D Analyst, ArcGIS Geostatistical Analyst) is effectively used for the mapping and GIS development (Fig. 2).

There is a lot of successfully industry-specific data models build on base the ArcGIS platform with the ESRI vision [7]. Basic goals are to simplify the process of implementing projects, and to promote and support standards that exist in user communities. In the geodatabase, all objects represent a real planet features such as craters, and are stored in a row in a relational database table. Object classes are not represented geographically; however, they can be related to spatial information through a relationship class. Conversely, all of the features in a geodatabase are geographic objects that have a defined spatial location. Basically, a feature is just like an object but it also has a geometry or shape column in its relational database table. The hierarchical data structure of the geodatabase (Fig. 3) allows the feature classes to inherit all of the attributes and behaviors of the object, but retain the spatial capabilities [8].
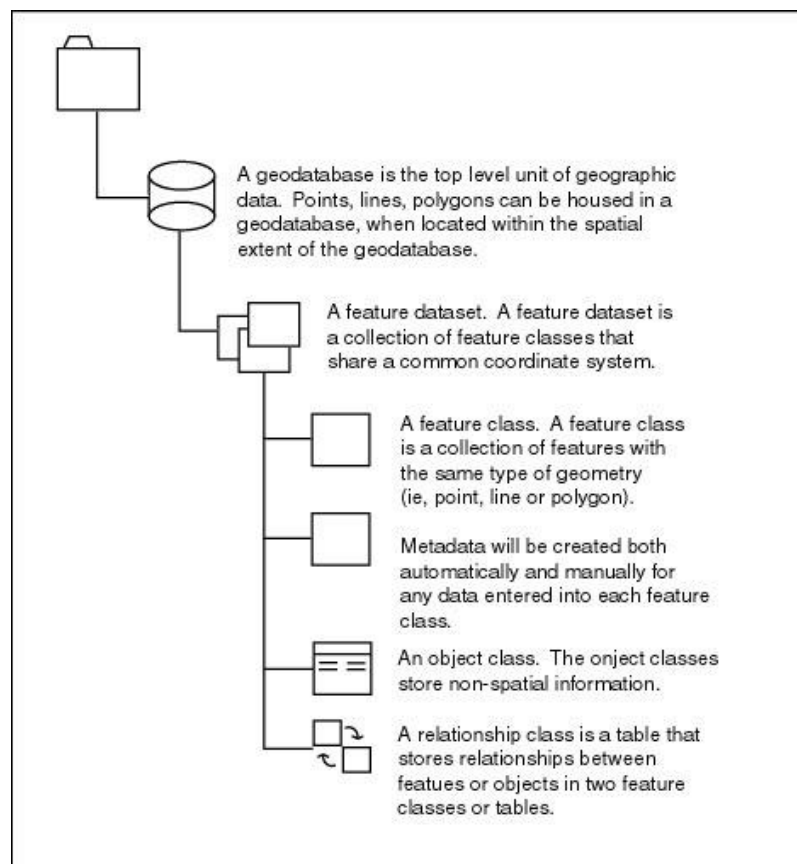

A geodatabase is the top level unit of geographic data. Points, lines, polygons can be housed in a geodatabase, when located within the spatial extent of the geodatabase.

A feature dataset. A feature dataset is a collection of feature classes that share a common coordinate system.

A feature class. A feature class is a collection of features with the same type of geometry (ie, point, line or polygon).

Metadata will be created both automatically and manually for any data entered into each feature class.

An object class. The onject classes store non-spatial information.

A relationship class is a table that stores relationships between features or objects in two feature classes or tables.

Fig. 3. The organizational schema of the ESRI geodatabase.

