

CARTOGRAPHIC GENERALIZATION AND CONTRIBUTIONS TO ITS AUTOMATION

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The purpose of cartographic generalization is to represent a particular situation adapted to the needs of its users, with adequate legibility of the real situation and its perceptual congruity with the representation. Interesting are those situations which to some degree vary from the real situation in nature. This is a purposeful generalization where attention is directed towards particular, thematically valuable objects and their details. Difficulties in accomplishing the objectives of cartographic generalization are reflected in the basic approach. Some cartographers encourage the idea of complete prevalence of subjective approach to the process, yet accepting partial solutions that enable automated data processing of certain chart elements. Others stand for objectifying of all procedures, or schematic solving of all issues in the process, which will gradually lead up to the level where it could be termed automated. The latter is considered more acceptable by the authors of this paper, implying the necessary human intervention in the generalization, yet not to determine the course of the process, but just to act as a mediator.

Key words: cartography, generalization, chart, subject, object, process

Svrha kartografske generalizacije prikazivanje je određenog stanja, prilagođeno potrebama neposrednog korisnika, uz dostatnu čitljivost materijala i opazajnu podudarnost stvarnog stanja s prikazom. Zanimljive su situacije u kojima se, u odgovarajućoj mjeri, odstupa od stvarnih stanja u prirodi. To je svrsishodna generalizacija u kojoj se pozornost usmjerava prema određenima, tematski vrijednim objektima, te njihovim detaljima. Općenito, teškoće u realizaciji ciljeva kartografske generalizacije ogledaju se u temeljnom pristupu. Pojedini kartografi promiču zamisao o potrebi potpunog prevladavanja subjektivnog pristupa procesu, ali se prihvaćaju i parcijalna rješenja koja omogućuju automatiziranu obradu podataka za pojedine elemente iz sadržaja karte. Drugi se pak zalažu za objektiviziranje svih postupaka, *shematsko* rješavanje svih pitanja u procesu i njegovo postupno privođenje razini na kojoj ga se može nazvati automatiziranim. Autori članka drugi pristup drže prihvatljivijim, prema kojemu bi se novi načini u generalizaciji realizirali uz nužnu čovjekovu intervenciju, ali na način da on ne određuje tijek procesa, već obavlja samo posredničku ulogu.

Ključne riječi: kartografija, generalizacija, karta, subjekt, objekt, proces

Introduction

In natural environment human senses perceive globally, without details. Only when one has a particular interest he observes details, and this is a normal process, otherwise abundance of details would lead to confusion.

For similar reasons, in the process of cartographic generalization many details are omitted. Generalization is a natural occurrence present everywhere, as well as in cartography. Generalization in the process of compilation of the chart content is called *cartographic generalization*. This paper aims to explain the whole process of generalization and help towards its simplification and bringing it up as close as possible to the level of automatism.

Generalization (Lat. *generalis*) means the subjecting of individual to general, the reducing of everything under one notion. Its basic principle is evident from the analysis of the word meaning: reducing of individual to general.

Generalization is one of the most important determining occurrences in the modern cartography, included in cartographic representations (SALIŠČEV, 1976). Real quantitative and qualitative basis of cartographic generalization is determined by the chart purpose and scale, geographic indentedness, symbols, features of the represented objects, and other factors.

Besides on mathematical cartography, the main chart characteristic is based on the reducing of objects and representing them in a generalized form (FREITAG, 1977). It is a fact that modern determinants of chart and cartographic generalization largely correspond with each other (PETERCA ET AL., 1974).

Cartographic generalization is a set of processes by which the content of cartographic original is transformed into the content of a derived cartographic representation, so that they correspond perceptually with one another and with reality.

The chart scale has the greatest influence on generalization (HEISSLER, 1970). When dimensions of a representation are reduced, generalization is necessary not only for technical reasons (reduction of areas) but also for the essence of generalization, i.e. transition from individual features and occurrences to the general ones of global importance (SALIŠČEV, 1976). Because of the transition to a smaller scale, transformation in the cartographic process first implies the reduction of content. The reduction of content elements is bound to change some graphic details, which means that they are generalized to the required degree, so as to conform to the modified scale.

From the position of mathematical cartography, influence of scale on the content generalization is determined by the common definition of scale and its mathematical precision. From the position of cartographic generalization, influence of scale on the generalization of a chart original cannot be exactly determined.

With large scale charts, the process of cartographic generalization first of all implies reduction of the content of cartographic originals. Changing to smaller scales, the reduction procedure moves to a selection procedure. In addition to other factors, chart scale determines the procedure and degree of generalization, i.e. employment of particular generalization procedures and their intensity.

From the broadest position, it is hard to find any procedure in cartography that does not take account of the chart scale. For example, the commonly accepted classification of charts is based on the chart scale. The way of cartographic representation is changed depending on its scale. When laying down mathematical model of

cartographic generalization, the scale holds central position. Mathematical model of cartographic numerical generalization (TÖPFER, 1974) is based on the relations between the scales of *basic* chart and *derived* chart. The chart purpose is in a cause-and-effect connection with its scale, and it may have the same or even greater influence on other factors in the process of generalization, as well as on the chart scale (TJABIN, 1949).

