Session 5

Mass Media Cartography

Chairman:
J. Miranda I Canals, Inst. Cartografic de Catalunya (Barcelona, E)

Maps, Myths and the media: cartography and the "new Europes"

P. Vujakovic (Cambridge, GB)

Abstract

The transformation of the political geography of Europe has resulted in a plethora of new cartographic depictions. These maps of 'new Europes' are a continuation of an historic sequence of cartographic definitions of Europe as a continental and as a cultural-political entity.

This paper focuses on the role of cartographic representations in the creation of new ideas, metaphors and myths of Europe in the 1990s. All texts, including maps, are seen as 'battlegrounds of meaning' that must be fought over; a contest between the intention of the author and the interpretation or comprehension of the reader.

Examples are drawn primarily from the British news media, and from a televised party political broadcast by the Social Democrats (UK). Maps are seen as an essential element in the creation, reinforcement and subversion of ideas concerning the nature of the political geography of Europe.

Introduction - maps and myths of Europe

> *"The old Europe has gone. The map is being rolled up and a new map is unrolling before us. We shall have to do a great deal of fundamental thinking and scrapping of old points of view before we find our way through the new continent which now opens before us."*
> General Smuts, the Empire Parlimentary Association, November 25, 1943[1].

The changes in the political geography of Europe of the past few years have reinvigorated debate concerning the nature of Europe as a geographical and political-cultural entity. A profusion of cartographic portrayals of 'new Europes' have accompanied these discussions. Cartography has always played a crucial role in the definition of Europe, both as a continent, and as a culture area. Maps provide a concrete representation of ideas and myths of Europe, however, like any other form of text, a map is a *battleground of meaning*; a contest between the intention of the author and the interpretation of the reader. The term myth, in this context, represents 'an intellectual construction which embodies beliefs, values and information, and which can influence events, behaviour and perception.[2]'

For centuries maps have reinforced the notion of Europe as a separate continent. However, in purely topographical terms it is difficult to sustain such an idea. It can be argued that 'Europe is simply one rather small appendage of the continent Eurasia, merely a westward-reaching peninsula'[3]. The concept of a distinct continent has roots in classical cartography, and was reinforced by both Christian and Moslem cartographers of the medieval period. The Greeks assumed that the saline

Caspian was the southern extension of an ocean separating Europe from Asia, however, when it was recognised as an inland sea, the divide became identified with the River Don or Tanais.

Such views of Europe were increasingly challenged by advances in exploration and the need for accurate cartography. Renaissance maps acknowledge the fact that Europe is not joined to Asia by a narrow isthmus, but by an extremely wide wedge of land. A new divide had to be found to perpetuate the continental myth. It became generally accepted that the Caucasus and Ural mountains, together with the Black Sea formed this divide [3]. This entirely arbitrary topographical division has implications for other concepts concerning the nature of Europe.

The idea of Europe as a cultural-political entity and the possibility of European unity has more recent origins, although antecedents may be traced to the dichotomy between civilization and barbarism in classical Greek thought and culminating in the religious division between Christianity and Islam ('Christendom' of the early medieval period was roughly coextensive with generally accepted definitions geographical Europe). Tartar and Ottoman invasions of the eastern Orthodox lands during the thirteenth century saw the contraction of Christian dominance to the Catholic lands in the west and the concept of Christendom became associated with north west Europe as a stronghold against Islam [4,5]. The vulnerability of the eastern europe to Asiatic influence has long prejudiced western perceptions of the limits of Europe and '*Europeaness*'. It was not until the sixteenth and seventeenth centuries that ideas concerning 'Europe' as a cultural-political entity began to take shape. This coincided with the rise of secular states and the failure of religion as a unifying force during the wars of the reformation [4]. Cartography played a part in the battleground of ideas, for example, Harley[6] shows how maps were involved in the myth creation of early modern Europe, stressing in particular the importance of political silences in maps. Maps produced during the period of the Reformation by catholic cartographers of southern Europe tended to remain silent on matters concerning the religious schisms and the ideological battles of the period, while maps with origins in the protestant north often contained information on the variety of sects which were spawned by the Reformation. These maps represent two very different views of Europe, one in which maintaining the centrality of Rome is all important, and the other in which the Reformation is seen as a release from centralised control.

More obviously propagandist attempts to use cartography to manipulate political images of Europe are those which use deliberate visual metaphors. Hill[7] describes examples in which Europe is depicted as a queen. The most famous versions were those printed between 1544 and 1628 in Sebastian Munster's *Cosmographia*. "The design has west at the top of the map, with Spain as a crowned head...". Hill points out that in the Munster prints the figure may not be of a woman, but the Holy Roman Emperor, Charles V. The map can be seen as a political metaphor, symbolic of the need for Europe united under catholisism. 'Europe *as* Christendom' is a recurrent myth.

During the following centuries the European idea underwent a variety of transformations. The idea of European unity, the 'European Dream' was 'shared by many thinkers and men of letters, including Dante, Rousseau, Victor Hugo, Saint-Simon, Bentham and Garibaldi'[8]. Cartography continued to play a role in reinforcing or subverting these ideas, for example, cartographic devices were widely used in political graphics to satirise or support Napoleon's attempt to enforce a unified Europe.

In this century the fall of east-central Europe to Soviet dominion reinforced earlier myths of a western European core (a 'stronghold' against authoritarian, collectivist and monolithic influences issuing from Asia). Hence, for much of the Cold War period 'Europe' came to mean western Europe, while to 'become part of Europe' meant membership of the European Community[5]. Only in the 1980s were the countries of eastern Europe beginning to be reincorporated into new, vaguely

defined ideas of 'Europe' [9].

The events of the late 1980s and early 1990s have thrown the Cold War myths of Europe into disarray, and questions concerning the nature of Europe and Europeaness are again being debated. The simple division into East and West has disappeared and a range of metaphors, cartographic as well as verbal, are being employed by politicians, academics and the media to describe a variety of 'new Europes'. Many of the ideas make direct reference to older myths and metaphors.

Maps in political and social discourse

> *"As a discourse created and received by human agents, maps represent the world through a veil of ideology, are fraught with internal tensions, provide classic examples of power-knowledge, and are always caught up in wider political concerns."* J. B. Harley[10].

Harley points to the need to understand the wider cultural milieu in which cartography is grounded, rather than simply regarding maps as products of a value-free, scientific and technical discipline. Weigert[11] had made a similar point as far back as 1941:

> *'it is surprising that we are not all conscious of the important part which the map and the art of map-making plays in the process of creating a new conception of the world. We simply rely on maps as if they were facts in this transformation of thinking and seeing...this naive confidence in the truthfulness of the map indicates that many of us are not aware that maps are weapons. Like the written and spoken word, like photographs and cartoons, the map has become a psychological weapon in a warring world where the souls of men are as strongly attacked as their lives.'*

However, the generally accepted view of maps as objective representations of the phenomenal world is only now being widely questionned. Maps are becoming accepted as complex, cultural artifacts; 'texts' which are infused with the values and ideas of the belief system in which they were constructed. Cartography is seen as taking its place within a wider realm of social and political discourse. In this context, the term 'text' means more than the traditional notion of the printed word in book form, instead, it has come to signify any artifact which communicates meaning about the individual, their social setting and/or the world around them[12].

Harley's [6,10,13-16] advocacy of deconstructionist approaches to the study of maps has played an important part in encouraging a shift in thinking. He argues that 'rhetoric is part of the way all texts work and that all maps are rhetorical texts...All state an argument about the world and...are propositional in nature.' [14]. The task of those concerned with the study of maps is the unearthing of the hidden agendas present within the cartography and of the social practices that maps both reflect and employ.

The process of deconstruction involves 'reading between the lines' of the text to reveal the contradictions, tensions and silences that challenge it's apparent honesty [16]. The power of maps to reinforce values and meanings lies in the way in which rules of cartography are influenced by cultural rules, for example, 'ethnocentrism' [17] and 'rules of social order'. The application of such rules, even in the case of overtly political imagery, is not neccessarily a conscious act, but a reflection of the culture in which the image was created.

In arguing for a rhetorical reading of cartography, Harley makes reference to Foucault's ideas on the 'omnipresence of power in all knowledge' [14]. Harley distinguishes two types of power in

cartography, *external* and *internal* forms. External power is 'exerted *on* cartography...[and] exercised *with* cartography' by the state and other patrons. Internal power refers to the cartographic process itself, through which the world is ordered, producing a standardised image. Both forms of knowledge have relevance to the creation of new myths of Europe.

Maps, metaphors and myths

If we accept that the power of maps to create and reinforce values and meanings is influenced by cultural rules, we can begin to explore how such texts operate as part of political discourse.

Philippe[18], in discussing political graphics, points out the important role of 'visual metaphors' as a rhetorical device in political discourse. Visual metaphors have been shown to recur widely in traditional cartographic products and in political graphics which incorporate cartographic devices [19-21]. Recurrent use of a metaphor indicates that it, or an element contained within it, contains some generally accepted cultural meaning which can be exploited as a rhetorical device. Repetition and reworking of a metaphor can create a situation in which maps and other images can be simplified to a few key elements, yet retain their meaning[21].

The use of maps in political graphics (eg. posters and cartoons) demonstrates their importance as visual metaphors and should not be regarded as non-cartographic or non-geographic. Cartographic devices in mass consumption images have a very important role in projecting geographical concepts to large numbers of individuals. Because the majority of research has concentrated on traditional forms of map-making (often the product of the state), the role of political graphics in subverting and challenging official versions of 'reality' has often been ignored. Political graphics provide an alternative viewpoint on a range of geographic-political issues. As Boyer-Brun stated in 1792, 'Les caricatures sont le thermometre qui indique le degre de l'opinion publique'[22].

It should also be recognised that all texts are potentially unstable. The meanings embedded in images may not be read as the author intended, or if read by someone who is unfamiliar with the culture in which the image was created, may be misinterpreted. The problem of the instability can be demonstrated using examples of political graphics from European Community publications. For instance, a cartoon in *European Documentation*[23], designed to accompany an article on Spanish and Portuguese entry to the Community, appears to show the Iberian countries as inferior in status to the other member states. The illustration represents the Iberian states and the Community as anthropomorphised maps; Spain and Portugal are together represented as a diminutive, rounded figure, gazing up, child-like, at a refined individual created from the map outline of the other member states. The effect is one of condescension. It is very unlikely that such a 'message' was intentional, however, the maintenance of a stereotype image of southern European countries as backward or less developed is reinforced. The metaphor of physical status as representive of superiority is reinforced by the contrast of 'adulthood' with 'childhood'. A similar (unintentional?) reading may be made of another illustration in *European Documentation*[24]. In this instance the Community of the ten is represented by a simple line drawing of the map outline, viewed obliquely, and drawn as a raised plateau with steps leading up to it. On these steps, the anthropomorphic figure of Iberia (with the same immature features as described above) is seen ascending towards the superior status of Community Europe.

Media myths of Europe: promises for problems

The remainder of this paper is concerned with the role of maps in the discourse by which the news

and current affairs media are coming to terms with changes in the political geography of Europe.

The majority of the examples discussed below are drawn from the printed news media. These provide a relatively permanent form of imagery which allows the reader to study the significance of maps in relation to accompanying written text, however, the importance of televised material in mass communication cannot be ignored. Televised maps are generally instantaneous and ephemeral, little time is available for *conscious* examination of the mode of cartographic presentation and of the visual metaphors employed, hence, such maps may have a significant role in influencing our personal geographies at a subconscious level.

One of the major problems facing the study of the ideological content of media maps has been the lack of adequate analytical frameworks. Much of the work on (so-called) propaganda cartography, for example, has simply focused on technical aspects of cartographic presentation (use of symbols, colour, projection, and so on, to emphasise a particular viewpoint) and has failed to address the cultural mechanisms by which maps are able to influence beliefs. The present study attempts to resolve this by adapting a framework developed by Chapman and Egger[25] to analyse myth creation in advertising. They regard advertisements as having a *mythical* dimension which parallels the function and nature of traditional forms of myth; themes (real or fictitious) that embody cultural meanings and give expression to profound, commonly held sentiments. They view adverts as offering 'promises for problems', the advertisement acting as an anxiety reducing mechanism; 'this is done first by re-stating, on the deep level, the basic dilemmas of the human condition; and second by offering a solution to them. It re-iterates the essential problems of life - good and evil, life and death, happiness and misery etc, and simultaneously solves them.'[25]. The news media may be regarded as involved in a similar process, offering promises or solutions for contemporary political problems. In this approach, myths are frameworks of thought that seek to overcome the contradictions generated by society and which activate a promise [25].

In the case of the political geography of Europe a range of new problems have arisen as a result of the break-up of the Soviet Empire, the crises in the Balkans, and the evolution of the European Community. The news media has not only reported these changes, but has promulgated myths which provide *promises* to the *problems* that have resulted. Some of the problems are perceived to have deep historical roots (for example, ethnic/nationalist conflicts in the Balkans) and old myths of Europe are being resurrected to deal with them. Other problems are preceived as new, and new myths are being generated. Maps play a very major part in creating and reinforcing many of these myths.

The myth of 'stronghold Europe'

One of the myths being propagated is the recurrent theme of western Europe as a core area or stronghold; a bastion against alien influences from the east (barbarian hordes, Islam and Soviet communism). The myth in its contemporary manifestation takes a number of forms, often involving the incorporation of subsidiary myths and metaphors; for example, the myth of a European crisis zone in east-central Europe[26] and the ressurected concept of Central Europe or 'Mitteleuropa' [9]. The countries of east-central Europe are often presented as a geopolitical 'shatter-belt' (characterised by a turbulent history in the midst of the Great Powers).

The Sunday Times, in its map entitled 'Europe redrawn: the new continent' (27.10.91; p.30), emphasises the importance of this crisis zone, characterised by 'flashpoints', 'disputed borders', 'internecine feuds', 'tribal conflicts', and population movements. This *problem* zone is contrasted with the relative stability of the EC and the European Free trade Area (EFTA), which are presented

as offering a solution or *promise* (a 'grand continental vision') for the former eastern bloc. Colours and symbols are used effectively to reinforce the contrasts presented by the map. Fists and guns on red discs represent the disputed borders and flashpoints that characterise the 'tidal lands[27]', while a rash of new nationalist flags emphasise the rise in aggressive nationalist movements. The stability of western Europe is accentuated by the use of two shades of green, with connotations of coolness and calm. The promise is guaranteed by the continued existence of the *mythical* 'stronghold'.

The supposed existence of a 'stronghold' is reinforced by representing western Europe as under seige or threat of invasion. This is achieved cartographically by utilising 'dynamic symbols' to indicate the flow of economic migrants from north Africa and eastern Europe into the EC. Bold red arrows are used to show the immigrants 'flooding' towards the green core. The use of these vivid 'complementary colours' in juxtaposition, together with a shadow effect on the arrows, enhances the impression of dynamism and threat. This is a recurrent theme and makes use of principles developed for propaganda purposes in the 1930s[11,28]. A map ('the new invasion') published in *Time* magazine in the same year (26.8.91; p.15) propagates a similar message using similar techniques. Its message is reinforced by the way in which the arrows are drawn; immigrants from Asia and Africa are illustrated by arrows sweeping around Europe and entering from the west, while those from southern and eastern Europe complete the encirclement of the western European core area[20].

In apparent contrast, the double-page map of 'The New Europe' published by *The Independent on Sunday* (9.2.92;p.32-3) (also published in poster form) stresses the positive side of heterogeneity in a '...dazzling, diverse Europe...' Neal Ascherson[29], in a commentary to the map, uses the metaphors of a 'patchwork quilt' and of a 'mosaic' to describe the new Europe. He contrasts the 'austere solidity of our continent of nation-states' with the 'colourful mosaic' created by the rise of 'regionalism' in western Europe. This vision is reinforced by the multicoloured map showing the regional structures of a number of European countries. A '*Europe des regions*' is envisaged as being composed of an increasingly loose structure of highly adaptable, economically and politically autonomous units. The success of the 'Four Motors' project, a cooperative venture in commerce and cultural exchange between Baden-Wurttemberg, Rhone-Alpes, Lombardy and Catalonia, is held up as a model of regionalist development.

Regionalism is offered as a blue-print for the east; a way to '...cope with their minority problems.'[29] The concurrent revival of nationalism, particularly in the east, is recognised, but is seen as a temporary phase on route to 'accepting essentially regional status within Europe.[29]' However, contradictions are evident in this vision; while the map celebrates regional diversity, the concept of the nation state is accentuated by a display of national flags on the following page (the flags are an important part of the marginal information on the poster version). Flags are significant symbols of nationhood and their importance is demonstrated by the multitude of ways in which they have been revived and incorporated into the iconography of resurgent nationalism in east-central Europe. While the visual metaphor of the map acclaims diversity in regionalism, the flags are a reminder that nationalism is likely to remain a potent force shaping the political geography of Europe.

What unites these two seemingly disparate images of Europe is their insistance that the old eastern bloc states, having thrown off the shackles of communism, will find solutions (or promises) to their problems in *western* models of development. Both the 'Grand vision' of a united Europe and the diversity of a 'Europe of the Regions' have their origin in a myth characterised by a plurality of value systems, democracy, and modernism[4,9,30], upheld and defended by the western core area. However, such views have been criticised as the projection of a 'new capitalist frontier', at odds with the local realities of the east-central Europe. Such views are regarded as an interpretation of history along the pre-existing 'battle-lines' of the Cold War; the belief that Soviet power has been defeated by the verifiably superior ideals of democracy and the free-market[31,32].

Who are the Europeans?

The fragmentation of the Soviet empire and the emergence of new nation states has resurrected the question of the geographical limits of Europe. This is obviously of importance to those states hoping to benefit from membership of the EC. Article 237 of the Treaty of Rome states that any *European* state may apply for membership[5], but it does not define the limits. Under traditional cartographic definitions of Europe, the western Republics of the former Soviet Union (Belarussia, Moldavia, the Ukraine), the Baltic states and the Russian Federation, could qualify. However, opinion remains divided over how truly European they are in political-cultural terms[30]. The status of the Trans-Caucasian republics of Georgia, Armenia and Azerbaijan (all of which have indicated a desire to join the EC) is less clear still. Even though some of them have predominantly Christian populations they fall into a geographical grey-area which also contains Turkey; Islam has traditionally been regarded as an extra-European influence, even though it has left a profound mark on many parts of Europe and remains an important factor in the culture and politics of a number of European states (eg. Albania, Yugoslavia). However, recognition of Islam as a facet of life in Europe, both in terms of nation states and of mass immigration, is growing, and Europe may no longer be simply equated with Christianity.

