

TECHNICAL GEOGRAPHY: CORE CONCEPTS IN THE MAPPING SCIENCES

Ferjan Ormeling

Faculty of Geographical Sciences, Utrecht University, Netherlands

Keywords: approaches to cartography, scientific visualization, information theory, digital revolution, World Wide Web, cognitive mapping, generalization, coordinate systems, ellipsoids, data merging, global spatial data initiatives

Contents

1. Introduction, Formalistic and Communication Approaches in Cartography
 2. Mapping as a Value-Adding Process/Cognitive Reactions
 3. Digital Conceptual Influences
 4. The Complexity of Cartographic Messages
 5. Human Input into Map Reading
 6. Mapping as a Selection Process
 7. Aspects of Meta-Communication (Communication about Communication)
 8. Reference Frames and Mapping
 9. Merging of Data Sources
 10. New Trends
 11. Global Data Initiatives and Global Data Access
 12. International Mapping Framework
- Glossary
Bibliography
Biographical Sketch

Summary

The evolution of cartography from map production into the field that provides adequate visualized spatial information in order to support spatial decision making is presented, with the influences of information theory, the digital revolution, scientific visualization and the information explosion on the World Wide Web taken into account. The scientific aspirations of the field were promoted through psychophysical studies and feedback approaches that learnt the effects of different representation modes. As is the case in all mapping sciences, there is an increased tendency, because of automation of techniques, to shift attention from map production proper to geo-information management. The cartographers' traditional preoccupation with data quality has prepared them adequately for serving users' needs in the current and future spatial decision making processes aimed at preserving the sustainable development of our planet.

1. Introduction: Formalistic and Communication Approaches in Cartography

Cartography used to be considered as the science of preparing all kinds of maps and charts, including every operation from original surveys to final printing of copies (United Nations 1949). Nowadays we would regard this as a definition for the mapping

sciences that also include Surveying, Photogrammetry and Remote Sensing next to cartography.

The scientific challenge in those days used to exist in the selection of proper symbols and colors for specific map themes. Effectiveness rarely entered into the deliberations, and it can be said that cartography's approach used to be formalistic. The theoretical literature, primarily German (Eckert, *Die Kartenwissenschaft*; Arnberger, *Handbuch der thematischen Kartographie*; Witt, *Thematische Kartographie*) supported that approach. Only with the publication of Jacques Bertin's *Sémiologie graphique* in 1967 a new approach was heralded, which took the effects of the graphical signs into account, especially their role in visualizing relationships between map symbols, or between geographical objects in reality. A correct graphical representation of spatial reality came to be understood as a representation that conveyed the correct ideas about reality to the map-reader. And this goal could be reached by adhering to the graphical grammar developed by Bertin. It was in these days that cartography came to be understood not only as production of maps but as map use as well. The definition of the International Cartographic Association came to be: Cartography is the science, art and technology of producing maps as well as their study as scientific documents and works of art (ICA 1973).

Due to the informatics approach in the United States, primarily conceived in the 1950s for optimizing telephone communication, cartography came to be regarded there as communicating spatial information by means of maps. Terminology and concepts, such as *noise*, *senders* and *receivers*, came to be introduced, as was *redundancy*, needed to get across a telephone message, as there was an inevitable loss of data during the communication process. However, in the end it was realized that cartography did not fit this communication model. By mapping a phenomenon extra information is generated, because it is put in a spatial context. Generalization on the one hand diminishes the amount of data, but on the other presents new, more overall patterns and trends, hitherto hidden. Moreover, more than optical legibility was needed for getting a cartographical message across.

The communication approach was essential for the further development of the subject, however: it gradually dawned upon the cartographic community that maps were just a means, and not the final aim of cartography. These views had first been aired in 1967, by Christopher Board, and the impact and geographic course of the communication approach thus started can be superbly followed in the International Cartographic Yearbook - by looking at the year and geographical origins of the contributions on the communication theme. Board's *Maps as Models* (1967) was published in the midst of the quantitative revolution in Geography. Board had been influenced by communication models from Information (Systems) Theory (Shannon and Weaver 1949), which had a linear, one-dimensional approach to the process of information transfer. He transformed this linear model used in Information Theory to a circular one, at about the same time (1969) that Kolacny in Czechoslovakia developed a similar feedback view of the cartographic communication process. This feedback model was what really got cartographic research going beyond simple psychophysical studies.