In the production of thematic charts, primary generalization is related to the theme (purpose) of a chart. It is the so-called *purposeful generalization*. Its principles often differ from those of the generalization of general-geographic chart originals. In the process of purposeful generalization of a thematic chart original, the cartographer directs interest and attention to particular objects and their details in arrangement of natural features or occurrences.

As charts are used for all kinds of purposes, they differ very much in content. This requires the use of different cartographic originals, whose quality and quantity are significant factors that determine the procedures of generalization. On the thematically different charts, the same features or occurrences are treated differently. Such different treatment of the same cartographic originals predetermines the procedures of cartographic generalization. So, general rules of generalization are established only in principle. Generalization of charts with different themes is therefore prepared and carried out separately.

Cartography is a very old scientific discipline, and cartographic generalization dates back to the times of the first cartographic representation. Nevertheless, cartographers began to write about generalization only recently. M. Eckert (1921) was the first to observe that the point of generalization was in selection and reducing to general, its major factor being the purpose of chart. Eckert's opinion that cartographic generalization was a subjective process depending only on cartographer's skill, was considered wrong by K. A. Sališčev (1976). He claimed that cartographic generalization (as a practice of cartographer) was a process as much subjective as objective.

These issues were also dealt by other renowned cartographers as J. K. Wright, 1942, H. J. Steward, 1974, etc. Steward defines cartographer's subjectivity as a relatively spontaneous operation in which prevail personal ideas subject to variations that result from innate or acquired tendencies, knowledge and prejudices. He defines objectivity as an endeavour to reduce personal prejudices by systematic search of impartial criteria, widely applicable. Cartographic representation must be objective as much as possible, because of its application value and the use of chart itself. Demand for objectivity in the process of generalization is particularly evident when chart is made on several sheets, when more cartographic experts (chart compilers) work concurrently.

The first to lay down scientific foundations of the cartographic generalization was E. Imhof, 1937. According to him, large scale charts are more objective than the small scale ones. Procedures and methods of cartographic generalization aim to construct a new cartographic representation based on the original, so as to enable a reciprocally congruent flow of users' thoughts, and thus a correct perception of the charted area.

Major principles and methods in the cartographic generalization

Cartographic generalization is not a uniform mechanical reduction of content. Mechanical reduction may be used just as a tentative solution or a scheme in an

intermediate stage of the chart production. It would be wrong to apply the principle of uniformity in the cartographic generalization, as such mistake would demean generalization to a mechanical work, which would result in low-quality charts.

The principle of uniform employment of some cartographic generalization methods cannot be accepted either. Chart purpose and geographic indentedness are elements that give necessary *weight* to some generalization methods, determining which methods should be applied and to which extent. This requires from cartographers a deeper knowledge of the theme involved. Generalization of reality requires the knowledge and skill in selecting the significant from insignificant.

The principle of objectivity of representation also requires good knowledge of the theme. Generalization of reality requires distinguishing the significant from insignificant. Objectivity of representation is one of the factors that distinguish cartographic representation from the artistic one, ranking the process of generalization into a scientific creative work.

Some authors classify and elaborate generalization methods in different ways. Different methods of generalization are necessary not only for improvement of understanding, but also for the fact that, on chart, geographic reality is reduced, and this is the fundamental principle in the chart production.

Process of cartographic generalization is preceded by the selection of data (SOLARIĆ, 1997), so as to determine the kind of information to be represented on chart, as it is not possible to represent a large quantity of data on one sheet. Accordingly, all cartographic representations may be ranked into thematic ones.

Methods of enlarging, emphasizing, and selecting are contrary to the fundamental principle of cartographic generalization. Yet, these methods help to avoid mechanical uniformity when generalizing the content of cartographic originals.

Colours, marginal notes and other chart elements, which until recently were regarded as features of art, nowadays serve the purpose of technical or other requirements (e.g. biological, psychological, etc.). The result of such requirements is e.g. printing of some elements in fluorescent colours on modern charts.

Specific qualities of cartographic generalization in the production of thematic charts

Common principles of generalization are also applied in the process of production of thematic charts, taking into account special qualities of thematic charts. It is the above mentioned purposeful generalization. Thematic charts are specific, and they do not fit into standards as regards cartographic generalization. In the production of thematic charts, a certain theme is sorted out and emphasized, contrary to the common principle of generalization in the production of general-geographic charts. Content of thematic charts is of two kinds, including common geographic basis and special content which usually represents one theme, sometimes two or more.

Elements of the content of common geographic basis are not an ornament to the thematic content. They are the basis for identifying thematic content and enabling easier orientation on chart. Thematic and common geographic contents may have a fine inner feedback and reveal certain patterns.

The content of common geographic basis can be generalized up to a schematic representation. The concept of the common geographic basis content is aimed at

emphasizing and better understanding of the thematic content. Figure 1 shows the synoptic weather situation over Europe. Featured lines show isobars, the most important part of thematic content, whereas contours of European continent are generalized.