The news media provide a confusing variety of images of Europe beyond the EC. The position of the Trans-Caucasian republics illustrates this confusion. *The Daily Telegraph* (23.12.91;p.28) in its maps of the 'new nations...', associates the Trans-Caucasian republics with those of Central Asia, rather than with 'the new nations of Europe', stating that they 'have more in common with the Middle East than with Russia'[33]. *The Times* (4.6.1992;p.13, 26.6.1992;p13), in discussing the limits to Europe and the question of EC membership, does not include these republics (fig. 1), yet *The Observer* (10.5.1992;p.16) had already included them in its map, 'Mapping out a Europe of 42 countries', published a month earlier.

Both the *Indepedent on Sunday* (9.2.1992;p.32-3) and *The Financial Times* (4.1.1993;p.2-3) include the Trans-Caucasian republics in maps accompanying wider discussions of the meaning and future of 'Europe' (although the *FT* excluded the republics in a map of EC enlargement in 1992 (5.5.1992;p.2)).

Turkey appears to be included in almost all recent cartographic definitions of Europe published in the news media. An exception is *The Sunday Times* (27.10.1991;p.30) 'Europe redrawn: the new continent', which pointedly excludes Turkey, despite its Associate membership of the EC. The reference to the idea of Europe as a 'continent' reflects a traditionalist view, which regards Europe as ending at the Bosporus. However, a year later *The Sunday Times* (30.8.1992;p.12) includes Turkey, along with the Trans-Caucasian republics in a map of 'Europe's flashpoints'. Alternatively, *The Economist* (14.12.91;p.21) makes positive use of persuasive cartography to undermine a Europe of xenophobia and to argue for Turkey's '...claim to be considered as a candidate-member of the Europe of ideas, if not the Europe of formal geography.[34]' It maps the historic position of Turkey (Anatolia) within the Roman and Byzantine Empires; showing that for about 1,600 years, it partook in the marriage of Greek and Roman culture that gave rise to European civilization (fig. 2).

The danger from within: 'Tribal wars' and other myths

Media debate concerning the future of Europe has also focused on the internal pressures which are shaping the region. The resurrection of the concept of the 'shatterbelt' or 'tidal lands', in the context of the larger view of Europe, has already been discussed. A large number of articles containing

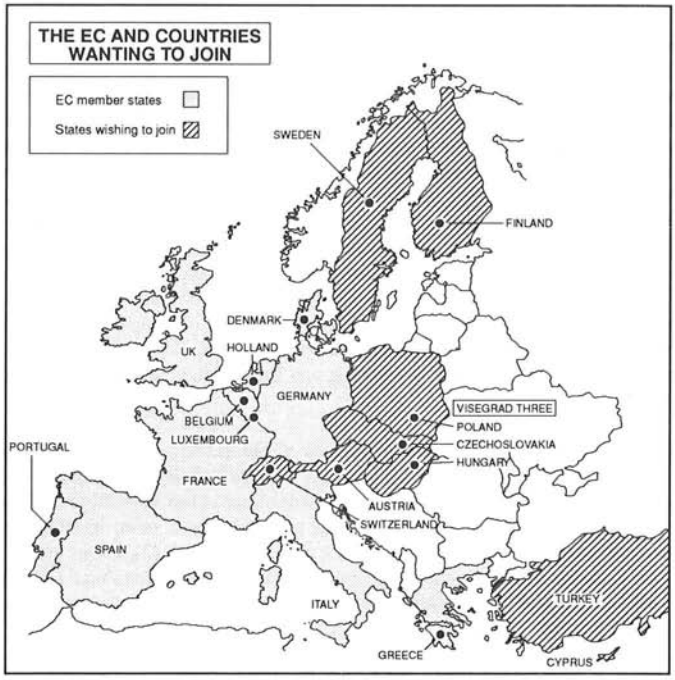

Figure 1: The EC and countries wanting to join. Adapted from *The Times*, 26.6.1992: 13.

Figure 2: Turkey - a member of the Europe of ideas. Adapted from *The Economist*, 14.12.1991: 21.

cartographic images, replete with visual metaphors, focus on specific 'local' issues. *Time* (*International*), for example, makes very effective use of maps in the debate concerning the future of central Europe. The existence of a shatter-belt in central Europe is reinforced by cartographic and verbal metaphors of an unstable ethnic 'patchwork' [35]. A broken jigsaw motif is used in *Time* and a number of other news publications as a metaphor for the fragmentation of the eastern Europe and the Soviet Union. A cartoon on the cover of the German newspaper *Handelsblatt* (30.8.91;p.1) shows Boris Yeltsin kneeling on a fragmented jigsaw of the former Soviet Union; he is vainly trying to stop the Ukraine from breaking away from Russia.

The scope of this paper does not allow for detailed examination of cartographic contributions to the discourse concerning localised aspects of the European debate, however, two examples of myth creation are worthy of brief mention.

The first example involves the creation of a myth of 'tribal war' in the former Yugoslavia. The reasons for its creation are complex and various[36]. An article by Robert Fox[37] (*Daily Telegraph*) entitled 'Tribal war poses new threat to Europe', provides a striking example of the way in which this myth of Europe is being propagated, and its role within a larger discourse of Europe. Fox sees Europe emerging from the Cold War into an era when 'The Europe of the nation state could be giving way to the Europe of regions and peoples.[37]' To argue the case for the death of the nation state, new designations must be applied to what might otherwise be viewed as nationalist conflicts. Hence, the terms 'tribe' and 'tribal war' have been introduced. Tribalism is used to imply a more primitive and unsophisticated (and perhaps, savage) form of organisation and identity than that of nationalism. This use of 'categorization' is a recognised device in the ideological construction of meanings in news media[38]. Maps are used in this and other instances of the 'tribal war' myth (for example, *The Sunday Times*, 9.8.1992, p.11) to emphasise the complex ethnic mosaic underlying the Yugoslav conflict; the implication is that 'ethnic' equates with 'tribal' forms of organisation, manipulating popular misconceptions of these terms. However, it is possible to explain events in the former Yugoslavia in terms of traditional definitions of the nation and of nationalism; for example, the motivation of Serbian and Croatian factions within Bosnia is clearly linked to the loss of formal political association with their national 'home' republics of Serbia and of Croatia (Croatia's secession from the Yugoslav Federation to become a unitary state is a prime example of the 'ultimate geographical realization' of nationalism[39]).

The second example relates to the cartographic treatment of German reunification. Anxieties concerning the consequences of reunification for the stability of Europe inevitably review the historical role of Germany, particularly its intentions towards eastern Europe, rehearsing 'fears that have existed ever since the Teutonic Knights roamed Eastern Europe'[40]. A number of articles use the classic 'propaganda' device[28] of paired (or multiple) maps to contrast the single, large Germany created by reunified, with former incarnations that have threatened the balance of power in Europe. This device was used very effectively by *Time* (*International*) in two articles debating the possibility of reunification (11.9.1989;p.14, 20.11.1989;p.22). The 'time-lapse' image of expansion and contraction of German territory presented in these maps provides a graphic reinforcement of the notion or myth of history repeating itself (fig. 3). The imagery also creates visual references to the ideology of *Geopolitik* and to organic metaphors of the state espoused in the 1930s; although it is unlikely that this was a conscious factor in design. However, organic analogies are used as deliberate rhetorical devices in other publications; for example, a Peter Brookes cartoon on the cover of *The Spectator* (24.2.1990) transforms the map outline of West Germany into the head of Helmut Kohl, shown sucking East Germany into his mouth (above the headline 'One Fatherland').

Figure 3: Germany 1815 to 1945. Adapted from *Time International*, 11.9.1989; p.14.

One vision of Europe: A case study of a political broadcast

A broadcast on behalf of the Social Democratic Party (UK) provides an significant example of the use of cartographic devices to promulgate a complex political message concerning the future of Europe via the mass access medium of television. The broadcast (12.9.1991), presented in its entirety by David Owen, the party leader, was a parting gesture from the rump of the Social Democrats and was broadly supportive of Conservative Party attitudes to Europe. The broadcast is interesting for its sophisticated use of cartographic devices. Maps are used on sixteen separate occassions in a broadcast of approximately ten minutes duration. Visual metaphors, which would not have been possible using static, printed maps, were created using techniques of animation.

The principal message of the broadcast is supportive of the present form of the European Community and a of single market, but is a warning against any moves towards a common foriegn policy and a European defence community:

'A strong unified European Community of nation states, not a United States of Europe.'

The message is essentially anti-Federalist.

The broadcast commences with a statement concerning the need to maintain an independent defence and foreign policy. Owen emphasises this message by suggesting that a 'European', rather than a British, reaction to various recent international crises (the invasion of the Falklands, and of Kuwait, and the Soviet coup), would have have been determined by the 'lowest common denominator', resulting in hestitant and ineffective responses. Maps are used to enhance this message; for example, the Iraqi flag is superimposed on the country outline (a wedge shape with its point towards Kuwait), the image is animated to create a visual metaphor for the penetration of Kuwait by Iraqi forces and the obliteration of Kuwait as a distinct political entity by the colours of the Iraqi flag.

More subtle uses of cartographic devices are reserved for the discussion of the single market and currency, and for the role of Europe within a new world order. The unified EC (regarded as positive) and a federalist Europe (negative) are identified throughout by their own cartographic motifs; the unified EC is identified by a map showing the EC in golden-yellow (creating an image of prosperity[41]) with the national borders of the member states clearly displayed (indicative of national sovereignty), while the concept of a federal Europe is identified with a monolithic, undifferentiated map of the EC, with the blue, 'star spangled' flag of the EC superimposed (representing the loss of sovereignty to a supernational body). These motifs are used to reinforce Owen's rhetoric when appropriate; for example when Owen is discussing the advantages of the single market, the yellow-gold map is displayed, but when he turns to discussing the problems inherent in a single European currency, the map is transformed into the 'monolith' image, reinforcing an impression of loss of national sovereignty.

These motifs are also used to reinforce Owen's argument concerning federalism:

> ('Monolith map') '*It would be an error of tragic proportions if the European Community was to try to bottle it's own nations together in a federal state.* (Transformation to yellow-gold map) *The community by contrast should be placing more emphasis on urgently extending its membership to include Poland, Hungary and Czechoslovakia, nations that have only recently rediscovered their nationhood.*' (Note emphasis on nationhood).

And at another point the contrast is made (verbally and cartographically) with *decentralising* tendencies in eastern Europe:

> (Neutral world map outline) '*The challenge of the next century is to develop international groupings which would contribute to the cohesion of world order. That is what the nations that were yoked together under communism, the Soviet Union* (monolithic map of USSR, red with hammer and sickle, which then transfoms into map of independent nations) *and the Yugoslav Federation* (similar transformation) *are now attempting to do.*'

This imagery is then contrasted with the federal 'monolith' image of Europe (an '*error of tragic proportions*' according to Owen).

The use of these contrasting cartographic motifs to reinforce positive and negative images of Europe breaks down at only one point during the broadcast, when David Owen is making a *positive* remark with regard to the potential expansion of the EC to twenty-four nations, and the *negative* 'monolith' motif is adopted.

Other recognised techniques of persuasive cartography are used in the broadcast; for example, 'paired maps'[28], are used to subvert the concept of a federal Europe:

'...France, Britain and Germany's relationship to Brussels would have to attempt to mirror that of Louisianna, New York State and California to Washington."

This comment is supported by the requisite maps. The image of physical remoteness in the American map augments a visual metaphor of cultural-political distance in the European example.

The broadcast can be analysed in terms of the 'promises for problems' framework. Political and economic instability in the post-Cold War era are identified as the key problem areas, these are emphasised by verbal, photographic and cartographic reference to the Gulf War, the Falklands War and to the Soviet coup. The promise is presented as the maintenance of a 'strong unified European Community of nation states...', rather than '...a United States of Europe.' A federalist solution (or promise) as an alternative to the nation state model is continually undermined. The argument is built on a myth of British self reliance, reinforced by imagery from the present (British initiatives in the Gulf and South Atlantic) and reference to the past (the broadcast opens with film of Spitfires guarding Britain's skies during the Second World War).

Conclusion

The importance of cartographic images to the creation of new myths of Europe is corroborated by the variety of situations in which maps are used to reinforce messages about the changing political geography of the region. The structure of the texts examined (both verbal based and graphic) indicates that the process of myth creation can be understood as the provision of 'promises to problems'. The new myths of Europe which are being created or resurrected as an attempt to provide frameworks of belief that overcome the contradictions generated by the rapid geopolitical changes in the post-Cold War world.

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Weather maps on television in the USA

J.R. Carter (Normal, USA)

On all television stations in the U.S. that present a general news program, there will be a weather forecast segment. In almost all of these weather presentations the weathercaster points to features on a variety of maps and comments on the patterns of the weather. The number of TV weather maps produced and the number of viewers of these maps may exceed all other forms of map production and viewing. On any given day many millions of viewers will see one or more weather forecast programs with varieties of maps. The purpose of this paper is to look at how maps are used and presented in this environment. No attempt has been made to evaluate the design of the individual graphics, nor is consideration given to how the maps are made.

There are some common elements in all of these presentations. In all cases observed there is a person controlling the sequencing of the maps and talking about the weather elements portrayed on the maps. All of the presentations are in color. There is usually a synoptic weather map with fronts and areas of precipitation. Likewise there will be a forecast map showing weather for the next day. Maps of forecast high and low temperatures are common to all presentations.

There are two dynamic image maps that are common to most presentations. Each consists of a loop of image data over a period of a few hours. One is a loop showing cloud cover over the past 12-24 hours moving over a base map with political boundaries and hydrography for reference. In most cases the cloud cover is from the GOES satellite centered at about 110° West and covers all of the Western Hemisphere. Presenters may show the entire hemisphere or only a local portion of the image. Colors may be employed to enhance features in the cloud images. The presenter may cycle through this loop a number of times and many times will freeze the loop to look at a particular situation. The U.S. government has a radar network and the images from this network are integrated into a dynamic loop. This imagery covers only the lower 48 states of the U.S.A.

The persons making these weather presentations vary greatly in the skills they bring to the task. In some cases the person making the weather presentation is selected based on appearances in front of the camera and knowledge of weather, maps, and geography is of little concern. In other cases these presenters are formally trained meteorologists. Many of the more formally trained persons make their own forecasts and add interpretations. The American Meteorological Society certifies 'weathercasters'--the name they use for persons making these presentations. The more than 500 Weathercasters so certified can display the AMS seal, which is a matter of pride for many stations.

In many ways the presentations of weather maps on television do what we in cartography aspire to do. Remote sensing imagery and vector data are combined.

These presentations visualize abstract concepts in map form. Many of the presentations are dynamic, showing change of one or more variables over time. Some of these dynamic presentations represent the past, but others are simulations of projected data.

These television presentations represent a unique map viewing environment. In most news stories on television where maps are used the viewer has little anticipation of what map will be presented, when it is coming or how long it will be shown. By contrast, these weather maps are presented in a consistent fashion on the same base by the same personalities at the same time of day, day after day. Viewers become comfortable with a preferred format of presentation and tune in to see new information imposed on a familiar series of map bases.[1]

The author identifies four types of weather presentations on television. 1 - Local stations will have a weather segment lasting less than five minutes two or more times a day. The focus is the regional weather but most include an overview of the national pattern. Many of the maps used in these presentations are unique to the local station and vary greatly in quality. 2 - National networks have short weather segments with national maps showing the synoptic pattern and temperatures. These presentations are normally quite brief. In many cases the national network provides an opportunity for the local station to inject a local weather update. 3 - AM Weather is a 15-minute weather program carried on many Public Broadcasting Stations on weekday mornings. A portion of this presentation includes information for pilots. 4 - The Weather Channel represents the ultimate presentation environment. This channel is available 24 hours/day, 7 days/week, and features an almost continuous display of maps interspersed with commercial advertisements.

A discussion of each of these environments follows. The Weather Channel and AM Weather are one of a kind, so that the only question of what to observe and sample was choosing programs. For the national networks and the local stations the choice of what to report on was a matter of what was available for viewing and personal tastes.

Local Stations

Each commercial local station is likely to do three or four news presentations per day: early in the morning, in the early evening, and one at the end of regular programming before most people go to bed. Most of these news programs will be 30 minutes long. Many stations also do a news segment at noon and may have short segments interspersed between other scheduled programs. The news will be presented by a news team, consisting of one or two general news reporters, a sports reporter, and a weather person. For weekends and periods of vacations, there will be replacement persons for each of these individuals. The weekend replacements are likely to be the least trained of all of the weather presenters.

Because most stations purchase the forecast information from one of the firms who provide the data and the graphics, at a minimum the person needs to select some graphics and text and put it together into a segment. Many of the better and more experienced weather persons add their own flourishes to the graphics, create some of

their own maps and charts, and revise the national forecasts according to their own studies. At the other extreme the local team may produce almost all of their own weather information.[2] It is very difficult to generalize about local weather presentations. In a 30 minute news program 2-4 minutes may be given to the weather segment. Most involve data on local conditions and a look at conditions nationally. All will involve the use of maps. Almost all use a loop showing cloud movements over the area in the last 12 to 24 hours. Likewise, many will use a loop of radar echoes. Some will show the image of the local radar with the beam extending out of the center. In some areas the weather person will name the 'weather spotters' who contributed local observations used in the presentation.

A Unique Local Presentation

Tom Skilling is an AMS Certified Weathercaster who does the weather segment in the 9:00PM news on WGN out of Chicago. As such, this presentation may be thought of as a local presentation but it is not a typical local presentation. Although WGN calls itself a 'SuperStation' and may be seen in many parts of the country, the program has a Chicago bias. I have chosen to detail his presentations because I have watched him for many years and have been fascinated with the details he incorporates into his presentations. It would be impossible to sample all weathercasts from across the country, so I offer this as but one sample of what can be done in a local presentation. There may be more dramatic and more animated weather presentations, but I have not seen them.

The details of one presentation are given to illustrate the use of maps. The length of time the image is displayed is given. This was the presentation of November 18, 1992. In 3 minutes 7 seconds Skilling presented 19 maps, in the following sequence. Many of these maps were dynamic presentations so that there were far more than 19 images shown in this program.

