"CARTOGRAPHIC KNOWLEDGE GAINED BY RURAL AND URBAN CHILDREN OF SRI LANKA THROUGH FORMAL AND NON-FORMAL EDUCATION"

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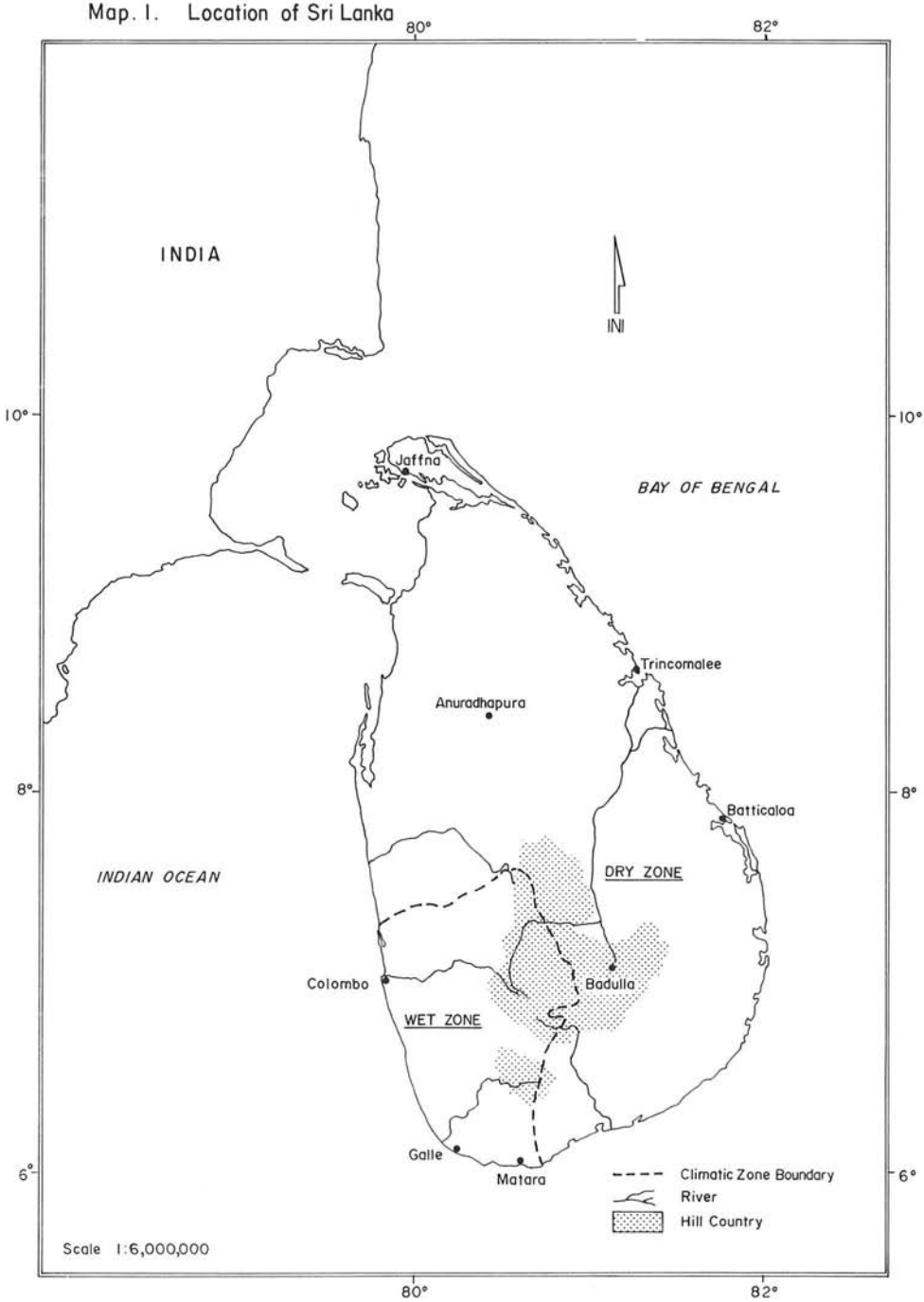
Sri Lanka is an island situated in the Indian Ocean to the west of Bay of Bengal. It is seperated from the Indian peninsula by a strip of sea about 22 miles wide. Land extent of the island is 25,332 sq. mls. The topography of the island is such that the highland is situated in the middle surrounded by a plain traversed by several rivers. This plain is divided into two sections viz. the wet-zone and the dry-zone on the basis of rainfall. The wet-zone comprises the southwest quadrant of the island and the rest of the plain is the dry-zone. (Map 1)

Population distribution of the island is not even; 60 per cent of population being concentrated in the wet-zone which covers only 23 per cent of the land area of the island. In fact, 75 per cent of the island's urban population resides in this zone. Of the nine districts (ie. Colombo, Gampaha, Kalutara, Galle, Matara, Ratnapura, Kegalle, Kandy, Nuwara Eliya) which comprise the wet-zone, Colombo district is the most urbanized. Leading state and international schools and also private schools with very good educational facilities (eg. well equipped libraries, laborataries) are located in this district. Colombo which was the capital city for nearly 175 years (upto 1982) and the primate city of the island boasts of the best urban facilities of the country. On the other hand, Badulla district situated nearly 100 miles east of Colombo has a majority of rural population viz. 92 per cent. For the entire district, there are seven urban centres. The rural population in the district can be categorized into two on the basis of accessibility to an urban centre viz. those who live close to an urban centre and those who do not. Those who live close to an urban centre enjoy the urban facilities thereof while those who live in so remote areas that urban centres are almost inaccessible, live in near isolation. Almost all the needs of the villagers are met within the village and communication with outside world is negligible. Whatever communication carried out is done by elders of the village mostly, thus confining the children to the village environment.

Map. I. Location of Sri Lanka



For the present study 75 children (12-16 years of age) studying in two leading schools and one international school in Colombo were selected randomly. As for the rural sector, 50 students were selected randomly from a school in the economically very backward Dambana where the aborigines of Sri Lanka live and two other schools situated 10 miles and 8 miles away respectively from the closest town of Mahiyangana.

Data collection for the study was carried out through formal and informal interviews, structured questionnaires and observation. In addition, the students were requested to draw maps based on environments familiar to them. For instance, the routes students take either to go to school, church or kovil (place of worship) were mapped. For urban students however, an additional method was used which was carried out on the basis of an oral questionnaire for which only the best students were chosen. This measure was taken to find out the highest level of Cartographic knowledge attained by the best students of leading schools in Colombo which can be considered an indication of the highest level of Cartographic knowledge among children in the island. The principals of the respective schools were forwarded a questionnaire which dealt mainly with details of educational facilities available and extra curricular activities carried out in the schools. Although it was intended to interview the teachers of Social Sciences (under which falls Geography) it was not possible because investigations in rural areas were carried out during a week-end when teachers were not available. It was planned to survey the male and female students seperately; however, this too was not possible as attendance of rural students was not as anticipated.

The findings of the survey are presented in the following paragraphs mainly on a comparative basis.

The knowledge of World Geography of rural students was somewhat imbalanced in a number of respects. Only 30 per cent of the students surveyed knew the spherical nature of the earth. It appears that majority of the rural children were not familiar with the concept of the "shape" of the earth. This was evident from some of the answers provided for the question on as to what a globe was. Some wrote that a globe is the earth, some wrote the globe to be all the names of countries in the world, some stated that globe is circular while some mentioned that globe is all what the world has. This hazy picture majority had in a way is to be expected given the background they come from and the poor educational facilities available in those schools. In fact, no material was available in their schools depicting the earth or the planetary system in three dimensional form for the children to grasp at least the idea unlike in urban areas where even television programmes are shown to students describing the plane tary system, the galaxies and so on. However, it was heartening to note that at least a few (8 per cent) of rural students knew the meaning of a globe as some went to the extent of describing a globe as a sphere on which all the continents, mountains and rivers are marked. On the other hand, more than 95 per cent of urban students' image of the earth was quite clear. One answer given states that a globe is a model of the earth on which features on the earth along with

the hypothetical lines are marked for the use of educational purposes. Through the word "model" it is obvious that the student is aware of the fact that the globe is constructed to a scale. However, the image some of the students of the international school had in this regard was surprising. A student who has been abroad nine times seem to be ignorant of what a globe is.

As for the knowledge of what an atlas was, majority of the rural students seem to be clueless on this. One student states that an atlas is a book where exercises in Cartography are given, another had written that an atlas is a book where world activities are depicted and yet another had stated that an atlas is the earth. In fact, of the rural students surveyed, only 14 per cent knew what an atlas was. This could be due to the fact that only one atlas was available for each rural school surveyed for the use of all the students. This fact was pronounced by principals of the respective schools. On the other hand, each student of urban schools owned an atlas and hence was quite aware of not only what an atlas was but also how and for what purposes it could be used.

Knowledge of terminology used in Cartography and the concept of scale were investigated among students for which they were requested to describe terms like the continent, ocean, sea, island, north pole, south pole, equator and the scale. It was discouraging to note that majority of rural students were ignorant of these terms except the term island which they had described correctly. In defining the term country, most of the students had defined it as Sri Lanka. Except for a few students who gave correct answers, others seem to have only a vague or wrong understanding of the meaning of these terms which is a clear indication of formal education being at a low ebb in the area. Scale which is a basic element in Cartography seems to be not clear to majority of rural students. It is quite possible that since they are not exposed to other environments, their image of the country (Sri Lanka) is limited and hence their notion of distance and area is hazy. In fact, of the students surveyed, more than 78 per cent had not even visited Colombo - the capital of the island for nearly 175 years. To the question on the most memorable feature seen on their longest journey in the country, some students' answers were the sea beach, sea waves, vehicles, the botanical gardens, the zoo and the ruins. On the other hand, the urban students' knowledge of terminology used in Cartography was much higher and much clearer. They not only knew the meaning of scale but also knew how to use it in various situations not only in relation to maps.

The knowledge of Geography of Sri Lanka was investigated with the aim of finding out if they could draw a map of Sri Lanka correctly showing given features. About 80 per cent of rural students knew the correct number of districts of the island. However, their knowledge of the respective locations on the map was low which is a clear indication of the low level of map use. It was disturbing to learn that, though few in number, some students from Dambana, an area of aborigines of Sri Lanka, did not know the name of the country in which they live. When a map of Sri Lanka was shown

too, some could not recognize it. As for the urban students, not only could more than 80 per cent of them give the number and names of provinces and districts but they could also give their correct locations on the map.

The ability of drawing maps was tested through various measures. First, students were requested to draw a map of Sri Lanka with certain given rivers and towns. The rural childrens' maps though somewhat 'crude' had the correct shape of the island.In two cases, the maps were drawn out of proportion; the northern area being too narrow and the south being too wide. It was however clear that they were knowledgeable of at least the shape of the island. In marking the north direction, some rural students had marked it with an arrow pointing towards the north while some had written the word north on the top of the map. In still another instance, one student had depicted the north by a dot and had written the word north by the side. This certainly is another indication of their being not familiar with finer details of maps. The manner in which towns and rivers were marked differed considerably among rural students. Some had written the names of towns and rivers without symbolizing them while some had symbolized towns and rivers both with the same symbol which fact indicates their poor knowledge of the importance of using different symbols for different features. It was heartening to know that some students wrote the names of rivers along the river courses while ofcourse some wrote the names of the rivers in such a way that a part of the name fell outside the outline of the map (ie. in the sea area). However, judging on an overall basis, drawing of a map and marking of features thereon by rural students was good. Secondly, the students were requested to draw on paper the routes they take to go to school, temple, kovil and so on, depicting the features they see on the way. Through this exercise it was intended to extract their knowledge of how to use symbols and colours in depicting various features familiar to them. Though symbols used by rural students were mostly pictorial in nature there were students who did select cartographically appropriate symbols. However, an ambiguous case was detected where three symbols presented in a `bunch' depicted just one feature. On enquiry it was found that the several symbols depicted the school, its gate, and teachers' quarters. Another interesting point was that in certain cases symbols used by rural students were arbitrary and had no relation whatsoever to the feature being depicted. For instance, a student had symbolized a boutique and a temple both by two flowers. A forest infested with elephants was depicted by `green coloured trees' dotted with `black coloured elephants'. Spatial distributions were thus symbolized on maps in their own way. It was encouraging to note that some students had attempted to map roads and footpaths through lines of different widths thus indicating their ability to express levels of importance of features on a map correctly. Wells were also classified and symbolized in a similar manner. On enquiring on this somewhat unusual capability of students, it was learnt that these students came from villages that are being developed through an institution which "uses" maps as a tool of promoting awareness of rural resources among villagers. The field officers concerned get the villagers to "draw" maps on the ground and using freely available material like leaves and flowers of trees depict features (roads, houses etc.) in

the village including the resource base of the village also. This practice has been carried out for the past four years in the area. Its healthy influence on the children has thus certainly nourished their knowledge of maps in an indirect manner. Discussions with the relevant officers of this institution reveal that children are better 'map makers' than their elders who have had relatively little exposure to maps. As for the colours used in maps, all the rural students had used green for vegetation and blue for water bodies. In the case of urban students, it was apparent that their maps were less detailed than those of rural students. Another distinguishing feature was that their maps showed features in large sizes unlike in the case of rural students. As a result their maps contained relatively less details. Although the rural and urban students were given the same sized paper - 83cmx58cm - for drawing the maps, the rural students were able to "squeeze in" much detail into it (not to scale) while the urban students found it difficult to do so (several complaints were made with regard to the size of the paper given for the purpose). This entire exercise gives an indication of their power of observation, memory capacity and also their ability to map them suitably on any area provided in relation to urban students. It is possible that details of the only environment rural students become familiar with throughout their lives have got firmly registered in their minds and thus are in a better footing than the urban students in this particular respect (a clear example of the result of non-formal education).

In the case of urban students, their varied activities, experiences and exposures have nourished their knowledge of Cartography which situation resulted in their drawing good maps. However, it was noted that a student from a leading school had mapped two rivers touching each other - a very basic element of Cartography being wrongly depicted. It should be stressed that maps drawn by urban students were neat and orderly.

The power of observation of students was tested through questions such as, as to what they remembered of the size of letters on maps, colours used to depict water bodies, contours, vegetation on maps. The rural as well as urban students did remember the relevant colours correctly. The memory of the size of letters on maps was poor in both rural and urban students.

The students' ability to read maps was tested through two diagrams - in the first diagram a symbolized cart track was drawn going over a symbolized water line and in the second instance, the cart track going under the water line. These diagrams were interpreted in various incorrect ways (except for one student) by rural students while all the urban students were able to interpret them correctly. The students' ability to select appropriate symbols for maps was tested by giving several symbols for the same feature and requesting them to select, in their opinion, the most suitable symbol to depict the particular feature; reasons for their choice was also to be given. It was encouraging to note that rural and urban students selected symbols appropriately based on good reasons.

It is opportune finally to present the background of the rural and urban students surveyed. Villages surveyed were remote from the urban centres; as such, their needs were almost met within the village. This situation has limited communication with `outside world' thereby `confining' children to the village. The survey revealed that only 22 per cent of rural students had visited Colombo city - an indication of their limited exposure to other parts of the island. In fact, nearly 25 per cent of students surveyed did not recognize the picture of a telephone - some recognized it as a clock probably because the digits were given in circular form. As for the economic background, all parents of rural students surveyed were farmers. Their low and fluctuating income did affect the childrens' education adversely. According to the school principals, there are students who keep off from school due mainly to economic reasons. Facilities in schools are limited. One school had only three maps and one atlas for the use of all the students (508 in number). The rugged paths in mountainous areas the students have to traverse in getting to school obviously make them exhausted on reaching the school and home on return. There are days when children cannot go to school for fear of elephants being on the way. On the other hand, students of urban areas had numerous opportunities to broaden their knowledge and also experience different cultural and physical environments. 95 per cent of the students surveyed had televisions at home, 90 per cent of them were members of libraries and using them regularly. Considerable number of students, specially from the international school, had been abroad and were exposed to different cultures too. Economically urban students did not encounter any financial problems whatsoever. 95 per cent of them travelled to school either by hired or private vehicles. Unlike rural students whose leisure time is spent on attending to house hold chores such as bringing water from wells and fetching firewood for the house, the urban student engaged in sports, listening to music, watching the television or reading books and the like during their leisure time. One salient feature among urban students was that they spent as much as Rs.7000.00 as tuition fees monthly whereas the rural children got help in studies either from the father, elder sister or brother.

LANDSCAPE CHANGES MAPPING BY APPLICATION OF AERIAL PHOTOGRAPHS

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Introduction

The repeated data acquisition on Earth's surface (temporal resolution), as well as further characteristics - the spatial, spectral and radiometric resolution, typical for the remote sensing data condition their increasing use also in the sphere of the basic georesearch.

Among the contemporary trends of application of this data two approaches dominate:

The first of them emphasizes the acquisition of information, often primary, on coverage of extensive territory of only one time horizon, for instance, the entire Europe, etc. The European Commission Project "CORINE Land Cover" is one example. The aim of the project is to create digital database of Europe's land cover at scale 1:100 000, by application of LANDSAT TM data (Heymann et al. 1994).

The second approach is connected with the application of multitemporal remote sensing data for acquisition and presenting (for instance by maps) of information on changes of landscape objects (Ihse 1987, 1995, Skanes, 1990, Feranec 1992, 1996).

The aim of the paper is to show the changes of rural, especially agricultural landscape in Slovakia identified and mapped by means of aerial B&W photographs and satellite images (space image maps as applied in the CORINE Land Cover Project - the 4th national level), on example of the western part of the Liptov Basin .

Work hypothesis

The changes of landscape objects in the most general sense represent a sequence of linked up states of these objects characterized by a particular time horizon through a set of physiognomic properties, functions and relations to their environs.

Objective picture of the landscape's state is provided by aerial photographs and satellite images of the chosen representative time horizons. Their analysis using the relevant attributes allows for the identification, location and causal explanation of the mentioned changes. A suitable object, by means of which it is possible to determine the landscape changes is land cover. It represents a materialized projection of the natural, spatial (morphopositional and bioenergetic) assets and simultaneously of the contemporary land use, i.e. spatial projection of the natural and by human society re-shaped (cultivated) or created (artificial) objects of landscape (Otahel, Feranec 1995).

Used methods

Information concerning the changes of landscape objects were obtained by interpretation of aerial B&W photographs of the years 1953 and 1973 (in approx. scale of 1:30 000, Figs. 1,2) and satellite image (space image map at scale 1:50 000 produces of the LANDSAT TM data 4., 5. and 3. of spectral bands by combination of red, green and blue colour with resampling to 10 m resolution, and SPOT PAN of 1992.

Photographs of 1953 show the landscape state before collectivization, photographs of 1973 show the state of the landscape after the collectivization, photographs of 1992 bring information on the most recent state, when the constructions of industrial development were finished and the transformation of agricultural farms as a part of the social and proprietary changes.

The visual photointerpretation (Fig. 3) was applied for obtaining information about land cover classes. For each temporal horizon one independent layer containing the corresponding land cover classes were identified.

The used land cover nomenclature contains 84 classes. It was proposed for the 4th national level as a part of the CORINE Land Cover Project for the Czech Republic, Hungary, Poland and the Slovak Republic (Feranec, Otahel, Pravda 1995), Tab. 1. Application of this nomenclature simultaneously represents an attempt at linking the interpretation results of the satellite images of CORINE Land Cover Project obtained at the national level at scale 1:50 000 (4th level), to the interpretation results of the aerial B&W photographs.

The schemes created by the visual interpretation were digitized, transformed and redrawn into topographic map at scale 1:50 000 in a Gauss-Krüger projection and analyzed in GIS SPANS and Topol software.

Evaluation of landscape changes was realized based in analysis and comparison:

- of the area changes of land cover classes identified for the quoted three temporal horizons (Tab. 2),
- occurrence frequency of the classes within the corresponding temporal horizons.

Analysis of changes (case study of western part of tha Liptov Basin)

Analysis of landscape changes is demonstrated on example of the western part of the Liptov Basin between the towns Ružomberok and Liptovský Mikuláš. Fig. 4 and Tab. 2 bring the areas and frequency of occurrence of the land cover classes in chosen intervals of time. The quoted characteristics provide an exact evidence of significant changes. Agricultural land prevails in study area. It was submitted to greatest changes in the study period of 1953-1992 (see Tab. 2 and the Figs. 1, 2).

In 1953 the pattern of class 2421 (area 1542 ha), clearly prevailed. Mosaics of small plots of arable land and meadows belonging private farmers represented a typical structure of rural landscape before collectivization. Large area arable lands (2111 and 2112 - 268 ha) of farmers or just introduced agricultural cooperatives occurred only sporadically on plain relief of flood plains and fluvial terraces. Grassland was thesecond most frequent agricultural class (2311 and 2312 - 792 ha), with a close linkage to more inclined slopes of the basin hilly land or subbergland.

Change of the ownership in after-war years, but mainly as a consequence of agrarian

Fig. 1. The willages Nižné Malatiny, Krmeš and Fiačice surrounded by the agricultural landscape with predominance of the complex cultivation patterns (242) of 1953.

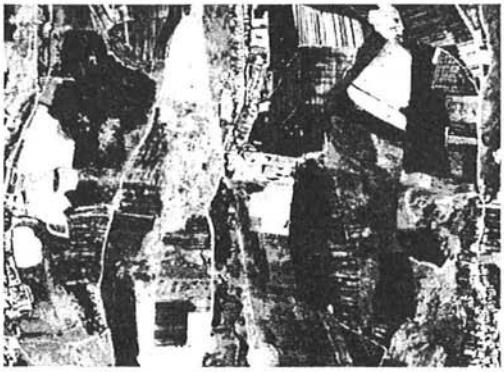

Fig. 2. The willages Nižné Malatiny, Krmeš and Fiačice surrounded by the agricultural landscape with predominance of the arable land (211) and pastures (231) of 1973.

policy (the 50-ties and 60-ties) brought about the introduction of large agricultural units (cooperative, state farms). Collectivization has, besides the organization of farming, changed the structure of the rural landscape. Class 2421 (253 ha) of the private farmers was substituted by large-area arable lands (2111 and 2112 - 893 ha), pastures (2311 and 2312 - 1058 ha) of the cooperatives.

By the beginning of the 70-ties the construction of two artificial reservoirs on the river Váh were started (Liptovská Mara - 360.5 mil. m^3 and Bešenová - 9.8 mil. m^3).

Analysis of the state of landscape in 1992 after the most recent social and ownership transformations (transformation of economic and social relations, privatization) is illustrated by Tab. 2. Privatization of the agricultural land has not been accomplished yet in an extent capable to affect the structure of the rural landscape.

Extension of water areas (5122 - area 408 ha) is due to the filling of the reservoirs and the functioning of the water power plants.

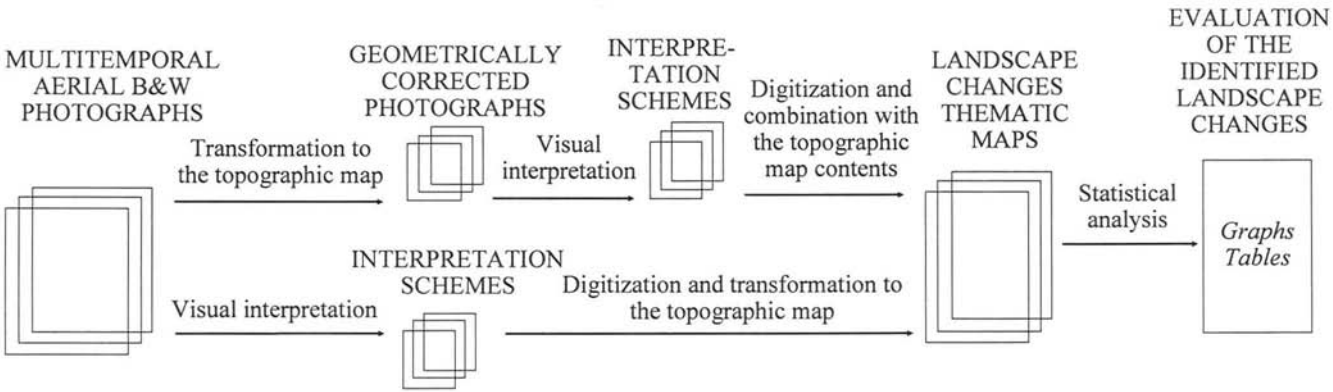

Fig. 3. Procedure of the identification and maping of the landscape changes by the visual interpretation of the multitemporal aerial B&W photopraphs.

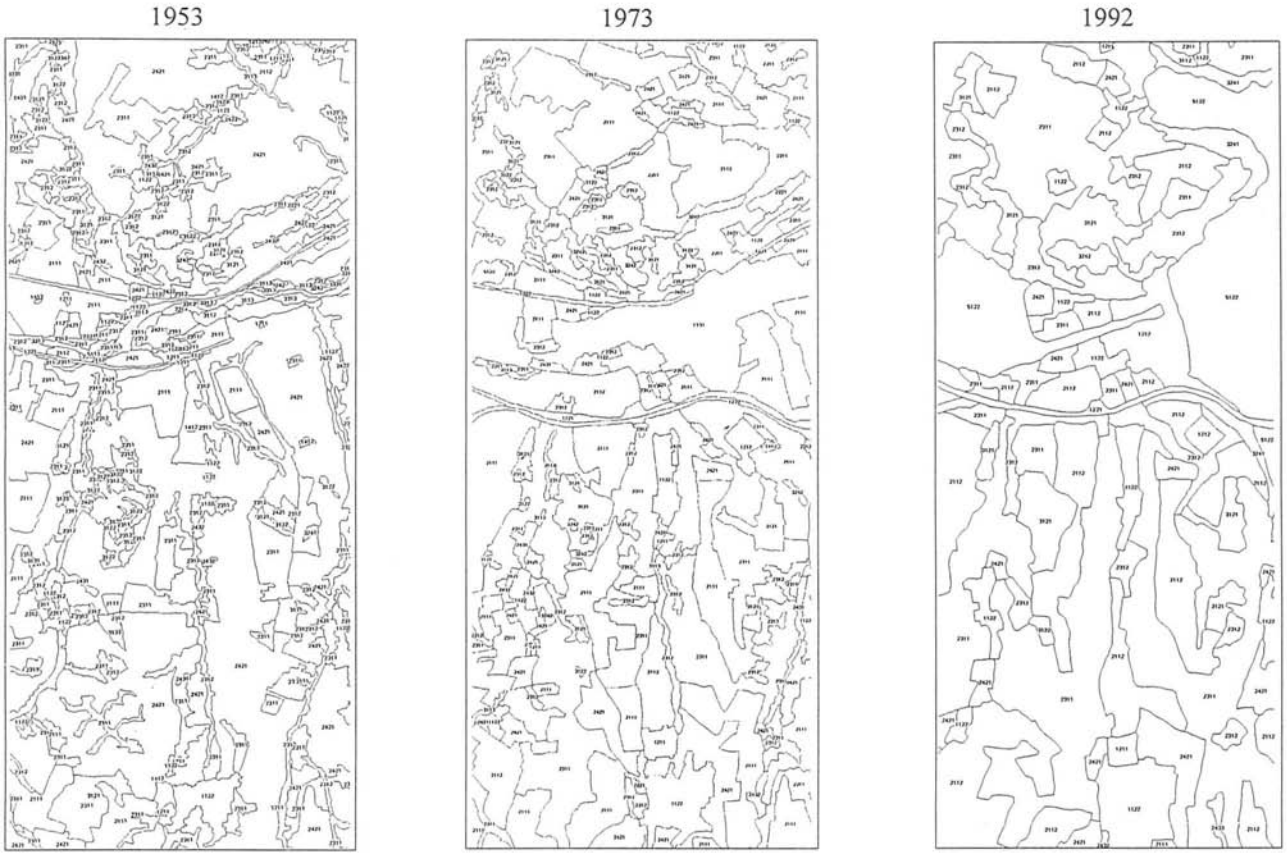

Fig. 4. Patterns of land cover.

Tab. 1. CORINE land cover nomenclature 1:50 000 (Feranec, Otahel, Pravda 1995)

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1 Artificial surfaces	11 Urban fabric	111 Continuous urban fabric	1111 Continuous urban fabric
		112 Discontinuous urban fabric	1121 Discontinuous built-up areas with multiflat houses prevailingly without gardens
			1122 Discontinuous built-up areas with family houses with gardens
			1123 Discontinuous built-up areas with greenery
	12 Industrial, commercial and transport units	121 Industrial or commercial units	1211 Industrial and commercial units
			1212 Areas of special installations
		122 Road and rail networks and associated land	1221 Road network and associated land
			1222 Rail network and associated land
		123 Port areas	1231 Commercial, fishing and naval ports
			1232 River and lake ports
			1233 Shipyards
			1234 Sport and recreation ports
		124 Airports	1241 Airports with artificial surfaces of runways
			1242 Airports with grass surfaces of runways
	13 Mine, dump and constructions sites	131 Mineral extraction sites	1311 Open cast mines
			1312 Quarries
		132 Dump sites	1321 Solid waste dump sites
			1322 Liquid waste dumps
		133 Construction sites	1331 Construction sites
	14 Artificial, non agricultural vegetated areas	141 Green urban areas	1411 Parks
			1412 Cemeteries
		142 Sport and leisure facilities	1421 Sport facilities
			1422 Leisure areas
2 Agricultural areas	21 Arable land	211 Non-irrigated arable land	2111 Arable land prevailingly without dispersed (line and point) vegetation
			2112 Arable land with scattered (line and point) vegetation
			2113 Greenhouses
		212 Permanently irrigated land	2121 Permanently irrigated land
		213 Rice fields	2131 Rice fields
	22 Permanent crops	221 Vineyards	2211 Vineyards
		222 Fruit trees and berry plantations	2221 Orchards
			2222 Berry fruit plantations
			2223 Hop plantations
			2224 Wild willow plantations
		223 Olive groves	2231 Olive groves
	23 Pastures	231 Pastures	2311 Pastures prevailingly without trees and shrubs
			2312 Pastures with trees and shrubs
	24 Heterogeneous agricultural areas	241 Annual crops associated with permanent crops	2411 Annual crops associated with permanent crops
		242 Complex cultivation patterns	2421 Complex cultivation patterns without scattered houses
			2422 Complex cultivation patterns with scattered houses
		243 Land principally occupied by agriculture, with significant areas of natural vegetation	2431 Agricultural areas with significantshare of natural vegetation, and with prevalence of arable land
			2432 Agricultural areas with significant share of natural vegetation, and with prevalence of grasslands
			2433 Agricultural areas with significant share of natural vegetation, and with prevalence of scattered vegetation
			2434 Agricultural areas with significant share of ponds, and with presence of scattered vegetation
		244 Agro-forestry areas	2441 Agro-forestry areas
3 Forest and seminatural areas	31 Forests	311 Broad-leaved forests	3111 Poplar plantations
			3112 Other broad leaved forests with continuous canopy
			3113 Other broad-leaved forests with discontinuous canopy
			3121 Coniferous forests with continuous canopy

		312 Coniferous forests	3122 Coniferous forests with discontinuous canopy
		313 Mixed forests	3131 Mixed forests created by alternation of trees 3132 Mixed forests created by alternation of stands
	32 Scrub and/or herbaceous vegetation associations	321 Natural grasslands	3211 Natural grassland prevailingly without trees and shrubs 3212 Natural grassland with trees and shrubs
		322 Moors and heathland	3221 Heathlands and moorlands 3222 Dwarf pine
		323 Sclerophyllous vegetation	3231 Sclerophyllous vegetation
		324 Transitional woodland-scrub	3241 Young stands after cutting and/or clear cuts 3242 Natural young stands 3243 Bushy woodlands 3244 Forest nurseries 3245 Damaged forests
	33 Open spaces with little or no vegetation	331 Beaches, dunes, sands	3311 Beaches 3312 Dunes 3313 River banks
		332 Bare rocks	3321 Bare rocks
		333 Sparsely vegetated areas	3331 Sparse vegetation on sands 3332 Sparse vegetation on rocks 3333 Sparese vegetation on salines
		334 Burnt areas	3341 Burnt areas
		335 Glaciers and perpetual snow	3351 Glaciers and perpetual snow
4 Wetlands	41 Inland wetlands	411 Inlands marshes	4111 Fresh-water marshes 4112 Saline (alkali) inland marshes
		412 Peat bogs	4121 Exploited peat bogs 4122 Unexploited peat bogs
	42 Maritime wetlands	421 Salt marshes	4211 Salt marshes
		422 Salines	4221 Salines
		423 Intertidal flats	4231 Intertidal flats
5 Water bodies	51 Inland waters	511 Water courses	5111 Rivers 5112 Channels
		512 Water bodies	5121 Natural water bodies 5122 Reservoirs
	52 Marine waters	521 Coastal lagoons	5211 Coastal lagoons
		522 Estuaries	5221 Estuaries
		523 Sea and ocean	5231 Sea and ocean

Conclusion

Obtained results document the possibilities of identification and mapping of the changes of agricultural landscape in Slovakia (on example of a part of the Liptov Basin) applying the aerial B&W photographs.

A significant contribution of the aerial photographs use is a correct spatial interpretation of the agricultural landscape structures in analyzed temporal horizons. Graphic examples of landscape patterns enlighten the casual connections in single stages (ownership situation, way of use, size and organization of the plots) representing an efficient expression of the analyzed changes.

Statistics confirms (see Tab. 2) the significant changes of analyzed land cover, namely classes complex cultivation patterns (242), arable land (211), pastures (231), construction sites (133) and water bodies (512).

It should be emphasized that the aerial photographs are often the only available source of the mentioned information. Such information complements the classical statistic providing above all macro-structural indices on landscape.

Acknowledgement

The paper was prepared in the frame of scientific project No. 1060 "Analysis of the Landscape Changes Application of the Remote Sensing Data" supported by the Grant Agency VEGA. Specially we would like to thank to M. Šuri and T. Cebecauer for technical help.

Tab. 2. Statistics of the land cover classes

	1953		1973		1992	
CLASSES	Freq. [n]	Area [ha]	Freq. [n]	Area [ha]	Freq. [n]	Area [ha]
1122	24	98.40	14	140.67	13	164.06
1211	11	6.01	6	15.50	4	12.06
1212	-	-	1	11.86	2	77.02
1221	1	6.61	1	21.43	1	22.85
1222	1	12.10	3	28.66	1	3.66
1311	-	-	2	0.33	-	-
1312	1	0.67	-	-	-	-
1331	-	-	1	228.20	-	-
1412	6	2.80	3	1.69	-	-
2111	17	253.92	38	760.21	2	2.36
2112	3	14.01	5	133.28	23	589.65
2221	2	1.52	2	10.78	-	-
2311	96	591.31	31	909.61	15	1065.11
2312	83	200.81	53	158.09	16	200.78
2421	37	1542.03	43	253.44	15	139.53
2422	6	10.51	-	-	-	-
2431	3	4.38	5	16.52	-	-
2432	6	5.68	3	6.27	5	1.67
2433	-	-	-	-	1	4.79
3112	2	4.68	-	-	1	5.84
3113	9	18.29	8	71.30	1	0.74
3121	12	98.69	16	137.29	9	164.87
3122	20	35.04	11	10.25	2	4.93
3131	1	0.36	-	-	1	0.02
3212	-	-	-	-	1	4.10
3224	-	-	1	6.30	-	-
3241	1	1.36	-	-	3	66.91
3242	3	6.12	7	24.77	2	15.91
3313	7	7.27	-	-	-	-
3331	2	4.67	-	-	-	-
3342	1	1.58	-	-	-	-
5111	1	21.21	1	-	-	-
5122	-	-	1	7.35	3	407.61
Total	356	2950.02	255	2953.81	121	2954.45

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GIS AND ITS USE FOR THE PURPOSE OF DIGITAL CREATION OF THEMATIC MAPS IN THE POVODIE DUNAJA, š.p.

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Maps and plans were created by a man from the very beginning of the human society. Military and strategic purposes were the main impulses of their creation but their importance were also from the point of view of the orientation in the country. Water economy has a long-termed tradition and its first historical evidences of water constructions come from the beginning of the 16th century already. With this fact it is connected maps and plans creation for managing interference to the country, at first they are historical maps of the mine reservoirs and water supply system, and later the projects of protecting weirs and dams.

Povodie Dunaja (the state enterprise Danube River Basin Co., further PD) is the organization of public interest. It manages on the territory of 5896 km^2 (12 % of Slovakia) 1157 km of flows, 710 km of the protecting dikes, 800 km of irrigating and draining canals.The water level regime of the ground water in lowlands Podunajská and Záhorská nížina PD regulates by 58 dams of various construction and 26 pumping stations with the output more than 150 m^3.s^{-1}. PD provides a complex of activities connected with the shipping on the Danube that has become an important navigation highway after the opening of the Rhein-Main-Danube Canal. The great importance is laid on the protection against the floods that caused large damages in the past, especially in the southern part of Slovakia and in the north-western Hungary.

For managing of all these activities exact and proper information are required. The most of it has geographic character and so it is useful to order and update them in the Geographic Information System (further GIS). PD creates GIS in the environment MGE (Modular GIS Environment) of INTERGRAPH company since 1992. The topographic basis of GIS at PD is acquired by digitalization of the basic map in scale 1:10 000 in raster and vector form. In the areas of the interest - inundation of the greater flows (Danube and its main tributaries) the topographic basis is exacted by more detailed topographic informations obtained from the aerial pictures.

More detailed thematic information about the flows and buildings on them, waterworks, irrigation and draining chanells, water quality, water traffic and flood effects are joined to this basis. Text data saved in the database Microsft SQL are joined to graphical data. In some areas of interest there is a supplement of picture information in the form of the orthophoto maps form the real color or infrared pictures. Also the multispectral pictures are used which are not transformed onto the field model. With

the exception of the basic storing of the objects GIS has the advantage of creation of new information by analytic and synthetic operations from original ones or modeling or forecasting of events. Outputs from GIS are important for supervision, managing and planning of many PD's activities. Many operations are provided directly in the field terrain where there is more practical to have these outputs not only in the digital form but also in the form of purpose-made maps and plans on the paper.

The Danube is an important European waterway. Through the Slovak territory it flows or border upon it only 172 km of it and they belong to the most critical ones in the whole navigation way section. For Slovakia follows from the international conventions an obligation to secure the navigation in this section of the Danube in the cooperation with Hungary and Austria. It is duty also for all other countries that the Danube flows through. One from these obligations is also to cooperate in creation of "The Navigation Map of the Danube ". It is issued by the Danube Commission that has a site in Budapest every 8-10 years for the whole river Danube. It offers basic data about the waterway and serves for shipping companies, supervisory authorities and ship crews.

PD is a coordinator and also an administrator of the activities providing determined parameters of the waterway. The Slovak-Hungarian border section of the Danube is the most critical section in Danube waterway at the present. The Nagymaros project incompletion means lower water levels and more difficult navigation conditions in sections with insufficient depth of water. The parameters of the waterway had to be limited in these sections by the navigation regulations. Inspite of those regulation is required to provide adjustment in the river chanell and continualy optimize the course of the waterway and its marking. For this activity it is yearly worked out "The Project of Danube Navigation Way Alignment". An agreement about two-year mutual alternation of works is valid in the border section with Hungary. This project serves also as an actual basis for "The Navigation Map of the Danube" creation. Both cartographic works are in a scale 1:10 000 in optimum division into sheets for the Danube river in a co-ordinate system JTSK (used in the Slovak territory). They contains current data about the waterway, depth of water in the channel, shipping conditions that vary depending upon the time and water discharge and of the location of the navigation signs. Besides these bearing information it contains numeric information about the flow velocity and depth of water in the waterway. In the sections where the Danube river is crossed by the bridges there are drawn their transverse profiles indicating navigation conditions under the bridge constructions. Information about possible services in the vicinity of the waterway and about the efficiacy of the supervisory navigation administrators are marked by the symbols. The river surroundings is completed with the topographic information (roads, sites, weirs, buildings, bank line, electric line, water level, railways), border of the vegetation, state border and the description obtained from the aerial pictures.

Primary information for "The Navigation Map of the Danube" so as for the "The Project of Danube Navigation Way Alignment" are in the river channel of the Danube. For the bottom relief measurment PD uses a special boat vessel with the measuring system Krupp-Atlas Polartrack. The boat followed by the bank laser ray measuring system scan the bottom with the double-canal sonar linked to the control computer in which the position and time information are added to the depth

information. The control computer offers also information for the navigation unit and in accordance with it the ship captain controls himself. Output from the system are the text files containing bottom points with the coordinates x,y,z, in cross or transverse profiles. These data are saved after the primary correction and then they are processed in the MicroStation environment into the graphic form of the spatial curves in the real true altitude (Balt height system after adjustment). They are exact and high-quality information about the river bottom relief. But for the ship captain it is important the depth of water in relation to the bottom of his ship. Therefore for "The Navigation Map of the Danube" and "The Project of Danube Navigation Way Alignment" it is necessary to reduce measurement of the river bottom by the minimum navigation water level. This level is determined by the common Slovak-Hungarian agreement for each whole kilometre of the river in the absolute height. The depth is for cartographic use better expressed in izolines 0, 2,5 and 5 m from the minimum navigation water level. From these information it is better seen where the minimum navigation depth 2,5 m is observed and where it is necessary to optimize the course of the waterway, or, if need be, to propose river channel adjustment by the regulation constructions or by dredging works. For the determination of the izolines - lines of the same depth it is used an analytic instrument of GIS MGE Terrain Analyst. From the profile measuring in the river channel it is created "The digital Terrain Model"- DTM of the Danube river bottom. The tachymetric measurements of the shallow areas and branches are attached to this model so as the photogrammetric evaluated water level and the direct stream surroundings. Such a DTM is an exact input to modeling. From the numerical values of the minimum navigation water level in kilometres distance it is created the DTM of water level. By the conjunction of these two models was create differential model. It is possible to automatic generate the lines of the same depths with interval 2,5 m. An automatic generation requires the checking and correction of data especially in the locations where the different measurings were connected together. Information for the creation of "The Navigation Map of the Danube" and "The Project of Danube Navigation Way Alignment" are thematic stored in GIS, in the levels according to their structure. With the creation of the cartographic output were these levels placed one onto another. In the MicroStation environment are the topographic files of the river surroundings, depths, navigation signs, waterway centre line, state border an others linked as the reference files with the elements located into the levels. The elements were cartographic modified in accordance with the marking key. The library of the navigation signs was created and the depths were color differentiated according to the izolines. Finally it was created the frame of the map sheet with the frame-data. With regard to the fact that all GIS levels are in the connected form, was the frame with the frame-data at the creation of print files applied as a mask for each separate sheet. The print files created like this are then printed on the plotter.

The storage of information in GIS in thematic layers has the great importance at their updating. Each thematic layer can be updated separately according to our needs. The evolution of the natural river bottom is in relation to the morphology of the surrounding terrain much more dynamical. Its updating is necessary every year. Critical sections are measured still more often. The measurements in the river bottom are saved in GIS an they are exact and precise input to the DTM creation. Attribute data are linked to them: the date of measuring, stream and the river kilometres of the measured

section, distance of the profiles, absolute height of the current water level, purpose, observer and the measuring condition description. By the mutual comparing of the time successive measurings it is possible to observe the evolution in the river bottom-deposition and washing-off of the bottom sediments, effects of new-construted regulation works and another phenomena. It is realised by conjunction of two models from repeated measuring in a certain location. DTM of the river bottom in a connection with inundation is the basis also for the further modeling as a simulation of floods and a water level course of high water. It serves also for the projecting activities and with that joined volume analyses like is "The Project of Danube Navigation Way Alignment". It is based on a conjunction of the natural river bottom model with the navigation corridor model. By the representing of this analysis we can see insufficient depths in the navigation trajectory and so we can suggest very rationally excavating, concentrating and regulation constructions and others. These activities enable obtaining of needed information for the strategic decisions with the great economical impacts.

Relatively detailed description of the thematic-purpose maps creation that is needed not only for PD´s activities proves GIS utilization possibilities as a primary source of data inclusive of analytic and synthetic operations.

Besides that PD within the scope of the activities shown into in the introduction creates great numbers of another thematic maps for this own needs and also for the needs of the state administration authorities. Next there are required for issuing various kinds of licenses for build activities, for study and plan documents, environmental project and others. Concrete examples can be introduced:

- Map of a surface water quality in a scale 1:200 000
- Sanitary and water management map in a scale 1 : 50 000
- Surface and ground water resources map in a scale 1 : 50 000
- Map of the pollution recourses and of the large industrial off-takes in a scale 1 : 50 000
- Map of the take-off status and hydromelioration equipment in a scale 1 : 50 000
- Territory sensitivity map
- Map of anthropogenic activities in relation to the water economy
- Map of the territory charging
- Flood plans, flood effects maps and others.

Especially the flood plans are the very important documents containing great numbers of the maps required for the operation of the technology staff alloted to the flood sections. They offer information about historical important flood effects, altitude states, geological subgrade of the weirs and their crossing with no more existing branches, importnat buildings in the flood plain, inhabitant and farm animals evacuation processes, access roads, flood material stocks and a number of other useful information for the orientation in the unknown territory also at night. They are made out in scales with adequate preciseness of information. Dangerous areas are processed in a very detailed way.

For the needs of research projects and historical studies we use also historical maps. Regularly they are scanned and transformed to the coordinate system used at the

present. For the morphology of the river channel development consideration are these historical maps overlapped by their current status.

All these purpose-made maps were created from the graphic database of GIS. For many of them is necessary also an analysis and synthesis and the GIS analytic tools are very useful for it. The result of these analyses is as a new thematic layer stored in GIS. So it is in a digital form accesible for the users with viewing software. In case of the cartographic output is together with the topographic base printed on the paper. The thematic maps created in this way are published in an amount from 1 to 100 copies. Some of them, as is e.g. "The Navigation Map of Danube" are published in an edition up to 1000 copies.

From the point of view of the closer utilisation and their relatively frequent updating is the used technology more effective and in a digital form also practically immediatelly accessible. From the standpoint of the cartographic proceeding is also the aesthetic aspect on a qualitatively higher level as the manual completion of the thematic content into the classical map.

GIS and the rich graphical and alpha-numerical database offers great number variations in thematic map creation.

THE GIS AS A SOURCE OF INSPIRATION FOR THE DIGITAL MAPPING

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Preface

The development of the modern geoinformatic technologies affects the improvement of the technical and programmable facilities (i.e. software and hardware) which increase effectiveness of the labour procedures in many geographical disciplines either in scientific research or praxis. The digital mapping has become an inseparable part of this process.

Creation of both standard topographical maps and specialized thematic maps can provide and really provides us with plenty of creative impulses for the further development of the digital mapping.

This article is based on our experience gained during creation of specialized, resp. model types of geoinformatic systems (the GIS), and deals with some aspects of the GIS applications.

First pattern which deals with creation of the geomorphological informational system (the GmIS) is aimed at geomorphological and ecological studies with emphasis on environmental impact assessments (EIA).

Second pattern presents creation of the regional GIS aimed at solving some human-geographical and regional-geographical explorations on the territory of Slovakia.

Different objectives of both examples provides the larger view on coherency between methods and contents of data collecting, their processing and specialized mapping which should meet requirements laid upon the optimal database of the mentioned GIS.

The geomorphological GIS

Geomorphological research, and mapping which is firmly connected with them, create the suitable basis for the implementation of the GIS technologies and for digital designing of the complex geomorphological maps. Having based on some works written in this discipline (Minár J., Kusendová D. 1995a, Kusendová D., Minár J.

1995b, Kusendová D. 1995) let us quote some essential information concerning creation of mentioned maps.

Purpose and essence of the geomorphological informational system

The object of created GIS was to design such methodological and methodical procedures which should connect traditional forms of geomorphological explorations with possibilities of the contemporary GIS development. We used here mainly synthetic approach known as complex geomorphological research, resp. mapping. The geological GIS is the environment for storage of the basic outputs from the mentioned complex research and mapping, for their further processing and cartographical presentation in the form of digital complex geomorphological maps.
In contradiction to traditional, in this new method of complex mapping all relevant data are attached to the areas of the elementary forms of the georelief (Minár J., 1992). The first informational level of this GIS is being created from the entire position of the elementary forms areas and their boundaries which in the most highest resolution level present the geotops - the smallest and relatively homogenized complex units of landscape. Further information levels attached to this primary structure of landscape characterize genesis of particular elementary forms, their age, morphogenetic parameters (e.g. slopes, orientation, different curves) and features of predominant georelief processes (e.g. the type of the process, its intensity in space, etc.).

Geoinformatic and cartographic aspects of the geomorphological informational system

Our GIS was created as the specialized GIS which had to ensure (with the help of commercial programmes available in our country) processing and cartographical presentation of the results of geomorphological mapping. The automation of the mentioned processes required managing the next stages of work:

a) detailed specification of the structure of the GIS database;
b) choice of the appropriate hardware and software which should comfort all planned GIS functions;
c) creation of the appropriate procedures for formal and contents checking of data inputted into the GIS and data processing on the basis of specified in details applications;
d) creation of procedures which should present the results of application in the form of the cartographic model.

Review of completed stages

As to the data structure, the object-topological spatial data were divided into primary and secondary. The primary data were presented by the boundaries of the elementary forms in the shape of polygones and scalar points fields of altitudes which became later the base to the future digital model of terrain (DMT). The secondary data were calculated from the DMT-pattern in the form of the morphometric data. Non-spatial data had expressed in codes the above-mentioned genetic, morphologic and other features of the elementary forms (fig. 1).
Semi-automatic way of the digital maps creation together with the other factors (i.e. the level of positional accuracy of the inputted data, quality of methods and steps used for terrain survey, accessibility of other technical facilities) determined the choice of a

software and a hardware. We have used mainly that types of the GIS programmes, which are provided with the flexible formal tools and should be modified according to the demands of their users.
For spatial data storing and processing the wide scale of procedures and forms was used: from the vector digitizing with the help of digitizer through digitization over the raster image - up to creation of secondary sources of the spatial data. We are seeking now for ways of straight implementation of the total stations and the GPS into terrain survey.
As to processing of the GIS database, we are now on the level which enables modified calculation of the secondary spatial data, choice of the particular features of the elementary forms depending on required features and their internal validation based on data obtained from the GIS database.
In this initial stage of the GmIS creation the next results should be considered as the important ones:

- creation of the suitable flexible database;
- procedures of synthesis data obtained from terrain survey and digital terrain model;
- procedures of internal validation of the geomorphologic data;
- creation of the complex geomorphological maps;
- creation of specialized maps from newly generated data levels (i.e. maps of the environmental hazards, for instance).

This newly created GmIS should be transformed as well into the physical-geographical informational system.

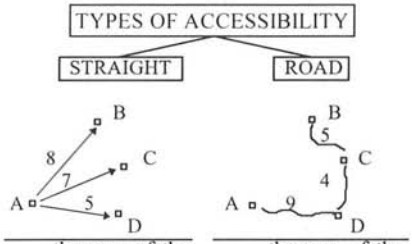
The object of the GIS regional database and its creation

It should be mentioned, that "the regional GIS" is the working term, because our work was aimed at creation of the flexible database for particular theoretical and empirical generalizations within the framework of regional and human-geographical explorations on the territory of Slovakia. Created database was applied on the dynamic model of population potential of Slovakia settlement system, and on the secondary model of settlements accessibility in the GIS environment. This way of the GIS implementation enabled us to increase quality of the mentioned models and to enlarge them by further modifications (Kusendová D., 1996).
Creation of the models was divided into two stages. The first one was connected with searching for the suitable mathematics expression for calculation of population potential values and empirical values. The second stage tackled the simple and practical implementation of the chosen model in the GIS environment and its presentation in the cartographical digital form.
Values of population potential were calculated according to the following formula:

$$\mathbf{V_i} = \sum_{j}^{n} \frac{\mathbf{M_j}}{\mathbf{d_{ij}} + \mathbf{1}}$$

where $\mathbf{V_i}$ is the value of population potential of the settlement $\mathbf{i}$; $\mathbf{M_j}$ is population rate of the settlement $\mathbf{j}$; $\mathbf{d_{ij}}$ is the air distance, resp. minimal road distance between centroids of the settlements $\mathbf{i}$ and $\mathbf{j}$.

The variable quantity $\mathbf{M}_j$ serves for subsequent substitution of population rates in particular settlements of Slovakia in five "time cuts" taken out from 1869 to 1991 which add dynamic character to the model. Centroid of the each settlement was transferred from the topological maps of scale 1:10 000; road distances were taken from the road network maps of scale 1:50 000.



the sum of the straight distances from the settlement A to all other settlements of Slovakia (B,C,D...) in km

the sum of the shortest road distances from the settlement A to all other settlements of Slovakia in km

Creation of either cartographic model of Slovakia population potential or road accessibility of the settlements in Slovakia had included procedures similar to creation of the GmIS.

The cartographic models appeared to be the final results of analysis and presentation of the particular explorations. That is why the data structure was divided into primary spatial data (i.e. area of their boundaries, centroids of settlements, the road network), secondary spatial data (cartograms, resp. choropleth maps of surface trends), and non-spatial data (i.e. identificators, which were codes and names of the settlements, calculation of road accessibility and population potential values).

Choice of the hardware and software was determined by their capacity and was made according to demands concerning with their flexibility and usefulness in the process of cartographic modelling. Having completed our work, we have got the spatial object-topological database in the solitary system of co-ordinates with maximum resolution level 1:50 000, and the relational database of the relevant non-spatial data which should be used in the same studies in Slovakia. Having analyzed created models, we have used cartographic modelling techniques which can be implemented, resp. can be realized in the environment of the GIS technologies and methods of cartographic presentation known as the "desk-top publishing".

Discussion

While creating the databases of both our GISes we came across the different problems, which could provide explorers with the new impulses for digital mapping.

In case of the GmIS creation we had no digital model of terrain (DMT) in required scale 1:10 000. Public topographic maps of this scale cannot be considered as suitable. That is due to the fact that digitization of their contour lines as well as other elements was being made from the scanned printing originals with unsatisfactory contents accuracy. Making validation of the single informational levels from the complex maps in the GIS environment it was found out that circa 30% of inaccuracy was of topographical character. Moreover, taking into account the current rate of transferring the whole map set of this scale into the vector digital form we can guess that it may lasts for quite long period. The similar military maps which became available for the general public comply more with the requirements for complex geomorphological research, both for their accuracy and contemporancy. But the latter one (being created

for the Army Geographical Information System) are still in the process of digitization and will have become available somewhere in undetermined future. That is why we had to create the DMT by ourselves using facilities that were at our disposal at the moment.

Detailed high-scale geomorphological mapping cannot be adequately compensate by any of the mentioned sources of inputted data, which existence in the near future will be inevitable from the viewpoint of everyday praxis. Apparently, such mapping will be carried out in some ecologically threatened areas in Slovakia, mainly due to realization of the EIA act. However, round-the-state mapping had not become actual yet, that is why it should be considered about creation of the new national-wide thematic state mapping, similar to such state map series as geological or hydrographical (water economics).

In order to achieve certain level of automation (if complete, is impossible so far) in creation of final geomorphological maps, while developing GmIS we paid attention to methods and methodology of primary data gaining and further their processing, to standardization of the database and digital maps. Orientation on the price available hardware and software, should help to implement used procedures into geomorphological, resp. ecological praxis.

While applying the population potential model, we chose a centroid of a settlement, resp. the area of its territorial-administrative boundaries, as a basic space unit. Why a settlement ? Because the state informational service which keeps social and economical records including census of population records is based on the settlement as a primary unit. Movement towards the lower territorial-administrative levels (i.e. to the part of the settlement, urban district, etc.) is almost impossible due to the fact that the current (accessed to the public) records of census data are completed in the way which disable to identify unambiguously data which belong to the lower units. It becomes possible only after standardization and attaching the space units of social-economical statistics to another national-wide universal unit, to the postal codes, for example, as it was done in the United Kingdom (Department of the Environment, 1987).

While creating the regional GIS database, we came across another two problems. The first one is concerned with methodical issues and refers to the entire localization of the central point of the settlement. Despite the fact that we are familiar with many methods of area definite point (or label) statements in the different GISes, the vast majority of them are of geometric character which is related not to data, but to the GIS programme procedures. Definition of the settlement centre as a "point" where human activities and traffic connections have being gravitated needs to be analyzed more deeper. In order to extend the usage of spatial analysis it would be useful to create within the framework of the state GIS 10 000 (Vojtičko, 1995) the database of defined settlement points, which should reflect mentioned "geographical" reasons.

The second problem refers to updating of Slovakia road network in the framework of state map series, because their present state disable realization of spatial analysis in larger scale by means of the GIS technologies. That is why we had to satisfy with the resolution level of our database in scale 1:50 000.

Conclusion

Summing-up the above mentioned, we can say, that the problems we had tackle with in the process of both GIS creation are of the same character. They are concerned with absence, resp. inconveniency or inaccessibility of the large-scale digital data, which creation still is in state competency, and mainly with kind of data (as DMT, communications networks, etc.) which should form the total base for the future specialized databases, either for research or for practical usage. The outcome of these facts is poor market of standardized database information systems of geographical type in the state. The state activities are being substituted by the private ones and very often to the detriment of the quality.

But we are looking forward with optimism. With increasing of competency and professionality in geoinformation technology and efforts to co-ordinate the state information policy in this matters, the interdiscipline co-operation is developed parallely as the natural corresponding thing. Without sharing gained experience, putting up with individual reasons and interactive co-operation it is impossible to combine these means of scientific research into the universal integrated operational system.

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Fig. 1 The map of slope angles - from the set of complex geomorphological maps

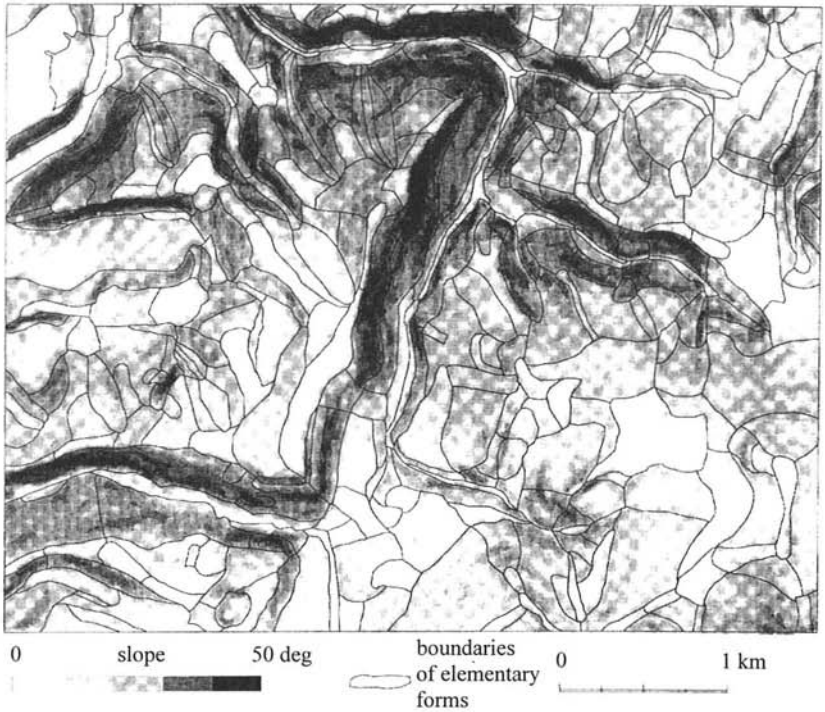
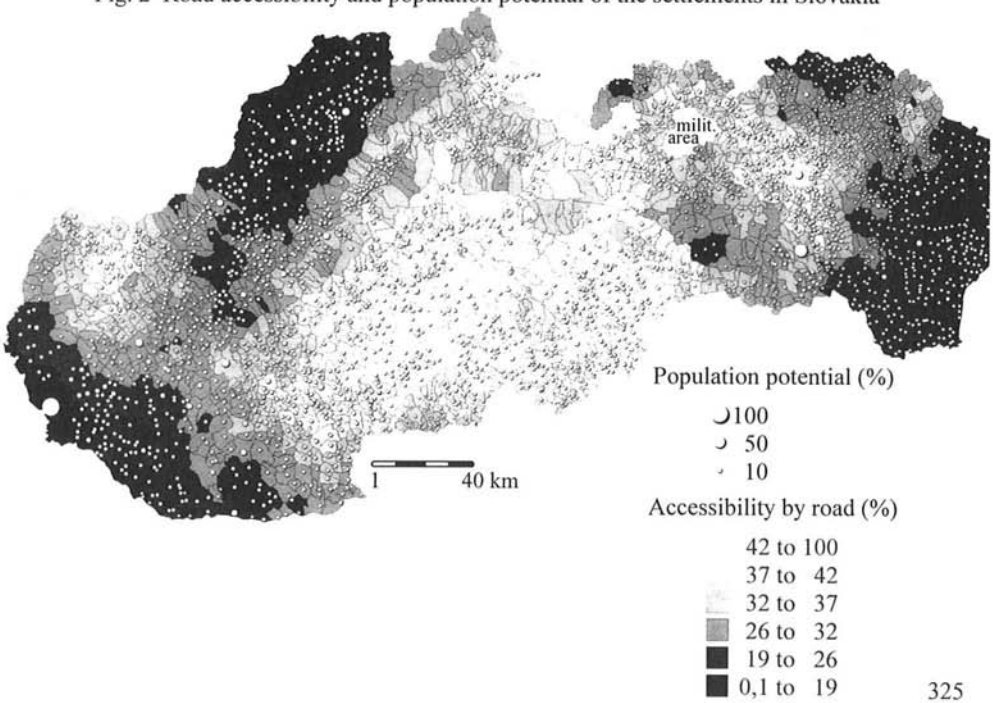


Fig. 2 Road accessibility and population potential of the settlements in Slovakia



MAPPING OF BOTTOM COMMUNITIES FOR ECOLOGICAL MONITORING PURPOSES: MULTIVARIATE DATA CLASSIFICATION

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1. Introduction

Traditional methods of mapping of main bottom population characteristics include data on biodiversity, biomass, biological communities and trophic zones (as a rule the latter are singled out on the principle of species or species group prevailing in total biomass). Enumerated methods are usually univariate and their ability to characterise the environment in a proper way was not quantitatively evaluated till recently. Meanwhile, it is quite clear that for the purposes of ecological monitoring and Environmental Impact Assessment (EIA) classifications, reflecting the environment in the best way, should be regarded as the most effective. But the question about the correct choice of benthic classifications, mostly sensitive to changings in bottom dweller habitats, remains open up for today.

Main goals of the present study are: (i) to work out recommendations for choice of the most "ecologically significant" classifications of bottom population for the purposes of ecological monitoring and EIA implementation and (ii) to describe shelf communities of the Barents Sea and adjacent areas on base of the classification considered to be the optimum. Super-aim of the work is to create reliable basis for marine ecological monitoring of the Russia western Arctic on perspective.

2. Material and Methods

Data, discussed below, are obtained during ecological cruises, organised by VNIIOKEANGEOLOGIYA in collaboration with scientists of the RINCAN, Zoological Institute of RAS and some other organisations in 1991-1994 (Pogrebov, 1996). On ecological stations main properties of water, bottom sediments and benthos were studied (including their contamination by total petroleum hydrocarbon - TPH, persistent organic pollutants - POP, trace metals - TM and radionuclides - RN). Total of more than 500 stations in the Barents, White, Kara, Norway and Greenland Seas at a depth from 12 to 1540 i is studied. However, in the methodological section of the work only 100 stations, mostly provided by data on all characteristics of the studied components, were included. About 50 stations are used for the analysis on the Barents Sea and adjacent areas and the same number is used for the analysis on the south-eastern part of the Barents Sea (so called Pechora Sea). Into the resulting classification data on all the studied stations are included.

In the course of the methodological section of the work implementation following univariate classifications are tested: (i) by the similarity of species number per sample, (ii) by the

similarity of total benthos biomass per station, (iii) by dominating species, (iv) by prevailing in total benthos biomass taxonomic and (v) trophic groups. Multivariate classifications are carried out: (i) on base of Sorensen coefficient, (ii) on base of Bray-Curtis coefficient, (iii) on base of Euclidean distance and (iv) on base of MacNaughton-Smith distance by: (i) absolute values of biomass, (ii) using "double square route" transformation, (iii) with per station presentation of biomass as a share of total, (iv) with Gauss data standardisation. For evaluation of the species list reduction on the results of classification, calculations for species contributing not less than 90, 75 and 50% to the total biomass are made parallel with calculations for the complete benthos data matrix. Data on biomass of high taxon and trophic group representatives are analysed too. Total number of tested variants of biological classifications is 90 for the Barents Sea and adjacent areas and 52 - for the Pechora Sea.

Quantitative comparison of biological classifications with "standard" environment classifications, constructed on base of data on near-bottom water and bottom sediment properties, is carried out by means of transformed MacNaughton-Smith distance with the following calculation of non-parametric Fowlkes-Mallows statistic (Nemec, Brinkhurst, 1988). This statistic change its value from 0 (classifications are completely different) to 1 (classifications are identical). In the course of data analysis on the Barents Sea and adjacent areas standard environment classifications were tested on base of abiotic data sets taken in two variants. In the first case data on *all recorded factors* (including concentrations of TPH, POP, TM and RN in near-bottom water and bottom sediments) were used (total number of observed abiotic parameters is 22). In the second case this list was limited by the values of only the most ecologically significant factors (their total number was 8). According to the results of expert evaluation following characteristics were included into the analysis: depth, temperature, salinity, water transparency, oxygen content, concentration of organic carbon in bottom sediments, average grain size of sediments and coefficient of grain size variability (Trask coefficient). In the course of the Pechora Sea data analysis values of 14 leading ecological factors were used in the environment classification. Calculations are made for variants of station classifications with 5, 10 and 15 clusters. Classification was considered to be optimum if it provided the highest value of Fowlkes-Mallows statistic by the sum of all three accomplished comparisons.

For the resulting presentation of bottom communities of the Barents Sea and adjacent areas total of 171 station, evenly located on the study area, is used. Initial floristical and faunistical classification of observations is carried out on base of Sorensen coefficient. Station groups, forming 5 large complexes, similar by the species composition and occupied area, were included into the following analysis on base of the Euclidean distance measure. Per station biomass values are standardised and transformed using "double square route" transformation. Cluster analysis is carried out according to the weighed pair-group method and the method of "the distant neighbour". Results of the latter were considered to be mostly obvious and ecologically interpretable and because of that they are used for the final presentation. In the process of community description understanding of this term by E.I. Mills (1969) was used.

3. Results and Discussion

3.1. Comparative evaluation of "ecological significance" of biological classifications

Summarising of the methodological results of the study had revealed the following. For obtaining benthos classifications, reflecting the environment in the best way, one should use: (i) multivariate data analysis, (ii) data on species (but not data on higher taxons and trophic groups), (iii) transformed measures of MacNaughton-Smith and Euclidean distance,

(iv) standardised per line or per station biomass values or (v) transformed biomass values. Besides that, it is useful to take into account that elimination from the analysis species, contributing less than 10, 25 and even 50% to total biomass of stations under comparison, do not decrease the similarity of biological and environmental classifications (and what is more, sometimes such a reduction even increases this similarity).

3.2. Description of bottom complexes and communities of the Barents Sea and adjacent areas, singled out on base of the optimum biological classification

16 main bottom communities are singled out in the resulting benthos classification of the Barents Sea and adjacent areas (see Figure). The communities singled out are forming 5 floristical and faunistical complexes (see Table). These complexes to a great extent corresponds to the geological zones, singled out in the Barents Sea according to the totality of chemical processes, taking place in the surface layer of bottom sediments (Klyonova, 1960; Danyushevskaya et al., 1993), and to the division of the Barents Sea shelf into districts, accomplished on basis of hydrodynamics regime and contemporary process of sedimentation (Gurevich, 1995).

Community complex of the central part of the Barents Sea is located in the area which is poorly influenced by the terrigenic discharge. It occupies the area of deep-sea accumulation, zones of slow and specific sedimentation (Northern Plateau). Various taxons of subsurface deposit-feeders are prevailing.

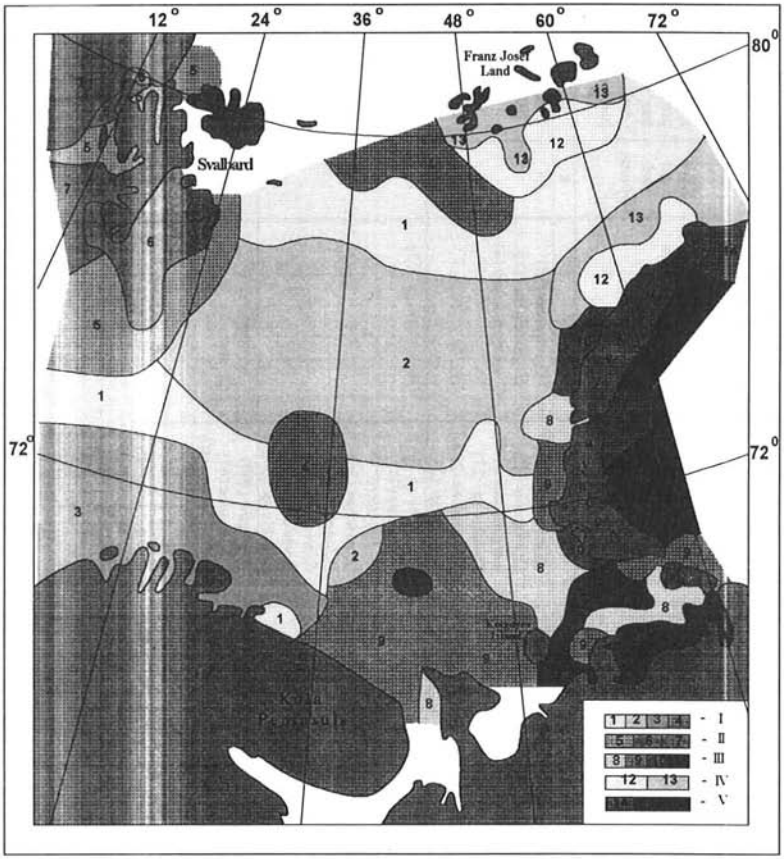
Community complex of the Bear Island and Svalbard region is typical for the area of slow sedimentation. It is subjected to a significant influence of terrigenic discharge and is characterised by an intensive hydrodynamics. Bottom sediments are eroded and redeposited. Bottom communities are highly variable and patchy distributed. "Slope" fauna (sponges, hydroids, bryozoans, barnacles, sea cucumbers *Cucumaria frondosa*) is well represented.

Community complex of the southern accumulation region (the Pechora Sea and adjacent shoal) is subjected to a significant influence of terrigenic discharge. Sedimentation is taking place in the conditions of shoals with high hydrodynamics activity. Communities are distinguished by high biomass mainly due to the presence of large bivalves (*Tridonta borealis, Serripes groenlandicus, Ciliatocardium ciliatum, Macoma calcarea*).

Community complex of the Franz Josef Land and Novaya Zemlya Northern Island offshore occupies an area, characterised by complicated relief, terrigenic origin of the organic matter and slow sedimentation which is going on in the conditions of coastal shoals with high hydrodynamics. Communities are characterised by high variability and patchiness of distribution. Echinoderms, hydroids and barnacles are prevailing.

Community complex of the Kara Sea offshore of the Novaya Zemlya Archipelago is subjected to a significant influence of terrigenic discharge. Sedimentation is slow. The role of echinoderms (brittle stars and sea urchins) and bivalves in communities is significant.

Concluding the result presentation, let us note that complexes and communities, singled out in our study, differ from the ones described earlier (Brotskaya, Zenkevich, 1939; Kuznetsov, 1970) as well as from the communities singled out in our study by means of univariate methods on base of species, taxonomic or trophic group prevailing in total biomass. The most similar classification to the presented one is the classification of trophic zones published by A.P. Kuznetsov (1970).