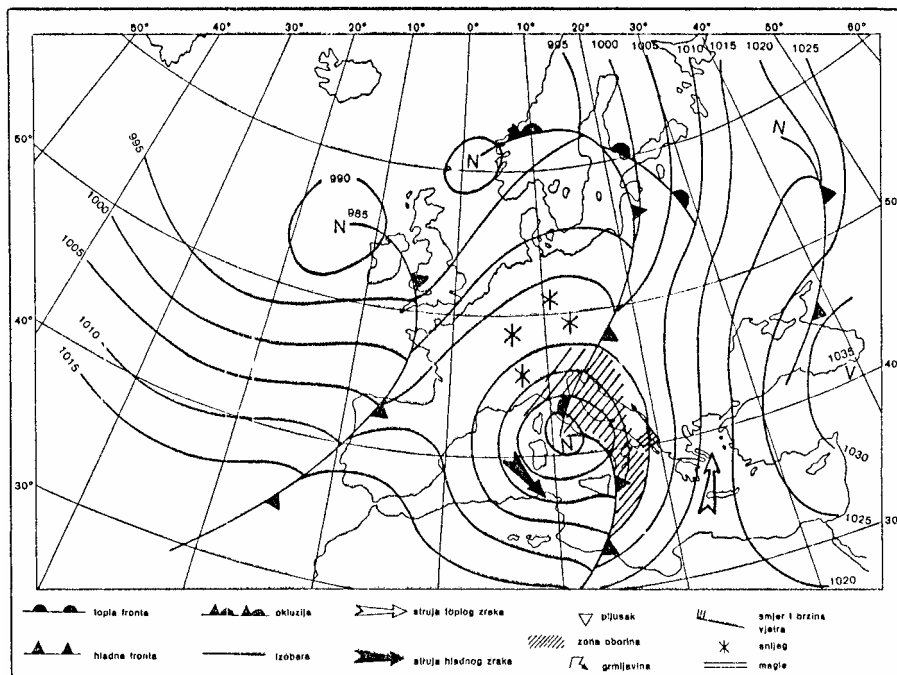


Fig. 1 Synoptic chart of Europe
Sl. 1. Sinoptička karta Europe

Elaborated theme defines more or less all other elements which finally determine the chart appearance. The theme and purpose of chart determine its scale, as well as the kind, form and size of chart symbols. Even geometrical precision and geographic authenticity of the chart content are subject to the theme.

The theme elements are not equally important, so there is stratification within the thematic content: emphasizing, selecting, suppressing, etc. This is the process of cartographic generalization of thematic content, being specific for each theme. The purpose of chart within the same theme may impose different demands. It may determine the appearance of a chart and thus require specific qualities in the process of generalization. When extreme demands are concerned, a part of thematic content may be considerably or completely omitted, or some details which in normal circumstances should be omitted may be represented. A good example are navigational charts.

Figure 2 shows a segment of the general chart of the Mediterranean Sea (scale 1:2250000) issued by the Hydrographic Institute of the Republic of Croatia (HHI) in Split. The islands of Jabuka and Palagruža and their shoals could not be represented to the

(intertidal areas) and earth's magnetic field. The distribution of geographic features is represented so as to include different natural and cultural features on sea, land, and in the submarine area.

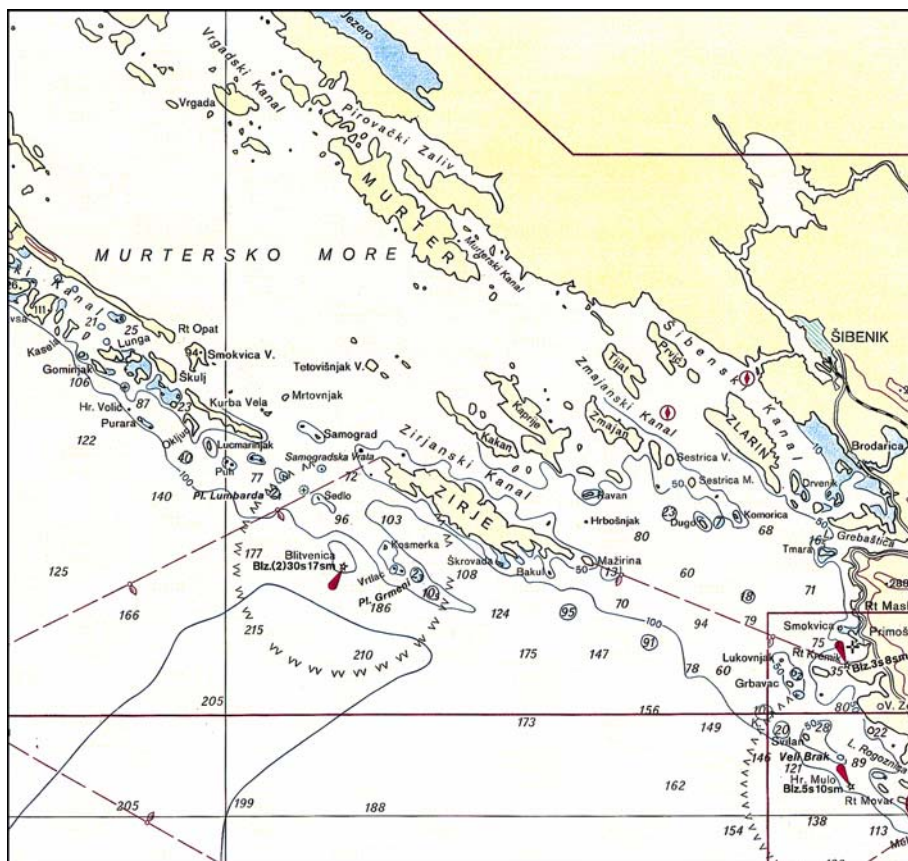


Fig. 3 Segment of sailing chart (Deutsches Hydrographisches Institut, 1993)

Sl. 3. Isječak pomorske kursne karte (Deutsches Hydrographisches Institut, 1993.)