- Loop of the satellite view of clouds over the Midwest in and around Chicago; the clouds are gray to white depending on temperature; 12 seconds
- Color enhanced version of the same loop of clouds; 8 seconds
- Loop of radar echoes as they move over the Midwest; 11 seconds
- 3D satellite representation of clouds in the Midwest; 7 seconds
- Map of the forecast weather for the next 48 hours in the Midwest; bright patches of colors identify various bodies of air and the fronts; many air bodies are labeled; 15 seconds
- Map above put into motion showing how the pattern is expected to move over the next 48 hours; 11 seconds
- Shaded relief map of the U.S. extending from Mexico to Hudson Bay with loop of cloud coverage over the past few hours; 13 seconds
- Loop of radar echoes imposed over the same base map; 11 seconds
- Loop of enhanced satellite image showing Florida and a large storm to the east; 15 seconds
- Map of the synoptic weather pattern extending on the same base from Mexico to Canada; air bodies and fronts symbolized in the bright patches of colors as above; map is put into motion in 3 steps; 15 seconds

- Map of upper air pattern with the jets on the same base; again using comparable color schemes and put into motion in steps; 10 seconds
- Satellite image loop of entire hemisphere from North to South Pole showing the Americas and the Pacific Ocean; 6 seconds
- Same loop focused on the western U.S.A.; 9 seconds
- Dynamic map of a storm system that was predicted to affect the Chicago area; presented in steps; 10 seconds

Skilling then presents statistics on the recent weather in the area before returning to more maps; 15 seconds

- Map of forecast of precipitation in next 24 hours in the USA and Canada; isohyets are employed in a simulated 3D effect; 7 seconds
- Dynamic map of projected storm tracks; product of numerical models; on the same base as former map; 7 seconds
- Same map with areas of cloud cover added and the projected positions of the major center of Low Pressure for the next four days; 7 seconds
- Supercomputer forecast map for 5 days out with fronts and isobars; 9 seconds
- Same forecast map with projected areas of cloud cover and precipitation; 4 seconds

The weathercaster then provides his forecast in terms of statistics as he completes his part of the news show.

Skilling often employs some other devices to help explain the behavior of the weather. One common technique is to use a 3D grid suspended over the map surface to give visual form to a large dome of high pressure. This grid is viewed from a perspective position. With a dynamic presentation he then shows how the pressure surface will change with time. Another interesting map presentation is his attempt to show a spatial interpretation of the probability of precipitation. He has done this with a grid of square cells imposed over an urban map.

National Networks

In the United States each of the three networks ABC, CBS, and NBC, have weekday morning news programs. These programs are built around a host and hostess and a weather person. The regular weather person on each of the networks is quite well known and will have a personal following. At regular intervals the weather person will do his weather presentation. It is appropriate to say 'his' in this case for as far as I know only men have served as the weather persons on the three networks. In all of the other weather presentation environments, women are well represented as weather presenters.

All of the three networks have associations with local stations. In many cases the national broadcast of weather will consist of two or three national maps presented by the weather personality and then a cut-away to the local weather person for a brief segment on the local situation. When the local station chooses to not take the opportunity to cover the local weather, a filler such as a listing of the weather in the major cities around the nation is shown.

Of the three national maps likely to be shown, the first map will feature the weather for the day with areas of precipitation and cloudiness highlighted. Fronts may be represented, as well as areas with extreme weather. In most cases these maps are quite generalized. The second map will be similar to the first but will be the forecast for the next day. A third map is likely to portray the predicted high temperatures for this day. The total time for such national presentations is likely to be 30 seconds to 2 minutes. The local weather segment will be about 30 seconds long. This may be as simple as a map of high temperatures for the day with a voice-over of the local forecast. In other cases the presenter may show a map of the counties in and around the viewing area. Icons will be used over selected cities to indicate the type of weather and high temperatures will be written beside the icons. A radar image may be shown if precipitation is present. If weather is a problem with driving on this day then a map may be used to indicate problem areas. The local segment will probably include some statistics.

The Cable News Network, or CNN, is still another type of national channel. This television network is available only to cable subscribers and in many cases cable subscribers have to pay an extra charge to get access to CNN. With regularity, weather and other news items are provided. As on the other networks the weathercasters on CNN have become well known personalities and interact with the other news broadcasters on the show.

Unlike the other national networks, CNN does not have local affiliates. Therefore, there is no local weather, only the national picture of the weather. There appear to be two types of weather presentations made on CNN. One is a quick overview of perhaps 40 seconds duration. This may consist of a map with fronts, clouds, and types of precipitation for the U.S.A. and Canada following by a similar map showing the prediction for a day later. The other type of weather presentation will be much longer and will have the weathercaster standing in front of the maps and making interpretations. The base map used by CNN shows most of the Gulf of Mexico on the south to much of Hudson Bay in Canada on the north, the same as employed in most weather presentations focusing on the U.S.A. The weathercasters on this channel often show an integration of the radar loop over the cloud loop to give a dynamic image of the recent history of precipitation and cloud cover over the country.

AM Weather on Public TV

This 15-minute program is produced early in the morning Monday through Friday and is made available to Public Television stations. Public Television is non-commercial. The individual stations can show it when they want to and more than 300 stations carry the program. In central Illinois one public station shows it at 6:15AM and another shows the same program at 7:15AM. Not all public television stations chose to show the program while some show the program more than once.[3]

From day to day all programs look alike, although there might be a special segment where interesting data are available or where an unusual weather event dominates the news. There are three meteorologists associated with the program and two of them

are seen in each broadcast. The meteorologists use a wooden pointer to point out specific items or areas of interest as they talk through the maps. The persons are not visible when the maps are viewed, unlike most other television weather presentations. The basic map used to show the U.S.A. extends north to include southern Canada and extends south to include much of the Gulf of Mexico. This map does not extend east to include all of the Maritimes of Canada, nor is there any attempt to include Alaska or Hawaii. The producers of the show are aware of the extent of their ability to forecast in areas where data are limited and therefore they do not try to forecast where they cannot give reliable forecasts.

The synoptic charts used on television employ a subset of the traditional weather symbols used on standard National Weather Service synoptic charts. To help the reader use these charts the producers distribute a guide to the symbols to anyone who sends a self-addressed stamped envelope. The symbols used on the TV synoptic charts are bolder than the standard symbols and are in color to aid in recognition. For example, haze and fog are in yellow and black and are the only two symbols employing yellow.

The following sequence of maps illustrates the nature of the program flow and the use of maps in one of these presentations. This particular presentation was December 30,1992. The program begins with the title lead-in, followed by credits and sponsoring organizations. The meteorologists then introduce themselves and make brief comments about the nation's weather. Then the following set of maps were shown. In most cases the shift from one map to the next is instantaneous.

- Satellite view of North America extending from northern South America to the Arctic Ocean, showing cloud patterns over the eastern Pacific Ocean; starts with a static pattern of clouds; low clouds are dark gray and higher clouds are white; the focus is the jet streams which are shown as ribbons using a symbol that implies movement; 15 seconds
- The jets are removed and the clouds are set in motion; the cloud loop covers 23 hours up to about 2 hours before the program is produced; 14 seconds
- Same satellite image map but the coverage is limited to the conterminous 48 state and southern Canada; the clouds are put in motion and then turned off and on as the meteorologist reviews specific events; 50 seconds
- Same cloud map focused on the west coast where there have been heavy rains: 30 seconds
- Radar imagery showing precipitation for the 48 states; shown as a loop which is then frozen; where high tops of clouds prevail the elevations of those tops are shown; 32 seconds
- Current synoptic map of the U.S.A. and southern Canada; 77 seconds

Then one meteorologist comes on and introduces the forecast segment; 8 seconds

- Projected fronts and areas of projected precipitation by type for the coming evening, about 12-24 hours away; 32 seconds
- Same map for the next evening; 27 seconds
- Same map for two evenings hence; 29 seconds
- Projected high temperatures for this day; 22 seconds
- Projected high temperatures for tomorrow; 18 seconds
- Projected low temperatures for this coming evening; 17 seconds

- Projected low temperatures for tomorrow evening; 14 seconds
- Projected quantities of precipitation over the next 24 hours; 22 seconds
- Projected five day forecast of temperatures showing areas predicted to be above and below normal; 12 seconds
- Projected five day forecast of precipitation showing areas predicted to be above and below normal; 15 seconds

Then one meteorologist introduces the section on flying conditions; 10 seconds

- Map of current flying conditions showing areas where instrument flight rules and marginal visual flight rules exist; 18 seconds
- Same map with contours of freezing level heights imposed; 17 seconds
- Same map with areas of turbulence indicated; 15 seconds
- Comparable map of flying conditions that afternoon; 11 seconds
- Same map with projected areas of turbulence indicated; 12 seconds
- Map of winds aloft, at 2,000 feet above the ground surface; broad arrows are employed to show general trends; colors are used to show areas where speeds range between 25-50 knots; 6 seconds
- Winds aloft map at 10,000 feet mean sea level; 11 seconds
- Winds aloft map at 18,000 feet msl; colors show areas where winds are 25-50 kts and 50-100 kts; 13 seconds

Then one meteorologist introduces weather advisories and warnings in a section called 'weather watch'; 3 seconds

- Northeastern U.S. and Canadian Maritimes; 12 seconds
- Northeastern U.S. to Great Lakes area in U.S. and Canada; 10 seconds
- Southeastern U.S.; 6 seconds
- Eastern 1/2 of the U.S. showing areas with gale warnings; 10 seconds
- Upper Midwest/Plains States of U.S.; 16 seconds
- Northwestern U.S.; 17 seconds
- Southwestern U.S.; 23 seconds
- The Pacific Coast of the U.S.A.; 19 seconds

The producers extended the coverage of the forecasts to southern Canada in response to requests from Canadians who could pick up the program. Because of a lack of data they will not extend the forecasts to include Mexico. Based on the correspondence received the producers estimate a viewing audience of about one million persons for these broadcasts.[4] When unique items become available they may be included in a program. One day last summer they included a loop of three months of the AVHRR vegetation index for North America, showing when the vegetation greened up from winter into summer.

The Weather Channel

This channel is included in the basic cable TV package in most areas. Its sole programming consists of reports on current weather, forecasts of weather, and weather related activities 24 hours/day, 7 days/week. The programming is fairly predictable but is flexible enough that in the event of interesting features or natural disasters the weathercasters will give greater emphasis to such events.

At the top of the hour there will be a segment showing the current and forecasted weather for the nation. This segment is likely to last for at least six minutes without interruption. The presentation will include satellite image maps of the country in which the clouds are put into motion and stopped as the presenter points out particular events. In most cases this presentation will include close-ups of areas with particular problems. Viewers will also see a national map showing the loop of radar echoes as they have evolved over the past 90 minutes. There will be forecast maps for the coming three to five days. There is likely to be a map of departures from normal for temperatures or for precipitation, depending on which is more dramatic at the time. Included in this section may be discussions of why the weather is as it is. For instance, when freezing rain was covering a large portion of the Midwest, the meteorologists created a map showing how a large trough of cold air was penetrating into the center of the country while a layer of warm air was moving north and overriding the cold air mass. This presentation was dynamic as the warmer, moist air was seen to slide northward overriding the colder air.

Many of the maps in this current weather presentation will be shown again and again during the day. However, the weathercasters are sensitive to the data they are showing and maps are revised as needed. For example, the author observed a presentation on wintery travel conditions in which the weathercaster made a point of indicating that he and his colleagues had extended the zone of freezing rain to the east of the area shown on the map and that colleague were updating the map as he spoke. He even commented that this is one of the advantages of working in live television.

Interspersed throughout the presentations by the weathercasters will be segments on local weather and commercial advertisements. There may be 10 of these local weather segments in an hour, each lasting for a little more than a minute. A major function of TWC is broadcasting the National Weather Service local forecasts for each of the over 800 NWS zones.[5] In total, the local weather segment may account for one-fifth of the total programming. This segment is automated and contains either a recorded voice-over or music. The items included in each local weather segment vary and may include any of the following:

- text description of the National Weather Service forecast for the next 36 hours for the local area
- statistical weather data for the local city
- regional sunrise, sunset, and moon phase data
- regional forecast map with weather icons and temperatures for major cities
- current local radar loop showing movement of precipitation, if any, in the area during the past 90 minutes
- the extended forecast being weather icons, highs and lows for the local city for the next 3 days
- forecast for cities nationwide, being a scroll of data about 23 cities

Advertisements may account for one-fifth of the total programming. Many of the advertisements are related to weather. Having built an interest in weather, viewers want more which has created other business. TWC advertises its own books, videos and services. Being able to telephone for detailed weather information for any of about 300 cities around the world is one of these services. They now have a segment

called the 'Weather Classroom' which is repeated many times late at night. They suggest that viewers record the segment and play it later at their convenience. They sell a workbook in support of the Weather Classroom.[6] This book includes instructions on reading weather maps.

The Weather Channel features 'international weather' at regular intervals. In most cases the only thing presented is Europe. The likely presentation will last 50 seconds and will include a satellite loop of cloud cover, a forecast map of the weather for the next day with isobars, and a map of predicted precipitation or a map of predicted highs. Sometimes the international segment will include a synoptic map of the northern Pacific Ocean showing lows, fronts, isobars and significant areas of precipitation. This map shows the countries that border the Pacific on the west. This map will be followed by a map of Hawaii showing temperatures and weather descriptions for selected cities. Then a similar map of Alaska is shown, followed by a map of Wind Chills for the same Alaska cities. This Pacific sequence may consume 40 seconds. Sometimes the Pacific sequence is preceded by a presentation of the GOES satellite loop showing the west coast of the U.S., Canada, and Alaska.

The Weather Channel employs a great diversity of maps of many types. Some maps are used as tools to help the weathercasters explain a particular weather situation. Other maps are interpretations of weather information, such as the map of 'clothes to wear to school', or the 'discomfort index for persons subject to allergies.' Even choropleth maps are employed to show incidences of outbreaks of disease related to weather conditions. Other maps will address beach and boating conditions, the status of fall colors, the potential for fires, and ski conditions. During the ski season they report of the weather conditions in the areas of the ski resorts and will show maps of regional snowfall with the locations of the ski resorts on the map. Because the Weather Channel is commercial some maps carry the name of the sponsor above the map. It is not uncommon to see the name of the maker of a cold relief medicine attached to a map of 'air stagnation'.

The Weather Channel is unique in that the graphics and maps created by the staff are able to be shown over and over again. The maps that are shown in the sequence at the beginning of the hour may be shown many times over during the hour. In any given hour, three or four weathercasters will alternately make presentations. Each weathercaster prepares his/her own presentation so that each presentation will reflect the individuality of the preparer even though they use the same maps.

Last year the Weather Channel celebrated its Tenth Anniversary. While in the early years many questioned that a 24 hour television weather program would survive, today this channel is available to more than 50 million subscribers.[7] The substance of this television channel is a continuous display of weather information portrayed on maps. The cartographic community should take satisfaction that the population of television viewers will support a program that is essentially map presentations.

Concluding Comments

In total, the use of maps for the presentation of weather on television in the USA represents a major industry that is viewed by a very large population. Tens of millions of viewers in North America rely on the availability of systematic weather presentations at predictable times. These presentations serve to disseminate warnings and guidelines, give helpful advice, aid in planning activities and travel, as well as giving peace of mind. In the process millions of persons are exposed to maps that contribute to knowledge of geography and the atmospheric sciences. And, these maps are seen in a way few other maps are viewed in that day after day a similar collection of maps are presented in a systematic way by the same people.

These weathercasters and weather programs are but one step near the end of a large and complex process. The industry is that of weather observation and forecasting. Collecting the data to common standards, bringing the data together at central facilities, incorporating the data into complex models, analyzing the data and generating forecasts, distributing the processed data back out on the networks, and putting the data into graphical form are all done by people not seen on television.[8] And, all of this is done in near real time. The weathercaster takes this packaged information, adds some refinements and enhancements, designs a program around the maps, and integrates herself/himself into the presentation. The results vary, but obviously there is a market for these presentations.

Weather is something that everyone can identify with. Monmonier cited a study noting "70 percent of the TV news audience is highly interested in the weather."[9] Wright reported on a study that found 95 percent of the audience watched a local station in Florida for the weather.[10] Obviously, people tune in to look at weather maps. Lindgren[11] detailed the use of maps on television during the Gulf War showing that that media event was another situation where viewers wanted to see maps. It is appropriate to ask if there are other 'mappable' subjects that would draw a supportive audience? This question should be examined in terms of the map use environment, which integrates the subject matter with the personalities making the presentations and the medium.

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Newspaper maps in Germany

W. Scharfe (Berlin, D)

Traditionally, map-making for more or less very special civil and military purposes and mostly for a relatively small elite needs careful preparation concerning topographic and thematic sources, semiotic analogy and graphic design. This cartographic tradition took some sixthousand years. In our century maps are produced and sold not only in millions of copies for school, road traffic and vacation, but they are also spread out daily by newspapers and by television. Maps seem to have developed into a very popular information tool.

Contrary to this public relevance neither journalists nor cartographers did show any interest in newspaper maps for a very long time. We can only mention a lonely article of Walter Ristow published in 1957 (1). During the seventies and the early eighties internationally as well as in Germany the period of „discovering the journalistic maps" started. During this first weak start of „discovery" the traditional cartographic meaning of what a map has to be remained dominating. Professional cartographers considered the journalistic maps in newspapers, magazines and television to be rather simple and rough drawings in comparison with maps of topographic and of scientific origin and they refused to put some interest upon those vulgar maps. In the United States, in Canada, in France, in Poland and in the Netherlands some contributions were published in this cartographic field (2) but they were strictly limited to very special aspects or contained descriptions of what seemed to be insufficient in respect to journalistic maps. Approaches to a methodologic research were still missing.

At the 1986 annual meeting of the Canadian Cartographic Association one of the sesssions was devoted to „Cartography in the media". Cartographers as well as journalists from Canada, USA, France and Great Britain presented papers and contributions to a round-table discussion which offered different approaches (3).
Gronoff (4) tried to apply the Bertin system (5) to the analysis of newspaper map functions, while Balchin (6) gave a report on a four week „media watch" in the United Kingdom. But this watch was realized without any methodologic base and without any attempt to distinguish between different medias, between graphic and cartographic images and between reference maps, weather maps and maps in advertising. In a more solid way Bonin (7) examined for about six years some French newspapers, but he mixed reference maps and maps in advertising and did not explain the method and the criterions of his research. Gilmartin (8) presented the results of an opinion poll concerning the effect of newspaper maps in respect to the reader's mind, the reader's learning and the reader's attraction; this poll was based on the answers of 20 students only and cannot be considered to be representative. Contrary to the cartographers' opinions the contributions of journalists (9) underlined the practical needs which determined their daily work characterized by the pressure of time, the overwhelming amount of information and the limited space on a newspaper's page. The discussion between cartographers and journalists (10) remained deeply unsatisfactory because each group gave its own statements without trying even gently to enter into the viewpoint of the other group.
Even more unsatisfactory than the result of this final discussion was the fact that all contributions were presented as if no newspaper's reader existed who could have been asked for his opinion about the maps published in his newspaper.