Bottom communities, singled out on the shelf of the Barents Sea and adjacent areas according to the results of multivariate classification

Complexes:

- **I - central part of the Barents Sea complex**
- **II - complex of the Bear Island and Svalbard region**
- **III - the Pechora Sea and adjacent shoal complex**
- **IV - offshore of the Franz Josef Land and Novaya Zemlya Northern Island complex**
- **V - the Kara Sea offshore of the Novaya Zemlya Archipelago complex**

1-16 - bottom communities which characteristics are presented in the Table

General characteristic of bottom communities of the Barents Sea and adjacent areas, singled out according to the results of multivariate classification for ecological monitoring purposes

Complex	Community	Occupied biotopes: Location Depth Bottom sediments Hydrodynamics	Number of identified species and groups of benthos	Total biomass (g/sq.m), min-max (mean)	Species with the largest occurrence frequency (%)	Species prevailing in total biomass (%)	Ratio of epi- and infauna	Trophic groups prevailing in total biomas	Comments
1	2	3	4	5	6	7	8	9	10
I. Central part of the Barents Sea	1 Subsurface deposit-feeders and foraminifers	Northern Plateau, Central Depression, St. Anna and Bear Troughs **136-1540 m** Silty clay with sand Slow sedimentation	95	0.1-68.5 (24.4)	*S. typicus* (91) *C. crispatus* (32) *G. margaritaceum* (27) *Nephthys sp.* (27) *H. globulifera* (23) *Yoldiella sp.* (23)	*C. crispatus* (14) *H. globulifera* (13) *G. margaritaceum* (8)	1:1	BDF*, SDF	In St. Anna Trough SFF are prevailing
	2. Sea cucumber of gen. *Trochostoma*	Central and Persey Heights, Central and North-Eastern Depressions **146-302 m** Clayey silt, sometimes with sand Heightened accumulation	71	23.8-571.1 (179.5)	*Trochostoma sp.* (89) *S. typicus* (78) *L. fragilis* (67) *O. sericeum* (56) *O. bidentata* (56) *C. crispatus* (56) *S. droebachiensis* (56) *Nephthys sp.* (56)	*Trochostoma sp.* (53)	1:2	BDF	
	3. Sea urchin *Brisaster fragilis*	Norway Trough **145-468 m** Sandy mud, muddy sand with coarse-grained material Slow sedimentation, intensive hydrodynamics	48	11.2-501.1 (210.4)	*B. fragilis* (100) *G. norvegica* (67) *G. margaritaceum* (50) *O. sarsi* (50)	*B. fragilis* (50) *Lithothamnion sp.* (15)	7:3	BDF	Influx of warm Atlantic waters rises the near-bottom temperature to +4 - +7°C

Table continuation

1	2	3	4	5	6	7	8	9	10
	4. Bivalves of fam. *Astartidae*	Central and Northern Plateau, **91-220 m** Clay + silt + sand	66	24.5-255.0 (96.2)	*E. elliptica* (100) *O. sericeum* (50) *S. typicus* (50) *G. margaritaceum* (50) *C. crispatus* (50) *H. arctica* (50)	*E. elliptica* (26) *Buccinum sp.* (19) *Ch. islandica* (15)	1:1	MFF	Biotope occupies areas of comparatively flat bottom
II. Bear Island and Svalbard region	5. Slope fauna: sponges and polychaetes--subsurface deposit-feeders	Bear Island Bank, Svalbard offshore **16-806 m** Silty clay with sand + coarse-grained material Intensive hydrodynamics	85	5.0-2389.0 (261.8)	*S. typicus* (46) *Nephthys sp.* (38) *L. fragilis* (38)	*Th. muricata* (61) *P. thielei* (8)	4:1	SFF, BDF	Community is highly variable within boundaries
	6. Sessile filter-feeders: sea cucumber *Cucumaria frondosa*, barnacles *Balanus balanus*, soft coral *Polythoa mammilosa*	Southern part of Svalbard submerged slope **22-120 m** Sand (sometimes slightly covered by mud) with pebbles, gravel and shells Intensive hydrodynamics	89	10.0-2404.8 (736.9)	*B. balanus* (78) *T. borealis* (78) *Hydroidea* (56) *Nephthys sp.* (56)	*C. frondosa* (23) *B. balanus* (15) *P. mammilosa* (15)	6:1	SFF	
	7. Sea urchin *Strongylocentrotus droebachiensis* and brittle stars *Ophiopholis aculeata*	North-western part of Svalbard offshore **25-512 m** Silty sand with coarse-grained material and shells Intensive hydrodynamics	85	17.2-555.2 (163.6)	*O. aculeata* (100) *S. droebachiensis* (89) *O. robusta* (78) *O. sarsi* (67)	*S. droebachiensis* (31) *O. aculeata* (23)	7:1	SFF, MFF	
III. Southern accumulation region (the Pechora Sea and adjacent shoal)	8. Large bivalves - filter-feeders	The Pechora shoal **20-129 m** Sand (muddy sand) with pebble and gravel (up to 20%) Intensive hydrodynamics	117	0.1-956.7 (337.6)	*T. borealis* (92) *M. sarsi* (69) *S. armiger* (69) *C. ciliatum* (62) *S. nodosa* (62) *M. calcarea* (54) *Gammaridae* var. (54)	*T. borealis* (37) *C. ciliatum* (20) *S. groenlandicus* (17)	1:10	MFF	Thick cover of sedimentary rocks, flat relief, depth increases gradually

Table continuation

1	2	3	4	5	6	7	8	9	10
	9. Red algae and periphyton species	Kanin Peninsula and Kolguyev Island shoal, Goose Bank, submerged slopes of Murman and Novaya Zemlya Southern Island **23-127 m** Sand with large amount of pebbles, gravel and shells, sometimes - basic rocks and boulders Intensive tidal and constant currents	148	39.4-12037.0 (1074.4)	*P. pubescens* (75) *S. droebachiensis* (65) *B. balanus* (55) *Nephthys sp.* (50)	*Rhodophyta* var. (53) *B. balanus* (11) *Ch. islandica* (8) *M. modiolus* (5) *M. edulis* (5) *Lithothamnion sp.* (5)	9:1	AT, SFF, MFF	Area of coarse-grained sediment accumulation
	10. Bivalves *Macoma calcarea*	Offshore of Novaya Zemlya Southern Island and Vaigach Island **71-184 m** Silty clay with sand, sometimes - with pebbles and gravel Intensive hydrodynamics	69	87.4-460.0 (294.9)	*M. calcarea* (100) *T. borealis* (83) *L. bellotii* (83) *M. sarsi* (67) *N. pernula* (67)	*M. calcarea* (33) *Trochostoma sp.* (16) *T. borealis* (13)	1:5	SDF	
	11. Bivalves *Ciliatocardium ciliatum, Macoma calcarea* and *Serripes groenlandicus*	The Pechora shoal **15-78 m** Sandy mud Intensive hydrodynamics	82	7.3-497.0 (125.0)	*M. calcarea* (85) *P. hyperborea* (77) *S. nodosa* (77) *Gammaridae* var. (62) *C. ciliatum* (54)	*C. ciliatum* (16) *M. calcarea* (15) *S. groenlandicus* (14) *M. sarsi* (11)	1:6	MFF, SDF	Biotope is similar to *No* 8 but bottom sediments are more fine-grained
IV. Offshore of the Franz Josef Land and Novaya Zemlya Northern Island	12. Periphyton species	Offshore of the Franz Josef Land and Novaya Zemlya Northern Island **32-100 m** Clay + silt + sand + coarse-grained material + shells Intensive hydrodynamics	100	34.1-1414.0 (328.7)	*H. arctica* (82) *S. droebachiensis* (82) *O. robusta* (82) *B. balanus* (73) *Nephthys sp.* (73)	*B. balanus* (28) *Hydroidea* var. (17) *S. droebachiensis* (15)	10:1	SFF, SDF	

Table termination

1	2	3	4	5	6	7	8	9	10
	13. Sea cucumbers *Trochostoma sp.* and *Psolus phantapus*	Offshore of the Franz Josef Land and Novaya Zemlya Northern Island **76-520 m** Silty clay with sand, pebbles and gravel Intensive hydrodynamics	90	2.2-454.2 (114.9)	*O. sericeum* (50) *S. typicus* (50) *G. margaritaceum* (43) *Nephthys sp.* (43)	*Trochostoma sp.* (37) *P. phantapus* (12)	1:2	SDF, BDF	
V. The Kara Sea offshore of the Novaya Zemlya Archipelago	14. Sea urchin *Strongylo-centrotus droebachiensis* and red algae of gen. *Lithothamnion*	Novaya Zemlya Archipelago offshore from the Kara Sea side **50-76 m** Clay with sand and small-grained material Intensive hydrodynamics	65	28.0-399.0 (134.3)	*S. droebachiensis* (100) *Actiniaria* var. (100) *O. bidentata* (100)	*S. droebachiensis* (46) *Lithothamnion sp.* (22)	7:1	AT, C&H	
	15. Bivalves *Astarte crenata* and *Bathiarca glacialis*	Novaya Zemlya Archipelago offshore from the Kara Sea side **35-111 m** Silty clay, sometimes with sand Intensive hydrodynamics	90	14.1-57.1 (27.0)	*A. crenata* (100) *O. bidentata* (86) *O. sericeum* (86) *Eunephthya sp.* (86) *P. groenlandicus* (71) *S. typicus* (71) *Picnogonidae* var. (71)	*A. crenata* (25) *B. glacialis* (23)	1:3	MFF	
	16. Brittle stars *Ophiopleura borealis*	Novaya Zemlya Trough **333- 403 m** Clay Faint hydrodynamics	29	0.6-36.1 (13.5)	*Thyasira sp.* (88) *S. typicus* (75) *H. globulifera* (75) *L. fragilis* (50)	*O. borealis* (34) *Paraedwardsia sp.* (19) *Eunephthya sp.* (15)	5:2	SDF	

* AT - autotrophs, SFF - sessile filter-feeders, MFF - motile filter-feeders, SDF - surface deposit-feeders, BDF - subsurface deposit-feeders (burrowing;), C&H - carnivores and herbivores

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EFFECTIVENESS OF GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS IN FLOOD MANAGEMENT DURING AND AFTER HURRICANE FRAN

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ABSTRACT

The nature of GIS use at the local, regional, state and federal levels in response to flood conditions after Hurricane Fran is the subject of this paper. The origins and sharing of high water data between U.S. government agencies in the response and recovery stages of the disaster is traced.

The spatial information flow that maps provide is an essential tool for emergency managers responding to flood conditions during and after a hurricane and for verification of insurance claims by those enrolled in the National Flood Insurance Program (NFIP). In recent years more and more local, state and federal agencies and institutions have employed geographic information systems (GIS) in order to collect, manipulate, analyze or display data. GIS is a powerful tool and in many cases is necessary to eliminate guesswork when it comes to decision making in a disaster situation. Models created with a GIS, for example, can provide useful support when evacuation decisions have to be made based on calculations as to the size of the potential storm surge of a hurricane. After a hurricane passes, not only flooding in coastline areas but also inland flooding from heavy rainfall can delay the return of victims to their homes. Also, spatial data in support of insurance claims, both for private insurance and for National Flood Insurance Program members, need to be gathered. These are a few of the many functions where GIS support is of great value. While GIS is often hailed for helping to solve the majority of problems, in practical terms, there are major limitations in the use of a GIS. Trained personnel may not be on hand, especially after a disaster; power outages may prevent GIS applications; and data input may be a problem at the scene, for example.

1. INTRODUCTION

Hurricane Fran swept across North Carolina on September 5th and 6th, 1996. The eye of the hurricane moved directly over the coastal city of Wilmington and continued to move on to Raleigh, the capital of North Carolina. The storm surge caused severe coastal flooding and continuous rainfall added to the problem; - 10 inches of rain fell in less than 12 hours. The storm was slow moving, and intense rainfall quickly flooded the coastal areas while major inland areas were flooded from swelling rivers and saturated lowlands. For eleven hours the storm thrashed the state with winds clocked at 115 mph on the coast and up to 79 mph at Releigh, located in the center of the state. After dawn broke, it was clear that Hurricane Fran was one of the worst storms to have hit this hurricane-prone state in decades.

The storm claimed twenty-two lives in North Carolina, left more than 1 million people without power and damaged tens of thousands of buildings. Debris could be found everywhere. Property losses, along with agricultural, tourist industry and business losses, left the economy of the state in disarray. President Clinton declared 51 out of the 100 counties in North Carolina as federal disaster areas. Estimates are still being revised upward, but Fran will clearly be North Carolina's most expensive disaster so far with estimated losses to top 4 billion dollars. Figure 1 shows the path of Hurricane Fran and the location of counties declared as federal disaster areas.

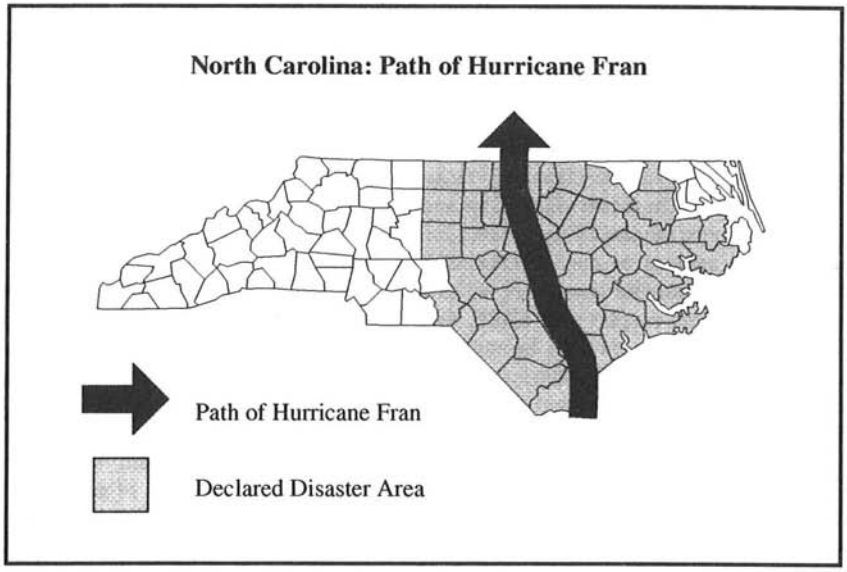

Figure 1: Location Map

In recent years, geographic information systems (GIS) technology has been applied during and after major disasters, but its effectiveness is still being questioned.

Research after Hurricane Andrew [1] demonstrated that the application of GIS was still not accepted by many Emergency Managers. Nearly four years have passed since Andrew, and GIS technology has become a household name in many government circles. This project examines the use of GIS in the pre and post disaster management of Hurricane Fran.

2. THE ROLE OF GIS DURING FRAN

2.1 The North Carolina Geographic Information Coordination Council (GICC)

In contrast to many other states, the North Carolina Geographic Information Coordination Council (GICC) was established in 1994 by the Governor through executive order to direct a statewide data coordination initiative. As a result, the State of North Carolina Center for Geographic Information and Analysis (CGIA) was staffed to support the Council and to maintain the data. Throughout the ensuing three years, a corporate geographic database has been compiled through efforts of numerous public and private organizations. The CGIA serves as a clearinghouse for this data. Federal Content Standards for Digital Geospatial Metadata were applied to assure quality when data is provided from different sources. Currently, the CGIA maintains about 60 data layers. Including:

USGS Basemap Files, Municipal, County Boundaries
Census Boundaries/Population Files
Water Quality, Air Quality
Coastal Area Management Act Information
Land Use and Land Cover
Hydrology/Hydrography
Hazardous Waste Facilities
Hurricane Storm Surge Inundation Areas
National Wetland Inventory
Soils
Topography
Transportation
Water Supply
Historical Sites [2]

2.2 The SLOSH Model

One of the efforts the CGIA had undertaken before Hurricane Fran was the preparation of Hurricane Storm Surge Inundation Area maps. These maps showed the extent of hurricane storm surge inundation for four southeastern coastal counties in North Carolina. The areas were identified by application of a computer program called the Sea, Lake and Overland Surges from Hurricane (SLOSH) Model. Maps were produced for both fast and slow velocity hurricanes. The maps showed land susceptible to flood inundation by the severity of different hurricane categories. The inundation information

was overlaid on a 1:24,000 United States Geological Survey, 7.5 minute Series Quadrangle. This provided basic information about the areas such as roads and topography. These maps proved to be very useful and were the basis for the preparation of evacuation maps.

2.3 Coastal North Carolina Hurricane Evacuation Restudy Maps

With the use of the SLOSH model Hurricane Evacuation Restudy maps were prepared. These maps showed storm surge heights in feet above National Geodetic Vertical Datum. They were prepared for slow and fast moving hurricanes of categories 2, 3 and 5 since the same evacuation maps are used for category 4 and 5 hurricanes. These Hurricane Evacuation Restudy maps were applied to analyze the risk for flooding. Emergency managers employed the maps to guide the evacuation of residents in the State's coastal and lowland areas.

2.4 Data Layers Provided to the Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) quickly identified the valuable data layers available at North Carolina's CGIA. Before Hurricane Fran even arrived, FEMA requested data on hurricane storm surge inundation areas, state-owned complexes, historical sites and districts, and natural heritage element occurrence sites and sought county road maps with municipal boundaries. FEMA worked closely with the CGIA in preparation for this storm. All computer files were carefully backed up before the storm arrived. The CGIA did not lose power during or after the storm, but it had no telephone services operating.

2.5 Other Map and Data Requests

Besides FEMA, data and maps on Hurricane Storm Surge Inundation were provided to the American Red Cross. The Division of Forest Resources requested maps of Forest Damage. These maps were created by overlaying various forest cover layers with the hurricane storm surge inundation data. A map of the declared disaster counties and the path of the storm was requested by the Geographic Information Coordination Council, and this map was prepared after the storm by the CGIA. County-wide basemaps were requested for various agencies, including the Department of Environment, Health and Natural Resources, which was prepared for the planning of mosquito spraying. Data was provided in ARC/INFO, ArcView, MapInfo and Atlas GIS formats. [4]

2.6 Technology used by Federal Agencies

In contrast to previous disasters, such as Hurricane Andrew, most federal agencies brought their own GIS's to the Disaster Field Office in Raleigh or were directly connected through the World Wide Web (WWW) or through the Internet with their home offices. Situation reports were released daily over the WWW to keep politicians, such as the Governor and cabinet members as well as emergency managers, abreast

of the changing situation in the field. Weather conditions, the physical conditions, such as debris removal, social impacts, and cultural impacts, were monitored, and reports on these subjects were sent out over the WWW. In addition, requests for supplies, equipment, and volunteers were broadcast over the WWW to the population at large. Field data were available within a few hours, not only to emergency responders on the ground, but also to the emergency community at large on the Internet. This was a decided contrast compared to information flow after previous natural disasters such as Hurricanes Hugo and Andrew. FEMA had also greatly speeded up its process of identifying those who qualified for disaster assistance. Within just a week, some victims received checks for repairs needed to their properties. Clearly, information technology has found its way into disaster management operations which has taken much guesswork out of the response process for emergency decision makers.

3. THE NATIONAL FLOOD INSURANCE PROGRAM

Congress passed the National Flood Insurance Act of 1968 and established the National Flood Insurance Program (NFIP) in response to mounting flood losses and disaster relief costs. The public could purchase insurance from the fund if their own local governments implemented and enforced measures to reduce flooding risk in new construction. [5] To set appropriate premium rates, Congress authorized the systematic identification of flood-risk areas across the nation. FEMA's Mitigation Directorate is in charge of creating and updating flood maps, which are called Flood Insurance Rate Maps (FIRMs). These maps identify the risk factor of flooding in local communities. The most significant risk factors are flood zone and elevation differences. In recent years these maps have been made available in digital format, and the maps became Digital Flood Insurance Rate Maps (DFIRMs). [6]

3.1 Address Matching

There were about 62,500 National Flood Insurance policies in place in North Carolina, mostly along the coast, as Fran pounded the state. FEMA awards disaster grants to the States for subgranting to individuals and to local governments. The task is to match the DFIRMs to the addresses of people requesting funding for repairs to determine the eligibility of those applying for NFIP funds. FEMA hired consulting firms to deal with this matching task. These private firms developed a database of georeferenced addresses for application in GISs; communities can now purchase this database for their own use. Final figures on the number and amounts of National Flood Insurance Program monetary awards to individual claimants resulting from Hurricane Fran flooding are not yet completely compiled.

4. CONCLUSIONS

The goal of this research was to identify to what extent GISs were applied before, during and after Hurricane Fran by emergency managers. On the local level, GIS was

not, or was only scarcely, applied at the early stages of response. Local communities were so hard hit physically that they were without power. Local offices were closed or had to respond to more urgent problems. At the state level, the data layers provided by North Carolina's CGIA were without question of major importance in the management of this disaster and will be especially valuable in the future for mitigation decisions. This availability of detailed data gathered before the extreme event occurred constituted a major difference between disaster information flow after Hurricane Andrew in 1992 and Hurricane Fran in 1996. It was clear that, in the four years since Hurricane Andrew, all federal agencies identified in this investigation of Hurricane Fran's effects had reached the Information Age. With GISs available, they took an active role in fast and efficient dissemination of field information. This speedy information flow was the most outstanding characteristic of the management of disaster conditions after Hurricane Fran. Many federal employees predicted that Fran will provide the impetus for additional GIS applications within their agencies. With the dramatic rise in disaster costs, all possible forms of technological advances must be explored on a continuing basis at all three levels of government in order for disaster response to become as efficient as possible.

ACKNOWLEDGEMENTS

This research was funded by a Quick Response grant from the Natural Hazards Research and Applications Information Center, Boulder Colorado. The map was prepared by Deborah Morida in the Cartographic Laboratory at Kent State University.

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STRENGTHENING GEO-COURSES IN HIGHER EDUCATION OF CARTOGRAPHY IN CHINA

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Today, under the circumstances of rapid development in technology and sharp competition in economics and talent, universities such as Wuhan Technical University of Surveying & Mapping which is a national university in China with the main disciplines ------ surveying & mapping, are confronted with a severe problem: how to educate modern technicians of Cartography with a strong adaptability and creativity, i.e., how to train "cartographers with multi-abilities" instead of "single technician" or "tool-likes" of cartography.

PROBLEMS IN HIGHER EDUCATION OF CARTOGRAPHY

For long time past, we only stressed the introduction of mapping techniques in the process of producing cartographers, and ignored to train their abilities of technique application in China. We paid more attention to the detail of techniques themselves and overlooked the circumstances of techniques, such as what fields the techniques can apply in, under what conditions the techniques can play a greater role, what can push the techniques ahead and so on. These problems are concentrated in the system and contents of the courses, and the teaching methods and means. Therefore, all these problems lead to the

core problem ------ quality for educating cartographers. And the main effects caused by the core problem are cartographers produced with lack of comprehensive analyzing capability, lack of managing capability, poor adaptability and poor diathesis. The simple problem tree is shown in Fig. 1.

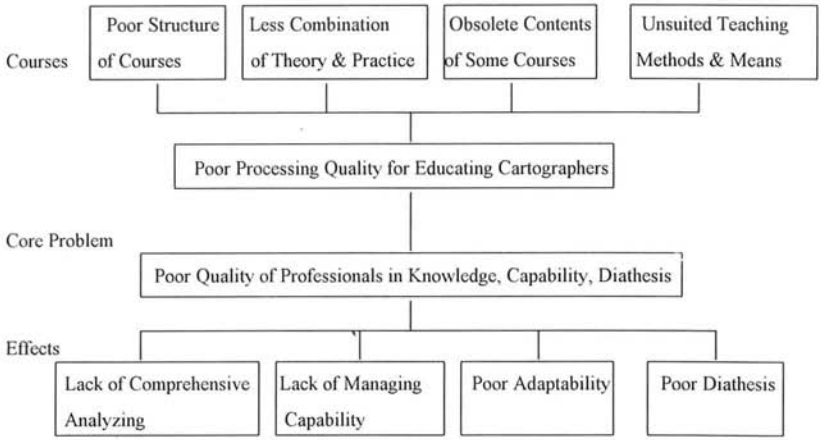

Fig. 1 Problem Tree

According to the wide-ranging survey, cartographers graduated from WTUSM usually dealt with basic data in the past. They had less capability of doing further data processing and passive position in data processing. In many cases, they were always instructed by land managers, planners and environment engineers since they are not aware of the internal relations between these thematic data.

How to solve these problems? We should take the rational and comprehensive educating model for cartographers into account. We carried out a project starting with strengthening geo-courses to improve the capability of future cartographers, aiming at these problems.

IMPORTANCE OF STRENGTHENING GEO-COURSES

Based on the analyses of the positions about the geo-information and geo-courses in data representation and cartographer producing, we understand data can not be well represented without awareness of their internal relations and cartographers can not well serve the country without geo-courses training. Cartographers can get at the innate characters and internal relations of the thematic data such as physical data and social-economic data through the geo-courses such as physical geography and economic geography. And then they know why to represent the data and how to use the data to serve the construction of the social-economics. As we see in Fig. 2, geo-courses act as a bridge which connects professional techniques and application fields. Since geo-courses are organized and introduced according to the development procedure of physical, social and economic phenomena, the logical thought of students can be inspired and their intelligence can be improved, so that hey can do better in generalization of map elements.

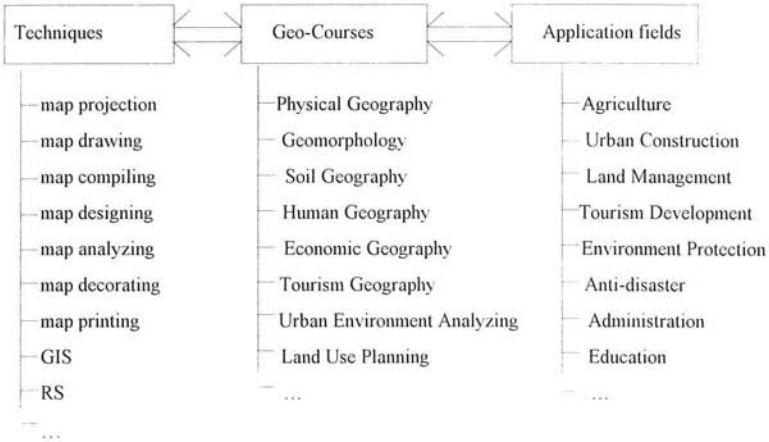

Fig. 2 Bridging Model of Geo-Courses Connecting Professional Techniques and Application Fields

OBJECTIVES OF STRENGTHENING GEO-COURSES

In strengthening geo-courses, we should have a clear aim, which consists of a series of objectives at different levels, aiming at the core problem. The main objective at high level is optimizing the procedure for educating cartographers. And it can be described by several sub-objectives, such as opening up the applied fields for cartography, improving comprehensive analysis ability, enhancing adaptability, increasing practical capability and inspiring logic thought. All these objectives can be defined as a set of operational indexes, including establishing a rational geo-course hierarchy, updating, enriching and improving the contents of the courses, applying the methods and means with the superiority of surveying & mapping, strengthening practical training, improving teaching material with the integration of geo-science and surveying & mapping, promoting the mutual, impellent combination of teaching with researching, and bringing about a geo-specialty ------ Planning & Management for Resources & Environment which gives support to cartography in our university, as shown in Fig. 3.

OPTIMIZING THE GEO-COURSE HIERARCHY

In order to let students have a good grasp of general principles and processes of physical and human phenomena development, and a solid base for well dealing with geo-data organization, storage, inquiry and modeling as well as automatic mapping, geo-courses offered in our University are considered based on two main points: (1) giving the integration points of connecting cartography with geo-science as well as practical application; (2) paying more attention to the integrity and connection of geo-courses and their contents. Geo-courses are divided into two classes, principle courses and method-application courses. The former includes courses in natural aspect ------ Physical Geography, Geomorphology, and Soil Geography, and human

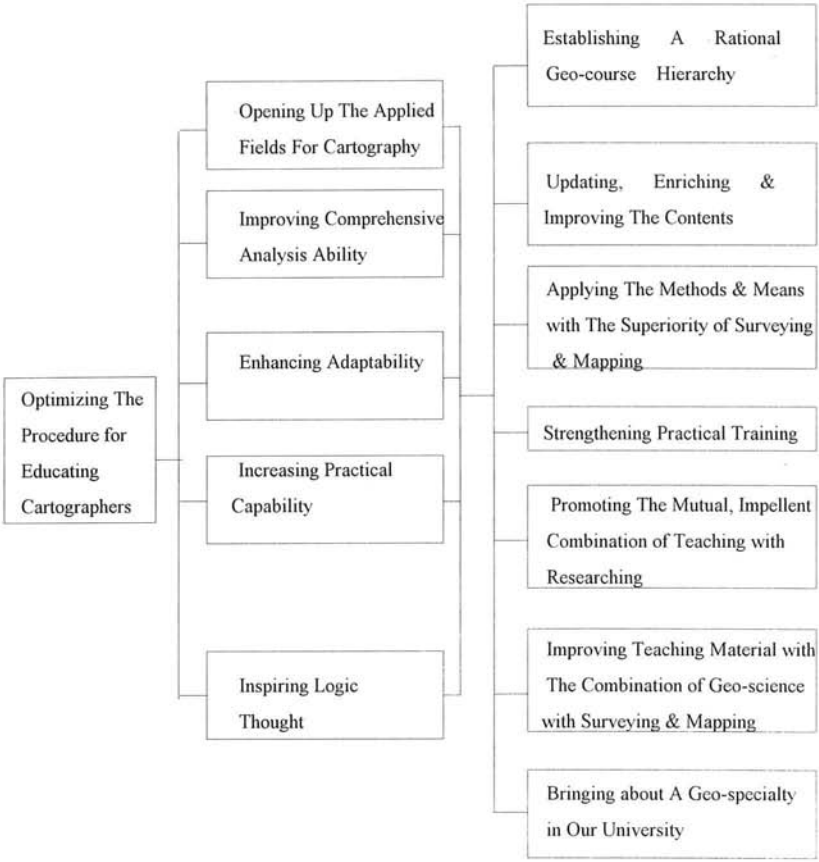

Fig. 3 Objective Hierarchy

aspect ------ Human geography, Economic Geography and Tourism Geography. The latter contains Land Use Planning (general and macroscopic) and Urban Environment Analyzing (detail and microscopic). In the organization of the courses, method-application courses follow principle ones. The percentage of the geo-courses period out of the total class hours in 4 studying years is about 16.8 %.

CONCENTRATING THE CONTENTS OF THE GEO-COURSES

In the selection of the contents of the courses, we pay more atention to the newer and more practical contents, especially those related to the application of surveying & mapping. For example, we stress not only on the analyses of shapes or patterns in Geomorphology for map generalization, and but also on the analyses of the causes of formation for thematic mapping and map use. In Physical Geography, we emphasize the integrity of the natural environment system and introduce the systematic analysis on theses elements. In Economic Geography, we discuss the relationship between human beings and environment and introduce the concept of sustainable development, showing the hot point of the present application fields.

The concentration of the contents is a process of integration of updating, enriching and improving. Based on the selection, we have finished compiling the corresponding teaching materials.

INTRODUCING THE METHODS AND MEANS OF SURVEYING AND MAPPING IN TEACHING

Since our university emphasize the disciplines of surveying & mapping, we have a lot of maps, aerophotos and satellite images, which are wonderful aids to object teaching for location analyses. So, we apply these means in geo-course teaching as much as possible. And at the time, we think, it's a good chance for students to practice map use which can help them to design map from the angle of map use.

For example , in teaching Economic Geography, we use a series of maps or images, including topographic map, soil map, temperature map, rain-fall map, and land use map etc.. to analyse the growth condition for crops, and then to make decisions step by step. The results of decision-making are also

represented in maps, such as map of suitable zone for crops, map of production bases for crops, map of production structure of crops, map of crop growing system, map of soil improvement, and planning map of irrigation works etc..

STRESSING ON THE COMBINATION OF THEORY WITH PRACTICE

Based on the classroom teaching, we pay more attention to that how the knowledge and theory can be further grasped by students. So we adopt 3 measures: (1) Classroom discussions on several topics for each course, usually 3 or 4 hours for each; (2) classroom practices such as Urban Land grading with the help of airphotos and relevant maps, usually 2 or 3 weeks sometimes, using computer; (3) field work as a comprehensive practice, usually 3 weeks. For field work, we have constructed a field survey base in famous tourism spot -- Lushan Mountain, for comprehensive practice on Physical Geography, Geomorphology and Tourism Geography. It's a good chance for not only examining their awareness of physical & economic principles, but also training their practical application capability of techniques such as map analysis and photo interpretation, and their judgment ability and comprehensive decision-making capability. We have compiled complete sets of practice materials, including practice atlas containing varied kinds of field base maps, airphotos, practice instructions and so on.

After long time discussion on what kind of future cartographers will be produced, we think, we must pay more attention to their widespread knowledge, strong capabilities and high diathesis, and these all must be concentrated on curricula, of course, on geo-courses. And we have achieved main objective to a certain extent.

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STRUCTURED APPROACH TO IMPLEMENTING AUTOMATIC CARTOGRAPHIC GENERALIZATION

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ABSTRACT

Taking the generalization of river network, relief forms and grouped point objects as examples, in this paper a new complete theory system for structured cartographic generalization is founded on the graph theory, fractal and computational geometry, and a logical operation sequence is established.

Keyword: structured generalization, river network, relief forms, tree structure, Voronoi diagram, grouped point object, convex hull, selection.

1.Introduction

The essence of automatic generalization lies in using the computer technique to accomplish the creative map compilation work instead of cartographer. How to assign a creativity to computer is a kind of computer vision problem in the case of spatial data processing.

The aim of generalization is to represent important objects as much as possible on a given map. " Important" means a necessary evaluation. Therefore, the core problem lies in how to recognize and estimate the spatial objects.

2. The DLM View of Generalization

Though the generalization sub-processes are very diverse. But we can summarize these operators into two groups: DLM group and DCM group.

The first group includes operators about information transformation and the second group about graphic representation ("digits to graphic" conversion) without respect to information change in principle.

Based on this view point we can concentrate the core problem in the studying of the first operator group which aims to change the map content and its details. Here author introduces a concept about the DLM view of generalization as follows:

Generalization is a process of DLM transformation which transform the initial DLM1 information(scale1, purpose1, entity set1,relation set1 ...) into destination DLM2 (scale2, purpose2, entity set2, relation set2 ...). All map making operations are directed at map entities. The core operations of generalization should lie in the transformation of entity information, including the entity concept transferring (classification, hierarchy etc.), entity set forming (how many should be selected, what and which should be selected) and simplifying the entity attribute information without respect to the graphic representation operations. The entity concept transferring should be accomplished during the map design process.

Map design offers "conception configuration" about new map to be compiled . This conceptual map can be considered as a kind of mental map which includes the predetermination of map feature selection norms.

3. Structured Approach To Generalization

After establishing the norms of map feature selection the key problem is " how to do the selection or which / what objects should be selected" . This is a new map "feature configuration" process. We call the generalization based on the consideration of both the global geo-feature distribution and the local / regional characteristics together as the "structured generalization". To carry out the structured generalization computer should be able to "understanding the whole map content at a glance" taking main attention to the macro-structure information. While in the individual entity handling the computer must be also able to estimate the local importance of each entity with respect to map features all around beside its other attributes. The sum of these functions can be considered as "computer vision" in automation of cartographic generalization.

Taking the generalization of river network, relief forms and grouped point objects as examples, in this paper a new complete theory system for structured cartographic generalization is founded on the graph theory, fractal and computational geometry, and a logical operation sequence is established.

4. The Supported Environment of Structured Generalization

In order to survey the whole map content at a glance and estimate the every geo-entity real-time by computer, a powerful support by a "Cartographic DBMS — CDBMS " will be necessary. The CDBMS should be able to perform a lot of retrievals: such as selection by feature classes, windowing, by irregular polygon, selection by topological relations and buffering etc. These functions can guarantee the computer to " watch " any feature object, any region polygon etc. attentively as if a " browsing " operation is being activated.

5. Structured Generalization of River Drainage Network

River drainage system is a typical tree structure. The essential task lies in

the automatic creating tree structure. Therefore, a global description of river system through tree structure is straightforward.

5.1 Automatic Creating the Global Tree Structure of River Network

Based on the river entities under the support of CDBMS the core operation of constructing tree structure of river network is the recursive calling the "buffering" to form strip zone along each river. After this, a selection of rivers by this irregular polygon (buffer) will be done for collecting the tributaries and an appropriate index of "father / sons" will be created.

In Fig.2 there are 31 rivers. Therefore, we can create a incidence matrix with 31 rows (father / sons records) in which the row numbers stand for the father's key, the column numbers the son's keys.

Only the incidence matrix is not enough to reasonably evaluate the importance of each river globally in the tree structure. Therefore, in order to evaluate each river completely it is necessary to reveal the position of each river in the tree structure, because the river as a node whose depth in tree structure will provide the global / structurized criteria besides quantitative /

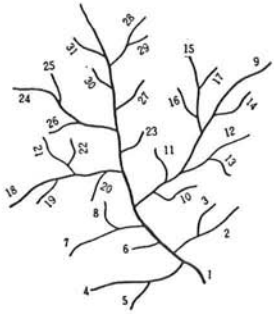


Fig.1 A simulation river network

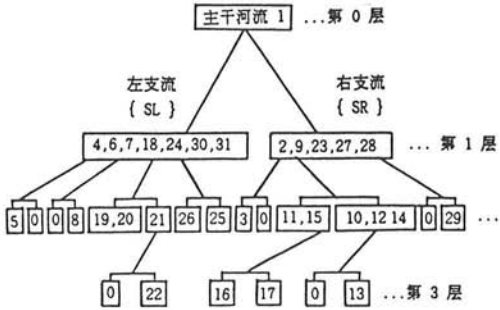


Fig.2 Tree structure of the simulated river network

qualitative indices of river itself. From above mentioned, it has been followed that the incidence matrix must be elaborated further in order to have a more compact form as Fig.3

The table of sub-tree depths is just the proper tree structure which provides key basis for global evaluation .The selection operation is to be concentrated on tree leaf's nodes in principle. The tree structure can automatically provide the all node information supporting batch processing rapidly (Fig.3) .

5.2 Automatic Generating the Local Descriptors for River Entities: Automatic Generation of Voronoi Diagrams

Considering the general selection norm and the basic view of selection operation concentrating on the leaf's nodes, a new problem arises: what kind of

The depths of tree levels	3	2	2	1	1	1	1	1	1	1	1	0	0	...
Database keys of river	1	9	18	2	4	7	12	15	21	24	28	3	5	...

Fig.3 The sub-tree depths of each river

leaf's nodes should be selected ?

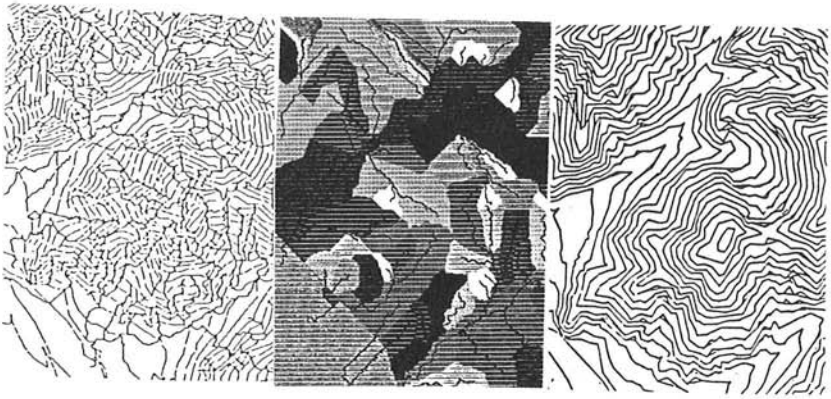
Besides simulating the conventional map compiling operations, here we can use the raster data processing method to create a line based Voronoi diagram which provides drainage basin areas for each related river. Area of each Voronoi polygon is proportional to the length and the distance between every two neighbouring rivers. Thus, the bigger the area the smaller the density of river network. Therefore, the Voronoi diagram gives an additional quantified index for evaluating the river entities or other map features in the sense of automatic differentiating the objects occupying the same tree structure hierarchy level. Finally, Voronoi diagram will enhance the objectivity and the reasonableness of generalization operations.

6. Structured Generalization of Relief Forms

There are three approaches to solve the problem: relief break line based explicit structured generalization, terrain height strip (vertical zone) based structured generalization, and fractal theory based pseudo-/implicit structured generalization.

Fig.4 Automatic generation of tree structure of drainage basin of river Nandu of province Hainan (the river hierarchy levels are represented by line widths)

Fig.5 Automatic generation of Voronoi diagram for each river of drainage basin of river Nandu of province Hainan (the Voronoi polygons are represented by different hatchings)



a. Tree structure of break lines

b. Vorovoi graph of break lines

c. Structured handling relief forms through their substitute (break line)

Fig.6 Generalization through structured lines

6.1 Relief break line based explicit structured generalization

Relief structure (break) lines are often called as skeleton of relief forms. These lines can serve as representative of relief forms (substitute). Thus the generalization of 3-D relief forms can be transferred into generalization of their 1-D structure (break) lines. Because relief structure lines appear also as tree structure, therefore those procedures used in "structured generalization of river drainage network" are available in this case(Fig. 6).

6.2 Terrain height strip (vertical zone) based structured generalization.

Terrain height strip means a vertical zone between two different heights Ha and Hb. A contour line whose height lies between Ha and Hb can be considered as descriptor of the terrain strip.

Here a inverse process is realized: generalization of 1-D contour lines though 3-D terrain strip. The results of generalization using this method appear as considerably elastic(Fig.7).

6.3 Fractal theory based pseudo- /implicit structured Generalization

In order to improve the application of fractal theory in map generalization first of all the line feature object (contour line) should be automatically divided into several segments by its local curvature.

After curve segmentation the fractal method generalization will be carried

out for each curve segment individually. The main procedures are as follows:

a. A part of original contour map b. Result of low degree generalization c. Result of high degree generalization

Fig.7 Generalization of relief forms using method of terrain height strip

Determine the Fractal Dimension Number by following formula of dependence between L and D :

$$\log L = \log C + (1-D)\log d$$

D -- the fractal dimension number.

L -- the length of curve segment.

C -- some constant.

According to , for example Toepfer's radical selection law, a relationship between curve length and map scale can be established:

$$L_2=L_1(M_1/M_2)^D$$

here L_1, L_2 the curve lengths before and after generalization respectively; M_1, M_2 the denominators of map scales before and after generalization. L_2 can be seen as a kind of regressive expectation value by which the desirable offset distance d for line simplification can be determined:

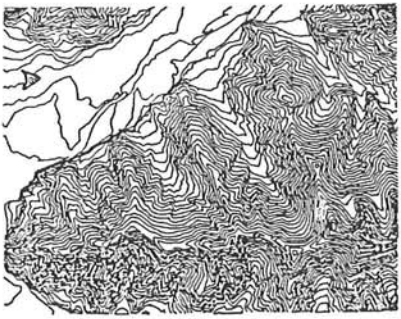
$$d_2=\exp\left(\frac{\log L_2 - \log L_1}{1 - D}\right)$$

Namely, if d_2 will be accepted as offset distance for generalization, then after generalization the new line will have length L_2 approximately.

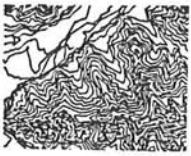
7. Generalization of Grouped Point Objects

With the help of convex hull algorithm a multiple embedded convex polygons for grouped point objects are constructed which represent their distribution structure and provide a control mechanism for structured selection of point objects. Voronoi diagram gives an additional quantity criterion guaranteeing a more reasonable selection. The main steps of generalization consist of two sub-processes: reducing the number of embedded polygons through merging the neighbouring polygons

and selecting the point objects along the new generated polygons.



a. Original map
scale: 1:50 000
h=40 meters



b. Generalized map
scale: 1: 100 000
h=80 meters

c. Generalized map
scale: 1:200 000
h=120 meters

Fig.8 Generalization of relief forms using the fractal theory.

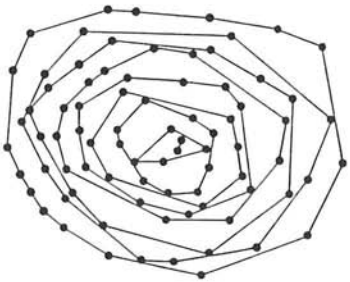


Fig.9. Grouped point objects and their convex hulls

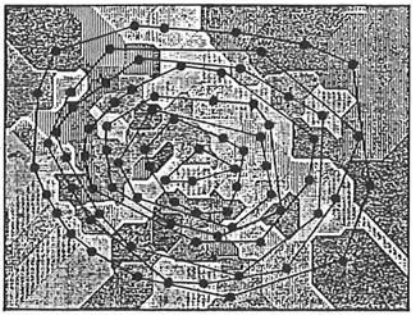
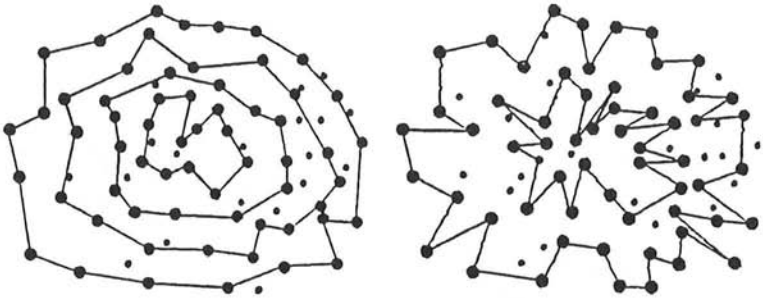


Fig.10 Voronoi diagram of the grouped point objects



a. Low degree generalization b. High degree generalization

Fig.11 Generalization of grouped point objects using the method of convex hulls

Acknowledgement

The author acknowledges the support of National Natural Science Foundation of China for the research.

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LINGUISTIC CHARACTERISTICS AND AUTOMATIC UNDERSTANDING OF CARTOGRAPHIC INFORMATION

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Abstract The widely accepted map language concept is presented in this paper for its significance of promoting the progress of intelligent cartographic data processing and as a good framework to cover and guide the researches of automatic understanding of cartographic information. Several main points are discussed here based on the linguistic viewpoint of cartographic information, which include the formal and functional analogy of map with natural language, the Artificial Intelligence related impetus to our discipline besides as a understanding paradigm of cartography and finally the steps we should take facing the challenge.

Introduction

It is widely accepted that map is formally and functionally a kind of language, which has been long used as a understanding paradigm of cartography and the guide of map design. As the deepening of cartographic data processing , the linguistic characteristics of cartographic information find their new implementation. This paper concentrates on the old topic with the new application in consideration.

Map is regarded as a carrier of information and the symbolic representation of map a two-dimensional graphic language. Natural linguistics has developed for more than one hundred of years. And automatic understanding of natural language, as the focus of Artificial Intelligence has brought us into the times of machine interpretation. One the other hand, the development of Computer-assisted Cartography and GIS has made little advance in cartographic language , especially for the purpose of machine interpretation of graphic information, which has become the bottle-neck of any progress in intelligent data processing in cartography and GIS such as automatic generalization of cartographic and geographic information . We must find the solution back from map itself .

Linguistic Characteristics of Cartographic Information

It is a long time since cartographer began to refer map frequently as a kind of language. Cartographer have noticed the similarity of map with natural language and map is considered as a representation with its own syntax like natural language.

The cognition of linguistic characteristics of cartographic information came very likely from intuition at the very beginning. As we think more about it, we must acknowledge that map is analogical with nsatural language from at least the following two aspects.

1.*Analogy by Form*

Natural language is linear and one dimensional sequence in its form. It is constructed by a hierarchical structure in which different language units with different meaning resided in, among which phoneme is the basic unit and in which some well-known concepts such as word, phase, sentence and paragraph etc. are included. Syntax represents the constructive laws of various language units.

Graphic is basically the extension of natural language, in which the most significant extension is in dimension. Graphic language is typically 2-dimensional. With the dimensional extension it becomes more compound in its constructive laws. Graphic language possesses most of characteristics of natural language and also a lot of specific characteristics.

2.*Analogy by Function*

More strong argument comes from the functional equivalence of the both, while both of them are alternative efficient information carrier for communication. They share the same processes of encoding of information sender and decoding of information receiver, although for graphic both processes are more complicated and professional.

Nevertheless, simple and mechanical analogy will not work. Graphic language and natural language are anyway different things. A practical attitude is that we should not attempt the exact analogy but just borrow the philosophy and research methodology. For example we can not exactly find the counterparts natural language units and constructive laws in graphic language, but we can take the hierarchical constructive mode of natural language like in computational linguistics. In other word we adopt only a linguistic viewpoint to our discipline.

What Linguistic Viewpoint Brings to Our Discipline

The linguistic viewpoint of cartography brings us foremost a kind of philosophy and methodology. Because language is the most common phenomenon of human society, it is the key topic of so many researches. Linguistics is constantly developed to a large family of branches which extend to every field where language exerts its influence.

Linguistics is more and more a universal methodology rather than a particular discipline. With linguistic method, we can review our discipline to find what we can do with map as "the second language" of human being.

Analogizing map with language offers us a good framework of formalize our discipline. Following are the branches of Linguistics and their possible counterparts in Cartography:

1.*Phonology*

Phonology is about the basic units of spoken language and their distinctive feature(DF). In cartography we have researches about visual variables, including size, shape, texture, hue, value, orientation and location etc., this meaning-free variables construct meaningful map symbol just like meaning-free phonemes combine to meaningful word. The variables and their combinations are much richer as new visualization means brought by computer graphics, which should be constantly researched.

2.*Syntax*

Syntax is about the constructive law from phonemes to word and words to sentence. The existence of syntax is most recognized by cartographer to describe the related set of map symbols as a whole to represent a higher level of geographic meaning, nevertheless, this field should be exclusively paid more attention , especially when we take computer technology into account. Map design technology is close related to this field.

Syntax of map is subordinated to that of general graphic language. Apart of semantic, all graphic forms share common syntax. The context-free law of how different graphic variables construct symbol and how symbols combine spatially to higher level pattern (chunking process) are main content of syntax of graphic. 2- even 3-dimensional graphic syntax possesses much more operational possibility of basic units than linear natural language syntax, some examples of which include intersecting, parallelling, connecting, separating, containing, bounding and co-bounding etc.

There exists also dispute about whether syntax exists for map and what dominate the combination of map symbols. However, we should agree on its existence because it is the underlying law that makes map a map but not other thing, although the syntax of map is dominated partially by geographic laws at its root.

3.*Semantics*

Semantics is connected with the meaning of word and sentence, which associates language and the reality it describes. In cartography symbol is ideographic, map design, first of all symbol design is very close related to geographic meaning from the very beginning, not to mention map use. The research of semantics can not separated from that of syntax. Semantic is basically realized in two levels, one is symbol recognition

which deals with the meaning of single symbol, another is symbol syntagme and paradigme which deals with the construction of higher level of geographic entity.

4.*Pragmatics*

Pragmatics touches upon the usage of language. In our discipline map use has become the widely concerned topic as much as map production. It is the common acceptance that the development of cartography depends on map use to a great extent.

5.*Psycholinguistics*

The relation between cartography and psychology is often mentioned. Cognitive cartography is the common interest of many cartographers. The psychological process of map reader is critical to map understanding and exerts considerable influence to map design.

6.*Mathematical Linguistics*

Mathematical Linguistics consists of Statistical Linguistics and Algebraic Linguistics. Cartographers keep trying to apply mathematic model to recognize and describe the internal structure of map and direct the procedure of map production. Mathematic Cartography is one of the most fruitful fields in our discipline.

7.*Computational Linguistics*

Computational Linguistics is a new branch of Linguistics. It concerns with the language processing with computer. It is the highlight of linguistic research for it is related to machine interpretation, which requires the overall progress of linguistic research. The automatic understanding of natural language has become an indicator of how intelligent computer is and thus the focus of Artificial Intelligence. In Cartography what we can do now is to utilize computer to capture, manage and output cartographic information, among which computer can complete some less intelligent tasks. Application of computer in cartographic data processing is the most active field., however more intelligent data processing ,e.g. map generalization, is not yet available.

There are also other analogical field such as application of comparative method in cartography. We have to notice the close relation between the two disciplines which seem apart from each other. We should not ignore the long history and adorable research achievements of Linguistics.

Besides a understanding paradigm, linguistic viewpoint of cartography offers us very practical guide and stimulation that we should pay more attention to real intelligent processing of cartographic information in the era of computer technology, when more and more computer scientists even linguists begin to be concerned with the graphic processing especially intelligent processing, while in the past their main attention is paid on the text processing

Automatic Understanding of Cartographic Information

Computer-Aided Cartography and GIS technology has greatly changed our discipline. As the deepening of computer application in cartography, more and more manual work are now fulfilled automatically by computer.

Up to now the advantage of computer over human is in those simple and repeated work, while the shortage of computer is shown in the intelligent and knowledge based assignment. The fact is that we are urgently in need of a framework to formalize cartographic knowledge and make them acceptable by computer so that computer can become more and more intelligent. What the linguistic viewpoint of map gives us is such a good framework.

Foremost any intelligent processing of cartographic information is based on the understanding of map. This fact could be widely recognized, however little progress has been made in this field in the past years. The situation is partially due to the absence of a theoretical system for cartography to cover and guide all researches toward this direction. Map is a typical example and one of the most important parts of graphic representation, so the understanding of map is tightly connected with many related disciplines, in which Digital Image Processing and Computer Vision are included. With the background we should say many significant approaches have been proposed, however, they scatter over different disciplines for various purposes. A good and practical theoretical framework should be the most important step we must take to integrate these approaches and carry the researches forward for our discipline.

1. *What Automatic Understanding Means for our discipline*

Our discipline is in a critical crossway as the coming of information era. Computer technology changes many aspects of cartography. Conventional cartographic view is constantly changing. We must re-think it in a digital environment where media and tools of mapping, methods of visualization, channels of communication and modes of map use are considerably enriched.

It has been proved by practice that cartographic intelligent processing can only be promoted by us cartographer, or less absolutely, any progress in intelligent processing must be made by professional research of cartography, it is not only for the attention of AI scientist is not yet extended to our discipline, but also for cartographic knowledge is the basis for cartographic data processing.

Automatic understanding of cartographic information is the basic issue of intelligent processing of cartographic data, just like the basic issue of AI is automatic understanding of natural language. It should be recognized to the high level that *automatic understanding is the part of AI which leads to computer's understanding ability not only*

limited in verbal language but also extended to graphic language like maps. AI without graphic and cartographic understanding is not perfect at all.

Automatic understanding is the pre-requiste of computer's substitution for human intelligent work including in map design and map use. According to researches of natural language understanding, automatic understanding can be measured by four standards: question-answering, summarizing, paraphrase and translation. Accordingly we can measure cartographic understanding by at least following standards:

- Ability to individualize basic cartographic object from an analog map in both raster and vector format;
- Ability to integrate basic cartographic objects into higher-leveled and complex geographic entity;
- Ability to visualize and symbolize digital information into standard analog map;
- Ability to change among different mapping strategies;
- Ability to draw out geographic information and re-tell them in another non-cartographic languages such as mathematical model, text, table, chart or other graphic forms;

We can also enumerate many standards it should meet. All of them must be knowledge-based and free of human-involving.

2. *Way Leading to Automatic Understanding*

The current status of automatic understanding is just in its initial stage and yet optimistic. In the researches of last decades in CAC and GIS and other related disciplines, those knowledge relatively easy to be formalized has been embodied in computer software to solve some intelligent tasks.

On the other hand, we are facing unprecedented difficulty in CAC and GIS field, after simpler tasks have already been solved by computer. Computer needs more cartographic knowledge to solve more complex tasks other than interactive data processing , data management and pre-defined visualization etc.. Back to cartography we have done little to make our cartographic knowledge formalized, even the objective and rational side of them summarised. A throughout investigation of cartographic knowledge is obviously necessary for the purpose of map understanding.

We can draw out a sketch which leads to formation of formal cartographic language and automatic understanding of cartographic information based on linguistic viewpoint.

- The basic language unit of map ,which is equal to graphic element indispensable in any AI approaches should be foremost checked. Map symbol is generally viewed as the basic language unit of map, but what is a real symbol especially linear and areal symbol needs further discussion. In addition, cartographic entity in digital environment has much more forms such as in raster mode and vector mode, which are always alternatively important for different processing task.

- The possible mechanism of attribution and spatial based combination of the basic language unit into higher level of language unit should be then checked. Here syntax and semanteme of cartographic information will take effect. This combination process is comparable with chunking in natural language. This step could be the most important and the most difficult in the formalization of cartographic knowledge. It is also connected with knowledge of neighbour disciplines such as Geography and Geometry related theory. The hierarchy of language unit and their interrelation embodied with different 2-dimensional operations will sketch out a integrated system of cartographic language. This step is basically the task of cartographer which can not be completed by anyone else.

- The rapid development of computer technology especially AI technology will help us carry out the next step. We must take the best computer technology to capture, represent and utilize our knowledge about cartographic language in computer environment. Here we have a large amount of research achievement to borrow from. Some successful methods have been proposed for cartographic processing in some special field of CAC and GIS such as in full automatic digitisation of map. Because the research of machine understanding of natural language has introduced many achievements from disciplines such as cognitive , communicative and psychological theory, various theoretical concepts of cartography can find technological application here. This field will continue to develop and offer us more technology, but critical effort must be made in our own discipline.

We have a long way to go, and every step forward is significant and promising. From simple to complex, from low level to high level, we adopt appropriate strategy to make our cartographic knowledge understandable by computer, in the same time, we are reviewing our discipline and preparing for the challenge of the new era.

Conclusion

Map language concept is called "third force in cartographic theory", which can be a good understanding paradigm of our discipline combining with other theoretical concepts. But it is not the only thing linguistic viewpoint brings to us. A down-to-earth research of cartographic language will promote our discipline. Besides a tool, computer also gives us an impetus to reform our knowledge, idea and understanding model.

Acknowledgements

The author acknowledges the support of National Natural Science Foundation of China and Huo Yingdong Educational Foundation of National Education Committee of China for this research.

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MINING–GEOLOGICAL MAP — A NEW TYPE OF LAND–USE MAPS.

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One of the objectives of economical and social development is utilization of underground space that was formed by geological medium within the economically reasonable and technically accessible. The planning of the underground space utilization calls for the assessment of its parameters from the standpoint of feasibility and economic expediency of its development. It is advisable to undertake such evaluation first at the regional level with subsequent selection of some limited areas, whose geological medium is most favourable for the underground development. This evaluation necessitates the creation of a new type of maps that can be referred to as mining–geological maps.

This type comprises different maps (map showing condition of development of underground space; map showing possible burial grounds for waste including highly radioactive waste; maps showing complexity of geological conditions for undertaking geological prospecting; predictive maps of geomechanical and other factors affecting the geological medium; etc.). The preparation of the above maps calls for the use of generalized emergent characteristics of geological medium and integrated evaluation of its features which are specific for a particular cartographic problem.

One of the examples of the mining–geological maps is the "Map showing condition of development of underground space in Russia" on 1 : 10 000 000 scale, which is part of the Geological Atlas of Russia (1996). It contains evaluation of the suitability (favourability) of geological medium for the development of underground space and the prospects of such development in different parts of Russia.

In recent decades, the underground space is increasingly utilized as a place for setting up industrial units harmful for people and environments (nuclear power stations, etc.), for storing various products, underground constructions (factories, tunnels, etc.), burial of harmful waste, etc. It is also used for municipal needs (metropoliten, underground garages, shops and markets, etc.) and for defence purposes (underground military factories, silo command post, etc.).

The starting positions. By underground space, one understands part of geological medium situated at a depth, which is rational for the possible use in the next 20–25 years and in the more remote future (over 25 years).

Geological medium is a complex entity, composing rocks, geological bodies and structures formed by such rocks, fluids, flowing through such bodies and structures or saturating them (ground waters of different composition, etc.), geophysical and geochemical fields, generated by the above components. The character of geological medium is determined by the emergent combination of properties of its components.

The mining–geological characteristics of the medium and rocks massifs within its limits are controlled by multi–factor relationships between its components in hierarchical system of heterogeneities of the medium. The conventional geo–engineering classifications describe the rocks proper, not reflecting the character of the geological medium as a whole, primarily because of inadequate knowledge of the naturally strained conditions of rocks, the scale of effects and the complexity of processes of interrelation with engineering structures.

Therefore, as a theoretical basis, for regional evaluation of condition of development of underground space, we selected the general geological approach, which takes into consideration the most general emergent structural–compostional characteristics of geological medium. The classifications that are developed on this basis are empirical ones.

In a general way, the evaluation of geological medium as an underground space to be utilized can be done with reference to the generalized types of rock association and conditions under which it is subject to external forces.

At present, underground space is used mainly for locating various underground structures (including opening or holes which are formed as a result of mining of economic minerals). Accordingly, the main type of external action is geomechanical one, for which most important are mechanical properties of a rock massif as a whole. Properties of other components of the medium (fluids and, in the first place, ground waters, gases, geochemical and geophysical fields) are external in respect to geomechanical properties of the rock massif, though they may strongly influence the possibility of the underground space development (e.g. radon presence is an important negative factor, since radon being heavy inert gas has a tendency to accumulate in various underground cavities calling for certain ventilation).

Thus, the characteristics which determine the possibility to use underground space, can be divided into two groups:

a. internal factors of geological medium, i.e. the mining–geological properties of rock massifs, and

b. external factors, i.e. seismicity, dynamics and the properties of fluids (primarily — ground water), gaseous components, climatic factors (primarily — permafrost), and technogenic changes of the medium (including surface engineering factors), etc.

The internal factors are the homogeneity (continuity) and stability of rock massif, when inside it or on its surface opening are created. *The homogenity* — the rock–type composition of the geological medium does not change much over the area under discussion, folding is not pronounced (horizontal or gently dipping strata are prevalent), fracturing (including tectonic features) is slight and, accordingly, the permeability coefficient is low. The homogeneity (continuity) may be in one, two or three dimensions.

The stability — the geological medium may be quite stable on open slopes (up to vertical walls); in underground working, the support is necessary (but not always) mostly at the places of tectonic fractures.

The above characteristics depend on regional geological conditions, i.e. composition of rocks, composition and morphology of geological bodies and the extent to what the rock massif is disturbed by the interfaces (tectonic, sedimentogenic interfaces, etc.).

The external factors comprise:

a. geodynamic factors (seismicity, volcanism, and the like), which may adversely affect the safety of underground structures;

b. hydrogeological factors, which may be indicative of negative condition of underground space development. These are ground water regime (water–yielding capacity and character of ground water flow) and water composition (in particular, the degree of aggressiveness towards concrete and steel);

c. climatic factors — the permafrost helps increase the degree of homogeneity and, partially, stability, being favourable to storing certain substances and products;

d. geo–environmental factors — tectonic faults and areas of tectonic faults, which were active in the Quaternary period; radon hazard;

e. technogenic factors — the structures that may be damaged as a result of the utilization of the underground space (nuclear power stations, repositories of the nuclear cycle waste, oil and gas trunk–lines, railways) and the density of population (the utilization of underground space is, as a rule, economically expedient only in the areas with sufficiently dense population);

f. environmental conditions of different areas of Russia.

Two integral evaluations were used during compilation of the map:

1. *the degree of suitability* of the area — the integral assessment of the sum total of internal factors whether the underground space is suitable for the use, is given in three versions (suitable, moderately suitable, hardly suitable), and

2. *the degree of prospects* of development of underground space. This assessment into account the degree of suitability of mining–geological complexes and the external factors of development in their qualitative form (good prospects, moderate prospects, hardly prospects).

The depth of the development of underground space can be divided into three main levels: 1. from just a few meters to 50–70 m; such depth of development is normal for

populated areas and occasionally outside such areas (underground roads, storages, nuclear power stations, etc.); 2. from 70–100 m to 500–600 m. Specialized engineering structures outside city limits (underground storages of different kind, waste disposal sites, etc.); 3. from 500–600 m to 1000–1500 m; this level may be reached in the process of mining of solid economic minerals (the depth of hydrocarbon extraction is not taken into account). Because of small size of the utilized underground space, there is, as a rule, no point in evaluating the degree of suitability of the first depth interval. The use of underground space within a depth interval of 50 to 70 m in big cities is very close to the second case. Therefore, in the process of map compilation most attention was concentrated on the 50 to 500 m depth interval.

The main map unit for this purpose is **a mining–geological complex**, composed mainly of formations of approximate composition and characterized by the similar mode of occurrence of geological bodies, degree of variability of their composition, similar interfaces of geological bodies and the more or less similar degree of homogeneity and stability. The classification of mining–geological complexes is based on general geological laws governing the formation of petrological (lithological) composition of geological medium and its three–dimentional variations, it is also based on the presence and distinctness of interfaces between the tectonic complexes.

Map compilation procedure — the GIS technology in its manual version in the following succession:

1. The elaboration of classification of internal factors of underground space development aimed at singling out (on the basis of the character of homogeneity/continuity and stability) regional mining–geological complexes, geological bodies and tectonic structures through generalized description of their mining–geological and geo–engineering characteristics and the evaluation of the degree of suitability of the complexes for the underground space development.

2. The compilation of the layer of mining–geological complexes based on geological, formational, space–geological, mineragenic, etc. maps with the necessary generalization.

3. The compilation and generalization of layers of external factors (individually or by groups) on the basis of hydrogeological maps, maps of active Cenozoic faults, maps of space–geological objects, radon risk, seismisity, etc.

4. The elaboration of the cartographic design of the map.

5. The overlapping of layers in a single map, generalization, design work, and printing.

The legend consists of two blocks. The first one reflects the internal factors of geological medium as a characteristic of mining–geological complexes by such parameters as homogeneity (continuity), stability, and degree of suitability for the underground space development. The second block reflects the external factors, which may constrain or favour the utilization of the underground space. These factors are subdivided into natural and technogenic (man–made) ones, and also by their influence upon the degree of suitability.

The cartographic design is different for the two blocks of the legend. The main cartographic means. There, different colours are used like in the railway semaphore, i.e. suitable (favourable) complexes are shown by green colour, unsuitable (unfavourable) — by red colour, and the remaining complexes are shown by yellow and brown colour. Mining–geological complexes are denoted by two–letter indices, the first letter designating the tectonic structure, the second one — the generalized petrological/lithological composition.

The legend of the second block makes use of the not–to–scale symbols and hatching, the different colour being used for different groups of factors.

The map showing condition of development of underground space in Russia on 1 : 10 000 000 scale represents the first attempt to the regional description of this condition of the vast and diverse country. A comprehensive review of various factors has made it possible to work out general recommendations on the possibility of developing the underground space and singling out areas with good prospects of such development. The technique (permitting necessary amendments), that was worked out, can be used in the course of more detailed zoning of promising areas and as a basis for compiling more comprehensive maps of condition of underground space development.

MAIN STAGES OF GEOLOGICAL CARTOGRAPHY IN RUSSIA

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1st period - XVIII century. During the first 2/3 (approximately till the beginning of 70's), geological cartography was restricted to registration of mineral deposits and mines in general geographic maps. In the last third of the century (after 70's), compilation of geognostic maps, mainly with petrographic contents, reflecting occurrence fields of different rocks and sections, started. Among them is, for instance, the first geognostic map of the region of Nerchinsk Works (Transbaikal area). Geognostic mapping was mainly conducted on the medium and large scale for mining regions and mineral deposits. It was completed by compilation of the Atlas of mining regions and mines (1778-1779).

2nd period - 10's - 70's of the XIX century. At this stage, sketch geological research was conducted with compilation of small-scale band maps (along observation lines) and schematic geognostic and geological maps of the European part of Russia (V.T.Stragnweiis, 1824; A.K.Meiendorf, 1841; G.P.Gelmersen, 1841; R.I.Murchinson et al., 1845; etc.). In the course of this research, general geological features of this territory were revealed and a new geological unit of the General Stratigraphic Scale was distinguished - the Permian system. At the same time, compilation of detailed geognostic (essentially petrographic) maps of mines, deposits, and mining regions was carried on.

3rd period - 80's of the XIX century - 10's of the XX century. The most notable event of this period was organization of the Geological Committee of Russia. The Committee, from the beginning of its activity, placed major emphasis on unification of symbols in geological maps; proposals on cartographic design of geological maps, developed by its member A.P.Karpinsky, were approved by the 2nd Session of the International Geological Congress (Bologna, 1882) and had a significant effect on development of the world geological cartography. Modern colour ranges in geological maps, symbols for designating elements of rock layers occurrence,

a system of indices for geological units are in most countries based on developments of the Committee (A.P.Karpinsky, 1882).

From the very beginning of its activity, the Committee started systematic geological mapping of the European Russia and compilation of geological maps on 1 : 420 000 scale ("ten-verst" - its scale is 10 versts in 1 inch; a verst is 1.06 km). During the 3rd period, 30 Sheets of this Map were published. For this Map, the Committee developed a special instruction (1883). Simultaneously, the Committee was compiling and publishing a number of geological maps on a smaller scale for extensive territory of the European Russia: 1892 - Geological Map of the European Russia on 1 : 2 520 000 scale (supplemented and re-published in 1915); 1897, Geological Map of the European Russia on 1 : 6 300 000 scale; from 1893, compilation of Sheets of the International Geological Map of Europe on 1 : 1 500 000 scale started, which cover the territory of Russia, etc.

For solving practical tasks of public economy, the Committee also accomplished a number of more detailed studies on 1 : 168 000 - 1 : 42 000 scale for industrially developed territories (Donets Basin, Urals etc.). In the Asian part of Russia, the research based on certain routes was conducted; it was mostly connected with solution of practical tasks (such as, for instance, research along the Trans-Siberian Railway construction line, etc.).

Generally, the considered period laid foundations of the Russian geological cartographic school. Theoretical cartographic developments, accomplished at that time, were of great significance for the world geological cartography. At the same time, theoretical developments on cartography were of a normative character, having predetermined subsequent normative development of geological cartographic work, which was clearly demonstrated in the XX century. A characteristic feature of contents of geological maps during this period was prevailing stratigraphic (age) approach to distinguishing objects of mapping. Lithostratigraphic approach, based on the study of petrological composition of geological formations, is only starting to be formed in the course of detailed geological surveying and compilation of large-scale geological maps for regions, which are of practical interest (Donets Basin etc.).

4th period - 20's - 40's of the XX century. During this period, small-scale geological mapping of the European part of the USSR is carried on: in 1932, the Map of Quaternary deposits of the European part of the USSR on 1 : 2 500 000 scale was published, and in 1933, the Geological Map of the European Part of the USSR on 1 : 2 520 000 scale. Simultaneously, extensive mapping of the Asian part of the USSR started. As far back as 1922, the Geological Map of the Asian Russia on 1 : 10 500 000 scale was compiled and published; and in 1927, the Geological Map of the Asian Part of the USSR on 1 : 4 200 000 scale. Later, this made it possible in 1937, to the 17th

Session of the International Geological Congress (Moscow, 1937) to compile the Geological Map of the entire territory of the USSR on 1 : 5 000 000 scale; and in 1940, on 1 : 2 500 000 scale.

Geological surveying on 1 : 420 000 - 1 : 1 000 000 scale during this period to a certain degree covered the entire territory of the country. By the end of the 30's, surveying covered 45% of the territory, and compilation of maps for the European part (including Urals and Caucasus) had been completed; maps had also been compiled for large territories of Kazakhstan, Central Asia, North East of the country and mountain structures of southern Siberia. Since the end of the 30's, systematic preparation for publication and publication of the geological map on 1 : 1 000 000 scale started (unfortunately, it was interrupted by the 2nd World War; really extensive compilation was conducted during the subsequent period).