It must be remembered that navigational chart is a scientific instrument, and must be handled like any other carefully produced and precisely calibrated instrument. Nautical chart differs from map because map can be useful even if it gives just a sketched representation of land, with no scale or relative relations, whereas chart must be exact. While features on land are visible and recognizable, most of the details on sea that are vital for navigation are hidden under the sea surface; navigator must rely on his chart, as there are no visual possibilities of checking the provided information on which the safety of his ship depends (CHRISS & HAYES, 1946).

Navigational charts can be classified among traffic charts, as well as economic or military charts (LOVRIĆ, 1976). The purpose of chart determines the kind of cartographic original to be used, procedures and degree of generalization, scale, and also exerts influence on editorial solutions. Another classification divides charts into marine charts and land maps (PLEIĆ, 1968, LOVRIĆ, 1976). According to it, navigational charts should fall under thematic charts, as they are used for solving complex problems, typical of maritime navigation. Distribution of geographic features and other occurrences important for surface navigation are therefore represented in a particular way. This is also reflected in a different treatment of the sea bottom relief and subjecting of all chart elements to meeting the needs of navigation and navigational safety, which is an essential characteristic of thematic charts.

In the production of thematic charts certain theme is selected and emphasized. This is contrary to the valid standards for generalization of general-geographic maps. So, in the process of production of thematic charts standards for generalization of cartographic originals are changed (HAKE, 1970).

Like with other thematic charts, the content of navigational charts is of two kinds: general-geographic and thematic. General-geographic content also serves the purpose of navigation and differs from the representation on general-geographic maps. The most important part of thematic content is emphasized and shown in magenta. Cartographic generalization of the data for representation of the navigational chart content is purposeful. It applies all the procedures and methods in the theory and practice of purposeful cartographic generalization. From the above mentioned it can be concluded that navigational charts are thematic. Within thematic charts there are classifications according to scale, coverage area, etc.

The difference in representation (for different purposes) is evident in figure 4. In the upper part there is a segment of topographic map on 1:100000 scale, and in the lower one a segment of navigational chart on the same scale. Both charts show the same area. It is obvious that the same features are represented in different ways. This results from different treatment of content on charts with different purposes.

Representation and generalization of the land content on navigational charts

Land content on navigational charts is represented restrictively, usually being reduced to a narrow strip of land along the coast. Details in representation of land depend on the chart scale, whereas its coverage depends on the configuration of relief. If the coastal relief is unindented and relatively low, the represented strip of land usually extends up to six nautical miles from the coastline. If in the represented area there is a watershed, this strip can be even narrower, extending only to the watershed. It is therefore reduced to the strip of land observed from the sea (SOLARIĆ, 1997).

Details in representation as well as the width of the represented land area also depend on the purpose of chart and its scale. On larger scale charts which are used for terrestrial navigation the land is represented in more details than on the sailing charts. General charts show the least amount of details on land. The land of islands is shown complete.