This meeting in 1986 stimulated the interest in journalistic maps especially in the English speaking world where this topic was introduced by Mark Monmonier in the „Map appreciation", published in 1988 together with George A. Schnell (11), and one year later in his „Maps with the news" (12). In „Map appreciation" the „maps in journalism" and the „weather maps" are for the first time objects of special chapters in a publication pretending to be a cartographic textbook. The main subject of „Maps with the news" is the development of maps in American newspapers, magazines and television in dependence on the technical progress, in particular on the computer technique. Monmonier himself characterizes his working as rather unsystematically and his approaches of methodologic relevance are presented without any proof of empiric base.

Internationally on the one hand we can see a certain and growing attention paid to maps in the media and several research and publication activities based on different approaches. But on the other hand there is no strict methodologic approach which considers cartographic aspects as well as journalistic needs, the graphic influences upon both fields of activities and the opinions of the newspaper map readers about those maps respectively the real effects of newspaper maps upon the newspapers' readers. In the same way one could wonder about the unrealistic mixture of advertising tools with information instruments, graphics with maps and newspaper with televison.

Day by day about 5-6 million of reference maps are published by German newspapers in their general news parts (13) plus the same quantity of weather maps. Besides the maps in television news the newspaper maps could be considered quantitatively as the most important German line of cartography. But except a short article published in 1953 (14) there is no published proof of interest in this cartographic field up to the seventies.
In Germany only Günter Hake tried to draw the cartographers´ attention to journalistic maps (15), but at first without reaction because the general cartographic opinion refused to care about these „non-maps". Furthermore in this period the cartographers' attention was occupied with the computer technique and its impacts on map making.
Hake himself revealed the problems to treat this new field by the uncertainties to find an appropriate concept for „maps in the media". In 1976 he called them „topical maps" (16). Hake supposed that many people would gain their knowledge of topical facts with spatial relevance without exception or almost exclusively through these „topical maps".
One year later Hake discussed the conceptional problem again, drawing back from the „topical map" and testing other concepts, finally coming to a certain conclusion in creating the „short-time map" (17). Moreover in this paper he stressed the psychological barrier of many traditional cartographers concerning their idea that a real map is one that has a certain graphic elegance and can be considered as an artistic object with a long expectation of life. Consequently the newspaper maps - short-time maps - would be of minor importance, having been produced without high elegance and artistic effort and being characterized generally by a very short expectation of life, being an article of consumption. Nevertheless, Hake predicted an increase in significance for these maps within the next future especially in connection with the growing use of computer technique in cartography. Consequently cartography should pay more attention theoretically as well as practically to the „short-time maps".
In the same sense Hake expressed his opinion in his 1985 cartographic textbook (18), now using the combination „media map (short-time map)" for the maps in newspapers and television.

Contrary to Hake's notions I may mention the traditional cartographic view expressed by Werner Witt in 1979 in his „Dictionary of cartography", catchword „politics, media": „The maps in the newspapers and in television serve as daily offered political and economic information, mostly using strongly simplified images focussing on political activities, military actions, regions of disasters, terrorism and calamities. Often the primitiveness of those maps cannot be exceeded and the newspaper illustrators at least one time should take the chance to look over the shoulder of a cartographer. On the other hand cartographers could learn several things by

advertising specialists, above all to use the graphics in a psychologically and propagandistically effective sense" (19).
This dictionary as well as most of the cartographic manuals in Germany, Austria and Switzerland published between 1970 and 1990 did not contain entries like „newspaper map", „media map" or „short-time map" (20). The first cartographic compendium dedicating an article to the „journalistic map" („Pressekarte") came out in Leipzig in 1983 (21).

In comparison to cartography and cartographers, journalism, communication sciences and journalists did generally not rack their brains over maps in newspapers or in television.

Since more than twentyfive years my favourite cartographic line was the history of cartography drawing me to special maps and atlases, to the regional history of cartography, but more and more to general research on the basic relevance of maps and cartography within the frame of social, cultural and political processes and interactions of the past . This research led to the theory (22)

- that making and effective use of maps as analogous graphic spatial information systems were and still are
- characteristics
  - of a quantitatively small group of leaders within a society or
  - of special societies exceeding other societies in power.

Cartography is an expression of power, and power conditions cartography.

In connection with the increase of maps published in the media, especially in newspapers, in 1985 my working group at Freie Universität Berlin, Cartographic Institute, started general research on this phenomenon and focusing on whether this theory could be verified even in the case of the current journalistic maps or whether the increase of these maps would turn the society democratically in terms of communication falsifying this theory for the present time.
In a first step it seemed necessary to define exactly the subject of research and to find a methodological base for a cartographic analysis of the respective maps. It was decided

- firstly to distinguish between the different media - newspapers, magazines, and television - because the conditions of map making are different in each of the media,
- secondly between the different types of graphically based images - diagrams/charts and maps - because their making presupposes different conditions, and
- thirdly between different operational fields of the maps - geographical reference of the news, weather situation/forecast and advertising because the maps are produced at different places with different tasks.

Research on the reference maps in newspapers and magazines was defined as the main task (23) while the weather maps in newspapers should be investigated in a second step (24). Obviously television and other media containing „short-time maps" could not be neglected (25). These decisions were made considering the map as a tool of consciously offered and consciously perceived information in a cartographical sense contrary to advertising. Within this field of activities the very first step must be to elaborate a methodological framework and to test it by researching a limited set of printed media. This was done in 1986 by Dieter Jung during his graduation (26). He investigated four national newspapers - three „elite" journals and one gutter press journal - and three magazines, considering the period of the first six months in 1986. He created the first strict methodological approach and drew the following conclusions:

- Maps are often and regularly used in German „elite" newspapers and magazines contrary to the gutter press journal.
- A very considerable part of the maps are published in the „travelling" parts of the media and mostly in the newspapers' weekend editions. Most likely the time dedicated to these maps by the reader put them into the group of „long-time maps".
- A lot of maps do not show a sufficient conformity with the text they belong to in respect of topographic names in general as well as in orthography. This problem is caused by different sources of map and text.
- A scale is often missing or not correct so that the reader cannot identify the spatial dimensions shown in the map.
- If an article contains text, photo and map („visual competition") the map portion of the total surface is generally the least with about 10 % only.
- The map size is generally dominated by the respective column-width of text without respecting the graphic differentiation of the map content.
- Most of the maps are placed in the upper parts of the pages which might be caused by layout reasons.
- According to the type of news offered in newspapers and magazines respectively the newspapers prefer maps of small sized European regions while magazines publish spatial images of much larger non-European areas with priority.

These conclusions led to the following thesis:

- Maps in printed media are published with almost absolute priority under journalistic conditions. There is no evidence that within the journalistic field cartographic principles are known or used to keep or to enhance the communication effect of maps.
- Maps in printed media are created almost totally by people skilled in graphics but not educated in cartography.
- The main factor of map making seems to be time. Magazines contain maps made more effectively and with more diligence than daily newspapers.
- A certain, but quantitatively not exact fixable part of the maps published in newspapers and magazines is spoiled and not readable because of useless map originals or careless reproduction processes.

At this time the approach to and the general view of this field above all were cartographically. But the research results of Jung very clearly showed that this narrow-minded view could not lead to a satisfactory inventory and analysis of the facts, the problems and the significance of the „short-time maps". Moreover it seemed operationally necessary to separate the research on newspapers from the research on magazines. In preparing a comprehensive research program this second approach was combined with an investigation plan concerning the editorial staffs and the graphic pools of a representative set of newspapers and the general graphic services which supply above all regularly the German newspapers with graphics (diagrams/charts) and maps. As a third factor absolutely necessary for the program the newspapers' readers should be included, but at this time we were unable to find a reliable way to a representative group of readers and their opinions about the effect of newspaper maps.

Based upon this program the „Deutsche Forschungsgemeinschaft" (German Research Foundation) provided the funding we requested for four years beginning September 1988. To improve the first narrow-minded and only cartographic approach, cooperation and consultation were started firstly with the branches of communication sciences at the Berlin Free University and at the Berlin Technical University, with the Department of Journalism at the Hannover High School of Arts and with the Press Office of the Federal Government at Bonn. A very important success had been that the colleagues from Hannover placed a set of 34 German newspapers at our disposal, containing the copies of the first six months in 1986 and being representative in respect to scientific principles of journalism (27). This set of 34 newspapers comprised on the one hand national journals as well as regionally bound

journals and on the other hand the whole range of newspapers from „elite" journals to examples of the gutter press (28).
Based upon these preparations the first part of our program started: the autopsy of newspaper maps comprising a comprehensive analysis of the content and the functions of maps in the newspapers of our representative set, following cartographical principles.
In the second part of the program the editorial staffs and the graphic pools of our newspapers as well as general graphic services were investigated by visits and correspondence. By this investigation we tried to analyze which particular decisions within the newspapers' departments and within the graphic services' pools are leading to the publication of maps concerning in the same degree the respective communication reasons and backgrounds, the cartographic man power and the technical possibilities.
Within this program we also wanted to find an answer to the question whether or not the newspapers of our set could be distinguished in the same manner according to journalistic characteristics and to their respective map equipment.
As mentioned above the readers of the newspapers still had been excluded from the program at that time. But when realizing the last part of our 1988 program we succeeded in finding a way to the readers' opinions by participation in an „omnibus poll" of a famous German opinion polling institute (infas). The results of this poll will reach us in spring 1993.

The 5000 copies of 34 newspapers having been published during the first six months of 1986 contained in total 1967 maps - only reference maps in the general news parts, excluding weather maps (29) and maps in advertising. These about 2000 maps are distributed to the newspapers and combined with the topics of the news in very different ways. The quantitiy of maps within the newspapers ranged from 5 to 133 and the quantity of maps attached to one topic from 2 to 330 (regarding firstly 15 different topics).
The methodologic approach was improved several times during the program and finally we distinguished between

- seven topical parts in the newspapers
  - travelling
  - politics
  - regional news
  - economics
  - sport
  - public announcements
  - others

and

- twelve analysis parts concerning formal aspects, content and functions of the maps
  - map position
  - topic
  - „content conformity index"
  - article size / visual competition
  - location / size of the mapped area
  - form / accuracy of scale
  - identification of the mapped area
  - map size
  - relations between map scales and sizes
  - legend
  - map content
  - map author / maker

The following summary can pick out only some results of our program, the complete report (30) containing about 230 pages with many maps, charts, diagrams and tables.

Concepts

In general the maps published in newspapers and investigated in our research program belong to the main group of „short-time maps" contrary to the traditional group of „long-time maps". „Short-time maps" are graphically and in respect to their content rather simple maps, can be produced within a relatively short time (in newspapers within two hours, in television within ten minutes), are shown to the spectator or observed by the reader for a moment only and in general they are objects of consumption with a short expectation of life being parts of greater publications.

„Short-time maps" can be subdevided into „mass media maps" („journalistic maps") and „customer's media maps" (for example maps in air-traffic brochures), the first of them subdevided into „printed journalistic maps" and „television maps", moreover, the first of them again subdevided into „newspaper maps" and „magazine maps". The „mass media maps" („journalistic maps") generally comprise cartographical images as elements of information showing either the geographical reference of the news - „reference maps" - or the weather situation or forecast - „weather maps".

The newspapers' journalists and illustrators do not seem to have any knowledge or consciousness of the autonomy of maps and cartography, in general expressed by calling the map a „graphic" and by making no distinction between a map, a diagram, or a chart. The reason for this confusion must obviously lie in the practice of the newspapers' map makers skilled in graphics, but not educated in cartography.

Operational conditions

The decision whether a map is to be published or not is generally made under pressure of time and principally depends

- whether a map suitable to the respective news is available and
- whether there is enough space on the respective page for the map to be placed on.

This decision might be subject of very personal preferences of an editor.

A suitable map can be available because

- the newspaper's archives comprise such a map made or used sometime in the past independently from the topical news;
- the text of the news and a map made just suitable to this text by a general graphic service (or an unnamed person) are dropping into the editor's office just at the same time;
- the editor orders a suitable map to his own graphic pool after having received a news text to which he thinks a map would be a good addition.

The first situation can be considered as unusual. According to the frequency the maps are made or originated by unnamed persons in the first place, by general graphic services secondly and by newspaper's graphic pools thirdly, but with a relatively small percentage only.

Maps from unnamed persons form a very inhomogeneous mixture, characterized by the fact that most of them obviously has not been produced taking into consideration the special conditions for publication in a newspaper. These maps predominantly appear within the topics „official announcements" and „travelling" and are more or less graphically spoiled because they are based on originals like photos or large scale topographical maps.

Contrary to this group of map-makers and maps the general graphic services like „Globus", „Index", „Carpress", „Imu" or „Hansapress" are regularly sending their well-done and effective maps and graphics to the newspapers. These maps are made by specialized graphic editors and artistically working illustrators without cartographic education and realized graphically considering the special newspaper's conditions. In this case - i. e. text and map coming from different sources - it may be that the topographical contents of the map and the text show only a reduced conformity, a fact which the editor cannot improve by the pressure of time; another bad habit can be to reduce the size of a graphic service's map according to the column-width of the newspaper so that the letters in the map cannot be read anymore.

Among the 34 newspapers investigated 16 pretended to have their own map-making and graphic pools, but only seven journals proved to have published maps of their own. On the top

of these journals we can find the „elite" newspapers, only one of them using the skills of a real cartographer.
Besides two general graphic services with a good stock of different maps at their disposal almost all graphic editors and illustrators use very common general and school atlases as well as city plans to produce journalistic maps.

Attributes and functions
Obviously there are two main functions correlated with maps in newspapers:
- on the one hand a map is a pure or primarily „graphic image" working as an „eye-catcher",
- on the other hand a map is an „analogous spatial information" showing the „spatial reference" of the news.

The „eye-catcher" function is the result of a newspaper graphically being the domain of the text mainly. Each graphic element interrupting the graphic text uniformity more or less automatically slips into the function of an „eye-catcher". Considering this function firstly the photo, secondly the graphic (diagram, chart), and at the last position the map is estimated to be very effective. In German newspapers maps are not consciously used for eye-catching although this function is accepted in a secondary line. But in American journalism the „eye-catching" function - also by maps - is used just to draw the attention of the reader to a certain map and by this to a certain article; because the editors know quite sure that the reader will not be willing or able to pay attention to all articles of a newspaper or a magazine.

As an intermediate map feature between „eye-catcher" and „spatial information" the „flash" is guiding the eye not only to a certain area on the newspaper's page and by that to a certain article but moreover within the map to the special region of interest explained in the text.

We don't know anything about the real information effect of a newspaper's map. Hypotheses may not have been verified and assumptions are dominating. On the one hand - for instance - Hake assumes that people would learn a lot by looking at these maps while on the other hand editors of Berlin newspapers are opposed to this opinion stressing that the reader pays attention to a newspaper map for a moment only and forgets about it in the next moment. Several specialists in the field of communication sciences, cartography, and journalism do agree about the tendency that it would be much easier and more effective to bring information to the reader by using pithy graphic and cartographic images than by presenting complex texts or statistics. There are strong indicators and several proofs in German newspapers - weather maps included (31) - that this information function of newspaper maps is increasing.
As a special aspect of the newspaper, map and its respective article are connected with each other formally by the common place on the page and in respect of contents by the conformity concerning topographic names. If this conformity is reduced or even missing the information effect of the map can partially be destroyed because in this case the map can tell another story than the text will do. About 60 % of the newspaper maps we investigated showed a more or less reduced conformity containing different topographic names in text and map.
There are further sources of information problems concerning this conformity. The conformity is totally missing if the printed map has been spoiled by useless map originals or careless reproduction techniques; maps like this had a general percentage of about 7 %, some newspapers showing more than 20 %. One can get a similar bad result in reducing the original map size in such a high degree that the map is no longer readable; again more than 20 % of the maps showed this phenomenon. Especially those deficits are concentrated within the topics „official announcements" and „regional news".
The unnamed authors are the main reason of those less effective maps, expressing a strong carelessness about maps mainly among the editors of certain newspapers.

Significance

Under the aspect of information the significance of German newspaper maps is an antagonistic one. On the one hand about 5-6 million of reference maps are published day by day and their production is still increasing by the newspapers' graphic pools as well as by general graphic services. On the other hand we can generally prove a very poor consciousness and an extensive carelessness about maps. Journalists having ordered in the past as in the present a huge mass of polls did not dedicate a single one of them to maps in newspapers; only few operational interest has been paid until now to the possible functions of maps. So the daily use of maps in newspapers seem to be principally based on the special graphical form and not on the spatial information connected with the map. Maps are situated at the periphery of the world of news.

The image of the world presented to the readers by the newspapers maps is well known since the beginning of history. Attention is predominantly paid to local, regional, and national regions represented by large sized and large scale maps; the farer the regions from Germany or Europe the less their presentation frequency, their sizes, and scales and the larger the regions' dimensions.

This general statement does not hold true for the German „elite" newspapers *Frankfurter Allgemeine Zeitung*, *Frankfurter Rundschau*, and *Süddeutsche Zeitung* their readers representing distinctly leading persons in German politics, economy, administration and science. These newspapers demonstrate an unprecedented use of maps and map features starting with the quantity of published maps and the percentage of internal map production and ending with a very positive conformity between text and map and a high percentage of maps showing non-European regions.

In general the German newspapers maps very strongly seem to verify the theory mentioned above that making and effective use of maps are still characteristics of an „elite", a quantitatively small group of leaders within a society.

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(30) See (28).