More detailed geological and hydrogeological surveying was extensively conducted on 1 : 200 000 scale (several Sheets were published before the 2nd World War) and within limited areas in mining regions, large cities, etc., on 1 : 100 000 and larger. By the end of 30's, surveying on 1 : 200 000 scale had covered more than 9% of the country (as compared to 0.2% during the preceeding period); and that on 1 : 100 000 or larger scale, 4.5% (as compared to 0.45% during the 3rd period).

During this period, the content of small- and medium-scale geological maps starts changing - distinguishing of cartographic units acquires lithostratigraphic features, which makes this period clearly different from predominantly stratigraphic (and often also biostratigraphic) distinguishing of these units during the preceding period. This change is associated with the necessity of solving a more extensive range of practical tasks (primarily connected with extension of raw-material base of the country), for which purely stratigraphic solutions appeared to be insufficient (Instruction, 1933).

Theoretical developments of this period are mainly noted by a normative character of definition of requirements to maps with geological contents.

5th period - the second half of 40's - the first half of 60's of the XX century. This period is noted for a more detailed and diverse, than previous, geological study of entire territory on 1 : 200 000 (1 : 100 000) scale, and later, on 1 : 50 000 (1 : 25 000) scale.

Starting with the second half of the 40's, mass compilation and publication of geological maps on 1 : 1 000 000 scale for the country's territory, interrupted by the War, was recommenced. Compilation of the first edition of these maps was completed at the end of the period (1966).

From the beginning of the period, large regions were covered by geological and hydrogeological surveying on 1 : 200 000 scale; and from the mid-50's, following the Resolution of the USSR Government (1954), extensive

compilation and publication of the State geological and hydrogeological maps on 1 : 200 000 scale commenced.

Geological surveying on 1 : 50 000 (1 : 25 000) scale at the beginning of the period was still concentrated within limited regions, which were of the greatest practical significance (mining regions etc.). However, starting with the end of 50's - the beginning of 60's, areas covered by this surveying increase markedly, signifying transition to the next period.

Along with growing extent of medium- and partly large-scale mapping, compilation of small-scale maps for the entire territory of the country and some of its regions is carried on. At this time, several geological maps of the USSR on 1 : 2 500 000 - 1 : 7 500 000 scale are compiled, maps of Quaternary system of the European part on 1 : 2 500 000 scale etc.

Characteristic features of content of geological mapping during the 5th period are:

a) enhancement of lithostratigraphic approach, recorded in the 4th period, partly also extended to cover compilation of small-scale maps in the form of presentation of petrological composition of mapped units;

b) transition to Atlas mapping in the form of preparation and publication of map sets on each geodetic trapezium - for instance, the State Geological Map on 1 : 200 000 scale comprised geological maps, registration map of mineral resources, and, in some regions, map of Quaternary deposits and hydrogeological map. Later, the Atlas approach to mapping becomes the basic one for geological mapping of Russia.

Theoretical developments are still mainly of normative character, in the form of compilation of detailed instructive documents, regulating contents and cartographic design of geological maps. These developments were necessary due to a marked increase in the number of young specialists, for whom normative indications were necessary to ensure uniformity of geological cartographic information. The instructive documents became widespread in socialist countries - Instructions on geological surveying on 1 : 299 999 scale and preparation for publication of geological maps on this scale were translated into Chinese, Polish and other languages and were adopted as common documents at Geological Surveys of some countries.

6th period - the second half of 60's - the first half of 80's - is noted for several characteristic features:

In small-scale mapping, compilation and publication of diverse maps with geological contents for the entire territory of the country was carried on: geological maps with usual contents, maps of Quaternary deposits etc. Simultaneously, the development, compilation and publication of some new types of maps with geological contents started: maps of crystalline basement of the Russian Platform, tectonic (including structural formational maps), maps of sedimentary, volcanogenic, and magmatic formations, mineral deposits (among them metallogenic), hydrogeological (including

hydrochemical), engineering geological and other maps on different scale for the entire territory of the USSR and many of its regions. During this period, the Atlas of Geological and Geophysical Maps of the USSR on 1 : 10 000 000 scale was compiled and published (Editor-in-Chief A.A.Smyslov, 1982) and Atlas of Hydrogeological and Engineering Geological Maps of the USSR (1977).

During this period, several Maps of the World and Continents were published. A number of Sheets of the 2nd edition of the International Geological Map of Europe were published, as well as the unique Geological Globe of the World on 1 : 15 000 000 scale (1977), Geological Map of World continents on 1 : 15 000 000 scale (1973), Geological Map of the Pacific mobile Belt and Pacific Ocean (1973), Geological Map of Eurasia on 1 : 1 000 000 scale (1975). Contemporaneously, several historical geological maps were compiled - Atlas of Lithological Paleogeographic Maps of the USSR (1967), a set of Paleotectonic Maps of the USSR on 1 : 5 000 000 scale (1977, 1979) etc.

From 1963, compilation of the new series of State geological maps on 1 : 1 000 000 scale in a new enlarged Sheet division and in accordance with new instructive documents (see the paper by V.K.Putintsev et al.) begins. The new series of maps on 1 : 1 000 000 comprised for each Sheet both obligatory maps of pre-Quaternary formations and minerals, and a number of additional special maps, depending on specific features of mapped area and its development potentials (Quaternary formations, groundwater, prediction for oil and gas, and subsurface structure for platform areas). Therefore, the new series developed the Atlas approach to geological mapping, which allows a sufficiently diverse characteristic of geological structure and a more complete satisfaction of requirements of society for the geological base for public economy.

During this period, the study of the country on 1 : 200 000 was practically completed (by the mid-80's, over 90% of the territory had been covered by surveying on this scale), and a significant part of ready maps on this scale (over 60%) was published.

The 6th period is the time of intense geological surveying on 1 : 50 000 (1 : 25 000) scale - by the end of this period, about 30% of the territory of the former USSR were covered by surveying on this scale. Large-scale surveying during this period is noted for two specific features, distinguishing it from earlier surveying:

a) it has a more distinct practical orientation and is, particularly, accompanied by application of diverse methods of mineral prospecting (geochemical, geophysical, geological etc.);

b) clearly distinguished in it is the Atlas approach to mapping, primarily in the use of diverse methods of studying the territory - geological, geochemical, geophysical, materials of space surveying etc., with compilation of the corresponding maps.

During this period, the first theoretical works on geological cartography appear (Yu.A.Kosygin, V.Yu.Zabrodin, V.A.Soloviev and others), which are, however, mainly of a general theoretical character. Nevertheless, most of developments on geological cartography still have a normative character, being presented as different instructive documents. The negative feature of the period is delay with transition to applying new geological theories, primarily lithosphere plate tectonics.

7th period - end of 80's - beginning of 90's - time of restructuring of the entire system of geological mapping (see the paper by A.F.Morozov). The most characteristic features of the period are renewal of extensive compilation of geological maps on 1 : 200 000 scale, primarily those based on materials of geological surveying on 1 : 50 000 scale, and change in the status of geological surveying on 1: 50 000 scale (it loses the federal status, which they it in the past). In the new series of geological maps on 1 : 200 000 scale, the Atlas approach, which had long been developed by the Russian geological cartography, was even more evident - the new map represents a set of three obligatory maps (geological map of pre-Quaternary formations, Quaternary formations, and mineral resources and their distribution pattern) and some additional maps on the same or smaller scale, whose compilation is determined by specific geological structure and practical requirements of development of the territory. The new series is based on a special instruction, which represents a new step in development of contents and cartographic design of geological maps. This instruction is a creative presentation of evolution experience of the Russian and world geological cartography and contains are several original cartographic developments.

Among small-scale geological cartographic works, it is necessary to place special emphasis on compilation and publication of the Geological Atlas of Russia on 1 : 10 000 000 scale (Editor-in-Chief A.A.Smyslov, 1996). The Atlas comprises 40 maps of diverse geological content, including some new types of maps (economic geological conditions, engineering ecological, showing conditions of subterranean space development, objects of nuclear fuel cycle etc.). The Atlas has no equivalents in world geological practice in its the scientific geological foundations and complex characteristic of geological structure, mineral resources, conditions of their exploitation and conditions for development of geological environment. A number of theoretical problems of geological cartography were solved in the course of its compilation, reflected in Explanatory Notes for maps.

Theoretical developments of this period consisted in elaboration of the cartographic research method in geological studies (works by A.M.Berlyant, A.I.Burde and others), developments of new types of maps with geological contents (A.A.Smyslov, B.A.Ivanov, A.I.Burde and others) and renewal of

instructive documents on geological maps and surveying on 1 : 200 000 and 1 : 50 000 scale.

Development of Russian geological cartography during three centuries from the beginning of the XVIII to the end of the XX century proceeded in accordance with development of world geological cartography. In certain aspects, the results obtained by Russian geological cartography were important not only for Russia, but also for the world geological cartography. Special emphasis should be placed on the Atlas approach realized as several sets of maps and geological atlases. At the same time, there are also some negative aspects of development of Russian geological cartography; this is primarily enthusiasm for normative cartographic trend along with insufficient development of the theory of geological cartography, and theory and practice of studying maps with geological contents.

INDOOR RADON, ACTION LEVEL, AND CHOROPLETH GENERALIZATION: THE POLITICAL-SCIENTIFIC CONSTRUCTION OF AN ENVIRONMENTAL RISK MAP

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Introduction

In 1993, the U.S. Environmental Protection Agency (EPA) issued a large (68 by 52 cm) three-color map that assigned each of the nation's 3,141 counties to a category described in the key merely as "Zone 1," "Zone 2," or "Zone 3." Titled "EPA Map of Radon Zones," this vaguely labeled map is an exemplar of environmental propaganda. Brilliant red area symbols in Zone 1 counties warn of average indoor radon concentrations exceeding the EPA's action level of 4 picocuries per liter (pCi/L), whereas orange and yellow announce lower but nonetheless serious levels of 2–4 and <2 pCi/L throughout the remainder of the country. This paper examines scientific, political, and cartographic issues underlying a flawed and biased map that was neither wholly unreasonable nor fully adequate.

Radon as an environmental hazard

As a colorless, odorless, and potentially lethal gas, radon is a significant but newly recognized health hazard (Brodansky 1987). A product of the radioactive decay of radium, which occurs naturally in rocks and soil, radon is an inert gas that seeps into buildings through cracks or pores in the foundation. Its most stable and common isotope, Radon-222, is the result of the nuclear disintegration of Radium-226, itself a decay product of uranium. With a half-life of 1,600 years, Radium-226 is comparatively stable and relatively harmless. By contrast, Radon-222, with a half-life of only 3.8 days, is merely the first link in a chain of five much more rapid atomic disintegrations, each of which yields a highly unstable isotope of polonium, lead, or bismuth as well as an alpha or a beta particle. Alpha particles are the real danger: despite a range of only 50 microns (0.05 mm), they can strip electrons from atoms, create free radicals, and damage genes. These particles attack the lungs because radon atoms attach readily to tiny, aerosol-size particles of dust and moisture—

miniature Trojan horses that settle on the outer, mucous layer of the lungs when we breathe. The health risk is thus greater in homes with higher levels of radon.

American epidemiologists largely ignored indoor radon until 1985, when Stanley Watras, an engineer at the Limekiln nuclear power station, near Pottstown, Pennsylvania, set off a walk-through radiation monitor (Reilly 1990). Intended to detect contamination among employees leaving for the day, the monitor sounded its alarm when Watras reported for his shift. Investigators looked first for an abnormal occupational exposure within the plant. Finding none, they checked Watras's home, which registered an extraordinarily high concentration of radon gas—greater than 2,000 pCi/L. Although concentrations seemed normal in neighboring homes, unusually high residential radon levels in the community suggested a far greater hazard, worldwide as well as national in scope.

Because all air, outdoor and indoor, contains radon, the obvious question was: How high is too high? Or, in other words, at what concentration should a home-owner or landlord take action to reduce or eliminate the hazard? To address this question, public health officials turned to the most relevant data on low-level exposure to airborne radionuclides: the exposure and mortality rates of uranium miners who in the 1940s and 1950s worked long hours in confined spaces with what were believed to be above-average yet nonetheless acceptable levels of radioactive aerosols. Although the health effects of this exposure were not immediately apparent, uranium miners as a group have experienced markedly above-average mortality rates for lung cancer.

The linear hypothesis

To assess the mortality consequences of much lower levels of radon, epidemiologists applied the so-called *linear dose-response model*. Widely used to estimate radiological hazards, the linear hypothesis assumes that exposure to radiation has an arithmetically incremental effect (Harley and Harley 1991). That is, if a cumulative exposure to X units of ionizing radiation results in 50 cases of lung cancer in a population of 10,000 people, a cumulative exposure to 2X units would yield 100 cases. Figure 1 describes the use of this assumption to relate the extraordinarily high exposures of uranium miners, represented by the dot at the upper right, to more typical residential exposures at the lower left. In this example, the high occupational exposure anchors a model line drawn outward from the graph's origin. At the lower left, near the origin, a line drawn upward from the horizontal axis represents a much lower residential dose, and the point at which this vertical line intersects the model represents the estimated response: the level of risk measured as a mortality rate, which can be used to compute expected deaths among the population at risk. That in a nutshell is how health physicists concluded (1) that indoor radon accounts for 7,000 to 30,000 lung-cancer deaths annually in the United States and (2) that indoor radon concentrations of 4 pCi/L or higher call for repairing a home's foundation or improving its ventilation (U.S. Environmental Protection Agency 1992).

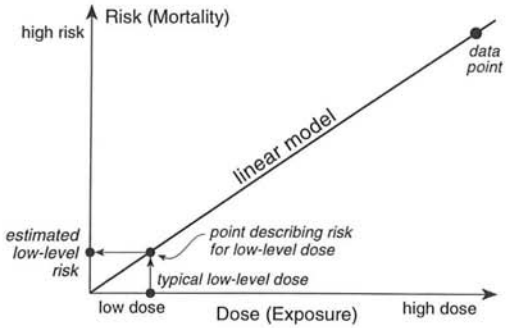

Figure 1: Use of the linear dose-response model to estimate the health risk of a low-level dose of ionizing radiation.

Critics of the linear hypothesis point out that the model is little more than an educated guess (Martel 1987). Without intermediate data points, they contend, there is no way of knowing that a straight line is more appropriate than one of the alternative models in Figure 2. Some scientists argue that the linear assumption overstates a hazard better represented by a *linear-quadratic* function, whereby risk increases at a faster rate than exposure, or by a *linear-threshold* model, which postulates an essentially harmless threshold dose. By contrast, advocates of the *supralinear* model allege that the linear hypothesis underestimates the impact of low-level exposures. Without convincing data, these opposing arguments cancel one another, leaving the linear assumption as the simplest, most plausible interpretation.

A flawed, overly steep model?

A more serious objection to the 4 pCi/L action level accuses health physicists of underestimating the radiation doses received by uranium miners. Figure 3 explains this challenge. The relatively reliable model represented by the moderately sloping line through the high-dose area at the upper right forecasts a comparatively low risk for a much lower, more or less typical dose of indoor radon. But if, as critics charge, the original studies overestimated the miners' dose, the result is a flawed model,

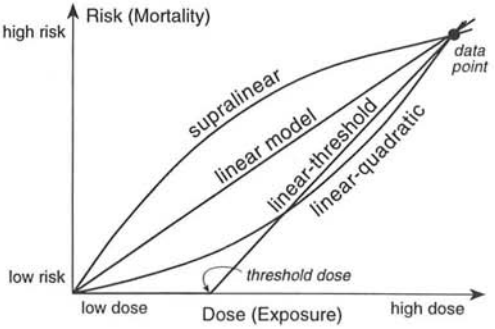

Figure 2: Alternatives to the linear dose-response model.

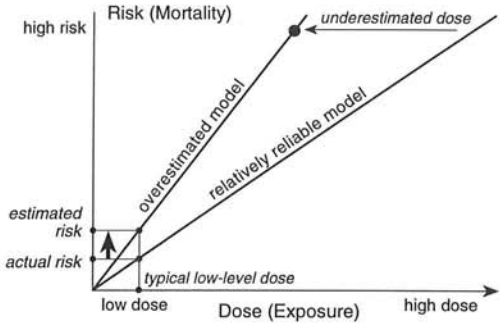

Figure 3: Underestimation of the dose exaggerates the risk.

anchored on a point farther to the left, which yields a more steeply sloping line, which in turn overestimates the risk associated with the same low-level indoor exposure. (To understand better this apparent paradox, consider that if uranium miners had received little more radiation than average homeowners, many more of us might look forward to an early, radon-induced death.)

There is convincing evidence that the original epidemiological studies had underestimated the miners' exposure by assuming working conditions no worse than officially tolerated levels. Interviews with survivors indicate that many miners worked longer hours than reported, under conditions markedly more severe than allowed (Abelson 1991a). Moreover, miners who smoked—and most of them apparently did—were exposed to a demonstrably riskier hazard, tobacco, which might account for many, and perhaps most, of their cohort's "excess deaths." These charges provoked considerable scientific debate over whether indoor radon was a serious threat. Philip Abelson, a former editor of *Science* and a fierce critic of the 4 pCi/L action level, accused the EPA of deliberately frightening the public. In ridiculing the agency for endorsing an earlier annual estimate of 43,000 radon-induced deaths, Abelson (1991b) observed that some studies "seemed to demonstrate that, if anything, moderate levels of radon are beneficial to the public health."

Abelson was not the EPA's only critic. According to Anthony Nero (1992), a respected physicist at Lawrence Berkeley National Laboratory, the 4 pCi/L action level not only exaggerated the threat but spread detection and remediation efforts too thinly over too wide an area. Instead of exaggerating the threat, the agency should focus its efforts on the country's "hottest homes," in areas where a high geologic potential for radon warranted revised building codes and the more careful testing of all dwellings. The American strategy, he argued, was less efficient than Canada's approach, based on a less alarmist action level of 20 pCi/L.

Political scientist Leonard Cole (1994, 28) not only challenged the EPA's science but questioned its motives. Radon, he maintained, afforded "a unique opportunity" for both politicians and regulators:

> Unlike most environmental hazards, radon is largely a natural phenomenon with no industry to blame for its presence. Moreover, present policy urges that homeowners pay for testing and fixing out of their own pockets. The financial cost to government is negligible, and "protecting" homeowners against the gas has been more politically convenient than for other alleged hazards. The absence of an industrial "culprit" means the absence of an interested party who might be expected to underscore the uncertainties about the issue. This has made it easier for political and regulatory leaders to push aggressive policies of questionable warrant. For public officials, radon is environmentalism on the cheap.

Despite such criticism, the EPA steadfastly affirms its 4 pCi/L action level, adopted in 1986.

Mapping the radon hazard at the national scale

Electing to err on the side of extreme caution, EPA officials must have been uneasy about their map of "Areas with Potentially High Radon Levels" included in Michael Lafavore's 1987 book, *Radon, the Invisible Threat: What It Is, Where It Is, How to Keep Your Home Safe*. Developed jointly with the U.S. Geological Survey and based on limited measurements, the black-and-white map clearly understated the area in which indoor concentrations of 4 pCi/L or more were not only likely but common, and required an elaborate disclaimer. Even so, this "interim" exhibit was no doubt useful in persuading the Congress to fund the national survey needed for the more authoritative cartographic statement published in 1993. (See Monmonier (1997, 174–86) for a more detailed account of the EPA radon map and its predecessors.)

An accompanying "fact sheet" attributes the 1993 "EPA Map of Radon Zones" to sections 307 and 309 of the 1988 Indoor Radon Abatement Act, which provided initial funding for a multi-year collaborative effort by the EPA, the U.S. Geological Survey, and the Association of American State Geologists. The House of Representatives committee that developed the Act "expect[ed the] EPA to provide to the public information on outdoor radon levels at a degree of geographic resolution that is accurate and useful to the public" (1988 U.S. Code Cong & Adm News, p. 3617). But the law itself offered no guidance on geographic detail and said nothing about a small-scale national map. Section 307, addressing "Radon in Schools," directed the EPA to "identify and compile a list of areas within the United States which the Administrator [of the EPA] determines have a high probability of including schools which have elevated levels of radon" (15 USC 2667). And Section 309, titled "Study of Radon in Federal Buildings," called for "a list of areas within the United States which the Administrator, in consultation with Federal departments and agencies, determines have a high probability of including Federal buildings which have elevated levels of radon" (15 USC 2669). American lawmakers, it appears, are more comfortable with lists than with maps.

Based on tenuous measurements and tendentious assumptions, a small-scale national map of radon might seem the epitome of cartographic generalization. As

demonstrated by radon testing in the Watras neighborhood, indoor radon can vary widely within a locality, even where bedrock geology suggests a high potential for radon. Factors that affect indoor concentration include depth to bedrock, use of insulation, condition of the foundation, and lifestyle of the occupants—because frequently opened doors promote an exchange of indoor air and outdoor air, a large family with pets typically has a lower level of radon than, for example, an elderly couple. Topographic situation is also important: built into the side of a hill on thin soil, a house with well-insulated walls easily accumulates more radon than a less-well insulated house built on a slab in a region comparatively rich in uranium and radium. Although these uncertainties might argue against producing any small-scale map, EPA officials apparently considered a national map appropriate for promoting testing as well as enhancing building codes.

To address Congressional concern that the information be "useful to the public," the EPA adopted the county as the basic geographic unit for its map of radon zones. In addition to facilitating the mandated lists of areas with elevated levels of radon, the use of counties obviates whatever difficulties homeowners and local officials might encounter in transferring geologic boundaries from small-scale maps onto local street maps. (Each state was involved in its own geologic assessment, the results of which are published in separate, state-specific booklets, which depict statewide radon potential on a single page-size map.) In selecting this set of well-known political boundaries, the agency seems to have met—in a general sense, at least—the need for "a degree of geographic resolution that is accurate and useful to the public."

In generalizing from geological to political boundaries, EPA cartographers conveniently exaggerated the extent of the map's highest-risk zone. Consider, for example, the case of Minnesota, described in Figure 4. The left-hand map, on which smoothed boundaries assign geologic provinces to one of two levels of radon potential, presents a less alarmist view than the corresponding county-unit map on the right. Almost all counties with minor amounts of land in a geological province identified with "high" radon potential emerge as "Zone 1" counties. Elsewhere in the country, a similarly expansive generalization strategy inflates the extent of Zone 2 at the expense of Zone 3.

The map's graphic design is even more persuasively biased. Its key offers no interpretation of the three hazard zones, which are merely labeled "Zone 1," "Zone 2," and "Zone 3." Scientifically curious readers might—if they haven't lost it—consult the accompanying "fact sheet," which notes that "Zone 1 counties have a predicted average indoor screening level greater than 4 pCi/L," whereas the other two zones have levels "between 2 and 4" and "less than 2," respectively. But few viewers, I suspect, will look past the map's three provocative hues: the inflammatory red delineating Zone 1, the slightly less ominous orange for Zone 2, and the nonetheless cautionary yellow for Zone 3. Although authors of risk maps sometimes use the traffic light sequence of colors (red–amber–green) to describe high, medium, and low levels of risk, the EPA's map designers were apparently reluctant to suggest an association between low risk and no risk.

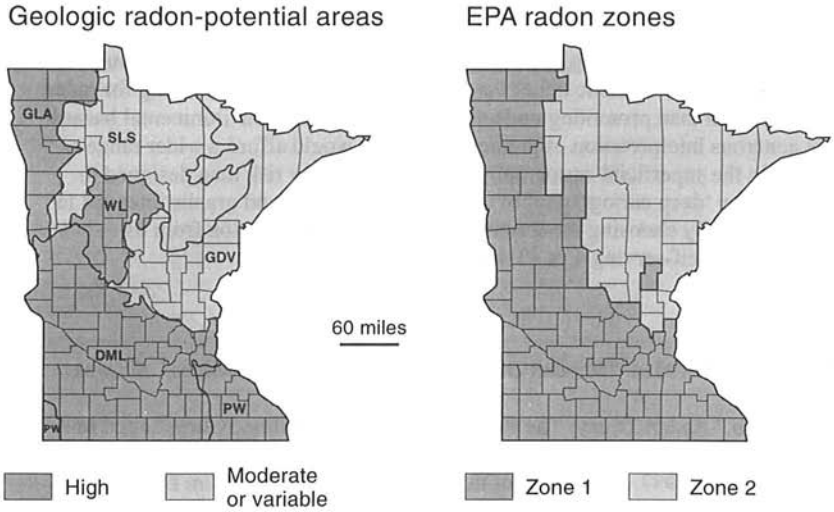

Figure 4: As this example illustrates for Minnesota, generalization of radon-potential areas (left) to county-unit radon zones (right) enlarged the territory in the highest-risk category. Labels on left-hand map refer to names of geologic provinces.

Ethical dilemmas and 'deep cartography'

At one level I can readily condemn the EPA Map of Radon Zones as alarmist propaganda. At another level, I can respect its visually effective, dramatically persuasive exploitation of design principles to communicate the message hidden at the end of a block of text engulfed in the map's dark blue background: "All homes should be tested regardless of geographic location." This warning is good advice, and the map might well save lives by convincing residents of high-radon homes to test and remediate. Hazard maps, one might argue, are intrinsically alarmist.

But what might a more scientifically valid map reveal? Would a higher, more meaningful action level identify pockets of much more seriously elevated levels of radon lurking unidentified in areas the EPA sees fit to color red, orange, or even yellow? Surely the EPA map ignores enclaves with a strong likelihood of far higher and demonstrably more deadly levels of indoor radon. Or would a map that focuses on these "hot zones" merely discourage radon testing in less hazardous regions? Does the likelihood of finding some of the nation's "hottest homes" outside a smaller, more restricted high-risk zone justify the current, more strident strategy? If so, then why not eliminate Zones 2 and 3 altogether, color the entire map red, and be done with it?

The ethical dilemma here is not manichaean. It arises instead, I think, from the perceived need for an oversimplified one-map solution—a need rooted, no doubt, in a well-intentioned paternalistic belief that frightening the public into testing for radon is more important than promoting understanding of a complex environmental hazard. A more generous interpretation of public intelligence would afford a wider range of options, from the superficial cartography of a three-category risk map designed to instill fear to the 'deep cartography' of complementary maps and graphs intended to foster reflection. By choosing the former, the EPA diverted attention from its questionable and self-serving 4 pCi/L action level.

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FROM GEOGRAPHICAL DATA TO GRAPHICAL PRESENTATION

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abstract

A map as a visual object representing geographical data plays a very important role in map analyses and applications of GIS. As an output function of GIS, a cartographic system is an effective tool to convey geographical data to proper graphical forms(symbols,colors,diagrams,etc.). The fundament requirement to realize the transformation between GIS features and cartographic feature is to bridge the gap between GIS data model and cartographic data model. This paper will analyze the difference between the two models, which is often overlooked. The data model in GIS may focus on the data precision,completeness of an object and spatial dependence, whereas the data model in cartographic system may pay more attention to the two dimensional diffusion,flexibility and visual perception. Visualizing operation on geographical objects are also discussed in this paper. Different types of geographical objects may require different visual elements. Symbolization is the major means to visualize the geographical data. Two processes are often used to turn data into visual forms: from the geometric data and from the attribute data. Non-procedural symbolizing methods are the better choices for creating a flexble,convenient,capable visual environment. We will introduce several operators to implement the procedure-independent methods to realize graphical presentations of geographical objects according to the geometry of the objects. The main feature of the methods is that the objects to be visualized are taken as one kind of variables and the geographical elements to be presented are taken as the other so that the operators are independent from the graphical elements.

Key words: *data model, geographical object, graphical cell,visualizing operator*

1. Introduction

As an analysis tool, Tomlin(1991) demonstrated the powerful functions of maps through a series of examples. Visual analyses are also effective means for geographical data. In general, a GIS is a device for turning data into information and one of the key aspect is that the visual forms are the effective ways to

communicate and understand spatial data(Bishop 1994). Maps can be used for visual representation of a lot of aspects of socia-economic data(Bracken 1994,Gatrell 1994), human geographic data(Dorlin 1994) as well as many other kinds of aspatial data, besides graphical presentation of spatial data. Thus, a map as a visual form representing geographical data plays a very important role in map analyses and applications of GIS.

A set of geographical data is a special kind of data. Although text and digital data are good media to describe geographical phenomena, the graphical forms depicting geographical phenomena are much easier to be perceived by the human beings. Because the sensitivity of the human sensory and cognitive systems for visual pattern recognition is very strong. It is estimated that at least half of the brain's neurons are associated with vision. Interpretation of a graph or chart is often more efficient than interpretation based on a string of numbers representing the same data, and it makes sense to represent reality an abstract form(Buttenfield and Mackaness 1991).

In comparison with one dimensional text and digital data, two dimensional graphical forms have the capacity to reveal principles of some geographical phenomenon and characteristics of its distribution. Proper graphical presentation can uncover the past of some geographical event and foresee the future and the trend. The fact that, Alfred Wegener got the first idea about plate tectonics which may be regarded the greatest influence on the earth science in this century(Jean-Claude 1985), is such a typical example.

Geographical phenomena are usually represented in the forms of objects in computer system(such GIS). Attributes(names) and corresponded values are used to describe geographical state in reality. Maps are the major media to present those data in graphical forms. However, graphical forms representing the same geographical objects are different between GIS and Cartographic system(CS). For instance, a point may not have size in GIS but it must have some size in CS. That means that there are different requirements for data modelling in these two systems.

Map making(Cartography) is a very powerful means to convey geographical data to graphical forms, but also a complex process including determination of map topic, choosing valuable data, data processing, map design and map printing. Therefor, for general graphical presentation of data, we here only deal with the aspects related to turning data to graphical forms. We will also discuss the general method to present graphically an object not only its geometric feature.

2. Different Requirements for Two Data Models

It is very common to display geographical data (or spatial data) stored in GIS in graphical forms because of spatial(geometric) features of those data. These graphical elements are likely to take the pure geometric form, but the graphical presentations in a map must occupy some real space in an Euclidean plan. We should pay more attention to the distinction between the two graphical

presentations so that geographical data in GIS can be easily turned into graphical form on a screen even into a standard map.

2.1 differences

As known to us, spatial data play different roles in GIS and in CS. It is very important to be aware of the distinctive aspects in design of data model. The major differences are probably the followings:

----*precision of the location*

Geographical objects in GIS must have precise spatial location so that GIS can supply different users with reliable data which may not only be used for visual purpose. The coordinates are usually kept the same when the objects are turned into graphical elements. However, the graphical elements may have different location (coordinates) in CA when conflicts happen in a plan. An example is shown in figure 1.

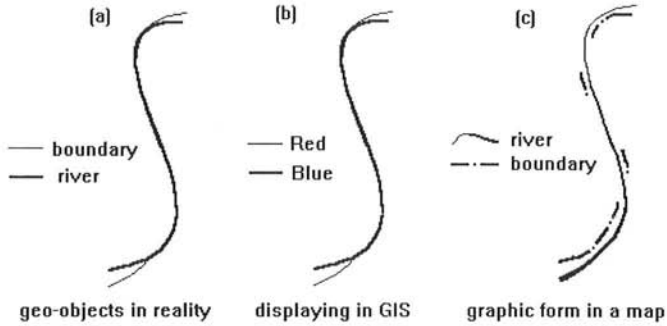

Fig. 1 different graphical appearance

There are two geographical objects(a boundary and a river) in reality with sharing some segment. When displayed in GIS, the two may be distinguished in different colors and the locations of the two objects are kept the same shown in fig.1 (b). However, when the two are depicted in a map, the river will remain its correct location, but the boundary will appear at the modified location so that their symbols can be read clearly shown in fig.1(c). In case (c), we will get wrong area of a region with this boundary when the boundary is used to measure its size.

In addition, a line without width displayed in a GIS is available, that means that it is a pure geometric line represented by a string of coordinates. A graphical line in a map, both of a string of coordinates and its width must be required, for this line must occupy a certain space when printed in a sheet. A line is modelled as a two dimensional diffusion (expanding) object (a string of points with its size).

----*completeness of an object*

An object must be completed in GIS, but it will be available only if it is

looked as a complete object whether it is represented in a completed form or not within a cartographic system which requires more flexible forms so that they are operated easily.

For instance, shown in fig.2, a river is stretched continuously with a bridge above it but not intercepting it within a GIS, but when appeared in a map, it is divided into several segments with certain gap between two successive segments.
A continuous line in a GIS will become two lines in a CS. There is a little space within the bridge between the two lines (l_1 and l_2 in fig.2 (b)).

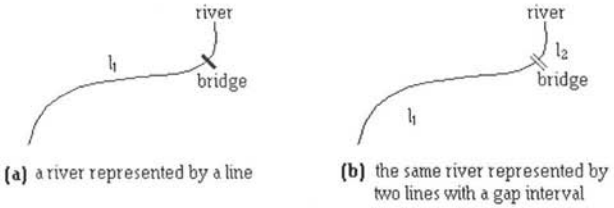

fig.2 completeness of a river

----*spatial dependence*

Some related elements must always be tied with their objects and can not be handled individually in a GIS. However, it may be more efficient to handle them individually in a CS because it will be a unnecessary job when tying to tie all related elements together and then handling them. That will also make the visual process very complex and tidies.

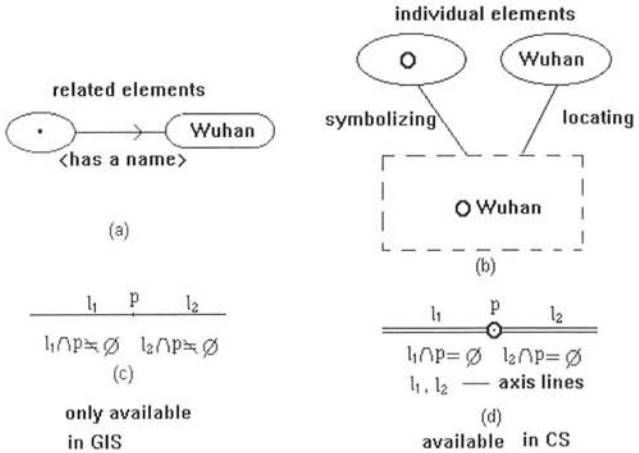

Fig.3 two data forms

Labeling is a job of this kind. A name or a string of alphanumeric symbols is always tied with its described objects in GIS because data or text related to the

objects must be supplied with when to pick such objects. However, it is not necessary to tie such elements to related objects because ease and convenience of completing visual process are more emphasized than the relationships among data items. Figure 3 (a) and (b) are used to demonstrate such a case.

Figure 3 (c) and (d) show different spatial relationships for the same objects. Both figures demonstrate the correct situations in different systems. After symbolizing, a point takes the form of a circle so that the two axis lines are cut of a little segment by the circle. In a result, the original spatial relations are modified, but readers can recover the correct relations through viewing the drawings.

Both spatial and aspatial relationships among the geographic objects must be clear and correct so that a GIS can cater for different applications. However, the visual effects of geographical objects in a CS are more important than those existed relationships.

----*geometric feature*

There are a lot of cases to change geometric feature of objects in the process of transferring those objects into graphical forms. A point in GIS may become an area in a map and a line may also take the form of area. For example, if a point symbol in figure 3 (d) is filled with some color or pattern, the circle is the boundary line for filling. The similar situation may happen within the line symbols in figure 3(d).

2.2 bridging the gaps

It is clear that a GIS is not a CS. It is no doubt that there are differences between the two systems(Wood et al 1994). A GIS can be a set of spatial analyses tools including visual analyses. Precise representation of reality is the main purpose for a GIS to model geographical phenomena. The objective of a CS is to supply with a series of tools which are used easily to turn geographical data into graphical forms. Those forms are perceived correctly to represent the original phenomena although they do not actually reflect the precise location of geographical objects.

Those different requirements usually make a visualizing(or cartographic) process irreversible. That means that we can transfer geographical data into cartographic presentation, but we can not recover the precise geographical data from graphical data in a map.

However, we can build a bridge if we know clearly the gap between the two required data forms. It is an available method of merging the differences to separate graphical presentation from precise spatial data completely and building a linkage between them. In that way, geographical data are always remained in their precise values even if their graphical elements require modification of the original data for some visual needs. Graphical elements can be changed without complying with spatial relations among and completeness of geographical objects.

Figure 4 shows a schema to work in such way. There are two processes to convey geographical data into graphical forms (a map). One is to turn geometric data of geographical objects into drawings. Another is to make attribute data into graphs. Graphical elements are separated from the represented graphical data. As know to us, symbolizing is major means to fulfill such tasks. According to this schema, it would be better to make symbolizing processes independent from concrete symbols or certain graphical descriptions. We will discuss this topic in the next section.

In this figure, geometric features are points, line and area(polygons). Those are the basic graphical elements. Those basic elements will become geographical objects when they carry geographical attributes with them and be turned into cartographic elements (symbols) when they occupy certain space (have size) on a plan(namely on a map).

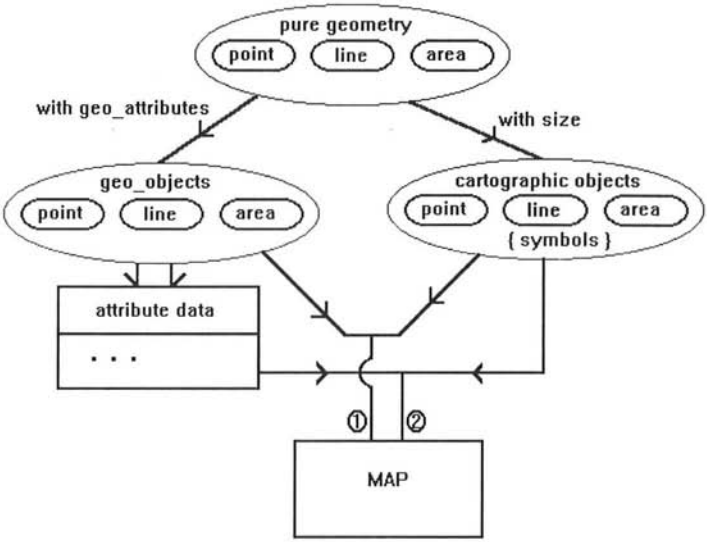

Fig. 4 schema of from geographical data to a map

3. Symbolizing Methods

There are several methods to symbolizing geographical elements. However, the procedure-independent methods are used for bridging the gap between two data models. In such a procedure, drawing symbols is independent from the graphical descriptions of those symbols. A graphical cell is used for realization of a described symbol.

3.1 from geometry to symbol

Geometry of geographical objects is a special kind of attribute. It is of

graphical form itself. It is very common to turn this kind of data into related symbols according to the class and geometric feature of the objects. There are three kinds of symbols to be turned to. These symbols are usually used to display the class of objects, not to represent certain value.

----*Point symbol*

There are a lot of point objects to be displayed in point symbols. A graphical cell is the basic elements to represent a symbol. There are different cells for different symbols. Any cell can be represented in a set of basic geometric elements: points, lines, polygons(area). It is very easy to draw such a symbol using its cell and geometry of the object.

Supposing a cell C is a set of points, lines and polygons. A translation operation (called visualizing operator) is applied to draw the required symbols in correct position. The operator is implemented on two kind of operands. A cell is taken as one and a point as another, which can be expressed by following form:

$$C \Theta P = T(x,y,C)$$

C is a set of organized coordinates, P=(x,y), T is a translation. Figure 5 shows such a case.

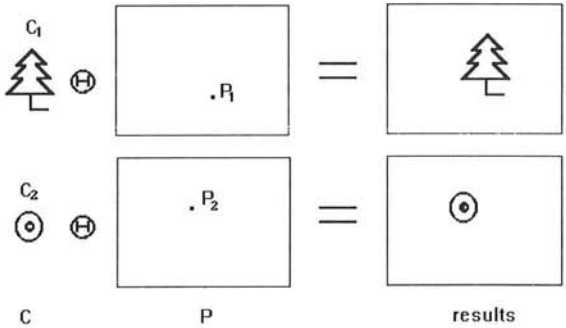

Fig.5 Translation operator for point symbols

If a direction is considered in such operator, the results can be arranged in different directions.

----*Line symbol*

Line symbols along different axis lines can also be realized in such way(Lin et al 1992). Such visualizing operator works like algebraic operator shown in figure 6.

Different graphical cells applied to the same axis line will produce different line symbols along the same stretching line, which represent different geographical objects.

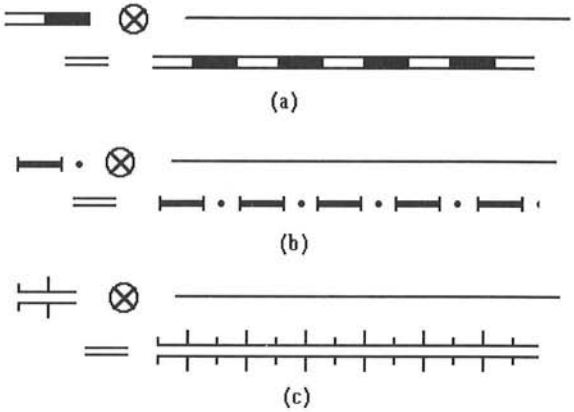

Fig.6 algebraic operator for line symbols

----*Area symbol*

Area symbols are expressed by polygons with some patterns filled within them. Those patterns (graphical cells) are used to distinguish the different attributes of the geographical objects. These cells can be represented in the form of a matrix(Lin 1994) or in the form of a bitmap so that visualizing operator works in the same way as above operators, shown in figure 7.

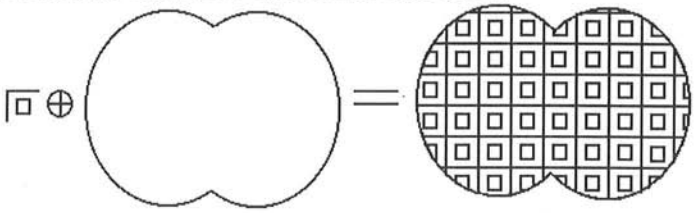

Fig.7 operator for area symbols

Complex area symbols can be realized by combining several simple area symbols which are obtained by related matrices.

3.2 from digital data to symbol

To visualize a geographical object, a lot of attributes of this object also need to be presented in the graphical form. Statistical data are good examples to be depicted in diagrams or charts. For " data exploration relies heavily on data charting ... . Graphical display has been a cornerstone in recent developments in statistical description and exploration,... ."(Buttenfield et al 1991).

We can also apply procedure-independent method to turn such digital data into graphical forms(Daosheng and Lin 1993). Graphical cells play a very important role in representing those values. There are two ways to symbolize

values:we may use graphical size to reflect the values and we may also use the number of cells to depict the values. This visualizing operator can be represented by the following form:

$S=\{v_i\}@\{c_j\}$

S-- result, $\{v_i\}$-- value set of index, $\{c_j\}$-- a set of cells, @-- the operator.

However, this operator is more complex than the above. Because changing values will lead to changing graphical form, which may result in modifying the geometric relations among the cells.

4. From Attributes to Graphical Presentation

In general, if we consider labeling as a graphical form for a string of text, almost all attributes of geographical objects can be presented in graphical forms.

There are two elements(without consideration colors) to be needed for graphical presentation, namely, graphical cells or symbols and geometry or location of the symbols(or cells). For labeling, we define label mode as all requirements of labeling a text. This label mode includes: text size, font type, font shape and mode of locating a text.

We use G(syb,geo) to denote symbolization "syb" of some attribute of an object in geometric feature "geo", L(L_mode, p) placing a text at the location "p" according a label mode "L_mode". A process to visualize attributes of an object can be regarded as projection function from attributes to graphical presentations: V: {Attrs}->{ G(Syb, Geo), L(L_mode,p)}

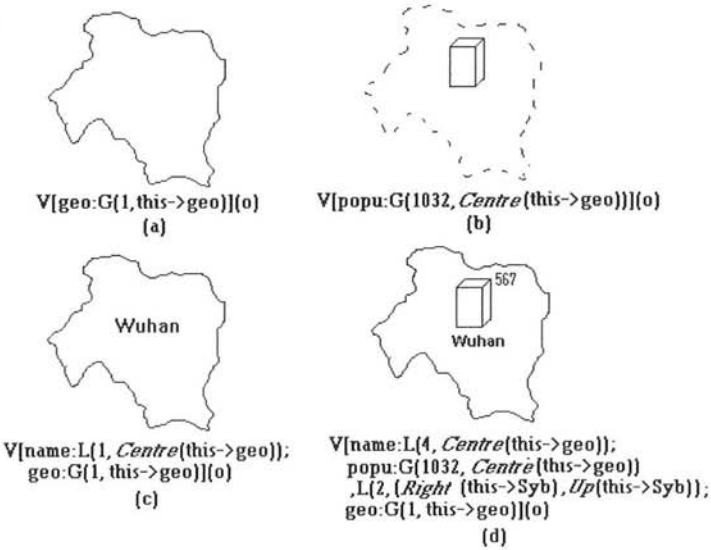

Fig.8 Graphical presentaion of an object

If an object has attributes: Attrs(o)=[$attr_1$; $attr_2$; ...,$attr_n$], graphical presentation of the object can be expressed by:

V[$attr_1$: G(Syb,geo),L(L_mode,p);
$attr_2$: G(Syb,geo),L(L_mode,p);
...
$attr_n$: G(Syb,geo),L(L_mode,p)](o)

In this way, we can view more than one attributes of an object at the same time. Figure 8 demonstrates such a case.

There is a geographical object o having three attributes: name, population and geometry. Its geometric type is the area and the value is represented by a boundary line. Supposing, this represented place is called Wuhan and 567 million people live in this area. That is,

Attrs(o)=[name; popu; geo], Vals(o)=["Wuhan"; 567; {p}]

{p} is a set of ordered points representing this boundary line.

In this figure, case (a) means that only geometry of the object is displayed; case (b) only population is graphically presented; case (c) both geometry and name are viewed; case (d) all three attributes are visualized and some attribute (population) is visualized in two methods(symbolizing and labeling).

From this example, we find it is very convenient to turn geographical data into graphical presentation in this way.

5. Remarks

Graphical presentation of geographical data is very useful tool in spatial data analyses and plays very important role in practical applications. It is also very important function in GIS. Cartographic system is powerful tool to visualize geographical data, but it is not always an easy process to make a map. But for some reasons, we need not a cartographic system for visualizing geographical data in a GIS, instead we need a flexible, easy operating visualizing process to present these data graphically, like the method discussed in section 4.

Symbolization is a very common way to turn geographical data into graphical forms and it is convenient to apply procedure-independent methods in visualizing process in a GIS and a CS. If we want to fulfill a task of symbol design and build flexible symbol library, Procedure-independent methods are the better choices.

For general graphical presentation of geographical objects, graphical presentation of the attributes,discussed in this paper, is a very effective and simple method. In this way, Many kinds of attributes can be displayed either individually or simultaneously. It is also very useful for design interactive presentation languages for a GIS because when querying for some geographical objects, meaningful presentation of the results can give users real geographical sense and help users to grasp the nature of the objects. It is worth probing the topic more deeply.

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TERMINOLOGY AND LEXICOGRAPHY IN MODERN CARTOGRAPHY - EXPERIENCES AND PRESENT TASKS IN GERMANY

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1. Introduction

Terminology is meant to include all the technical words of a scientific discipline or an occupation.
The science or theory of terminology is an interdisciplinary science that is characterized by a close collaboration between linguistics formal logic, computer science and a particular discipline.
On the other hand, a special or applied theory of terminology forms part of an individual scientific discipline. German cartography for example classifies the theory of terminology not only as an aspect of theoretical cartography (OGRISSEK, 1987), but also considers it to be a part of general cartography (KOCH, 1995) and likewise ranks it among the scientific and theoretical foundations of cartography (BOLLMANN and UTHE, 1995).

Cartographic terminology is of great importance not only for research and education but also for practical work. Productive professional communication on a national and an international scale would be impossible without a body of specific and clearly defined terms that is constantly being used.
The International Cartographic Association has been dealing with the issue of terminology since 1964. This was when the commission „Definitions, Classification and Standardization of Technical Terms in Cartography" was established. In 1973, the „Multilingual Dictionary of Technical Terms in Cartography" was published (1st edition). A second extended and improved edition will appear in the middle of 1997. Chairman of the German working group was J. NEUMANN.

All international work regarding terminology is dependent on the existence of unambiguous, complete and up-to-date technical cartographic terms an a national level. In Germany, technical cartographic dictionaries have been published in 1979 and 1983 by W.WITT and R.OGRISSEK. These dictionaries were still strongly influenced by classical cartography and are thus no longer in keeping with today´s standards.
The new theories and processes (technologies) of the 90´s urgently require equivalent classifications and definitions including new dictionaries and other reference books whose content and form are adapted to the demands of the computer age.
For this reason several projects headed by the writer have been in progress in Germany since 1994.

2. Analysis in the development of cartographic terminology since the reunification of Germany

Due to various influences, cartographic terminology in East and West Germany has developed along widely differing lines in the past 47 years. Not only have new terms with different usages arisen in East and West, but also new terms have been adopted from abroad. Other terms have either become obsolete because of new technological developments or they have changed their meaning altogether. At the beginning of the 1990s, about 10 to 15% of all cartographic terms were specific to the new states. These terms were mainly found in map editing and map design including map generalization, map making and map uses.

With the political change of 1990, the conditions underlying cartographic work, education and research in Germany have also changed. This in itself would justify extensive research into the situation and the dynamism of the changes that are presently occurring to the technical language used in Germany.
Yet second thoughts have led to the decision to wait several years before attempting such an analysis for all of Germany, especially since significant changes are still to be expected in the years to come. Events in Germany clearly indicate that, from a social, economic and scientific point of view, the process of fusing both parts of Germany is occurring much slower than originally anticipated.
The first project of this kind was carried out in 1995, when an analysis of the cartographic terminology of the new states on the territory of the former GDR was carried out (KOCH, 1996), with 26 firms, state agencies and educational institutes participating in a written survey.

This empirical research clearly showed that a considerable amount of former GDR terminology is still being used today. Half of the people surveyed indicated that they only use these terms, with about 20% revealing that they use both terms, either the one or the other as required in the specific situation. 6% of those interviewed replied that they use completely new terms.
This shows that the process of converging the cartographic terminology in Germany is making visible progress even though it has not yet been completed.
The process mainly involves the alignment of the East to the West.
The working group "Cartographic Terminology" of the German Cartographic Society is monitoring this development and attempting to influence it through its active linguistic and lexicographic work.
More attention should be given to newly developed terms in the future. New terms should be thoroughly examined to see if they are clearly definable and if they have been designated according to the accepted cartographic terminological systematic (FLUCK, 1991, DIN 2330).

3. F.I.G. - Technical dictionary, German edition, Cartography volume

The Institute of Applied Geodetics in Frankfurt/Main was already commissioned in the late 1960s with compiling a multi-volume technical surveying dictionary. Volume 8 ("Cartography, Map Reproduction") was published in 1971 as the last volume at the time. This dictionary, while being a quite worthwhile reference work for its time, failed to list numerous cartographic and map designing terms. This was mainly due to the fact that the authors themselves were photogrammeters and geodesists.
The dictionary of surveying contains 17 volumes with an alphabetical index in German, English and French. It is now being published by the Institute of Applied Geodetics, Leipzig branch, as a new edition within the "FIG—Technical Dictionary".
The working group "Cartographic Terminology" of the German Cartographic Society had already declared its willingness in the 1980s to revise the "Cartography" volume. Because of various reasons, work on this volume has been delayed until now. The basis for this new edition is the last edition published in 1971, the contents of which are now naturally extremely incomplete and dated. Numerous gaps have to be closed, dated terms replaced and some definitions have to be altered or completely rewritten. For this work, the new ICA / ACI cartographic dictionary (Multilingual Dictionary of Technical Terms in Cartography, 1997) is only of limited value because it does not contain the latest terms of digital cartography and geo-information systems.

Also, the cartographic technical dictionary "ABC of Cartography" (OGRISSEK, 1983) only has a limited value as a reference aid. Along with the revision work being completed on the new German cartographic dictionary, it is also intended to revise Volume 8 of the "FIG Technical Dictionary".

The fact that this dictionary only contains the terms along with their definitions makes the work easier. On the other hand, more comprehensive entries for the individual terms have to be written for the new cartographic technical dictionary. This work will be explained in more detail in the following section.

4. Dictionary of cartography

4.1 The necessity of a new dictionary

The technical dictionary of cartography is the major project of the terminological and lexicological work that is being carried out by the German Cartographic Society. Ten years after the old dictionary of cartography, "ABC of Cartography", was published, discussions began at the Institute of Cartography at the University of Dresden with the aim of revising this technical dictionary. In 1994, the German Cartographic Society commissioned the working group "Cartographic Terminology" with this task.
A first elaborate draft was put forward in 1995. During this time (1995/96), the working group engaged in basic discussions concerning the expediency of work on such a comprehensive new dictionary at this point in time when considering the rapid development currently taking place in theoretical and applied cartography.
In the end, the question of a new dictionary was answered positively because the contents of the older German cartographic dictionaries no longer meet the demands placed on modern reference books and the producers and users of maps urgently require an efficient reference book. Special demands are also being placed on cartographic education. Longer waiting would not have changed the situation in the least.

4.2 Content and structure

The dictionary is supposed to deal with the whole field of cartography, including geo-informatics. As far as they are cartographically relevant, neighbouring disciplines such as geodesy, geography, computer science, psychology, semiotics, etc. have also been included.

Almost 1800 entries have been planned with a total of approx. 700 pages Numerous illustrations (two-colours) and multicoloured map sections will add to and illustrate the texts. There will be two versions of the
technical dictionary: one in bookform on paper and an electronic version on CD ROM. A hypertext system has been developed for the electronic version. First results of research undertaken are already available (WITTEK, 1996).
The dictionary is meant to reflect the current status of cartography as an applied science as well as to include those classical terms that are still of interest in a historical context.
Of fundamental significance for future theoretical work is a systematic structure of cartography as a field of knowledge. Such a structure also has practical implications for the compilation of the dictionary as well as being indispensable for the structuring of the electronic version of the dictionary. The entries are of course being arranged in alphabetical order.
New cartographic structures have also been researched and discussed, e.g. HAKE and GRÜNREICH (1994), ROBINSON et al. (1995), DENK (1995), GROSSER (1995), KOCH (1994), STAMS (1995) as well as BOLLMANN and UTHE (1995).
Agreement has been reached that all work on the dictionary should stem from the following three main sections of cartography: basic theoretical premises, general cartography and applied cartography.
A more detailed structure of the work on the basis of proposals put forward by BOLLMANN and UTHE is still being discussed.
A so-called working structure comprising 32 branches has been established for determining the working areas of the approximately 20 contributors as well as to allow a preliminary assessment of the content of each contribution in relation to the whole work.

4.3 Type and structure of the entries

The following types of keyword articles are to be written:

a) Overview articles
They allow an overview of large, connected areas, such as geo-information systems, map projection, map design, etc.

b) Main articles
They provide informative summaries about higher ranking terms such as cartographic communication, cartographic generalizations, cartographic visualization, etc.

The overview articles and the main articles are meant to deal with other related information and to give an overview. They are also meant to refer to secondary entries. Referrals are to be indicated with the help of arrows.
Overview articles and main articles are to include bibliographies.

c) Individual entries
These are to describe certain facts, types of maps, devices, procedures, uses, etc.

d) Referral articles
They only list the respective key word and refer with the help of an arrow to another key word which explains the term in more detail.
Synonyms are not designated with an arrow but rather with an addition "svw." which means that there is another entry of the same meaning.

The key words are structured as follows:

The article begins with the key word. The key word is either the most commonly used technical term or the respective standard term. The corresponding English and French terms are listed after the German key word. The key words are followed by the synonyms and possibly by the most commonly used abbreviations. After the synonyms or the abbreviations—if these are missing, then directly after the key word—the key word is defined in a concise but comprehensive and unambiguous manner. Additional explanations of the key word follow its definition.

Articles dealing with similar terms (e.g. types of maps: geological maps, ground maps, vegetation maps, etc.) are included in a similar manner.

5. Updating cartographic entries in a popular encyclopaedia

As far as this author is concerned, updating cartographic entries in a large popular encyclopaedia such as the Brockhaus Encyclopaedia is just as satisfying as working on a highly technical cartographic dictionary.
In the former case, the cartographic terms are set out in a completely different context, with the entries being directed at the general public. This means that the definitions and the text have to be formulated in an easily comprehensible manner while at the same time assuring a high technical standard and including the latest information. During a first working stage, a large part of the total of 250 key words were brought up to date and some new key words were included.

6. Summary

Work in the fields of cartographic terminology and lexicography has been intensified since the reunification of Germany.
Along with fundamental research into the development of cartographic terminology and the useage of the specialist terms common to the former GDR, work was begun on two technical dictionaries. These dictionaries should be completed by 1998. In addition, entries in the "Brockhaus Encyclopaedia" were updated. Practical technical terminology work was also undertaken for the Ordnance Survey Offices (Landesvermessungsämter). These additional activities have not been included in this paper.

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A CLASSIFICATION SYSTEM FOR TACTILE MAP

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1. Introduction

Tactile maps and other tactile media are an important special field of cartography. This special field has rapidly grown in importance in the past decades. A special ICA/ACI commission was established in 1984 („Commission on Maps and Graphics for Blind and Visually Impaired People"). Widespread theoretical an practical activities have since place on a world scale.
The specific situation regarding the manufacture and use of tactile maps is dependent on two requirements that appear contradictory at first glance. When considered more closely though, they can bee seen as being closely linked together:

1. Methodes, rules and technologies have to be developed that are quite different from those of conventional visual cartography. The reason being that the cartographic information is perceived in a tactile manner and not visually.

2. Some of visual cartography´s fundamental theories and experiences are of general significance and thus valid for all categories of maps. These theories must now be reconsidered and adapted to the field of tactile maps.

Regarding the second aspect, some very interesting adaptations of the cartographic communication process have been introduced by R. VASCONCELLOS (1995) and innovations in the systems of graphic variables made by J. BERTIN.

In the past, only sporadic attempts have been made at classifying tactile maps. Scales were usually used as a classifying feature (Brambring, 1979, Möller, 1985 et al.).

A more comprehensive system is not yet available. This paper will attempt to show the basic principles for such a system. A more complete systematic structure can only be estabished following further research.

2. The nature and purpose of a classification system

Classifying maps actually means dividing an amount and/or a category of maps into subcategories, whereby the individual subcategories are not allowed to share common elements. Yet overlapping subcategories cannot always be avoided when classifying tactile maps.
A scientific classification system is required whenever the area under scrutiny becomes too large. Along with a systematic order, the appropriate terms also have to be found. A distinct relationship thus exists between the issues of classification and terminology.

The usefulness of classifying tactile maps lies in the following:

- *A growing variety of maps can be systematically classified and thus made more transparent.*

Since Martin KUNZ developed the first maps for the blind in the middle of the 19th century, a vast number of tactile maps and graphics have been produced in Europe and later throughout the world. Today, a large variety of maps with different scales from a variety of areas with numerous projection forms and map topics are in use. Along with maps in the strict sense of the word (orthogonal projections), there are also map-like projections (globes, profile etc.) available for the blind.

- *The underlying similarities of the various tactile maps can be better recognized*

Basic principles and rules apply mainly to the structure of signs and the "map language" of tactile maps and are therefore of a semiotic and linguistic nature. The way in which maps are designed along with the perception of maps are questions that are currently being investigated in the areas of tactile as well as visual maps.

- *Documentation and cataloging is definitely simplified . which in some cases would not have been possible previously.*

Regardless of whether the catalogizing is to be carried out in a conventional manner or with the aid of computers (in the libraries of all large educational institues or in the central libraries for the blind), a complete and logical classification system is imperative. The maps that have been produced with different methods should all be filed and stored according to the same technical classificiation features.

- *Technical production can be organized and specialized accordingly.*

For example, it is not very meaningful to produce large-scale city maps with highly specialized methods in the same factory together with small-scale overview maps that are used for educational purposes. Factories exclusively producing educational material for schools for the blind can achieve a higher degree of efficiency through a higher degree of specialization.

3. Proposals for a basic classification system

3.1 Initial considerations

Classification systems have been in use for a long time for maps that are being used visually (PILLEWIZER, 1964, SALIŠČEV, 1967, OGRISSEK, 1980 et al.). More than five pages of the latest edition of the well-known textbook "Elements of Cartography" (ROBINSON et al. 1995) have been devoted to this issue. Scale, function and subject matter have been used as classification features. This, however, does not make for systematic completeness.
ZACH (1978) has pointed to important aspects that are still worth considering today. He has shown that an optimal organization system cannot be primarily based on user specifications but that it must rather be based on scientific aspects. According to this line of thought, a basic distinction would be made between complex and elementary maps featuring either polymorphism or monomorphism. Additional modifications of his classification system would be along the lines of function, scale and graphic expression.
The special conditions that apply to tactile maps fit in very well with the system that has been suggested by OGRISSEK (1980) for visually used maps. It would therefore be necessary to make minor adaptions and extensions to this system. The organizing features that have been discussed and analysed by HAKE and GRÜNREICH (1994) also convey valuable impulses.
OGRISSEK has additionally coined special terms for map categories in connection with classification features (feature specific purpose: map category, feature scale: map group, feature degree of complexity: map type etc.).

These terms will not be used here since they have neither been able to gaine acceptance on a national nor on an international level.

Objects are always classified according to specific and essential features. This is also true of tactile maps.
Because a variety of different features can be used as this basis for classifying objects, there is more than one way of classifying maps in general and of classifying tactile maps in particular. Listed below are examples of possible classification features.
The following classification features are being proposed for tactile maps:

A. Primary classification features
- Subject matter
- Specific purpose
- Depicted area
- Scale
- Degree of complexity
- Conveying of information

B. Secondary classification features
- Method of representation
- Form of use
- Type of map construction (in German: „Bauart")
- Master construction
- Map reproduction
- Further features

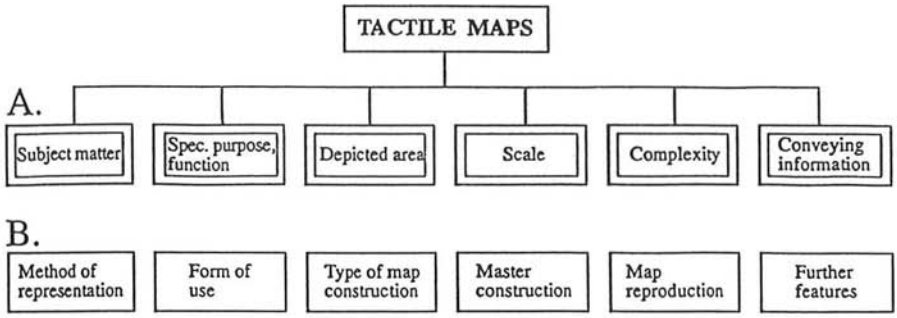

Fig.1: Primary (A.) and secundary (B.) features for classification of tactile maps

3.2 Subject matter

The subject matter has been placed at the front of all primary features that are to be distinguished because of the fact that the structure of geospatial reality is a primary determinant of the structure of a map (this also applies to tactile maps)—compare PAPAY, 1973. The function is the secondary determinant of the map structure. Whilst most of the tactile maps were either topographically or geographically defined in the past, the number of thematic maps has grown considerably in the last ten years (compare Tactual Atlas of Australia, 1987, BEYER et al. 1993, map analysis of KINZEL, 1995). Topographical overview maps, traffic maps, settlement maps, population maps, vegetation maps, economic maps etc. are being made today as tactile representations.

3.3 Specific purpose, function

VASCONCELLOS (1996) lists in her graphic model "Tactile map production and use": general reference (large to small scale), thematic (medium to small scale) and orientation and mobility (large scale). This clearly shows the close relationship between functions and scales of tactile maps. In addition, the educational purpose should be clearly indicated since a large percentage of the tactile maps are being used in schools and other educational institutes. Relevant terms in this sense include: orientation maps and orientation plans, teaching maps, school maps.

3.4 Depicted area

Here the close connection to the scale and the scale range should be pointed out. Tactile maps represent locations covering a small area (e.g. airports with reception area, school yards, etc.), locations covering a medium-sized area (cities, regions, countries) and locations covering a large area (continents, the whole earth). The equivalent terms are known to classical cartography and thus do not have to be newly coined: City maps, country maps, continent maps, earth or world maps. In addition, there are also planetary maps (moon maps, mars maps).

3.5 Scale

In general, maps are distinguished between large-, medium- and small-scales. This classification system can also be basically applied to tactile maps.

Designation of maps	Geographic dimensions	Scales	Elements of depiction
Plans, topometric maps	Topologic dimension	1:100 to 1:2 000	Buildings, interior structure of buildings, ways, steps, benchs, obstracles for blinds etc.
Town plans, city maps (plans), topographic maps		1:2 000 to 1:50 000	Districts, blocks of houses, streets, town traffic, topographic subjects etc.
Chorographic landscape maps	Chorologic dimension	1:50 000 to 1:250 000	Topographic and thematic subjects of territories
Chorographic landscape maps		1:250 000 to 1:1 000 000	Selected topographic and thematic subjects of landscapes
Geographic detail maps	Regional dimension	1:1 000 000 to 1:10 000 000	Selected topographic and thematic subjects of states and groups of states
Continental maps World (Earth) maps	Global (geospheric) dimension	< 1:10 000 000	Political division, state boundaries, selected waters, mountains etc.

Fig.2: Dimension levels and accessory scales for tactile maps (Koch and Kinzel)

It must be remembered though, that the scale used must be at least twice as large as that of a visually used map in order to convey anywhere near the same amount of information.
For this reason, tactile maps cannot be classified within the general graduated geographic dimension model (BARTHEL, 1983, STAMS 1993). For example, maps in the scale range of 1:5 000 to 1:20 000 are already considered to be overview maps etc. Figure 2 shows a graduated dimension model for tactile maps. It begins with topometric detail maps (topologic dimension, scale range 1:100 to 1:2 000) and ends with geographic detail and overview maps (on a regional and global dimension, scale range 1:1 000 000 to about 1:100 000 000).
Finally, it must also be said that it is very difficult to classify city maps, which are known to make up a large percentage of the tactile maps, according to scale. The scales vary considerably depending on the density of the contents and the ground covered by the cities.

3.6 Degree of complexity

Tactile maps are available as element maps (analytical maps) and as complex maps. It would be better though to speak of polyelement maps instead of complex maps since the limited information density of tactile maps does not permit actually complex representations in the sense of classical cartography.
The question, if one should turn to an "additive information presentation" (PODSCHADLI, 1988), i.e. distribute the elements of the contents onto several maps which can possibly serve as over- or underlays to the first map, has yet to be clarified.

3.7 Conveying information

Here one must distinguish between visual-tactile, tactile and audio-tactile maps. If visually handicapped people still have some remaining vision, then a combination of rich and well-contrasted colours, large map signs and large map inscriptions with relief features that can be perceived by touch can be meaningful.
Purely tactile representations cannot use colour as a design medium. Audio-tactile maps and dialogue systems (PARKES 1995, LÖTZSCH 1995, KOCH and LÖTZSCH 1996) are becoming increasingly important today. They use both touch and listening as a substitute for seeing.

3.8 Secondary classification features

These features are less important that the primary classification features. They are also significant for a section of a primary classified category of tactile maps.
The **method of representation** can be meaningfully used as classification feature. Relevant terms would include: Signature maps, line maps, areal maps, choroplethic maps etc.
Forms of use of tactile maps include hand maps, atlas maps (more seldom), wall maps (very seldom, compare OBERHAMMER, 1996).
A further classification according to the **"Type"** („Bauart" - the structures to be touched either as negative or as a positive form in the relief map—line-by-line representation, grid system, block type) is only relevant for maps using a large scale.
Further classification categories are the **master construction** and the **reproduction**. In the first case, VASCONCELLOS (1996) distinguishes between black ink (computer / handmade), 3 dimensional model (computer / handmade), embossed (aluminium) handmade and collagem (handmade). And in the last case: puff ink with silkscreen printing, microcapsule paper and vacuum forming (plastic).

Further classification features could also include: island maps and scale maps as well as analog and digital maps. However, they will not be further discussed here.

4. Final remarks

The production and use of tactile maps has increased world-wide over the last years. Modern technology has also made its appearance. This requires that the theory of tactile maps be extended and developed further.
When classifying tactile maps, there are several special features that need to be considered as compared to maps that are used visually. This paper has attempted to discuss some of these features.
The development of the technology used to make and use tactile maps, including multimedia products, will further extend the scope of the classification employed in the future.

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IMPLEMENTATION OF AN AUTOMATIC / SEMI AUTOMATIC DIGITAL CONTROL SYSTEM AT THE NATIONAL CARTOGRAPHIC CENTER (N.C.C.) OF IRAN

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INTRODUCTION

The National Cartographic Center (N.C.C.) of Iran has been entrusted with the Parliament of the Islamic Republic, as the responsible organization for the national base map and associated National Topographic Data Base (NTDB) of Iran, at the scale 1:25,000. N.C.C. has passed successfully the transition from analogue to digital production line. The main objectives of this transition were to increase productivity over the whole process and to reduce the huge amount of interactive editing, while ensuring the high quality standards, and more important, to use possibilities of automation techniques.
As cartographic maps are the final result of many people hard works that comes to the end users, it should be in the form that users can rely on its contents as much as possible. For this purpose an automatic / semiautomatic digital control system implemented at the "N.C.C. Cartographic Control and Supervision Section (C.C.S.S.)," to ensure producing maps, with maximum reliability and good quality.
In this paper, first the general steps of N.C.C. production line have been introduced and then types of "Controls" which are doing in C.C.S.S. are given. For each control steps the possibilities of using automation methods explained.

1. N.C.C. 's PRODUCTION LINE

Digital methods and systems were implemented in N.C.C. map production line because of several expected benefits. Better accuracy preservation, cost reduction in revision and map drawing were central aspects.
An overview of the N.C.C digital production line is given in Diagram 1. From "Photogrammetry" step is that digital methods play a functional rule. After each "Execution step" (i.e., photogrammetry, graphical processing, cartography) there is a control step.
The "Cartographic Control and Supervision Section" is located somewhere after "cartography" box, titled by "Carto. Control". In the next sections we discuss about controls accomplish (in "Carto. Control" section) on output digital files exited from "cartography" section .
Some of these controls may accomplish in the previous control step as well.

2. SYMBOLOGY CONTROL

Each feature class should be represented on the map by a series of unique graphical symbology assigned to them. These symbologies are defined in the mapping project specifications. A sample is given here:

FEATURE NAME	LEVEL (LV)	COLOR (CO)	WEIGHT (WT)	STYLE (ST)
Road	50	0	1	0
River	32	1	1	5
Bridge	41	0	2	0
.....	.....	.....	.....	.....

- Style: we can have infinite styles (coded by integer numbers) according to the ratio between gap and dash strokes lengths and number of their repetitions.
- Weight: thickness of the lines (coded by integer numbers), as they appear on the monitor or plotter / printer.
- Color: they have been usually coded according to CMYK color model.
- Level: we can have a limited or unlimited number of levels (depend on the software used).
- Geometric type: e.g. : line, arc, ellipse, point, closed shape, etc.

The preservation of symbologys uniquness for each feature class has these main advantages:

- Having an uniformity in map features display,
- Possibility of performing graphical queries for locating (finding) features,
- Possibility for performing next control steps (such as the one given in section 4),
- Possibility for selecting all features at the same class, and then
- doing some proccesses (for different tasks ,such as: generalization) automatically by recognizing featurs by it's unique symbology,

To control symbologies correctness, the programme has been written to control this automatically. It's simple algorithm has been given on Diagram 2.. The programme input and output file are graphic "original file" and a new opened graphic file called "error file" respectively. Where "error file" contains elements with wrong assigned symbology. The controller, then changes color of all elements (existing in the error file), to the color that has never been used for any other feature (called NU color), according to specification. By referencing error file to the original file, and navigating NU color elements, elements with wrong symbologys can be easily found.

3. COMPLETENESS CONTROL

This is one of the main controls should be done. Because of too many processes

accomplish on data from the first step to cartography step, there is chance of unwanted deleteness or displacement of graphical elements, by operators of the previous steps. The completeness of data should be controled in each control step.