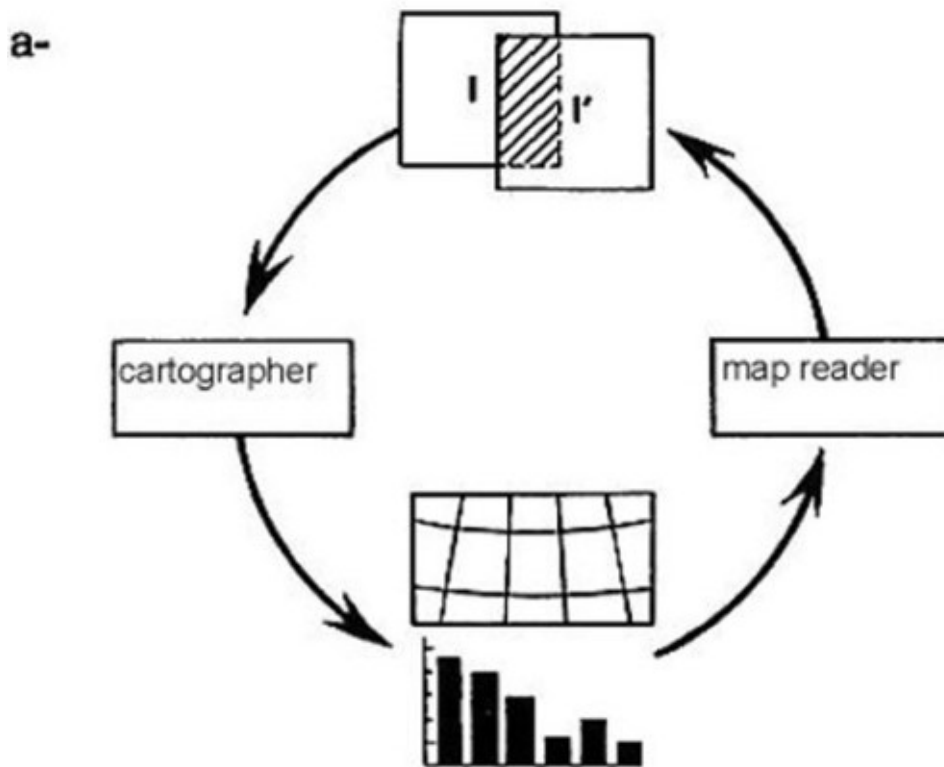


Figure 1: Model of cartography as a feedback view of the cartographic communication process, based on Kolacny and Board.

So it was through the influence of Board and Kolacny that cartographers began to view maps as means of spatial information transfer instead of as an end product. The central tenet was, from then onwards: how to get geographical information to the user in the visualized form he or she needed. A major research effort was started in order to answer this question, but useful results only came in after the circular cartographic communication model was modified by Muehrcke (1972) into a practical, restricted structure which viewed cartographic communication as a series of transformation processes, whose starting point was not provided by an intangible mass of spatial knowledge but just by the raw data used for the map.

2. Mapping as a Value-Adding Process/Cognitive Reactions

The terminology introduced by the Information Theory approach was adopted in cartographic communication, even though it was realized that no such thing as linear communication existed in cartography, and even though in most forms of communication it was realized that feedback, as a way to introduce learning into the system, should be accounted for. The first point was made by both Salishchev and Bertin. Salishchev (1978) himself was a partisan of the cognitive approach to cartography, which implied that during the mapping process information was actually added. Bertin showed that communication through maps was not a linear but at least two-dimensional process, and that the concept of information loss during communication and its compensation through redundancy actually did not apply to maps. Getting there by other routes than Salishchev did, Bertin also emphasized the

added value concept of maps. The concept that mapping puts information in a spatial perspective and so makes hidden patterns visible and unveils relationships, this whole added value concept which is linked to mapping is alien to Information Theory. As a matter of fact all major steps in cartographic visualization add value to the information: they characterize, make visible, legible, understandable and accessible.