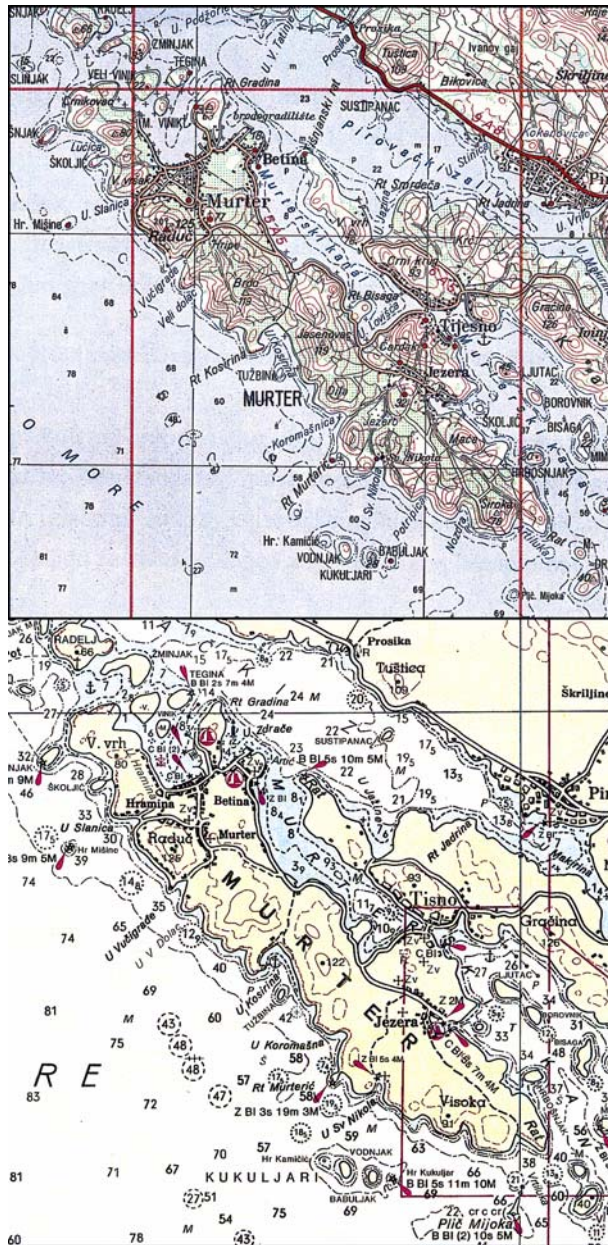


Fig. 4 Parallel representation of the island of Murter and a part of the coast on the topographic map and nautical chart (VGI, 1986 and HHI, 1996)
 Sl. 4. Usporedni prikaz otoka Murtera i dijela obale na topografskoj i pomorskoj karti (VGI, 1986 i HHI, 1996.)

Representation of natural and cultural features on land is typically thematic. By emphasizing the features that are conspicuous from the sea, and omitting or suppressing those insignificant, the purpose of representation for terrestrial navigation is achieved. The purpose of such representation is an easy and unambiguous recognition of appropriate landmarks.

Topographic base (relief, settlements, roads, railway, etc.) serves for rough orientation and easier recognition of conspicuous landmarks. Navigation at night or in poor visibility conditions requires special facilities - lights and lighthouses. The objects on navigational charts that serve navigational purposes are charted with higher geometric precision, and lighthouses are determined by the coordinates in the state survey system. Suitability of landmarks is checked by the field control in the final stage of production of compiling original.

On the navigational charts of the Croatian Hydrographic Institute land area is shown in light yellow colour. On the charts issued by hydrographic institutes of other countries, the tint of land may be different, but it is usually orange or ochre (SOLARIĆ, 1997). Yellow tint is suitable for use by night when the light is poor, as it is in contrast to the white colour of paper showing the sea area, not dazzling or impeding its legibility.

Land relief is shown by contour lines, additional conventional symbols and spot heights. Equidistance is greater than that on the topographic maps of the same scale.

Crops are not represented. Non-navigable water streams are shown by black lines. Special attention is paid to the representation of coastline features (steep, rocky, flat coast, etc.). When using such way of land representation, greater parts of a chart may remain without drawings. Gaps are usually used to insert plans of harbours and passages, showing dangerous parts of the sea area covered by the chart.

Representation and generalization of the sea content on navigational charts

In the process of production of a navigational chart special attention is paid to generalization of the sea content and its representation. Basic cartographic originals for the representation of sea on navigational charts are fair charts. As a rule, their scale is larger than the one of a nautical chart, and should be reduced (Fig. 5 and 6) to the scale of the chart to be published. Content of the cartographic original obtained by reduction is not generalized. Generalization is done in the process of production of the compiling original.

The basic rule for generalization of the fair chart content is simple: it is necessary to represent those depths that are essential for marine navigation procedures and safe guiding of a vessel. Besides depths, it is necessary to show natural and cultural features important for safe navigation: rocks, lights, buoys, beacons, etc. (Fig. 7)

Nevertheless, generalization of the sea area content according to the above mentioned rule is a very complex process. In difficult areas (straits, passages and channels, shoals, rocks, etc.) manoeuvring of a vessel requires much more effort and skill (Fig. 8). Besides physical obstructions, sometimes unfavourable meteorological conditions occur: wind, waves and currents. To ensure navigational safety, such sea area is marked by lighthouses, buoys and beacons, either lighted or not. Light characteristics consist of a series of alphanumeric signs of considerable length, e.g. (original size):

B DBI (3) 240s 110m 22M

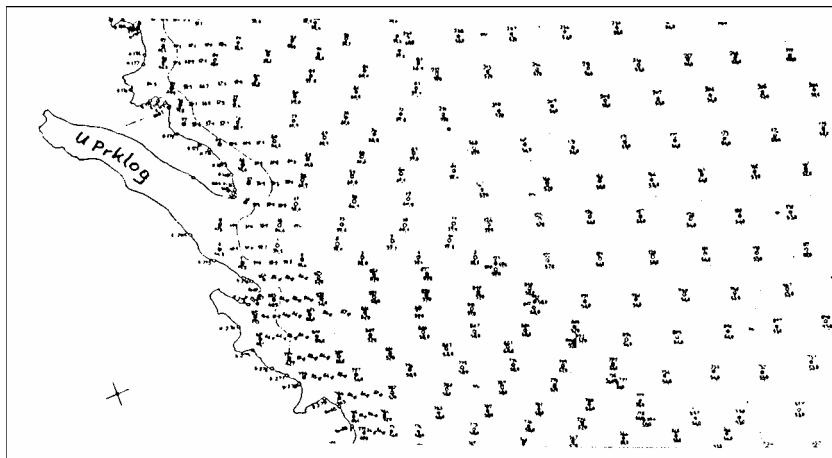


Fig. 5 Part of fair chart on 1:25000 scale, photographic reduced to a scale of 1:55000 (chart Riječki zaljev, 50-4, HHI, 2001)

Sl. 5. Dio hidrografskog originala u mjerilu 1:25000, fotografski smanjen u mjerilo 1:55000 (karta Riječki zaljev, 50 – 4, HHI, 2001.)