1. At "Stereo control" the controller should compare "aerial photograph" with "digitized file." Positional accuracy that is expected inequality of geographic location of an object (in the digitized file) and its true position (on the aerial photo) can obtain here. Actually we cannot have exact fitness of these two types of data, so good estimate is needed to find out how close we are to the truth. According to National Map Accuracy Standard (NMAS) of U.S., for maps on publication scale of 1:20,000 and smaller, not more than 10% of points tested shall be in error more than 0.5mm. RMSE for planimetry should be less than 0.3mm. For heights accuracy no more than 10% of the points tested shall be in error by more than one-half of the contour interval.

The best method to evaluate the completeness of data set is using superimposition techniques. This is possible in two methods:

- Raster pre-processing: (Warping scanned photo): In this method the "scanned raster photo" should project to the ground system coordinate to delaminate relief displacement.
- Vector pre-processing: The "digitized file" coordinate system should transfer to "photo coordinate system," by using photo center coordinate and space line equations..

The second method is preferred because the process on the vector data is faster than on the raster data that has a larger size.

So the programme has been written to fulfill the second method. The result vector file does not have relief displacement and should fit on the scanned raster photo when superimposing. Then by view panning, the controller can find elements, have been changed positionally.

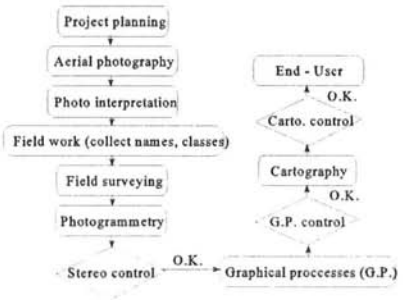

Diagram 1: N.C.C. digital production line

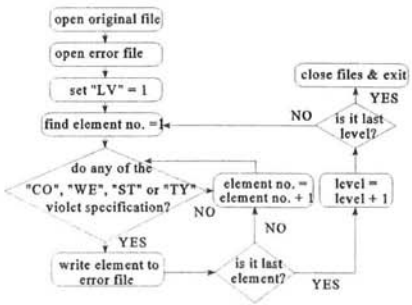

Diagram 2: Symbologys controling algorithm

2. At "G.P. control" the controller should compare output file from "Stereo control" with output file from "G.P.". In the "G.P." step, the processes on the elements (such as arc - node formation, remove over/under shoots, etc.) are for cleaning the file and making it appropriate for further processes (i.e., cartography, database). Normally there is no displacement, deletion, or smoothing of elements. So the programme can be developed

to differ the two mentioned files from each other and write the result elements (i.e., deleted or displaced elements) to the new file. The controller, then should decide whether those deletions / displacements were necessary or not! . This programme will take many time for processing, as it should compare each element in input file with all elements in output file, to see if it can find the same element.

3. At our section ("Carto. Control"), but the above mentioned programme is not usable, because mostly all elements have been modified and cartographic processing has been done on them. The elements may symbolized, displaced, smoothed, or even deleted (due to generalization purpose). So by now the controller should reference input and output file of "cartography" section and compare elements interactively, which is a labor and time-consuming work. For large mapping projects it seems impossible to do this for searching for all missing features, since we are faced with the huge amount of information. A better alternative is to use acceptance sampling procedures for random check. In this approach, the mapping specification should contain statements about minimum completeness percentage and producers and cunsumer's risk.

4. LOGICAL RELATIONS BETWEEN MAP FEATURES CONTROL

According to the reality on the earth, we know there are some relations between features, and these relations must completely transferred to the map. Some of these realities are as follows:

- Normally each habitable state, river, mountain, . . . should have a name.
- No transportation (including hydrography, road, . . .) can stop suddenly in the middle of nowhere, or passes through structures (such as buildings).
- All hydrographic transportations must pass through the middle of breaklines.
- No building or residential area must exist without an access road.
- No hydrographic transportations features can pass the same contour line more than once.
- No contour line can cross another contour line.
- Compatibility of height points with contour lines.
- No road transportation can pass through river, stream, . . . unless a bridge exists.
- No contour line can pass through the roofed building or constructed road

An expert system can be implemented to control these relations, and check if any of the above facts has been violeted. If symbology control has been already performed (as mentioned in section 2), and it's correctness has been guaranteed, each feature class can be recognized by it's unique symbology.

An example algorithm is given in Diagram 3 (see the sample specifications given in section 2.). When the process is finished ,roads passed the river ,without existence of a bridge is flagged at intersection.

Such an expert system must contain many of these modules. Each kind of "fact violation" will marked with a certain flag (e.g. with a certain color), on the graphic file.

Logical consistency, refers to how well logical relations among data elements are maintained. In digital environment this is more important than traditional hard copy mapping, as in hard copy mapping the user supplied the logic. In digital mapping, logic (such as topology), may be used for further processing, so a logically consistent data is needed to produce correct result. The proposed standard for digital cartographic data, has

defined three groups of tests for logical consistency :

1.Should examine the data set in terms of permissible values.

2.General tests for graphic data. In this step the data set is subjected to the following general questions:

. Do lines intersect only where intended ?

. Is any line entered twice?

. Are all areas completely described?

. Are there any over / undershoots?

. Are any polygons too small, or any line too closed?

For non-topological data model, the logical consistency tests are limited to the two groups of mentioned tests. In practice we need the numeric values as maximum allowable error for mentioned items; for example for over / undershoots we need maximum allowable distance between end points of line segments.

3.Specific topological tests for areal coverage: It considers a polygon as a chain of line segments and demands an automated procedure to verify the following conditions:

. All chains intersect at nodes.

. Cycles of chains and nodes are consistent around polygons.

. Inner rings embed consistently enclosing polygon.

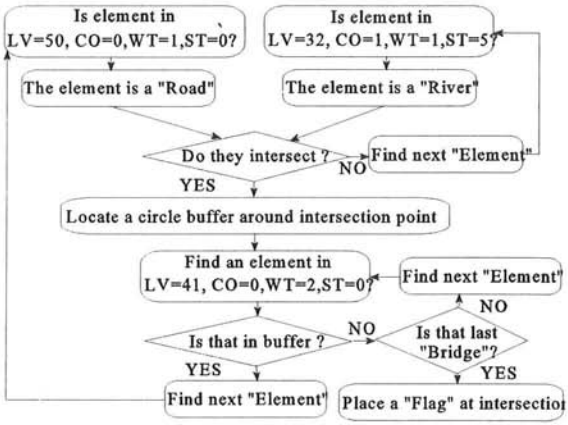

Diagram 3: An example of logical relation control algoritm

5.GLOBAL POSITION (COORDINATE) CONTROL

For topographic map series to be georeferenced the coordinates should be correct according to a selected system projection and coordinate system. Iran map series supposed to be in the U.T.M. projection system and referenced to WGS84 ellipsoid.

The programme has been produced (for use in "cartography" section) to draw Cartesian grid for a sheet by asking operator, the sheet number. Sheet number is a unique number according to the 1:100,000 international map index. So the programme can find lower left

and upper right latitude and longitude of the corresponding sheet. Then by converting it to X and Y coordinates, draw the grid lines by spaces defined in the map series standard. Another programme (used in "Carto. Control") draws the corresponding block. Each block contains 96 map sheets and occupies space of 1*1.5 degree of latitude and longitude. By referencing each sheet to this block, controller can see if map sheet is exactly in the right position or not.

6. ATTRIBUTE CONTROL

In topographic mapping, attributes always have the form of categorical data (than continuous), that using a CAD system, can be presented graphically in form of color, style, size of points and line features, and texts (for names, and necessary descriptions). Classification accuracy is the probability that a class assigned to a location on the map is the class that would be found at the location in the field. Attributes also refer to name of locations.

At N.C.C. , the field wok (for attributes collecting) is performing before photogrammetry step. Attibutes are assign to the features, by putting texts or simple symbols on the aerial photo. Stereo plotter operator uses appropriate icon to digitize the feature according to it's attribute indicated on the aerial photo. Other features not containing in photogrammetry feature list is transfered to a check plot to use by cartography operator. He / she symbolize features according to it's attribute identified on the check plot.

Attribute correctness can only be controlled by random check at the field. The suggestion has been given to check one or two sheets for each block (containing 96 sheets). If the result is that more than 15% of features have wrong attributes, then the field work must be repeated for the whole block.

7. REPRESENTATION CONTROL

According to the cartographic principles each feature on the earth should be represented on the map by an appropriate symbol. Symbols can be point, linear, or areal.

The controller should check to see whether a feature has been correctly symbolized with it's defined symbol (at project specification) or not ?. In general controller must compare the check plot (mentioned in previous section) with cartographic output, and also compare a symbol on the map with a symbol on the legend (or specification).

Another subject to control in this section is toponomy. Some features on the earth have a name or description which represents on the map by a text with appropriate characteristics (such as font, size, slant, inter character space, etc.). These are defined in the mapping specifications, and should be uniform for each feature according to it's size and class. For example as a rule, text of hydrography features is with an italic font. Size and inter character spacing depends on size of the feature.

With the help of the same programme as one mentioned in section 2 , correctness of text characteristics of features can also be checked automatically.

8. GRAPHICAL FILE INTERNAL STRUCTURE CONTROL

Data acquisition (digitizing), editing and other processing accomplished on the graphic file may result on creation of some problematic elements. These problems can be grouped in three levels:

1.Warning : Problems that still allow the file to operate with some minor problems. These problems are generally easily correctable. For example:

- Components of a complex element do not match the header of the complex element.
- The text string is zero length.
- The complex header does not include any elements.
- Element data overflows element size.
- The active angle is out of range (-360, +360)
- Low range of the element is greater than high range.

2. Error : Problems that have significant impact on display and operation of the file. Elements are usually disfunctionate and non-displayable. This may result in a file that will not even open and display. For example:
- A deleted element in a complex group..
- The element is off design plane.
- Number of vertices is greater than maximum allowed number.
- Not enough vertices for the element.
- End of the file encountered in a complex element.

3. Fatal: Indicates the file is corrupt.
- Element type zero.
- Number of "Words to follow" is out of range.
- The file does not have header or end-of-design indicator.

The programme is written to make an ASCII report about the graphic file, and give some information about the file, such as
- Active settings,
- Range of coordinates,
- Levels, styles, colors, and weights, used in the file,
- Number of elements separated by geometric type,
- And finally, number of good, warning, error, or fatal elements (if any exist) in the file.

The controller just views the mentioned ASCII report file to find if any problematic element exists. If the problem is not correctable, the element should mark and then delete from the file. This element should again digitize, and pass all other processes.

9. STANDARD CODE FORMATS

One of the main differences between digital maps (data on the computer file) and traditional maps (the paper maps) are that, in the digital environment, operators (users) can easily change (delete, move) map features. This can be an advantage of digital maps, when we are concerning with editing or updating maps. But it can also be a disadvantage, as the operator can easily by disusing available tools change reality, accidentally or deliberately. From a legal point of view this is an important subject, when someone wants to illegally use the modified digital map as a document for invoking. It is specially more important in large scale (Cadastral) maps production.

Therefore it is necessary for each map producer company to have itself standard code format known only by a reliable staff.

For this purpose a programme has been written in N.C.C. that has two parts:

a) Export part: gets graphic file and meta data file as input files and gives a coded file with N.C.C. Standard Format (NSF). This part is secret and of course not available to the public.

b) Import part: gets the NSF format file as input and gives three separate out put file as

follows:
1. The graphic file
2. Meta data file
3. A report file about the graphic file internal structure (mentioned in previous section 7)
This part is available to all users. Infact none of the three above files should provide to customers directly. Instead they receive only the NSF format file and "Import part" of this programme.

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REVIEW OF CARTOGRAPHIC COMMUNICATION: INFORMATION THEORY TO POSTMODERN SEMIOTICS

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Abstract

Robinson's text, *The Look of Maps,* published in 1952 began a process of extensive introspection on the part of academics involved in producing and studying maps. Robinson's goal was deceptively clear: study maps "scientifically." The first systematic attempts to understand cartographic communication employed the mathematical information theory of Shannon and Weaver. The early information theorists viewed the process of map communication as merely a cartographer (sender) communicating a message (information on a map) to a map user (receiver). However, early in these theoretical investigations researchers conceded that the basic analogy did not explain much about how maps do whatever they do.

Another thrust in the scientific study of maps began an exploration of maps with the tools of psychophysics and human factors assessing the effects of light, color, shapes and so forth on map user perceptions. These initial attempts to understand maps relied on the general concepts of behaviorism: A stimulus (or message) was to evoke a predictable response from the map user. Positivist and empirical science were to be the beacons to understanding maps and map usage. A subtle goal of these approaches was to find the one best map.

Soon another approach consisting of linguistic and semiotic perspectives emerged. Many variations evolved from the analysis of maps with formal or artificial languages as well as from natural language grammar paradigms. The natural language paradigms included attempts at explication by syntactical, semantic, discursive, and pragmatic perspectives. The linguistic view was inherently more intersubjective and led to less controlled and more qualitative investigations. These latter linguistic and semiotic attempts to explicate map communication led in various directions of myth and metaphor analysis, to the deconstruction of the concept of map, and, ultimately, have led to the tentative formulation of a postmodern, multivocal framework for cartographic products. The one best map goal has evolved into attempts at explicit statements of assumptions and an atlas of map views seeking greater interactivity of data and map viewer in a more dynamic, constructionist, and multimedia environment.

Introduction

The purpose of this paper is to review the developments in cartographic communication since WW II and to suggest future trends in the study of map understanding and theory. The interplay of the two main, ongoing themes of behaviorism and semiotics provides a framework to untangle the developments in cartographic communication.

As is well-known, the need for useful maps for practical navigation on a worldwide scale began in earnest as the European powers strove to explore, control shipping lanes, and exploit the rich resources of their colonies in the 16th and 17th centuries. New projections, better printing techniques, and other technological advances supplied cartographic tools to stay on course. The artistic embellishments of early maps soon gave way to more Enlightenment views of practicality and reason with just the "facts." These maps were asked to perform very limited tasks. Maps and map construction became instruments of national policy and maps soon became state secrets with the increasing needs of navigation and land surveying.

However, theoretical questions of map communication or the deep understanding of how is it that maps support user understanding of the milieu were rarely asked before Robinson's text *The Look of Maps* was published in 1952. Robinson's book began a process of introspection on the part of academics involved in producing and studying maps. His goal was deceptively clear: Study maps 'scientifically,' implying sound analytic and experimental methods to better understand how to present information and graphics correctly on maps. Before Robinson's call map analysis tended to be very descriptive in line with older geographic analysis. Robinson fostered a search for the holy grail of cartography: the one best map of a particular place or region. The one best map meant the one map that would serve all users at all times for all tasks. An Enlightenment or modern perspective suggests one correct way and many wrong ways to aid those with spatial information needs. After much effort in applying information theory and behaviorism derived from the positivist views of reality, an awareness has developed that multiple semiotic and postmodern views of reality require an atlas of cartographic support rather than the one best map.

In this paper we can only briefly sketch the various thrusts of the continuing quest to better understand map use and knowledge: information theory, behaviorism and cognitive science, semiotics, and postmodern views of cartographic communication. We will mention various definitions, assumptions, methods, results, interpretations, and generalizations of each of these thrusts.

Information Theory in Cartography

The basic assumptions of cartographic information theory derive from mathematical models of communication. Such models seek the most efficient mechanisms for assuring an exact match or the fidelity of a received message with the message sent across a communication channel. The mathematical models of Shannon and Weaver (1949) are the starting point for all these analyses. Their work concentrated on establishing algebraic mechanisms for assuring that the codes (Morse,

ASCII, etc.) for the alphabetic characters sent were those that were received. Shannon and Weaver investigated information as an analogue to thermodynamic entropy: More information is received when there is more uncertainty in the options for the message; that is, the more the uncertainty is reduced by a message the more information received. Unfortunately, Shannon and Weaver (1949) were not interested in verifying that the meaning received was the meaning sent but merely the proper transmission of the alphabetic codes. Application of their work to data compression and error correction in transmission has had wide application and is especially useful for remotely-sensed data and in geographic information systems (GIS).

However, when applied to humans who are attempting to convey meaning the theory may be necessary but insufficient. Map communication was initially viewed from an information theory perspective as merely a cartographer (sender) communicating a message (information on a map) to a map user (receiver). Many investigations were explications constructing isomorphisms between the telecommunication and cartographic environments. Extensions to the basic information theory model incorporating noise, changing the map to channel, and providing feedback were still not satisfactory. The faithful transmission of alphabetic characters does not assure communication of meaning between humans. The definition of information as the negative of the log base two of the number of binary digits has not had any significant impact on understanding the meaning of a map or map use. The early attempts to measure map complexity that provided measures but did not correlate well with human use or understanding of map content provides one minor example (Monmonier 1974).

Behaviorism, Psychophysics, and Cognitive Science for Cartography

Soon after studies employing information theoretic approaches began psychophysical, psychological, and cognitive science approaches were also used to assess cartographic communication. Psychophysics is based upon the groundbreaking work of Fechner, Weber and their followers in the latter part of the 19th and early part of the 20th centuries (Gescheider 1976). Psychophysics assumes that human sensitivity to sensory stimuli is basically constant across individuals and that the ability to discriminate various levels of stimulation or to assign a sensory magnitude is related by a power function to the actual stimulus intensity. The specific exponent in the relationship, now called Stevens Law, varies depending upon the scale units, sensory modality, and stimulus conditions. The first cartographic research using psychophysics focused on illumination levels, sizes of symbols such as graduated circles, and choices for map symbols. This work was done in parallel with the work of the information theorists and the two quickly merged in discussions of cartographic communication theory.

Human information processing (HIP) models are consistent with these psychophysics assumptions. HIP models assume human behavior is akin to the processing by a computer: inputs, outputs, and a black box in which processes occur that are not directly observed but inferred. Seeking consistent output behaviors associated with given input stimuli drives this work. The impacts upon cartography of

psychophysics were and continue to be rather limited, except for the amount of effort and resources expended. The cartographic theorists were soon disappointed with psychophysics because it found no significant and unambiguous pairings of stimulus map conditions with map viewer/user responses. However, work in this area continues to be supported.

The early disappointment with psychophysics led theorists to encompass broader work from psychology using more robust HIP models (Lindsay & Norman 1977). The inclusion of these broader psychological concepts permitted map use investigators to employ less behavioral and more cognitive paradigms and methods (e.g., Thorndyke & Stasz 1980). Typical variables include reaction time, time on task, accuracy, and error rates from which extensive theoretical inferences are made about the underlying human processes. Application of the work of psychologists Piaget, Inhelder, and Bruner have also influenced cartographic research (Wadsworth 1989; Morrison 1978). The cartographic HIP work focuses mainly on map reading, retention, and imagery. Similarly the image debate in cognitive science over whether human mental storage is done with images or propositions has spilled over into cartographic research.

The goal of the behaviorists was a lofty one that sought major effect size change in a craft thousands of years old. This has not occurred but the cognitive scientists engaged in cartographic issues have contributed in significant ways to understanding social and contextual variables, such as experience in viewers' map use and understanding.

Much to the credit of cartographic communication theorists has been their willingness to seek practical solutions and not be overly wed to dogmatic positions. The work of the International Cartographic Association (ICA) under Morrison's leadership had definite goals but within the guidelines entertained many avenues of research.

Classical Semiotics and Linguistics in Cartographic Communication

Semiotics is the study of signs. A sign is a technical term for semioticians referring to the triadic or dyadic relationship of a real world object, its representation, and its meaning to an observer. The work of Saussure (1966) and Peirce (1931) early in the 20th century stimulated this work providing two different approaches to understanding signs. By the 1960's linguists and semioticians hearing Robinson's call began applying their techniques to understanding cartographic communication. Linguists, of course, soon ran into a problem in describing the map language and its grammar since natural language is generally linear and sequential in its presentation while maps are clearly multidimensional. Dacey (1970) soon observed this and Robinson and Petchenik (1976) discounted there being a map grammar solely on these grounds. But the search for a set of rules for how maps are put together continues. This search for "the" map grammar is the linguistic and semiotic equivalent to the one best map.

Dacey (1970) flatly stated that all communication is language and therefore must have some set of rules or grammar to be understood. Additionally the issue of

what is the unit of map grammar for analysis is not trivial. What aspect of a map plays the role of letter, morpheme or phoneme, word, sentence, or paragraph? Much work in this regard has been done by cartographers such as Head (1984) and Schlictmann (1985), though frequently not agreeing among themselves.

Bertin's (1967) work in seeing eight visual variables (horizontal and vertical position on the plane, size, gray scale, color, texture, shape and orientation) has led to additions and refinements by MacEachren (1995) and others that have aided clarification of what constitutes a map and how maps work. Similarly, Tufte's (1983, 1990, 1997) works in design of graphics in general has added other aspects to the traditional semiotic and linguistic approaches to map understanding and communication such as chart junk and data to ink ratio. More literary approaches to linguistic analysis and semiosis include the work of Child (1984) who viewed map construction as isomorphic to poetry construction and Wood and Fels (1986) efforts to describe cultural myths embedded in maps.

Postmodern Semiotics: Multiple Views for Cartographic Communication

Immediately after World War II and into the 1960's there was a strong push for highly quantitative research. Robinson's call for the scientific study of maps was of this tradition for geography. The epistemological emphasis of GIS remains so positioned. However, as positivist geography became more balanced and tolerant of constructionist views in research during the 1980's and 1990's the understanding became apparent that the quest for the one best map was an illusion. Tasks, situations, user experience, and geographic palimpsests illustrate how diverse development can result from similar forces at different places. Such diversity requires analysts and the public to see the world from many perspectives simultaneously. Thus, a postmodern perspective of different realities entered mainstream geographic thought. Pickle's (1995) and Sheppard & Poiker's (1995) introduction of critical perspectives into GIS research further illustrates geography's move in this more constructionist and inclusive direction.

As this epistemological shift to multivocality occurred the technological tools to more easily create multiple representations became available. Experts using GIS could now develop multiple views and scientific visualizations including animation and multi-mediated information. The work of Buttonfield and McMaster in cartographic generalization is one positivist response to provide multiple views Their efforts involve seamlessly shifting the map image one resolution to another as the scale is varied. MacEachren (1995) and Gesmerel's (1990) extensions to Bertin's (1967) visual variables, and Monmonier's cartographic scripting (Monmonier & Gluck 1994) help clarify how cartographic multimedia information communicates and is understood. Exploration of such tools and analyses resulted in interesting presentations at least in research facilities. Work at Pennsylvania State University are exemplars in this regard: Gould's (1991) AIDS spread propaganda maps, DiBiasi's (1991) work in earth systems science, MacEachren's (1995) text *How Maps Work*, and his work with Taylor (1994) addressing visualization in modern cartography point towards these understandings and tools.

Observing cultural understanding and the role of maps in society also lead to postmodern views of map communication. Wood and Fels (1986) work in mythology of maps, Harley's (1989) deconstruction of maps, and Monmonier's (1996) popular *How to Lie with Maps* and his work in risk analysis, have directed cartographic understanding toward the need for multiple maps and the importance of taking all stakeholders' views into account as we re-present geographic information.

The Future: Applying Socio-Semiotics to Cartographic Communication?

The future for understanding cartographic communication lies, it seems to me, in the collaboration of technology, expert analysts, AND users of the products. A shift to collaboration with users reflects MacEachren's (1995) call to extend the study of cartographic communication to cartographic representation. Users provide the necessary reality check and validity assessment for the work in cartographic communication. Ultimately it is only the user who can evaluate the success of a cartographic product. An excellent design meeting all the experts' prescriptions that does not provide the user with the information in a form he or she can employ is much like the surgeon who performed the operation successfully yet the patient died. The critical and semiotic analyses of Harley (1989), Sheppard (1995), Pickles (1995) and the multiple view analyses of Monmonier (1996) and MacEachren (1995) omit one crucial component: methodologies to create frameworks for exploring the role of the user as collaborator in the cartographic analysis and product development.

Most previous analyses, expositions, and technological developments are by and for experts, or view users as less than fully human subjects. Somehow Harley's (1989) deconstruction of the map is more equal than others' explications: He was the expert. MacEachren (1995), in the introduction to his text on how maps work, is clear that "One of the major flaws in the communication model paradigm for cartography was that it failed to account for the active role of the map user in *deriving meaning* from maps [p.23]." One might claim that the expert's view is just as flawed for similar reasons. Humans make sense with more holistic tools than are assessed by measuring time on task or error rates collected in artificial settings. Egenhofer & Mark's (1995) work in naive or commonsense geography, Mark's (1995) work in applying user-based input to natural language understanding for GIS, and this author's work (Gluck 1996) in blending sensemaking and semiotics for geographic information indicate a need and methodologies for user input in the understanding, design, construction, and evaluation of products for cartographic communication.

The collaborative nature of users and experts requires a belief that users are not *respons-ible*, they do not blindly follow expert prescriptions but, rather, are *respons-able*, able to express their needs and wisely decide among a menu of cartographic products those that meet their needs. Another aspect of this collaborative nature is the need for usability in the design of cartographic tools and products. Users must not only be able to use the product (is it legible?) but they must find the tool or product useful in accomplishing the tasks driven by their own context or situation.

Cartographic communication and map understanding are, perhaps, not on the threshold of large effect size changes by treating users as informants and collaborators.

However, this is an epistemological shift to accepting a more robust ontology for what it is to be human, and where such a shift will lead is not yet clear. Using Gottdiener's (1995) terminology, we appear to be embarking on applying socio-semiotics to cartographic communication and representation. Socio-semiotics takes seriously the views of users of the artifacts. Applied to cartography socio-semiotics incorporates cognitive, affective, and social understandings with the hope of developing improved design of cartographic products.

In summary, cartographic communication has been and continues to be a flexible, adaptive, and pragmatic domain. Cartographic theorists continue to embrace Robinson's spirit of systematic study of how maps work and how users' employ maps to the mutual benefit of maps and their users.

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FUNCTIONS OF THE MAP LEGEND
(ABSTRACT)

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The map legend, i.e. the explanation of the symbols used in a map, deserves more attention than it receives in many cartographic textbooks. It is a separate subsystem within the semiotic system of a map and relates to the representation in the map face in various ways. Put differently, it has several functions, not all of which need be present in a given case. Tentatively five such functions are identified.

(1) The best-known function is that of a "dictionary": the legend establishes the links between symbols and their meanings.

(2) At the same time, the legend groups specimen symbols according to their meanings, so that conceptual units appear not individualized but linked in a structure. Criteria of grouping - substantive, temporal, and spatial ones - obtain separately or in combination. Substantive criteria are most frequently encountered. A temporal criterion applies where geological strata are presented in an age sequence. Under spatial criteria, specimens for vegetation units are arranged by elevation, or symbols for landforms and water features are assembled in a fictitious auxiliary map (as is known from some topographic series). Thus the legend visually models structural traits of the information. The two dimensions of the legend panel are put to service in this modelling.

(3) In addition, a legend may furnish information, in terms of units or of structure, whieh could not be accommodated by the symbolization in the map face. Example: the specimen symbols in the legend of a stratigraphic map are presented in the fashion of a drill-core column, and their heights are proportional to the normal thickness of the strata.

(4) A legend may further show the derivation of conceptual terms which have been mapped. A frequent case of such derivation is the definition of class intervals: quantitative values are grouped into ranges (classes), and these are treated as ranks and mapped. Here the legend serves to record ways of data-processing.

(5) Occasionally a sample out of many mapped cases is given. In the legend of a dot map, for example, one may include a few dot clouds and add the corresponding numerical values of areal density. In this case the legend facilitates map use by furnishing interpretation examples.

DANUBE DELTA BIOSPHERE RESERVE ATLAS

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"As the geologist, searching the Dobrodja's land, finds out a surprising variety of formations, from the Paleozoic ones to the recent sediments; and as the climatologist and biogeographer meet in this corner of the planet numerous characters, which carry us to Mediterranean Sea, others to Ponto-Caspic steppe, some to Central Europe, others to Anatolia Tableland, so the anthropologist and the ethnographer see in Dobrodja people quite a mosaic of races and nations, a living ethnographic museum; the historic, following the destinies of this area, follows a succession of overlap cultures and political changes."

C. Bratescu -1921

Abstract

The Danube Delta Biosphere Reserve ATLAS is an environmental regional atlas, which will present by means of a collection of maps, graphics, tables, images and texts, the entire geographical picture, from the territory genesis to the in-house population and its activity.The Atlas will illustrate, on the one hand, the fact that the Danube Delta Biosphere Reserve (DDBR) belongs to the universal heritage of the world and on the other hand the modern techniques to catalogue the biodiversity of this Universe Corner.

The Atlas's theme comprises memory pieces that are destined to emphasize the personality of this geographical unit.

The beginning set localize this geographical unit on the globe and in the present case of the Danube and Black Sea hydrographical basin. Also, a section concerning the Danube Delta and Razim-Sinoie Lagoonary Complex genesis hypotheses, together with the image of the river mouth of Istre (Danube River) to Euxin Pontus (Black Sea) will make more attractively the presentation of this geographical unit.

From the physical-geographical point of view, this vast depression territory with a large opening to the Black Sea is not a homogeneous zone. The alignment of the Tulcea Hills separates two gulfs: one of them is a liman with a triangular shape in North, which the Danube discharges itself; another one with an irregular shape, in South named in antiquity as Halmyris, is occupied nowadays by the Razim-Sinoie Lagoonary Complex.

The DDBR has a special flora and fauna, constituting a natural park of huge dimensions with an own world, born on the silts brought by the Danube river from the long distances or on the Sands thrown by the neighboring sea waves. DDBR - by the

great variety of its ecological conditions, presents a living medium very diverse and complex, fact that explains its populating in different proportions and in certain periods, with flora and fauna groups belonging to the diversest geographical kinds. In the same time the Danube Delta has unique species for Romania's fauna, strictly bound by the specific Delta's conditions.A number of over 5000 flora and fauna species was identified within 1991-1995 by means of researches performed thoroughly and systematically by a complex team that reunited specialists throughout the Romania country.

All these aspects are produced exclusively with digital technology, which done possible editing of an electronic version. The idea is to taking over products (maps, charts, spreadsheets) editing in GIS mode, which will bring up to date in every moment and will be a broad source of geoinformation for a majority of the learned society, while the electronic version will be a data collection for the computer users, specially for GIS users. In same time the Atlas will be constitute a «guide tour» for Biosphere Reserve.

The research efforts have divided up into the two modules that are operated in parallel: GIS team what developing data bases and basic maps and Atlas presentation team for displaying maps on screens, improving charts and drawings for presentation, creating a CD with electronic version (1997) and prepare the draft of the Atlas printing (1998).

Introduction and background

The establishment of the Danube Delta Biosphere Reserve (DDBR) in 1990 and approval of an adequate legislation by the Romanian Parliament - 1993, permitted the development of scientific activity in favour of the natural heritage and social patrimony knowledge.

The boundaries of the Reserve encompass the Danube Delta, the Murighiol-Plopu salt-marshes, the Razim-Sinoie lagoon complex, the Isaccea-Tulcea flooded sector of Danube as far as Cotul Pisicii and the Black Sea shore until 20m isobath (from Chilia Branch to Cape Midia).

Because of the biosphere reserves' importance and the great informational volume collected in course of time about this geographic unit, the DDBR Authority & Danube Delta Institute started to elaborate the DDBR Atlas, paper what will present the state of reserve and will sketches the future objectives for ecological restoration and conservation.

The DDBR Atlas as regional atlas has to present in maps, charts, spreadsheets, photos, drawings & text, all geographic aspects beginning with the territory genesis to native people and their activities. In the same time with the Atlas of Biosphere Reserve, a great heed is necessary to grant those aspects what determined the establishment and registration of reserve among international patrimony with a distinctive value. Among main aspects are those concerning flora & fauna, but these are integrated into a system which works accordingly to specific rules. The essential condition in a biosphere reserve is to maintain all systems in a good state - nearly to natural state. Without doubt the water has a leading part through hydrological cycles in working of respective ecosystems.

The main aspects will be present in maps, constitute a processing which is done directly on computers using GIS techniques - based maps as supports vectored

and processed in ARC/Info and Arc/View; drawings and schedules presented in Corel Draw package. The themes of DDBR Atlas will include numerous pieces destined to surprise the personality of this unique geographic unit, especially the stage of 1990 years - the beginning of its new statute.

Danube Delta Biosphere Reserve (DDBR) was created through the Decision of the Romanian Government No. 983 of August 1990 and is listed within three international environmental protection networks: the International Convention for the Protection of the World Cultural and Natural Heritage (1990), the Convention of Wetland Zones of World Importance (RAMSAR Convention - 1991) and the International Biosphere Network (UNESCO - M&B program). The law of DDBR (approved last year), in conformity with the criteria and methods is to establish the structure of Biosphere Reserve, state the boundaries that include: strictly protected area, variously protected buffer zones, where certain human activities may be performed, transition or economic zone, where traditional economic activities are permitted and areas for ecological restoration, reconstruction or renaturation.

The boundaries of the Reserve encompass the Danube Delta, the Murighiol - Plopu salt-marshes, the Razim-Sinoie lagoon complex, the Isaccea-Tulcea flooded sector, the marine sector of the Danube as far as Cotul Pisicii and the Black Sea shore from the Chilia Branch to Cape Midia, the inland marine waters and territorial waters of Black Sea, to -20 m isobath. The continental boundary of the Reserve lies between Dobrogea Tableland and the moist and wetland. The DDBR covers 5,800 km^2.

The Atlas compilation is destined to present a comprehensive view of this geographic unit with all characteristic features in present, but also past aspects, too.

Thematic of DDBR Atlas

1. Danube Delta among world deltas, geographic position, limits and dimensions.
   1.1 Spreading of principal 50 deltas on Terra
   1.2 Climatic conditions favourable to deltas formation
   1.3 Geographic position of Danube Delta - in Europe and Danube Basin
   1.4 Danube Delta and Razim-Sinoie lagoon Complex as part of Black Sea's Basin
   1.5 Danube Gulf (liman) at the Northern-Western shore of Black Sea
   1.6 Geographic limits and co-ordinations of Biosphere Reserve Danube Delta
2. Danube, its river mouth in historic and cartographic documents, old and actual.
   2.1 Danube river mouths map by Claudiu Ptolemeu
   2.2 Danube Delta and the Northern-Western corner of Black Sea by Strabon
   2.3 Danube Delta and Halmyris Lake by another antique scholars
   2.4 Danube river mouths and maps from XVII - XIX century (included the Map of European Commission of Danube from 1870-1871 edited by Sir Charles Hartley)
   2.5 Fishery Map drawn out by Eng. I.Vidrascu 1910-1911 (fragment)
   2.6 Danube Delta Map edited in Geography Institute (Petre Gastescu)
   2.7 Danube Delta - satellite image

3. Hypotheses about Danube Delta genesis

3.1 The map of Grigore Antipa, Constantin Bratescu, George Vâslan

3.2 The map of recent authors

3.3 The level variation of Black Sea and lithologic stratum chart of Danube Delta deposits

3.4 Maps with paleogeographic evolution of Danube Delta in Prequaternary and Quaternary

4. Maps of lithologic deposits of surface and morphogenetic divisions

5. Hypsometric configuration of Danube Delta

6. Morphohydrographic configuration of Danube Delta before the Sulina branch rectifying -1860

7. Actual morphohydrographic configuration of Danube Delta

8. Morphohydrographic evolution of marine shore and Danube's mouths

8.1 The withdrawal or advancement process and its yearly instalment of shore in Danube Delta and Razim - Sinoie Complex

8.2 The secondary delta evolution of the Chilia branch under cartographic documents (1830 - 1990)

8.3 The genesis and evolution of Sacalin Island (1897 - 1990)

8.4 Evolution of Sulina Branch Mouth

9. Climatic conditions

9.1 Radiation and sunshine duration

9.2 Multiannual average temperature map of January and July

9.3 Multiannual average rainfall map

9.4 Wind direction, frequency and speed map

9.5 Complex topoclimatic map

9.6 Bioclimate and therapeutical potential map

9.7 Charts of DDBR climate and topo-climate

10. Hydrologic data about Danube, branches, main channels, brooks, lakes, and seacoast waters

10.1 Variation of the level and liquid discharge

10.2 Distribution of discharge on the branches (Chilia, Sulina, Sf.Gheorghe)

10.3 Evolution of solid discharge and water quality of Danube

10.4 Map of average, maximum and minimum discharge along the branches

10.5 Hydrologic balance of main lagoon complexes

10.6 Map of water volumes in concordance with the level

10.7 Floodplain map of Danube Delta

10.8 Charts of water temperature

11. Map of hydro-chemical types and mineralization degree of underground water

12. Water quality of Danube and DDBR

12.1 Ammonium, nitrogen and nitrate variation chart

12.2 Chart of oxygen variation and CBO5

12.3 Chart of pollution substances

12.4 Saprobity map of DDBR

12.5 Eutrophication map of DDBR

12.6 Water quality and lacustrine deposits relationship

13. Physical and chemical aspect of marine sea-coast waters
    13.1 Temperature distribution at surface
    13.2 Salinity distribution
    13.3 Water pollution areas map
14. DDBR soils
    14.1 Soil category map
    14.2 Salty soils map
    14.3 Peat deposits map
15. DDBR flora
    15.1 Charts and spreadsheets of flora diversity
    15.2 Pictures of the most representative species
    15.3 Species introduced by man
    15.4 Vegetation map
16. DDBR fauna
    16.1 Charts and sheets of fauna diversity
    16.2 Images of the most representative species
    16.3 Zoogeographic map
    16.4 Map of bird migration ways
    16.5 Charts and sheets of main bird species
    16.6 Foreign species
    16.7 Fauna of marine seacoast water
    16.8 Sportive hunting permitted areas map
17. Geographic divisions of DDBR
18. People and settlements in DDBR
    18.1 Stages of Danube Delta peopled reflected in archeaological vestiges and historic documents
    18.2 The people's evolution in the XX th century (charts, sheets)
    18.3 Villages and cities (classification after structure and texture)
    18.4 Classification of settlements depending on economic functions
    18.5 Types of houses (photos and drawings)
    18.6 Tools for traditional activities
    18.7 Types of popular costumes
    18.8 Traditional customs and religious ceremonies
19. Economic activity
    19.1 Map of fishing zones
    19.2 Ichthyofauna modifications in the last 30 years, foreign species introduced in delta system
    19.3 Fish production evolution
    19.4 Fish collecting points network and the itinerary of the ships to the centres of industrial process
    19.5 The fishing into the marine seacoast water
    19.6 The itinerary of the migratory fishes
    19.7 The map of sportive fishing
    19.8 Agricultural activities
    19.9 Specific and traditional crops in Danube Delta
    19.10.Domestic animal breeding - map with grassland zones in DDBR

19.11 Reed harvesting areas
19.12 Traditional utilisation of vegetal resources (wickerwork)
19.13 Industrial activities
19.14 River and sea shipping
19.15 Sulina Port (tradition and actuality)
19.16 Commercial network

20. Tourism
    20.1 Tourism potential map
    20.2 Tourism types
    20.3 Tourism accommodation bases
    20.4 Tourism route map
21. Main ecosystem map types
22. Organisation system and monitoring network in DDBR
23. Nature ,deltaic ecosystems and fauna with a special scientific value protection
    23.1 Protected areas map - before the DDBR creation
    23.2 Integral protection, buffer and transition area map of DDBR
    23.3 Integral protection area maps to detailed scale emphasising each specific
    23.4 Proposed and arranged areas for ecological restoration
    23.5 Danube Delta Biosphere Reserve's law
    23.6 DDBR watching and control corps
24. DDBR general map 1:100.000

Arguments of thematic Atlas

The Atlas of Danube Delta Biosphere Reserve (DDBR) as regional atlas has to represent in maps, charts, sheets, photos, drawings & text, all geographic aspects begining with the territory genesis to native people and their activities. In the same time as atlas of Biosphere Reserve, a great heed is necessary to grant those aspects what determined the establishment and registration of reserve among international patrimony with a distinct value. Among main aspects are those concerning flora & fauna, but these integrated in system which work accordingly to specific rules. The essential condition is to maintain all system in a good state - nearly to natural, that so those specific rules to permit the unfolding of the processes which lead to the conservation and the development of the rare species and own ecosystems. Above all delta's system is wet, the water has a leading part through hydrological cycles in working of respective ecosystems.

Owing to delta ecosystem's brightness, also the man intervention organised adequately for economics purposes and not controlled individual action of people, direct to breaking the ecological equilibrium and its destruction.

The themes of DDBR Atlas include numerous pieces destined to surprise the personality of this geographic unit, specially to the stage of 1990 years - the beginning of its new statute.

1) The beginning set for any atlas, which deals with a region or geographic unit, is the position in the continent and particularly, in this case in the Danube Basin, because the delta is the result of hydrographic basin. In some maps we will place Danube Delta among the biggest deltas of the rivers on the Terra. Also it is useful a plan with NW shore of Black Sea where appeared some gulfs what are distinct

entities: - Nistru (liman); the former lagoon (liman) of Danube, in our days occupied by delta with same name, and Halmyris gulf that was closed from belt seacoast and transformed in lagoon complex Razim - Sinoie. Hence another problem was established, present perimeters of biosphere reserve include two geographic units, that differ from genesis: delta and lagoon complex, where the sea coast water reaches till the isobath of 20 meters.

2) The next grouping of plans and information refer to manner how was seeing Istru (Danube) mouth in Pontus Euxinus (Black Sea), through how many branches flow into the sea and the names of these branches. The position of Danube mouths to Pontus Euxinus, the antique fortress in its shore, the interest of the former great powers made this geographic area to have information and even cartographic documents from 2500 years ago. It is useful to remark through facsimiles and samples from some representative maps made special for Danube Delta:

- The map of Sir Charles Hartley, 1871,
- The map of Eng. I.Vidrascu, 1907-1911,
- The map of Geographic Institute, coordinated by P.Gastescu in 1983.

Also in this grouping it is established an actual satellite image, reduced to A4 format.

3) In the section about delta and lagoon complex genesis it will be included hypotheses, quotes in majority of geographic papers work from Romania. About Danube Delta genesis there are many hypotheses and this will be not finished at 1990 years. However personalities like Gr.Antipa, C.Bratescu, G.Vâslan who emitted hypotheses must to be register, also it will be adding the result of the latest researches from the air space photos analyses, drillings and radioactive determinations which established plausible evolution stage.

In this section it will be introduced a map with lithological deposit of surface (4) and a chart with the level variation of Black Sea from Superior Pleistocene to 2000-3000 years ago.

Few maps will be introduced comprising the hypsometry configuration and morphohydrogeography not disturbed and modified due to polders and another anthropic intervention (5, 6, 7). The hypsometry configuration will be made on the computer on maps to scale 1:50,000 elaborated in the Geography Institute with 0.50m level curves for the sea-river sector and 1.00m for the river sector. These maps give a relief image of delta and permit to compute the water volume that is stored at different levels of Danube. The next chapter will refer to the morphohydrography of shore between Capul Midia and Gârla Musura.

It is well-known the complex and contradictory process of shore evolution as a result of climatic and anthropic factors. The comparison of cartographic documents from over 100 years and surveys to point reference during 30 years, permit the determinations of sectors where is withdrawal or advancement process and yearly instalment. The secondary delta of Chilia and Sacalin Island will be a subject which reflects the abrasion and accumulation process and will be represented in graphics.

The climatic conditions included at point 9 will be reflected through maps which register the temperatures, rainfall and winds. At this point we refer through charts and plans at bio-climate and therapeutical potential particularly of sea shore. Will be included a map of main topo-climats, extremely useful in the flora and fauna

protection activity. This map is based on main climatic parameters and the results of researches undertook during the last 20 years.

The hydrological regime (10) , hypsometric and morphohydrographic maps constitute the main support in the ecosystems condition. In this chapter we start from the variation regime of Danube at Ceatal Chilia through charts of liquid and solid flow, water mineralisation, water distribution on these three branches but also on the main channels. These aspects will be presented evolutionary in time. The hydrological image will be completed with balance models of lagoon complexes, charts of water volume accumulated, regime stages, flooded areas at different hydro-units, temperature of water.

Concerning the water quality (12, 13) as one of the biological productivity condition, which the Danube depends on, they will be analysed parameters such as oxygen dissolution, consumption of oxygen (CBO5), ammonium, nitrogen, nitrates, pollution substances (phenols, heavy metals, pesticides) at Ceatal Chilia. However it will be marking its evolution in reserve (including sea-oast water) in long-term. As maps, these will be elaborated in two variants of saprobity and eutrophication.

Because we are in new land development, the soils (14) will be made on three maps: with soil categories, organic deposit soils and soil salinity in DDBR.

As it was previously mentioned, flora and fauna are components which grant personality and fame to Danube Delta. These aspects will be represented through maps, sheets and special pictures and photos (15, 16). Special heed will be granted to the rare and protected species. Also for catching the aspect of flora and fauna there will be represented the modifications due to the polders creation and it will be changed the water quality.

Especially, sedentary bird species, corridors of passage, migration lines will be represented in maps, as these things give a great importance to the Danube Delta..

Also hunting fauna will be marked with effective species and their areas.

At the 17-th point it is stipulated a map with geographic divisions of reserve, these being useful for the general orientation of research and management of the protection activities.

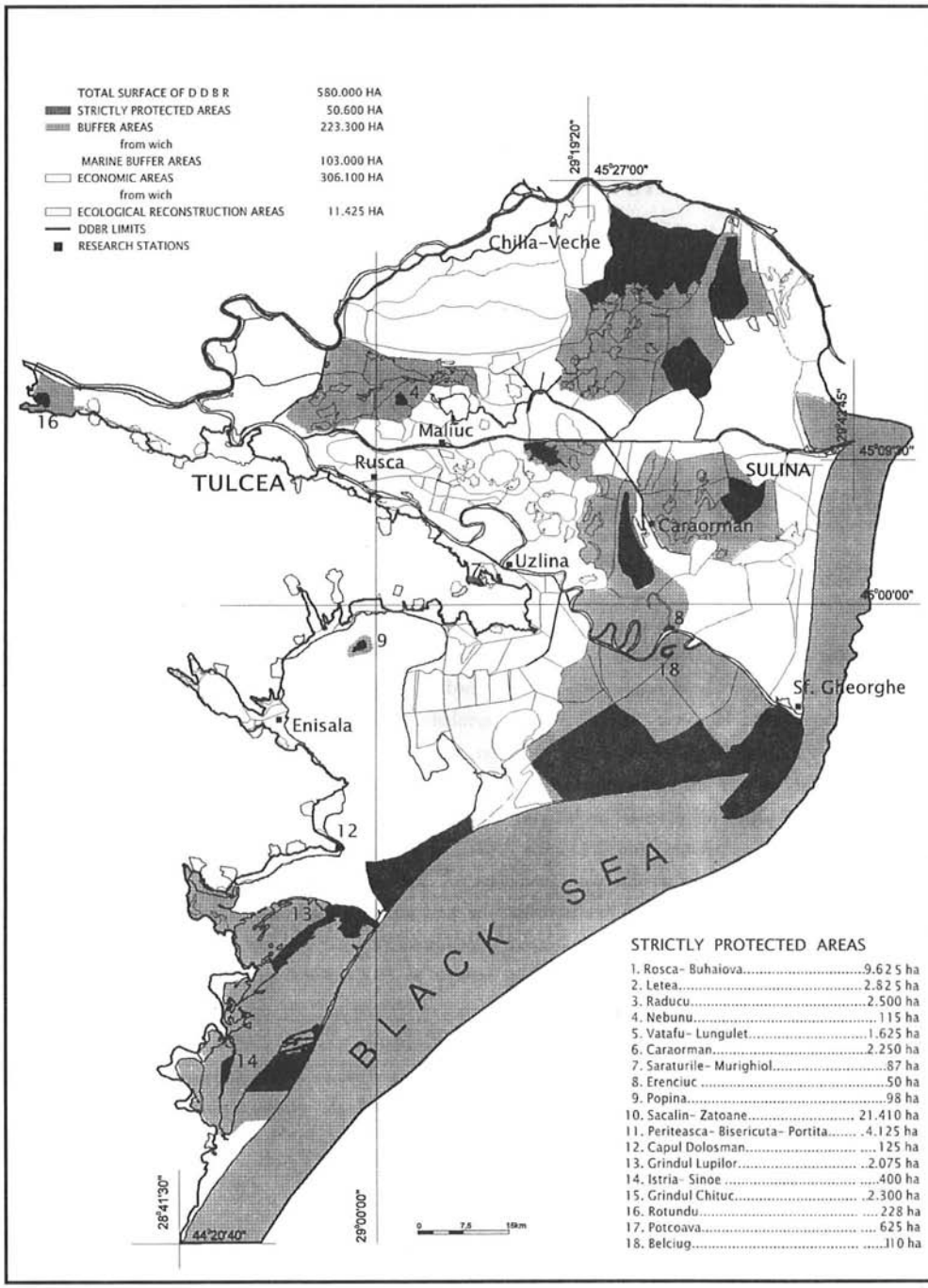
Population and settlements (18) represent an important section, that means stages of Danube Delta population and the structure the actual people - it will be analysed the development and regress during the last 50 years. Also it will be highlighted traits, specific characters of local population (costumes, kind of houses, religious and ethnic customs).

The sea transportation on Sulina branch, evolution of Sulina port, industrial activities are aspects that will be registered through charts, sheets and maps.

At the end of the Atlas (24) it will be represented, a map of DDBR on 1:100.000 scale.

The DDBR Atlas is a collective work that continues the old traditions and preoccupation in the Romanian scientific Atlas subjects, such as: the Geographic General Atlas, the Romania Atlas, the Climate Atlas, the Road Romanian Atlas, the National Atlas of Romania. To this work contribute famous institutes from our country, such as: Danube Delta Institute from Tulcea, Geography and Biology Institute of Romanian Academy, Pedology and Agro-chemistry Research Institute from Bucharest, Eco-Museological Researche Institute from Tulcea.

THE BIOSPHERE RESERVE DANUBE DELTA



THE PHILOSOPHICAL LEVELS OF MAP SYMBOL AND THE EXPLORATION OF ITS INFORMATION FUNCTION

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Abstract In order to get a comprehensive and thorough recognition of map symbol and a better exploration of its information function, it is not enough to study only from the angle of practical technigue, but also to analyse the essence, characteristics, function and law of operation from the height of ideology, culture and philosophy. It is analysed in this paper that the map symbol is an artificial indicator as well as the essence of map-makers' ideological expression; it is expounded that map symbol, compared with other signs, has both generality and distinction with them; it discusses various functions with respect to expression, cognition, thought, culture and desthetics; it also puts forward the opinion to make the information function of map symbol better.

Symbol is an essential element of a map, and the study of symbol is one of the basic problem of cartography. During mapping practice, people have already carried on long-term study of map symbol and summed up various laws of symbol-designing and applying. However, being a kind of symbol, map symbol's characteristics and functions manifest themselves not only on practical technique level, but also on thought, culture ane philosophy levels. So it is not enough to study map symbol just from the aspect of practical technique, and we must further understand symbol's essence, characteristics, function and its operation laws from the angle of philosophy

Looking back the traditional viewpoints of cartography (also including map symbol), we probably have to admit that the view put forward by D. R. F. Taylor is reasonable——"the ideas of cartography is comparatively narrow and limited, poor and lack of imagination"[1]. Especially today, as modern castography is facing challenge of the information era, map-makers are obliged to "use modern scientific theory, including philosophy, aesthetics and mathematics to direct the technique of map-making, to deepen the knowledge and understanding of cartography, and to strengthen the construction of cartography theory and the study of application basis"[2]. In fact, for any kind of well-developed subject of study, the deeper the

study goes, the more philosophy is desired, including the direction of scientific thinking and methodolohy[3].

Symbol, a tool created by man, has close connection with people's understanding activity as well as our practical activity. It exists everywhere in understanding activity as an approach to change object to subject inwardly, and at the same time, it plays an active part in pratical activity as a medium to transform subject into object outwardly. Without symbol, people's understanding and practical activities would be impossible[4]. Therefore, symbol has become one of the objects of philosophical study from the very beginning. In the modern world, the study of symbol philosophy is not only a mark of philosophical deepening, but also harmonizing with modern technical revolution, and every subject of study also starts to study symbol from its own angle. Take cartography for instance, in the modern information processing technique, based on computer, simulation of thought, artificial intelligence and so on are all connected closely with symbol phenomenon.

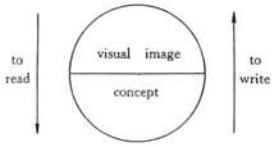
1 The Essence of Map Symbol

F. D. Saussure, one of the explorer of the modern cartograghy, pointed out that "in essence, symbol is social", and any expression method accepted by the society belongs to symbol, including languages, characters, music, …… symbolic rites, military signals, etc.[5]. Map symbol is among them. Symbol, created by man, takes great number of forms, and can be divided into symbolic symbol, signal symbol, language and characters symbol and scientific symbol[4]. Map symbol is a specialized symbol created and applied in map-making. Based on cartography theory, it simplifies and replaces the statement in geographic theoretical language through the conventional meaning, and expresses the conclusion of geographic information and geographic thought. Obviously, map symbol belongs to scientific symbol. But, at the same time, it possesses the features of visual image. Many symbols describe and analogize mapping objects through direct and vivid images. Figure of symbol contains its explanation of the content. So it is also similar to symbolic symbol.

1.1 The philosophical substance containing two elements

What is symbol? A. Schaff said very precise, "Symbol represents a 'thinking object' by a material object, or strictly speaking, it represents an abstract concept"[6]. Map symbol does the same. What it connects is not object and name, but concept and a material figure. Generally, map symbol is not desised or is impossible to show every specific object, but is to express essential characteristics of all kinds of objects. To do this, it demands comprehensive analysis and abstraction of mapping objects. There would be no symbol without abstraction.

According to Saussure's analysis of language symbol, we can draw a model picture of map symbol. This model picture illustrates that map symbol is a psychological substance containing two elements. One is the concept of mapping object that has been comprehensively abstracted, being called indicated (signifié). The other is visual image of symbol, being called indicating significant. The so-called image is not necessary to be actual material figure, but it also can be a kind of perceptible psychological impression-idea. Indicated and indicating are two aspects that are both opposite to and depend on each other. Lacking any aspect, the characteristics of symbol would not exist. When creating and applying symbols, people transform a concept into a figure, or creat a material figure and give it a certain meaning. And when reading out symbols, they change material figure into relevant concept. The former action is "to write", while the latter is "to read". These are a couple of contrary processions.



Indicating of symbol consists of expression level, and indicated makes up of content level. Generally speaking, the former can be considered as the form of symbol, meaning the image that can be sensed by some method (such as vision, tactual sensation, etc.). It is a carrier with certain information. The latter indicates the content that can be inferred or understood. It is an object that is brought into man's knowledge scope, and grasped by man's thought and then possesses idea form.

There are two problems worth paying attention to: First, the two elements of symbol are often not symmetric in people's psychology. In many cartography books, the word, symbol, always indicates "symbol's form" actually. But none of the map-makers should forget that it would not be a perfect symbol if only the symbol's form is noticed but the relation between its form and meaning is neglected. Secondly, any symbol will be effective only in its own symbol system. The value of symbol consists of their distinction and connection between each other in the system. We should not consider symbol from an isolated angle, but define every symbol's elements from the dependent entirety[7]. When referring to designing map symbols, we, obviously, should build up two kinds of relations. One is to define the relation between a visual figure and a mapping object. The other is to define the relation among symbols.

The connection of the two elements of symbol can be done by two methods. One is conbining automatically according to social convention. The other way is conbining through the artificial conscious regulations. The former belongs to natural symbol, likd natural language; the latter belongs to artificial symbol, like map symbol,

mathematical symbol, etc.

1.2 Artificial indicator and thinking expression

Mapping is to describe the regional geograghic statement to people. When dealing with the regional objects, map-makers should use symbol to stand for them, in order to "refer to" these objects at any time in the map. In view of this, map symbol is what people use to indicate, mark or name certain object. It is the indicator or mark of certain objects[4]. "Name" and "substance" are unseparable. Symbol can't exist isolatedly apasting from object. Once the relation is settled, symbol will appear just as object's substitute. People see symbol as if they see the object for which it stands and the idea of the indicated object is aroused.

Although map symbol is the artificial indicator of the object, it is separated from the object after all. It neither exists among objects, nor is an equivalent of the object. And there is no inexorable connection between symbol and object, but a rational relation artificially conventionalized. In order to replace object's image by symbol's image (and vice versa) in thought, people consciously connect symbol and object in thinking field, and realize the transformation of two different images. Here, people's thought becomes a tie linking symbol and object[4]. So the active function of man's thought will surely be transplanted to symbol itself, and this makes it possible that map symbol can surpass the object's perceptual level to reach the level of object's inner character, abstract generality and its decomposition and composition, when indicating object. This also makes map symbol show not only common and objective perceptual objects, but more abstract and more profound rational objects as well.

2 Map Symbol's Characteristics

Map symbol is a subsystem of the social symbol grand system. It belongs to scientific symbol, but it is different from the extremely abstract scientific symbols, such as maths, physics, and so on. It is it's visual image nature that makes it possess some characteristics of symbolic symbol, but it is different from ordinary symbolic symbol, such as art symbol, etc. In characteristics, compared with other symbols, it has both general character and individual features.

2.1 Nature of convention

One of the differences between map symbol and language symbol is the distinction of the ways of conventionalization of the two elements. Natural language is formed naturally through long period social life, while map symbol is regulated artificially by map-makers. Facing the objective objects, map-makers go into a series of treatments, like classifying, grading, synthesizing and summarizing, and then set for them corresponding rules for symbol forms and symbol relation. We can say that

the process of formation of diagrammatic files is the process of building up the convention of the one by one corresponding relation between symbol form and the abstract concept. Once the relation is settled, symbol is formed and has binding force to map-makers and users.

2. 2 Nature of option

Being an artificial indicaton of the object, map symbol is not bound to have necessary relation with the object. It is of great arbitrariness to define a symbol form for an object. For the same object, people can always conceive various symbol forms, that is to say, there is a set of symbols and each of them can indicate the same content[8], so they are equal in characteristics. Just because of this nature of option, map-makers can choose the best according to themselves, and unite the principles of use and satisfaction very well, then form their own style of mapping. The starting point from which they choose symbol form in theset is usually not internal laws of symbol itself, but external factors, such asmap scale, usage, characteristics of mapping objects, map-readers' and map-makers' psychological factors[8]

The nature of option in maps often appears as variable mature. Asymbol figure, such as a triangle, stands for control point in this map, and can represent mineral deposit in another map. A kind of red spot shows paddy's distribution scope in this map, and may mark the red soil's location in another. Since the number of map symbols is much less than that of language symbol, map symbols are unavoidably used repeatedly. As a result, legends, as the symbols' conventional explanation is an indispensable appendix on maps.

2. 3 Nature of abstraction

Although all the map symbols' figures are concrete and sensible material figures, as symbols they all own the nature of abstraction. The content of map figure is abstract. Each indicates the concept of a certain kind of objects or abstract characteristics of some features, and it can not be a very concrete object. The figure of symbol is abstract, too. "A figure, used to transfer visual information, no matter how true it is to the original type, the process of choosing it will always express the map-maker's explanation to the things he concerns"[9]. In addition, all the symbols must abide the principle of simplicity and clarity. Only abstracted and simple symbol can scientifically express the rich contents of the map.

It is thus clear that map is different from the variable true world and there is even very great distance between the two, although map is called figural model of the objective world. This distance is not a demerit of maps, but a result of cartographic abstraction.

2. 4 Nature of accuracy

Map symbol is abstsact, but it owns unquestionable accuracy. Though people consider that map symbol as well as language symbol has fuzzy nature, compared with language symbol, map symbol is much more accurate, as it is a kind of scientific symbol, after all. However, map symbol is principally equivalent to noun in language, and it has no parts of speech as verb, function words, etc. Under general condition, every map symbol has precise concept. Fuzziness exists mainly in the relation of symbols. So map symbol can express object's character concept, quantity concept, grade concept, location concept and logic concept.

2. 5 Nature of symbolization

Symbol's optional principle shows that there is no grounds for necessarily representing an object by a sole symbol. Symbol figure and its indicated object has a relation of code, which does not require any special reason. On the other hand, the aim ot map symbol is to establish a kind of symbol-figural model to describe this world, so the nature of symbolization must be emphasized. The similarities between symbol figure and indicated object, no matter in shapes or colors, will give us an impression of natural correspondence of the two. In order to get correct knowledge, peole have to rely on their own knowledge and experience, and project these into figures when reading maps. Symbolic symbol can better arouse map-readers' memory of the original knowledge, and make the process of cognizing symbol more convenient and quicker. This is what the discipline of symbol application asked.

It is thus evident that map symbol should advocate using symbolic figures, no matter on tourist maps or scientific seference maps, and the only difference should be in artistic degree and method of abstracting.

2. 6 Nature of space

Visual symbol and audio symbol have essential difference. The latter (such as nature language) takes time as the major constitutional force while the former adopts space[10]. This is also an important distinction between map symbol and language symbol. Even if we change oral language into writter language, the linear character of language will keep its nature of time alignment. Map symbol shows striking nature of space and integration. It is good at indicating the space character and transversal relation of objects. No matter in mapping or in map using, it is stressed to study the problem from transversal, spacial and integrate angles. As a result, map's cognition and thinking method has strong character of thinking in terms of images[11]

Of course, this does not mean that map symbol has absolutely no ability to represent time logic. The spacial surface logic of map symbol can appear somewhat

inconsistent with its information's objective logic. Simultaneous symbol figure can also show certain sequential constitution, in order to show some successively appearing and changing things. Proper mapping technique can fulfill this task.

3 Poly-Function of Map Symbol

Being a tool created by man, map symbol is a medium of people's cognition activity, thinking activity and practice activity. So its function has various aspects.

3.1 Being both expressing approach and directly recognized object

Symbol's essential function is transferring information as a carrier of information. Map symbol is no exception. In transferring information, map symbol's function actually expresses itself in two aspects: one is an approach to translating map-maker's thought, the other is an object for map-users to recognize directly.

No matter what kind it is, map-makers' knowledge of the objective world is a result of cognition and thinking. We have to depend on symbol to transform "the inner language" of thinking activity to maps. Because, when people want express his (or her) understanding of a certain thing, it is impossible for them to use every concrete thing. He (or she) must abstract the concrete to the general, that is, to use ordinary symbol to express objects. Without symbol, map-makers' knowledge of the objective world would be limited within the mind, but never be known by others nor has any value.

At the same time, being the extension of map-makers' knowledge, map symbol is also the direct realized object for map-readers. The same as we learn knowledge from our predecessors by books, and know the world situation by newspapers. People need not step over every spot, but know geographic knowledge everywhere by maps. In this way map symbol has the function of cognction, as people's directly recognized object. It "guides and introduces" mapping objects to people's cognition activity. Map-readers will grasp the objects indicated by symbols in idea, by meeting some symbols and grasping the meanings of them.

3.2 Being a tool of thinking operation

It is approved by thinking science that people's thinking activity has close connection with symbols. All the thinking activities are a series of processes of concepts' tranformation and circulation. And concepts are all embodied by its representative-symbol figure. So thinking activity is symbol's operation activity, manifesting itself as processes of expension, decomposition, composition, regeneration and so on, of the symbolic symbol units. Language is the most essential symbol, and it is the most frequently used "inner language" in thinking activity. Not only natural language can be used as a tool of thinking operation, but also can the

map symbol, as a kind of figural symbol. But only in different thinking ways, the symbol's figure and abstract method applied are different. In abstract thinking the abstract symbol, such as the language, is the major tool, while in figural thinking, figural symbol is the major tool. The symbol operation of thinking in images consists mainly of analysis, synthesization, induction, deduction, analogizing and inferring of figures[12]. R. Arnheim condidered that the abstractly processed image is a medium and concludion of all thinking activities. We can even say that is "the flesh and blood of thinking activity"[13].

Experienced map-makers would easily understand this situation: when he is analyzing the morphology of the land form, it is not necessary for him to transform the winding shape of every contour line into concept type, but he can directly determine the geomorphic character and type according to contour lines' winding shapes and their combination. This approves that map symbol can take part in the thinking activity as a thinking image. The problem is how can the design for the map symbol be more proper for the map thinking's requirement.

3.3 Being a cultural model

There is a tendency existing in cartographic circle for many years, that more attention is paid to map's technique aspect, but less is given to its culture value[14]. However map is not only a simple tool, its culture value should not be neglected, which prevails over the tool in significance.

One symbol system should inevitably correspond to a certain kind of thinking method, A Japanese expert gave an example of language symbol: in English, the word, "brother", can refer to either old or young, and Americans seem never considering to distinct elder brother and younger one. But in Japanese and Chinese, "elder brother" and "younger brother" are definite, and it is an obligation to use language symbol to distinct them[15]. It obviously shows that the relation between elder and younger brothers has different implication in different culture (in eastern culture, the two brothers have different obligation and rights). In language's constitution laws, different language types have great distinction. This approves that regulating a symbol system is to regulate a culture value system and is to define what to be understood and how to understand.

Map symbol can not deeply express the social view of culture value, like what language symbol can do. But these two symbols are the same in nature. Object indicated by map symbol is no longer the pure objective things out of people's sight of cognition, but the object that is brought into people's cognition scope and has idea form. So it is bound to express human's idea. Once the symbol process is completed

and the symbol system is determined, it becomes the rules to direct and restrain those who have a good command of it map-makers and users. People must observe and recognize the figured object under their rules, and recognize the mapping object from their deepth and width. So, the formulation of map symbol system—the legend norm possesses great importance.

3. 4 The aesthetic function

The so-called aesthetic function is opposite to the practical function of map symbol from the general sense. In view of its practical function. symbol, being a method for transferring certain contents has its value only when it affects on certain aim, while the aesthetic function is embodied by symbol figure itself. Practice and aesthetics are two extremes of symbol's sense function[15]. The former is wholly conventional and normalized symbol sense, possessing scientific nature, the latter is unconventional and unnormalized symbol sense, possessing aesthetic nature.

The same as people not only pay attention to expressing clearly but also emphasizing on artistic language by wording and phrasing and on artistic calligraphy by pretty writing, when people write articles with written language, map-makers make use of symbol's aesthetic function, including the artistic shape of each symbol and the artistic constitution of the relation of symbols, when they creat maps. The aesthetic function of map symbol is one of its inherent funcions.

4 The Exploration of Map Symbol's Information Function

Through the theoretical analysis for map symbol, we see that symbol's essence is not simple mark or signal, nor its function is to mechanically reproduce the objects. It contains people's active reflection for objective things as well as culture significance. It is really very proper that people use "language" to modify map symbol. Map symbol is far more less rich and profound, compared with language, but it possesses the same philosophical nature as language and some characters that language doesn't have. How to give full play to symbol's information function is a comprehensive problem that demands overall and thorough study and experimental veritication. In my recent view, the following points should be paid much attention to:

4. 1 Design of map symbol should be brought into the systemmetic process of cartograthic symthesization

In many cases, map-makers often accomplish the symbol, taking it for a single procedure. Actually, from the very beginning to the end, the whole mapping process is a process in which map-makers abstract the objective world scientifically, and symbolization is one part of the systematic process. Map-makers procure the abstract knowledge and go in for symbolization. These two processes appear as two sequent

steps, but in fact, they can by no means be separated. The former is to form symbol's inner concept, the latter is to form symbol's outer figure. So when designing map-makers should not isolatedly consider the problem just from the angle of symbol figure, but in the light of laws of system engineering, use a series of orderly and well organized symbol figure to stand for the aimly abstracted object and its internal relation. With such symbols the internal relations among them can be emphasized from the very beginning and it will be possible to proceed a reasonable and efficient coordination when making use of them.

4. 2 Building up the symbol system according to the natures of integration and constitution

"Only those languages, which attain the sentence level, could be called real language, because the complete process of people's grasping of objects could only be perfectly expressed by sentences"[4]. The isolated design of symbol can't create a symbol system at language level. So we must solve the symbol problem from the angle of syntax and the constitutional relation between symbols.

Gestalt psychology one of the modern theoretic basis for visual sensibility of map, considers that in a perception field, all the elements and components belong to the entirety, and each partial change would lead to reorganization of the entirety. The constitution of perception follows "a law not being of addition nature"[16]. That is to say, the map entirety is not the sum of all the symbol information, and the entirety goes not only far move beyond the sum, but forms an new entirety independent of these components. It's easy to see that these derived information comes from the constitutional relations of the symbols. Map-makers should try to organize symbols intentionally at every level, and form a corresponding equiconstitutional relation with the object world. Only in this way, map has more profound implication, as model of the object world.

From the angle of cognition and thinking, regular symbol constitution is more suitable to symbol operation in mind. Isolated symbol can neither express deep information, nor be easily recognized and memorized. Scientific experiment approved that people always memorize things with group block of different forms as unit[17]. Take maps for instance, the so-called group block is the information group containing certain contents of information. So, map-makers should not consider only the semantic function of single symbol, but should further consider how to express the contents by the relation of symbol organization. The different purposely organized symbol group blocks of different scales are surely helpful for map-readers to get more information.

4. 3 Emphasizing the effect of "language surrounding" to concrete symbol information

Map symbol and its entirety do not only show their own information value, but reversely affect the cognition for other symbols. "In any piece of information, both normal and ambiguous methods exert pressure of 'language surroundings' upon all other informations"[10]. Symbol "code" and "language surroundings" have a relation of mutual supplement[15]. All the symbols their constitutional relation and other factors in the map surroundings constitute a kind of "Language Surroundings" comprehensively, which synthetically, has individualizing effect on symbol's meaning, just like the case, where for the same sentence, the implication would be greatly different if it is spoken out by different person, on different occasion, under different atmosphere, with different expression. Map symbol would have completely different implication in different image surroundings. For example, the same mineral deposit symbol can mean a very potential mineral zone in a group of spots on a certain kind of geologic map, while it may be casual and odd mineral spot in another group of spots.

There is another example, on the common maps compiled by positioning diagram method or choloplethis method, it is not enough only to define the ratio relation of symbols to express the difference between various quantities and we have to settle the general scale of those objects indicated by these quotas, and the positions they should be placed. For instance, there is a map of piggery industry, under the presupposition of showing the ratio relation correctly, the size of symbol on one map is commonly very large, and the map coverage ratio of symbols is very high; while the size of symbol on another map is very small, and the map coverage ratio is very low. When people read the data on the former map, they will have the impression that the piggery industry is prosperous in this area, and it should be one of the local major industries. On the contrary, when reading data on the latter map, they will find that the piggery industry is only one subsidiary and supplementary industry of this area, although the numerical value is the same. This is caused by the language surrounding.

4. 4 Supplying with reprocessed information and compound information

The concept for an object expressed by the map symbol constitutes naturally a certain effective information, but people often analyse the map to seek the deeper level information to meet the demand. Because of the difference in map-readers speciality knowledge background and ability for analysing maps, it is not sure to obtain correct and complete conclusion. What's more, there is a law in information theory, saying

that in the course of information communication the information would be somewhat differed through every link and every transformation. So, to reduce to the full the intermediate links and to directly supply the map-readers with processed secondary information and compound information constitute a new request for maps from the modern society. To directly afford the map-reader those deeper level informations, such as inherent laws, analysed conclusion, forecasted tendency and so on, would no doubt greatly raise the map's practical value. Prof. Chen Shupeng has a very vivid analogy: miracle would be created if we pass the relay baton a bit farther[2].