The added value concept of cartography also has to do with art. In the 1970s, in the rush to get Cartography recognized as a science in its own right, cartographers tried to do away with art. But insofar as art leads us to view the essentials -- of a person's character, of a landscape, of a relation between persons or objects -- it is similar and related to cartography, which tries to convey the essential aspects of spatial distributions through optimal classification systems, generalization, scale selection, etc. Just as a portrait painter would try to get to know the person he or she is going to paint beforehand, so a cartographer should analyze the essential characteristics of the theme, in order to highlight the most important aspects and organize the various levels of information hierarchically on a number of visual planes, in accordance with their relative importance. In this way they would adapt the graphical priority (through applying the necessary contrast) to the message priority. This is why the cartographer cannot be satisfied with the role (usually assigned to him by others in the surveying and mapping field) of merely tidying up the graphical image, but should analyze the information contents of the message first.

The communication approach allowed cartographers to test whether the output (information received by the map readers) equaled the input (raw data processed into the map). The success of a map came to be regarded in terms of the percentage of overlap between input and output. The goal of cartography according to the communication approach came to be the maximizing of this overlap (see model in figure 1). Otherwise this approach put the cartographer in the role of communicating, passing on, spatial information, without much creative input. The cognitive approach put it that cartography was the process of getting to know reality by mapping (as a form of modeling) it. By modeling reality, comparing the model against reality and checking and fine-tuning it, one gets to know reality.

3. Digital Conceptual Influences

It should be understood that without the digital revolution the modification in cartography's goals from map production to spatial information transfer could never have been implemented. It would have been practically impossible to produce customized maps, to experiment with design issues (projections, classification systems, map types, colors or shading patterns), or to experiment with map contents without the help of digital means, that provided the necessary speed. The only exception to the impossibility of providing customized maps before the digital revolution was provided by the Tripticks of the American Automobile Association and its European sister societies, which bundled route segment descriptions into customized route guides for their tourist members. The texts for these descriptions were stored in an analogue database, a sort of manual GIS, and the relevant maps were added to this GIS by pasting them in. But in the overall development this AAA initiative merely is an anecdote: It should be borne in mind that the communication revolution was followed by an

automation or digital revolution, and this one separated the two functions of maps that had been combined since the inception of mapping, that is those of *storage* and *display*. This had tremendous implications for map design, as it allowed for the on-line production of customized maps from a database, by the combination of those information layers that were deemed necessary for a particular task for a particular client (group), to be used under given conditions.

A good example of the contribution by the computer can be shown by the electronic chart. Nautical charts have never been outstanding means of information transfer, because so much data had to be stored in them, even though they were part of an information system that also consisted of Notices to Mariners, Sea Current Almanacs, Tidal Tables, etc. Information on directions of lights, on shoals, and other hazards, soundings, rights of way, had to be combined with shoreline data, and this made them too complex, really, to be compared with other navigational aids such as radar or coastal outlines. Nowadays, in an electronic environment, the pilot can select those layers he is interested in (e.g. only soundings or only isobaths, or only those areas too shallow for his craft highlighted), can have his ship's position indicated on the electronic map, and can even have the radar image superimposed over the map, so that not only his own but other ships' positions will be rendered in overlay on the map. See figure 2.

Now, as from 1985 onwards, the storage function could be played by the digital files from which, based on the specific application of demand, a selection could be presented, answering these requirements. Customized maps could be made, instead of general maps that had to answer all kinds of requirements. The computer also allowed for new visualizing techniques. Since the 1840s, really, no new types of cartographical representation had been developed until the advent of the computer. All map types known were in existence by then already. But due to the computer, the regular production of animations and 3D representations became economically possible, and the map got additional function, that is of exploration. Researchers that wanted to get insight in the hidden patterns in spatial distributions mapped them with different techniques, transformed them, changed classification methods, colors, exaggerated dimensions, changed aggregation levels, until some meaningful relationships emerged. This new approach to cartography can be termed visualization cartography, as opposed to communication cartography. For the first, no grammar exists as yet.

Finally, our view of cartography is affected again by the information explosion since 1995, when the World Wide Web and Internet emerged. Spatial information is available everywhere around us, to be reached via the web (Kraak and Brown, 2000). Maps, plans, satellite images can be downloaded, frequently free. The role of the cartographer changes and consists now also of showing the spatial information available to us, and how to adjust it so that it can support our spatial decision making processes. Because of this the definition of cartography can be reformulated again; cartography is making spatial information available, adjusting it to specific uses and communicating it, stressing visualization and interaction, adjusted to solving spatial queries and problems.