Our study of the ArcGIS new geodatabase is caused by the need to link information about the planets of the Terrestrial group from many sources. For integrating spatial information we developed Planet Cartography Data Model (PDM). The PDM is a data model designed specifically for the planet cartography specialists to provide a better understanding of ESRI's geodatabase data structure. In the PDM the feature data sets and classes cover a very broad range of thematic maps applications.
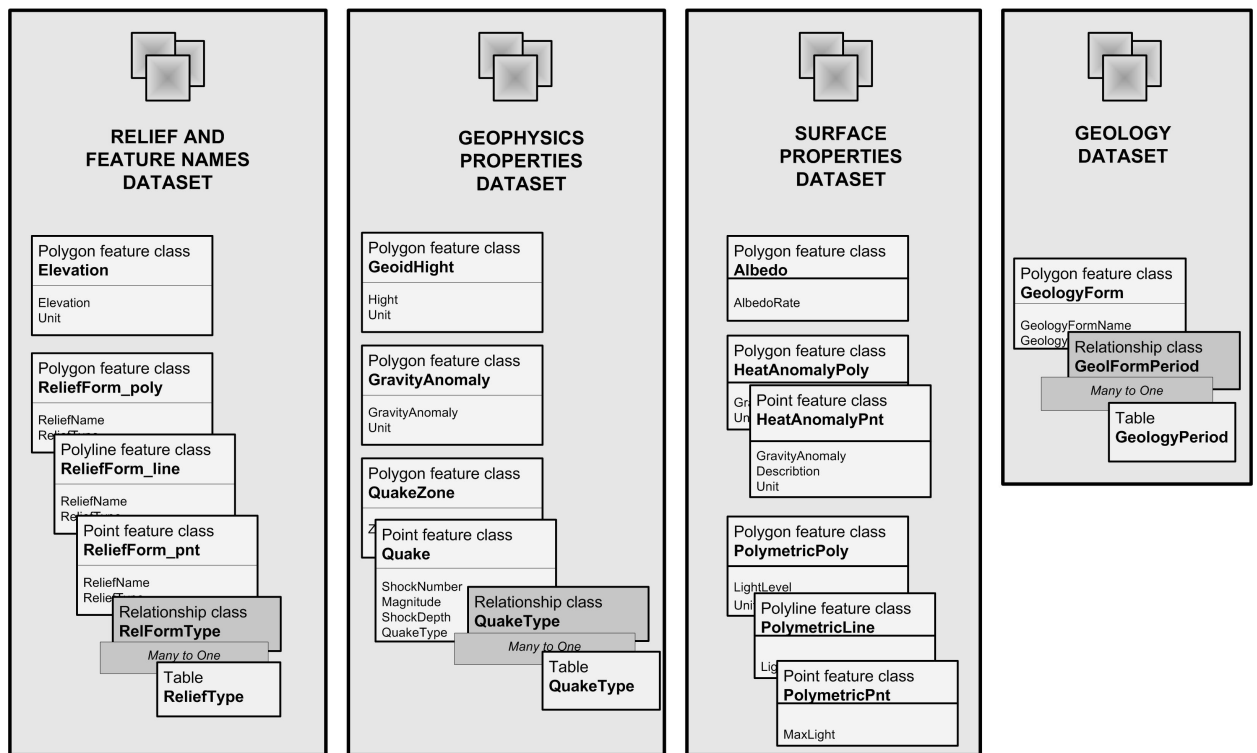

Fig. 4. The structure of the Lunar personal geodatabase.

At first stage there were analyzed data structure from "Atlas of the Terrestrial Planets and their Moons" [1]**.** In the Atlas every planet or body is represented by the same set of characteristics (geology features, geophysics properties, and etc.) in small scales series maps. The Moon is represented by the fullest number of characteristics, therefore, it was chosen as a base object for planetary database modeling.

Planetary Data Model is built with an easy-to-use Table Designer in ArcCatalog (ArcGIS). Initially database consisted of four spatial dataset: (1) Relief & Feature Names, (2) Geology, (3) Geophysics, and (4) Surface Properties. Feature classes structure will be developed for each dataset. Some characteristics of planets were supplemented with non-spatial index tables, related to the proper feature class by means of relationship class. All tables have a key field, on which the user to query related information throughout the tables.