4.5 Making map symbol and language symbol supplementary to each other

E. H. Gombrich pointed out in his study of image science, that "The correct interpretation of the figure is controlled by three variables: the code, the verbal explanation and the context"[9]. Among the three, "code" indicates the regulations for figure's symbol concept, the so-called "context" is actually the language surroundings referred before. He pointed out that although figure owns ots advantages without the help of characters, "it is almost impossible to march with the stating function of language". It can be imagined that, any map's figures could almost be stated by language. Maybe we should use large amount of stntences, but generally speaking, we can give a clear expression. On the contrary, language statement could not be always translated into graphic image. This is because that map symbol has no complete grammar rules and logic words as the natural language does. In this way, map symbol actually can not be separated from language. It is very necessary for the understanding and using of map symbols that we use other verbal explanation to supply some background information and supplement for the contents of the map, besides the legend verbal explanation which ditermines the semantic relation of map symbols.

On thematic maps, we are accustomed to simply use map symbols. Even if verbal explanation is needed, we always separate the figures and the characters, or print the figures on the right side and the characters on the obverse side (and it is always a lengthty speech). The separation of figures and characters, if frequently employed, is unconvenient for use and seems rigid and lacking flexibility. In fact, on most thematic maps brief words concerning the contents are disposed at the blank space, which can both enliven the picture and make up the defect of figure cognition, furnishing guide and suppliment for reading the figural symbols, so as to improve the using efficiency. This is economical and worth while, being after all a wise move.

Reference (be omitted)

SOME BASIC MATHEMATICAL MODELS FOR FEATURE DISPLACEMENT IN DIGITAL MAP GENERALIZATION

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Abstract

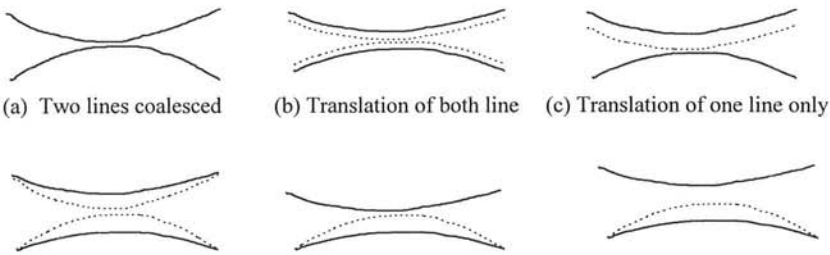
Generalization is a very important topic in cartography/GIS. After generalization, a process called displacement might be required for the following reasons: (a) features being coalesced due to a reduction in graphic space available; (b) spatial conflicts being created by inappropriate algorithms or procedures; (c) the characteristics of the structure of some map features (i.e. a road junction) needing to be kept. In this study, two types of feature displacement are distinguished, i.e. feature translation and feature modification. Some mathematical models for both types of displacement are presented, which are based on the operators developed in mathematical morphology which is a science dealing with form, shape and structure of objects. These models have also been experimented using real map data sets. The results show that these models are very promising.

Introduction

Map generalization is a process to derive representations suitable for maps at a smaller scale from maps a larger scale. In this process, since the target scale is smaller, the graphic space available on target map also becomes smaller. Therefore, features may be coalesced and therefore need to be displaced. In addition coalescence, feature displacement becomes necessary when either of the following situations occurs: there

being a need for exaggeration of some particular characteristics such as a road junction of and there being a spatial conflict between two features, which might be created by inappropriate algorithms. The operation for displacing features is called feature displacement in literature and it is one of the main operations in digital map generalization.

Two types of displacement can be distinguished, i.e. translation and modification. Fig.1 is an example illustrating these two types of displacement.



(a) Two lines coalesced (b) Translation of both line (c) Translation of one line only

(d) Modification of both lines (e) Modification of one line only (f) Both types involved

Figure 1 Two types of displacement: translation and modification

Also, operation can be applied either to both features or to one feature only. Of course, there is a possibility of a third type, i.e. a combination of translation and modification. For example, if the separation between the two continuous lines in Fig.1(d) is not large enough, then a translation may be applied to one of them (Fig.1(f)).

Feature displacement is a complex problem and has been tackled by only few researchers (e.g. Monmonier, 1987). Feature displacement can be carried out either in vector mode or in raster mode. It is the authors' understanding that it should be more convenient to carry out generalization operations in raster mode, since generalization is caused by a reduction in graphic space when map scale becomes smaller, and raster is a space-primary data structure. As a consequence of this reasoning, the models developed in this study are in raster mode. More exactly, they are based on operators developed in mathematical morphology -- a science dealing with shape, form and structure of objects. If the original data are in vector format, then one needs to (1) rasterise the data, (2) perform displacement operation and then (3) vectorise displaced features.

Following this introduction will be a brief description of mathematical morphology which serves as the mathematical basis of this study. Then mathematical models for feature translation and modification will be presented.

Mathematical Basis: Morphological operators

In order to facilitate the discussion of those mathematical models developed by the authors, the basic concepts in mathematical morphology are introduced here.

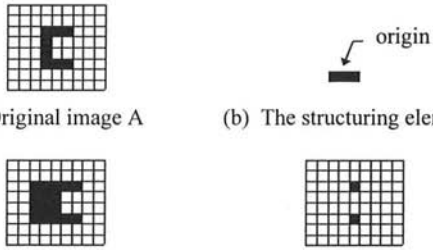
Mathematical morphology is a science of form and structure, based on set theory. It was developed by French geostatistical scientists G. Matheron and J. Serra in the 1960s (Matheron, 1975; Serra, 1982). It has since then found increasing application in digital image processing. Recently this toolkit has also been applied to digital map generalization (Li, 1994; Li and Su, 1995; Su and Li, 1995; Su *et al*, 1996a, 1996b, Su *et al*, 1997).

The two basic operators are defined as follows (see Serra, 1982; Haralick et al, 1987):

Dilation: $A \oplus B = \{a + b: a \in A, b \in B\} = \cup_{b \in B} A_b$ (1)

Erosion: $A \ominus B = \{a: a + b \in A, b \in B\} = \cap_{b \in B} A_b$ (2)

where A is the image to be processed and B is called the structuring element, which can be considered to be an analogy to the kernel in convolution operations. Examples of these two operators are given in Fig.2, where the features are represented by black pixels. The origin of a structuring element is at its geometric center if there is no specific indication there. This convention will be followed throughout this paper.

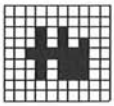


(a) Original image A (b) The structuring element B

(c) A dilated by B (A ⊕ B) (d) A eroded by B (A ⊖ B)

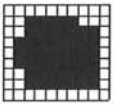
Figure 2 Two basic morphological operators: dilation and erosion

The structuring element is the critical element in a morphological operation. It could take any shape (square, cross) and size (e.g. a 2x2 or 3x3). If a symmetric structuring element is used for dilation, then the shape of the original image will be expanded uniformly along all directions. The dilation in this particular case is called expansion. Similarly, the erosion in this case is called shrink. These two special operations are illustrated in Fig.3.

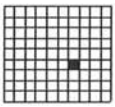


(a) The original image A

(b) The structuring element B



(c) Expanded image C=A ⊕ B



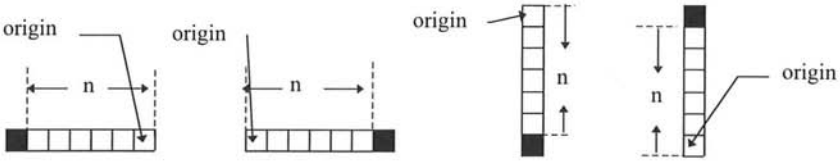
(d) Shrunk image D=A ⊖ B

Figure 3 Expansion and shrink: special cases of dilation and erosion

Based on the two basic operators, i.e. dilation and erosion, a number of new operators have also been developed, such as closing, opening, thinning, thickening, hit-miss, conditional dilation, conditional erosion, conditional thinning, conditional thickening, sequential dilation, and conditional sequential dilation, and so on. However, detailed discussion of these operators lies outside of this paper.

Algebraic models for feature translation

As pointed out previously, the structuring element is the key element in a morphological operator. Using the same morphological operator but different structuring elements, one would obtain very different results. In this section, it will be demonstrated that, with some specially designed structuring elements, the simple dilation and erosion can be used to achieve feature translation.



(a) To left (b) To right (c) Down-wards (d) Up-wards

Figure 4 Four basic structuring elements for translation in four basic directions

There are two approaches for feature translation using morphological techniques. The first one is through dilation and then erosion, using different structuring elements. The second one is a one-step dilation (or erosion). However, the structuring elements are different in these two approaches. The basic model for translation through dilation is as follows:

$$D = A \oplus T_d \tag{3}$$

where A is an original feature and T_d is one of the specially designed structuring elements. These specially designed structuring elements are shown in Fig.4. The translation of a linear feature by 2 pixels to the right side is illustrated in Fig.5. However, this doesn't mean that one can only translate a feature in one direction by up to 2 pixels. In fact, one can translate a feature with any magnitude, to any of these 8 directions, as one wishes. If one wants to have a feature translated by a larger magnitude, then the size of structuring elements required will be larger. A practical example extracted from an Australian map is shown in Fig.6.

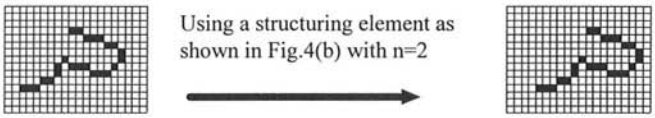
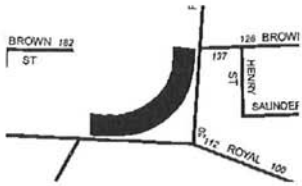
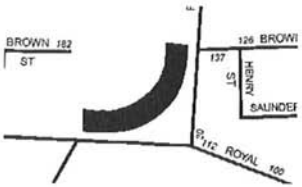


Figure 5 Translation of linear feature to the right by two pixels

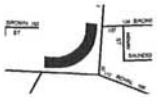


(a) Source map at scale 1:20,000 consisting of a road network and a building

(b) Reduced to 1:40,000, where features are coalesced and need to be translated



(c) The building is translated to the upper/left



(d) Reduction of (c) to 1:40,000

Figure 6 Translation of a building (crescent) by an erosion operation after a reduction of scale from 1:20,000 to 1:40,000.

In fact, the same effect of feature translation can also be achieved by the erosion operator. However, the set of structuring element will be different (Li and Su, 1995).

Algebraic models for feature modification

As discussed in the previous section, a translation can be easily implemented by an dilation operator using a set of specially designed structuring elements. However, for modification of features, it is much more complicated. In this case, a set of procedure needs to be followed. This will be discussed in this section.

Considering the distribution of map symbols, there are many possibility of neighboring relationships, e.g. a point feature with a linear feature, two point features, a point feature with an area feature, a linear feature with an area feature, two linear features and two area features. This paper will concentrated on the case of two coalesced linear features.

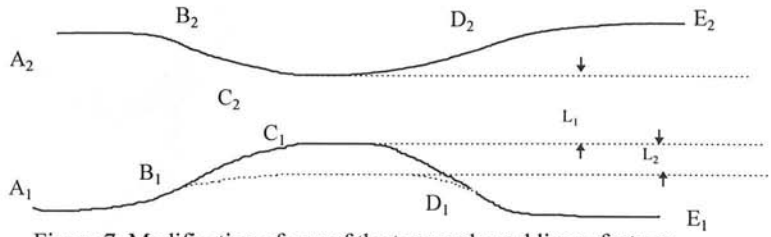


Figure 7 Modification of one of the two coalesced linear features

The process of modifying two coalesced linear features can be illustrated in Fig.7. That is, one feature to be modified so that the smallest distance between two linear feature is increased from L_1 to $L_1 + L_2$. The principle of achieving this result using morphological operators can be described as follows:

(a) To dilate both linear features to obtain two area features with desirable amount of overlap:

$$C_1 = A_1 \oplus B \tag{4a}$$

$$C_2 = A_2 \oplus B \tag{4b}$$

(b) To cut off the overlapping area from the area feature dilated from the feature to be modified:

$$D = C_1 \cap C_2^c \tag{5}$$

(c) To obtain skeleton of the area feature which is cut:

$$E = D \ominus B_1 \text{ (optional)} \tag{6}$$

$$F = S(E) \tag{7}$$

(d) To perform pruning operation to cut off parasitic branches:

$$G = P(F) \tag{8}$$

(e) To obtain final result by overlay operation:

$$R = G \cup A_2 \tag{9}$$

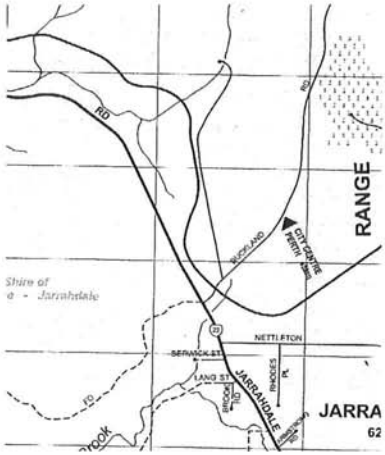
where A_1 and A_2 are two original linear features. A practical example extracted from an Australian map is shown in Fig.8. The size of the structuring element B is computed from Eq.(10) and (11):

$$2*R=(2*L_2+L_1) \tag{10}$$

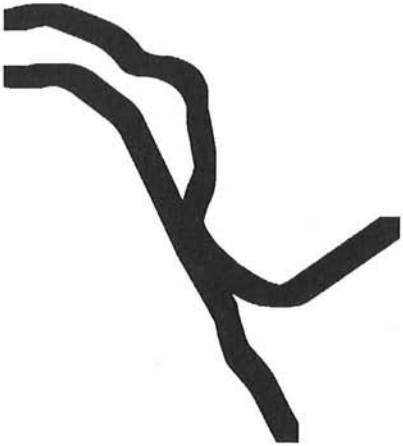
If it is expressed in terms of the number of pixels, B_{size}, then it becomes:

$$B_{size} = INT\left(\frac{INT(2*R/\text{Pixel\_size}+0.5)}{2}\right)\times 2+1 \tag{11}$$

where INT means to take integer part of a value.



(a) A portion of Australian Map at 1:20,000



(c) The two lines are dilated to form overlap

(b) The two main roads on the map will be coalesced if map scale is reduced to 1:100,000

(d) The overlap area on one line is cut and the skeleton to be derived from it will be the modified result

(e) The result after modification

Figure 8 Modification of one line features only in the case of two coalesced lines

Concluding remarks

It has been recognized that feature displacement can be classified into two basic types, i.e. feature translation and modification. It is also possible to have a combination of both. This paper describes some of the mathematical models for both feature translation and feature modification.

For feature translation, the models are very simple. In this case, the most important thing is the set of structuring elements developed. The advantage of this methodology is that all features in the same layer can be translated together if desirable. For feature modification, only the modification of one linear feature in the case of two coalesced linear features. More detailed information for other cases can be found from another paper by the authors (Li and Su, 1995).

It should also be pointed out here that morphological operators are good only at displacement but also at other operations in generalization such as combination, smoothing, elimination, etc., as illustrated by Li (1994), Li and Su (1995), Su *et al* (1996a, 1996b), Su *et al* (1997).

Acknowledgment

Dr. Li would like to thank the Hong Kong Polytechnic University for financial support of this project (PolyU 74/96E). Mr. Su would like to thank the Australian Vice-Chancellors Committee for partial support of his study.

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MORPHOLOGICAL TRANSFORMATION FOR DETECTING SPATIAL CONFLICTS IN DIGITAL GENERALIZATION

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Abstract

The detection of spatial conflicts is one of the main issues in digital generalization. This paper describes some mathematical models for this purpose. These models are based on the basic operators developed in mathematical morphology which is a science of shape. More concretely, an operation called translation (or transportation) is realized using morphological operators; then this translation operator is used for detection of spatial conflicts. The detection is achieved by a translation and then an overlay operation. These models are experimented with real map data.

Introduction

Generalization in digital environment has been a major research theme in GIS/Cartography community since early 1980s. In spite of international efforts for many years, many problems remain unsolved. Recently, the following three topics in this research area have been put to the research agenda, i.e. quality assessment, knowledge formation as well as conflict detection and resolution. This paper deals with the first part of the last topic, i.e. conflict detection. It might also be considered that there are two types of conflicts, i.e. topological and spatial conflicts. This paper deals with only the spatial conflicts. More concretely, it provides a mathematical basis for the detection of spatial conflicts, which is built upon the operators developed in mathematical morphology.

Spatial Conflicts: The Problem And Possible Solutions

Spatial conflicts are caused either by the nature of scale reduction or by the use of inadequate generalization operators (i.e. algorithms). In general, they can be classified into three groups, i.e. crossing, touching and coalescing, as shown in Figure 1.

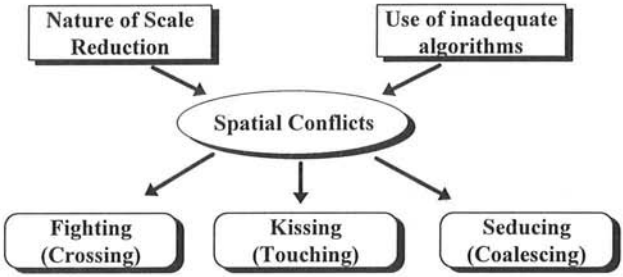
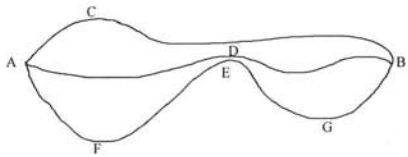
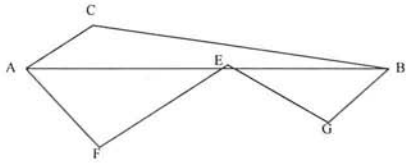


Figure 1 Three types of spatial conflicts

These spatial conflicts need to be resolved if happened. Indeed, it would be even better if they can be avoided. Those caused by the nature of scale reduction cannot be avoided and thus need to be resolved. However, those caused by generalization operation should be avoided by using more adequate algorithms. It can be noted that the "crossing" type of spatial conflicts is mainly caused by the use of inadequate operators and should be avoided. Classic examples are those various types of problems which can be created by inadequate line generalization algorithm (Monmonier, 1987; Müller, 1990). Figure 2 shows an example.



(a) Original line feature



(b) Spatial conflicts after generalisation

Figure 2 Possible spatial conflicts created by inadequate line generalization algorithms

In this figure, ACB, ADB and AEB are three curve line segments. After applying the Douglas-Peucker algorithm to each of these three lines using the same criterion, one will get the results which are "fighting" each other in space. This is because this algorithm doesn't takes into consideration the scale and space. This can be avoided by the use of space-primary algorithms (Li and Openshaw 1992) as pointed out by Weibel (1996). Therefore, the discussion of "crossing" case is not necessary and is thus excluded from this paper. In other words, this detection of these "touching" and "coalescing" types of spatial conflicts is the main theme of this paper. In fact, "touching" is a particular case of "coalescing", therefore, only the "coalescing" case need to be considered.

To revolve "coalescing" type of spatial conflicts, after the deletion operation, an operation called displacement may be needed, which has been deal with in a separate papers by the authors (Li and Su, 1995; 1997). Indeed, this paper will concentrate on the detection of spatial conflict.

From literature, it can be found that not much research has been done in the area of detection spatial conflicts. Only a few researchers carried out some work in vector mode (e.g. Mackaness, 1994). This paper will discuss a mathematically elegant technique for the detection of spatial conflicts which work in raster mode. This new technique makes use of the combination of overlay and translation operation. and the later is developed upon the operators in mathematical morphology.

The basic operator in mathematical morphology

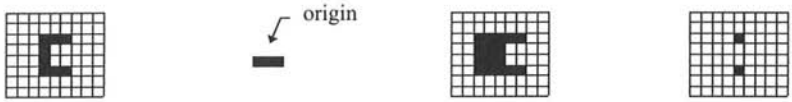
Mathematical morphology is a science of form and structure, based on set theory. It was developed by French geostatistical scientists G. Matheron and J. Serra in the 1960s (Matheron, 1975; Serra, 1982). It has since then found increasing application in digital image processing. Recently this toolkit has also been applied to digital map generalization (Li, 1994; Li and Su, 1995; Su *et al*, 1997).

There are two basic operators in morphology, i.e. dilation and erosion. They are defined as follows (see Serra, 1982; Haralick et al, 1987):

Dilation: $A \oplus B = \{a + b: a \in A, b \in B\} = \cup_{b \in B} A_b$ (1)

Erosion: $A \ominus B = \{a: a + b \in A, b \in B\} = \cap_{b \in B} A_b$ (2)

where A is the image to be processed and B is called the structuring element, which can be considered to be an analogy to the kernel in convolution operations. Examples of dilation operator is given in Figure 3, where the features are represented by black pixels. The origin of a structuring element is at its geometric center if there is no specific indication there. This convention will be followed throughout this paper.



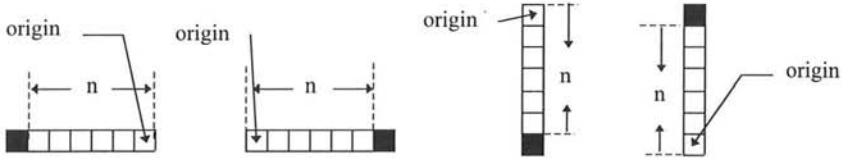
(a) Original image A (b) The structuring element B (c) A dilated by B (A ⊕ B) (d) A eroded by B (A ⊖ B)

Figure 3 The two basic morphological operators: dilation and erosion

The structuring element is the critical element in a morphological operation. It could take any shape (square, cross) and size (e.g. 2x2 or 3x3).

Features Translation Based On Dilation Operator

If linear structuring elements shown in Figure 4 are used in Equation (1), then the features within A will respectively be translated n pixels toward four basic directions . An example translating features to left side two pixels is shown in Figure 5.



(a) To left (b) To right (c) Down-wards (d) Up-wards

Figure 4 Four basic structuring elements for translation in four basic directions

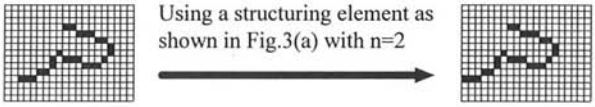
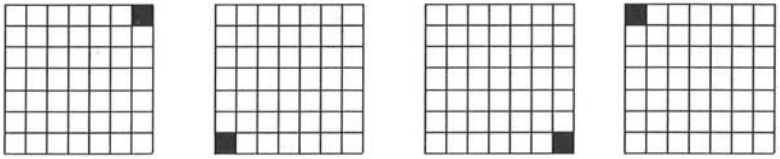


Figure 5 Translation of linear feature to the right by two pixels

For the translation of feature along the diagonal directions, i.e. upper/left, lower/left, upper/right and lower/right. The structuring elements shown in Figure 6 can be used.

Also the erosion operator can be used for translating features. However, it will translate features in the opposite directions as an dilation operator does. More detailed discussion of this topic can be found in another paper by the authors (Li and Su, 1995).



(e) To upper/right (f) To lower/left (g) To lower/right (h) To upper/left

Figure 6 Structuring elements for translation in four diagonal directions.
(The origins are at the corners opposite to the black pixel along the diagonal)

Detection Of Spatial Conflicts By Overlay And Translation

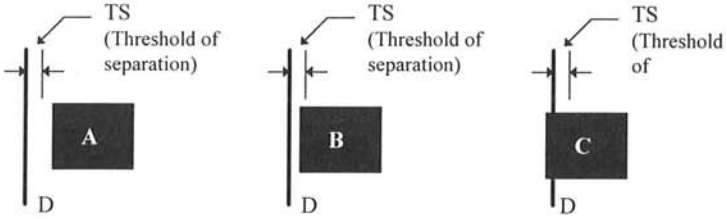
In this section, a discussion will be conducted of how spatial conflicts can be detected by these techniques described in the previous sections. However, as pointed out previously, only the "kissing" (touching) and "seducing" (coalescing) types of spatial conflicts will be discussed in this paper. The technique to be used for detection of these spatial conflicts in this study is a combination of overlay and translation. The principle is as follows:

> *Spatial conflicts exist if there is an overlap between two objects after one is translated by an amount less than or equal to TS (i.e. the threshold of separation between two objects) towards the other.*

It can also be expressed in a mathematical format as follows:

$$Conflicts = \begin{cases} True\ if (D \cap A_T) \neq \Phi \\ False\ if (D \cap A_T) = \Phi \end{cases} \tag{2}$$

where T =[0, TS] and Φ stands for an empty set; D and A are two features of concern and A_T is the A image translated by T. It can be illustrated in Figure 7 where two objects are on two different layers.

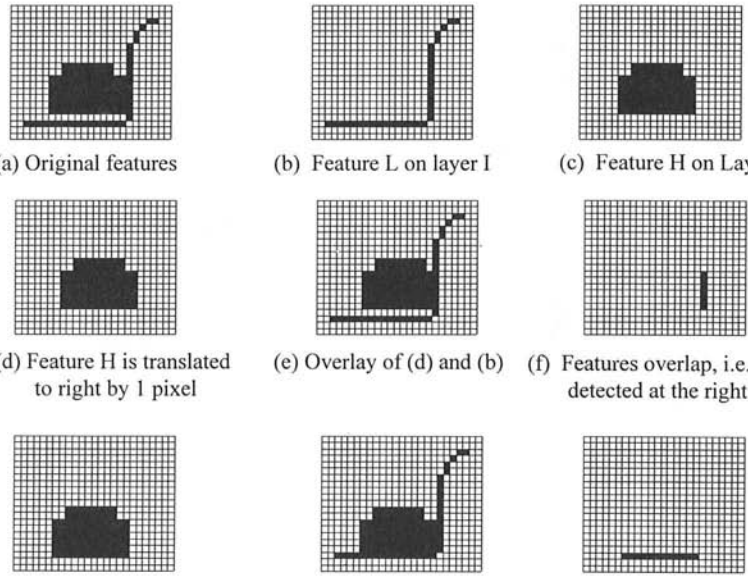


(a) No conflicts (b) There is a conflict (c) Spatial conflict detected

Figure 7 Conflict detection by overlaying objects after translating an object by TS

In this diagram, if one translates the rectangular object at position A by TS to the left to a new position B as shown in Figure 7(b), there is no overlap between these two objects after overlay and thus there is no spatial conflicts between these two objects detected. However, if one translates this object at position B to the left by TS to a new position C as shown in Figure 7(c), there is an overlap between these two objects after overlay operation and thus there is a spatial conflict between the two objects (i.e. Line D and the rectangular object at position B).

Normally the TS (threshold of separation) value is 0.2mm at map. It means that these spatial conflicts will be detected by a translation of few pixels. In other words, spatial conflicts may have been detected by translating on object by few pixels in normal case as shown in Figure 8.



(a) Original features (b) Feature L on layer I (c) Feature H on Layer II

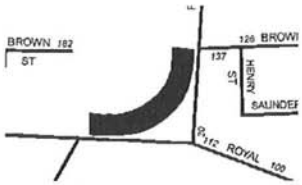
(d) Feature H is translated to right by 1 pixel (e) Overlay of (d) and (b) (f) Features overlap, i.e. conflict detected at the right side

(g) Feature H is translated downwards by 1 pixel (h) Overlay of (b) and (g) (i) Features overlap, i.e. conflict detected at the lower side

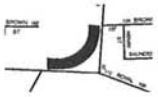
Figure 8 Spatial conflicts detected by translating an object

It is, therefore, suggested that objects be translated in a direction by only one pixel at a time. The translation could be along any of the four basic directions. As a result, spatial conflicts in one direction may be detected after more than one translations and overlays. Also the detection of spatial conflicts in other directions is very similar and is not discussed here. An alternative to the translation is the dilation using a squared

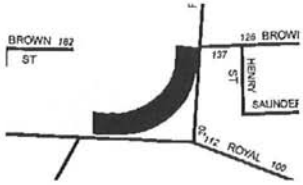
structuring elements so that features will be really dilated. In this way, an overlap will be created after overlay if there is a spatial conflict. A practical example extracted from an Australian map is shown in Figure 9.



(a) Source map at scale 1:20,000



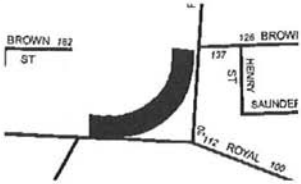
(b) Target map at 1:40,000



(c) Crescent feature is translated to right by 3 pixels

Features overlap

(d) Features overlap, i.e. conflict detected at the right side



(e) Crescent feature is translated to down-wards by 3 pixels

Features overlap

(f) Features overlap, i.e. conflict detected at the downwards

Figure 9 Spatial conflicts detected by translating an object with real map data

Concluding Remarks

In this paper, a discussion of the detection of spatial conflicts is conducted. The new methodology proposed in this paper is based on the basic operators developed in mathematical morphology. More concretely, an operation called translation is realized using morphological operators and then this translation operator is used for detection of spatial conflicts in conjunction with an overlay operation.

Emphasis is given to the possible mathematical basis instead of actual procedures. Indeed, no discussion regarding which features should be displaced is conducted in this

paper since it mainly aims to offer a mathematically elegant solution for the detection and resolution of spatial conflicts. Indeed, it might be assumed here that proper order of generalization (see Keates, 1989) is followed so that it is already known what type features has a high priority in this process before one starts the detection of spatial conflicts.

Acknowledgments

Dr. Li would like to thank the Hong Kong Polytechnic University for financial support of this project (PolyU 74/96E). Mr. Su would like to thank the Australian Vice-Chancellors Committee for partial support of his study.

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GEOINFORMATION SYSTEM "MINERAL RESOURCES OF RUSSIA" - THE FIRST MULTIOBJECTIVE DIGITAL CARTOGRAPHIC PRODUCT ON NATURAL RESOURCES OF RUSSIA

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The first digital version of the Map of Mineral Resources of Russia was compiled in the Department of Information Systems of the JSC "VNIIZARUBEZHGEOLOGIA" (Moscow). This product is based on the appropriate map at a scale of 1:2 500 000 which master's copies were prepared for publication by geologists of A.P.Karpinsky Russian Geological Research Institute (St.-Petersburg) and specialists of VNIIZARUBEZHGEO-LOGIA. This map was accomlished with breif descriptions of mineral deposits, and oil and gas fields.

On this map it were shown practically all deposits of commercial significance as well as majority of occurences (except of the same for construction marerials and mireral springs). For each object was given the follow information: it's size, mining status, genetic type of mineralization, morphology of ore bodies, composition and age of host rocks.

The chief manager of this project is Dr. Gennady L. Chochia. Technology of data preparation for digital recording on CD-ROMs as well as possibility for CD-ROM copying were provided by the PROGIS company (Villach, Austria).

Nowadays this project appears to be the most complete summarized information on mineral resources of the former USSR, being also the first stage in performing of thematic GIS series on the land and natural usage in Russia. The priority of mineral resources is determined by the role while estimating of economical potential of Russia as a hole country as well as of the most its parts in particular.

The project is performed both in Russian and in English for users' convenience.

Cartographic base of the map

The standart conic equidimenitional projection was used, with axial meridian on 102° E and section lines on 62° N and 47° N.

Geographical elements include principal drainage network, political and administrative boundaries, main settlements and transport lines.

Special details of the map

More than 6,000 deposits and occurences of raw materials are shown on the map related to 15 countries: Russia, Azerbaijan, Armenia, Belorussia, Georgia, Kazakhstan, Kyrgystan, Latvia, Lithuania, Moldova, Tadjikistan, Turkmenia, Uzbekistan, Ukraine, and Estonia. For all this countries other than Baltic states and Moldova administrative boundaries are shown also.

All variaty of minerals are subdivided into 5 groups: fossil fuels (two subdivisions), metals (five subdivisions), industrial minerals (four subdivisions), mineral salts and brines, gems and semiprecisious - stones. It is counting up to 124 kinds of minerals including gems and semiprecious stones, which are related to 12 genetic types of minerals.

Names of host rocks of sidementary and metamorphic genesis are given in accordance with their petrographic composition, while intrusive and volcanogenic rocks are labelled by their chemical composition. In all, 18 types of country rocks are identified.

Database

In accordance with the informational structure the database is subdivided into two arrays: graphical and textual spatialy positioned information and non-positioned one.

Graphical information is represented in WinGIS environment, and attributive information is done in GUPTA. Formally, database comprises 16 informational fields for each object, for 7 of them it is possible the searching and selecting on ordered parameters. The system includes three auxiliary bases of the attributive information: on political and administrative subdivisions, settlements, and tectonics.

Structure of the database on mineral resources

The information is assigned to 16 informational fields:

1. Geocode.
2. Area - the digital meaning of a selected area.
3. Column P2 - "Name of Deposit". Russian names are formally transliterated into English, for instance: "Белая Гора" - "Belaya Gora". When small objects had no proper names they were called by neibouring geographical object and translation of the latter was

performed: "Река Куртах" - "Kurtakh river". Such position appears to be the searching parameter for more than 6,000 objects.

4. Column P4 - "State". Countries are labelled by their official brief name instead of the full protocol one. It was done for users' convenience; for example: "Russia" instead of " The Russian Federation" or "Kazakhstan" insead of "The Republic of Kazakhstan" and so on. This parameter is also searching indicator on 15 positions.

5. Column P5 - "Region". For large countries such as Russia, Kazakhstan with many administrative units there were shown natural geographical regions: East, Central, West Kazakhstan, for example. This parameter appears to be the searching indicator.

6. Column P5-P8 - Geographical coordinates of the target. Coordinates are done with an accuracy of 1° of the longitude and the latitude. Sometimes on the map one common symbol is plotted for approached groups of the uniform deposits (metalliferous or kimberlite fields, coal and oil basins). In this case, the geographical coordinates in the database are done for the geometrical center of such groups or basin. The coordinates are the searching indicator also.

7. Column P9 - "Main commercial components". It comprises a list of the minerals or fossil fuels defining the economic value of a deposit or a field. This is a formalized searching indicator on 124 positions.

8. Column P13 - "Associated commercial components". They are not stricly formalized and are just for indicating associated valued components and admixtures presence.

9. Column P14 presents a range of reserves. It involves information on mineral raw material resources according to gradation assumed in Russia: "1" - very large or unique, "2" - large, "3" - medium, "4" - small, "5" - mineral occurence. Quantitive measures for each gradation of every commercial components are different.

10. Column P15 presents the extend of a deposit knowledge. All the targets are subdivided into three groups: 1 - deposits which are being exploited, have been exploited or are being prepared for exploitation; 2 - explored and evaluated (subeconomic and non-commercial); 3- the other deposits including those which are being explored or have not been exploited but not evaluated.

11. Column P16 comprises non-formalized reference data on composition of host rocks. Their lithological, petrographic and sometimes chemical composition is presented.

12. Column P17 presents age of host rocks. It is given in symbols of the international geological scale. Expectation for the Cambian (Cm) and Paleogene (Pg) are due to the lack of appropriate symbols among computer type faces.

13. Column P18 presents the material composition. It comprises non-formalized reference of ore and non-metallic mineral resources, petrographic composition or the grades of hard combustible minerals, chemical composition, density and other characteristics of liquied fuel and gases.

14. Column P19 presents genetic type of a deposit. It comprises generally formalized information corresponding to V.I.Smirnov's (1982) classification.

15. Column P20 presents the assumed age of minerals. It is characterized in the same way as the age of host rocks. The reliability degree of information is different: the highest one is for targets of sedimentary origin.

16. Column P21 presents the description of ore bodies.

Graphic information

Special graphic information on mineral resources is presented with symbols used for perfomance of mineral deposits and occurences. These symbols indicate the kind of mineral resources and their location.

As an accomplished graphic information there are three maps in the structure of the project: Map of Oil- and Gas-bearing Regions in the USSR at a scale of 1:2 500 000 (provinces, basins), schemes of tectonics and princilpe elements of the Earth's crust structure.

GIS possibilities

The GIS has wide functional, informational and consumer's possibilities for its users.

In view of functionality the system makes possible to input, store, process, search, retrieve information according to user's request. Beside that, any visualizatoin or output as hard copy are available.

Informational possibilities of the GIS are defined by the capacity and object integrity of used data. The system may help to solve any different analytical tasks connected with mineral resources on the huge territory about 22.4 M sq.rv in the spatial interrelation with different natutal factors.

The GIS, being user-friendly product, is very effective as a guide while planning any activity on studying and development of the Russian territory and the former Soviet republics. Besides, this system may be used as a valuable training appliance on different cources for students-geologists.

An openness of the GIS to converting all graphic products into another international software as well as English version appears to be the real demonstration that Russian specialists are ready to participate at the international informational and technological exchange in the early closed informational sector as raw material complex of Russia was recently.

Conclusions

The presented geoinformation system is oriented for the wide range of users and is the first and single complete legal product on mineral resources on the ex-USSR, prepared in Russia. There is a plan that this GIS will be the first one in the series of GIS on mineral resources of the World performed in VNIIZARUBEZHGEOLOGIA

PARTICULARITIES OF TOPOGRAPHIC MAPS OF THE SHELF AS DATABASE FOR GIS AND AUTOMATED MAPPING SYSTEMS

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Abstract.
The paper contains proposals on the theoretical basis for the contents of topographic maps of the Shelf of the World Ocean. Using examples of the bottom flora and fauna, there are shown some approaches to the mapping of the main components. That creates the pre-requisites for international cooperation in the domain of the use of informational base of maps.

The World Ocean covering 70.8% of the Earth, is now an actively studied and explored zone.

The development of Marine Cartography, traditionally related to the navigation, hydrographic and oceanographic research, has lead to the creation of a fund of maps of navigational purpose (general, special, referential, supplementary ones) with the use of hydrographic surveys periodically repeated. Physico-geographic and thematic maps are mainly represented in fundamental cartographic editions, such as Ocean atlases and monographs generalizing results of scientific research, and usually being in small scales.

In view of intensifying exploitation of the World Ocean resources, having the greatest anthropogenic impact on shoal zones, many countries started cartographic works of large scale mapping (comparable to the topographic one, i.e. 1:10,000 - 1:250,000) in the Shelf regions. There are compiled maps of bottom sediments (France); maps of underwater vegetation and of geological structures, gravimetric and bathymetric ones (Japan), maps of the Earth magnetism, tides and streams, geological maps (USA), etc. When analyzing these maps one could see a trend for developing interconnected maps and their series. In several countries there were elaborated and are now being implemented the programs for mapping the resources of the Shelf, e.g. in USA, UK, Iran, Norway. These programs include the compilation (updating) of basic topographic marine maps which are sometimes, and not too correctly, called hydrographic or bathymetric maps.

Detailed topographic survey and maps are to help in solving the problem of geographic study of the Shelf, in supporting geological and geophysical exploration, in the exploitation of underwater resources, in the construction of marine engineering

installations, in taking water-protection measures. They also constitute the base for the compilation of other maps. On the whole they provide the solution of different problems of national economy, trade etc. at national and international levels. This versatility of application of marine topographic maps makes them universal and quite different from navigational maps.

Along with the development of geoinformational mapping in the majority of countries there is observed a trend to create funds of cartographic and geodetic data, to convert this data into digital form (electronic maps, digital cadaster) and to found GIS Centers. The cooperation in the domain of informational exchange, international GIS network, in the field of maps' use for different purposes in development of economic ties, solution of ecological problems at inter-regional and global levels, becomes rather urgent.

A great role in providing information to GIS is played, among other sources, by marine topographic maps which represent the detailed multipurpose information about the World Ocean and its Shelf zones.

The maps of Shelf are supposed to cover the band the area delimited by the coastline and the line of sharp change of depth and of bottom slope (called continental slope). The main particularity of topographic survey of the Shelf carried out in Russia consists in continuous mapping of the Shelf including adjacent dry land as genetically related parts. It results in the presentation of topography of the dry land and the sea bottom as indissoluble community. That is why the maps of the Shelf have the same scales, mathematical base and datum as used for topographic maps. Different approaches to the presentation of the coastline on topographic maps of dry land, navigational charts and maps of the foreshore areas, are already agreed upon. The differences between these approaches are caused by diurnal, seasonal, long-term and non-periodic fluctuations of the sea level and coastline position in the zone of interaction of four superficial spheres of the Earth, namely the hydrosphere, lithosphere, atmosphere and biosphere. There are found the ways for the coordination in presentation of coastlines of the seas with tides and without them. For the seas having tides * two shorelines are usually shown. One of them corresponds to the highest level determined by long-term observations, the other one corresponds to the lowest theoretical level.** The outlines of mainland and islands washed by the seas having tides up to 0.5 meters (non-tidal seas), are shown by the shoreline corresponding to the sea level determined by long-term observations. These maps also contain the data on average long-term level and the lowest theoretical one in relation to the zero of the Kronstadt water gauge, a correction being also indicated. The shorelines are represented as definite or undetermined (changing).

The planimetric base of topographic maps of the Shelf compiled in Russia, is constituted by reference points of the State geodetic triangulation and polygonometric network, points of fill network and survey points. Altimetric base consists of

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* Tides over 0.5 meters

**The width of drying area not less than 1.5 m

benchmarks of the State levelling in Baltic datum, reference points of the State and filling networks, survey points determined by geometric levelling, as well as of permanent gauging stations linked to the State levelling network.

Survey plats are characterized by mean square error in the positioning of sharp outlines and dot features situated at foreshore areas in relation to the closest reference points, not exceeding 0.7 mm for the objects situated on islands and artificial facilities linked to the State geodetic network and 1.5 mm for other objects.

The contents of the Shelf maps, apart from common natural features inherent in topographic maps of dry land in the foreshore areas (such as drying areas, their soils and relief, foreshore vegetation and installations), should include following features:
- bottom relief in the limits of the Shelf right to the continental slope;
- bottom sediments;
- data on the properties and dynamics of water masses;

- information on bottom flora and fauna.

That means that the contents of the maps of foreshore areas englobes several important components characterized by the plurality of objects and indices of the World Ocean. The use of these maps as an informational base for the creation of banks of data and knowledge and for GIS in a country or at international level, demands the classification of objects to be done and strict requirements to be met. The most important of these requirements are as follows:

1. When developing a classifier one should bear in mind the importance of the choice or elaboration of classification of objects to be mapped. This classification is to be based upon the current scientific knowledge.
2. The classification should be coherent to the type of maps (topographic in our case) and allow for existing traditions and mapping approaches.
3. The selection of objects' classes is to be done on the basis of important properties and relations ensuring hierarchical order.
4. The classification should be of open type and adaptable for extension.

According to these requirements we developed a general system of contents for topographic maps of the Shelf which includes unified models of classification and the systems of signs based upon these models for following components:

- foreshore of seas, big lakes and rivers (this section is the same for the maps of dry land
  and foreshore waters);
- bottom relief;
- bottom sediments and soils;
- bottom florae and fauna;
- water properties and dynamics;
- the program of complex ecological and geographical reference which is to accompany the maps of foreshore regions.

Let's analyze the main streamlines of this development using example of criterions and principles of selection for the mapping of bottom flora and fauna, since it seems to be the less developed elements of contents. The urgency of such a development is

substantiated by the fact that the majority of life species of the World Ocean is connected with its Shelf. The main attention of researches is attracted to the study of biological structure of the Ocean, to the quantitative analysis of the distribution of flora and fauna, to the determination of productivity, to the study of general development of biological processes in different regions in order to organize the exploration of the World Ocean's biological resources in the most efficient manner, without undermining them.

The concept discussed further consists in systematic approach to the methodology of mapping in contrast to existing partial approaches to the representation of biological information on maps discussed herein. A systematic approach provides for taking into account the fact that the communities of flora and fauna species in different regions of the Ocean, have structural and functional particularities that could be represented on maps of given foreshore areas.

It is known that the organic life in the Ocean develops in the pelagic zone and at the bottom (benthos zone). The organisms are further classified by the place of their residence into species living in pelagic zone (passively floating plankton and actively floating nekton) and species living in benthos zone. Plankton is then classified into phytoplankton and zooplankton. Benthos species are classified into phytobenthos and zoobenthos. Scientific systematization the species of animals and vegetation are classified on the basis of anatomic and morphologic similarity [1,2,3,4].

With the use of the complete systematization we managed to build up a classification of species that takes into account the way of their life and their distinctive signs. From all the variety of life forms there were selected the following ones:

- widely present in the Shelf zone;
- having great importance for the life of the World Ocean;
- having great importance for the exploitation of resources of the Ocean.

The extent of detailing is not the same within this classification. For instance, such species as echinoderms, mollusks and crustaceans without which the benthal zone could hardly be imagined, by contrast, the worms which are omnipresent in the Ocean, are represented only by three types and 21 classes since they have no significance as a resource to be explored. Five types of plankton algae (phytoplankton) are unified as being important as a primary base for biological productivity of the World Ocean (their specific changes do not lead to the change of their nutritional properties).

When determining biological contents of topographic maps of the Shelf one should allow for another circumstance, the permanence of the spreading of these mapping features in a place. Plankton is characterized by diurnal, and seasonal migrations, its specific and quantitative content changes a lot during a year. The main part of the nekton is in a permanent movement, covering long distances sometimes. The way of life of the inhabitants of the Benthos zone is not so dynamic, the fauna species are mostly stationary of slow-moving, the fauna is always stationary. The Shelf is typical of vertical stratification of bottom flora and fauna forming clear belts inhabited by one or a few prevailing types. As a matter of fact, the forms of life in the Benthos zone have stable boundaries of spreading.

Taking into account the factor of stable place of spreading we could generalize the classification shown in fig. 1 into another one shown in fig. 2. For phytobenthos and zoobenthos there is proposed a system of signs shown in fig. 3. The information on plankton and nekton is better to be given in geographic reference to the basic map. The communities of the species living in the World Ocean could be shown on maps as combinations of conventional signs. Separate signs could be used to show prevailing species in an community, not more than three of them.

The limits of communities' spreading may be subdivided into clear ones that is typical of bottom flora and undetermined ones for the Benthos fauna existing in absence of flora.

It is proposed to show on maps the quantitative parameters of fauna based upon biological mass indicating the density of biotop inhabitants, and namely, average indices of biomass per 1 square meter of the bottom (see fig. 3).

Similar models of classification and sign systems based upon current scientific ideas, were developed for other components mentioned above (p.3).

The elaboration and scientific substantiation of contents of the maps of the Shelf, will enable to provide for a coordinated approach to the topographic mapping of foreshore areas in global scale. That could be done on the basis of achievements in Earth-related sciences and computer technologies. The efficiency of this development will stimulate the intensification of research in many countries and the extension of cooperation between them supported by interested international organizations.

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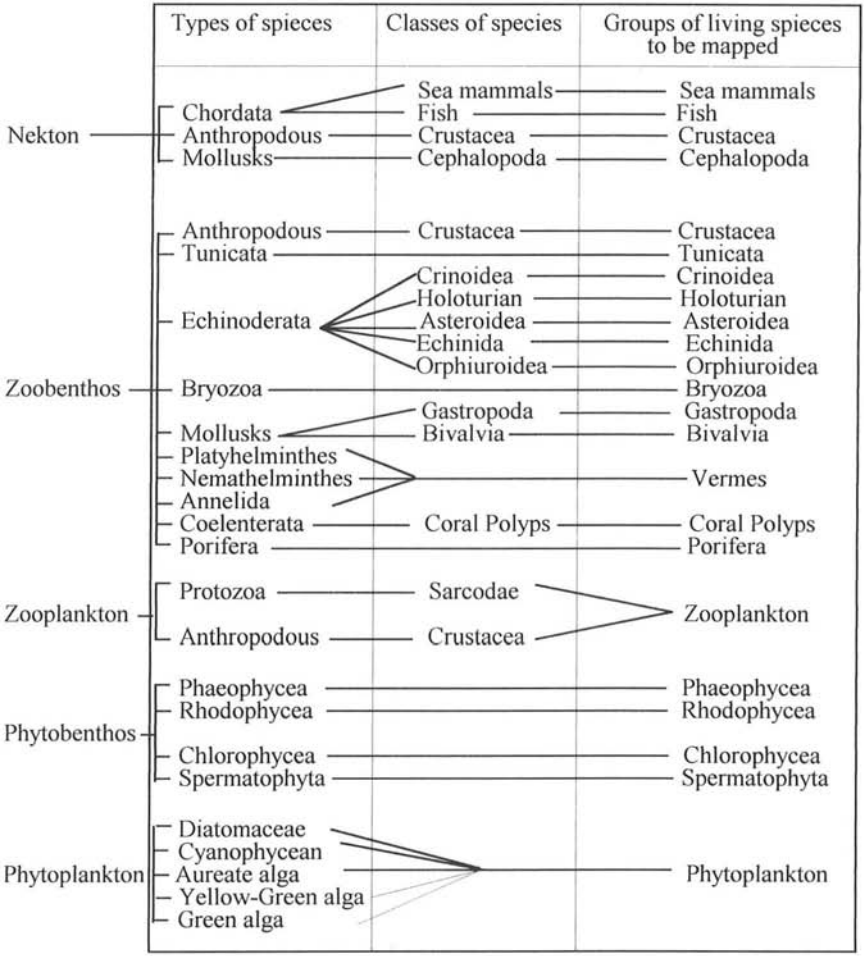

Fig. 1. Classification of Living Spieces Based upon Their Way of Life and Specific Features

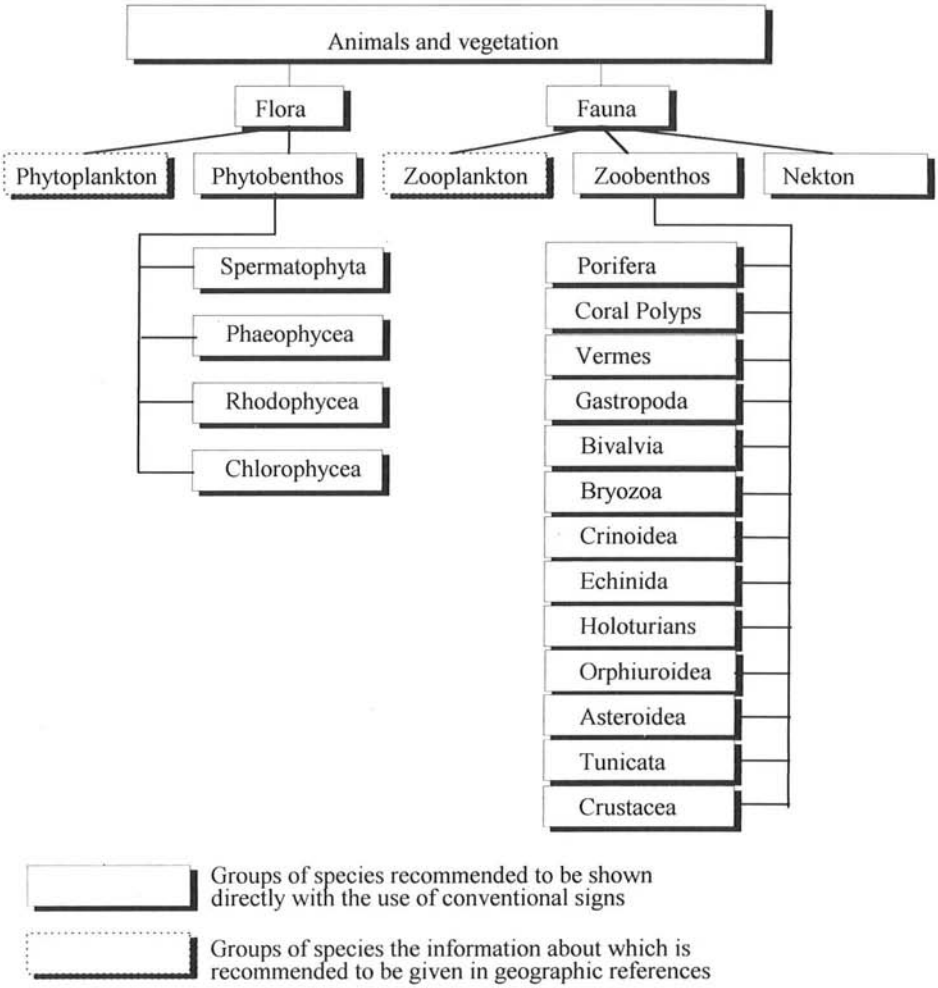

Fig. 2. Classification of Living Spieces Based upon the Permanence of Their Spreading

Clear limit of spreading

Undetermined limit of spreading

FAUNA

	Porifera		Echinida
	Coral Polyps		Holoturians
	Worms		Orphiuroidea
	Gastropoda		Asteroidea
	Bivalvia		Tunicata
	Bryozoa		Crustacea
	Crinoidea		

FLORA

	Spermatophyta
	Phaeophycea
	Rhodophycea
	Chlorophycea

CHARACTERISTICS OF FLORA AND FAUNA

1. $\frac{1.2}{0.25}$ Nominator : biomass of fauna species (kg/m^2)
Denominator : biomass of flora species (kg/m^2)

2. $\frac{1.2\text{-}2.5}{0.3\text{-}0.7}$ Nominator : biomass of fauna and flora species (kg/m^2)
Denominator : ratio of biomass of fauna species to the total and ratio of biomass of flora species to the total

Fig. 3.Signs For Representing Living Species

MAP GENERALISATION: AN INFORMATION THEORETIC APPROACH TO FEATURE ELIMINATION

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I am very greateful to Gro Helene Hansen who prepared the computer programme for the presented case study.

Abstract

The present paper contributes to the formalization of feature elimination as a sub-process of cartographic generalization. The methodology used in this paper is based on Shannon information theory. It is shown how to preserve the main characteristics of the spatial distribution during the elimination process by the application of spatial constraints in the entropy computations.

KEYWORDS: Information theory, feature elimination, map evaluation, automated cartographic generalization.

1 Introduction

For a time in the 1970s the mathematical theory of communication [SW64], normally termed "Shannon information theory," inspired several research papers in cartography. The Shannon information theory also became popular in several other disciplines (for example engineering, psychology, biology and cartography) in the first twenty years after its introduction, but it never reached a high level of sophistication outside electronic communications. The mathematical concepts of Shannon information theory is reviewed in the appendix of this paper. Bjørke [Bjø96] discusses why information theory until recently has not successfully been applied in cartography. He presents a framework for an entropy based map evaluation and shows that the awareness of the levels of communication are essential to the application of information theory in cartography. The three levels of communication are defined as:

syntactic regarding the relationship among the signs that are employed in the communication;

semantic regarding the relationship between the signs and the entities which they represent, that is, the designation of the meaning of the signs;

pragmatic regarding the relationship between the signs and their application.

[Bjø96] discusses communication problems at the syntactic level and gives some examples on the application of Shannon information theory to cartography. The present paper is concerned with one of these examples; the feature elimination case, and discusses the need for spatial constraints in the entropy computations.

2 Background

2.1 Map Information Sources

Information theory deals with *variation*. Therefore, when applying the theory to cartography we should carefully identify the elements which make up the variation of a map. Based on [Bjø96] we define a map information source as:

Definition 1 *A map information source (X, C) is an object which contains a set X of map entities and a characteristic C of them which make up their variation. A map entity can be a map symbol, a part of a map symbol, groups of map symbols, an attribute of a map symbol or a derived characteristic of a map which can serve as an entity for entropy computations.*

[Bjø96] identifies the following map information sources: (1) the *topological entropy* of a map (which considers the topological arrangement of the map entities), (2) the *metrical entropy* of a map (which considers the distance between the map entities), and (3) the *positional entropy* of a map (which considers the map entities as unique events).

2.2 Similarity and transition probability

In equivocation computations we need to know the transition probabilities. The transition probabilities can be derived from a similarity function. [Bjø96] defines a similarity function as:

Definition 2 *A function $\mu(x, y)$ which defines the grade of perceived similarity between two map entities x and y, will be termed similarity function. The similarity is measured on the interval $[0, 1]$ of real numbers. If x and y are clearly separable, the similarity grade is 0. If x and y are completely unseparable, the similarity grade is 1.*

Generally, the similarity between x and y is different from the similarity between y and x. Therefore, we need the notation $\mu(y \mid x)$ of conditional similarity, where $\mu(y \mid x)$ is the grade of membership of the relation from x to y; i.e. how similar map symbol x is to the perceived map symbol y. Similarity grade and transition probability are related to each other, but they are different. Mathematically we can define a mapping from similarity grade to transition probability by a normalization. Consider a set X of map entities and a set Y of perceived map entities. The transition probability $p(y \mid x)$ that map symbol x is interpreted as symbol y is defined as:

$$p(y \mid x) = \frac{\mu(y \mid x)}{\sum_{y \in Y} \mu(y \mid x)} \qquad \text{for each } y \in Y \tag{1}$$

Equation 1 ensures that: $\sum_{y \in Y} p(y \mid x) = 1$, for each $x \in X$.

2.3 Map Design Based on Information Theory

[Bjø96] presents a conceptual model for a map design process which incorporates information theory. The model has two main parts: a *map creation* process and a map *evaluation* process. The map creation process creates maps based on knowledge about cartographic design while the map evaluation process evaluates syntactic aspects of the maps based on information theory. The map evaluation process is decomposed into three operational areas: (1) *source* model; (2) *stochastic* model; and (3) *entropy* model. The source model describes which map information sources, i.e. the map events and their characteristics, are to be selected while the stochastic model describes their stochastic properties as spatial correlation and transition probabilities. Finally, the entropy model uses the source model and the stochastic model to compute different entropy measures. An automated system based on the proposed map design model is a stepwise procedure. The map creation process generates different maps and thereafter the map evaluation process computes entropy measures for the maps. The information measures are sent to the map creation process, which enables it to draw conclusions about which directions to alter the map design in order to get more efficient maps. The process cycle of map creation and map evaluation terminates when the map index requirements are met.

3 Entropy based feature elimination

3.1 Description of the elimination procedure

Elimination routines can be used to simplify maps. The criteria may be (1) minimum feature size or (2) proximity to neighbouring features [RMM+95] (p. 466). Assume a map with equally sized area features (Figure 1). Due to exaggeration, as a part of map generalization, the map symbols may overlap or may be very close to each other. This is often a problem in small scale maps. [Bjø96] proposes a feature elimination process which eliminates the most conflicting element, i.e. the element with maximum local equivocation. The process cycle terminates when the useful information R of the map reaches its maximum value, see Equations 10-12.

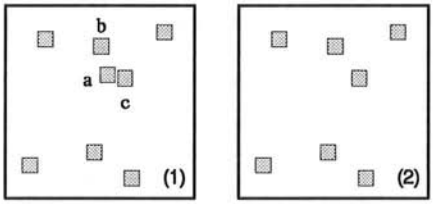

Figure 1: Simplification by area elimination. Feature a is a candidate for elimination in map (1). This feature is eliminated in map (2).

The computation of a candidate to be eliminated, will be illustrated. Related to Figure 1, assume the following similarities: $\mu(a \mid a) = \mu(b \mid b) = \mu(c \mid c) = 1$, $\mu(a \mid b) = \mu(b \mid a) = 0.1$ and $\mu(a \mid c) = \mu(c \mid a) = 0.4$. All other similarities are assumed to be zero. The corresponding transition probabilities are computed from Equation 1: $p(a \mid a) = 0.667$,

$p(b \mid a) = 0.067$, $p(c \mid a) = 0.266$; $p(b \mid b) = 0.909$, $p(a \mid b) = 0.091$; $p(c \mid c) = 0.714$ and $p(a \mid c) = 0.286$. The local equivocations are computed from Equation 7 as:

$$H(Y \mid a) = -0.667 \log_2 0.667 - 0.067 \log_2 0.067 - 0.266 \log_2 0.266 = 1.16$$

Similarly, $H(Y \mid b) = 0.44$ and $H(Y \mid c) = 0.86$, which gives the priority list for feature elimination: (a, c, b), i.e. feature a is to be eliminated since it generates a higher local equivocation than c and b.

3.2 Case study

Figure 2 demonstrates an application of the elimination procedure described in the previous section. The similarity function in our case study is defined as a function of the distance d between x and y, i.e. $\mu(x, y) = \Omega(d(x, y))$ where $\Omega(d(x, y))$ can be any number in the interval $[0, 1]$ of real numbers. The most conflicting element, in terms of local equivocation, is eliminated from the map. The procedure continues until the overall useful information of the map reaches its maximum value.

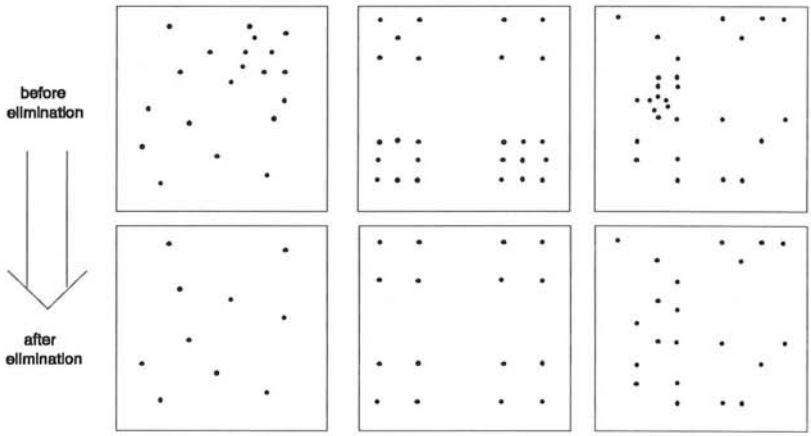

Figure 2: Unconditional feature elimination can give false impression of the variation of the number of elements per area unit.

The elimination procedure considered is unconditional elimination which can lead to maps which give false impression of the variation of the density of the map features, i.e. false impression of the variation of the number of features per area unit. This property of the procedure can bee seen from Figures 2 and 3. Dense areas will after elimination look like sparse areas. This is an obvious consequence of our elimination of the most conflicting element. In order to preserve the characteristics of the spatial distribution during the elimination process, spatial constraints can be added, but how to formalize such constraints is not a trivial task. The problem has at least two aspects:

- what are the user important characteristics of the spatial phenomena considered?

- how can spatial constraints be formalized so that they can be operational to entropy computations?

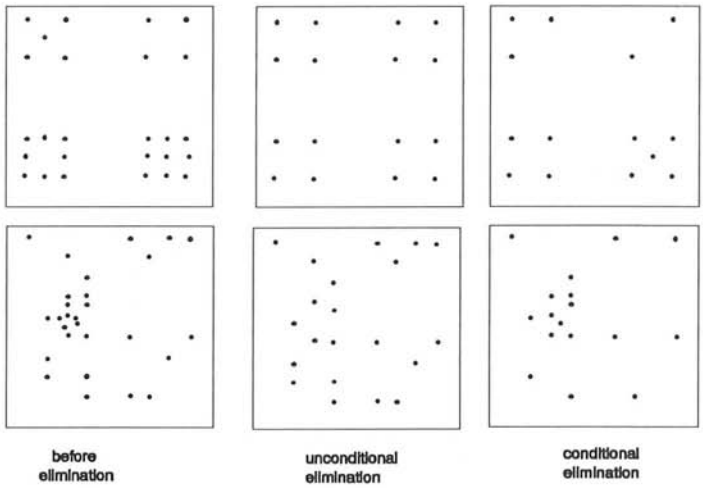

Figure 3: Conditional feature elimination. The condition preserves the impression of the variation of the number of elements per area unit.

Figure 3 demonstrates conditional feature elimination. In this case the similarity function takes the form $\mu(x, y) = w \cdot \Omega(d(x, y))$ where w is a weight which considers the number n of map elements in a local neighbourhood of x. The weight is designed so that when n takes high values, $0 \leq w < 1$, and when n takes low values, $w > 1 \mid w \cdot \Omega(d(x, y)) \leq 1$. Since the similarity function must take values in the interval $[0, 1]$ of real numbers, the proposed computation of the similarity function can be formulated as

$$\mu(x, y) = \min[1, w \cdot \Omega(d(x, y))] \text{ where } w \geq 0. \tag{2}$$

This design of $\mu(x, y)$ says that we accept higher local equivocation in dense areas compared to sparse areas. The definition of w for a certain map is a design task which can be based on the application of test plates and user interaction.

Discussion

In the previous case we formulated a rule which considers the variation of the density of the map elements. But there may be other characteristics of the spatial distribution which we want to preserve during the elimination process, such as the shape of the patterns. This kind of spatial constraint calls for further research.

Since generalization heavily relies on the users requirements, the definition of user models is important to the generalization. A challenging task in the application of information theory to map generalization is the construction of user models which enable us to set up rich entropy models; i.e. entropy models which can describe the semantic aspects of the spatial distribution.

Further research should go into this topic and analyze how to define entropy models for different aspects of the spatial distribution of 0-, 1- and 2-dimensional map objects.

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A Properties of Shannon Entropy

The principles of Shannon entropy are presented in several textbooks such as [SW64] or [KF88]. This section briefly reviews some concepts of Shannon entropy necessary for the development of the theoretical basis of this paper. Given two sets X and Y we can recognize three types of entropies:

1. Two *simple entropies* based on marginal probability distribution,

$$H(X) = \sum_{x \in X} p(x) \log_2 \frac{1}{p(x)} = -\sum_{x \in X} p(x) \log_2 p(x) \tag{3}$$

$$H(Y) = \sum_{y \in Y} p(y) \log_2 \frac{1}{p(y)} = -\sum_{y \in Y} p(y) \log_2 p(y) \tag{4}$$

2. A *joint entropy* defined in terms of the joint probability distribution on $X \times Y$,

$$H(X, Y) = -\sum_{(x,y) \in X \times Y} p(x, y) \log_2 p(x, y) \tag{5}$$

3. Two *conditional entropies* defined in terms of weighted averages of local conditional entropies:

$$H(X \mid Y) = -\sum_{y \in Y} p(y) \sum_{x \in X} p(x \mid y) \log_2 p(x \mid y) \tag{6}$$

$$H(Y \mid X) = -\sum_{x \in X} p(x) \sum_{y \in Y} p(y \mid x) \log_2 p(y \mid x) \tag{7}$$

It can be shown that:

$$H(X,Y) = H(Y) + H(X \mid Y) = H(X) + H(Y \mid X) \tag{8}$$

which can be generalized to

$$\begin{aligned} &H(X_1, X_2, X_3, \ldots X_n) = \\ &\quad H(X_1) + H(X_2 \mid X_1) + H(X_3 \mid X_1, X_2) \\ &\quad + \cdots + H(X_n \mid X_1, X_2, \ldots, X_{n-1},) \end{aligned} \tag{9}$$

The information loss in a noisy channel is termed *equivocation* [SW64] and is expressed as a conditional entropy. Let X and Y denote the set of input signals and the set of received signals respectively. The *useful information* R is obtained by subtracting from the source entropy the average rate of conditional entropy (equivocation).

$$R = H(X) - H(X \mid Y) \tag{10}$$

$$= H(Y) - H(Y \mid X) \tag{11}$$

$$= H(X) + H(Y) - H(X,Y) \tag{12}$$

where $H(X \mid Y)$ is the equivocation of the information source when the received signals are known and $H(Y \mid X)$ is the equivocation of the received signals when the signals sent are known. The first expression measures the amount of information (variation) sent less the uncertainty of what was sent. The second measures the amount of received information (variation) less the part of this which is due to noise. The third is the sum of the entropy of the signals sent and the entropy of the signals received less the joint entropy. The *capacity* C of a noisy channel corresponds to the maximum rate of the transmission and is defined as:

$$C = \max(R) \tag{13}$$

REMOTE SENSING AS A MEANS FOR PROVIDING REGIONAL FOREST MAPS AND OTHER GEO-REFERENCED ENVIRONMENTAL FOREST INFORMATION

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Abstract

The FIRS (Forest Information from Remote Sensing) Project of the Space Application Institute, JRC, has provided a regionalization and stratification map, with a corresponding data base, of European forest ecosystems. In the FIRS application Theme on forest mapping, an experiment has been carried out on the useability of NOAA AVHRR data to produce a map of European forests and for monitoring forest areas. EUROSTAT statistics and Landsat TM data have been used for assessing the accuracy of the first NOAA AVHRR-based experimental results.

Introduction

Existing information on Europe's forested areas and their structural elements is mostly statistical in nature. Mapped information is generally only provided at local levels, at large mapping scales, and is not readily or publicly available. This lack of geo-referenced cartographic information on forested areas, which constitute approximately 30% of the land surface area in Europe (EEA, 1996), is becoming an important issue because of the growing need from environmental planners and managers and the general public, for accurate and timely maps. In the past, the cost of providing cartographic information was usually too high to cater for, except for the most basic needs. National geodetic and cartographic services generally provided forest maps with a few very broad classes, often designed for military applications. National forest inventories were carried out in the form of statistical sampling surveys, which only served to produce very generalized, small-scale thematic maps. Furthermore, privately

owned forest land was often excluded from national inventories.

On local and national levels, aerial photography became one of the most important tools for national forest inventories. The use of aerial photographs enabled the production of local forest maps, and provided an effective means for stratified forest sampling. However, the costs involved are still too high for providing maps covering large areas at a medium scale, and are also far too high to permit frequent updating. Aerial photographs and colour video are today the most useful means of providing forest maps at local levels, while satellite imagery provides the most versatile source of data for cartographic information at regional and European scales.

Background

In 1989 Council Regulation N° 1615/89 (EEC 1994) led to the establishment of EFICS (European Forestry Information and Communication System) which was initiated as a means to provide the needed information on forested area and its general growth conditions, and which would constitute an information tool for the EU member states and the Standing Forestry Committee.

In 1994, the Joint Research Centre of the European Commission, in cooperation with the Commission's Directorate General VI (Agriculture, Forestry and Fisheries) FII.2 and EUROSTAT, launched the FIRS (Forest Information from Remote Sensing) Project (Kennedy *et.al.*, 1994). The aim of the FIRS Project is to assist EFICS in developing methods for the provision of geo-referenced and statistical information on forested areas in Europe using primarily remotely sensed data and Geographical Information System (GIS) techniques.

A regionalization and stratification of forest ecosystem types in Europe was carried out under the first FIRS Foundation Action (Folving *et.al.* 1995, Kennedy *et.al.* 1995). As a part of this study, several geographical information layers (GI) were developed, allowing the overlay and cartographic presentation of the data and the results produced. The regionalization and stratification are required in order to achieve a correct forest classification for the whole of Europe. In the second Foundation Action, a survey of existing European forest nomenclature systems was carried out, and, for the first time, a common European forest nomenclature system, for use with remote sensing, was produced. The third FIRS Foundation Action, which is currently in its initial stages, will provide accurate, geo-referenced data from a network of test areas. These data are necessary for the calibration and validation of satellite-based forest mapping results. Concurrently with the three Foundation Actions, a computer software system has been developed which includes tools for the automatic delineation and identification of homogeneous forest stands. This will allow a faster and more accurate forest mapping over large areas than is possible to achieve without remote sensing-based methods.

Both the Foundation Actions and the system developments constitute the basis for a set of Application Themes. Presently the FIRS Project is concentrating on developing methods for assessing the following descriptive forest variables or indicators:

- Forest and other wooded land area
- Forest structure - species grouping and crown density
- Stand volume and biomas
- Structural and compositional biodiversity
- Role of the forest in the protection of the environment.

Of these, the first three are traditionally supplied as statistics, not geo-referenced information. The last two are new indicators originating from the Helsinki Convention (ISCI, 1996).

Detection and assessment of change of the forest indicators is one of the main driving information needs.

Regions and strata

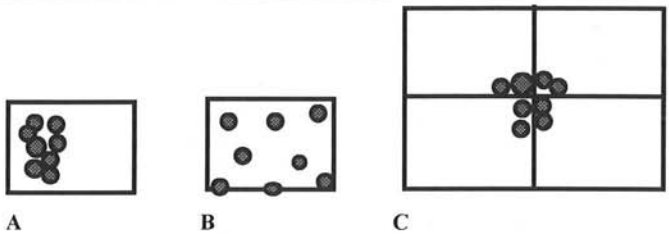
Making a regional forest map of Europe is not as simple and trivial as one perhaps would think. No harmonized nomenclature exists (Köhl and Päivinen, 1996); the definitions used in the various countries are not the same (Table 1), and, as stated previously, for large areas no forest maps exist which makes a compilation into useful information impossible.

Table 1. Differences in forest definitions.