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Directing the design of maps for public information on the base of a user oriented communication model

A.-D. Uthe (Berlin, D)

Abstract:

The paper demonstrates a cartographic communication model by the modelling of thematic maps in which the integration of maps in the courses of action is considered. It enables the formal description of different situations of action and of communication in which maps are used to process and to represent spatial information. Conditions and demands arise from both situations for map modelling. Various communication situations result from the different phases of courses of action. They are caused by information needs, methods of information processing and also by the modes of perception of the map users. The maps have to be adjusted to these conditions. For example, in a planning process maps represent the same information but the function of these maps can be either to inform the public or to offer ideas to politicans.
Therefore, a map has to consist of an information layer representing the structure and meaning of transmitted information, as well as a communication layer organizing the perception and processing of information and also the orientation of communication. The graphic structure of this communication layer is based on conditions of communication derived from the differences between the condition of the user and the demands of the map. The graphic map structure can be realized by specific functions of different symbols.

1. Introduction

These days geographic information systems, multi-media systems or computer animation are applied to the processing and representation of spatial information in many domains, such as regional planning, environmental impact accessments and in the field of public works. These sometimes complex graphic representations are often modified to the technical conditions of these systems. Little attention is directed to the concept and graphic design with the regard to the methods for visual perception and the consequent mental processing of information. The conditions in which maps are used as a communication medium for the transmission of information are barely considered. People communicate which each other by maps, while map users form ideas or images through the employment of maps.
Maps are meaningful representations of the environment as geometric/graphic images of models of the space. The reproduction of space by means of graphic analogies can certainly support the mental aquisition of the space in representing the external structure of space. But ideas which are connected with this structure can exist in the mental system of human beings as well. Ideas and knowledge are combined with received information. Then the mental reproduction of the environment is created according to each person's individual mode of perception. These reproductions may not correspond to the reality or to the image of the model on maps.
The individual modes of perception play an important role in communication and also in actions. As a result of this the following questions arise. Which are the conditions in order to communicate with maps? Which functions can have symbols to alter the representation of information on maps to these conditions in order to support the processing of information on maps and to facilitate the integration of information in actions?

In the paper a communication model will be presented in which the processes of communication are embedded in actions. The conditions of communication will be presented which have to be considered in map modelling, in the concept and design of maps.

2. Situation of action

Action is defined as mental or physical activities to reach a goal, i.e. goal-oriented as opposed to reactive or instinctive activities. They consist of a complex sequence of coordinated efforts varying in accordance to the environment or to the individual situation in the environment. The prerequisites of any particular action are the cognitive process that means the reception, storage and processing of information through the process of perception, learning and thinking. These procedures are followed by emotional factors like needs, feelings, attitudes and motivation.

Action itself occurs within situations of action; this being a short term state of a general course of action. Courses of action may be:
- implementation of environmental impact accessment of a garbage dump or of a ring road,
- preparation of planning concepts in regional planning,
- determination of the optimal routes in transportation systems.

Therefore, the appertaining problems to the courses of actions have to be operationalized by defining the goal of action and by determining the methods for reaching the goal. A course of action takes place this way in several phases. For example, in planning there are the phases of searching and developing of goal ideas, of offering ideas, or of weighing the conflicts and alternatives. All these phases are followed by actual situation of action. Situations of action are described by the three components: object of action, system of action and information of action. These components are briefly mentioned here. The object of action is the part of reality in which attributes and rela-

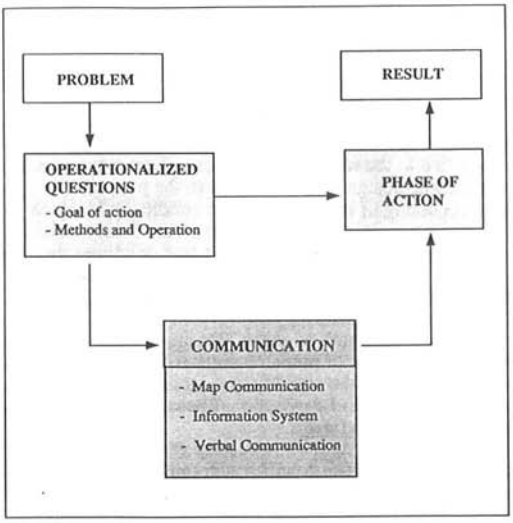

Fig.1 Process of action

tions are potentially concerned by transformations caused by the goal of action. Information of action are the attributes of the object which are to be communicated in order to reach the goal. Furthermore the methods of information processing which are necessary for this to reach a goal. Action systems carry out actions for reaching the goal with the help of information.

Action is supported and controlled by information processing, and is not possible without communication. Within the communication the reception and processing of information follows. A phase of action makes specific demands on the communication and the operations of information processing. Therefore, a corresponding situation of communication is related to the situation of action (see fig.1).

3. Situation of communication

First of all, the orientation of communication is determined by the actual situation of action. The orientation may be information, coordination, controlling, development of model or documentation. The orientation of communication is linked to modes of communication, such as communication followed by information systems, by map communication or by verbal communication. The higher communication function of digital and graphic maps is determined by the adjustment of information processing. Here the information processing on graphic maps is oriented to the creation of new information in the form of abstraction by selection and connection, the checking of information by affirmation, verification or falsification and the matching of map information with mental information by reductions, improvements or corrections. Maps facilitates, among other things, the description of the initial and goal state of the object of action, the comparison of states, the representation of demands or the organisation of mediate results.
The orientation of communication requires specific forms of communication as demands, such as rapid change of image on the display in order to present series of maps or interactive input to identify symbols on maps. The organisational structure and conditions of the components of the communication situation are determined by the demands of the action situation. These demands have to be fulfilled by the states of the components - "communication content", "output system" and "reception system".

The communication content, derived from the relation of object and goal of action, are the information and their meanings which are to be transmited and which are necessary for the mental reproduction of the object corresponding to the goal of action.
The output system are i.e., the map system which provides these information in communicative and cartographic structure.
The reception system is the user who will receive, process and deliver the information of the map system in order to reach the goal of action respectively to put them into actions.

3.1. Components of the communication situation

These components are described by their states and relations. Here the whole frame of the communication model and the complete sequence from an actual situation of action to the map communication are not to be considered. The rest of the paper will deal with the relation between map systems and reception system, both of which are important for map modelling. The conditions of communication will be derived from the states and relations of these components within a communication situation. They include the conditions by which the orientation of communication, the use of maps and the function of maps are realized (see fig.2).

Functions of the Reception System

a) Functions of the sensory mechanismn: capacity of stimuli absorption, perception of contrast, differentiation of stimuli situation and so on
b) Functions of the cognitive mechanism: accessibility of cognitive systems and of cognitive methods, information storage and recall capacity
c) Disposition and readiness of user perception: motivation, aspiration level, activation, perception defense, attention.
d) Condition of social and cultural context: membership of groups, esthetic orientation

Functions of the Mapsystem

a) Physical structures as mediums or directions of performance
b) External structures, such as single map, extract maps, sequences of maps
c) Internal structures concerning the information and communicative structure of a map

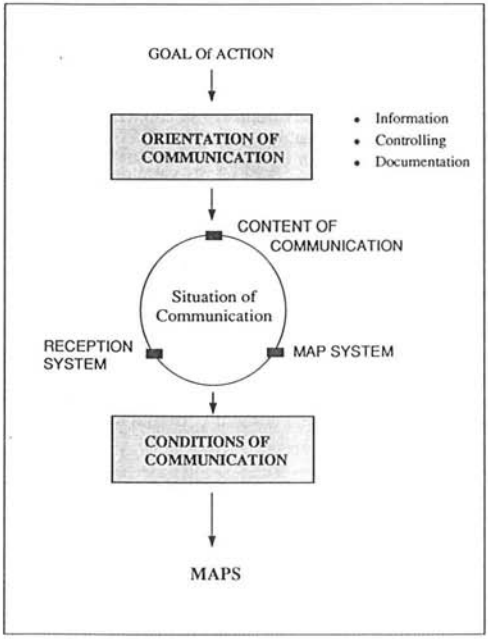

Fig.2 Communication model

Above all, the relationships between these systems are relevant to derivate conditions of communication. The relationships are shown as demands placed on the output system of the reception system and vice versa. Some demands from the map system to the reception system result from external conditions, such as location, facilities of interaction or technical resolution. Further demands arise from the internal conditions, such as symbol functions, extent of manipulation or auxiliary systems (scale, map grid, legend). The map system has generally to facilitate the mental reproduction of the object and the goal of action.

3.2 Demands of the Components

The demands from the reception system to the map system include the adequate or inadequate capacities of information perception and processing; the graphic, mental or verbal storage of provisional and final results; as well as, the position of the reception system as individuals or members of a group. The fuctions of perception are more essential to the modes of the reception systems, as opposed to the map system. The selection, accentuation, organization and fixation functions of perception are differentiated. The selection function controls the selection of a part of information as opposed to total piece of information. The organization function is the foundation for the information perception which corresponds with the motivation. A shift of selected information in regards to an additional accentuation, enlargement, reduction or decrease follows the accentuation function. This may occur by individual ideas of values and needs. In the fixation function the information that is only perceived are those that coincide with existing knowledge and experiences. And this information is not additionally checked and therefore no change or addition of knowledge will occur.

4. Layers of a Map

But differences will arise between the demands of the communication orientation and the given conditions of the systems within a communication situation. These differences may be cancelled out by graphic conditions on maps. These graphic conditions may assist or impede the perception and mental processing of information with regard to search, connection, comparision, estimation and preference. To convert communication conditions into graphic conditions on maps the realization of two map layers are necessary, an information layer and a communication layer.

4.1. Information layer

Within the information layer of the structure of information and of meaning will be presented by the logical data symbol reference. For representation following relations of information have to be determined:

a) the relation of information is fixed directly on the object of action with regard to the reproduction of codes, values and dimensions of objects, their properties and relationships

b) the relation to reality is defined by the information character:
   * the description of the condition of information relating to the accuracy of data, such as the degree of reliability or uncertainity of information
   * the description of the mode of information relates to statements concerning facts, goals, effects or causes; the information may be actual, normative, or they may reproduce forecasts or prognosis
   * the description of use of information relates to their numerical specification, to their checking or logical comparision.

   The information character exercises an influence on handling, as well as on the perception and on the consequent mental transformation of information.

c) the relation of information to the action defines the function of information. With reference to Morris the description function, the causation function, the evaluation function and the categorization function of information are to be differentiated by the modes of behaviour and thinking.

The transformation of information and data into symbols executed by the formal symbol assignment produces at first a neutral and logical structure of maps caused by the above mentioned relations. These maps should have a consistent and duplicating structure. The function of symbols on this information layer is to represent the information and the denotative meaning structure by means of logical and standard symbols.

4.2. Communication Layer

The layer of the higher communicative structure bases on the separation of information and communication. Information is in this sense of media of communication. This specific structure is absolutely oriented to action. Their conditions have an greater effect on the design of maps than the conditions of the information sructure. For example, in planning process of section of areas it has the same information structure but in different phases, it demands different structures of communication. These structures result from the given relationships between the reception system and map system, as well as the demands of the present orientation of communication.

The function of symbols on this layer relates to the organization of information processing on maps. With the goal of varying the optical situation of maps by graphic in such a way that the function of perception or at least the perception mode of the reception system is directed. On that score, symbols influece the operation of perception (discovery, differentiation, identification, selection, evaluation). The representation of information is varied by symbols on maps so that the symbols can work against the intended perception of the reception system.

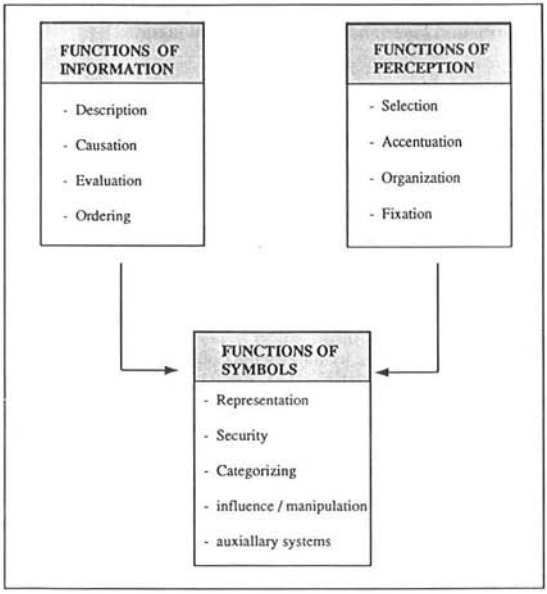

Fig. 3 Functions of information, perception and symbols

In fig.3, functions of information, of symbols and of perception are shown. In the course of action information is perceived, stored and exchanged. Within these processes information have specific functions represented by corresponding characteristics of symbols. The function of the social perception is not totally undisputed in literature. Therefore it is considered that the individual mode of perception never enables a neutral, objective reception and processing of stimuli and information conected to this stimuli. Then the function of symbols is to cancel out or to contrast these possible occuring discrepances between the intended meaning and function of information and to the actual perceived information.

Following symbols can be differentiated by their functions:
- **iconic symbols** represent the idea of information
- **redundant symbols** provide security for the perception of information. They increase the contrast between symbols
- **index symbols** carry no information, but they have a demonstrative and categorizing character as additional symbols
- **expressive symbols** influence and/or affect the perception of information. The manipulation and intended variation of information is not only produced by the methods of information reduction, such as geometric generalization or class calculation, it can also be generated by expressive symbols such as specific color modes.
- **auxiallary systems**, such as map grid or legend have the function of aiding in the referencing and storing of information in human memory. They assist the localization and also the provisional storage of information

5. Conditions of Communication

In order to realize these function in maps the concrete graphic structure of symbols are created by the conditions of communication. These conditions result from the differences between a given communication situation and the demands of the communication orientation. These conditions concern certain aspects of information which are processing, action and communication.

Communication conditions relating to the sensory perception :
These conditions require such a variation of symbols that the symbols satisfy the functions of the sensory mechanism of the reception system. This sensory perception is, among other things, influenced by the symbol dimension, the contrast of symbol, the degree of contrast to the map ground, the syntactic complexity of maps and of symbols.

Communication conditions relating to the cognitive processing :
The design of symbols should assist the different operations of thinking and storing in order to match the information structure to the cognitive function of the reception system. It concerns both the condition of information and of symbols. Here the symbols can vary by the level of aggregation, the geometric acuteness, the degree of approximation and of association to structures of reality, the degree of familiarity and of standardization.

Communication conditions relating to assistance of actions :
These conditions relate above all to the retrieval of perceived and stored information in order to put these information into action. Symbols facilitate the reproduction, evaluation and manipulation of information in relation to those existing in the cognitive systems.

Communication conditions relating to stimulation of communication :
In the cases that uncertain knowledge, common interests, conflicts or the need to establish contact are exist among different people a symbol structure is necessary which facilitates communication. In such a symbol structure both the uncertainity and vagueness of symbols and the degree of identification and alternative variation of symbols influence the perception and processing of information.

These conditions have a greater effect on map communication than the conditions of the pure information transmission. They contain the framework of possible behaviour and interaction as well as intentions of associated information processing systems. All the aspects which make the intuitive, arbitrary and esthetic elements in the representation of spatial information will be formally described by the communication conditions. The relations between perception, thinking, knowledge, attitudes and action are considered are not only relevant to the direct perception of the environment but also to the perception and interpretation on maps. The communication conditions are realized by the function and concrete variation of symbols. Therefore, the symbols normally representing objects and their properties are subjected to corresponding variation in order to fulfill their functions within a communication situation.

The formulations of the theses and conditions are based on the findings of perception and cognitive psychology, communication theory, cartographic sign theory, as well as theory of action and the analysis of information processing. As rules they can represent a part of the methods of map modelling. It is conceivable that the integration as knowledge base improve the systems which are involved in the processing and representation of spatial information by maps or other graphic presentations.

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Editing an international map series – specifics and problems

P. Jordan (Wien, A)

1 The mapwork as an example

Since 1989 the Austrian Institute of East and Southeast European Studies in Vienna has been publishing a mapwork entitled "Atlas of Eastern and Southeastern Europe".[1] The area portrayed in this atlas comprises essentially the former socialist countries of Europe as well as adjacent areas in Western Europe. Thus, the former socialist countries of Central and Southeastern Europe are represented on a scale of 1:3 million, while Central and Southeastern Europe plus the European part of the CIS are shown on a scale of 1:6 million. But the mapwork has been conceived to present not only surveys on very small scales. It also aims to highlight smaller regions, countries and parts of countries, e.g., a section of Central Europe on a 1:1.5 million scale, Romania, Hungary or Southern Poland and Transylvania.

The editors´ intention in producing this mapwork has little in common with the compilation of traditional regional or thematic atlases. The idea is not to present a coherent and thematically complete description of the region nor to elaborate a "prefabricated" programme. The main goal is to highlight major current developments and problems in the changing world of eastern Europe in the manner of a cartographic periodical or newspaper. Thus, proposed topics may be dropped in favour of more current ones, topics and the order of their publication depending very much on political and economic events. Subjects and regions of current interest are portrayed more frequently than others. Topicality is the touchstone for editing: the possibility of access to new data is a strong impetus for drafting a map; hence, the technical processing of the map manuscripts must be accelerated as much as possible, e.g., by means of EDP. In spite of this, the mapwork unfailingly adheres to high scientific standards and places a strong emphasis on excellent cartographic quality.

The atlas addresses mostly scientists and researchers in the fields of geography, spatial planning, economics and ecology, but also enterprises with an interest in the eastern market, schools as well as those segments of the general public taking an interest in developments in eastern Europe.

So far, 13 issues devoted to ecological, population, economic, spatial development and

political subjects have appeared, most of them by scientists from the countries and regions portrayed.
Although the map series is by no means typical of international thematic mapping, those of its maps portraying a variety of countries reflect and experience most of the specifics and problems connected with the publication of international thematic mapworks. The present paper will discuss the most important of these.

2 Specific problems and aspects of editing

2.1 Data collection

A basic principle of map design is to treat all parts of the areal section of a map in a homogeneous way thematically. Deviations from homogeneity must be indicated at least in the legend. In general, only a map or a mapwork featuring a single country, such as a national atlas, enjoys the privilege of a uniform database, drawing all data from a single collection (e.g., a population census). These data are surveyed and presented in accordance with a uniform system and refer to a specific point in time. As soon as more than one country is concerned data collection becomes much more difficult. In a strict sense, therefore comparable data across national borders are available only for a very small number of topics.