Next stage of our research was concerned to the problem of the import existing data to the PDM. Digitizing and processing of the Atlas data were made within educational program by the university students. During this process students receive a great experience of working with different GIS software (ArcView, MapInfo, GeoDraw) therefore planetary feature class tables were saved in several formats and with different spatial extent. A feature data set is a collection of feature classes that share a common spatial reference. The spatial reference is part of the definition of the geometry field in the database. Before any data were added to the geodatabase, the spatial extent and the projection of the feature classes were established, a Planet dataset stored in the Geographic Coordinate Systems for Planets and small bodies of Solar System, supported in ArcGIS (Fig 5.) with difference parameters for each objects.
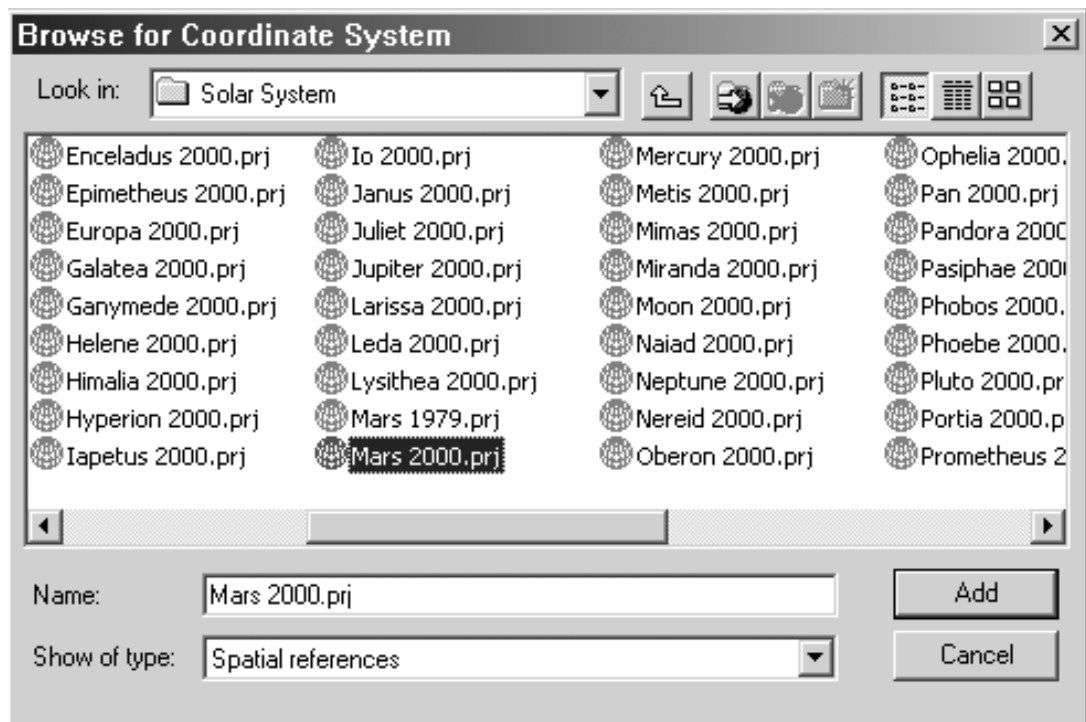

Fig 5. Choice for Coordinate System in ArcGIS (ArcToolbox)

With help of the Extract Data wizard in ArcCatalog all data will be integrating to the PDM. PDM will be personalized to fit the data analysis of separate space bodies. To personalize the PDM numerous field names and tables will be added to the geodatabase. The added tables will be PlanetInfo, PlanetSurvey, which are specific to each Planet (i.e., MarsInfo, VenusSurvey, ect). These tables further describe the SurveyPoint and SurveyArea feature class by providing information like survey dates, names of space missions, types of the space vehicle, countries conducted the survey, and which results were used for planetary mapping. For better utilization of planetary data information by experts and users there were used ArcGIS metadata tool given a short overview of each data set, and the data set source.

Planetary characteristics information can be intersect between each other and resulted in new information. Datasets, when combined together, can generate almost unexpected combinations of new layers. In that case interesting results can be obtained from data joining from different personal databases. For example, it is interesting to compare the value of albedo on the Moon and Mars interactively with using overlay tool or by queries. Besides, the need and desire to share data between and within organizations is also increasing. In response to these needs, the PDM geodatabase will provide a structure for assembling, managing, storing and querying planetary data in ArcGIS. This means that:

- Data can be stored and managed in one central database;
- Information compiled from various data types/formats into the geodatabase format which is easily shared and exchanged between research groups.

The geodatabase template is designed to meet the specific needs of the planet cartography community through the creation of feature classes and tables tailored to specific types of planet cartography data. The geodatabase provides a mechanism for the implementation of data content standards, in the form of metadata templates. The ArcGIS data model also supports existing data standards, to help simplify the integration of data at various levels of detail (small or large scales).

Finally, the authors express gratitude to the president of the company ESRI Jack Dangermond, with assistance of which to the employees of Laboratory of planetary cartography the opportunity of use of the software ArcGIS for scientific researches is given within the framework of realization of the submitted concept.

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