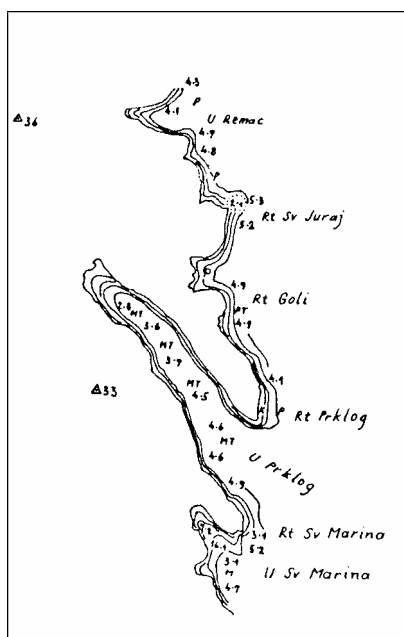


Fig. 6 Part of fair chart on 1:10000 scale, reduced by mechanical pantograph to a scale of 1:55000 (chart Riječki zaljev, 50-4, HHI, 2001)

Sl. 6. Dio hidrografskog originala u mjerilu 1:10000, smanjen mehaničkim pantografom u mjerilo 1:55000 (karta Riječki zaljev, 50-4, HHI, 2001.)

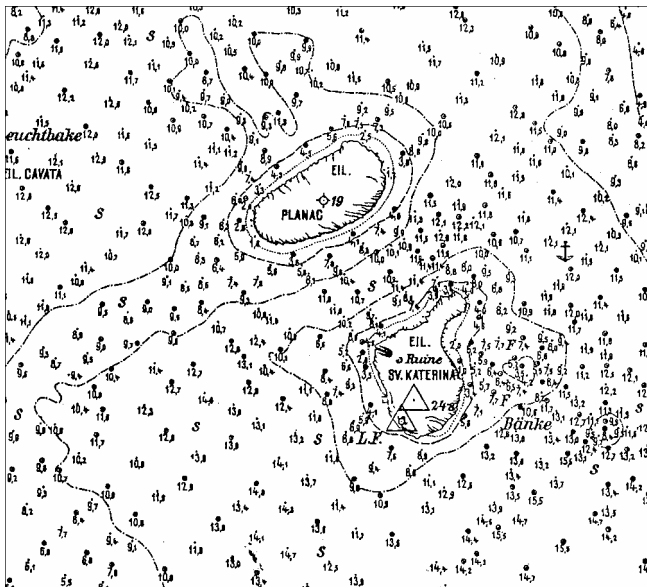


Fig. 7 Part of fair sheet on 1:12500 scale (Austrian Hydrographic Office, 1908)
 Sl. 7. Dio sondnog lista u mjerilu 1:12500 (Austrijski hidrografski ured, 1908.)

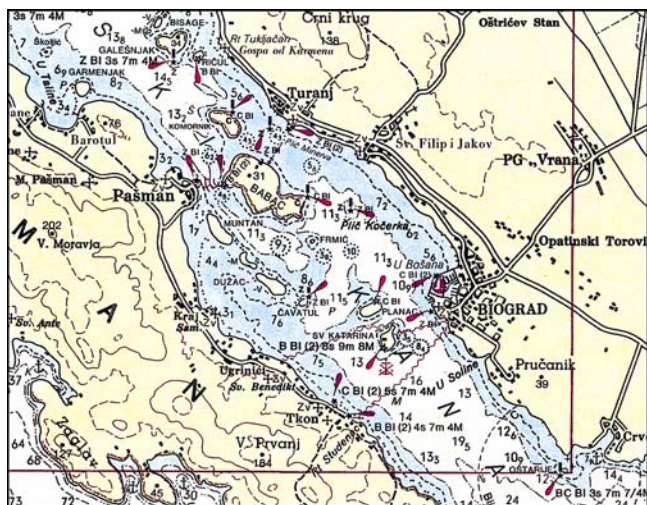


Fig. 8 Segment of chart 100-20, produced on the basis of fair sheet shown in Fig. 7 (HHI, 1996)
 Sl. 8. Isječak karte 100-20, izrađen na temelju sondnog lista sa sl. 7 (HHI, 1996.)

It is also very important to represent recent deposits of the sea bottom, underwater installations (cables and pipelines), wrecks, etc. The configuration of the sea bottom may be represented by depth contours. They serve their function only if represented in continuity. In the above mentioned circumstances it is not easy to obtain the continuity of depth contours.

The essential task in the chart production is to represent a particular area by generalization of content, so that the chart may provide quantitative and qualitative information sufficient for a navigator to make correct decisions for safe manoeuvring of his ship. In order to facilitate the tasks of generalization and representation of content, large scale plans of harbours and passages are produced. This is one of the reasons why the symbols on navigational charts are always of the same size regardless of the chart scale. Much simpler task is generalization of content and representation of the deep sea with unindented sea bottom relief.