2.1.1 Absence of national data

Although our map series uses a variety of areal sections, a specific section, once selected, has to be covered in a homogeneous manner thematically. The large-scale spread of air pollutants, was for instance shown for Central and Southeastern Europe on a 1:3 million scale. The only comparable data available for the entire region were those on sulphur dioxide levels collected by the International Ecological Centre in Stockholm. The classification of these data into four tiers of concentration, however, was very crude and insufficient for a map of this scale. For a more differentiated insight into most countries, it was possible to use other indicators such as mostly particulate and nitrogen oxide emissions to define regional and local air pollution peaks more clearly. In Romania, however, air pollution has not been subject to systematic monitoring so far. For the overall mode of representation to be extended to Romania, estimates by local experts had to replace monitoring data. Not to represent Romania on an equal footing would have meant not to elaborate the map at all, since Romania formed a central part in the areal section of the map in question. Not receiving comparable data from Albania (where there is no monitoring, either - and no Albanian expert was ready to give an estimate of air pollution) was regrettable, but did not impede the publication of the map, because

small Albania formed the margin of the map sheet. Therefore it made little difference if it remained untreated thematically. The absence of data from Western Germany (equally marginal on the map sheet), while no insurmountable problem, meant a substantial loss thematically, however, since it would have been quite elucidating to have a comparison between air pollution in the former socialist countries and an intensively industrialized country of the West.

2.1.2 Deviating key-dates

The large number of different key-dates is of no account for many topics as long as they are within a couple of years. Thus, the fact that the former Federal Republic of Germany concluded its population census in 1987, the former Soviet Union in 1989, Hungary in 1990, former Czechoslovakia and Yugoslavia, Poland, the former GDR and Austria in 1991 and Bulgaria as well as Romania in 1992 does not present an insurmountable obstacle for the drafting of a comparative map on population density or population development. It is, however, impossible to use data of such a temporal diverseness for the compilation of a map on unemployment, which may change substantially from month to month. The lack of a specific key-date or at least key-year prevents us, e.g., from the compilation of a map on freight traffic in Central and Eastern Europe - a topic of the utmost interest in the wake of the opening of Eastern borders. Given the rapid shift of freight transport from rail to road in the former socialist countries as well as the recent political events, which have, e.g., forced all transports to bypass ex-Yugoslavia, data sources differing by more than a few months are virtually without value.

2.1.3 Deviating classifications

All data are collected and documented according to qualitative, frequently also quantitative, classifications. International standards for data classification exist and are observed mainly in the fields of physical features, demography and infrastructure. Other fields have a variety of national classifications. Thus, it is comparatively easy in terms of classification to compile (not to get hold, though, of the data for) international maps on the power industry. The classification of both power stations according to production types and of transmission lines according to capacities is in accordance with international standards.

But already in the sphere of physical geography we encounter varying classifications. I would like to mention the familiar examples of groups of soil and vegetation types. Surprisingly enough, even wind directions are classified in different ways. In Bulgaria, e.g., wind frequency counts do not take into account days without wind and do not indicate frequencies in per cent of all observations, as it is usual in the majority of countries.[2]

The more we turn to human and economic activities, the more classifications differ. A land use concept such as "permanent cropland" unanimously subsumes only vineyards, orchards, citrus and olive cultures. Bi- and triennial crops, mixed cultures of annual and permanent crops are classified partly as "arable land", chestnut cultures partly as "forests", tree nurseries with a predominance of fruit-trees, and commercial as well as house gardens with permanent crops partly as "gardens".[3]
Retail trade sometimes includes and sometimes excludes pharmacies, tobacconists, filling stations or banks.[4]
Generally, all these cases may still be represented on a single common map, especially a map of a smaller scale. In some instances, it will be in the interest of clarity to use a modified cartographic symbol to indicate a slightly different thematic classification. Variations of classifications must be indicated in the map legend. There are features, however, for which classifications in different countries diverge to the extent, that comparative cartographic representation no longer makes sense. A characteristic example of this is the field of education and schools. Data from this field are inextricably linked with the individual school and education systems, which are radically different from country to country. Therefore some fields will always be "off limits" when it comes to maps comprising several countries .
Not all variation observed in classifications is warranted by necessity (cultural divergencies, etc.), and major efforts on the international level towards greater standardization are highly welcome. The diversity of cultures, lifestyles and economic systems, however, will never permit a complete harmonization of classifications in all fields.

2.1.4 Data of different areal accuracy, non-matching statistical reference areas

The problems posed by networks of different widths with point-referrenced data resemble those created by deviating sizes of reference areas when data refer to statistical areas. Similarity in size is essential for comparability within the map´s areal section. Figures for larger areal units have a lower level of accuracy than those for smaller units. Average values of larger units will never range between such extremes as values of smaller units.
Making statistical data of similar accuracy available for the whole of Central, Eastern and Southeastern Europe is not an easy task. Often statistical data can be obtained only for regions [oblast´] in the CIS, only for voivodships [województwo] in Poland and only for districts [judeţ] in Romania . The average oblast´ is about five times the size of a Polish voivodship and a Romanian district, about 30 times the size of a district [okres] of former Czechoslovakia and about 60 times the size of an ex-Yugoslav commune - administrative units for which most of the statistical data from these countries were available. A map series illustrating this region without using those data would be restricted to a very narrow range of topics. But with topics such as commuting, where

the sheer extent of the reference unit is part of the definition of the subject, reference areas of widely differing sizes preclude comparable representation. The only way out is to extrapolate the original data to another level of the administrative subdivision - provided such a level exists and is closer to the required size.

2.1.5 Deviating structures of reference areas

Not only the sizes, but also the internal structures of statistical reference units have to resemble one another to produce a comparable map. This requirement remains clearly unfulfilled, when in some cases (as in Polish voivodships, Hungarian counties [megye], Romanian districts, ex-Yugoslav communes, Bulgarian *oblast*) capital cities/towns and their surroundings form a single administrative unit, whereas in others (as in German *Landkreise/Stadtkreise*, Austrian *Politische Bezirke/Städte mit eigenem Statut*, ex-Soviet urban/rural *rajon*) capital cities/towns are administratively separate from their surroundings. For nearly all features in the anthropogeographical sphere - from population development to ethnic structure and election results -, there is a distinct differentiation between urban and rural areas. To overcome the respective differences between the data available, one may have to resort to the lowest common denominator, i.e. to add the data of capital cities/towns and their surroundings where they are surveyed separately.

2.1.6 Instability of reference areas over time

If a map has to represent the development of a particular feature over time, changes in administrative subdivisions used for areal reference of statistical data can be quite disturbing even within a single country. Source data have to be recomputed to allow for the present state of affairs. Difficulties multiply with the number of countries involved. The former socialist countries of Europe in particular have experienced a lot of change in their administrative subdivisions in the course of this century. First, their administrative subdivisions were adapted to the "requirements of socialism". Later, they underwent renewed change in some of the countries (especially Poland, Romania and Bulgaria). Now, in the wake of the democratic revolutions, major administrative reforms are once again under way.

2.1.7 Hierarchies of importance

Maps of the complex-analytical type which portray larger geographical regions may give rise to the question which of the issues is to be given priority in terms of cartographic representation. It may happen that different countries attribute different priorities to one and the same feature. It may also happen that a specific single feature warrants a different kind of priority when seen from the cross-frontier and international points of

view other than from a national or domestic standpoint. Thus, our map on the use of the environment in Central and Southeastern Europe showed the impact of tourism on the environment only in terms of its general importance within the whole region, i.e. only by a thin areal screen almost in the manner of a supplementary issue, although the tourist industry has a strong impact on parts of this region, e.g., in Austria and along the eastern Adriatic coast, where tourism is a mainstay of economic activities.

2.1.8 Insufficient comparable data for synoptic and synthetic issues

For the elaboration of maps with synoptic and synthetic themes, it would be of advantage to have a choice of a variety of indicators for a specific feature and use them in combination or individually, following a meticulous process of selection. When mapping a larger geographical region, one is faced with the fact that the choice is rather limited or practically inexistent. Since only a few data are documented in a comparable manner in all the countries, one is compelled to describe a complex feature with only a few indicators, perhaps not even the most characteristic ones. In many cases, the lack of comparable indicators makes it impossible to represent synoptic and synthetic issues internationally.

One map of our series, which is to highlight the current process of socio-economic transformation in the former socialist countries, e.g., will have to be elaborated on the basis of the indicators "production development in agriculture and industry", "turnover development in trade", "rate of unemployment" and "net out-migration". And even the computation of production and turnover developments is a questionable task, having to be done on the basis of currency units for most of which only nominal values are documented. To compute the increase or decrease in real money values is difficult, not only because official inflation rates are sometimes unreliable, but also because inflation rates may vary within larger countries.

2.1.9 Making data available

When it comes to sources for obtaining internationally comparable statistical data, the international statistical yearbooks edited by the United Nations and those of other international organizations are the first to come to mind. Unfortunately, their materials are no better comparable than the data which are found in national and regional statistical sources. In fact, they merely reflect the data of national compilations, their footnotes pointing to deviating national classifications. Information that is lacking in national documentations is also lacking in international ones. To learn more about national classifications, it is advisable to refer to national statistics. They generally offer more accurate and more comprehensive explanation. Another major advantage is that they are published before international compilations.

In many cases, statistics published in the shape of periodicals are not sufficient for the

production of more detailed, scientific maps. More basic data collections such as population censuses are required. Most of them are no longer published in the form of hard copies, but can only be used by way of accessing computer files. This has not made it easier for foreign users. Our map series has shown that it is advantageous to use a scientist on the spot as a mediator it being easier for someone acquainted with the customs and language of the country concerned to select and retrieve the appropriate data.

2.2 International scientific collaboration

2.2.1 Map authors, data collectors

In elaborating our map series so far, we have practised a variety of different modes of international collaboration. They may be classified roughly into three types.

The kind involving the least amount of foreign collaboration is to have members of the editorial board author a map from inception to cartographic transformation and to receive the requisite data from institutions or individual scientists in the countries to be represented. Our network of scientific correspondents and branch offices helps us to considerably accelerate this procedure. Such comparatively loose cooperation with scientists abroad is mostly used for statistical maps of a larger geographical region, based on clearly pre-classified data. Our maps on the power industries and the 1990 elections in Central and Southeastern Europe have resulted from such a procedure, for instance.

A more intensive kind of international collaboration is the joint conception of a map by a member of the editorial board and a scientist from the country represented. The colleague abroad provides us with the knowledge of what may be interesting, to be the specifics of the situation, including all interrelationships with other features, as well as the availability of data. The "scientist on the spot" collects the data and acts as an advisor when the information is classified and systematized. This form of cooperation combines the advantages of a strong local/regional input of knowledge with complete control by the editorial board over the progress of work. This method is preferable for topics which, once they have been carefully structured and classified, require no or little further interference from someone familiar with the local situation. These are mainly topics of a statistical nature, too. Examples of this kind of collaboration within our mapwork include a map on the availability of central facilities in rural settlements of Transylvania and a map on population development in Poland in 1980-1990.

The mode of international cooperation which requires the strongest involvement of colleagues abroad is the elaboration of the complete map manuscript by a foreign author or authors. In this case, the editorial board will only exercise some sort of accompanying control and undertake the final systematization of the contents as well as the final

definition of the cartographic symbols. This mode is without doubt best for topics of a non-statistical, non-technical nature and/or for works where the paucity of data calls for familiarity with the region represented. It is in fact indispensable when the drafting of the manuscript requires continuous decisions, i.e.when the boundaries imposed by the theme do not follow a topographic network of boundaries, e.g., administrative units. In our series, the maps on air pollution in Southern Poland, the double issue on the use of the environment and the resultant problems in Central and Southeastern Europe as well as the map representing topoclimatic types in Central Europe were elaborated along these lines.

As regards collaboration with a multitude of authors abroad, we have found that when more than two authors are involved, it is useful to appoint a main author. When the number of authors exceeds 9 or 10, the main author should be supported by the editorial board or an editorial team of 2 or 3 further authors who are entrusted with the incorporation of individual contributions into the general manuscript. A case point has been our map on the use of the environment and the resultant problems in Central and Southeastern Europe, in the production of which 15 authors and another 27 consultants from 9 countries took part. We had one main authoress and an editorial team of 3 from different countries.

2.2.2 Handling of politically sensitive topics

A map series devoted to current developments and problems is always likely to touch on politically sensitive issues. Especially with countries such as the former socialist countries of Europe, which are about to develop their democratic institutions and suffer from a general economic and social slump almost any topic will have some political significance. But of course, topics such as ethnic structure and language distribution, critical zones, underdeveloped and peripheral regions, the state and progress of socio-economic transformation and the state of the environment are more sensitive than others. In these cases it is necessary to involve a high-ranking scientist from the country represented in the elaboration of the manuscript. Otherwise the editor will encounter difficulties with the political authorities of the country, perhaps even with its scientific community. This is especially true of maps which are not only based on official data.

2.3 Editorial layout

2.3.1 Toponymy

A map series devoted to a larger geographical region and designed for an international readership has to reflect the toponyms in the official language(s) of the countries represented. This refers to names of settlements and administrative units as well as to

names of other geographical features such as mountains, rivers and lakes, which are generally not in such an official way documented. Our practice is to give endonyms without exonyms. In multilingual areas, we indicate names in all official languages, provided they are considered official within an administrative category of a certain minimum size, e.g. within autonomous regions [oblast´] in the Russian Federation. To reflect official multilinguality even within smaller administrative units whose boundaries are not on the map would be too confusing for the reader.
Names in non-Latin script alphabets are transliterated according to the recommendations of the United Nations. This means that for the transliteration of the Russian Cyrillic alphabet the GOST 83 system is used, that the Bulgarian Cyrillic alphabet is transliterated according to the Bulgarian standard (BGN/PCGN 1952) and that transliteration from the Serbian-Cyrillic and Macedonian alphabets follows the system employed in the Yugoslav gazetteer (Imenik mesta). For the Ukrainian and Belorussian Cyrillic alphabets, for which the United Nations has not yet recommended transliteration systems, we have used transliterations analogous to the GOST 83 system which is used for the Russian alphabet.

2.3.2 Titles, legends and explanatory texts

To underline the international character of a mapwork and secure its wider international distribution, it is advisable to give map titles and legends not only in the language of the country of publication, i.e. in our case German, but also in the most widely used international language, English. This, of course, requires great care with the translation of scientific terms and, as regards in particular the legends, economical space use. To use additional languages would be unlikely to create a wider readership, but would certainly reduce the possibility for explaining contents sufficiently in the legends.
For international mapworks explanatory texts are of special importance. They may fill gaps resulting from scarce and inhomogeneous databases and are necessary to explain clearly and comprehensively differences in data accuracy as well as between classifications. They are all the more useful for a map series like ours, which does not follow a systematic and concise programme, but responds flexibly to topics of special current interest. The accompanying text of such a mapwork also saves to connect the topic presented with other features, i.e. place it within a network of interrelationships. Our accompanying texts have the length of scientific papers and provide the reader with further explanations, sources and background information. They are translated into English in their entirety. If required by the topic of the map, they are supplemented by tables, maps in black and white as well as indices.

2.4. Marketing

It is a general observation that scientific maps and mapworks are difficult to sell to a wider public. Even maps which have been received enthusiastically by the scientific community and have also been given attention in the mass media do not become bestsellers in the same way as books of comparable contents. It seems there is a substantial reservation vis-a-vis maps, even among members of scientific communities other than those used to presenting their research in cartographic form. Even people with some appreciation for maps frequently consider a map as a commodity which one does not have to pay for.

Scientific maps focusing on a larger geographical region may elicit wider interest than maps of a single country. In the latter case customers might be confined chiefly to the country itself and its vicinity. A case in point is regions receiving such worldwide attention as eastern Europe at the moment. Nevertheless, success is mainly qualitative, confined to scientists, scientific libraries and institutions and insignificant in quantitative terms, i.e. a commercial sense, if we consider the high cost of production. One of the rare chances to turn a scientific mapwork also into a commercial success is to introduce it to schools. This, however, is very difficult, since the "school market" is well-supplied and, as a rule, also covered by school atlases. A second option is to produce generalized versions of the scientific maps and sell them to publishers of school atlases.

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Session 6

Mapping Land Use

Chairman:
R. Dahlberg, Northern Illinois University (Dekalb, USA)

The application of satellite image and image map in urban planning of Bangkok metropolitan

S. Silapacharanan (Bangkok, T)

Introduction

The rapid urbanization of agglomerations and megalopolis in the region of Bangkok is uncontroled. The effects of this situation reflects the lack of suitable and use and enforcement, indequate provision of infrastructure and facilities. The area of urban and regional planning needs up-to-date and good quality of information. The satellite data of Landsat Thematic Mapper (TM) and SPOT Image open a new route of image exploitation.

Objective of the study

- To evaluate potentiality of high resolution satellite image : Landsat TM and SPOT image in the field of urban and regional planning;

- To apply information resulted from satellite image in urban and regional planning.

Urban Growth Situation

Bangkok, the capital of Thailand, celebrated it's bicentenaire in 1982 and becomes the age of 211 in 1993. The metropolis covers the area of 1,567.8 km^2 called "Bangkok Metropolitan Administration (BMA)", the adjacent cities area called "Bangkok Metropolitan Region (BMR)" included Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom. In 1980, the urban planning concept of Bangkok usually integrated with the BMR territory. At present, a larger region as Greather Bangkok Region (GBR : BMA, BMR and Ayutthaya, Saraburi, Chon Buri, Chachoengsao) should be also considered in the planning process. This is due to rapid economic growth in this region especially the internationalization of industry and trading.

The transformation of urban space in the metropolis depends on the availabity of vacant land, land price, construction control and distance from the city centre.

- The historic area. The major land uses are; administration, education, commerce and residence area. High-rised buildings are inhibited. This area lost their population for more than 1 decate.
- The inner district area. This is the most important business area with high-rised buildings (offices, hotels, commercial centers, high-income apartments). There is no more vacant space left. The only land use change phenomenon is the transformation of low-rised building to be high-rised building.
- The outer city district. Major land uses are composed of low density residential area which has been developed for more than 20 years. The new trend of this area is high-rised residential building for medium to low income people.
- The suburb area. The ribbon developments appeared along major roads and large agricultural areas are abandoned, waiting for urbanization process. Built up area has been increased rapidly as well as population immigration due to the lower land price and new highway development in this area.