-
-
-

TO ACCESS ALL THE 21 PAGES OF THIS CHAPTER,
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

Bibliography

- Amberger, E. (1966), *Handbuch der thematischen Kartographie*. Wien: Deuticke. [Description of formalistic aspects of the design of topical maps]
- Bertin, J. (1967), *Sémiologie graphique*. Paris/Den Haag, Mouton. [Most important text on cartographic communication]
- Blakemore, M.J. and J.B.Harley (1980), Concepts in the history of cartography. *Cartographica*, vol. 17-4, pp 5-107. [First presentation of the theoretical background of the history of cartography]
- Board, C. (1967), Maps as models. Pp 671-725 in: R.J.Chorley and P.Haggett – *Models in Geography*. London: Methuen. [First presentation of cartography as a communication science]
- Eckert, M. (1921), *Die Kartenwissenschaft. Band I und II*, Berlin und Leipzig: De Gruyter, 1921, 1925. [First presentation of cartography as a science]
- Global Map (2000), Global Map Version 1.1 Specifications adopted at 7th ISCGM meeting, Cape Town, 16 March 2000. Downloadable from ISGCM homepage: <http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi?page=Documentation> [Specifications for a unified global map series at the scale 1:1Million]
- Al Gore (1998), The Digital Earth: Understanding our planet in the 21st Century. Speech held January 31-1998. Downloadable from http://www.isde5.org/al_gore_speech.htm [Summons for a free exchange of spatial data for scientific, sustainable development purposes]
- Head, C.G. (1984), The map as a natural language: a paradigm for understanding. In: *Cartographica* vol 21-1, pp 1-32. [Text that shows how the information from a map is inserted in the spatial knowledge of our environment]
- International Cartographic Association (1973), *Multilingual dictionary of technical terms in cartography*. Wiesbaden, Steiner Verlag. [Fundamental for mutual understanding in cartography; now outdated as it lacks the terminology on digital cartography]
- Knöpfli, R. (1990), Die Bedeutung der Ästhetik für die Übertragung von Information (The significance of aesthetics in transmitting information). In: *International Yearbook of Cartography* vol. 30, pp 71-79. [Stimulating text on the importance and function of generalization]
- Kolacny, A. (1970), Kartographische Informationen. Ein Grundterminus der modernen Kartographie. *International Yearbook of Cartography* vol X, pp 186-193. Also: Cartographic information: a fundamental concept and term in modern cartography. *Cartographic Journal* vol 6-1, 1969, pp 47-49. [Presentation of cartography as a communication science, where feedback from map readers is crucial for improving the map as a model of reality]
- Kolaczek, B., Kovalevsky, J. and Mueller, I. (eds.) (1989), *Reference frames*. Dordrecht: Kluwer Academic Publ. [Fundamental text on datums and the geoid]
- Kraak, M-J. and A.Brown (2000), *Web cartography*. London, Taylor and Francis. [Manual for map production and dissemination on the Internet]
- MacEachren, A. (1992), Visualization. Pp 99-138 in R.F.Abler, M.G.Marcus and J.Olson, *Geography's inner worlds*. New Brunswick, NJ: Rutgers University Press. [State of the art of cartography, produced for international geographical conference in Washington]

MacEachren, A. (1994) – Visualization in modern cartography. Chapter 1 in A.MacEachren and D.R.F.Taylor – *Visualization in modern cartography*. Oxford: Pergamon. [Highlights the emergence of visualization vs communication in cartography, aimed at data exploration]

MacEachren, A. (1995), *How maps work*. New York and London: The Guildford Press. [Overview of the state of the art in cognitive mapping and map reading]

McLuhan, M. (1962), *The Gutenberg galaxy*. Toronto: Toronto University Press. [General view of the impact of printing on our global society]

McLuhan, M. (1964), *Understanding media*. New York: McGraw-Hill. [Comparatory description of the specific influence of different media]

Muehrcke, P. (1972), Thematic cartography. Commission on College Geography Resource paper, Washington: Association of American Geographers. [Most accessible text on topical map production]