Cartographic generalization of the sea area content starts with a careful exploring of the fair chart content. It is necessary to define the coastline and its characteristics (e.g. steep, rocky, flat, etc.). Special attention is paid to shoals and rocks, which are defined first.

Alterations of depths are interesting, especially their sudden increase. Such features become completely defined by showing their nearest surroundings, so their configuration is represented in the whole.

The remaining sea area is filled up by typical depths. Their distribution must be uniform but not arranged geometrically. The distribution of the depths on chart should not be indicative of the depth survey lines. The density of typical depths must create an impression of a uniform survey, to provide the users of charts with a sense of safety and reliability. An excessive density of typical depths results in illegibility, rendering shoals and other important features less observable. Lack of experience in the selection of depths usually results in their excessive density. In the area of an unindented sea bottom relief, depths are equal in importance, i.e. typical, and the procedures of generalization conform to that.

Any obstruction and danger to surface navigation must therefore be represented on chart, as well as all objects used to mark them.

Symbols and abbreviations used on charts play a prominent role in the manner and procedures of generalization, and the possibilities of representation (SALIŠČEV, 1976). However, it is not possible to represent every detail on chart. For this reason pilots, as supplements to charts, are published.

Possible objectifying of cartographic generalization

Many cartographers would probably disagree about total excluding of subjectivity and complete objectifying of cartographic generalization. However, new technological approaches in the production of charts undoubtedly follow this course. As it was previously stated, such process probably cannot lead to a complete automation, but in an effort to optimize cartographic generalization, quantitative relation between the *subjective* and *objective* has been already changed in favour of objectivity.

Complete objectivity of representation can be achieved only by establishing the subject patterns of cartographic generalization. Such patterns have not been established to

date. In the opinion of some cartographers, it will never be possible to establish the patterns which would allow the process of cartographic generalization to proceed as per a mathematical formula. Their chief argument is the creative process of cartographic generalization, which makes any definition of its mathematical model impossible. However there are other opinions, considering that methodological approach to the process of cartographic generalization should be completely changed. By such interventions, the level of mathematical model will not be obtained immediately, but will become considerably closer.

Nowadays, cartographic generalization is still regarded as an all-creative activity which is not subject to any patterns. In spite of it, efforts are made to establish patterns which would approximate modern generalization as much as possible, yet without going to the other extreme. Principles, methods and procedures of generalization should be studied in the light of current mathematics, theory of information, cybernetics and other sciences, and the process of generalization transformed in accordance with their operational possibilities. There is no doubt that most of the principles, methods and procedures can be efficiently redefined without any threat of endangering the very purpose of cartographic generalization. After comprehensive scientific research (TÖPFER, 1974) certain results were achieved and some patterns were very exactly defined. Nevertheless, even on the basis of such patterns the process of cartographic generalization has yet to become completely automated.

Being a particularly inventive process, generalization can be analyzed in different ways, among which the following procedures are usually mentioned:

- *generalizing* (representing of general characteristics, omitting of details, subsuming under a general notion);
- *reducing* (condensing; less important part of the content may be reduced in order to highlight another part);
- *replacing* (if unable to be represented, a part of the content is replaced by another representation);
- *restricting* (if a part of the content, characteristic of an area, is too extensive, its representation is restricted);
- *joining* (linking together, representing in entirety or condensing; areas are usually joined into a whole in order not to lose smaller, scattered parts);
- *simplifying* (condensing; turning of some complex forms into the simpler ones);
- *enlarging* (enlarging of some small, very important features; typical procedure in the production of thematic charts);
- *selecting* (quantitative and qualitative; it is selecting according to a key);
- *emphasizing* (highlighting in different ways, e.g. by conspicuous colour);
- *shifting* (two important features close to one another are shifted apart to represent both of them); depending on scale, kind of chart and representation any chart element may be shifted; natural features are usually last-shifted;
- *changing the way of representation* (for the sake of importance of features, the way of representation is changed according to scale; e.g. the river navigability regardless of its width);
- *excluding* (relevant to some features or parts of a whole);
- *suppressing* (representing in the background, in a lighter colour, etc.);
- *classifying* (ranking of features; e.g. bathymetric chart), etc.

From the analysis of the above mentioned procedures and methods it may be inferred that some of them overlap, i.e. they are more or less contained in one another. The conclusion arises that such methods and procedures may be joined together. Joining should be done very carefully. Special consideration must be given to the possibility of defining the united procedure or method, so as to provide the highest possible level of exactness. The point is to extend the possibility of construction of mathematical models, that is automation in the short and long run. When selecting and uniting the methods and procedures of cartographic generalization, due attention should be also paid to the existing software tools and computer operation in general.

It is not always possible to construct mathematical model, but other sorts of interpretations can be applied, which can be automated (e.g. geometric interpretation). In general terms, it is necessary to set a logical, unambiguously repeatable pattern of elements needed for regular development of the process. Unambiguous repeatability of process that meets habitual procedures of cartographic generalization, is objectifying of the process of cartographic generalization, which is an ultimate objective in its development.

Conclusion

Cartographic generalization is a set of processes by which the content of cartographic original is transformed into content of a derived cartographic representation, so that they correspond perceptually with one another and with reality. The real quantitative and qualitative basis of cartographic generalization is determined by the chart purpose and scale, geographic indentedness, symbols, represented features, and other factors.