Country	Minimum crown cover, %	Minimum size, ha	Minimum width, m
Albania	30		
Austria	30	0,05	10
Denmark		0,5	
Finland		0,5	
France	10	0,05 / 0,5 / 4	15 / 25
Germany		0,1	10
Greece	10	0,5	30
Hungary	30		
Ireland	20	0,5	
Italy	20	0;2	20
Netherlands	20	0,5	30
Portugal	10	0,2	30
Spain	10		
Switzerland	20		
UK	20	0,25	20
FRA 1990	20		
EUROSTAT	20		

It is evident that the use of RS (remote sensing) data for vegetation mapping automatically leads to complications. Not least due to the limited geometrical resolution. RS data consist of a spectral signature integrated over the pixel area. So even if RS would detect 'wooded biomass' it might not be considered a forest in any national forest inventory. And a small well defined forest might easily be missed by RS (Fig. 1).

The different compositions, and often also structures of forest (McCormick and Folving, 1996) can constitute a problem. It often becomes impossible to use the same criteria for defining forest area in a spectral 'sense' over large regions. This becomes especially difficult when the species composition change over distance, for instance from north to south in Europe. Therefore, it is necessary to divide an area of the size of Europe into homogeneous regions. Ideally such regions should be defined using spectral variation, but, as complete data sets always have to be mosaicked, and as the factors controlling the spectral variation vary in a completely uncontrolled manner, it was decided to use geo-botanical criteria for the regionalization. The variation in silvicultural practice was used together with other more management and function oriented criteria, in the creation of sub-regions - the strata.



	A	B	C
Area defined as	forest	non forest	forest
Area detected as	forest	forest	non forest

Figure 1. Definition versus detectability at an arbitrary pixel size.

The regionalization was carried out in two steps (Anonymous 1995; Folving *et.al.*, 1996). The first step consisted of the definition of the most significant and determining bio-climatic types based on temperature, precipitation and seasonality *etc.*. In total six core types were identified, 13 transitional types and a set of mountain climate types - giving a total of 22 region descriptions. The definition of these bio-climatic forest ecosystems have been made using statistical analysis of climatic records from a large number of observations (Walter, 1976). No general delineation in geographical terms had been made (Fig. 2). Thus a method for delineation had to be chosen. For this purpose the Potential Forest Ecosystem map defined by Rubner and Reinhold (1955) and the FAO soil map were used (FAO, 1988). These two geo-botanical and geo-physical factors are believed to represent the best possible means for a delineation into stable regions. The regions are thus defined by statistical characteristics and their borders have been drawn according to landscape features.

The single forest ecosystem regions have been further divided into strata according to two sets of variables. Where the regionalization was based on growth conditions, the first level in the stratification was based on forest appearance, *e.g.* the structure and the composition of the forests, like species, density *etc.* The second set of criteria for the stratification was based on management and use indicators. In total, 115 strata have been defined and delineated. These strata are used for defining homogeneous areas for sampling design and for the selection of test areas for mapping by remote sensing.

Small scale, regional assessment

NOAA AVHRR data have been used in the first large area mapping experiment based on the results from the regionalization and stratification (Kennedy *et.al.*, 1996). AVHRR channel 1 and 2 data from 1993 were composited into monthly maximum NDVI data and channel 4 and 5 data were composited into maximum surface temperature data (Roy et.al., 1997). The compositing is made in order to reduce the number of missing pixels due to cloud cover, which constitutes a severe problem over most of Europe, and, in order to reduce the variation in the data caused by differences in scanning angle, differences in grey levels along mosaic borders

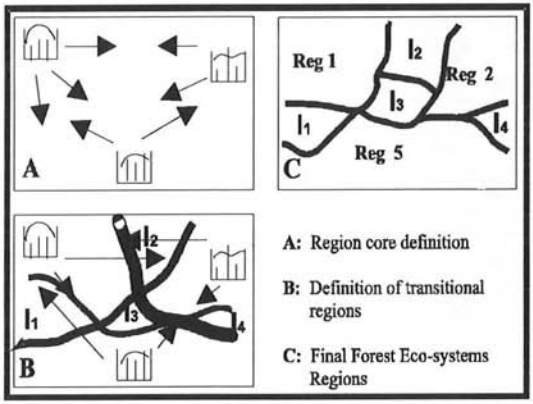


Figure 2. Schematic illustration of the principle used in the definition and delineation of the forest ecosystem regions. (See text for explanation).

etc.. The surface temperature is included in order to enhance the possibility to distinguish between forest and non-forest pixels - a technique which can only be used for data processing on a strata-basis. The geographical variation in temperature over Europe would constitute a problem if this variable was used over larger areas in one data processing step.

Training data were taken from the ISY map (Haeusler *et.al.*, 1993). Up to 500 pixels were selected randomly in each stratum for both forest and non-forest area. The maximum NDVI and surface temperature values were extracted for the corresponding image pixels and were used to establish a probability function for the maximum likelihood classification method (Roy, 1997b).

Figure 3. Part of the experimental forest probability map. Brightness is proportional to amount of forest cover within the pixel.

The classification results for the single strata were 'mosaicked' to produce the experimental one by one kilometer map, Figure 3. The result was tested on the part of the training data set not used for the classification. The comparisons were quite promising. It showed an overall accuracy of 86% (kappa 0.64). The NUTS-2 level statistics from EUROSTAT on percent

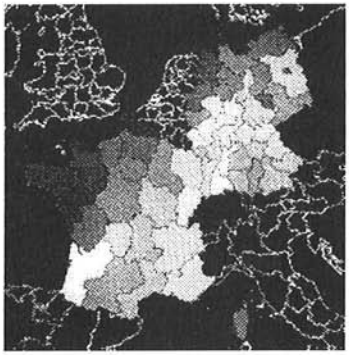


Figure 4. NUTS-2 areas showing the percentage of forest cover. Brightness proportional to percentage. Data from EUROSTAT 1993.

forest cover for the same area as used for the experiment is shown on Figure 4. The correlation between the two maps is rather poor (0.6), unless the experimental result is corrected for missing pixels. Once 'calibrated' the correlation is significantly better (0.9). The correspondence between the experimental result and the NUTS-2 map is shown on Figure 5. It can be clearly seen that the NOAA-based result is biased; NOAA data tend to 'underestimate' forest area when only a small proportion of the pixel is covered by forest or forest patches.

The experimental AVHRR based forest map was also tested by means of Landsat TM data (Lohi, 1996). In-house available TM scenes from the MARS (Monitoring Agriculture by Remote Sensing) Project test sites were classified into forest and non-forest. The resultant forest masks were geometrically rectified into the same coordinate system as the AVHRR forest/non-forest map, and the TM pixels were resampled into 'AVHRR pixels'. The comparison showed that if a 50 percent forest cover per pixel was used, the overall accuracy between the AVHRR forest map and the TM forest masks was 82 percent. But, only 22 percent of the forest pixels were correctly classified. If the TM scenes with a total forest area below 5 percent were rejected from the comparison, the amount of correctly classified forest pixels rose to 30 percent, however, the overall accuracy fell a little, to 80 percent.

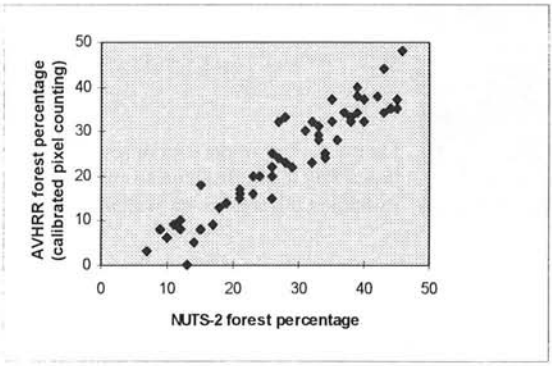


Figure 5. Correspondence between experimental forest map result for the area delineated on Figure 4 and NUTS-2 level EUROSTAT forest data for the same area.

Discussion and conclusion

It was already illustrated in Figure 1 how much the pixel size, and, in relation hereto, the definition of forest area will influence the correct assessment of forest cover by means of remote sensing. As the majority of the forest ecosystem regions in Europe have very fragmented forest areas the results from this study clearly indicate that the pixel size of the NOAA AVHRR is too large to be used for a highly accurate statistical assessment and especially for obtaining accurate geo-referenced information. On the other hand, the study showed that it is quite feasible to use AVHRR data if no high degree of accuracy in geo-reference is required and that a reasonably good statistical result can be obtained for large areas. As it is foreseen that 1 km resolution data will be provided continuously in the coming years, it could on this background be considered useful to develop regional change detection methods and very small scale modeling using such data. Main emphasis, however, should be put on medium spatial resolution data such as RESURS and IRS data for more accurate regional mapping purposes.

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SUSTAINABLE MEDITERRANEAN LANDSCAPES AND CARTOGRAPHIC TOOLS

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1. Global Change, settlement, landscape, and cartography.

Cartographic tools can help to reassemble and interpret certain important themes related to the Human Dimension of Global Environmental Change. I refer as much to current instruments as to those of the past, and by the past I mean those dating back to the middle of the eighteenth century.

Environmental sustainability, and to an even greater degree, the sustainability of development that is so topical today, are two utopian issues that will necessarily assume the urgency of reality, if the human race is to survive. Interestingly, many places in the past treated these issues not as utopian, but as concretely real. Let us investigate this proposition for a moment. Sustainable development seeks an appropriate exploitation of the planet's natural and human resources for the benefit not only of current but also of future generations; such development eliminates, or signifcantly reduces the incentive to consume, and the stripping of the natural environment, that are both determined by the dominant macroeconomic concepts. But, at the same time, sustainable development really does mean development for those populations and regions that are hardly, if at all, underdeveloped. Apparently utopian, these issues, and their resolution, are utterly indispensable if the Earth is to continue to host the human race.

Sustainable settlement, from the isolated abode to the city or conurbation, from the industrial mainstream to the peripheral tertiary settlement or to the scattered backwater, is the concrete synthesis, the sign and effect of the sustainability of territory, or, often, of its unsustainability. The landscape, by which I mean a synthesis of geographic space informed by substantial, responsive and perceptible factors of the historic relationship between humans and the natural environment, is a slow-moving, but honest 'indicator' of sustainability and of global change.

In the Mediterranean region, settlement is dense, historically stratified and very diverse in terms of quantitative and qualitative typologies: one finds ancient rural abodes, whose forms sometimes reappear after periods of 2,000 years, and metropolitan areas of vast dimensions, like Barcellona, Naples, or Istanbul. In the present day, two economically and socially different worlds confront one another at the great dividing lines of the northern and southern borders, and these divisions evidently draw together the dynamic conflict between the North and South of the world; between development and underdevelopment, between weak or absent demographic growth and a growth which is rapid and uncontrollable. These are the two spirits which the conception of sustainable development, as sanctified in the Bruntland Report, seeks to yoke together.

Many coastal or littoral settlements in the Mediterranean region were certainly sustainable in the past: there are various examples of harmonious symbiosis between human inhabitants and the natural environment. Even now, many minor centers record clearly visible traces, still alive and not only archeological, of this ancient alliance, which recent generations have seen fit to intrude upon and break apart, with stupidity and imprudent obstinacy.
Geographic matrixes, and their wide-ranging cartographic implications, all within the overall context of the HDGEC matrix, are the subject of two studies by a group of Italian geographers; these studies seek to comprehend how the towns, the environments and the historic human footholds in the Mediterranean can still express the sustainability of which one speaks so much today (CNR Research, Comitato 15, "The Italian landscape as a cultural and geo-human benefit and feature", a specific "Historic Minor Centers" project, and "Human aspects of environmental change in the Meditteranean", an ex-40% project). To renovate the structures in, and the approaches to, the territory, would it be enough to rediscover the old wisdom of inhabitation and settlement, and, at the same time, to apply some of the avant-guard technology? This question, too, is utopian, but no stranger than the issue of sustainable development itself, with regard to which the pessimist will ask who and what must do the sustaining.

2. Present sustainable landscapes in the old, well-made maps.

Is it possible, in our epoch of GIS, satellite images, real or virtual cartographic or electronic elaborations, to return to old cartographic documents to excavate determining or guiding elements for sustainable behavior? Certainly, if one returns to reliable maps. It is known how geographic maps, like every reconfiguration and elaboration of the visible and perceptible landscape, are subjected to the interpretation of the executor, who in any case seeks to produce a document which will be appropriate for a certain commitment, to a wide or restricted public. I am referring to basic cartography, the topographic kind, and not to the thematic variety; or to basic cartography with limited thematic interpretations (for example, a topographic map with archeological sites, or a topographic and nautical- hydrographic mixture, etc.).
Attempts have been made in the direction of an experimental assembly, in which facts and elements drawn from various epochal maps are gathered together to create another map that synthesizes and thematisizes the materials in their entirety: for example, maps of the drainage of certain fluvial deltas, or of variations in the coastlines. But the quality of the old documents used is fundamental: in general, official cartography, that which was financed and promoted by the State or by smaller organizations involved in state activities, is more reliable. Ornate, artistic scrolls, the greater or lesser complexity of watermarks, the quality of the printing - all these are of minor interest to a researcher of territorial facts, while of great interest to collectors and to the antique market. Sometimes may happen messes when map collectors aspire to scholarly authority on questions of territory, this latter as represented by such maps; the confusion may be imagined.
The key to sustainability of the landscape and of its constituent parts - be they physical, human, habitational, agricultural, silvicultural, military, hydrographic, maritime, etc. - resides not only in the obvious minor extensions to the infrastructure (streets, bridges, railways, ports, etc.), but also in the structural complex in its entirety;

this entirety may be apprehended by comparison of differing documents, drawn in differing scales, and deriving from consecutive epochs. The regions around the Mediterranean, i.e. those named the "Latin Arch", (from Portugal to Italy crossing Spain and France) posses substantial cartographic resources that provide reliable information on at least the last two centuries. Resources that pre-date the eighteenth century can also be made use of; for example, the highly prestigious documents that the "Serenissima Republic of Venice" collected from illustrious cartographers of the Adriatic maritime region. In general, however, maps from the eighteenth century onwards are increasingly easier to compare.

At this point, we can try to conduct a partial trial, as an example of the research process. Environmental sustainability, both natural and human, was greatly respected in certain Mediterranean areas until the end of the eighteenth century. Our evidence lies in the various celebrated archeological sites, and in the equally famous verdant, historical places, like the pine woods of the maritime pine forests of the Italian coastlines, some of which already existed at the time of the ancient Romans. In addition, vast and humid coastal areas, with intact original vegetation, and dunal ponds and lakes, were not drained for irrigation: not because it was not possible or concieved of (the Romans had already done so 1,700 years earlier), but because it was known that the delicate environmental environments ought to be protected.

One could object that the argument is too obvious - that the relative paucity of population and of industrialisation made settlement less demanding and made sustainability not only greater, but naturally so. But the objection lacks validity because, for instance, in certain regions in the Italian Mezzogiorno, industry and artisan crafts were certainly more developed prior to the unification of Italy, especially between 1800 and 1861, the year in which the Kingdom of the Two Sicilies lost independence. The archeological sites of Pompei, Paestum, Agrigento, Selinunte, all had vast protected areas around them, in which all construction was prohibited. Since 1738, the same government of Naples promoted a campaign of excavation and restoration, accompanied by severe rules, in the name of environmental protection, as well as of cultural one.

Let us identify some useful cartographic documents for our present purposes. First of all, let us consider two documents produced by Giovanni Antonio Rizzi Zannoni, one of the most celebrated cartographers of the eighteenth century, who concluded his busy life as, "Geographer of his Sicilian Majesty", that is, as the director of the Geocartographic Office of the King of Naples. The documents in question are: *Atlante Marittimo del Regno di Napoli, 1792*, and *Carta topografica delle Reali Cacce di Terra di Lavoro e loro adiacenze, 1784*.

In addition to their artistic worth, these two maps are of remarkable cartographic and documentary value. The tables of the *Atlante* are in scales of circa 1:90.000; the *Carte della Cacce* of circa 1:65.000. The *Atlante* is imprinted in copper plates and black typographic ink, and the paper is watercolored. The charts of the *Atlante* cover the entire coastal perimeter, within the boundaries of the ancient Kingdom of Naples: i.e. from Southern Latium, the Tyrrhenian Sea to the Tronto River, between Marche and Abruzzi, and the Adriatic Sea.

The *Carte della Cacce di Terra di Lavoro* reconfigures the territory that runs from the Matese Mountains to the Tyrrhenian Sea at the mouth of the Volturno River. The map derives from King Ferdinando IV Borbone's passion for hunting. He was the son of the great Carlo III, who was sovereign of Naples from 1734 to 1859, and then of

Spain: the good king who promoted many magnificent works for the rebirth of the capital and of the entire Kingdom of the Two Sicilies. Although his abilities in the hunt bore comparison, King Ferdinand did not inherit the excellent governing qualities of his father. Rizzi Zannoni drew out and designed this beautiful map for the King, which today serves as a stimulus for understanding, for regret, and for a return, at least partially, to those conditions of sustainable environment. The forests are numerous, and many of them are protected (admittedly, on account of the King's zeal for hunting); the slopes of the mountains and hills are covered with trees, there is no lack of internal and humid coastal zones, and the settlements conserve the wonderful traces of a long and interesting history. This is indeed adaption to the conditions of ecology and to the passage of time. Valuing Capua above all, enclosed within the bend of the river, as the medieval Longbards had desired; and Santa Maria Capua Vetere, that reproduces on the plain the forms of the pre-Roman and Roman Capua with the *centuriatio* outlined by the gromatic legionaries (Manzi, 1982b).

The *Atlante Marittimo* reproduces the littoral regions to a depth of about twenty kilometers from sea line, beyond the prominent reliefs that are visible from ships. Therefore, the exact band which has been "concreted" in the last 30 or 40 years, is sometimes disrupted, and not only in Southern Italy, but also in Liguria, in France, Spain, and Portugal, in Turkey, and here and there in Northern Africa. The coasts of the eighteenth century Mezzogiorno often lacked important human settlements, but where they existed, as in the Gulf of Naples, (Table III), the quality of settlement was higher, because there was appropriate respect for the morphology of the land, and also for the volcanic nature of these places, which were potentially dangerous (for example at the high and low rims of Vesuvius); in recent years this risk has been ignored.

To what end might these regrets serve? To drive us to attempt to stop construction, to destroying unauthorised developments, to extend protected areas, and to redraft certain territorial borders, which have only recently been liberated from declining industry (as at Bagnoli in Naples or at Torre Annunziata and Castellammare di Stabia); and to undertake all these actions on the bases of the features preserved in the old maps. Tables XIV and XV of Puglia are also interesting in this light (Manzi, 1974; De Seta , 1980).

Shortly after the *Atlante Marittimo*, another work, this time on Sicily, was completed. It is an atlas entitled *The Hydrography of Sicily, Malta and the Adjacent Islands Surveyed in 1814, 1815, and 1816, under Directions from the Right Honorable the Lords Commissioners of the Admiralty* by William Henry Smyth, London, Hydrographical Office of the Admiralty, 1823. This atlas should be consulted in conjunction with the volume of comments entitled *Memoir Descriptive...* (1824) and with another book by Smyth on the entire Mediterranean area (1854).

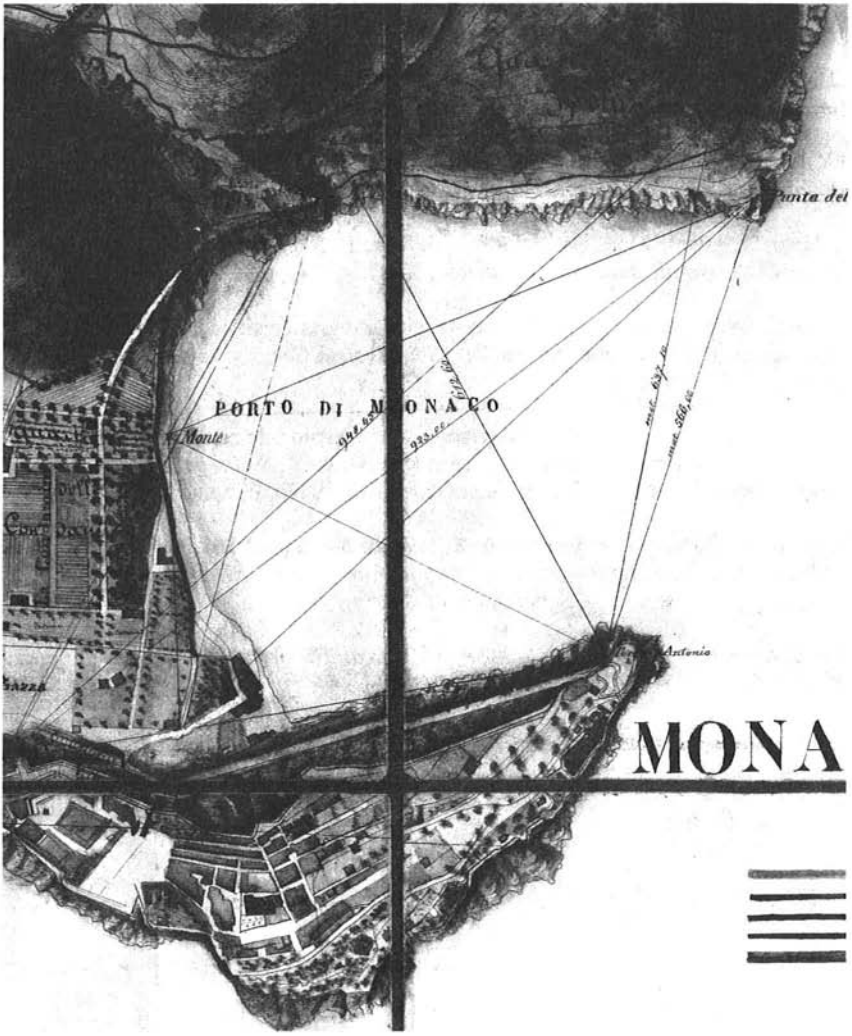
Smyth's work is very sound not only because he was a worthy seaman and surveyer-cartographer, but also because he knew the places, and Sicily in particular, very well. He therefore produced maps which were not only the fruit of the best technique of the times, but which also captured the "spirit of the places"; the expression will perhaps be incomprehensible to those who reguard map-making as a purely technical exercise rather than as the expression of the characteristics and perceptions of the given territory. A further feature of Smyth is that he loved archeology, and accordingly represented celebrated archeological sites in the maps, such as Syracuse (scale: circa 1:13.000) and Agrigento (scale: 1:44.500); aside from this one should also read the piece in *The Mediterranean* which speaks of Paestum. Smyth unites a series of *Sheets*

of Coast Views with the maps, which he himself designed, and which were engraved in copper by Walker, as were the maps. In the tradition of the times, one that lasted until the first years of the nineteen hundreds, nautical and coastal maps also contained drawn images of the places as seen from ships. These *Sheets* set the standard for the type of sustainability that one would wish for certain tracts of land along the Mediterranean coast. (Manzi, 1982a).

The *Carte genérale du theatre de la guerre en Italie et dans les Alpes depuis le passage du Var...* (Milan, 1798) by Louis Ghislain Albert Bacler d'Albe, engraved in copper by the Bordiga brothers, is another document of considerable prestige. It addresses the littoral strip of the current Cote d'Azur, an area that has been substantially compromised in the last thirty years by property development that is less barbaric than it is in other areas of the Mediterranean, but that is generally intensive and not always interspersed with restrictions on green or fluvial areas. Of great interest is the Principality of Monaco, which at that time, and indeed until 1848, was endowed with the communities of Rochebrune and Menton. The principle human settlements are Menton and the capital, Monaco Ville, which is constrained to the *Rocher*. A hypothesis we could explore with quantitative-stocastic methods is the fanta-geographic (and therefore fanta-cartographic) map of the Principality as it might be now with the frontier of the past. Perhaps the current Hong Kong in miniature, with its jostling skyscrapers on the Cote d'Azur, would have been rendered less intense by the greater availability of space.

Even more useful is a *Carta del Principato di Monaco*, by the Real Corpo cartografico di Stato Maggiore del Regno di Sardegna (a military cartographic office), in scales of circa 1:5.000, watercoloreds, drawn up around 1855 to resolve disputes over property situated on the boundaries between the subjects of the Principality and those of the Kingdom of Sardinia, which at that time possessed the County di Nizza around Monaco. It is a beautiful map, in which the inhabited abodes on the rocks stand out in relief: Condamine with its Mediteranean gardens, and small residential or rural holds within the orange and lemon orchards: a dream landscape, still sustainable, as it had been for more than 2,000 years. A Monte Carlo, on the promontory of the Spelugues, that remains to be built.

I have displayed only a few examples, and others could be added. For Spain, for example, there are maps from the Archives of Simancas or from those of Seville; other national resources include the collections in Istanbul and Ankara, and the Biblioteque Nationale in Paris. It would be even more interesting to assemble old maps into an authentic historic-cartographic GIS - the kind attempted successfully by naturalists for the journal, "Ambio" (1994), on the quota of space "disturbed" by humans (positivist-naturalism is evident in that "human disturbance"). Here are two hypotheses for the bringing together of maps for comparison: one, selections from historical documents; the other, a satellite image and a recent map. The first would be called *Coasts and sustainable settlements in the Mediterranean*; the other, *Insustainable landscapes of the Mediterranean*. Here I show two extracts: one is by Rizzi Zannoni, 1784, and the other is a Land Registry map of Monaco as published in 1855.


PORTO DI MONACO
Monte
Punta del
Antonio
MONA

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THE APPLICATION OF THE THEORY OF INDUSTRIAL DEPARTMENT STRUCTURE IN DESIGNING INDUSTRIAL MAP SET OF ECONOMIC ATLASES

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Abstract In recent years, China has published many economic atlases, which spent millions of yauns every year. However, there are some problems in these economic atlases, such as no standardized structure of industrial map sheets, and illogical order of arrangement of industrial map sheets, etc. These problems usually give rise to much difficulty in applying these economic atlases. In order to solve the problems, authors think that the theory of designing economic atlases must be in conformity with the principle of industrial department structare. In other words, the structure of industrial map sheets of an economic atlas must conform to the dividing systems of industrial departments, and the order of arrangement of industrial map sheets must accord with the demands of industrial department theory.

Key words the dividing theory of industrial department; the structure of industrial map sheets; the order of industrial map sheets

Introduction

In recent years, China has published a lot of comprehensive atlases and special atlases, which consumed much manpower and much financial resources. It is estimated that this situation will be for a long time. It indicates that Chinese economy and cartographic technology have been well-developed. Nevertheless, there are some problems which should be solved urgently in designing of economic atlases, especially in designing of industrial map set.

1 The Standardized Structure of Map Sheets in an Atlas

How to select the map sheets in an economic atlas is related to the purposes and the guiding ideology of mapping an atlas. The main purposes of an economic atlas are to provide scientific basis for various department leaders' formulating policys, workouting

medium-term or long-term plans, and providing the important data for us to study natural enviroments, natural resources and the development of society and economy, etc. And thus the map sheets selected must comply with the internal laws of economy. Four representative provincial atlases in China were choosed, as shown in the table. By comparison, we can find that the atlases have some common problems. The first problem is that the selected map sheets are difference and no common standard. For example, the amounts of the selected map sheets in industrial map set of Hubei provincial economic atlas are less than that of Hunan's. In fact, the amounts of Hubei industrial departments are more than the latter's, and Hubei provincial industrial economic strength is higher than the latter's, too. The second problem is that, in general, the contents of map sheets have no integrity and no systematization, and atlas's purpose being "economic data bank" isn't completely achieved. Although every province has her own particularity, the structure of map sheets of the industrial map set in each provincial economic atlas must be in conformity with the dividing principle of industrial department on economy.

1.1 The Classification of Industrial Departments

There are different dividing systems according to different dividing principles for industrial departments (Li Re, 1983). There are three common dividing systems on industrial department in China. The first dividing system is from the principle that every industrial department has same technological process. So industrial departments are divided into eleven great classes: ①metalurgical industry, ②power industry, ③fuel industry, ④chemical industry, ⑤engineering industry, ⑥building material industry, ⑦timber industry, ⑧fuel industry, ⑨the industry of textile, sewing and leather, 10 the industry of papermaking, cultural and educational materials, 11 other industry. Eleven great classes are further divided into forty-four industrial departments, and then into one hundred and fifty-five small classes. The second dividing system is from the principle that products of every industrial department has same economic usage, and industry is divided into light industry and heavy industry. The third is from the principle that every industrial department has same material consumption, industry is divided into excavating industry and processing industry. Of course, there are some other dividing sytems. For instance, industry is separated conventional industry from the new and expanding industry.

1.2 The Selection of Industrial Map Sheets

One of provincial economic atlas's main functions is to be a "data bank". And so how to select the map sheets must act in accordance with one through scientific

system. In other words, the selection of industrial map sheets in an economic atlas must agree with one of above dividing systems of industrial departements, and at the same time, must emphasize the importance of hierarchy, and the contents of industrial map sheets should be as overall as possible. Therefore, the amount of industrial map sheets in an economic atlas perhaps be 11 or 2, which are metalurgical industrial map, power industrial map, fuel industrial map, chemical industrial map, engineering industrial map, building material industrial map, timber industrial map, food industrial map, the map of papermaking, cultural and educational material industry, the map of textile, sewing and leather industry, and other industrial map, or light industrial map and heavy industrial map, or excavating industrial map and processing industrial map, and so on. Certainly, there are possibly different contents and pages in one industrial map sheet amongst different regional economic atlases, in the light of the practical needs of the regions.

Now, the selection of map sheets of industrial map set in many Chinese economic atlases is almost based on the first industrial dividing system, in which industry is divided into eleven great classes, and then into forth-four industrial departments. As shown in the table, the map sheets of industrial map set among each provincial economic atlas are completely difference and have indistinct hierarchy. For example, papermaking industry and chemical industry for daily use are put into the same map sheet. Obviously, this phenomenon is incorrect, because papermaking industry is one of eleven great classes and chemical industry for daily use is a category of chemical industry belonging to eleven great classes. Furthermore, the industrial map of machinery for daily use and household appliances has the same problem. The new and expanding industry, conventional industry are called modern concepts. Conventional industry is a kind of industries that consumes more resources and more labors and uses more conventional technique. Conversely, the new and expanding industry is the industry which uses more new techniques, more modern knowleges, and consumes less labors, less materials, and has less environmental pollutions and higher benificial results. The new and expanding industry includes computer industry, genetic engineering industry, new material industry, new energy industry, and oceanographic engineering industry, etc. It is a "pillar industry" in western developed countries. The development of China's new and expanding industry has been to a certain extent at some regions in China. And from the developing trend, the new and expanding industry will lastly substitute for the conventional industry. However, almost all Chinese economic atlases published didn't arrange the map of the new and expanding industry. This is imperfect for those economic atlases.

2 the Scientific Order of Industrial Map Sheets

From the above specification, the second dividing system is to divide industry into heavy industry and light industry, heavy industry provides capital goods and light industry provides consumer goods. The developing direction, scale and speed of light industry influnce that of heavy industry. Thus light industry is the base ment of heavy industry, and we must give priority to develop light industry. Because the order of priority of industrial map sheets in an economic atlas indicates someone's standpoints on the relation between light industry and heavy industry, the map of light industry must be in front of the map of heavy industry in an economic atlas. From the table, the map of light industry is at the head of the maps of heavy industry in the economic atlases of Hubei province and Helongjiang province. In the light of the above viewpoint, the order of industrial map sheets in these two economic atlases is correct on the whole. Nevertheless, the order of the map of light industry and heavy industry in the economic atlases of Hunan province and Shanxi province is just opposite, these two economic atlases are imperfect. Moreover, industry is divided into excavating industry and processing industry in the third dividing system, and processing industry is dividing into raw material industry and manufacturing industry according to the processing extent. The products of excavating industry are the materials of raw material industry and the products of raw material industry are the materials of manufacturing industry. And so the former is the foundation of the latter's development. Direction, scale and speed of the former's development will influence that of the latter's. Thus the order of industrial map sheets is from the map of excavating industry to the map of raw material industry and to the map of manufacturing industry. The excavating industry contains parts of coal industry, petroleum industry and timber industry, etc. Raw material industry includes metallurgical industry, power industry and chemical industry, etc. And manufacturing industry is mainly made up by engineering industry. Thus, the economic atlases of Hubei province, Shanxi province and Helongjiang province are rather inappropriate. In addition, conventional industry is the base of the new and expanding industry, so the map of conventional industry should be in front of the map of the new and expanding industry. Finally, we must emphasize the importance of the relation of hierarchy of industrial departments, and industrial department belonging to different grades can't be laid at the same map sheet or industrial department belonging to the same grade can't be put at the differnet map sheets.

3 The Scientific Selection of Contents of Industrial Map Sheets

There are quantitative relations and proportional relations between different industrial departments, and this phenomenon indicates that there are insparable connections between each industrial departments. We know, economic atlas is a language to present the features of nature and economy and society of some region. Economic atlas present not only regional economic distributions and regional economic layout, but inner connections of regional economy too. In particular, as the above specification, we must emphasize the importance of some basic industries, such as light industry, excavating industry, raw material industry and convertional industry, etc. Thus the datum to show the developing direction, the developing scale and the developing speed of these basic industries with their associated industries must be in an economic atlas. Therefore, various department leaders are able to make policy on the basis of imformation from the economic atlas.

4 Conclusion

Almost all economic atlases recently published in China are provincial atlases or regional atlases. They have been disigned or compiled by their own provinces or their own regions, and these economic atlases play the important roles of "data bank" for the provinces or the regions. However, these economic atlases are not only some provincial data banks or some regional data banks, but a part of the national atlases too, and these economic atlases should have countrywide significance. There are great differences on the layout of map sheets, the selection of map sheets' contents and the methods of expression in the provincial economic atlases published in recent years. Some map sheets having the same content can't be matched among provinces. And some common contents are shown in one provincial economic atlas, but in another provincial economic atlas there is not a map sheet to show it. And statistical time of data is inconsistent between each provincial economic atlases. The main causes of these problems are that designers can't recognize the national significance of economic atlases, and there are not uniform standard, and most mappers lack the geographical knowlege. Hence, the application of economic atlases is quite limited and the social economic benefit of economic atlases greatly lessens. In order to solve the problems, we must have the aid of the theory of industrial department structure to direct the map designing. Firstly, the selection of industrial map sheets must accord with the demands of the dividing systems of industrial departments. Secondly, the order of industrial map sheets' arrangement must comply with the inner relations between each industrial departments. Lastly, we

must adopt the standardized methods to show the characteristics of cartographic elements.

Acknowledgements

We would like to thank professor Hu Yuju, Who is the editor-in-Chief of the cartographic journal in China and the former vice Chairman of the International Cartographic Assiciation(ICA), for expert guidance and the support after we finished the first draft.

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Table Comparison of Map Sheets of Industrial Map Set in Four Economic Atlases

Economic atlas of Hunan province(1990)	Economic atlas of Hubei province(1988)	Economic atlas of Shanxi province(1976)	Economic atlas of Helongjiang province (1976)
Structural map of industrial economic departments	Map of electronics industry	Map of metalurgical industry	Map of textile industry
Distribution map of large-middle industrial enterprises	Map of textile industry	Map of machine-building industry (1)	Map of food industry
Map of coal industry	Map of food industry	Map of machine-building industry (2)	Map of light industry of daily use (1)
Map of power industry	Map of light industry	Map of coal industry	Map of light industry for daily use(2)
Map of ferrous metal industry	Map of coal industry	Map of coal industry	Map of oil chemical industry
Map of nonferrous metal industry	Map of metalurgical industry	Map of power industry	Map of coal industry
Map of Chemical industry	Map of engineering industry	Map of electronics industry	Map of timber industry
Map of engineering industry	Map of building material industry	Map of electronics industry	Map of metalurgical industry
Map of building material industry	Map of chemical industry	Map of light industry(1)	Map of agricultural engineering industry

Economic atlas of Hunan province(1990)	Economic atlas of Hubei province(1988)	Economic atlas of Shanxi province(1976)	Economic atlas of Helongjiang province (1976)
Map of electronics industry	Map of industrial economic benifit	Map of light industry(2)	Map of general engineering industry
Map of textile industry	Distribution map of large-middle projects	Map of light industry(3)	Map of power industry
Map of plastics industry			Map of electronics ndustry
Map of handicrafts and arts			Map of building material industry
Map of medical industry			
Map of food industry			
Map of papermaking industry and chemical industry for daily use			
Map of engineering industry for daily use and household applicance			
Map of other light industry			
Map of architectural industry(1)			
Map of architectural industry(2)			
Map of industrial economic benifit			

ASSESSING RANGELAND CONDITION WITH SATELLITE REMOTE SENSING AND GIS TECHNIQUES IN A SEMI-ARID PASTORAL REGION OF SOUTH AFRICA

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Introduction

There are approximately 9 million hectares of pastoral rangelands in the winter rainfall region of South Africa (See Figure 1). General veld condition information is required as a basis from which to derive and recommend sustainable stocking rates, assess the impact of drought and to assess the effects of resource conservation control. Rangeland is currently the single most important economic resource of the Ceres Karoo agricultural sub-region in the winter rainfall region of South Africa, an area of low rainfall and skeletal and saline soils which make the area suitable only for extensive pastoral use. As vegetation supply is influenced by rainfall, soil type and land use, management for sustained use can only be accomplished if the state of the resource and the effect of grazing impact on that resource can be measured.

This paper investigates the technical potential of using a localised veld condition assessment methodology for the Ceres Karoo region in conjunction with remotely sensed data for the identification and measurement of artificial boundary events for the purpose of long term rangeland monitoring. An artificial boundary event is defined as an abrupt change in veld condition at an existing fence line, in terms of species composition and cover. With regard to the management practices associated with pastoral farming, it is hypothesised that these artificial boundary events within similar vegetation types of the succulent biome can be directly related to fences that demarcate farming properties and the management blocks therein. Where these

boundaries are identified, differences in veld condition may be attributed to differences in land management practices. The successful use of remotely sensed data will greatly facilitate the identification of farms where the current land management practice is inappropriate and leading to loss of veld productivity. It will also facilitate veld condition assessment and the assessment of climatic impact or the effects of resource management decisions on veld condition.

Study area

The Ceres Karoo was selected for this research. Consistent veld survey data are available for the Ceres Karoo and several farmers have made their properties readily accessible for field work. Furthermore the veld in the Ceres Karoo is relatively homogeneous when compared to either that of the North-Western Cape or to that of the Little Karoo. This makes veld surveys less complicated and it is more practical to test new methods here than elsewhere. Additionally there are a number of farms which have been surveyed in the Southern Tankwa/Ceres Karoo which are in a seriously degraded state. The farm Kareekolk is one of these and was selected for specific attention and intensive survey.(See Figure 2). The veld on adjacent farms can be directly compared by using the fence line contrast method. These sites appear to offer the best opportunity for testing a survey and image processing methodology with the fewest problems of topographic and geologic variation. Photograph One shows a typical vegetation survey site.

Photograph 1: A typical vegetation survey site in the Ceres Karoo

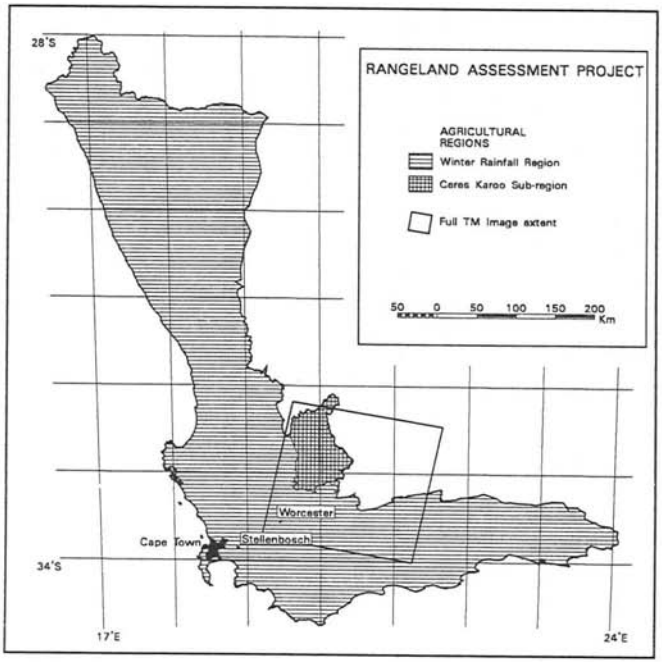

Figure 1: Location of the Ceres Karoo study area

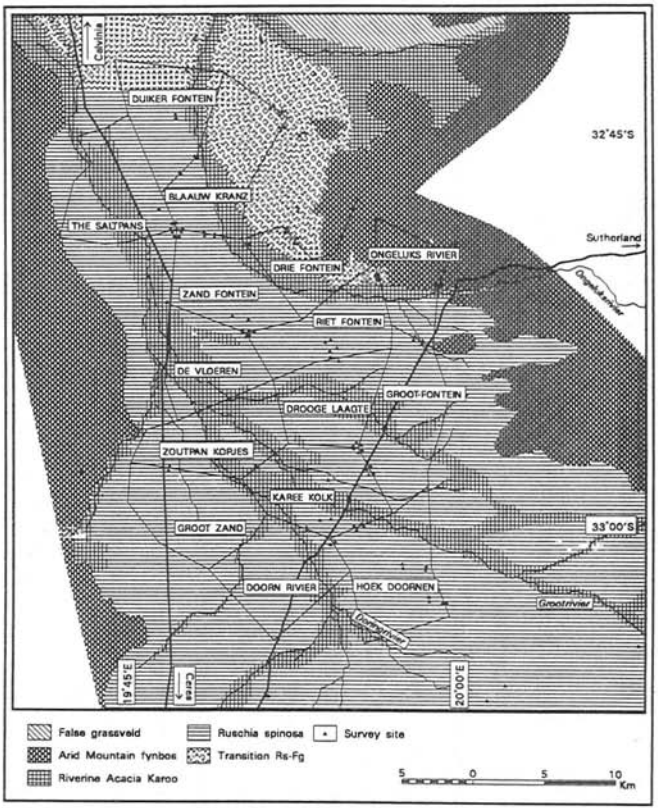

Figure 2: Detailed veld types and field survey sites in study area

Dissimilarity indices of field survey

A list of 172 surveys within the study area and the Ceres Karoo was compiled from an existing database of field surveys. Of these 159 were at sites that had a contrast pair (Figure 2). These surveys had been conducted closest to the time of the satellite overpass and image acquisition which was on 11 August 1992. In order to discriminate differences in digital image data at fence lines where there are known differences in range condition on each side of the fence, it was required to determine which paired surveys had large differences in species composition and cover. Investigation of these dissimilarities could then be used as indicators to where boundary events might occur in the image data, leading to selection of fencelines for more detailed analysis. In order to meet this requirement, a total of six dissimilarity measurements between paired surveys were determined.

Two dissimilarity measures on the basis of individual species covers were calculated for each paired survey, the *percentage dissimilarity by species cover* (%DSPEC), and *city block metric distance measure of species cover* (CBD). In addition to differences in species cover between surveys, two differences of cover between paired surveys were also calculated: the *absolute difference in vegetative cover* (ADVC) and the *percent difference in vegetative cover* (%DVC). Both these two difference measures were calculated as neither used individually can sufficiently measure the difference between two surveys where pasture is in a good condition and when the same difference occurs in two surveys where pasture is in a bad condition. The remaining two dissimilarity measures used are the *percent difference in estimated grazing capacity* (%DEGC), and the *percent difference in ratio of palatable to unpalatable cover* (%DPUP). The interested reader is referred to Mackay and Zietsman (1996) for full descriptions of all the dissimilarity measures utilised in this study.

Those survey pairs that had difference measures (cover, species composition, estimated grazing capacity and palatability ratio of cover) greater than a predetermined threshold value were selected for comparative purposes. This resulted in the selection

of 11 fence lines with a total of 17 pairs of vegetation surveys being identified for further investigation.

Manipulation of satellite imagery

As already mentioned, the Ceres Karoo has a low percentage vegetative cover. It was therefore decided that in order to minimise the background effect of soils, the most appropriate time at which to obtain imagery would be after the winter rains and thus during the period of greatest vegetative growth. In the Ceres Karoo region this is during late August or early September. A Landsat Thematic Mapper scene (WRS 174-83, Bands 1-7) processed to Level 6 was obtained for 11 August 1992. All subsequent processing of the image was performed using ERDAS 7.5 and IMAGINE 8.1 software in conjunction with Arc/Info 6.1.2 for providing GIS-support.

Derivation of a Vegetation Index

The development and use of vegetation and soil indices to transform digital data reduces anomalies caused by background radiation. Most vegetation indices have been developed and used in uniform and densely vegetated areas such as forest or croplands in contrast to sparsely vegetated and variable rangelands (Tueller 1989). Soil is an integral component of almost all remote sensing observations of the land surface (Wessman 1991). In rangelands canopy cover is often below 25%, and thus the soil provides the principal component of the spectral response (Tueller 1987). The mixed spectral signal must therefore be separated into the individual components contributed by the spectrally discrete materials on the land's surface if it is to be of any practical use.

The Soil Adjusted Vegetation Index (SAVI) is an index to minimise the effect of soil brightness when vegetation is the primary feature of interest. It is useful for areas where there are variations in soil brightness resulting from soil moisture differences, shadow, organic matter etc., and has been found to nearly eliminate soil-induced

variations in vegetation indices (Huete 1988). As the mean vegetative cover in the study area was 34,5% for the 172 survey sites it was decided that the SAVI would be an appropriate vegetation index for this study. Figure 3 shows the resultant SAVI image.

As previously described, 11 fencelines were identified with difference measures exceeding the stated threshold value. A further 10 fencelines were also visually identified from the SAVI image as suitable for further investigation.

Using the GIS, the selected fence lines were buffered on each side to a distance of 400 meters (Figure 4). A coverage of each buffer zone was created, producing a total of 42 buffers that fall into three areas. Each buffer zone was clipped to fall within one vegetation type. Each buffer coverage was imported into ERDAS as a polygon and then used to clip out the pixels that lay within its boundary from the SAVI image. The mean, standard deviation and frequency histogram were generated for each of the buffer images.

Dissimilarity measurement of SAVI

Each buffer image was treated as a sample set of pixel values and a comparison of the means of two independent samples was made using the Student t-test. A program was written with the Clipper programming language to process the data in the 42 buffer statistics files generated with ERDAS. The program extracted the mean pixel value and standard deviation from each statistics file. It also calculated the number of pixels in the histogram from each statistics file. Using these values, the difference in sample means and two t-test critical values (at 5% and 1% levels) were calculated for each pair of samples. In order to quantify the difference from one side of a fence line to another, the percent increase and percent difference in the means for each pair of samples were calculated.

All buffer images (with the exception of BUF3 and BUF4) clipped from the soil adjusted vegetation index differ significantly from the buffer image on the opposite side of the fence, and this indicates a difference in the state of the vegetation across

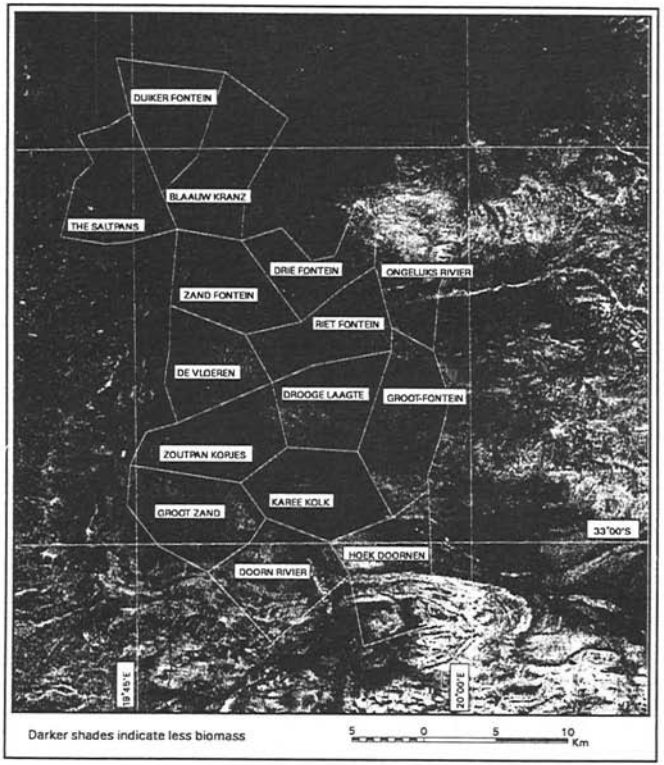

Figure 3: Image of Soil Adjusted Vegetation Index

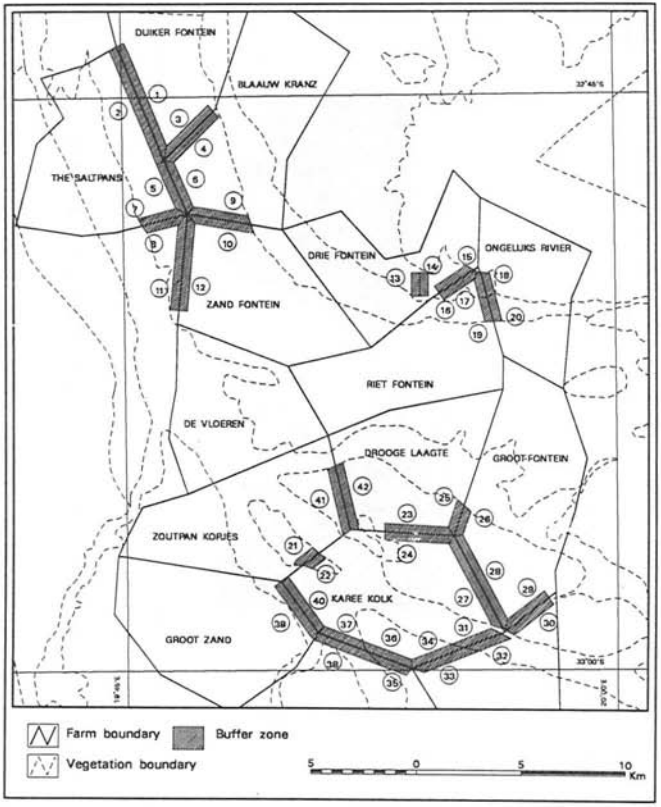

Figure 4: Location of buffered fence lines and vegetation boundaries

the fence line. Photograph Two is a good example of a paired survey site with such a significant fence line contrast in vegetative cover.

Photo 2: A paired survey site with a significant fence-line contrast in vegetative cover

Correlation of survey and digital image data

At this point it has been established that there is a significant difference in the value of the SAVI across all but one of the fence lines chosen for this study. A non-parametric Spearman ranked correlation coefficient procedure using the Statgraphics package was performed to determine the correlation coefficients for the relationships between the survey difference measures and the differences in the SAVI for the corresponding image pairs. The results are presented in Table 1.

An investigation of the correlation data shown in Table 1 leads to the following observations. The significant correlations between the image and survey data are those between percentage increase in the SAVI and the absolute difference in vegetative cover (ADVC), percentage dissimilarity by species cover measure (%DSPEC) which is highly significant, and the city block difference by species (CBD). This suggests that not only vegetative cover but species composition is also reflected in the soil adjusted vegetation index. The highly significant correlation of %DSPEC with the two difference in vegetative cover measures, the significant

correlation of CBD with the ADVC, and the highly significant correlation of CBD and %DSPEC support this view.

Table 1: Spearman Rank correlation of the difference measures

r_s (Significance)	Percent increase in SAVI	ADVC	% DVC	% DEGC	% DPUP	% DSPEC
ADVC	.5437 (.0352)*					
% DVC	.440 (.0884)	.9235 (.0003)**				
% DEGC	.2700 (.2956)	.6760 (.0088)**	.7246 (.0050)**			
% DPUP	-.0489 (.8498)	0971 (.7070)	.1471 (.5690)	.5552 (.0315)*		
% DSPEC	.6978 (.0069)**	.8353 (.0012)**	.7824 (.0024)**	.5302 (.0400)*	.2000 (.4386)	
(CBD)	.6206 (.0162)*	.6323 (.0143)*	.4466 (.0837)	.2827 (.2736)	.0192 (.9408)	.7664 (.0030)**

* $\rho = 0.05$
** $\rho = 0.001$

It has been determined that there is a measurable difference in the image data across all but one of the selected fence lines. For those buffer images where there are paired field surveys, the difference measure from the paired buffer images has been shown to be positively correlated to difference measures from the corresponding field survey pair.

Conclusion

The data presented in Table 1 and the simultaneous display of digital satellite imagery, farm boundary lines, and field survey data in the GIS demonstrate that there are artificial boundary events within similar vegetation types of the succulent biome in

the Ceres Karoo region. These boundary events are directly related to fences that demarcate farming properties and the management blocks therein. They are shown to be correlated with field survey data in which species cover and composition have been influenced by grazing management. These results indicate that it is feasible to detect fence line differences in rangeland condition at the farm scale with the use of satellite imagery that is geometrically registered to other relevant geographic data. These differences can be confirmed or dismissed by investigation of geographic data sets in conjunction with well directed field surveys.

The significance of this study is that a correlation was found between satellite derived vegetation index values and a range of vegetation indices computed from very precisely located and critically chosen ground vegetation survey transects. These results suggest that satellite remote sensing and GIS hold out great promise for operational application by extension officers for rangeland monitoring and management, especially in extensive pastoral regions.

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PLANETARY CARTOGRAPHY: RESULTS OF THE RUSSIAN PROGRAM AND PROSPECTS FOR THE DEVELOPMENT

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From a historical point of view planetary cartography is a fairy old science. The first drawing Moon map (compiled visually), which we now have, was made in 1603. Later several tenth of the Moon visible side maps were compiled by means of telescopic observations. In the past the attempts were made to represent Mercury, Venus and Mars surfaces on maps. In a definit sence it became possible thanks an application of photography and the development of terrestrial telescopic -photographic methods. So some albedo maps of Mercury and Mars were received.

Now we differ three principal various periods in the history of Solar System bodies cartography, namely prespace one, when all the observations were made from the Earth surface, transit one, when simultaneously with intensive terrestrial observations the first space missions took place, and space one, when the main role by receiving a scientific information began to play space vehicles.

Table 1

Methods \ Periods	Prespace till 1959	Transit 1959-1969	Space after 1969
a. On the base of terrestrial observations			
aa/ visual mapping by drawing	+		
ab/ visual telescopic drawing	+		
ac/ telescopic photography			
in optical band	+	+	+
in other bands		+	+
b/ On the base of space vehicles (photocameras, TV-cameras, radar and so on)			
bb/ survey in optical band		+	+
bc/ survey in other bands			+

These periods differ sufficiantly as by their technical abilities (Table 1) and professional level of concrete specialists, but, what is very important, by the quality and volume of received information.

The transit period was opened up by transmitting Lunar far-side images from the "Luna-3" automatic interplanetary station (AIC) in 1959. Then for almost 40 years the Russian and U.S. Space Programs routinely provided data for mapping extraterrestrial bodies. The contribution of Russian missions was faily considerable and especially for mapping the Moon and Venus.
It must be taken into account that mapping objects in this case have some peculiarities, namely

- great distances of mapping objects from the Earth,
- nonregularity of physical surfaces (especial by small celestial bodies)
- specific role of physikal parameters (albedo, rotation, illumination etz.)
- relief role as dominant component of map content,
- absence of antropogenic factors,
- availability specific features in praxis by every celestial bodies.

All these factors were tryed to take into account by planning Russian space program. In the transit period maps and schemas of the Moon far-side were compiled in Russia on the base of space survey (Lipsky at all, 1961, 1967). In 1967 the "Fotokarta vidimogo polushariya Luny" (Mosaic of the Moon visible side, scale 1:5 000 000) was prepared. It was made by the method of mosaics montage of images. In the same year " Polnaya karta Luny"(The General Moon Map, scale 1:5 000 000) was for the first time compiled and published. In this case data for mapping were used from terrestrial and space survey together.The transit period was finished by the second edition of this map.

Space survey planned for celestial bodies mapping has three clear phases till now, namely

- intensive survey of terrestrial planets and their moons (1970-1979),
- the expansion these servey by including giant-planets and their moon, comets and asteroids (1980-1990),
- return to survey of terrestrial planets and their moons, but on the base of modern technology (1991-2000).

Here it is necessary to underline that the beginning of space survey for mapping was in transit period, but wide using them for mapping was developped in 70th years. The survey of terrestrial planets and their moons was fulfilled launching space vehicles direct on the surface, by flyby the celestial bodies and from the artificial satellite orbits. Concerning the area extention it was local, regional and global. Of cause, not all the survey material was possible to use for mapping.

According Russian space program Moon mapping was based on survey results from missions "Luna" (24 automatic interplanetary stations - AIS) and "Zond" (5 AIS). Soft landing on the lunar surface made it possible to carry out a panoramic survey. The first topographic plans and sketch maps resulted from photogrammetric processing of panoramic images obtained from automatic lunar stations (ALS) "Luna9 and 13". They were at scales 1:20, 1:40. The activity of "Lunokhod 1 and 2" (ALS 17 and 21) was represented by the whole route sketch maps (10 km and 37 km correspondingly).

In order to continue the investigation on large-scale mapping of the Moon an experimental topographic map of the Moon was plotted for the crater Lemonie region at the scale 1:50 000 for the active zone of "Lunokhod 2". The goal was to perfect the method of the relief representation for large scales. Since it was impossible to show the really relief by cotour lines in every case with sufficiant level of detail, ways to enrich the contents were to be found by using other methods of relief representation. Thus, a method to develop was perfected a kind of an interim type of a topographic. Relief to be shown was plotted by shading and rare counter lines , but also using supplementary morphometric properties of relief features which could not be given in an assumed vertical scale. These morphometric properties are defined by interpretation indicators of images on base of a morphological classification of craters and numerical measurements done when this classification scheme was developped. The indicator provide a definition of morphometric properties for other relief features. The system of symbols was designed by means of a letter and figure system of logical correlation which was cosidered to be abstract scheme for indexing the content of a topographic map. The system can be changed by taking into account special demands made for a certain map. The advantage of the proposed method is to plot topographic maps by pictures in the case of data lack.

The problem of studying lunar surface by space photographic survey was solved by AIS "Zond 6,7, 8". For the first time the Moon film was brought to the Earth and used for compiling series of Moon far-side maps in the middle and small scales. The follows maps were published on this base:

- "Karta raiona lunnoi poverkhnosti" (Map of the Lunar Surface Region), 1:2 000 000, 1sheet.
- "Karta Luny. Chast' ekvatorial'noi zony nevidimogo polushariya" (Map of the Moon.Part of Equatorial Zone of the Invisible Hemisphere), 1:2 000 000, 1 sheet.
- "Karta obratnoi storony Luny" (Map of the Farside of the Moon), 1:1 000 000, 10 sheets.
- "Karta Luny" (Map of the Moon), experimental map, 1:500 000, 1 sheet.
- The last map was done in 6 versions (A,B,C,D,E,F). These versions differed from each other by thematic content.

In the field of thematic mapping of the Moon a series of maps and sketch maps of physical properties of the lunar surface was compiled by using the same cartographic projection. The Sketch Map of the Moon at scale 1:10 000 000 was used as a base map for this purpose. This serie included follow maps:

- "Map of the Lunar Surfase Albedo Properties",
- "Map of the Lunar Surface Polarimetric Properties",
- "Map of the Lunar Surface Colorimetric Properties",
- "Map of the Lunar Surface Thermal Properties",
- "Sketch Map of the Distribution of Thermal Anomalies on the Lunar Surface",
- "Sketch Map of the Distribution of Transit Phenomena on the Lunar Surface".

A possibility to analyze the surface properties represented on various maps and comparison with real relief features and with each other helps to find some correlations between them. The experience of compiling the outline map of the Moon and different types of of sketch maps has found wide application in the field of planetary thematic mapping. Soon it was propagated to other celestial bodies.

As it is known it is possible to survey Venus in visible band only from the planet surface. For the first time it was made by series of "Venera" stations after soft landing (Venera 9,10,13,14). They provided the first panoramas of the planet surface in the optical band. The large-scaled topographic plans were plotted on the base of these panoramas. The "Venera 15, 16" stations carried out the survey of the northern hemisphere of Venus. The Venus map of this hemisphere on 30 sheets was compiled at scale 1:5 000 000 on the base of this material. It was made before Magellan mission.

"Blankovaya karta Marsa" (Outline Map of Mars) was the first map of this planet plotted in Russia. This was a map of hemispheres at scale 1:20 000 000. The projection was chosen to make possible a comparison between thematic maps on the same typical base, which is important for comprative planetology analysis. The map at scale 1:5 000 000 covering a relative small region in the neighborhood of the Nirgal vallis was compiled on the base of the information of "Mars 5" station.

The development of projections for bodies of significantly unspherical shape has become acute due to investigations of the Mars satellites Phobos and Deimos by means of space technik, surveying the satellites of giant-planets, mapping the solid bodies (nucleus) of the Halley comet and asteroids. These bodies are characterized by a more complex reference surface of reference datum. It results from the calculations that, if the oblateness is about 1/5 and more, then a triaxial ellipsoid is to be preffered. For the first time it was used to plot a Phobos map at scale 1:100 000. Besides, map projections were derived for the maps of a Phobos globe (scale 1:80 000) that has the shape of triaxial ellipsoid too. A distinktive peculiarity of this globe is that its segments differ in shape and dimations.

The main results of planetary mapping were represented in a serie of Atlases, namely Atlas of the Farside of the Moon (Vol. I, II, III), Venus Atlas, Phobos Atlas and Atlas of Terrestrial Planets and their Moons. The last one can be considered as a common result of investigations in the field of planetary cartography till the middle of 90th years of this century. The surfaces of the terrestrial planets and their moons are represented in series and at comparable scales. The Atlas consists of one band and has 12 sections with several supplements. The text of each part not only explains the cartographic material given, but adds it to the data showing the physical sence of

phenomena processes taking place on the celestial bodies. a wide range of data on geometrical, physical and other properties of the celestial bodies are presented. The original idea of this atlas consists of the attempt to analyze the data from the comparative planetology point of view.

At present the main goals of the planetary cartography are as follows: visual representation of the space reseach results, navigation support of missions towards celestial bodies, development of extraterrestrial areas and dissemination of knowledge about celestial bodies. In particular due to preparation on the lunar base development all these materials become of interest for future works on various purpose constraction engineering, transportation network constraction and others. In addition one of the main tasks of celestial bodies cartography cosists in creation of various cartographic products for educational, inquiry and popularization purposes. Consequently study of the following aspects is of particular importance for future planetary cartography: through choice and development of maps product parameters (map mathematical basis, co-ordinate system, choice of projections ets.), stages of the data acquisition for mapping the Solar System bodies and co-existence of both traditional and digital maps. A series of special atlases of inquiry and encyclopedic character presenting results of planetary research is worth with taking into consideration a transfer from local mapping of celestial bodies (reconnaissance approach) to the global mapping (total survey).

PLANETARY CARTOGRAPHY AND THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION

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1. Introduction

The advent of spaceflight has created the opportunity to learn a sufficient amount of information about numerous planets and satellites to support the generation of cartographic products of many objects throughout the solar system. Spacecraft have flown past, orbited, or landed on more than 60 individual celestial bodies, each with its unique story preserved in its surface morphology, topography and chemistry. While the majority of the early spacecraft were built and launched by either the United States or Russia, many nations are now increasingly participating in the exploration of the solar system. We believe that it is time for those of us involved in studying and mapping these celestial objects to formally coordinate our efforts on an international basis. The International Cartographic Association (ICA) is an organization perfectly suited to such an activity. The authors have made some preliminary efforts toward the goal of eventually establishing a formal Working Group on Planetary Cartography within the ICA, but we now solicit the participation of all who are interested in various aspects of the cartographic representation of information from solar system objects. This paper summarizes the international effort currently underway in the generation of cartographic products for objects throughout the solar system, planetary cartography activities scheduled for ICC 97, and contacts for anyone interested in joining this international effort.

2. Background

In September of 1995, a proposal to form a Working Group on the topic of "Planetary Cartography" was given to Dr. Fraser Taylor, then President of the ICA, and subsequently to the Executive Committee of the 10th General Assembly of the ICA. This proposal was initiated by an international group of researchers with special interest in the subject, represented by Russia (Astronaut Prof. V.P. Savinykh, Prof. K.B. Shingareva, and Dr. B.V. Krasnopevtseva), Germany (Prof. M. Buchroithner), and the United States (Dr. J.R. Zimbelman). The primary reason for this proposal was

that among the 25 themes of the 17th ICA conference in Barcelona, there was no single theme that easily encompassed the broad range of features identified to date through mapping of extraterrestrial surfaces. The Barcelona conference included papers related to the international interest in planetary cartography, e.g. [1-3], but they were presented in sessions throughout the conference. The broad international interest in this topic makes the ICA an excellent forum in which to discuss coordination of planetary mapping efforts currently underway throughout the world.

Planetary mapping can be considered to date back to the first drawings made by Galileo in 1610, but it is during the past thirty years that the advent of spacecraft missions to other planets has dramatically increased our knowledge of the objects that orbit the Sun. The list of planetary cartographic products compiled to date includes planets, their various satellites, asteroids and comets. The information has been documented in maps, globes, atlases, digital data bases, thematic maps, etc., each portraying the great diversity of natural surfaces found within the solar system. Given the demonstrated global interest in mapping worlds beyond our home planet, it is time to formulate a planetary cartography working group within the ICA. Perhaps this interest will grow eventually to the level of a Commission on Planetary Cartography, particularly as a steady stream of new images and other data are being returned by spacecraft from several nations.

The proposed ICA group will focus on the mutual coordination of cartographic themes in various national efforts in planetary mapping. At the January 1996 meeting of the Executive Committee of the ICA, President Dr. M. Wood authorized a Presidential Task Force on Planetary Cartography, with the goal of the establishment of an official ICA Working Group. In this spirit, we have encouraged the participation of researchers and cartographers from various nations at the 18th ICC meeting in Stockholm. We believe that this effort will produce not only reports on international activities in planetary cartography, but also lead to discussions of the goals and future activities of the proposed Working Group within the ICA.

3. Planetary Cartography at ICC 97

Three sessions devoted to topics in planetary cartography have been incorporated into the schedule for the 18th ICA/ACI International Cartographic Conference in Stockholm, Sweden. "Session 9 - Planetary Cartography" is scheduled for Tuesday afternoon, June 24, with six oral presentations of 30 minutes each:

- "Planetary Cartography: Results of the Russian program and prospects for Development", Kira B. Shingareva, Russia.
- "Mapping Prospects for Future Missions to Mars", James R. Zimbelman, USA.
- "De- and Re-Shading for Optimal Relief Mapping of the Surface of Mars", Egon Dorrer and Xiuguang Zhou, Germany.
- "Mapping a Whole Planet - The New Topographic Image MAP series 1:200,000 for Planet Mars", Hartmut Lehman, Germany.

- "Mapping Irregularly Shaped and Rotating Bodies", Thomas C. Duxbury, USA.

- "Venus: Systematic Cartography and Geologic Mapping", R. Stephen Saunders, USA.

Poster Session 4 on Wednesday morning, June 25, includes "Special Session - Planetary Cartography", consisting of various poster presentations relevant to planetary mapping. Thursday morning, June 26, the formation of a new working group will be discussed in "Working Group meeting: Planetary Cartography - Call for interest in creating a new WG". Please take part in these sessions!

4. Are you interested in joining us?

We would like to hear from any and all cartographers and researchers who have an interest in the topics encompassed within planetary cartography studies. Contact either of the authors at the addresses provided beneath their names, either through conventional mail services or via e-mail. There is also a communal e-mail address (ica@ceps.nasm.edu) to which comments or questions can be submitted for transmission to those participants with access to e-mail. We anticipate that a home page will eventually be set up on the World Wide Web to facilitate rapid communication between interested parties in many nations. Both on-going and recently launched spacecraft should be returning an immense amount of data in the near future, particularly from the planet Mars. We are convinced that the news reports related to these studies will only increase the world-wide interest in cartographic studies of objects beyond the Earth. Please let us know of your interest in participating in the dissemination of this exciting new information.

References

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ROLE OF CARTOGRAPHY IN A COMPLEX REPRESENTATION OF THEMATIC INFORMATION ABOUT SOLAR SYSTEM'S BODIES

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Usage of the mapping technique for studying the Solar system's bodies dates back for many years. Every stage of studying celestial bodies was connected with a cartographic representation of the data obtained at a new turn of engineering capabilities. At first drawings and sketches were made, then maps were to be compiled on the basis of ground telescopic observations. Engineering solution for a task of putting spacecraft into interplanetary trajectories has opened principally new opportunities for an all-round widening the knowledge about the Universe. Each space flight was a capacious source of the data about the nature and evolution of the Solar system's bodies. This has created the conditions for a quick development of the planetary cartography which has made it possible to clearly and fairly reliably represent the most contemporary results of studying extra-terrestrial bodies and space as well as to obtain their precise qualitative and quantitative estimates.

At the first stage of studying the Solar system's bodies with the use of space technologies general mapping of extra-terrestrial bodies was most intensively developed. The general maps were presented in various projections and on different scales using various techniques of relief representation as the relief turned out the main feature to be shown on. However as the information was being accumulated for the planetary cartography the specific weight of various thematic maps increased. This was due to the requirements of a complex approach to studying celestial bodies as well as the necessity to perform the comparative planetological analysis. The planetary data thematic interpretation plays an important role in not only representation of various types of information about extra-terrestrial bodies but the solution of applied tasks, i.e. creation of special maps (navigation maps, design maps, etc.).

The best conditions for the representation and visual perception of all the totality of the knowledge about celestial bodies under consideration are achieved when a common mathematical base is used. Special outline maps are proposed as such a base. The outline maps presenting the relief by a system of conventional signs make it possible to survey the thematic data onto the actual relief. Generalization of the relief forms on outline maps has to be done so as not prevent thematic content perception because of the shown relief.

Thematic maps characterize various aspects of studiness of the celestial bodies. Analysis and estimation of the former make it possible to classify them in the following main types:

- -Maps of surface physical properties including albedo maps, colorimetric maps, radiation budget maps, polarimetric maps, maps of thermal anomaly and non-stationary phenomena distribution, etc.;
- Geophysical maps generalizing the contemporary knowledge about the gravity fields of the Solar system's bodies which can be presented by the maps of the geoid altitudes, gravity anomalies, magnetic anomalies and seismic activity;
- Hypsometric maps characterizing relief global features and presenting the qualitative characteristics of the micro relief forms, global height difference as well as about of the altitude belts, large orographic systems and slopes;
- Geologic and morphologic maps which represent the common mechanisms of extra-terrestrial objects' geologic evolution together with the prevalence of particular relief forms (craters, lineaments, etc.) and their distribution density. These maps are mainly based on geologic interpretation of surface morphology features using remotely sensed data as up until now the traditional geological techniques of studying rocks have been only used for the examination of the lunar soil samples which had been delivered to the Earth;
- Geochemical maps representing both the prevalence of particular chemical elements and the mineralogical composition of the surface rocks; these parameters are the basis for geochemical zoning of the regions; and
- Climatic maps fixing weather change for a certain time period (e.g., seasonal changes), wind velocity and direction, temperature changes, cloudage dynamics, etc.

The classification given for the thematic maps can and should continuously be widened together with the development of the techniques and facilities for studying Solar system's bodies as well as due to the increase of the number of aspects regarded for studying extra-terrestrial objects. The complex approach is the most efficient method making it possible to systemize the totality of the knowledge about celestial bodies. This technique can be implemented only if using the whole range of the capabilities provided for the atlas cartography for which maps serve as the main data source however each thematic aspect is accompanied with an explanatory text, broad inquiry information, schemes, tables, graphs, diagrams, illustrations and other types of auxiliary data. A cartographic atlas including maps joined by a common idea and common mapping techniques, turns out the best form for the thematic data complex representation. All the maps of the atlas are interrelated and complement each other. It seems expedient to compile atlases of two types:

- complex atlases of particular celestial bodies representing the complete knowledge about them; and
- complex atlases representing data about various extra-terrestrial bodies as a result of the comparative planetological analysis.