The rapid growth of Bangkok have resulted in economic losts and declining quality of life. The problems and constraints encountered area;

1) Traffic congestion; the rapid increasing of vehicles in the agglomeration reduces speed per hour.
2) Flood and land subsidence; the low-lying flood plain, pumping of under surface water, depression together with high tide have resulted damages from floods especially in the east and south - east of Bangkok.
3) Housing; the high increasing of land price and construction cost resulted in slum areas and long travelling distant and time between dwelling and working area.
4) Unefficiency of land utilization; the lack of proper land use enforcement, the integration of master plan of Bangkok and its adjacent cities affected land deeficiency and environmental problem.
5) Urban facilities and infrastructure services are unadeguate to the high increasing demand of urban growth (water supply, telephone, gabages, water treatement, flood protection, etc.)
6) Pollution; the over standard amount of dust in the air, non-treated polluted water divered to water channel decrease quality of life in this region.

Needs of Satellite Image in Planning

The application of remote sensing in urban planning commenced lately after other fields due to the size of resolution. The second generation of satellite image: SPOT and Landsat TM, with 10, 20 and 30 m. of resolution, bring a great advantage to this field. The selection of the most informative band for the needed information; limit of urban - non urban area, road network, landuse and its vicinity. The recent and repetitive data can be used for urban dynamic study and urban monitoring.

Material used

1) Satellite image:

Several dates of satellite image and used;

- 1st date: SPOT XS, acquired 10 March 86, SPOT image (323 - 622) level 1B;
- 2nd date: SPOT XS and P, acquired 5 Dec 87, NRCT (323 - 622) level 1B;
- 3rd date: Landsat TM, 6 bands (excluded band 6) 14 Dec 89, NRCT (129 - 51);
- 4th date: Landsat TM (b 2, 3, 4) photographic print, 2 Nov. 91.

2) Aerial photographes:

- 1st date: Bangkok 1985, scale 1 : 10,000;
- 2nd date: Bangkok 1987, scale 1 : 20,000.

Maps:

- 1st date : Bangkok 1969, RTSD, scale 1 : 50,000 RTSD;
- 2nd and 3rd date : Bangkok 1974 and 1983, RTSD, scale 1 : 20,000;
- 4th date : Bangkok 1980, BMA and JICA, scale 1 : 10,000 and 1 : 4,000

System used:

1) Image Processing System. The system "DIMAPS" (Digital Image Manipulation Analysis and Processing) installed at the Asian Institute of Technology. The station is connected to IBM 3083 at the Computer Center.

The maximum size of 512 x 512 lines and columns can be processed under selective algorithm. The coverage area of each subscene depend on the resolution of the image. (SPOT P = 26.21 km^2, SPOT XS = 104.86 km^2, Landsat TM = 325.93 km^2)

2) Autocartographic. The system Arc Info at the Thailand Development Research Institute are used to digitize the interpretated land use map from satellite image.

Methodology:

1. Geometric correction;
2. False color composite;
3. Principal component analysis;
4. Unsupervised classification;
5. Visual interpretation of photographic prints;
6. Digitization from the result of visual interpretation.

Result

1) Geometric correction

The method of bilinear interpolation is used by using control points of UTM grid coordinate for each data set.

2) False color composite

The combination of the three spectral bandes represent in 3 color composite: blue, green, red for band 1, 2, 3 of SPOT and band 2, 3, 4 of Landsat TM. The vegetation with active chlorophylle appears in bright red, old built up area in dark blue; recent built up area and metal covered construction appears in bright blue, bare soils and sand in white, deep water in dark blue to black, turbid water and shallow water in blue.

3) Principal component analysis:

The objective of this analysis is to reduce certain bands which are highly correlated. The advantage of this analysis is to produce a new band more interpretable. (Kaneko, 1978 Byrne et al 1980)

In the case of Landsat TM (14 Dec 89), bands 1, 2, 3 are very correlated and also band 5 and 7. The transformation resulted from principal analysis affected decorrelated information depending on the variance. The first component analysis contains 71.19 %, the second contains 23.25 %, then the first two components contain already 94.39 %. The first principal component represents very clear urban structure while the second stresses on urban - non urban limit.

4) Unsupervised classification

The algorithm of classification on the system DIMAPS is the maximum likelihood in which its principle base on the average and the covariance matrix of pixel's value of each data set.

The unsupervised classification method is processed for each data set because of the caracteristic of urban elements which are usually small and heterogeneous. Certain Twenty to thirty-five radiometric classes were produced and regrouped, then label into thematic classes.

One subscene (512 x 512 lines and columns) is used to classify land use by using XS1, XS3 and Panchromatic band. The pixel size of the maltispectral band are reduced from 20 m. to 10 m. after the geometric correction. The window of 26.21 km^2 covers the southern portion of Bangkok at the area of Bang Rak, Sathorn, Yannawa and Klong San.

The bidimensional histogram of XS1 and XS2 represents problem of mixed pixels. The classes of vegetation (orchard, bushes, grasses) and urban classes (recent built-up areas, bare soils) mixed together. We obtained 18 classes from this classification and they were regrouped into 7 classes (recent urban areas, intermediate urban areas, old urban areas, orchards, bushes, grasses, water).

The land use class of Bangkok by method of unsepervised classification is as follow:

- recent urban area; built up area with high reflectance of cement, metal or white covered surface;
- intermediate urban area; zone of medium reflectance, house with garden;
- old urban area, built up area with low reflected cover, dark colour roof;
- bare soils, sand;
- grasses, cemetery, abandoned land;
- bushes, garden, sparse vegetation;
- orchard, mixed orchard, dense big trees;
- water, swamp, river.

Visual interpretation and digitization

The visual interpretation of photographic prints is done on several dates of images. The four photographic prints of SPOT (23 Dec. 89) of NRCT at the scale of 1 : 50,000 are interpretated for land use map inside the administrative limit. The portion of Lat Krabang and Min Buri is interpretated from Landsat TM (14 Dec.89). Aerial photographs of 1987 at the scale of 1 :20,000 were used and field check had been also done.

After the visual interpretation, all polygons of land use classes were digitized by using the system "ARC INFO". The area and percentage of land use classes were obtained as follow. (Map)

Land use of Bangkok 1989

Land use	area (km^2)	%
- Commercial	22.6	1.44
- Residential : Mixed	225.4	14.37
- Residential : land and house	88.9	5.67
- Residential : land subdivision	40.1	2.56
- Residential : Apartment, flat	1.7	0.11
- Residential : slum	2.8	0.19
- Warehouse	4.1	0.26
- Government	27.7	1.77
- Education	8.0	0.51
- Temple, Cemetery	2.8	0.19
- Manufacturing	23.2	1.48
- Infrastructures	8.6	0.55
- Vacant area	983.1	62.67
- Golf Course	3.4	0.22
- Sport Yard	5.5	0.35
- Park	1.4	0.09
- Chao Phraya River	9.1	0.58
- Swamp, Humid Area	110.2	7.03
Total area	**1,568.7**	**100.0**

Table Classification result from visual interpretation

Level I	Level II	Level III
Urban area	- commercial area	
	- residential area	- land and house subdivision
		- land subdivision
		- apartments, flats
		- slums
	- administration & services	- administration
		- education
		- temples, cemeteries
	- industry and warehouse	- factories
		- warehouses
	- infrastructure	- transport
		- communication
		- utilities
	- recreation	- parcs
		- sport yards
		- golf courses

Level I	Level II	Level III
Acricultural area	- orchard	
	- crop	
Bare soil	- bare soil	
Water	- river	
	- canal	
	- swamp	
	- flooded area	

The digital classification of SPOT and Landst TM reaches level II and produces radiometric classes while visual interpretation reaches level II and III and produces thematic classes. This result is close to the classification of Ellicott City, Baltimou and Howard Country, Maryland (Dolan M.6 et al 1954).

Satellite Image Application

The information extracted from satellite image is applied in planning process of Bangkok Metropolitan area in different purposes:

- land use map inventory;
- land use change monitoring;
- green belt and flood protection;
- land use control and zoning policy;
- drainage system planning;
- road network planning;
- expressway planning;
- commuter train master plan;
- mass rapid transit system planning;
- etc.

Satellite data will take more roles in this field as well as others. The selection of data set, format, image processing and analysis could reduce budget and time consuming.

Conclusion

In urban and regional planning field in which activities of human being are diversified and dynamic rapidly, consequently, efficient information is strongly needed to monitor and to solve problems. At present, satellite data becomes a new performant tool which it might increase it is role in the future, especially for the study and planning of metropolis and megalopolis. The Landsat TM is suitable for the study of urban area and its environment at regional scale because of the longer wavelength in middle infrared. The SPOT in multispectral mode (XS) is favarable for urban study while SPOT in panchromatic mode provides most details in urban area compared to others. The next expected generation of satellite data should improve the resolution and proper wavelength for urban study.

Abbreviations

BMA	:	Bangkok Metropolitan Authority
JICA	:	Japan International Cooperation Association
NRCT	:	National Research Council of Thailand
RTSD	:	Royal Thai Survey Department

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Study of remote sensing thematic series maps

T. Ye (Beijing, RC)

The Research Institute of Surveying and Mapping participated in remote sensing investigation of the Loess Plateau in Ansai Remote Sensing Experiment Area, Shanxi Province, China in 1985—1989. It was the aim of this work to use satellite and aerial remote sensing technique to investigate the type, change and deterioration of land resources, the quantity, quality and disterbution characteristics of forest, grassland and vegetation resources, and water and soil conservation status, etc. We have also produced the following maps:

Land-use Map of Ansai
Farming Land Type Map of Ansai
Forest Type Map of Ansai
Grassland Type Map of Ansai
Grassland Evaluation Map of Ansai
Vegetation Map of Ansai
Geomorphological Type Map of Ansai
Soil Map of Ansai
Soil Erosion Map of Ansai
Land Type Map of Ansai
Land Evalution Map of Ansai
Water and Soil Conservation Measurement Map of Ansai

A set of thematic series maps consists of these maps. These are complex maps based on the principle and methods of composite mapping. The

maps provide the scientific basis for the comprehensive management and strategic decision of the Loess Plateau. In Ansai Remote Sensing Experiment Area, we obtained thematic information with the help of renote sensing and field investigation. Then we used the scale of 1 : 100000 and the united classification principle to display these thematic contents. And finally, we completed a group of maps on the basis of certain logical order and strict operational methods. These maps reflect the situation of resources and environment in the area completely.

The thematic series maps were completed in 1989 and were published by the Publishing House of Surveying and Mapping in 1990. Some explanations on these maps are in Chinese and English. This paper introduces the researches of producing the rermote sensing thematic series maps.

The production procedure of 12 sheets of thematic maps was:after united adjustment, author manuscripts were compiled and drown for obtaining printing plot; then map colour and the technology of map photomechanical process and printing were designed; finally, these maps were printed and published.

We used the following measurements in the production of the series maps:

1. In the reproduition of laser dot films of Ao format, we adopted CP—345 electronic colour—separator produced by German Hell Compary. It has the function of "laser dotting". The dots on the films are formed by "dot generator". The colour separator can produce the dots of 80—200 lines/inch with digital dot screen and control software. Because laser is used as reproduction illumination source and the dots are scanned dot by dot, the dots are clear and accurate and has higher densy and less error (less than 1%~2%). Therefore, it can be ensured that map colour is even filled.

2. We designed the thematic maps in according to four or five—colour technolohy. Because there were laser dot films with various scales (5% ~90%) and angles (0°, 15°, 45°, 75°), it was possible that map solid colour elements and some line colour elements were printed with three primary colours (Y, M, C).

When the reproduction of laser dots is less than 30%, there are five steps: 5%, 10%, 15%, 20% and 30%, which are more 3—4 steps than of screen line. It results the reduction of printing colours. If colour plates are combined with 5%, 10% and 15%, especially, if black plate is used, it is very convenient to design map colour. If laser dot film is used in map reproduction, solid colour elements and some line colour elements can be "dotted", i.e., solid colour, line colour, symbol, lettering and image can be designed with one or several kinds of three primary colours and black. The films can be combined based on standard four-colour when they are copyed. Finally, colour maps are printed with four or five colours.
To use standard four-colour reproduction technique can make the technology of photomechanical process and printing of the thematic series maps to be similar to colour printing operation. It provides possibility for the standardization and normalization of map production. Because primary cdour ink is used in standard four-colour printing, it is not necessary to dilute the ink. Thus, it can increase anti-water ability and lightering of printed elements and can make printed image more full and fresh.

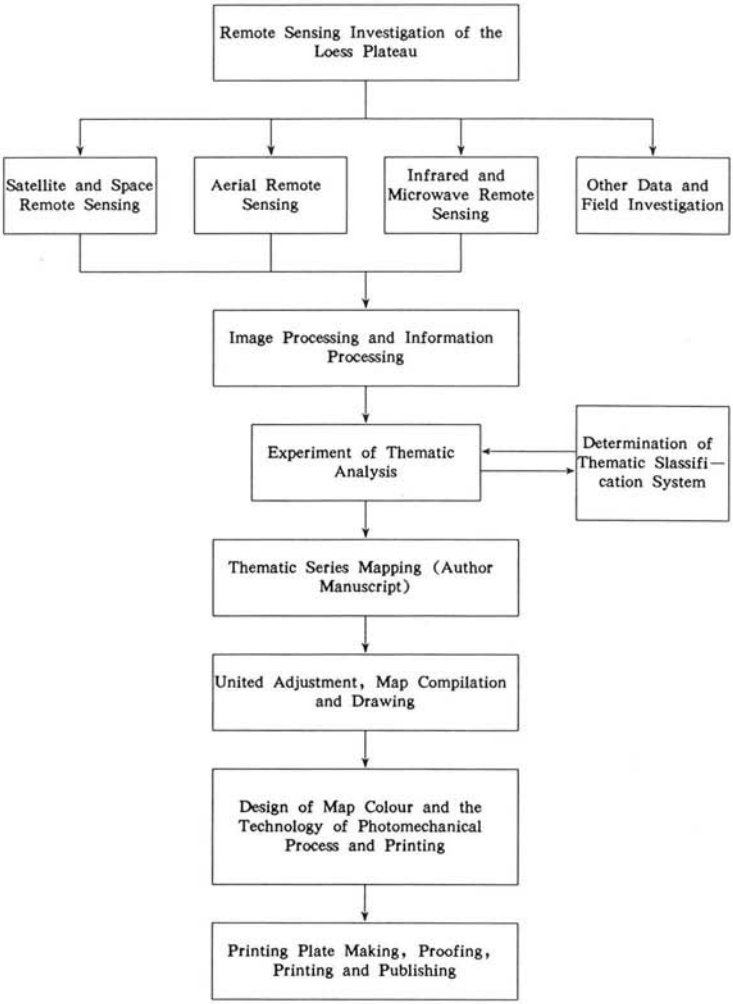
3. Technology Process of only Films: because 12 sheets of remote sensing thematic series maps were all Ao format, solid colour plates were produced by sensitized stripmask sheets of 0.15mm, which were made in U.S. K+E company, in order to ensure the register accuracy of these maps. When reversal positive sheets were copyed, three-hole slip was

used to position. The films were copyed, developed and fixed under the condition of constant temperature, for the purpose of less film deformation and better register accuracy (less than 0.02 mm). For example, colours in the legend of soil map, geomorphological map, land-use map, etc. were all more than 20 kinds and consisted of three primary colours (Y, M, C) and every colour plate was copyed 6—10 times, but they had better register accuracy.

4. We utilized such measurements and control ways as signal slip, exposure control slip and the like to ensure the quality of map copy, transmission, proofing and printing. To break away from the only experience and subjectivity, FOGRA—PMS control slip (produced by Germany) was used to control the quality of map copy, transmission, proofing and printing. In the process of map printing plate making, signal slip can display the right of exposure or not. In the development, it can show right development time. In the proofing, it can give account of printing ink, dot, etc. In the reproduction design and priting of the series maps, signal slip and optical densitometer had an important role in quality control. It provides effective experience for the standardization, normalization and quality control of map reproduction.

In a word, the reproduction technology of the remote sensing thematic series maps are apprecia-ted by cartographers, because of right technique design and more advanced methods. It is a successful example of reduction—colour printing for thematic maps.

The following table is the performance programme of remote sensing thematic series mapping.


Remote Sensing Investigation of the Loess Plateau
Satellite and Space Remote Sensing
Aerial Remote Sensing
Infrared and Microwave Remote Sensing
Other Data and Field Investigation
Image Processing and Information Processing
Experiment of Thematic Analysis
Determination of Thematic Slassifi— cation System
Thematic Series Mapping (Author Manuscript)
United Adjustment, Map Compilation and Drawing
Design of Map Colour and the Technology of Photomechanical Process and Printing
Printing Plate Making, Proofing, Printing and Publishing

Spatial data available regarding agricultural resources in Thailand

W. Thothong (Bangkok, T)

1. Introduction

The availability of adequate natural resources is a fundamental and indispensable factor relating to a nation's potential development. Agricultural development plans which overemphasise economic growth may create problems resulting in the premature exhaustion of a country's precious but limited resourced such as land, water, forests, etc., and later result in environmental problems which could serve to hinder national economic development.

In an attempt to combat the problem of resource exhaustion they must always be used to their optimum potential, but in order to do this it is necessary to understand and appreciate them fully. Thus from an agricultural standpoint it is important to collect as much data as possible relating to the types, distribution, amounts, and renewability, etc. of the resources. Currently the most common methods for the recording and dissemination of these data are by means of analogue/hard-copy maps. However, in the future Thai data will be captured in a digital form and processed, in a Resources Information System (RIS), in order to create a dedicated Geographic Information System (GIS).

In general terms land resources include the country's land forms, soils, water, vegetation and land-use. Data relating to these features are required at different scales and at various degrees of complexity. For example: in a reconnaisance form for regional planning; semi-detailed for identification processes relating to local development potential; and fully detailed for project planning.

II. Present Situation

Currently available spatial data relating to agricultural resource

development in Thailand are:-

A. Predominantly Geometric Data

1. Topographic data

Complete coverage of the country has been generated by the Royal Thai Survey Department at the scales of 1:50 000 and 1:250 000. The former series is at present being revised by using SPOT imagery.

The Land Development Department (LDD) produces topographic mapping at the scales of 1:2 000 and 1:5 000, with contours at intervals of 1, 2.5 or 5 metres depending on requirements. In any one year the LDD produces coverage equivalent to an area of about 280,000 rai (625 rai = 1 km^2) from aerial photography at 1:15 000. From topographic mapping it is also possible for us to abstract data illustrating: relief and drainage; the infrastructure; settlement patterns; and selected land-use patterns. However this is seldom sufficient for departmental requirements, and it may be necessary for the LDD to resurvey areas in order to capture new detail.