From the position of cartographic generalization, influence of scale on generalization of a chart original cannot be exactly determined.

In the production of thematic charts, primary generalization is related to the theme of a chart. On the thematically different charts, the same features or occurrences are treated differently. Such different treatment of the same cartographic originals predetermines the procedures of cartographic generalization. The generalization of charts with different themes is therefore prepared and carried out separately.

Cartographer's subjectivity is defined as a relatively spontaneous operation in which all unique qualities of a personal idea prevail and are subject to variations in a wide range. Objectivity is an endeavour to reduce personal prejudices by systematic search of impartial criteria, widely applicable. Cartographic representation must be objective as much as possible.

Cartographic generalization is not a uniform mechanical reduction of content. So, the principle of uniform employment of some methods of cartographic generalization cannot be accepted as an appropriate working method, because generalization of reality requires knowledge and skill in selecting the significant from insignificant.

The principle of objectivity of representation makes it possible to distinguish the significant from insignificant, as well as cartographic representation from the artistic one. Elaborated theme more or less defines all other elements. These elements are not equally important, so within the thematic content there is a stratification specific for each theme.

Land content on navigational charts is represented restrictively, usually being reduced to a narrow strip of land along the coast. Details in the representation of land depend on the chart scale, whereas its coverage depends on the configuration of coastal relief. On larger scale charts which are used for terrestrial navigation the land is represented in more details than on smaller scale charts (sailing charts). General charts show the least amount of details on land. Representation of natural and cultural features on land is typically thematic. By emphasizing the features that are conspicuous from the sea, and omitting or suppressing those insignificant, the purpose of representation for terrestrial navigation is achieved.

In the process of production of a navigational chart special attention is paid to generalization of the sea content.

New technological approaches in the production of charts lead towards total excluding of subjectivity and complete objectifying of cartographic generalization. By today, quantitative relation between the *subjective* and *objective* has been already changed in favour of objectivity, though the patterns of cartographic generalization have not been established yet. By the actions taken, the level of mathematical model will not be obtained immediately, but will become considerably closer.

From the analyses of procedures and methods of cartographic generalization, it may be inferred that some of them overlap, i.e. they are more or less contained in one another. This leads to the conclusion that such methods and procedures may be joined together, but special consideration must be given to the possibility of defining each united procedure or method. It is not possible to construct a mathematical model for any situation, but the other sorts of interpretations liable to automation can be applied (e.g. geometric interpretation).

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SAŽETAK

Z. Bičanić, R. Solarić: Kartografska generalizacija i prilozi njezinoj automatizaciji.

Kartografska generalizacija složen je proces koji se sastoji od brojnih postupaka temeljenih na karakterističnim načelima i različitim metodama. Izbor metoda i postupaka u realizaciji ovisi o namjeni, mjerilu karte, geomorfologiji akvatorija, simbolizaciji i drugim brojnim čimbenicima. Kartografska je generalizacija skup *podprocesa* s kojima se mijenja sadržaj kartografskog originala u nakani prilagodavanja sadržaja karte određenim potrebama (namjeni). Svrha same operacije je kartografsko prikazivanje određenog stanja, prilagođeno potrebama neposrednog korisnika, uz dostatnu čitljivost materijala i opažajnu podudarnost stvarnog stanja s prikazom.

Zanimljive su situacije u kojima se, u odgovarajućoj mjeri, odstupa od stvarnih stanja u prirodi. To je svrsishodna generalizacija u kojoj se pozornost usmjerava prema određenim, tematski vrijednim objektima, te njihovim detaljima. Ovo naročito vrijedi za zemljopisne objekte i prirodne pojave.

Teškoće u ostvarenju kartografske generalizacije ogledaju se u temeljnom pristupu. Naime, stanoviti dio kartografa promiče zamisao o potrebi potpunog prevladavanja subjektivnog pristupa procesu, budući je to (prema njima) oblik izrazito prisutnog stvaralačkog djelovanja, koji se temelji na punoj osobnosti kartografa. Djelomice su u pravu, jer opći algoritam za kartografsku generalizaciju još ne postoji. Međutim, postoje parcijalna rješenja koja omogućuju automatiziranu obradu podataka za pojedine elemente iz sadržaja karte (generalizaciju crta, riječne i kopnene prometne mreže, naselja itd.). Drugi pak, osobito suvremeni znanstvenici, problemu pristupaju na pragmatičan način. U prvom redu zalažu se za objektiviziranje svih postupaka, *shematsko* rješavanje svih pitanja u procesu i njegovo postupno privođenje razini na kojoj ga se može nazvati automatiziranim.

Autori članka drugi pristup drže prihvatljivijim i ostvarljivim u najvećem dijelu, svjesni okolnosti i potrebnih predradnja do njegove realizacije i oblikovanja kao matematičkog modela. Podržavaju sva nastojanja koja mogu rezultirati izvrsnim postignućima. Novi načini u generalizaciji svodili bi se na vrsnu pripremu podataka i operacijskog materijala, uz nužnu intervenciju sadašnjeg subjekta – čovjeka, ali tako da on ne određuje tijek procesa, već obavlja samo posredničku ulogu.