Muehrcke, P. (1990), Cartography and Geographical Information Systems. In: *Cartography and Geographical Information Systems*, Vol 17-1, pp 7-15. [Explains the relationship between the science of cartography and the GIS tool]

Mueller, I.I. (1992), Reference frames and mapping. Pp 9-17 in R.E.Dahlberg and F.J.Ormeling – *Teaching Surveying and Mapping aspects of visualization and GIS*. Utrecht: International Cartographic Association. [Survey of concepts used in geodesy]

Nebert, D.N. (ed., 2000) - Developing Spatial data Infrastructures: *The SDI Cookbook*. Version 1.0, 6 July 2000. <http://www.gsd.org/pubs/cookbook/>. [Information paper on improving the national spatial data infrastructure]

Ormeling, F.J. (1988), (Ed.), *Teaching computer-assisted map design*. Munich: International Cartographic Association. [Proceedings of the first of a seminar series aimed at updating the Basic Cartography manual series of the International Cartographic association]

Salishchev, K.A. (1978) Cartographic communication. Its place in the theory of science. *Canadian Cartographer* vol 15, pp 93-99. [Rebuttal of the consequences of applying communication theory to cartography]

Shannon, C. and W.Weaver (1949), *The mathematical theory of communication*. Urbana, University of Illinois Press. [First general text on communication theory]

UNGIWG (2000) - Cartography and Geographic Information Science. Report on the meeting of the United Nations Geographic Information Working Group. United Nations, New York 28-30 March 2000. Downloadable from: <http://www.un.org/Depts/Cartographic/ungis/meeting/march00/report.doc> [On the need for and the benefits from a global cartographic database]

United Nations (1949), *Base maps for world needs*. Lake Success, New York, United Nations Department of Social Affairs. [Addresses the needs for map production for rebuilding post WWII society and for alleviating poverty]

Witt, W. (1967), *Thematische Kartographie*. Hanover: Hermann Schroedel Verlag, 1967, 1970. [Description of formalistic aspects of the design of topical maps]

Xu, Guanhua and Chen, Yuntai (1999), Towards Digital Earth. Proceedings of the International Symposium on Digital Earth. Science Press, Beijing, China, 2 volumes. [First global conference on the benefits of an exchange of digital spatial data and a good geospatial data infrastructure for sustainable development]

Biographical Sketch

Ferjan Ormeling

Born Utrecht, the Netherlands, 1942. Took his BSc in Human Geography at Groningen University 1966, and his MSc in Human Geography and Cartography in 1969; worked for Wolters-Noordhoff Atlas Productions, Groningen 1961-1968, and for Utrecht University 1969-present. Received his PhD in the social sciences in 1983, at Utrecht University (thesis: *Minority names on maps: the rendering of minority*)

place names on topographic maps of Western Europe). Head of Cartography Dept, Faculty of Geographical Science, Utrecht University since 1981, Chair of Cartography since 1985.

Engaged in IGU/ICA Joint Working Group on Environmental Atlases 1976-1984, in ICA Commission on National and Regional Atlases since 1985 and in ICA Commission on Education and Training (CET) since 1972; chair CET 1987-1999. Secretary-General ICA 1999-2007. (Co)Organized seminars on Cartographic Education and Training in Morocco, Thailand, China, Indonesia, Turkey, Cuba.

Editor of Netherlands cartographic journal *Kartografisch Tijdschrift* since 1972. co-editor of National Atlas of the Netherlands. President, Netherlands Cartographic Society 1995-1997. Honorary member Netherlands Cartographic Society 2000.

Member for the Netherlands of the United Nations Group of Experts on Geographical Names since 1980, convenor of the UNGEGN Working Group on Training Courses on Toponymy. Participated in UN toponymy courses in Indonesia, the Netherlands, Tunisia, Mozambique and South Africa.

Research interests: electronic atlases, toponymy and the development of thematic cartography. Is co-author of two cartographic textbook series: *Basic Cartography* (4 vols, together with R.W.Anson, 1987-2002), and *Cartography, visualisation of spatial data* (with M-J.Kraak, 1996, 2002), also published in Dutch, Polish, Russian and Japanese.

UNESCO – EOLSS
SAMPLE CHAPTERS