The "Complex Atlas of the Moon" can serve as an example of the first type. It generalizes and systematizes the totality of the already accumulated knowledge about the Moon as a celestial body. The Atlas includes various purpose maps representing almost all the aspects of studying the Moon using ground-based and space means as well as the thematic maps representing optical, polarimetric, thermal, geophysical, geological, morphological and other characteristics of the lunar surface. In addition it

includes maps of the Moon's surface shown by various relief representation techniques as well as special sections giving information about the Moon mapping history, the spacecraft which examined its surface, results of these studies, etc. The Atlas was compiled as a series of maps on separate sheets of 380x580 mm in a map case. The Atlas's maps have been created on a common mathematical base. This has provided for the compatibility and concordance of all the maps. An outline map of the Moon in the Molveide equidistant pseudo-cylindrical projection was used as a common mathematical base. The base map was on a scale of 1:20,000,000 and represented the surface of the whole lunar globe on a single sheet. This is a fairly small scale and it is obvious that the information shown is strongly generalized. The information of such global character makes it possible to present the Moon's complex model which serves as a good base for further work on its studying and mastering.

The "Atlas of the Terrestrial Planets and Their Moons" is an attempt to create a complex atlas of the second type. The Atlas is the first cartographic product in which up-to-date knowledge about the terrestrial planets and their moons (Mercury, Venus, the Moon, Mars, Phobos and partially about the Earth and Deimos) is very complete and clearly systematized. The Atlas includes 12 sections. Each section presents particular characteristic information about these celestial bodies. The Atlas includes thematic maps giving information about physical properties of the surface, hypsometric, geophysical and geologic and morphologic characteristics. Intent attention was paid to the representation of these celestial bodies' surfaces. The relief features are shown by conventional signs and shading technique. The Atlas includes articles about the history of mapping the terrestrial planets and their moons, tables with the information about flights towards these celestial bodies, information about their photographic, geodetic and cartographic studyness and various-purpose inquiry data.

Outline maps in three projections including the Lambert inverse azimuthal equivalent projection, Postel inverse azimuthal equaldistance projection and Mercator normal cylindrical equal-angle projection with the polar area representation by a normal equal-angle stereographic perspective projection, were used as the Atlas mathematical base maps. The Postel projection maps were used for representation of point phenomena (thermal anomalies, non-stationary phenomena, seismic activity centers) on thematic maps as well as for the compilation of chart maps illustrating flights towards planets and their moons. The Lambert maps served as base maps for compiling surface maps for the celestial bodies as well as for the thematic maps showing area spread phenomena (maps of albedo, polarimetry, hypsometry, gravity anomalies , geological zoning) as this is the only projection preserving square without distortions. The Mercator maps demonstrated the maximum percent of the relief feature representation.

The above mentioned Atlases have been developed at the Moscow State University for Geodesy and Cartography together with several higher educational establishments, the Institutes of the Russian Academy of Sciences and industrial organizations.

It could be concluded that: the complex approach turned out the most efficient in the representation of a large amount of various material in almost all the trends of the planetary research. Due to a wide possibilities of various information presentation in an atlas the thematic maps were joined in a complex of mutually interrelated multi-

purpose maps. The works on complex thematic mapping of celestial bodies are fairly urgent as they make a detail forecast and planetary research data analysis possible as well as provide for planning of future scientific exploration of the Solar system and the Universe. To our regret it should be stressed, that cartographic methods are insufficiently widely used for studying the Solar system's bodies. The reason for this is in a considerable distance between planetologists and cartographers. The contemporary cartography transfer to using digital techniques for the creation of maps and atlases will promote the problem solution.

COORDINATING STANDARDS ON DATA QUALITY: AN IMPORTANT INGREDIENT FOR CARTOGRAPHERS

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Abstract

Cartographers are enthused by the increased availability of geographic datasets and the opportunity to obtain information without the redundancy and expense of data collection. Geographic information systems have become an invaluable tool for the process of developing cartographic products; thanks to large databases that provide the raw data and geographic information systems that support analysis and visualization of large amounts of data. The suite of standards proposed by ISO/TC 211 (the International Organization for Standardization's Technical Committee for Geographic Information/Geomatics) is of major importance to cartographers as it defines a schema for information on datasets which can be interchanged by geographic information systems. This paper focuses on the progress of Work Item (WI) 13 - Quality being undertaken by Working Group 3, Geospatial Data Information.

Introduction

The standards work of ISO/TC 211, WI 13 - Quality builds on several current and past efforts. Two fundamental works are those of the ICA (International Cartographic Association) Commission on Spatial Data Quality and the CEN/TC 287 proposed Quality standard[1]. Within the ISO/TC 211 scope of work, WI 13 - Quality is related to, depends on, and influences many of the components of the geographic domain being addressed in a suite of twenty work items; however, it is most closely related to WI 14 - Quality Evaluation Procedures and WI 15 - Metadata. This paper reports on the progress of WI 13 and summarizes the important harmonization between it and WI 14 and WI 15. The products of these three work items are of primary concern to every cartographer because together they will provide a consistent and standard way to report and evaluate data quality information as it is presented in the metadata of a digital file. This is the key that will enable a cartographer to assess the "fitness for use" of a digital file for map visualization. Assessments of competing files will be routinely necessary and greatly influence the products of any cartographer in the future.

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[1] The European Committee for Standardization's Technical Committee for Geographic Information, Working Group 2.2, Project Team 5 is drafting Pr EN 287 008 Geographic Information - Data description - Quality.

Scope of Work

ISO TC/211 allocated two work items in the ISO 15046, Geographic Information, twenty work item suite of standards to directly address the quality of geographic data. The two work items are WI 13 - Quality and WI 14 - Quality Evaluation Procedures (QEP). The original scopes of both were brief. Quality was tasked with developing a "definition of the schema for quality applicable to geographic data," while QEP focused on "development of guidelines for the methods of specifying/evaluating data quality." An early and ongoing objective for team members[2] developing the work items was to clarify the respective scopes of work. The process has been iterative. Team members recognize that harmonization between the work items is essential and the resulting documents must be supportive of one another in order to be of value. The two work items address interrelated, but distinct, topics. The title of WI 13 has evolved from Quality to Quality - Principles to reflect its role of defining a quality schema. The scope of Quality - Principles (including its purpose) is:

> "Definition of the schema for quality applicable to digital geographic datasets.
>
> A quality schema establishes the principles for describing the quality for geographic data and offers a data quality model for organizing knowledge about data quality. The components of data quality are defined and requirements for their use specified.
>
> A quality schema does not attempt to define a minimum acceptable level of quality for geographic data nor does it attempt to provide guidelines to define fitness for use. The data producer is responsible for documenting data quality while the data user is responsible for determining from this documentation whether or not geographic data is of sufficient quality for a particular application. Both data producers and users work within the data quality model to meet their responsibilities."

The title of WI 14 has been refined from Quality Evaluation Procedures to Quality - Evaluation Procedures; the hyphen indicates a level of significance with quality being the most significant element and evaluation procedures applicable to quality. The scope of QEP, still under development, currently is:

> "...provides data quality evaluation procedures applicable to digital geographic datasets.
>
> The framework of quality evaluation procedures defines the procedures for determining data quality results consistent with the data quality model established in Quality - Principles. The framework establishes the content of the evaluation procedures and their data quality results to be reported as a part of data quality metadata and, optionally, in a separate data quality report according to reporting guidelines."

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[2] The United States is the project lead for Quality; Japan is the project lead for QEP. Team members are experts from several countries including Australia, China, Finland, France, Japan, Netherlands, New Zealand, Norway, Russian Federation, Sweden, United States, Yugoslavia, and a liaison member representing the Digital Geographic Information Working Group (DGIWG).

The Data Quality Model

The Quality - Principles team concentrated its initial efforts on developing a data quality model. The data quality model is central to the Quality - Principles standard, providing a foundation for defining the expectations for and limitations of the standard as well as the responsibilities of data producers and users wishing to adhere to the standard. The importance of QEP in contributing to the development of the data quality model should be emphasized--the data quality model is designed to address the QEP requirement to measure the quality of a dataset. Several models presented in the ICA Commission on Spatial Data Quality's *Elements of Spatial Data Quality* as well as CEN's quality model were reviewed. The majority of these models emphasize a two step process of (1) abstracting reality to an "abstract universe" or "nominal ground", then (2) creating a dataset whose quality is a measurement of the degree of success in approximating the abstract universe. This idea was accepted and extended by the Quality - Principles team. The main concepts illustrated in the final data quality model (Figure 1) are:

1. An abstract universe is a subset of perceived reality and it, rather than reality, serves as the data producer's frame of reference for a dataset.
2. An ideal dataset results from a one-to-one mapping of the geographic data contained in an abstract universe and has an associated quality which is ideally measured by how well the dataset matches its abstract universe.
3. To measure how well the dataset matches its abstract universe, a data producer must identify a set of parameters which define the mapping of the abstract universe to the dataset. This is accomplished using a product specification or similar documentation. This measurement is one aspect of quality.
4. How well the product specification describes the abstract universe against which the dataset is being compared and measured has a major effect on quality. This aspect of quality requires a measurement of how well the product specification captures the abstract universe and was determined to be unmeasurable and, therefore, beyond the scope of work.

The base reference for measuring the quality of a dataset is the product specification. The product specification is created to ensure the dataset being created will meet specific needs. This reference is significant to the data producer but, unfortunately, may be meaningless to other data users having applications differing from those of the data producer which may be based on different abstract universes. The data user is not creating a dataset but is seeking an existing dataset which best meets their unique applications and needs. The data quality model recognizes that the measure of quality essential to the data producer may be only marginally valuable to another data user. The data user is interested in fitness for use[3] and must take a different evaluation path when using quality information provided by a data producer to assess the quality of a dataset

[3] Quality - Principles defines quality as "totality of characteristics of a product that bear on its ability to satisfy stated and implied needs" while fitness for use is defined as "totality of characteristics of a product that bear on its ability to satisfy the requirements of an application."

for their own needs. The data quality model recognizes two paths for evaluating quality and, additionally, QEP offers separate procedures for each path.

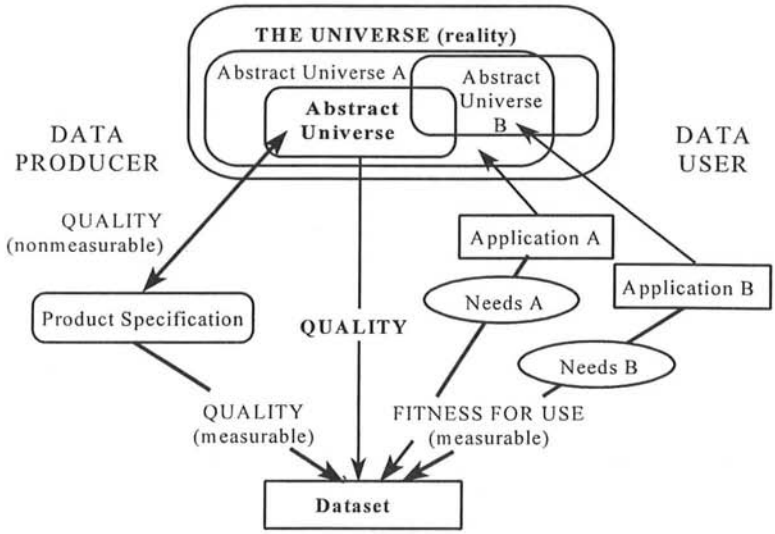

Figure 1. The Quality - Principles data quality model.

The Components of Quality

Quality - Principles recognizes two distinct components for describing the quality of geographic data: (1) quantitative quality information (data quality elements), and (2) non-quantitative or descriptive quality information (data quality overview elements) requiring a subjective evaluation by the user of quality information.

These components are applicable to datasets or to levels or reporting groups within a dataset identified as significant by the data producer (using the product specification). Quality - Principles clearly differentiates between these two components of quality whereas no distinction is made in existing ICA work. A major problem in comparing the work of ICA, CEN, and ISO is interpreting terminology--although basic concepts are similar the terms describing concepts differ. To simplify comparisons, Table 1 provides an overview and illustrates broad areas of commonality as well as lessor areas of divergence.

<u>The Quantitative Component of Quality - Data Quality Elements</u>

A data quality element is a recognized and accepted aspect of data quality which can be reported quantitatively. The ICA's Commission on Spatial Data Quality identified seven aspects of quality. The Quality - Principles team selected six of these aspects as quantitative (lineage was deemed non-quantitative). Although a valid theoretical concept, "semantic accuracy" was considered difficult if not impossible to actually

ICA Commission on Spatial Data Quality	CEN/TC 287 Quality	ISO/TC 211 WI 13 Quality - Principles
spatial data quality element an important aspect of spatial data quality *Seven are identified:* lineage, positional accuracy, attribute accuracy, completeness, logical consistency, semantic accuracy, and temporal accuracy	**data quality element** item of information describing the quality of a geographic subset *Three are identified:* lineage, usage, and quality parameters	No comparable term, though an understanding there are two components of quality information (data quality elements and data quality overview elements) exists
	quality parameter quantitative quality element describing the performance of a geographic subset compared to its nominal ground *Five are identified:* completeness, logical consistency, positional accuracy, temporal accuracy, and thematic accuracy	**data quality element** component of the quality of a dataset documenting quantitative information *Five are identified:* completeness, logical consistency, positional accuracy, temporal accuracy, and thematic accuracy
	No comparable term	**data quality subelement** one aspect of a data quality subelement *Nineteen are identified*, each unique to a specific data quality element
	secondary quality parameter quality parameter specific to certain types of geographic data *One is identified:* textual fidelity	No comparable term
	lineage The history of a geographic subset in terms of source material, dates, processing applied, and responsible organizations	**data quality overview element** component of the quality of a dataset documenting non-quantitative information *Three are identified:* purpose, usage, and lineage
	usage applications for which a geographic subset has been used	

Table 1. Comparison of terminology and definitions.

measure and quantitatively report and so was not included as a data quality element in Quality - Principles. The Quality - Principles data quality elements are: (1) completeness, (2) logical consistency, (3) positional accuracy, (4) temporal accuracy, and (5) thematic accuracy.

The Quality - Principles data quality elements are analogous to the CEN quality parameters. CEN allows further reporting of quality information through the use of secondary parameters specific to types of data. The Quality - Principles team allows further reporting of quality information through the use of data quality subelements specific to data quality elements. The data quality subelements are:

- completeness
    - commission
    - omission
- logical consistency
    - domain consistency
    - format consistency
    - topologic consistency
- positional accuracy
    - absolute accuracy, elevation
    - absolute accuracy, horizontal
    - absolute accuracy, 3 dimensional
    - pixel position accuracy
    - relative accuracy, elevation
    - relative accuracy, horizontal
    - relative accuracy, 3 dimensional
    - shape fidelity
- temporal accuracy
    - accuracy
    - temporal consistency
    - temporal validity
- thematic accuracy
    - accuracy of a feature attribute defined by a value
    - classification accuracy
    - misclassification

Measuring and Reporting the Quantitative Component of Quality

Identifying the important aspects of quality is a first step, but to be useful, a quality standard must offer guidelines for measuring and reporting quality information. In addition to defining data quality elements and subelements, Quality - Principles identifies the type of quality information (the parts composing data quality subelements) to be gathered and reported. As data quality subelements may be applicable to either an entire dataset or a level or reporting group within a dataset, the first part composing a data quality subelement which must be identified is the data quality scope(s). For each data quality scope, the following information is required: (1) the data quality measure names the specific test applied to the data quality scope, (2) the data quality procedure describes the manner in which a data quality measure is applied to the data quality scope, (3) the data quality result is the value or set of values resulting from applying a data quality measure to a data quality scope, (4) the data quality unit indicates the defined type by which a data quality result is being reported, and (5) the data quality date records the date or range of dates on which the data quality measure is applied.

QEP will provide the framework for applying quality procedures to a dataset, addressing procedures and methodology such as sampling. In their early work, the QEP team has proposed further quality information (a data quality characteristic) which must also be reported. Although much work has been accomplished in some areas of measuring

quality, notably completeness, logical consistency, and many of the subelements of positional accuracy, much work remains to be done in the areas of temporal accuracy and two subelements of positional accuracy (pixel position accuracy and shape fidelity.)

The reporting of the entire pathway of data quality information from data quality elements through the parts composing each data quality subelement is being harmonized with both WI 14 and WI 15. Quality information is considered to be metadata. WI 14 recognized many data producers wish to document quality more completely than is practicable as metadata and is providing a more comprehensive reporting form (whose use is optional). Figure 2 illustrates the harmonization of gathering and reporting quality information between WI's 13, 14, and 15.

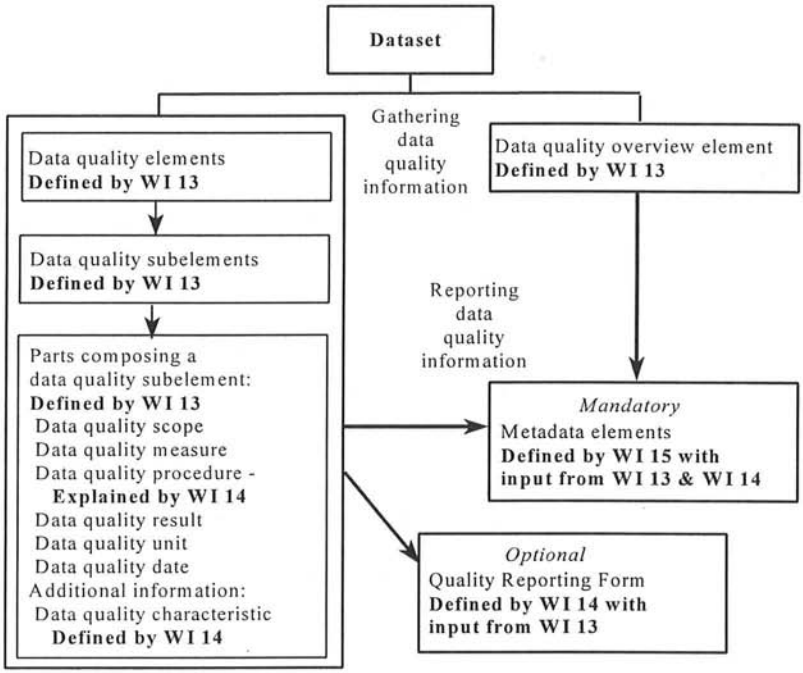

Figure 2. Harmonizing WI 13 Quality - Principles, WI 14 Quality - Evaluation Procedures, and WI 15 - Metadata

The Non-quantitative Component of Quality - Data Quality Overview Elements

Data quality overview elements provide informative data and are equally critical to a data user assessing the quality of a dataset against fitness for use using the data user's own criteria. Data quality overview elements provide non-quantitative information which must be subjectively evaluated by the data user.

Quality - Principles recognizes three data quality overview elements: lineage, purpose, and usage. The ICA Commission on Spatial Data Quality addressed only one of these areas: lineage (or source). All three are recognized by CEN, although purpose is not unique but considered to be a part of lineage.

The distinction between purpose and usage is rather subtle. Purpose records the data producer's rationale for creating a dataset and contains its intended use. Usage documents all the applications for which the dataset has been used. Although considered valuable information, several members of the Quality - Principles team have expressed concern over the undue burden that recording usages may place on the data producer. Realistically, the data producer is certain only of their own usage. The data producer must rely on other data users to supply additional usages of the dataset.

Data quality overview elements are reported as metadata but are not incorporated into the Quality Reporting Form.

Conclusion

Although there are differences between the work of ICA, CEN, and ISO, it can be concluded, from comparing the quality documents produced by the three organizations, that they share a common view as to what the description of the quality of a geographic dataset entails. Of course, minor differences do exist. The ICA work offered a general framework and did not address the specifics of gathering and reporting quality information. CEN discusses the quality of quality information (metaquality); this has not been incorporated into the ISO work. ISO offers details on measuring and reporting quality information. The work accomplished to date highlights what has been accomplished as well as the areas requiring continued discussion and research. The framework has been provided. The next step, and what the community is moving toward, is implementation. In recognizing both Quality - Principles and Quality - Evaluation Procedures in its suite of standards, ISO is moving toward the goal all users of spatial data seek--being able to describe and decipher the quality of a geographic dataset to aide in the usage of datasets as we move into the future.

THE CENSUS BUREAU'S ELECTRONIC DATA ACCESS AND DISSEMINATION SYSTEM: NEW CHALLENGES FOR CARTOGRAPHIC APPLICATIONS

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INTRODUCTION

The U.S. Census Bureau is developing a Data Access and Dissemination System (DADS) that offers census data electronically via the Internet. DADS will improve and extend access to official demographic, economic, and geographic information. This interactive electronic system will be designed to allow efficient and cost-effective access to data generated by the various areas of the U.S. Census Bureau. Users will access, through a single system, suites of data sets such as those from the Census 2000, the American Community Survey, and the Economic Census. DADS offerings include statistical data, geographic and cartographic information, metadata, and tools to access and display the data (including maps). Geography is the integrating principle for the data.

The goal is to offer a coordinated approach to data access and dissemination throughout the U.S. Census Bureau. DADS will support the Census Bureau's strategic plan in the following ways:

- DADS will provide timely data while remaining innovative and sensitive to the needs of data customers;
- DADS will be designed to be customer-friendly and market driven to provide products and services of superior value for Census Bureau customers;
- DADS will exemplify stated Census Bureau goals to adopt the most effective and innovative processes to improve cost-effectiveness, delivery time, and quality performance in support of core business activities.

WHY CREATE A DADS

Traditionally, the U.S. Census Bureau provides data tabulations as they become available for each respective census or survey. The data are made available in a variety of forms, from summaries and detailed characteristics organized as part of tables in printed reports to computer files that are offered on different media, including 9 track tape, diskette, and CD-ROM. As products, data from censuses and surveys generally are treated as discreet offerings. The "products" usually are designed by census staff who attempt to create tables, publications and files for the greatest number of users. This process, particularly the printed reports, takes

considerable time. Each stage of data movement requires detailed edits to ensure that the product (data) is not compromised.

Users who require collections of data, sometimes from the same census or survey, oftentimes have to acquire separate products due to the nature of the data "package." Details about the availability of data as well as general information similar to metadata is not always readily available to the consumer, even with the best intentions.

DADS will provide timely data in an innovative manner while meeting customer response requirements. It will be accessible to the widest possible user-base through the Internet as well as through intermediaries such as State Data Centers, libraries, universities, and private firms. Products such as statistical reports and data files will be prepared on demand. Disclosure protection will be built into the system design to ensure data confidentiality requirements.

The creation of a single system that serves as an entry point for access to any data made available by the Census Bureau is one of the goals. More importantly, the system will serve external customers of the Census Bureau as well as census staff who face similar types of challenges in gaining access to the extensive data collected by the Census Bureau. Data will be available within the same system regardless of the characteristics of the census or survey. Data from an economic census or survey will be available within DADS just as data from a population and housing census or survey. Users will have the same tools to access the data and related information.

GEOGRAPHY AS THE INTEGRATING FACTOR

Two basic ingredients for putting power and utility into the hands of data users are spatial data and associated statistics about that location. The spatial data are the geography. Statistics are limited only by what is collected, known, or estimated about that location.

Statistical data produced by the Census Bureau are referenced geographically, whether it is a summary level statistic for the nation, demographic characteristics about an individual, or economic activity about a type of business. The statistical data are anchored to a location. Initially that means the location where the data are collected. For dissemination, the data oftentimes are aggregated to higher levels of geography to conform with confidentiality requirements (Title 13 of the U.S. Code).

Data are associated with location through the use of a geographic code, oftentimes referred to as a geocode. In the United States, the Federal Information Processing Standard (FIPS) is one organized method of applying a consistent code as well as an agreed upon code scheme. FIPS codes cover a limited set of common geography. Where FIPS are not available, locally used codes are devised and applied.

One of the benefits of DADS is the user-defined nature of geographic and statistical queries. This has been a basic requirement for a subset of data users and this new technology will provide the data and tools for meeting their requirements. DADS will provide a mechanism to assign user-defined geographic codes to specified location and its associated statistical data. Typically, in a Census Bureau context, geocodes have usually been applied to geographic areas. There is no limitation, however, in applying similar requirements and techniques to other forms of location such as points, lines or other spatial characteristics.

DADS EVOLVES THROUGH TIME

The Data Access and Dissemination System development process is technological in nature. DADS does not currently exist as a product for sale and distribution. Therefore, it has to be created with technology that will meet DADS requirements. As this is a user-based system, the technology requirements are driven partially by user requirements and partially by technology developments not currently available to users. The magnitude of the effort is driven by factors such as the volume of spatial and statistical data, internal and external user requirements (including their expectations), availability of improved technology, and potential future technology developments. This latter factor requires that DADS be an open system architecture. As new capabilities emerge, decisions will be made as to their appropriate use within the DADS.

The DADS development process

With each day comes new possibilities for technology development. In the early days of DADS development, the DADS technical staff designed and programmed the first prototype (P1) based on overall system requirements. Realizing that only a limited amount of functionality could be accomplished, the technical staff concentrated on testing the speed with which multiple data sets could be accessed and queried by approximately 100 users. The size of the database. which included adequate space for indexes and processing, approximated 300 gigabytes. The data were organized geographically by name and/or associated geocode, with a limited capability to query by geography, however, there was no geographic browser of spatial data. No maps were included in P1.

Early in the process, the technical team was overwhelmed by new developments in areas such as web technology and improvements in server/system architecture. Commitments to a working process were being questioned before their implementation due to new technological developments within the industry. In addition, these new alternatives required expertise not currently available to the Census Bureau staff. Training was possible, but time was limited given the ambitious schedules for subsequent versions of DADS.

A decision was made to procure the services of a systems integrator. In this way, the Census Bureau could benefit from hardware and software resources outside of the Census Bureau while ensuring that internal and external user requirements were met. In addition, with an open architecture, new technology developments could replace or add to existing capabilities through the life cycle of DADS.

An iterative development process

Prototype 1, delivered in the fall of 1996, demonstrated a proof of concept for accessing large amounts of data via a web-based interface. The second iteration, Prototype 2 (P2), scheduled for the fall of 1997, will expand functionality, provide access to additional datasets, support a new annual American Community Survey for data dissemination, and implement a redesigned system architecture. Prototype 3, scheduled for delivery in the fall of 1998, will support the full set of requirements for the United States Census 2000 Dress Rehearsal and support the 1997 Economic Census. The final DADS production system, scheduled for delivery in the spring of 2000, will support the access and dissemination requirements of Census 2000. Beyond 2000, DADS maintenance will be required to keep pace with increasing amounts of data availability as well as technology advances.

As the process evolves, new requirements will be identified and existing requirements altered based on factors such as user reaction, changing technology, and experience. P2 will expand functionality in several areas. An initial operating capability for supporting tabulation and publication processing will be included. The geography component will be expanded to include a spatial database (TIGER data), an improved browsing capability with spatial visualization capabilities, and a mapping component. A metadata model will be included that will support the DADS architecture. Lastly, more users will participate in the testing process in which their reactions will serve to improve system functionality in areas such as the user interface.

Development of P2 includes tasks that correspond to the functional and architectural components. Working groups were formed to address task deliverables. Requirements analysis was divided among the following working groups: tabulation and publication; geography; search, query, and output; predefined products; user interface and common functions; technical architecture; and metadata.

P2 requirements analysis also identified areas that would not be included for implementation in this version. In the area of geography, choropleth mapping functions will exist but a fully functional thematic mapping capability will not be provided as well as reference mapping capabilities. In addition, geographic changes over time and the joining of data from different data sets over existing geography will not be supported in 1997. Under search, query and output functions, geographic queries against feature-based datasets will not be supported for P2. Within the metadata requirements, generation of output formats such as those required by the Federal Geographic Data Committee will not be supported. There are several other functions that have been scoped out of the P2 development process.

This exclusion approach is based on identifying functions that had a higher priority and had a higher success potential for development. By listing functions taken out of scope, it allows developers to clearly concentrate on the tasks with the highest priority for P2. Ultimately, the plan is to include these functions in subsequent versions of DADS, either as part of Prototype 3 or the final DADS production system.

CUSTOMER TYPOLOGY

In the earliest phases of DADS, census staff met internally to identify how to acquire requirements to begin the process. Two core groups were identified: internal census staff users, and external users. Without question, the number of external users far exceeds its counterpart. One consensus also emerged from this exercise. Participants agreed that Census Bureau staff should not determine the requirements for the external users.

Acquiring requirements from external users

In response, the Census Bureau coordinated day long working sessions with eight different focus groups. Census staff designed questions to stimulate discussion and acted only as observers during the exercise. An external facilitator guided the group through the process. The only rule was that consensus among the participants was not required or expected.

Approximately ten individuals from each focus group were invited to express their views about requirements for an electronic delivery system for census data. The focus groups included census data partners such as: the State Data Centers and Census Information Centers; federal agencies and the Congress; State, local and

Tribal governments; limited access; media; academics and researchers; libraries; and business. Within these focus groups there was diverse representation including the size and nature of organizations and groups as well as geographic distribution. For example, within the library focus group, the range of participants included representatives from a small community library and university libraries, as well as a representative on electronic data from the Government Printing Office, a supplier of library data.

The experiences gained from this exercise helped formulate a customer typology which will be used to determine the kinds and levels of access required from users. This will impact the type and amount of data in different categories as well as the functional tools required to meet the customers needs. One customer type that became evident through each phase of the process was that of the single individual.

Acquiring requirements from internal customers

The second core group of users, internal Census Bureau staff, have very diverse requirements. They include most of the requirements of external users in addition to others such as the requirement to access the lowest levels of collected data to calculate functions such as estimations of population. Under DADS, internal census users also will have a single system to access data sets produced by the Census Bureau, including spatial data.

Minimum functionality

The customer typology also provides insight into the range of functionality that DADS must have. The system must be user friendly. This means that novice users must find it easy to use while the interface and tools meet more experienced user needs. Speed of access is critical as well as system dependability. Oftentimes, the requirements for an electronic DADS are compared to more traditional data support services. Minimally, DADS must be an improvement over its predecessor, the traditional data product process.

WHERE HAVE THE PRINTED REPORTS GONE?

One of the goals of DADS is to remove the constraints imposed by offering printed reports. Undoubtedly, there are many benefits to printed reports. A distinction is necessary between "printed" and "paper copy." Printed implies pages usually of bound text, tables, charts and graphs and maps that are made possible by creation of negatives and printing plates that go through the traditional printing process. For copies beyond a specified number, this remains the most economical alternative.

There are disadvantages associated with printed reports. Flexibility is one disadvantage. The content and design of printed reports is imposed on the user. This form of media is time consuming to prepare and is inflexible in design. Decisions about what to include and how the information is presented must be determined prior to publication. The amount of data is physically limited by the amount of pages that are authorized for printing. Much more data exists than is offered in printed reports. A good comparison is the annual Statistical Abstract of the U.S. There is a printed version and a CD-ROM version in which the latter includes many more data items.

Cost is a significant factor. Decisions about the number of copies affects the cost of production. Underestimating results in delays and in the worst case, not meeting the needs of consumers if reprints are not authorized. Overestimating results in a different kind of cost, that of transportation and storage.

Paper copy refers to an extract from an electronic environment where users control what is sent to an output device such as a laser printer or ink jet plotter. Sometimes these documents have a fixed design, such as an Adobe .pdf file format, and other times users design their own output environment, from dimension of the output image/material to the format of the file sent to the output device.

Is there a need for bound hard copy reports for users to page through in their endeavors? Without question, the answer is yes as we have not moved so far in this technological world as to have at every turn immediate electronic access. Books are too convenient and they serve so many useful purposes which will not be addressed here.

Where will hard copy documents be available and who will produce them? As mentioned previously, some users will assume this responsibility for themselves. Other users will require this service which will create new opportunities for the Census Bureau and its partners. Specific plans will unfold as the DADS process evolves. Options include offering selected electronic documents that are designed for hardcopy output such as .pdf files. Partners will have opportunities to customize reports for targeted clients based on increased availability of data and tools to manipulate and extract the data.

MAPS AND MAPPING

DADS will provide map products as well as tools to create maps. Decisions concerning availability of maps and map files is partially determined by user requirements. As data is referenced by geography, the need to display the boundaries and their identifiers (usually geographic name) is a basic user requirement. How this function is offered in DADS varies based on the type of map. Maps that show the bounds, and in some cases the features that comprise those boundaries, will continue to be offered. Mapping tools will exist to allow users the option to design and produce their own maps based on unique requirements. The level of mapping complexity is dependent upon the sophistication of the mapping tool kit.

A selection of map types will be available by on-line ordering functions within DADS, in the same way other predefined products will be available. Maps traditionally made available such as monochrome plotted feature maps, will be available with several options. For example, plotted multi-colored maps will continue to be offered through on-line ordering services. Users who want the map files to plot in their own workspace will have that option available. Map files will be available in more than one file format.

Cartographic implications in electronic environments

The transition to an all-electronic environment poses new challenges in cartographic design and production. In a printed world, cartographers have knowledge of and can impose control over the mapmaking environment. In an electronic domain where users access predefined digital maps and/or create their own cartographic products through tools provided by DADS, developer knowledge and control of users' technical resources does not exist. As maps ultimately are designed for the final output device, whether it is a printing press in a conventional setting, or a PC monitor in a digital world, a technical challenge emerges where the cartographer attempts to maintain a consistent result across mapping platforms.

While improvements in technology have significantly increased mapping and GIS capabilities, electronic mapping is unintentionally complicating very basic map design and production decisions. Characteristics such as file format, resolution (source file, map file, screen image, output device specifications), map design with color or black and white, output media, and firmware limitations are examples of technical ingredients requiring consideration in a multi-purpose electronic system in which each characteristic has consequences when designing and producing cartographic products.

Planning and implementing an electronic mapping system is one challenge in which the hardware, software and the work environment are known. Disseminating products and functional capabilities for making maps to a user base that has the full range of computer technology is quite a different challenge. Both environments require solutions for technical obstacles. The ultimate goal is to satisfy user requirements and expectations.

CONCLUSION

The U.S. Census Bureau is responding to user and technology requirements by designing and developing the Data Access and Dissemination System. Increasing amounts of statistical and spatial data become available with time. DADS will provide a mechanism for accessing and dissemination that information using several tools including geographic and cartographic functions. The availability of DADS shows potential as a national resource for similar developments for other statistical and spatial databases. From a cartographic perspective, as users gain access to increasing amounts of data, the tools and methods required to map, display, and output cartographic products must keep pace with user requirements and changing technology.

"REAL FAR..., TWO SQUARES..., TWO WEST..., 10° LATITUDE 31.5° LONGITUDE "-- AN ANALYSIS OF KINDERGARTEN TO GRADE 11 STUDENTS' RESPONSES TO QUESTIONS DESIGNED TO EXPLORE THEIR UNDERSTANDING OF, AND COMPETENCY IN, SOME BASIC MAPPING CONCEPTS

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Abstract

This paper presents part of a recent study designed to provide insight into the knowledge of maps and attitudes held towards them by Quebec students five to 17 years of age. To place the study in context, a brief outline of Quebec's instruction pertinent to the introduction of basic mapping skills is presented. This is followed by an overview of the study's methodology. The students' responses to questions designed to test their competence in several basic map skills are then examined. Students were asked questions which involved symbol identification, cardinal directions, co-ordinate locations (alpha-numeric and geographic), and distance calculation. Arguing on the basis of the current trends in technology, that the students of today will be the map producers and map users in the next millennium, the paper concludes with a discussion of some of the implications of the findings for maps and mapping in the information society.

Introduction

Today, in many countries, there is an increasing awareness of the need to examine aspects of graphic literacy at the elementary and high school levels. However, prior to making any informed decisions on how 'graphicacy,' and specifically 'map literacy' can be improved for these students, we need to have a better insight of students' knowledge of, and attitudes towards maps. This paper presents some of the preliminary findings from just such an exploratory map study that was undertaken in 1995 with over 650 Quebec students between the ages of five and 17 years of age.

To put the exploratory study in context, the paper gives a brief summary of the major contents of Quebec's educational programs pertinent to the introduction of basic map skills. This is followed by an overview of the study's methodology, and the presentation of the responses to several of the survey's questions. In the paper's conclusions there is a

discussion of some of the possible implications of this work for cartographers as we approach the 21st century.

Mapping in the Quebec School Curriculum

Unlike countries with a national curriculum, e.g., the United Kingdom, in Canada, education is seen as the responsibility of each province or territory. In Quebec reference to maps and mapping are primarily associated with the domains of Social Studies and Geography. As a consequence many documents related to the definitions of the social studies and geographical domains, their learning objectives and curriculum guides have been produced by Québec's, Ministère l'Éducation (M.E.Q.) (M.E.Q., 1993, 1990, 1985).

In Quebec, Kindergarten is optional. Compulsory education starts with the elementary level which begins at the age of six when students enter Grade 1. The students' exposure to maps is primarily associated with the domain of Social Studies at this stage of their education. This is perceived as both an opportunity and a means of developing the skills and concepts students require for a basic understanding of the world in which they live. In the Grades 1 to 3, maps are viewed as materials, the technical use of which will assist in developing the students' awareness of the concepts of time and space. The curriculum guides suggest that, by the time a student enters Grade 4, they should be able to: decode the conventional symbols used on the available plans and maps of their environment, locate the four cardinal directions (north, south, east, west) on a map or plan, and compare relative distances (e.g., using the naked eye, or strip of paper etc.) and describe these as for example, "as far as," "nearer than" etc.. In Grades 4 through 6, students study the general geography and history of their home region, Quebec and Canada. By the time they complete Grade 6, the curriculum guides suggest that the students should be able to: read a map legend, give the locations of a place on a map as one of the cardinal and intermediate points and be able to read and use the graphic scale on a map. In the elementary curriculum, the nature and use of co-ordinate systems are introduced in the mathematics curriculum. In Grade 2, the introduction of chess acquaints students with alpha-numeric co-ordinates. Exercises presented in Grade 4 require students to work with small scale world maps to provide locations in terms of degrees of latitude and longitude. In Grade 6, students work with polar co-coordinates. The contents of the science curriculum also plays a role in introducing skills pertinent to maps and mapping, such as: graphing of observations, drawing objects to scale and producing models.

At the high school level (Grades 7 - 11, that is between 12 to 17 years of age), mapping activities are primarily associated with specific geography modules (M.E.Q., 1985). Compulsory geography modules are taught in two grade levels: Grade 7 (12 -13 years) and Grade 9 (14 -15 years). The greatest emphasis on maps and mapping skills is found in Grade 7. One of the Grade 7 modules is designed to teach students how to use latitude and longitude to locate features on a globe, world map and an atlas. Another module, concerned with topographic maps, road maps and city plans, contains a series of units, one of which is titled "the use of the principle components of maps." In this unit students learn about: symbols (legend); scales (graphic and numeric); co-coordinates (geographic with degrees and minutes, grids -- alpha-numeric, and the Universal Transverse Mercator) and relief representation.

In Grade 9, students engage in an in depth study of the physical and human geography of Quebec and Canada. Maps are used as one of the tools. In Grades 10 or 11, there is also the possibility of taking an optional module which is designed to explain the impact of human intervention on the organization of the planet's surface and the exploitation of its resources.

Methodology of the Exploratory Study

On first examination, the 'mapping components' in Quebec's curriculum guides appear impressive. But what happens in reality? Many of the students in my first year university introductory cartography course have difficulty working with basic mapping concepts such as scale. The majority also appear to be unfamiliar with topographic maps.

Recently, I conducted a study which was designed to provide insight into the knowledge of maps and attitudes towards them held by current Quebec students. In the winter (November through December) of 1995, over 650 students between the ages of 5 and 17, from four urban Montreal schools, participated in the survey. All the children were presented with nearly identical questions and material, in English or French as the teacher preferred. For the younger children, Kindergarten through Grade 3, the survey was presented orally, generally by one of their teachers. For Grades 4 through 6, the survey was presented to each child in a printed booklet and the questions read aloud. Each student provided written responses. The high school students (Grades 7-11) each completed an individual written survey. In this paper, I shall examine aspects of the students' replies to several map skills questions designed to look at performance and competency in symbol identification, use of directions, familiarity with co-ordinates (alpha-numeric and geographic) and distance measurement. In theory, according to the curriculum guides, by the time students enter Grade 8 they should have the knowledge and skills to successfully answer the survey's map skills questions. These questions appear below the simple black and white test map graphic in Figure 1. The Kindergarten and elementary students were asked five questions (Figure 1., questions 1, 2, 3, 4 and 5). Three more complex questions (Figure 1., 2b, 3b, and 4b) were added for the High School students.

It should also be noted that for each question, in addition to giving a "correct," "incorrect," or "no response (missing)" options, students were also provided with a "do not understand the question" (DNU) option. This choice allowed students who had difficulty with a question to indicate what word or words they did not understand. For students in Kindergarten through Grades 3, the question was read and students asked if there were any words they did not understand. In Grades 4 through 11 students were encourages to mark the DNU option provided for each of the map skills question and to circle the word or words they did not comprehend.

Responses to the Map Skills Questions

The percent correct responses to each of the questions found in Figure 1., appear in Table 1. Because of the nature of the responses to question 5, the elements of latitude and longitude are treated as separate components. A quick inspection reveals that while some questions were easy for many of the respondents, others proved to be difficult, even for Grade 11 students. The responses are examined under the four categories of symbol identification, cardinal directions, co-ordinate locations and distance calculation.

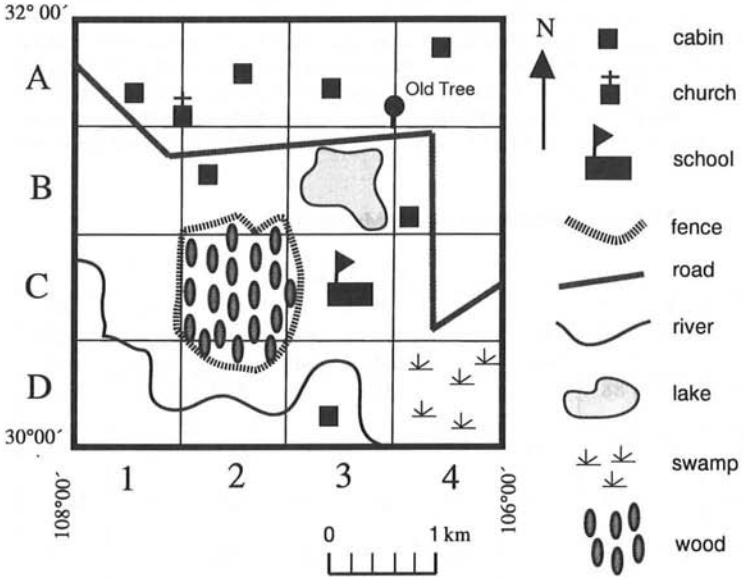
Symbol identification

The symbol identification task, "Put an X on the lake on the map" was successfully performed by students in all grades (Table 1., question 1). Kindergarten through Grade 3 students successfully pointed to the lake on the map shown to them on an overhead. However, there were a number of students in Grades 4, 7, 8, 9, 10 and 11 who failed to supply a response.

Cardinal directions,

Two questions concerning cardinal directions were asked. All students were requested to identify the feature located immediately to the **south** of the school (Table 1., question 4) and Grades 7 through 11 students were also asked, "What is located to the **south-east** of the school? (Table 1., question 4b). Correct responses to the question which asked all students to identify the map feature immediately to the south of the school are, in general, low. Although

Figure 1: Survey Test Map and Map Skill Questions.



Original dimensions of graphic box were 3.25 inches by 3.25 inches.

Questions (Answers appear in bold in brackets)

1. Put an X on the lake on the map.

2. What is shown in C2 ?_____ (**wood**)

2b.* Give the grid location for the lake_____ (**3B, B3**)

3. How far is the Old Tree from the church?_____(**2 Kilometres**)

3b.* What is the distance (to the nearest 100m) between the church and the school? _____km (**1.7 km to 2.3 km**)

4. What feature is located immediately to the south of the school?_____ (**river**)

4b.* What is located to the south-east of the school?_____ (**swamp and or road**)

5. What is the latitude and longitude position of the church?
_____latitude _____longitude
(**latitude 31° 30' or 31.5°**) (**longitude107° 30' or 107.5°**)

*Kindergarten and Elementary students (Grades 1 through Grades 6) were asked to respond to Questions 1, 2 3, 4 and 5. The three additional questions 2b, 3b and 4b were incorporated in the survey presented to the High School students in Grades 7 through 11.

willing to attempt the question, students in Kindergarten through Grade 2 provided answers that bore no relation to the question posed. Grade 3 responses of "cabin" indicated that they understood the question but had difficulty with the identification of the map's symbol. The mistake of "not seeing" the river as a map feature accounted for a large number of the error responses in all the grades. However, some students confused south with north (all grades), east (Grades 4, and 6-10) and west (Grades 4-6, and 8-9). There were students in Grades 7 and 8 who "did not understand the question." It is interesting to note that the percent correct responses for Grade 5 students (10 to 11 years of age) was higher than all but the Grade 10 students.

Table 1: Percent Correct Responses to the Map Skill Questions.

	Question								
Grade	1 lake	2 C2	3 dis-tance	4 south	5 lati-tude	5 longi-tude	2b grid	3b dis-tance	4b south-east
4 (9-10) [71]	97	88	23	32	0	0	N/A	N/A	N/A
5 (10-11) [51]	100	96	36	65	0	0	N/A	N/A	N/A
6 (11-12) [46]	98	98	59	36	0	0	N/A	N/A	N/A
7 (12-13) [85]	100	94	66	56	22	22	94	27	81
8 (13-14) [53]	100	96	63	42	9	9	96	44	82
9 (14-15) [72]	100	98	73	63	12	12	98	23	80
10 (15-16) [71]	100	97	65	76	6	6	100	37	87
11 (16-17) [59]	96	93	57	64	12	12	100	37	89

( ) Age of students in year [ ] Total number of students
N/A Question not asked

Note: Missing values and students responses which indicated that they did not understand the question were omitted in the calculations.

The high school students' percent correct response to the intermediate cardinal direction were in the 80's (Table 1., question 4b). Incorrect responses suggested that students did not identify that it was an intermediate direction they were being asked to work with as they identified features that were to the south and east of the school. Several students confused 'south east' with 'west' as their response was "wood." There were also students in Grades 7, 8 and 11 whose response was "DNU."

Co-ordinate locations

Questions relating to the alpha-numeric and geographic co-ordinate systems were asked of all students. "What is shown in C2?"(Table 1., question 2) was successfully answered by students from Grade 2 upwards. The responses to the question which asked

Grade 7 through 11 students to, "Give the grid location for the lake"(Table 1., question 2b) were also very high. In the Grades 8-10 this may in part have been due to "class assistance" as some students shared their results with their neighbours. In sharp contrast are the very low percent correct scores for identifying the components of latitude and longitude (Table 1, question 5). In theory, students had been introduced to the measurement of latitude and longitude in degrees by Grade 5. No correct latitude or longitudinal coordinates were given by any of the upper elementary students. In Grades 4 and 5, the students generally indicated that they did not understand both of the words 'latitude' and 'longitude.' The Grade 6 students attempted numeric figures. However, what constituted latitude (31° 30' or 31.5°) was confused with longitude (31° 30' or 31.5°) and where an attempt was made to indicate half a degree it was generally written as 50 minutes (based on the assumption that there were 100 minutes in a degree). Similar error responses were found in all the High School grades, The best performance (22 percent correct response) was given by students in Grade 7 -- the grade in which there is a module specifically concerned with co-ordinate systems. This percent correct dropped sharply to 9 percent in Grade 8 and fluctuated between 6 and 12 percent in the remaining grades. The latitude and longitudinal components were treated separately as giving latitudinal responses appeared to be easier than giving longitude (students confused east and west giving, for example, 108.5°). Very few students managed to get both the components correct. The students poor performance in this survey is much worse than reported in a recently published study. In June 1994 as part of a General Geography exam for Quebec Grade 7, 1053 francophone students were asked a four option multiple choice question which required them to select on a world map a pair of cities with particular latitude and longitude positions (given in degrees) (M.E.Q., 1995). Correct responses were given by 80.8 percent of the students. The discrepancies may be due to the fact my survey dealt with large scale material, dictated finer division and was open in structure -- which required the students to provide the answer.

Distance

Distance calculations were required in two of the survey's questions. All students were asked, "How far is the Old Tree from the church?" (Table 1., question 3) and, for the elementary students, these two points were identified to ensure that they could locate the map features correctly. Responses were given by students in every grade. In Kindergarten the responses were "a bit far" and "very far." In Grade 1, although similar responses to those of Kindergarten were given, there was also the notion of an actual distance in answers such as "two squares' and "two miles." Actual measurement of the map distance was undertaken by the students in Grades 2 and 3 which resulted in measurement expressed in inches or centimeters. The percent correct response was low in Grades 4 and 5 with many students expressing distance in term of "squares" (e.g., two squares, two squares east) or in measurements in centimeters as well as the verbal responses characteristic of Kindergarten students. In Grade 6, although there were still responses such as "two west" the percent correct improved. This was primarily due to the realization of students that their centimeter measurements could be linked directly to the map's graphic line scale. The percent correct score, with the exception of Grade 8, improved until Grade 9 and then declined, with Grade 11 students having a percent correct score below that of the Grade 6 students with a similar range of errors exhibited by the Grade 5 students.

The second question involving distance measurement asked of the Grade 7-11 students "What is the distance (to the nearest 100 m) between the church and the school _____km?"(Table 1., question 3b) posed many problems. A range of measurements was possible as it all depended upon the student's selected starting and finishing point (e.g., bottom of the church to the top of the flag of the school). Despite the range of values accepted (from 1.7 km to 2.3 km), in each grade there was a lower percent correct score for this measurement task than the previous calculation question. In the lower grades a large number of students indicated that they did not understand the whole question or particular

words (e.g., nearest 100 m) or failed to provide any response. The majority of answers given were numeric but demonstrated that students had difficulty working in kilometers and meter's. Some responses were presumably all in meters e.g., 2800, 1500 while others were given in kilometers but the distances were incorrect e.g., 4 .5 km. In all grades, many students underestimated the distance with their response of "1.5 km." The best results came from Grade 8 (44 percent correct), which is the grade following that which contains the modules emphasizing maps and mapping skills.

Table 2: Percent Total Map Skills Score.

	Total Map Skill Score									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Grade										
4*	-	19.7	47.9	22.5	9.9	-	-	N/A	N/A	N/A
5*	-	7.8	21.6	43.1	27.5	-	-	N/A	N/A	N/A
6*	-	2.2	32.6	43.5	21.7	-	-	N/A	N/A	N/A
7	1.2	4.7	3.5	10.6	12.9	21.2	23.5	15.3	7.1	-
8	-	1.9	3.8	13.2	20.8	18.9	22.6	17.0	1.9	-
9	1.4	-	-	6.9	8.3	31.9	25.0	25.0	1.4	-
10	-	-	1.4	4.2	18.3	21.1	26.8	26.8	1.4	-
11	-	-	1.7	6.8	30.5	22.0	23.7	10.2	3.4	1.7

N/A Question not asked
For Grades 4 , 5 and 6 the maximum total score possible is 6.

As previously mentioned, in theory, students by the time they enter Grade 8 should have the knowledge to enable them to correctly answer each of the nine skills questions given in Figure 1. We can now ask "What happens in reality?" Table 2 summarizes the percent total skills performance of students, by grade. For the elementary grades, the highest score which could be obtained was six, but because of their problems with 'latitude and longitude' the highest score was four, The best performance (27.5 percent of students with four questions correct) was associated with Grade 5. This is the grade after which mapping skills are introduced. In the following Grade there was a 5 percent decline in percentage correct scores. At the High School level the range of scores is considerable as a student in each of Grades 7 and 9 received a score of zero. In all grades a large percentage of students had a maximum score of 4 (Grade 9 [17%], Grade 10 [24%], Grade 7 [33%], Grade 11 [39%] and Grade 8 [49%]). Few students had high scores and only one Grade 11 student got each of the nine elements.

One of the other questions posed on the survey was "How do you feel about maps?"(Anderson, 1996). It was approached by the use of "the five faces" representing how children might feel about maps (hate, dislike, ok, like, love). In the early grades, prior to much formal map instruction (Kindergarten through Grade 3), the majority of young children appeared to love maps. But, students' love of maps starts to change in Grade 3, and by Grade 5 the majority of students ranked maps as only "ok." In the grades where there is some concentration of work involving maps, Grades 4, 7 and 9, a high proportion of the students identified that they liked maps. However, in the subsequent grades, particularly Grade 8, a marked decline in this percentage was evident. An analysis of how students felt about maps and their actual map skills performance is beyond the scope of this paper -- but an interesting next step.

Conclusion

For a variety of reasons, it may be argued that the results of the survey are not a true reflection of the knowledge of map skills held by Quebec's current school population. Some of you may consider the test map rather simple, the number of skills questions asked too few, and the student sample small and limited in scope since it was conducted in only four Montreal urban schools, These arguments notwithstanding, I believe that the findings of the study do have implications for cartographers, and for the role of maps and mapping in the information society.

I submit that many cartographers make the tacit assumption that the users of their products are generally 'graphically literate' and possess the fundamental concepts and skills required to handle graphic information in hard copy and/or digital form. In a similar vein, I believe that educators consider that the future generation of desktop map users and map producers are currently acquiring the necessary skills to handle and work with information in map form. However, the results of the Kindergarten to Grade 11 survey suggest that although basic skills pertinent to maps are in the curriculum their comprehension and retention leave a lot to be desired. For the majority of the tasks, the performance of the upper high school grades was worse than that of the lower high school students. With the exception of the latitude and longitude task, the performance of upper level elementary students was generally similar to that of the Grades 10 and 11 students. Are the findings of this study an anomaly or do they represent a general trend? Before this question can be answered, cartographers will need to become more concerned with cartographic education in the schools. In addition we need to conduct more comparative studies in order to assess progress in this regard.

In the information society, the process of mapping ever-expanding amounts of data and the increasing generation of digital and hard copy map products seems inevitable. To better understand the mapping process and the use of its products, it is imperative that both the creators and users of the products possess a competency in basic map skills. Surely this cannot be achieved without cartographers becoming actively involved in all levels and aspects of cartographic education?

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THE INTERACTION OF MULTIMEDIA MAPS

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Abstract

One of the important research topics in cartographic visualization is interaction that means how to build a cooperation between user and computer so that user can read what he wants freely. Interaction is more important in multimedia maps because there are large amounts and many sorts of information in multimedia maps.
A research and application about interaction in multimedia maps is reported in this paper.
According to the way of human thinking and relationship among information the four types of information interactive display: series way, parallel way, roam and navigation are summarized. Different displaying types can be controlled with handling icon, menu, hotspot, hotaera, keyword etc. by user. In order to reflect the interaction in multimedia maps hypermedia is the best way to organize all kinds of information at present. As the result of this research, some interactive multimedia maps on islands resources of China are designed.

1 Introduction

In recent years, ViSC(Visualization in Scientific Computing) is attracting more and more attention of scientists. ViSC is not only analog computing and graphs displaying but also a complex process to covert large amounts of unordered data into information which could be cognized by human brain. So how to reflect any useful information contained in these data in a easy way to be accepted and cognized by users, is an important content in ViSC research[1].

Actually, "maps have served as visualization tools in science at least since the advent of thematic mapping during the middle of the last century"[2]. But with the development of modern computer technology, the electronic map developed gradually, and it can not only use the traditional concept to electronic ones. The development of ViSC theory puts forward a new topic of map research, that's how to design maps which are easy to be accepted and cognized by users and how to build a cooperation between user and computer so that the visual communication and visual thinking are in the best way.

The development of multimedia and hypermedia technology makes it possible that many cartographic variables can be used in maps to show the information, and creates a new area for interaction between user and computer.

A study on interactive displaying, controlling and organizing information in multimedia maps is reported in this article.

2 The interactive display in multimedia maps

Information interactive display in multimedia maps is that user can choose the information actively by some interactive controls.

According to the relationship among information and the way of human thinking, the four types of interactive display in multimedia maps are summarized.

· Series way It's the way of displaying information which is in different grades. In this way information is showed one by one according to its level. Fig.1 illustrates a display of different information that belongs to the different grades in district or scale in series way.

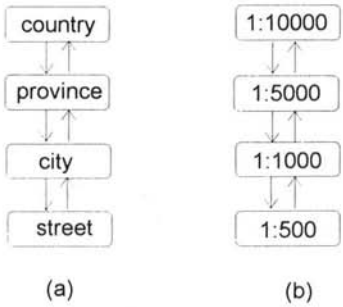

Fig.1 A display of different information that belongs to different grades in district (a) or scale(b) in series way.

· Parallel way It's the way of displaying information which is in parallel state. In this way the different information display can be changed one to another freely. For instance: population distribution map, statistical diagram, text, and animation of population growing up all of them can be used to express the theme of population of city. These different media information can be displayed at the same time or changed one to another freely (Fig.2).

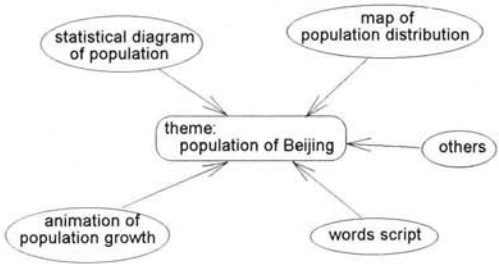

Fig.2 Different media information about the theme of population can be displayed in parallel way.

· Roam It's the way of displaying information which belongs to the same class (same media, same theme and same district) and is neighbored in space and time. For instance: user can read different area in the map which was enlarged through roam.

· Navigation It's the way of displaying the whole frame of all maps through building some navigation maps. In the navigation map, there is a label to indicate the position of the present map, so user is not only easy to know where he is but also easy to find the map what he wants.

These four interactive displaying ways are not isolated. They can be used together and repeatedly.

3 The interactive control in multimedia maps

The interactive display in multimedia maps can be realized through user's controlling the icon, menu, button. hotspot, hotarea, keyboard etc. , For an example, push a button or click a hotspot with mouse or input keywords through keyboard.

Suitable control for different display types should be chosen by designers, and, meanwhile the consistency, easy to understand and operate should be followed. Here the consistency means that the same control way should be chosen for the same display type in all maps.

4 The organized structure of information in multimedia maps

Hypermedia is a good way to organize all kinds of information. In this way the information in multimedia maps can be extracted fast and freely.

Every kind of information, e.g., a map, a paragraph text, a photo etc. or their combination, may be a node of hypermedia. All kinds of information displaying interactively are connected to be a non-lineal net through many kinds of chains of hypermedia. For instance: several media information about the same theme displayed in parallel way can be linked to a local net as Fig.3.

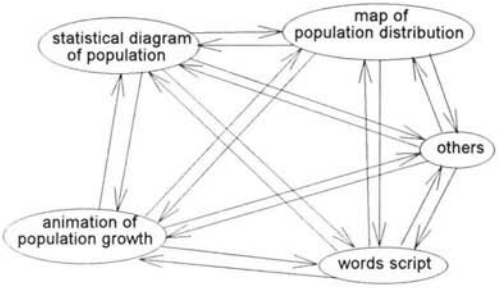

Fig.3 Some media information about population are linked to a local net.

Multimedia maps based on hypermedia are of the ability to show the information in multiview and multilevel. They not only supply a knowledge and information themselves but also contain their analysis and reasoning.

5 Application

Some multimedia maps are designed and compiled by author with material chosen from "The Islands Resources CD-ROM Atlas of China" which is being under the research and development. In this application PC 486 with 16Mb RAM, 2Gb harddisk and sound card Soundblaster are used, and authoring software Macro Media Director 4.0 and others like CorlDRAW 5.0 are chosen.

The structure of these maps is illustrated in Fig.4.

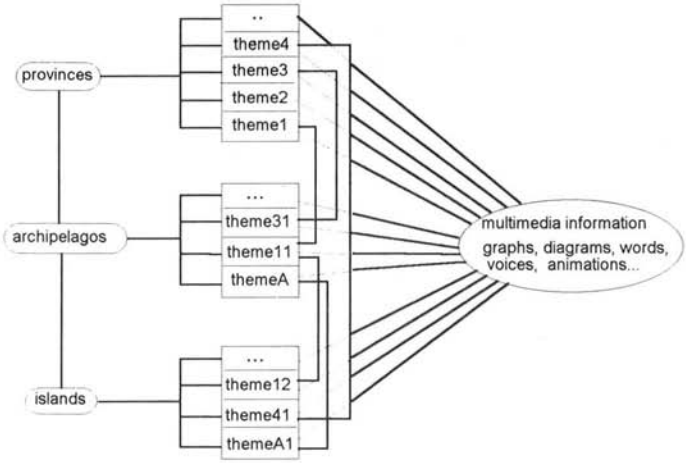

Fig.4 The structure of application maps

The process that the maps are made is illustrated in Fig.5.

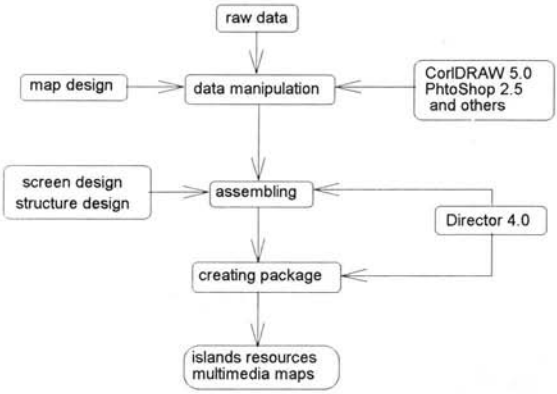

Fig.5 The process of islands resources multimedia maps making

Fig.6 is an example of interactive display of different media information about land use of SHICHENG island. Here with some icons controlled the land use map, a diagram and 3D mold overlaid by land use map and DEM can be displayed in parallel way.

6 Conclusion

One of the important research topics in cartographic visualization is interaction, that means how to build a cooperation between user and computer, so that user can extract what he wants freely. Interaction is more important in multimedia maps because there are large amounts and many sorts of information in multimedia maps.

According to the way of human thinking and relationship among information the four kinds of information interactive display types are summarized. Different display types can be controlled through handling icon, hotspot, hotaera, keywords etc. by user. In order to reflect the interaction in multimedia maps the hypermedia is the best way to organize all kinds of information at present.

Fig. 6 An example of interactive displaying land use information about SHICHENG island

Acknowledgments

The study and application reported in this paper are a part of contents of author's Master degree thesis which is directed by prof.Chu Liangcai and prof.Yao Xurong. Prof.Chu read an earlier version of this paper and gave some good advices. My gratitude is going to Pro. Chu and Pro. Yao. Thanks also due to Prof. Liao Ke who wrote a support letter for this paper.

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THE DIGITAL GEOGRAPHIC INFORMATION EXCHANGE STANDARD AND MILITARY MAPPING

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ABSTRACT

The Digital Geographic Information Working Group (DGIWG) has developed the Digital Geographic Information Exchange Standard (DIGEST) to support the exchange of geospatial data among producers and users. DIGEST enables interoperability and compatibility among national and multi-national systems and users. This paper describes the evolution and components of DIGEST, and its implementation in producing and exploiting DIGEST-compliant datasets/products. The paper also highlights the effort to harmonize DIGEST with other standards.

Today's military forces are required to fulfill a broad range of missions ranging from joint air, land, and sea combat within a coalition force, to humanitarian missions. Military organizations must be able to respond to rapidly changing situations anywhere in the world in a timely manner in spite of shrinking resources. Consequently, the focus on the deliberate production of earth-referenced information (geospatial information) has to shift to timely crisis response.

Accurate and timely earth-referenced information is mandatory to meet the mission requirements and information needs of modern military systems. As an example, the nerve center of any military organization, the Command and Control Information System, is composed of extensive time-tagged geospatial information. When implemented properly, technology offers increased opportunities and decreased levels of uncertainty in decision making.

On its own, no individual nation can afford to map the entire 149 000 000 Square Nautical Miles of the Earth. Cooperation in data production among nations allows for rapid and more extensive coverage. The required data volume and complexity dictate that multi-national agreements for geospatial data standards be established to assure compatibility and support interoperability.

INTRODUCTION

Digital Geographic Information (DGI) has evolved into an essential element in the planning and conduct of civil and military operations. The required data volume, demands and data complexity dictate that multi-national agreements for digital data standards be established to assure compatibility. In support of this aim these standards define those aspects necessary for the exchange of DGI, including: the data structures, format, feature and attribute coding scheme, exchange media, and administrative procedures. DIGEST is a comprehensive suite of standards intended to support the exchange of DGI among both producers and users. DIGEST-compliant datasets are being produced by several nations and exchanged to support a variety of military and civilian applications. Industry continues to develop and promote commercial software based on compliance with DIGEST.

BACKGROUND

The Digital Geographic Information Working Group (DGIWG) was established in 1983 to develop standards to support the exchange of DGI among NATO nations. Membership includes: Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, the UK, and the US, and four (4) observers: Australia, Portugal, Greece, and New Zealand. The DGIWG is not an official NATO body; however, the DGIWG's standardization work has been recognized and welcomed by the NATO Geographic Conference (NGC). DGIWG developed and maintains DIGEST as an exchange standard to facilitate the exchange of DGI to support interoperability within and between nations, and burden sharing of digital data production. The scope of this activity includes dataset specification development and harmonization of standards. The US National Imagery and Mapping Agency (NIMA) Vector Product Format (VPF) is one of several formats/encapsulations supported by DIGEST. Over the last few years DIGEST has become the basis for coproduction opportunities between nations.

DIGEST - AN OVERVIEW

DIGEST supports the exchange of raster, matrix, and vector DGI (and associated text) among producers and users. DIGEST can support the entire range of topological structures from no topology to full topology. Included in the DIGEST family of standards are Annex A based on ISO 8211, Annex B - telecommunication standard based on ISO 8824/5, Annex C - Vector Relational Format (VRF), Annex D - Image Interchange Format, and the Feature and Attribute Coding Catalogue (FACC). FACC is a comprehensive coding scheme for features, their attributes and attribute values. DIGEST has become a NATO standardization agreement (STANAG 7074).

As new technologies have developed, DIGEST has evolved to address these technologies and new geospatial requirements. DIGEST version 2.0 is scheduled to be released in 1997. This next version of DIGEST will support imagery, various compression algorithms, and mixing of data types; align DIGEST Annex C and the NIMA's VPF; ensure consistent Metadata across encapsulations; and logically restructure the document. Compatibility with other evolving standards such as the NATO Secondary Imagery Format (NSIF) and ISO base standards are important considerations in this next version of DIGEST.

Limitations caused by restrictions in computer memory or distribution media capacity require that large geospatial databases be divided into manageable units, or tiles. DIGEST supports tiling using a concept of organizing primitives by geographic units and provides inter-tile topology to maintain geographic features in a logically continuous manner across tile boundaries. To the user, the data appears seamless.

To support direct-use, DIGEST (Annex C) "coverages" group features by topological relationships ranging from no explicit topology to full topological relationships for all primitives. Varying degrees of integration are supported. When a product does not require relationships among data types, data can be stored in separate coverages. When full topology is required features may be combined into a single coverage. Complex features, and groups of features collected together and handled as a single entity, may be modeled. Utilizing these concepts, products may be designed as simple or as complex as necessary facilitating efficient storage and use. Some other features of DIGEST which enhance utility of geographic information are:

Self-Describing Format - In DIGEST (Annex C), each level has header tables that describe the information contained at that level and the level below. Each table has a header describing the table. This allows developers to design utility software which can adapt to any DIGEST(Annex C) database regardless of product design.

On-line Data Dictionary - The data dictionary allows the definition of features and attributes to be carried with the product to avoid misinterpretation by users. Users can employ this capability when adding their own data to the database. They can describe feature and attributes which have been developed solely for their own purposes. These can be defined in the database and passed on for all to use. This allows each coverage to be used by a wide range of users without prior knowledge of a coding system - enhancing interoperability and correct data interpretation.

Data Quality - DIGEST provides the capability to carry data quality information at the library, coverage, and feature Level. This information will help the user perform geographic analysis. It allows users to weigh a product's accuracy, currency, and completeness when performing analysis.

DIGEST DATA

DIGEST has gained credibility world-wide as a standard backed by production. A vast quantity of data compliant with DIGEST has been produced and will continue to be produced for many years. Development of new products continue as requirements and applications expand. Listed below are several examples of DIGEST-compliant products:

Digital Chart of the World (DCW)® - The DCW is a comprehensive 1:1,000,000 scale equivalent resolution basemap of the world. The database is contained on four CD-ROMs. The database contains more than 1,500 megabytes of vector data and is organized in 10 thematic layers. The DCW also includes an index of geographic names to aid in locating areas of interest. The DCW is designed to support geographic information system (GIS) applications. (The DCW is scheduled to be replaced by the VMap level 0 product identified below.)

World Vector Shoreline Plus(WVS+)™ - WVS+ is a product which contains the world's shoreline at an equivalent resolution of 1:250,000. It also contains international boundaries including off-shore territorial boundaries and country names. Also included are representations of the world's shoreline at equivalent resolutions of 1:500,000, 1:1,000,000, 1:3,000,000, and 1:12,000,000.

Digital Nautical Chart(DNC)™ - The DNC product consists of VPF databases comprised of varying resolution libraries over a specified operational area. These libraries contain maritime-significant geographic and navigation information typically found on standard nautical charts. Each library consists of 12 thematic coverages. As an example a DNC may contain a General Library containing 1:1.2 million scale equivalent data; a Coastal Library containing 1:300,000 scale data; an Approach Library containing approximately 1:75,000 scale data; and a Harbor Library containing 1:20,000 scale equivalent information. When used by a navigator on-board ship, varying levels of detail are accessed by switching libraries as needed.

Vector Smart Map (VMap)™ - VMap is a suite of products which contain basic topographic geospatial data at a variety of levels of resolution. All VMap products contain identical thematic coverages; however the attribution may differ depending on the resolution. The coverages include: Boundary, Data Quality, Elevation, Hydrography, Industry, Physiography, Populated Places, Transportation, Utilities, and Vegetation. There are several varieties of VMap:

- VMap Level 0 - is the replacement to the DCW product described above, but in addition includes generalized bathymetry.

- VMap Level 1 - will consist of approximately 234 CD-ROMs covering the world with 1:250,000 scale equivalent information.

- VMap Level 2 - consists of information with a resolution equal to 1:50,000 to 1:100,000 scale data. Individual Level 2 products cover small geographic areas determined by the geographic operational requirements of customers.

- Urban VMap - as the name implies, products cover urban areas. These products provide information at resolutions ranging from 1:5,000 to 1:50,000.

Raster products - ARC Standardized Raster Product (ASRP) and UTM/UPS Standardized Raster Product (USRP) are examples of DIGEST Raster products. All types of raster data are digital replicas of paper maps. ASRP and USRP are 8-bit Extended Color Coded (ECC), 100 micron resolution replicas of maps in which the data has been rectified, placed on a common projection and datum, margin areas removed, and finally merged with adjacent map sheets. The main difference between the two is that ASRP uses the Equal Arc-Second Raster Map/Chart (ARC) projection, while the USRP uses the Universal Transverse Mercator and Universal Polar Stereographic Projections.

Mixing of Data types - Several nations have developed national products that merge DIGEST compliant data types such as imagery/raster and vector data.

® "DCW" is a registered trademark of the National Imagery and Mapping Agency

™ "WVSPLUS," "DNC", and "VMap" are trademarks of the National Imagery and Mapping Agency

GEOSPATIAL DATA EXCHANGE

Concepts of Exchange - Geospatial data exchange is generally governed by a series of agreements among nations. Each nation is responsible for providing data to meet its international commitments and for holding data, both nationally produced and received from other nations. Nations may agree to arrange for the procurement of common hardware and software. However, standards have been developed with the assumption that, in general, nations are using different hardware and software. Standards for data exchange have been agreed to on a multi-national basis among DGIWG nations. The standards must allow for the exchange of both digital geographic products and basic geographic data. DIGEST supports global interoperability by supporting the following exchange relationships:

- Internal Exchange — the exchange within national agencies.
- Inter-agency Exchange — the exchange between map production agencies.
- Provision of Products — the transfer from data producers to their users.
- User Exchange — the exchange of data between user systems.

Coproduction - DIGEST has become the basis for many coproduction opportunities among nations. DIGEST Data is being produced, exchanged, and used by the military and civilian of NATO nations plus several nations outside NATO. The VPF profile of DIGEST forms the foundation of current coproduction agreements. Product specifications describe an implementation of the DIGEST standard. The agreed specifications and capture criteria built on the DIGEST foundation ensures consistent data production among coproducers. DIGEST-compliant products Vector Map (VMap) and Digital Nautical Chart (DNC) are being produced and exchanged by a number of nations. At least Fourteen nations have agreed to produce VMap with the intent of gaining worldwide coverage by the year 2000. Commercial companies in North America and Europe have developed software to import and export DIGEST data into their systems.

RELATION TO OTHER STANDARDS

Through the diligent efforts of the DGIWG, significant work has been accomplished to harmonize DIGEST with other international and national standards. DIGEST is gaining acceptance beyond NATO for civilian as well as for military applications.

Harmonization with the NATO Secondary Imagery Format (NSIF) - Since May of 1995 the DGIWG has been active in harmonizing NSIF with DIGEST. The NSIF standard defines the format and structure for imagery transfer in NATO. As systems merge imagery data with traditional map data, it is imperative that the necessary parameters to ensure correct, consistent, and precise georeferencing are compatible. With this in mind the DGIWG developed the Data Support Extensions Annex to NSIF to ensure compatibility with DIGEST. In addition a new Image Interchange Format consistent with NSIF has been applied to DIGEST as Annex D.

Harmonization with S-57 - Considerable effort has been expended over the last few years to harmonize DIGEST with the International Hydrographic Organization (IHO) S-57 standard. It is desirable that the two standards have a sufficiently high level of

compatibility so that it is possible to generate data in either standard from common surveys or other data sources. Compatibility is also desirable for situations where it is important to merge data sets. A Joint DGIWG-IHO Harmonization Working Group was established in 1995 in order to minimize the differences between the standards and to reduce data translation costs. An Interface Control Document (ICD) was developed to facilitate this harmonization and guide the evolution of DIGEST and S-57. The ICD compares and contrasts critical elements of both standards. Since 1995, significant progress has been made. The data models have been aligned to the point where data can be converted without loss of structure or information. A DGIWG-IHO certified mapping from the S-57 Object Catalogue to FACC is nearing completion.

Relation to ISO - The DGIWG continues to play an active role in the development of International geospatial standards in ISO, in particular in TC 211 - Geographic Information/Geomatics. TC 211 was established in 1995 to develop international geospatial base standards. DGIWG has a "class A" liaison with this organization and many DGIWG members are actively participating in ISO/TC211 activities directly or through their national standardization bodies. Promotion of DIGEST is very much welcomed in this ISO forum. WG 5 (Profiles and Functional Standards) of TC211 identified DIGEST as one of the three existing functional standards. TC 211 recognizes that DIGEST is already accepted by the user community and that there exists a vast amount of information in compliance with the standard. Development of profiles of ISO Standards that equates to DIGEST would herald a flying start for TC 211 standards. DIGEST is recognized as forming the bridge from military to ISO base standards. A DGIWG representative has been nominated to lead the Functional Standards new work item proposal. Other work items of particular interest to DGIWG in TC 211 include Cataloguing, Geodetic Reference Systems, Metadata, and Spatial Subschema.

Relations to National bodies - Over the years progress has been made to harmonize North American (US and Canada) national standards such as Spatial Data Transfer Standard (SDTS) and the Spatial Archive and Interchange Format (SAIF) with DIGEST. Similar harmonization efforts have occurred in Europe and other regions.

SOFTWARE DEVELOPMENT

Applications that use and/or integrate digital geographic data require access to standardized digital geographic data and services. At present, users of digital geographic data experience "data barrier" problems of accessing and integrating digital geographic data into application systems. Standardization of digital geographic services and related interfaces are a means to overcome the digital geographic data barrier. The data barrier affects users in several forms. More common issues related to the barrier include: the wide variety of digital geographic data products, different and incompatible data formats, the use of many different coordinate systems and projections, and geographically dispersed databases operating on heterogeneous computing platforms. Further considerations include the increasing quantity of digital geographic data, and the growing number of organizations collecting and using digital geographic data.

Other data barrier issues are related to the many and expanding uses of digital geographic data. Different organizations use digital geographic data for various applications, such as municipal planning, forestry, mining, environmental, natural resource, and command-and-control. Generally, each application area has specific

requirements (e.g., raster or vector representation, level of detail, projection, datum), and uses different systems to manipulate and store the data. Collectively, these data barrier issues increase the complexity of spatial data while also increasing the need for standardized solutions. Listed below are several software developments/applications which use DIGEST-compliant datasets or products:

DIGEST Software Tools Project - The DIGEST Software Tools, also known as the Open Geospatial Datastore Interface (OGDI), is open and highly flexible. The same object code can be used to access different geographic datastores (geographic information exchange formats or geographic products) without having to recompile using the "plug and play driver" concept. Applications using OGDI can ignore underlying data communication protocols between themselves and the datastore because data values are retrieved in a convenient and uniform transient data structure regardless of the source. Datastores can be accessed locally or remotely using a concept similar to that of the World Wide Web.

OGDI provides tools to solve digital geographic data interoperability problems. It maps digital geographic data formats into a uniform transient data structure, adjusts coordinate systems, cartographic projections and platform-dependent data representations, and retrieves geometric and attribute data -- all "on the fly." In short, OGDI provides a data interoperability solution to access the growing number of digital geographic data products and formats, using the Internet or Intranets as mediums to access/distribute digital geographic data products. Conceptually, the premise of OGDI is analogous to the multiplicity of spoken languages that coexist. If multilingual people can share information with each other without having to translate into their mother tongue, they won't have to learn to write in other languages. Similarly, if standard digital geographic services were able to open and read digital geographic data formats, GIS software vendors would not need to build translators and maintain techniques for the exchange of many diverse data formats. Advantages of this approach are that by allowing a basic level of access and heterogeneity, and reducing the need to update, access to digital geographic data can be simplified and expanded. The basic components of OGDI include:

- a naming scheme for uniform resource locators (URLs) to globally identify digital geographic datastores;
- a library of application program interface (API) client functions that allow applications to connect to any digital geographic datastore defined by a URL, and use queries to select sets of geographic features and retrieve digital geographic data regardless of the original native structure;
- an intelligent driver manager that performs driver loading, memory management, error services, coordinate and projection transformation, and a limited number of geospatial operators;
- a set of OGDI drivers that provide 'on-the-fly' access to native format digital geographic datastores; and
- a new transfer protocol to facilitate the reliable and uniform exchange of digital geographic information over the Internet or Intranet.

More info on the OGDI can be found at **http://www.j2geo.ndhq.dnd.ca**

VPFView Software - VPFView software is designed to access any database implemented in VPF. It allows the display of chosen combinations of features or themes for a user selected geographic area of interest. The software supports the display of VPF databases directly from CD-ROM, hard drive, or diskette without loading or converting the data. Display scale can be changed by zooming in or out. Portions of a database can be copied from removable storage media and saved on a computer's hard disk in VPF. Simple plots can be generated in postscript format.

Defense Mapping Agency MC&G Utility Software Environment (DMAMUSE) - DMAMUSE was developed to provide a sample suite of software exploiting NIMA digital products. DMAMUSE operates in the Windows, Macintosh, and SUN MOTIF/Openlook environments. Full source code is provided to allow users to understand and develop their own versions of access software. DMAMUSE provides routines to access and process a wide variety of DIGEST products. DMAMUSE supports raster importing, vector importing, demonstration/briefing display tools, map fusion (overlaying raster data with vector information), standard NIMA datum transformations and coordinate conversions, line of sight computation and display, and perspective scene generation by fusing raster map data and elevation data. DMAMUSE will extract data from VPF products; spatial extent is defined by entering geographic coordinates for the desired area; thematic selection is performed by allowing the users to define the coverages, libraries, and feature types to be accessed. VPF databases can be filtered by attribute by creating "thematic expressions". More information on DMAMUSE and VPFView can be found at **http://www.nima.mil**

CONCLUSION

Over 400 years ago Gerardus Mercator's dream was to publish a volume of maps, which would provide a history of the world since creation. Called the 'Atlas', the first edition was published in 1569. This important pioneering effort remains with us today. Our interpretation of Mercator's dream in the context of the 20th century is an on-line 'Atlas', a digital geographic data warehouse linked to digital gateways. This electronic 'Atlas' will allow tomorrow's user unlimited flexibility to exploit digital geographic data through the information superhighway. Standards such as DIGEST must continue to evolve to support the challenges of satisfying the requirements of the next generation of users and producers.

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AN INTERACTIVE CARTOGRAPHIC INFORMATION SYSTEM OF AUSTRIA - CONCEPTUAL DESIGN AND REQUIREMENTS FOR VISUALIZATION ON SCREEN

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1. Introduction

In 1994, the Institute of Cartography and Reproduction Techniques, together with five different institutes in Austria, started the project "Space and Society", sponsored by the Austrian Funds for Scientific Research. One part of this project is the production of a printed Atlas of Austria which will be realized at this institute. As in many countries in Europe, like Sweden or Switzerland, an electronic version of this National Atlas in the form of a prototype of an Interactive Cartographic Information System (ICIS) should be developed. The first part of this article outlines some conceptual ideas for this Interactive Cartographic Information System and above all represents the display of geographic and statistic data and a possible User Interface. The second part analyzes some examplary problems of cartographic visualization on screen and offers some opportunities to avoid these problems.

2. Interactive Cartographic Information System

This Interactive Cartographic Information System is an electronic atlas with a database and an extended functionality for cartographic analysis. The main purpose is the visualization of spatial data, and therefore, special attention will be given to the graphic presentation of maps on screen, as we are used to in Europe. The concept of this ICIS provides two different ways of data exploration (figure 1), depending on the experience and the state of interest of the user. The first part of this atlas is view-only, where the user can browse through prepared geographic data including topographic and thematic maps, statistics and an encyclopedia with photos, videos and animation. For the navigation through this Information System, the user will not have a rigid hierarchical or sequential structure (Mao, 1994, Skupin, 1995), but this hypermedia application will offer links between all possible methods of visualizing geocoded data.

The second part of this atlas offers the possibility of simple cartographic analysis of statistic data with the visualization of the results on screen. This data from the Austrian Central Office for Statistics will be available for all municipalities of Austria. Further information will come from the register of villages and towns. The analysis module enables the user menu-driven queries to thematic topics which is indispensible for the following on-screen display. The interaction feasibilities of this module are confined to the selection of the topic, the definition of query criteria and restricted options for the choice of graphic variables. The method of displaying thematic data depends on the topic and must be recommended by the program (cp. Sieber, Bär, 1996). These restrictions for cartographic visualization must be made and the graphics prepared for the screen because of unsolved problems of automated generalization and the drawback of the resolution and the size of the screen as discribed later.

3. Concept of Display and User Interface

The graphic presentation of topographic and thematic maps will be realized as a hybrid display of raster and vector data. The interactive module will present vector data, highlighted in bright colours or as blinking elements as results of analysis, with rasterized maps with reduced colours or in greyscale in the background. The view-only part of this atlas shows prepared maps in raster format with vector data behind it, for the links to the database, to get further information on elements. The access to these vector data is possible by a 'See-Through' - Tool like the Magic Lenses (Stone, Fishkin, Bier, 1994), with a selection of topographic features the user wants to get displayed in that window (figure 2). This lense should not be seen as a magnifying glass but as a user interface for presenting graphics and textual information in a new way. By dragging the lense with a mouse over a diagram the user might get the exact data of this diagram displayed in that window. The possibility of using multiple lenses allows the user to define feature levels for display. Each selected feature is represented in one lense window and the overlay of two lenses shows both levels.

Further functionalities for navigation can also be combined with these user interface lenses. Zooming into topographic maps is realized by 4 levels of different scales, contents and generalization, similar to the printed atlas. If the user wants to zoom into the map the user interface lense will change to the represantable size of the chosen scale to give the user the possibility to arrange the desired detail. The term scale is yet not applicable in conjunction with screens and should therefore be substituted by scale or contents level. These scale levels are indispensable for well-ballanced and readable appearance of map graphics (cp. Kelnhofer, 1995, Spiess, 1996), and necessitate a special preparation and symbolization of the maps for the display on screen.

A very important part of an electronic atlas is the user interface design which is mostly responsable for the sucess of a program. The concept intends plenty of space for maps that are besides graphic user interfaces. The first entry to topographic maps is at the scale of 1:2,250.000, as an overview map of Austria filling the entire screen. Due to the E-W extension of Austria there is enough space for a permanent legend on the bottom

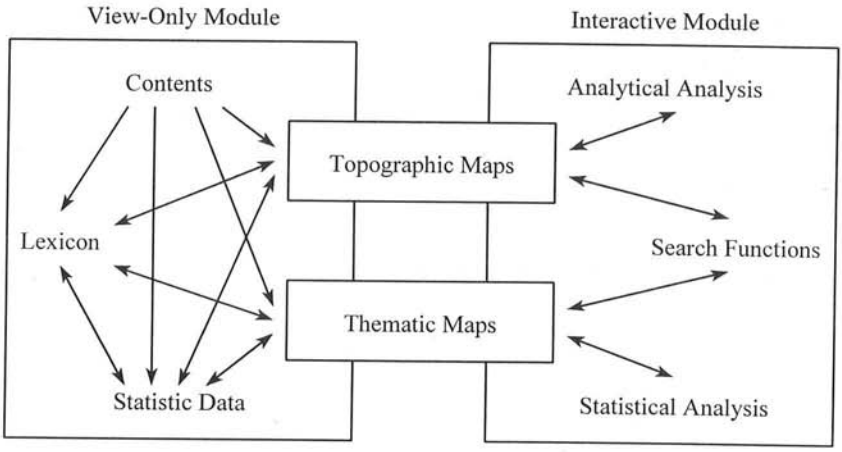

Figure 1: Concept of the Interactive Cartographic Information System

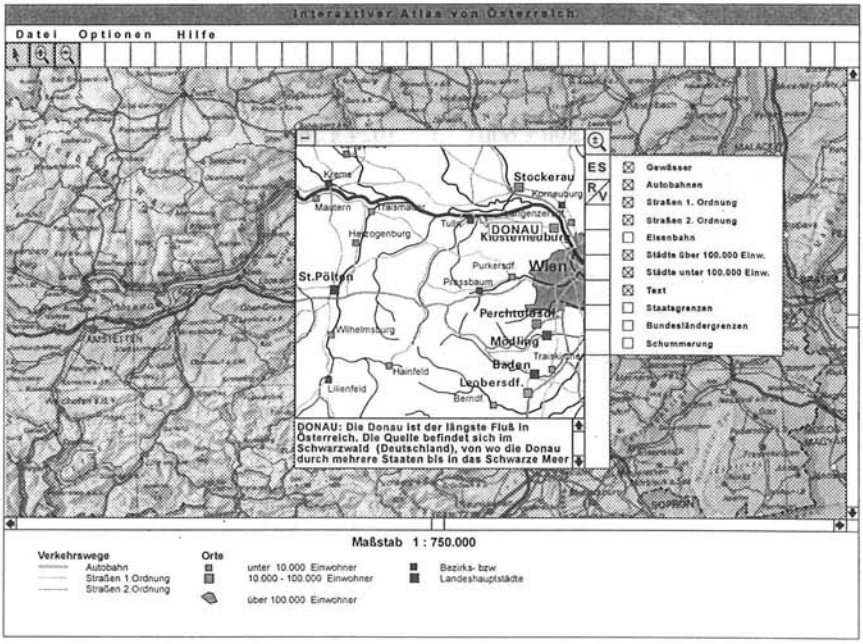

Figure 2: User Interface of the ICIS

of the screen, depending on the chosen vector data. For a maximum of useable area to display topographic maps of the other scales, this legend can be faded in and out at the bottom, as well as a window with a general view of Austria at the upper left corner. Scrolling within a scale level is possible by scroll bars or by moving the magic lense to the edge of the displayed map. The lense interface will have an information bar at the bottom of this window with the advantage for the user to get a brief information in his field of vision. Detailed information are available via hyperlink whereby the user is guided to the encyclopedia or spread-sheets of the database.

4. Cartographic Visualization on Screen

A nearly unexplored field in modern cartography is the visualization on screen and the requirements for a perfect cartographic presentation. While many investigations analyzed the limits of perceptive faculty of human beings to derive rules for designing maps, little research has been made for screens. Nevertheless, the perceptive conditions of screens are worse than human perception. Responsible for this fact is the resolution of graphic boards depending on the size of screens - on average 90 dpi - which is about the factor 20 worse than the resolving power of printing. Table 1 shows the size of the pixels of different screens in dependence on the resolutions of graphic boards sensible for the use in cartography. The description of screens specifies the size of the tube which is in fact reduced by about 10 %, primarily by a frame to minimize the distortion and by the user-specified area of display on-screen. Hence follows a resolution of 53 - 148 dpi which results in a pixel size of 0,48 - 0,17 mm.

Screen	Resolution of the Graphic Board		
	800 x 600	1024 x 768	1600 x 1200
15"	0,34	0,27	0,17
17"	0,39	0,30	0,19
19"	0,44	0,34	0,22
21"	0,48	0,38	0,24

Table 1: Pixel size of screens in mm with different resolution of graphic boards

Depending on these sizes, the minimum dimensions of lines and text has to be set. Further on, the width of lines can only be encreased by multiple pixel size. The quality of lines is best at an angle of 0, 45, and 90 degrees, aliasing appears strongly at angles near 0 degrees (figure 3[1]). A very bright colour of lines tempers this effect because of irradiation but causes problems in distinctiveness. A black background would improve the contrast but is not useable for a representation of hill shading. Conditional on the

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All the following figures to demonstrate the influence of the resolutions are screen copies of a 21" screen with a resolution of 1024 x 768 pixel.

resolution the use of line styles and multiple lines is not qualified for a perfect cartographic representation on the screen.Text fonts has to be chosen with particular care for the display on screen. Serif fonts are therefore entirely unsuitable (figure 4), only Sans-Serif fonts are in consideration, but even in this case some fonts are more qualified than other. Tests demonstarted that Arial and Univers are best for text visualization on screen (cp. Steinlechner, 1997).

In addition to the font the variables text size and style have to be considered. Figure 5 shows different text sizes of the font Arial. Single characters grow together at a text size up to 11 pts., the use of block letters brings a slight improvement to this effect. The distinction of the text sizes 9 and 10 pts. is nearly impossible. Larger text sizes are well readable but require a large area which is, depending on the size of screens, barely available. The style offers few possibilities to prepare text for display. Besides the options 'normal' and 'bold' none of the others can be used for the screen. Figure 6 shows some fonts in italic style where some characters cannot be distinguished. The use of italic text, which served for distinction on printed maps, can be compensated with the use of colours.

The alignment of text along a line shown in figure 7 which is used for lettering the hydrology, cannot be realized on screen. In that case the use of new digital forms should compensate this lack of visualization. In general text should be used scarcely because of huge space-consumption but supported with a short-time utilization of lettering on screen, for example the display of text when the user moves the mouse cursor over an element he wants to get information from.

The design of symbols also have to be made especially for the screen. The use of round symbols is only recommended in connection with a high resolution of the graphic board because of aliasing. Even the application of square symbols might cause problems as demonstrated in figure 8. The variation of the symbol with a centric double line entails problems if the distance between the lines is too thin. Therefore it can only be used as a large symbol implying a huge covering and displacing of other map elements. The use of colours might as well achieve better results for the distinction of symbols.

5. Further Outlook

Further investigations in the field of perception have to be made for cartographic visualization of maps on screen. Conditional on the lack of screens, by means of limited area of display and the resolution of graphic boards, the graphic presentation of maps must change to guarantee readable graphics. This disadvantage should yet be balanced with modern techniques of personal computers to change the maps and atlases from a static medium of information presentation to a dynamic way to show geographic and statistic data. In this connection the map as a graphic user interface offers a new opportunity for the concept of a hypermap with possible links to further and detailed information. Moreover the Internet offers the chance to provide the user of atlases in a very short time with actual data.

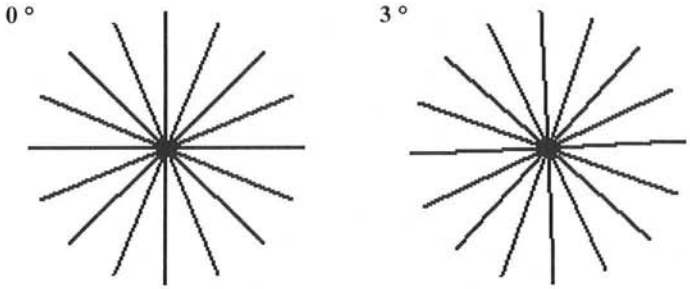

Figure 3: Aliasing of lines at different angles

Arial:

ABCDEFGHIJKLMNOPQRSTUV
abcdefghijklmnopqrstuvwxyzäöü
1234567890;,:. ("§/&!?´)

URW Grotesk T:

ABCDEFGHIJKLMNOPQRSTUV
abcdefghijklmnopqrstuvwxyzä
1234567890;,:. ("§/&!?´)

URW Garamond TDemExtNar:

ABCDEFGHIJKLMNOPQRSTUV
abcdefghijklmnopqrstuvwxyzäöü
1234567890;,:. ("§/&!?´)

Times New Roman:

ABCDEFGHIJKLMNOPQRSTUV
abcdefghijklmnopqrstuvwxyzäöü
1234567890;,:. ("§/&!?´)

Figure 4: Different fonts in Sans-Serif and Serif in 14 pts.

9: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn, Lilienfeld, Bruck an der Leitha

9: MÜRZZUSCHLAG, ILLMITZ, DEUTSCH WAGRAM, HOLLABRUNN, LILIENFELD, ZWETTL

10: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn, Lilienfeld, Zwettl, Bruck an der Leitha

11: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn, Lilienfeld, Zwettl

12: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn, Lilienfeld, Zwettl

14: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn, Lilienfeld

18: Mürzzuschlag, Illmitz, Deutsch Wagram, Hollabrunn

Figure 5: Different text sizes in Arial

Arial:

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

Univers Condensed:

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

Imperial:

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

ABFGHJKMNQRSUWXYZ
abefghjklmnprstvwxyzöü

Figure 6: Styles Bold and Italic of different fonts in 14 pts.

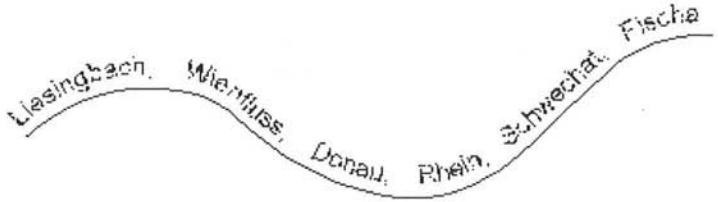

Figure 7: Alignment of text along a line in Arial 12 pts.

Figure 8: Square symbols and round symbols with single and double lines

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ECOLOGO-GEOGRAPHICAL ATLAS AS A TOOL OF A REGION STABLE DEVELOPMENT

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1.Introduction. Statement of a Problem.

Periodic moral aging and updating of technologies form cyclic recurrence of socio-economic development (Gritsai, Kotliakov, Preobragenski, 1994), and character and the features of socio-economic development are main source of ecological changes (Kondratiev, 1993).

The society has tested a number of such cycles or "waves", and is at present at a stage ecologization and informatization (Golts, 1988; Trofimov, 1990). At the beginning each stage is characterized by intensive socio-economic development, then by establishment of some balanced condition and, at last, by its steady (unsteady) condition (depending on general trend of development). At the present stage of ecologization and informatization an intensive way of socio-economic development (to which the most advanced countries of the world have come in the second half XX century), are assumed by gradual transition in global scale on the way of balanced and steady development (Ursul, 1994).

The strategic requirements of such character of development are already formulated in the most general way in the report MKOCP under the direction of G.X.Bruntdland (1989), in the reports of the conference in Brasil "The Declaration of Rio-de-Janeiro" and "The Agenda on XXI century" (Koptug, 1992).

Imperatives of steady development require formation of new means of management in global, national (federal) and regional scales, new policy ecologo-economic trend. Now we are dealing with more serious problems: an opportunity of survival further preservation of mankind, at satisfaction far from all, but only main (the most natural) vital requirements (Ursul, 1994).

The main principle of steady development of the environment as initial one should have the assumption about finiteness of natural resources, ensuring life of man.

B. Policy in the field of ecologo-economic regulation.

C. Main directions in the field of management of the environment.

D. Regional ecological examination of a territory.

E. Problems of informatization of nature preservation activity.

4. Ecologo-geographical atlas as a model expression of conception of balanced and stable development of a region.

The main task of the ecology nowadays can be defined as a problem of studing processes of exhaustion of vitally important resources, their distribution among human population and elaboration of methods of preservation and distribution favouring prolongation of life-time of human civilization. In this regard, corrected programs of socio economical, ecologo-economical, informational, etc. development and recreation at the level of global, federal and regional scales should began to work, in order to elaborate general ecologo-economical policy by means of conception of balanced state and stable development of a region.

As a model expression of the conception becomes "Complex ecologo-geographical atlas of a territory", providing integral, complete and balanced views of the environmental condition.

In the TR of ecology of Natural subsystems of Tatar Academy of Sciences appears to be a coordinator of atlas preparing, and informational, cartographical and computer modelling is conducted by the Ministry of Economy (Program "GIS of Tatarstan").

The atlas map making method is considered on the example of a more compound maps - ecology and ecologo-economical maps.

5. Ecologo-economic map - as a tool of scientifically justified ecological regulation, forecasting and management.

As was specified above, no one of ecological programs existing in republic has the most important constituent - conceptiality and integrated approach. Moreever, they are disunited, and, what is the most important, do not present the uniform integral-complex approach to compiting the ecological map of the Tatar Republic (let alone principles, approaches and etc.) (Trofimov, 1995).

Judging from a number of researches in the field of ecological monitoring, valuation of a condition and forecast for steady development, in the bases of the integrated characteristic of a condition of the environment it is expeditious to put a parameter ecologo-economical syndrom of a territory. It is a characteristic of potential

opportunities of the environment on a way of its preservation and improvement.

As a basis of ecologo-economic map of the TR the most adequate is the principle of determination of ecologo-economic syndrom of a territory. Its advantage is in ability of the description of hierarchical model of mutual relation of various environments, spaces, surfaces and parameters.

The work is conducted with "floating" set of indicators which allows to stress a specificity of objects. The procedure permits to elaborate system of diagnostic indicators. Its goal - to obtain such interconnected set of indicators for each unit (operational-territorial unit, or OTU) that is will show the greatest distinction with other OTU of the totality. Such set is called the regional syndrome of indicators (Kaganski, Novikov, 1989). The ecologo-economical syndrome then can be determined by a definite ecologo-economical set of diagnostic indicators.

Each indicators of the syndrom is considered as a component of OTU content, as the way to show the fact and mere distinctions between OTU and, finally, as the index of OTU specificity. Hence, the index of the syndrom - is an integral characteristic of the specific ecologo-economical orientation of a given unit of a territory.

The ecological map is constructed on the base of economical map with consideration for the system of indicators of environmental condition, of ecological load of different character, indicators of sickness rate of population and a number of indicators reflecting complex character of the influence of ecological situation.

System of indicators is chosen so that it reflects all aspects of ecologo-economical state and situation of the region, and with the help of the method described above it is transformated into the corresponding regional syndrom for every region. On the whole, ecologo-economical map gives a perspective sight of reflection of the present day ecologo-economical condition and orients specialists and authorities to take timely and effective management decisions in the field of regional policy (Fig. 1).

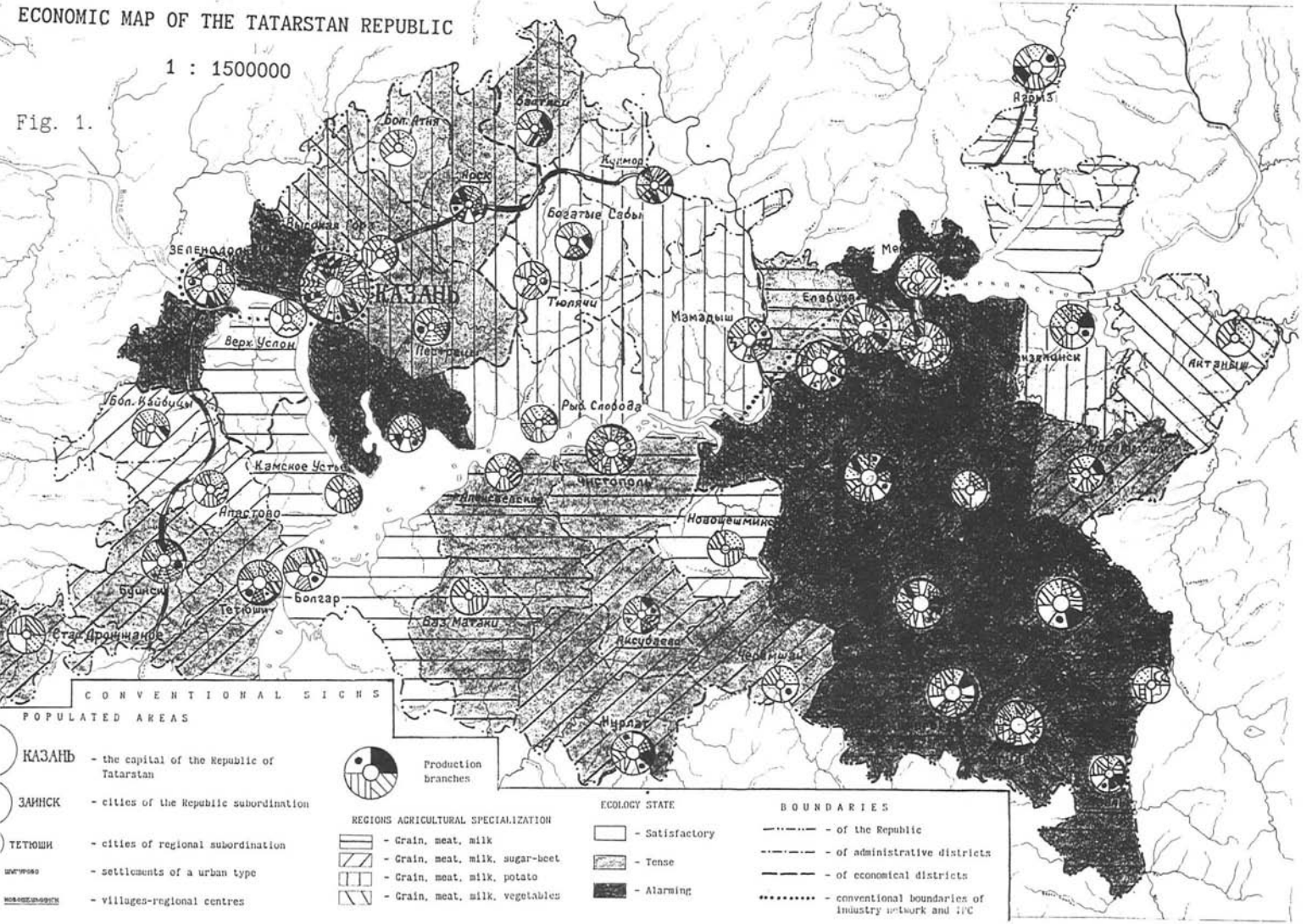
6. Conclusion.

Stated above conception of balanced and steady development of the TR is realized with the help of a number of the interconnected approaches. One of them - the binding one - is connected to construction of the map of ecologo-economic condition of a territory. As far as in the basis of map construction a parameter of ecologo-economic syndrom is put, it enables not only really to evaluate a condition of the environment, but also to make ecological regulation. The last means of permits to execute the following approach - forecasting of a condition of the environment, and is leading on

ECONOMIC MAP OF THE TATARSTAN REPUBLIC

1 : 1500000

Fig. 1.



CONVENTIONAL SIGNS

POPULATED AREAS

КАЗАНЬ - the capital of the Republic of Tatarstan

ЗАИНСК - cities of the Republic subordination

ТЕТЮШИ - cities of regional subordination

- settlements of a urban type

- villages-regional centres

Production branches

REGIONS AGRICULTURAL SPECIALIZATION

- Grain, meat, milk
- Grain, meat, milk, sugar-beet
- Grain, meat, milk, potato
- Grain, meat, milk, vegetables

ECOLOGY STATE

- Satisfactory
- Tense
- Alarming

BOUNDARIES

- of the Republic
- of administrative districts
- of economical districts
- conventional boundaries of industry network and TPC

steady development, that can be fixed in the basis of acceptance of the dministrative decisions for appropriate bodies.

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MAPS IN VEHICLE NAVIGATION SYSTEMS

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Abstract

The usage of maps in vehicles began approximately 10 years ago when Etak, a California-based company, introduced its vehicle positioning system. Today, vehicle navigation systems are a reality and many companies (Ford, BMW, Mercedes and especially Japan's ones) build those systems in their most expensive products. Vehicle navigation systems assist drivers in dynamic route planning, giving incremental instructions, saving time and fuel and guiding them through geographic space. In traditional car driving, both planning and decision making are based on a cognitive map, the driver's mental model of his environment. Vehicle navigation systems use digital map to provide already mentioned functions as well as to assist drivers in updating their cognitive map. This paper describes the usage of maps in VNav, prototype of vehicle navigation system which is developed in CG & GIS Lab at the University of Niš.

1. Introduction

Motoring is a complex task and puts high demands upon the driver's processing capacity, placing him close to his maximum processing limits. The driver is in a hazardous, divided attention environment, perceiving data from many sources. He constantly observes the environment, catching a variety of cues such as road signs, buildings and other landmarks. The perceived cues are then compared to the expected cues in driver's memory and are created by the driver's planning activity. Driver must quickly process this comparison and react to it in an appropriate manner, which requires a high level of mental processing.

Human beings refer to internal representation of environmental objects in order to find out their location and the direction of moving. It is believed that this representation is made structurally and the concept is called cognitive map. Cognitive map is the representation of the knowledge which human beings get by the spatial experiences

and are investigated in the field of geography, psychology and so on. It is obvious that in driving, both planning and decision making are based on a cognitive map, the driver's mental model of his environment.

In this paper we consider the role of a digital map in vehicle navigation systems as a helping tool for updating and constructing driver's cognitive map. Chapter 2 describes vehicle navigation systems in general and chapter 3 investigates the role of digital map and its requirements in these systems. In Chapter 4 we present a prototype of vehicle navigation system - VNav which is developed in Computer Graphics & GIS Laboratory at the University of Niš.

2. Vehicle Navigation Systems

The driver has a primary task that is to control a vehicle. As mentioned, this complex task of perception, processing and reaction, occurs in what is classified as a hazardous environment and demands a high level of attention.

Over the last decade there has been an enormous development in personal communication devices and in information systems. These mobile systems are continuously evolving and as users spend more time on the road, in-vehicle systems are becoming more important.

In this context, vehicle navigation systems have been developed into a large industry. Many companies (Ford, BMW, Mercedes and especially Japan's ones) build such systems in their most expensive products. These systems assist drivers in dynamic route planning, giving incremental instructions, saving time and fuel and guiding them through geographic space.

Vehicle navigation system is added data source in driver's environment. Hence, both planning and decision making are based on two input channels: first is the natural channel (described in chapter 1) and the second is vehicle navigation system. Vehicle navigation system should support both planning and decision making. This added channel helps the driver to reduce the amount of time which he spends to update his cognitive map. This saving of time is very important because the driver has more time for decision making. Figure 1 describes these processes.

Vehicle navigation system can be autonomous or integrated into Advance Traffic Information System (ATIS). Autonomous system consists of an in-vehicle unit which contains everything needed to accomplish all navigation tasks. In the last few years such systems have appeared on the market. For example, Philips developed their Carin [1] system, Rockwell developed PathMaster [2] system and so on.

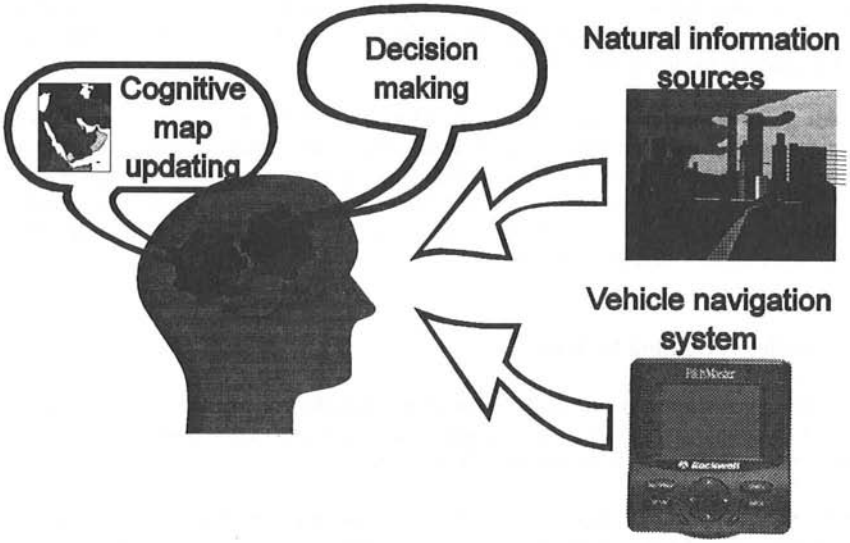

Figure 1 Two processes and information flow during driving

Vehicle navigation systems integrated into ATIS have more potential. They are dynamic navigation systems that take into account the current traffic situation. These systems consist of operating center, communication system and in-vehicle unit. Traffic Management System (TMS), which is also integrated into ATIS, collects data about traffic condition, accidents, road-works, weather conditions and other relevant data. Thanks to this information, vehicle navigation system can calculate an efficient route to the selected destination, avoiding traffic jams and other obstacles.

One of the most critical elements of an ATIS is its associated communication system. Several approaches to mobile communications are being explored. Euro-Scout [3] from Siemens uses infrared beacons. SOCRATES (System Of Cellular Radio for Traffic Efficiency and Safety) [4] uses cellular radio in an efficient way to provide two-way communications between information centers and equipped vehicles. Also, digital audio broadcast and microwave have potential.

Both systems, autonomous and integrated must interact with a few subsystems: sensors, spatial database and user-interface. The sensor subsystem determines the vehicle's location and direction of travel. Typical components include a compass (magnetic or gyro), accelerometers, odometer or Global Positioning System (GPS) [5] receiver.

Vehicle navigation system must have data about such spatial objects as roads, their intersections, landmarks along roads, cities through which drivers are driving. These

objects are all graphic in nature, because they have some properties with respect to their location, shape and neighborhood. Hence, vehicle navigation system must store, update and display these data. For that purpose, vehicle navigation systems use database system, but few of them use file-system.

As mentioned, the driver is engaged in a complex task that demands a high level of attention. Vehicle navigation system as the added information source might provoke problems. The user-interface must allow the driver to perceive and process information while maintaining a hazardous, primary task, driving a vehicle. User-interface must be designed having this fact in mind.

The user-interface subsystem communicates with the driver, accepting requests for service and delivering driving directions and other information. The added information flow (see figure 1) suggests that the driver might have to divide his attention to more information sources, which implies the potential risk of distracting the driver from control and causing more accidents. Therefore, interface must be very efficient. It means that this subsystem must be simple, easy and quickly understandable.

For this purpose, vehicle navigation systems use digitized or synthesized voice and graphic user-interface based on maps, as a means of delivering information.

3. Maps in Vehicle Navigation Systems

Maps are representation of a geographic area drawn or printed on a flat surface. They may be used for a variety of purposes, and as a result a number of specialized types of maps have been developed such as topographic maps, plans, 3-dimensional models and others. Maps are reduced representations of the real world and they usually contain limited amount of generally accepted symbols, which indicate the various natural, artificial or cultural features of the spatial objects. Maps have highly important informational and cognitive properties.

The basic type of map, used to represent land areas, is the referenced map [6]. Topographic maps, marine charts and urban plans belong to this group of maps. These maps show the specific natural features of the area covered. They represent scientific document and must be very accurate. Because of the great variety of information included, topographic maps are most often used as general reference maps. Referenced maps serve as basis for measuring and obtaining various qualitative and quantitative characteristics necessary for solving scientific and commercial problems.

Second type of maps are thematic ones. These maps are used to facilitate communication with users. Thematic maps include political maps, which show only towns and political divisions, weather, geological, population and many other kinds of maps.

Both types of maps contain a large amount of easily read information, and employ a system of symbols. Many commonly used symbols have become generally accepted or

are readily understood. Another important characteristic of map is a scale. The scale to which a map is drawn represents the ratio of the distance between two points on the earth and the distance between two corresponding points on the map.

In recent years maps have moved from analog images describing the distribution of features to geographically referenced digital data. Therefore, digital cartography has become very important scientific discipline. Today, there is a wide sector of computer industry which are focused on data acquisition, process, validation, storage and distribution. As a result, digital maps are used for many proposes.

In vehicle navigation systems digital maps play very important role. Their main task is to help driver to update and construct his own cognitive map. Basic functions of a digital map and requirements which must be met by this map in vehicle navigation systems are: (1) map positional accuracy of 15 meters; (2) map must show the vehicle's current location in the context of an appropriate geographic environment; (3) map must be constantly updated as the vehicle moves along the road (moving map); (4) map must be adopted to driver's cognitive map; (5) map must allow zoom in and zoom out operation, change the scale and the level of detail; (6) map must serve as background in displaying vehicle's route and the shortest path among two locations. Besides these functions, where digital map is used as graphical output or background for different information, there are some advanced requirements that must be met by digital map. A few of them are a detailed list of streets and places' numbers (to allow the user to select a destination) and an accurate representation of the road network with turn restrictions, one way streets, speed limits (in order to allow system to plan the best route and guide the driver on a turn-by-turn basis). In order to meet these requirements, a real navigable database grows out of this digital map.

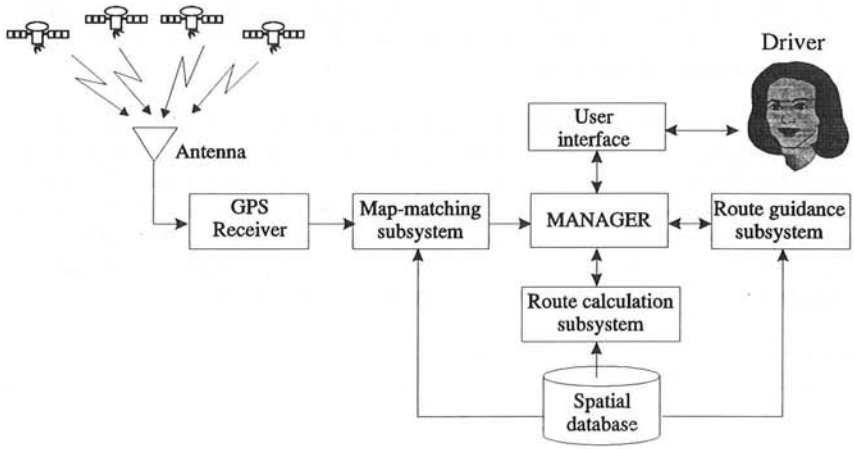

Figure 2 Vnav system architecture

4. Maps in VNav System

A prototype of vehicle navigation system, called VNav [8], which architecture is shown on Figure 2, is developed in CG & GIS Lab at the University of Niš. The system consists of seven subsystems: GPS receiver, map-matching subsystem, route calculation subsystem, route guidance subsystem, spatial database, manager and user-interface subsystem. We used commercial GPS receiver from Trimble as a sensor device. Also, system includes map-matching capability. It is a technique to enhance and correct in-vehicle positioning sensors. Map-matching subsystem follows the progress of the vehicle through an on-board digital map and matches the sensor output to the closest point on the map in order to correct sensor errors. For this purpose, we developed an AI based map-matching algorithm.

The route calculation subsystem determines a "best" route from vehicle's current position to a chosen destination. Depending on the driver's preferences, the "best" may mean the least duration, the fewest traffic lights, the least distance, the fewest left-turns or some combination of these criteria. The calculated route must be possible and legal, or in other words, system must know all one way streets and banned turn regulations.

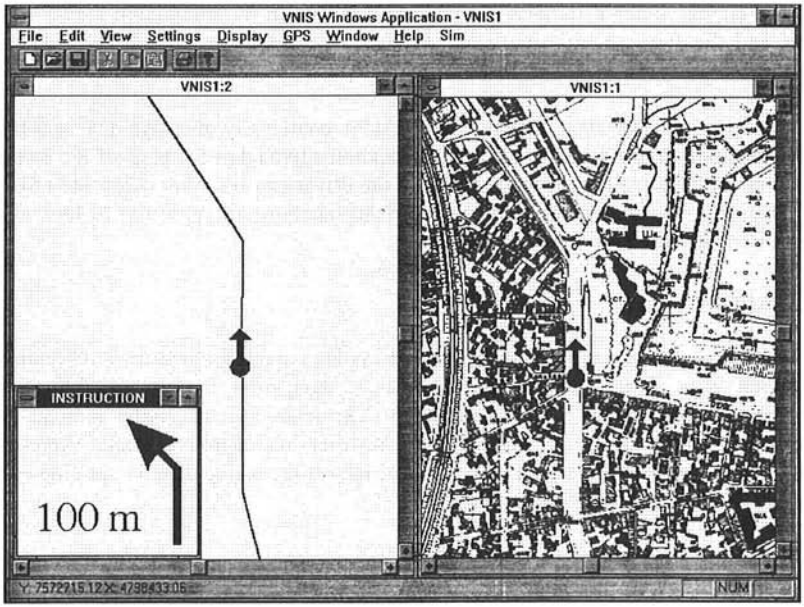

Figure 3 Map display in Vnav system

Route guidance subsystem has the task of delivering the directions to the driver. Directions not only have to be clear and nondistracting, but must be timely as well. Spatial database stores data about such spatial objects as roads, their intersections,

landmarks along roads, cities through which drivers are driving. Manager connects and controls other subsystems. And the user-interface subsystem uses digitized voice, graphics based on maps and large, easy to read turn arrows, as a means of delivering information.

Visual display shows scaleable maps which are captured in CG & GIS Lab using paper maps ranging 1:5000 to 1:25000 in scale. This digital map meets positional accuracy of 1 meter. It is evident that during the driving complex map display is not desired because it can confuse the driver. VNav has a possibility to change the level of map details (figure 3). The simple display with low level detailed map is used during the driving. This representation allows the driver to readily classify the geometry of the road network since it matches his cognitive map (his internal representation of the world). Maps with high level of details may serve as background in displaying vehicle's route and the shortest path among two locations. This representation helps driver in process of preplanning to create his own cognitive map.

There are two kinds of display forms to show a map. One is north-up form which keeps the North of the digital map up. Another is the heading-up form which rotates the digital map to keep the direction of movement of a car in upward form. Driver's potential cognitive characteristics are important factors in the interaction between the driver and the form of representation. As map representation should adapt driver's spatial orientation, we make both representations possible.

We also use moving map display. The system continually displays the real-time vehicle position on the map. As the vehicle location approaches the edge of the screen, the system automatically moves the map and the driver can see what is located around him. Different map scales, zoom in and zoom out functions allow drivers to look at an overall route or zero in his immediate route.

5. Conclusion

As mentioned, the driver is engaged in a complex, divided attention environment, perceiving data from many sources. Vehicle navigation system as the added information source might provoke problems. The main task of digital map in this system is to help driver to update and construct his cognitive map. Therefore, compatibility between the digital and cognitive map is the major issue in creating user-interface of vehicle navigation system.

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MAPEDIT - A SCANNING DATA ENTRY SOLUTION FOR GIS

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Abstract: *This paper presents data scanning entry solution for geographical information systems. This method is known as the fastest and cost-effective capturing data method which offers an array of capabilities adaptable to a wide range of user requirements. Also, the paper presents MapEdit - a software for supporting this data entry method.*

1. Introduction

Computer application in cartography, as also the appearance of Geographical Informational Systems (GIS) that are specialized for capturing, analyzing and displaying spatial data, has brought up many possibilities for research and presentation of Earth and it's natural resources. Geographical Information Systems enables scientists to look at things the way they could never do before. That should make better natural resources management possible as also, better synchronization of making activity in order to preserve Earth. But, the appearance of the GIS technology itself, is not enough for it's complete functionality. However, 80% of every GIS system are spatial data. Without data, the system is helpless. Luckily, this was realised very soon, so that many organizations, above all state organizatoins, but also private ones, started with spatial data capturing. There are many methods for data capturing, starting from measurement of the surface of Earth, digitalization and vectorization of the existing paper maps, all to the plane and satellite images. In order to prove the significance of this data, stands also the fact, that many states had launched at the Earth's orbit satellites in this purpose (Landsat - USA and Spot - France). Many states are investing large amounts of money for financing projects for making digital spatial databases. On the other hand, GIS marketing is the branch that has the fastest development in the computer program marketing.

Unfortunately, Yugoslavia was not taken - over by this trend. Our state institutions that were assigned for the spatial data capture for the digital database

hadn't done much concerning the matter. Under these conditions, a more massive application of GIS couldn't be expected, no mater how great was the need for such systems from many organizations (Telecommunications, Army of Yugoslavia, Police, plumbing,...) [1].

One of the ways for GIS, to inspite all, under these conditions, to be spread to these areas, also, is presented in this paper. The paper presents methods of scanning by which the spatial data is captured from the already existing mediums, i.e. paper maps. Special attention is paid to software for georeferencing - **MapEdit** that is developed in for Computer Graphics and GIS Lab at the Faculty of Electronic Engineering in Nis as the support for this way of data entering.

2. Scanning data entry solution

Considering huge expansion of Geographical Information System use around the world, translation of existing spatial data to the form suitable for applying and displaying on the computer, is needed more than ever. In particular, this is the case for existing paper geographical maps, being the most suitable for use and also considering the fact that they are the best tool for representing large amounts of corresponding spatial data. Various types of GIS use corresponding maps (geographical, thematical, etc.). GIS acquires data from diverse sources to compile a map. For topographic maps these include air photographs, data from remote sensors, field notes, coordinate lists and existing paper maps. GIS thematic maps rely on wider range of data sources such as census reports, meteorological records and historical documents. In modern cartography the volume of data sources is increasing, resulting in an exponential growth in the volume of data serving cartographic applications and GIS. Traditional methods of automating vector spatial data include three alternatives: contracting with a service bureau, in-house table digitizing, or COGO (coordinate geometry) data entry. Users now have an alternative to existing methods for creating vector databases — an option called scanning data entry. This new choice in data automation, scanning data entry, is affordable and uses mature, reliable technology. This method can be implemented with existing staff and integrated with existing GIS software and databases. Also, this method offers an array of capabilities adaptable to a wide range of user requirements.

Scanning data entry uses document scanning technology to create raster data sets, or "digital pictures" of the documents. The process flow is shown on figure1 [2].

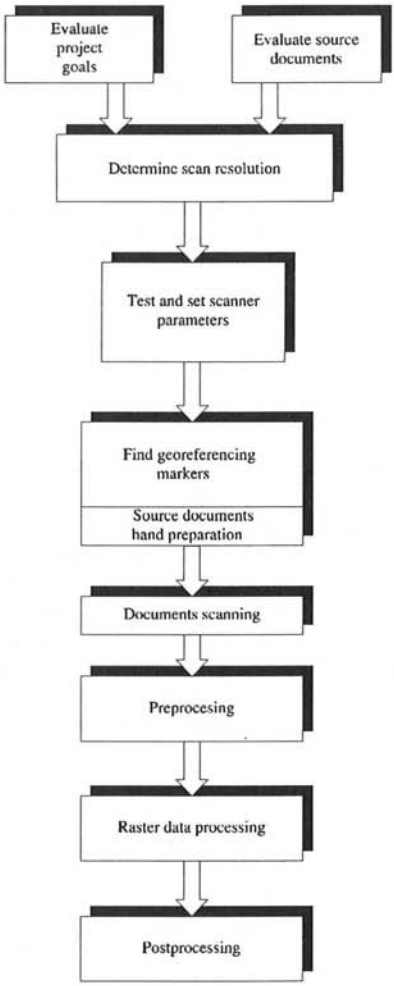

Figure 1. Scanning data entry method flow

GIS users should carefully evaluate scanning data entry in the context of project requirements, which can vary greatly. Factors to consider include data sources and their availability, map quality, update frequency, data volume, accuracy requirements, and system capacity.

The available data sources will also influence the feasibility of scanning data entry. The scanning data entry alternative is most appropriate when the data do not already exist in digital form but do exist in document form. Scanning data entry does require a source document of some kind. If these documents are of poor quality, scanning data

entry can be effective but will require more operator data cleanup. Scanning data entry is most useful and cost-effective when a high-quality data source (e.g., maps or air photos) is available. Feature layers on separate documents reduce processing requirements. When planning scanning data entry projects, it is very important to spend time assessing your needs before implementing a solution. Accuracy requirements and the characteristics of your source documents will determine the most appropriate hardware and software package. For example, the need for raster integration may require additional disk storage or a more powerful CPU.

Scanner resolution is important. There are two types of resolution:

- optical and
- interpolated resolution.

Optical resolution is the ability of cameras in the scanner to discern data. As a rule of thumb, the optical resolution of a scanner is expressed in this formula:

$$\textit{optical resolution in dpi} = (\textit{number of cameras} + 1) * 100$$

Thus, a scanner with three cameras can offer an optical resolution of 400 dpi. Scanners can also offer interpolated resolution, in which the data from the CCD are resampled into smaller pixels. Thus, a scanner with optical resolution of 400 dpi can also offer interpolated resolution of 800 dpi. This method can produce an output image with higher resolution, but not necessarily with greater accuracy. In general, GIS users should evaluate scanners for GIS applications using optical resolution.

When scanning resolution is determined, the scanning parameters should be test and set. These parameters include parameters such as contrast, brightness, etc.

The next step is finding markers needed for georeferencing and hand preparation of source documents.

When all steps above are finished, the scanning process can be started. Scanners take a "digital snapshot" of the source material and store this raster data on disk. The scanning process has special software requirements. In general, software tools used for this method should include following functions:

- raster data management,
- software data compression,
- georeferencing raster and vector data,
- raster data displaying,
- raster data editing and
- raster to vector conversion.

The data produced by scanning data entry must be organized in an orderly way. Georeferenced data should be organized geographically. Data management software can optimize storage and retrieval of raster data even when data volumes are large. For integration with other systems and scanners, the software should provide raster-to-

raster data conversion. Raster data management software can extract, edit, and merge a raster data set from a raster database.

Software data compression can minimize raster data storage requirements. A variety of industry-standard data compression formats are available. Industry-standard data compression formats include RLC and CCITT Group 3 and Group 4. The CCITT compression standards are implemented in the TIFF raster data standard. Eight to ten times data size reduction can be achieved with bi-tonal data. The amount of actual data reduction will depend on the compression algorithm used and the complexity of the data. Data that are compressed must usually be decompressed to be used, requiring processing power and disk space. Some applications find the overhead imposed by decompression to be undesirable and choose to keep grayscale data uncompressed for rapid access. To support this consideration, archived grayscale data can be compressed, while data being actively used can be kept in uncompressed format.

Georeference of raster and vector data is a basic requirement for raster data integration. All GIS databases are ultimately stored and managed in real-world coordinates. Software should be able to bring raster and vector data into the same coordinate system by either fitting the raster data to vector data or vice versa. Georeferencing of data is a requirement for heads-up digitizing, many editing functions, and any integrated use of data. Raster data must be georeferenced to be stored as a seamless database of adjacent images.

Raster data can be displayed with full control over display symbology and graphic overlay of vector data. Background values in bi-tonal raster data can be displayed transparently, thus allowing concurrent display of multiple raster data sets. Software can alter the display characteristics of grayscale and color images to suit the needs of the application.

The software should provide capability to cleanup raster data with tools that work directly on the raster data format. Raster editing is a common pre-processing step to raster-to- vector conversion. For example, raster editing software can remove speckling from raster data—and cleaner raster data are converted to vector data with less post-processing.

Also, the software should provide an array of tools for converting raster data to vector data. The tools should offer the flexibility to adapt to a wide variety of raster data. For high-quality media, batch vector conversion software may be a good choice. When source documents are lower quality or have much clutter, interactive line-following software is often preferable. When photos are scanned, heads-up digitizing can be appropriate. Maps that are scanned to capture coordinate information often have a wealth of feature attribute information as well. This attribute data can be interactively captured during scanning data entry procedures if the scanning software tools are well integrated with other editing functions.

Noise removal and clutter removal are pre-processing methods. Pre-processing prepares the raster data for the raster data processing step. Scanned maps will have a certain amount of noise. The lower the map quality, the higher the noise content. Noise is data that do not have informational content. For example, a common type of noise is tiny spots called speckles that are an artifact of the scanning process. The speckles are unwanted in the final vector output. Various methods can be used to remove noise from the image so that vectorization can proceed. These methods are collectively

called noise removal. Even a high-quality map may have unwanted data on it, such as annotation. Often maps show more than one data type or layer. For example, a map might show parcel boundaries and street names. When only the parcels are to be vectorized, the street names are clutter. Software filters that remove data below a given threshold size can be useful for removing the relatively small lines that make up annotation.

The raster data processing is the next step in this metodology. Depend of user requirements the raster data processing includes:

1) georeferencing and rectification,
2) "heads-up" digitizing,
3) interactive vectorization,
4) Batch vectorization,
5) Feature attribute capture,
6) ortophoto production and
7) incremental data automation

Once the raster data processing has been performed, the output raster and vector data can be post-processed. Post-processing is usually accomplished with vector and raster editing software to correct output raster and vector data.

3. MapEdit- a scanning data entry supporting software

MapEdit is a component of a GIS toolkit named **GINIS** [3] which prepares raster maps. **GINIS** is a GIS architecture suitable for implementation of end-user GIS applications under very limited resources. **GINIS** supports easy development of GIS applications. The framework is based on an object oriented (OO) mode. OO models are close to the way that end-users perceive real world and the data about it, so they are able to understand and specify their expectations more easily using such data models. At the same time, OO models are natural for highly structured areas such as GIS: they maintain a direct correspondence between real-world and application objects.

Some of the functions enabled in **MapEdit** are [4]:

1) filtering,

2) color palette reduction,

3) deskewing (rectification) of scanned maps through control points (this enables the compensation of both mapping errors, paper distortions and linear distortions introduced by the scanning process),

4) joining of neighboring segments,

5) division into pieces which can be compressed into separate files.

MapEdit enables few filtering operations which eliminate scanning errors noise and clutters and, together with rectification process, reduce or eliminate undesirable effects such as distortion of some map elements (antialiasing).

If true color palette (2^{24} colors) is used in scanning process, **MapEdit** will determine satisfactory number of colors for the entire set of scanned maps, and then create color reduction functions. This color reduction process significantly improves the system's performances (enabling fastest display and scroll).

MapEdit automatically connects scanned parts of paper maps and forms a continuos raster map on the basis of information obtained about control points on the scanned part. User determines control points on the screen, using special software zoom tool (like lens, see figure 3), and for each one enter numerical values of the coordinates (geographical: longitude and latitude, Gaus-Kruger's or any other local coordinates). On the basis of this information **MapEdit** computes all of the necessary transformations (for example, transforming coordinates from one Gaus-Kruger's system to another or translating longitude and latitude to Gaus-Kruger's coordinates, etc.), determines the correct place for the partial part in the continuos raster map and enters data in corresponding file of the map. The analyses we performed showed that this raster map creation method is very sophisticated (fast) and very accurate, i.e., the errors obtained are in the digitizing error range (± 1 pixel). For example, for maps at 1:25000 scale, these errors are equivalent of 4-6 meters on the ground. The whole process of creation continuos raster map using **MapEdit** software is shown in figure 2.

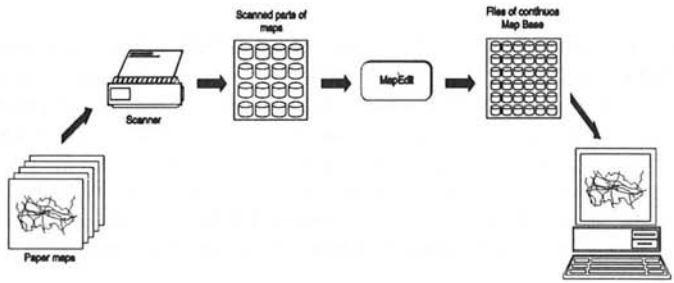

Figure 2: Continuos raster map creation process

MapEdit works with different scales of maps, starting at 1:1,000 for urban planning, to 1:1,000,000 for command and control systems.

4. Conclusions

Currently GIS users are challenged to efficiently convert paper or film based information into digital form. A cost effective way of meeting this challenge lies with the scanning technology. The scanning data entry method and one approach to raster

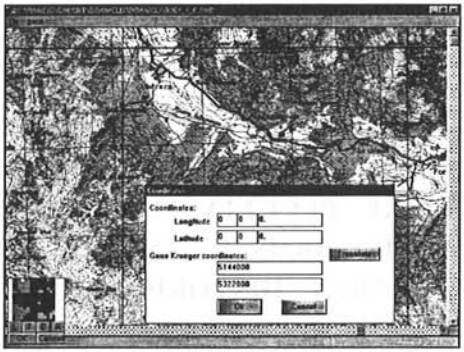

Figure 3: The **MapEdit** software

map creation, using scanned technology, is presented in this paper. The resultant raster maps must include all of information in the paper maps. Dimensions of the paper maps is often larger then the dimensions of available scanner, so the partially scanning of the paper maps is necessary, as well as process of connecting their parts all together. Connection must be done in such a way that connection points are invisible for users, and the whole parts of raster map must be treated as one. **MapEdit** is software, developed in in Computer Graphics and GIS Lab at the University of Niš, for creating these raster maps. PC based, low cost, relatively easy to operate and very accurate, **MapEdit** is well-suited for PC users looking to quickly make a map. Also, there are no hidden costs of additional training needed, since users are already familiar with the Windows environment.

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SYNTACTICAL PECULIARITIES OF SIGNS OF HYDROGRAPHIC OBJECTS IN PREHISTORIC AND EARLY HISTORIC MAPS

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Abstract

In this paper, a syntactical analysis of prehistoric and early historic maps has been made in order to show the development of cartographic signs when mapping one of the important terrain elements, namely hydrography in the temporal section from late Paleolithic to the beginning of Christian era.

1. Preamble

Researchers of prehistoric art (primitive graphic art) are very lucky - whole "galleries and musea" of primitive painting and sculpture are available to them which are known worldwide. This art has emerged in late Paleolithic. In the contents of primitive art, three subject groups can be detected. Zoomorphic and anthropomorphic image groups are the most representative ones. The third group which is represented quantitatively much less is composed of the remaining images. Cartographic (map-like) images belong to this group. Due to cartohistoric research, cartography has now approximately 60 to 70 examples of map-like old images /DELANO SMITH 1987/. For cartosemiotic efforts, it is already representative data, and it is advisable to proceed with studying them in the framework of a new cartographic discipline - paleocartosemiotics /WOLODTSCHENKO 1996/. Study of

syntactical peculiarities of prehistoric and early historic maps as semiotic space and time models of reality is one of important tasks of this disciple /WOLODTSCHENKO 1997/. In this paper, accent has been made on images with topographic elements, no celestial maps has been used for analysis. As a rule, following terms can form prehistoric maps in their contents (their semantic part) with topographic (landscape) elements: hydrography, relief, and dwellings (camp sites). Only some syntactical peculiarities of mapping of hydrographic objects will be discussed below.

2. Syntactical peculiarities of signs of hydrographic objects

10 map-like images selected for my poster at the 7th Cartographiehistorisches Colloquium in Bern in 1996 have formed initial data for syntactical analysis /WOLODTSCHENKO 1996/. Some images were added to them. They all contained various hydrographic elements. Fig. 1 shows only fragments of corresponding maps in the time row from late Paleolithic to 0 (beginning of Christian era). This chronological row may change due to disparity in dating some prehistoric maps.

2.1 Syntactical variables of linear objects

I have grouped together examples of hydrographic elements shown in Fig.1 by belonging to linear (rivers, channels) and area (lake, pond) objects. They are the two main groups with syntactic-geometrical features. Linear objects can be subdivided into two further subgroups (Fig.2). One subgroup (Fig. 2a) contains objects with double lines without any pattern, the other (Fig. 2b) one contains lines with internal pattern. In this case, a graphic variable by BERTIN /1974/ - a pattern - appears as a syntactical variable. The 1st subgroup may be syntactically characterized as follows: double lines without pattern give an idea about the shape or configuration of a river or a channel. Graphic information about water surface is absent. The 2nd subgroup of linear water objects - rivers and channels - is shown by double lines with various pattern or colour (e.g. black). Via the internal pattern, wavy surface of water my be graphically shown and the effluent or flow direction of the river be indicated (Fig. 3). Sign mapping by means of a pattern approximates them to a naturalistic form.

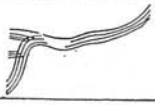
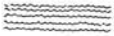
Nr.	Hydrographical objects		Name of map or landscape Dating Bibliography
	river/channel	lake/pond	
1			Pavlov-map 26000-24000 B.C. KLIMA(1987)
2			Mežirič-map 13000-11000 B.C. PIDOPLIČKO (1969)
3			La Sarga 6000-5000 B.C. PEREZ(1983)
4			Nuzi-map 3800 B.C. BAGROW/1951/
5			Tepe-Gawra 3500 B.C. D.SMITH/1987/
6			Nil-landscape 3500 B.C. SHORE/1987/
7			Maikop-map 2600-2000 B.C. EBERT/1921/ BAGROW/1951/
8			Nippur 1500 B.C. Muzeum.../1985/
9			Val camonica 1500 B.C. BLUMER/1968/ D.SMITH/1987/
10			Teben-garden 1500 B.C. SHORE/1987/
11			Shishkino-landscape 1500-1000 B.C. OKLADNIKOV, ZAPOROŽSKAIA/1959/
12			Theben 1140 B.C. DELACAMPAGNE, LESSING/1990/
13			Tubu 400 B.C. Muzeum.../1985/

Fig.1 List of analysed hydrographic objects

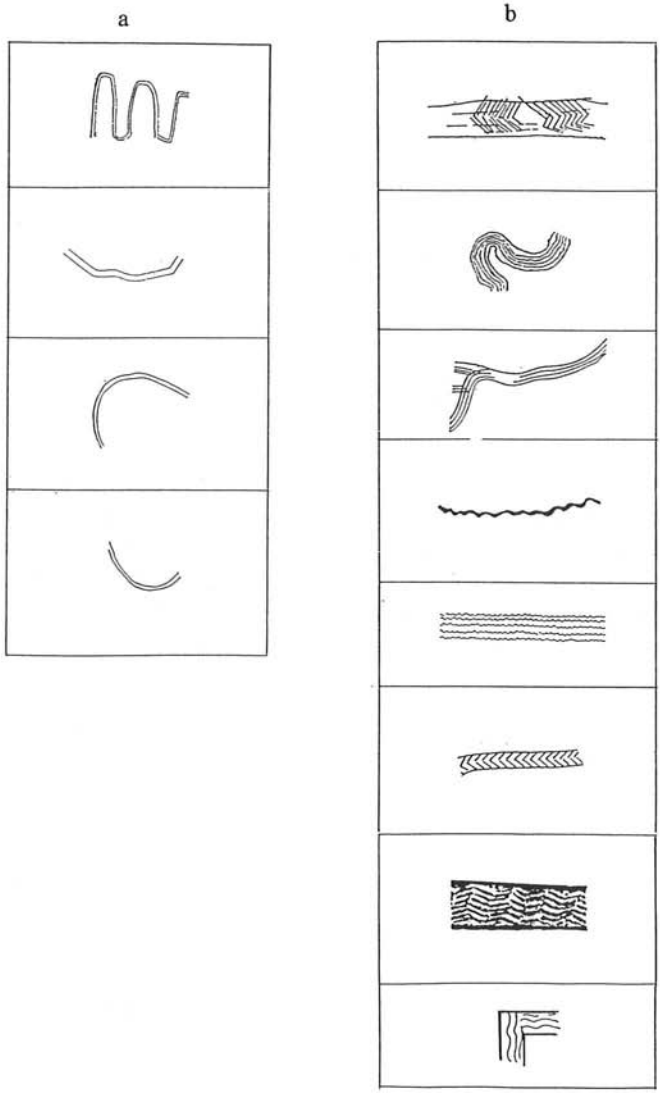


Fig.2 Double line objects - (a) and (b) - objects with difference pattern

Fig. 3 Direction of river stream or its origin

2.2 Syntactical variables of area objects

For area objects, only two examples have been selected (see Fig. 1). Syntactical unit for designing an area pattern/design is a "< - angle". Its symmetrical vertical or horizontal movement produces zigzag (broken or undulated) lines (see Fig. 4). Such lines form an area design (graphic variable: pattern) and cover the surface of the object. In such a way, wavy nature of the water surface is underlined.

Fig.4 Syntactic construction of undulated or zigzag lines of area objects

On some early historic maps (e.g. No 12 by DELACAMPAGNE, LESSING 1990), water surfaces are shown by blue colour. It corresponds already to modern mapping of water objects.

3. Summary

Prehistoric and early historic maps are not only archaeologic and cultural-historic monuments but also semiotic space - time models. Cartosemiotic properties of such models have not been studied at all. Cartographers (cartohistorians or cartosemiotians) are not responsible for it because a considerable accumulation of knowledge about such maps has happened within the last 7 to 10 years.

Syntactical analysis of some hydrographic objects on prehistoric and early historic maps (13 examples) has shown that two types of signs - abstract-geometric and symbolic (naturalistic) ones - may be found for linear patterns. Area signs are represented only by early historic maps which show the nature of the water surface by undulated or zigzag lines. Research of syntactical mapping peculiarities of water objects on prehistoric and early historic maps opens a new section or direction in the cartosemiotics. I believe that a new discipline - paleocartosemiotics - which is situated at the interfaces between cartosemiotics and history of cartography has to deal with such and other tasks (compare WOLODTSCHENKO 1997). That's an entirely new ground for cartosemiotians to be broken.

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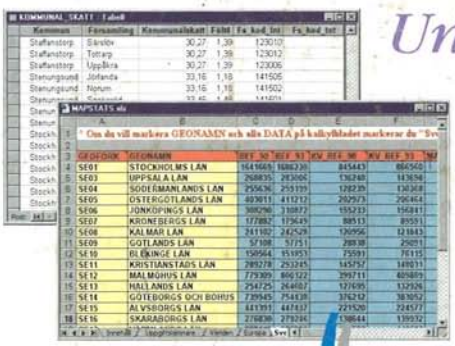

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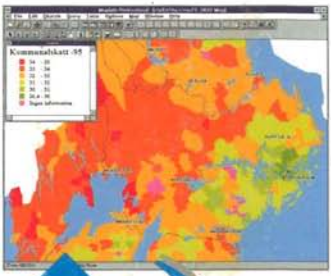

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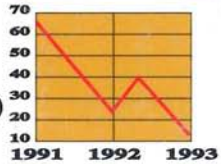

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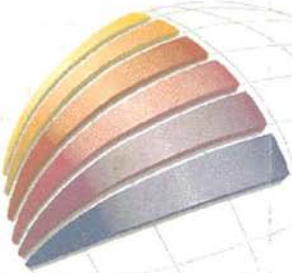

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