2. Land Holding Data

Mapping relating to this topic is produced by two government departments. The Land Department generates coverage of legal land and property ownership on maps at 1:1 000, 1:4 000 and 1:5 000 whilst the LDD produces mapping illustrating illegal holdings. The latter is exemplified by the depiction of land holding which are encroaching into forest areas at 1:5 000.

B. Predominantly Attributive Data

1. Soil Data

Production and publication of these details are the responsibility of the LDD.

1.1 General Soils Map

This document was published at 1:1 000 000, with each soil sub-order being represented on the map in a different colour. These are obtained by using various colour separation processes, tint-screens and eventual printing using the four

primary printing colours. In total there are 89 group levels of USDA Soil Taxonomy, and these serve to show the broad geographic relationship between soils whilst also illustrating contrasts between regions.

1.2 Detailed Reconnaissance Soil Maps

These are published by the LDD at a scale of 1:50 000. Soil boundaries are printed down in red on a base consisting of a monochrome version of topographic coverage produced by the Royal Thai Survey Department. To date detailed reconnaissance mapping has been prepared for all of the country's provinces, and the four in the north-east of Thailand have also been issued in a revised version. Soil mapping units are based on series, variants, and the association of series with land types. The resultant documents are mainly used in regional and provincial development planning, and for the evaluation of the potential of large irrigation or drainage projects. The content of maps constituting the series is derived from aerial photographs and ground surveys. Updating and revision is now carried out using SPOT imagery at 1:50 000.

1.3 Special Soil Maps

- Map of the Distribution of the Organic Matter of Soils in Thailand

The results of a national study of the distribution and amounts of organic matter contained in soils have been illustrated at the 1:2 000 000 scale. Evaluations were undertaken based on data held by the LDD, and consist of 631 profiles relating to 187 soil series and collected from different parts of the country. Data refer to both analytical and environmental aspects concerning differences in the organic matter content of soils.

- Maps of the Distribution of Saline Soils

Currently in preparation by the cartographic sub-division of the LDD, these sheets will comprise a multi-coloured series at a scale of 1:250 000. Coverage will be provided for the 11 provinces in the Northeast region and some other parts of Thailand. Contained data were compiled from provincial soil maps, hydrological

maps, geological maps and LANDSAT imagery, together with field checks by the staff of the Soil Surveyor and other specialists from the LDD.

- Semidetailed Soil Maps

Most of these serve to illustrate Amphoe levels at 1:35 000. They were compiled from detailed reconnaissance surveys of provinces, field checks, and photo-interpretation for more complex and detailed areas. Resultant sheets illustrate land suitability for: - paddy; upland crops; fruit trees; permanent pasture, crops or livestock ranching; engineering use; water storage; and mulberry tree cultivation.

- Coconut Plantation Suitability Maps

These depict areas suitable for coconut plantations and other commercial crops such as para rubber, cocoa, rambutan, cashew nuts (intercrop) and fruit trees. The 1:50 000 scale multicoloured sheets display the areas of Phuket, Pattani, Songkhla, Surat-Thani, Nakhorn Si Thammarat and Chumporn province.

- Soil Erosion Map

2. Land Use Data

Mapping is produced by the LDD at the following scales:-

2.1 Regional Land Use and Land Use Planning - 1:500 000. The contained data are derived from the visual analysis of LANDSAT imagery during the period 1986 to 1990. An updated series will be produced within the next five years.

2.2 Provincial Land Use 1:100 000. The contained data are derived from aerial photography at 1:15 000, supplemented by ground checking.

2.3 Special Land Use Maps. Specific areas have been depicted at various larger scales to satisfy the requirement of particular projects.

2.4 Provincial Land Use Planning Maps the scale of 1:250 000.

3. Forestry Data

The compilation and production of forestry mapping is the responsibility of the Royal Forest Department, and a number of series have been issued:

3.1 Map of Official Forest Boundaries - 1:250 000.

The content is derived by the visual interpretation of LANDSAT imagery.

3.2 Map of General Forest Types - 1:1 000 000. This official coverage classifies forests into the following types: evergreen; pine; mangrove; mixed deciduous and dry dipterocarpous. It was originally derived from serial photography, but is to be updated and reissued at the 1:250 000 scale using LANDSAT imagery.

3.3 Detailed Forest Mapping - 1:50 000. Compilation is undertaken using a combination of LANDSAT imagery and aerial photography at a scale of 1:15 000. The latter was particularly used for the classification of forest types, with the data then being reduced to publication scale. Included details relate to : - national parks; forest conservation areas; wild life sanctuaries; and mangrove forests.

4. Climatological Data

Original data capture has been the responsibility of the Meteorological Department which maintains national records, for the last thirty years, with reference to:

4.1 Mean annual and monthly rainfall;

4.2 Mean annual and monthly tempertures;

4.3 Mean annual and monthly relative humidity.

5. Population Data

These materials can be obtained from the National Statistical Office within the Office of the Prime Minister. Available data consists of:

5.1 A map of Thailand, published in 1980, showing post-code and administrative boundaries;

5.2 The following aspects of population have also been mapped:-
population density; urban area populations; average household sizes; the percentage of agricultural households.

6. Other Data

Details are available with respect to: - water supply; irrigation; dams; ground water; geology and mineral resources. All of these may be required for consultation for planning purposes.

III. Future Developments

A. General Concepts

Although the majority of data are still only available in an analogue form it is intended that they will be incorporated into a digital database in the near future. This will be the responsibility of the National Board of Surveying and Mapping which intends to establish a Resources Information System (RIS) for this purpose. However, the effective operation of this body will require consideration and decision making with respect to three potential areas of difficulty.

- Data Structure - and the distinction between geometric and attribute data.
  The former have been captured and utilised by the Royal Thai Survey Department and the LDD, while the latter have been derived by a variety of other agencies. A consequent problem will be compatability between available geometric and attribute data.

- Scale and Detail Data
  Because of the variety of scales at which information is presented it is essential to define specific detail in terms of its type and numerical value, together with consideration being given to the levels of employed generalisation. It is also necessary to establish standard scales for use within a GIS. For example:-

National	-	1:250 000 to 1: 1 000 000
Provincial	-	1:50 000
Project	-	1:1 000 to 1:5 000

- Data Organisation
  Problems here involve:-
  a) The establishment of layers of information;
  b) The inbuilding of a facility allowing the mathematical modelling of organised data;
  c) The employed system must necessarily allow data output in the form of an analogue map, whilst still permitting the construction and subsequent modification of the data-base.

IV. The LDD Pilot GIS

This scheme was originally devised to provide a GIS specifically for

use by the Land Development Department. However, if it were to be used in the field of more general national economic development different types of data should also be able to be integrated. LDD undertook initial research using the ILWIS GIS software developed by ITC in the Netherlands, but this could not be used in a wider applications area. The main concepts experimented with using ILWIS were:

Step 1 Land Unit Classification

Input Information relating to the following mapped topics:

1. Soils
2. Land Use
3. Irrigation
4. Forests

Output Land Unit Map

Step 2 Suitability Classification

Input 1. Land Unit Data
2. Land Use Type

Output 1. Suitability Table
2. Suitability Map

Step 3 Zoning

Input 1. Suitability Map
2. Forest Map

Output 1. Land Use Planning Map

Currently the cartographic quality of the map materials produced by using GIS is poor as compared to that generated by analogue means. In consequence it is evident that the development of dedicated software for use with the GIS is essential and necessary. Perhaps at some time in the future the Commission on National and Regional Atlases, together with other relevant bodies within ICA, will communicate their experiences in this area to member nations.

It is already apparent to the LDD that software intended for use on a PC is inadequate for the solution of this problem. Obviously a more appropriate system, with the processing capabilities of a workstation or better, is required to enable the input and manipulation of the data which are potentially available from a variety of organisations.

The present cartographic output from most GIS system is not really satisfactory or user acceptable, but it is hoped that the international community will take on the challenge of creating better maps within and from the GIS environment.

References

1. Land Development Department.
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The method of drawing the land resources map of the People's Republic of China

C. Chen (Guangzhou, RC)

Abstract

It lasted 10 years from 1979 to 1989, the work of drawing the Land Resources Map of the People's Republic of China had been completed. The map not only affords a large important data of land in the country, but also represents the types, quality, suitability, use conditions, developmental potentialities of land resources and its distribution law in space of the country.

Drawing the land resources map takes the land type, which is the classification of the nature difference of the land as base. First, to classify the land suitability types for agriculture, fo restry, animal husbandry, fishery and so on, and then divides the suitable grades of the land in accordance with the restrictive factors and the restricted degrees. There are 3 main land suitability types and 9 land degrees in the map. The least map spot is 4 mm^2 and some special map spots are 2 mm^2 which takes the land grades as the basis unit.

The author is in charge of drawing a part of Guangdong Province Land Resources Map. The theory and method of drawing map are expounded in the paper.

The land resources is a general term of the used land (for production of agriculture, forestry, animal husbandary, fishery, industry and for construction of residence, communications, market, tourism, etc) and other not yet used land. The land has many use forms, so the land resource appraisal and the drawing method of the land resources map are varied, but the agricultural use (including forestry use, animal husbandry use and fishery use) of land is the most important use and it is the main means that concerns the existence and development of mankind, thence the land appraisal for agricultural use is the most important and the most universal appraisal of land resources in the world at present.

In this paper, drawing Hainan Island Land Resources Map on the scale of 1:500000 and 1:1000000 is an example for expounding the theory and method about drawing map.

1. The land type is a base of appraisal of the land resources and a base of drawing the land resources map

The appraisal of the land resources is the theory for drawing land resources map, it's main aims or tasks are as follows:

(1) to divide the land suitability types for the agriculture, forestry, rubber and other tropic crops, animal husbandry, and the quality degrees of each land suitability types so that to find out the data of usable land of all kinds and their production potentialities.

(2) to demonstrate whether the use conditions of land are reasonable in accordance with the ecologic benefit, economic benefit, social benefit, and to put forward the direction using land reasonably.

(3) to point out the ways using land reasonably, the concrete measures for land protection and land reform in accordance with the retricted factors in land use. These are the theory basis of development and renovation of territory.

The land use for agriculture is a direct or indirect bio–reproduction. The factors controling or influencing bio–growth are the natural characters of land, which decide the suitability and the productive potentialities of land. The similar nature of land in a same district or the different nature of land in the different districts caused by the difference law of districts are the basis of land classification. It is to say that the land type is the land classification according to their differences of natural characters. The classified targets are the ecologic targets which decide the directions of land use (agriculture, forestry, rubber and other tropic crops, animal husbandry and so on) or the ways of land use (paddy field, nonirrigated farmland, protective forest land, developmental forest land, graze or barnyard raising and so on). These are the classified targets of land resources too, only their ways of expression are different. This is why the land type is a base of land resources classification, and the land types are not the simple classification of geomorphology, either.

In fact, the agriculture production is a man–made ecology system, therefore the land type is essentially the classification of natural or man–made ecology environment of land. The land type is transformed into the land suitable type and the land suitable degree, and expressed them on the map, that is the land resources map.

2. The classification of land type

The way of multistage classification is taken in dividing land type.

First, the district difference formed a same region of natural condition of agriculture, which represents in the level zone of climate, soil and vegetation. This is the natural zone of land which is not a continuous belt by the influence of distributions of sea and land. The land in a same land zone has certain sunshine and heat, and that has certain productive potentialities, so this land zone is called as the land nature district or the productive potentialities district of land resources, it is called "the land

district″ for short. This is the highest class unit of land type map, and it is the relevant unit on the land resources map. The land in a land district represents that suits certain crops, has same cultivation system, etc. Hainan Island is in tropic, and belong to the tropic land district. It suits paddy, sugarcane, tropic fruits, rubber, coco and othertropic crops to growth, paddy has 3–crop per year, output of crop is higher.

In a land district, the sunshine, heat and water of a belt are redistributed by the topography, formed the vertical zone of land. The land of a vertical belt is called the land kind. This is the second classification of land and it's classified targets are still ecologic target of vegetation or crops growth. These land categories are the basis whether the productive distributions are reasonable.

The most basic land type is the elementary district difference in less scale and non belt, which formed by many natural factors of micro–geomorphology, soil regime, soil material, surface water, water quality, plant community and so on. This ″little region″ of land which formed by these nature factors actting each other is called ″land type″, and which is the basis unit (that is map spot) of the land type map and it is the same on the land resources map. It is different to select these nature factors for the different scale of map. We only selected a few factors such as the micro–geomorphology, material composition of ground surface, and surface water when we drew the map on the scale of 1:500000 to 1:1000000. But it is necessary to select more nature factors for drawing the big scale map as a little limits region such as a county or a city. Lastly, taking the certain conditional limit of every nature factor which decides the use way of land or influences land quality as target of classification to divide the land type.

3. The classified targets of land type in Hainan Island

Hainan Island–– the second biggest island of China, situated by the South China Sea. The limit of it's land is in 18° 10′ to 20° 10′ N and has an area of 34 thousand km^2. It has a humid, tropical monsoonal climate with warm winter and belongs to the tropical land district. It's most land can be used for production as a result of the superior bio–climate condition, to divided the land types of various uses in agriculture, forestry, rubber and other tropical crops, animal husbandry and so on, is an important task of the land resources investigation.

The farmland is the land to plant the short–term crops, it is easy to bring the soil erosion because it is necessary to cultivate frequently, and it must be the lower and smooth land that the relative height is less than 20 m and the slope of topugraphy is less than 15°. The farmland may be divided into the paddy field and the nonirrigated land. The paddy field is the main cultivated land in Hainan Island. The ecologic environmental condition of paddy field is mainly hydrology factor. The land type of suitting as paddy field is to take keeping water as the basis condition, and it needs the land type which is the negative geomorphology and the nonsand soil. The

hydrological condition of nonirrigated farmlandis not strict, it demands only the enough moisture which can ensure growth of crops.

Hainan Island is the biggest tropic region in China for developing the production of rubber and other tropical crops, has an important significance in national economy, so to divide the land type that suits rubber and other tropical crops is the important task of the land resources investigation. The main ecologic factors for rubber and other tropical crops include sunlight, heat, water and thickness of soil layer, their targets are as follows: the mean annual temperature must be equal or more than 22℃. The lowest temperature must be higher than −5℃. The mean annual precipitation is more than 1200 mm and the number of months that the monthly precipitation is less than 50 mm must be less than 5 months. The thickness of an effective soil layer must be more than 50 cm and it isn't sand soil. The ground water level must be lower than 100 cm below surface. On the other hand, the land planted rubber forest needs to cultivate and that is easy to bring the soil erosion, so the slope of topography must be less than 25° and the sea–level elevation must be lower than 400 m so that it will ensure enough sunlight and heat.

The forest has a extensive suitability to the land, it had covered the whole island of Hainan. The forest is the main body of ecological systems, has various ecological effects, it not only plays economic effect but also plays ecologic effect and the later is more important function, so the use land of forestry not only is the suitable land for forest, but the more important thing is that the land to be protected for playing it's ecologic actions. So the forestry may be divided into the developable forestry and the protective forestry. The formers include the fruit forest, economy forest, timber forest. The laters include the coastal wind break forest, forest of water and soil conservation, headwater forest and forest of protecting nature resources. These kinds of land for suiting above–mentioned forestry include sea beach, coastal sand land, platform, hills and mountains. They are divided into various land types in accordance with the appropriate targets of soil regime, height of topography, slope, geology and biotic resources condition.

The pasture land is only the herd land, to divide land type of suiting pasture is to take the condition of water and grass on the land as the classified targets. But strictly speaking, in the humid tropic or sub–tropic regions, only few of land is used in nomas, and it is so in Hainan Island. The most grassland in there is not natural grassland, which formed by the forest to be cut repeatedly. The economic effect is low and it is unfavourable to protect the land if the grassland were only used to herd. Therefore the most grassland in the tropic and sub–tropic, humid regions (for example Hainan Island) must be used to develop forestry that include economy forestry, only a part of grassland may be used to herd and must be combined with developing forestry. The land types of pasture land need that the slope is less than 30° and the height is lower than (sea level height) 500 m so that it is favourable for water and soil

conservation and the land protection.

4. The appraisal of land resources

The appraisal of land resources is to demonstrate the feasibility of land use, it takes the land type as a base, incorporates various land types into the suitable types of land use and the qualitic degreea of each kind land in accordance with the natural characters and the limited factors and it's limited degrees, then to mark them in symbol on the map. That is the land resources map.

The appraisal principles of the land resources are as follows: (1) it is identity of the use way with the nature character of land, this is that the man–made ecologic type of land is suitable with the nature ecologic environment, and the productive potentialities of land will be brought into full play, for example, the land which has enough water resources may be used as the paddy field, and it will play it's superiority of water resources. (2) The use way of land must be favourable to protect the land, The use way of land may be selected as that it is varied, especially, the kinds of crop are varied, a good use way of land not only plays it's productive potentialities but also ensure that it will be used perpetually. (3) The use way of land will be favourable to play it's economic effect. This is the principle using land in line with local conditions.

Since the aim of dividing land type serves the land use in agriculture, to classify the land types as the suitability types is the land resources types. Every land suitability type is divided the land degree in accordance with the limited degree of every limited factor as hydrology, irrigation , drainage, soil layer, soil material, height and slope of topography.

But the expressive ways in the different scale maps are not same. Varied factors which influence the quality of land are complicated, especially in the tropic and the sub–tropic mountains regions, the topography is very complicated, the natural environment is deverse, there are many kinds of land types even in a little strectch of land. For example, in a valley basin which has an area of less than 1 km^2, there may be the waters, beach land, paddy field, nonirrigated farmland, grassland of platform and so on. All of these land types are impossible to show on the little scale map even on middle scale map. The land resources map of the People's Republic of China took the scale of 1:1000000, the appraisal of land resources is only more rough, but it is a large scale work, also an arsuous task. This big work had completed and it has a great significant for practice.

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Digital landscape model and its cartographic presentation in land use planning

T. Ruutiainen, K. Artimo (Espoo, SF)

INTRODUCTION

Visualization of landscape has always been difficult. Only the artists have been able to present landscape in a natural way. In the early days we had only two-dimensional maps and the most common way to show height information on those maps was to use contour lines, hachures or shadings /1/. Today we have digital three-dimensional models and possibilities to view them dynamically in perspectives as well as much more information about our landscape; we still have the problem, how to get the landforms aesthetically and informatically visualized for planners.

In Helsinki University of Technology we have studied different methods of visualization aiming to find an efficient way to produce a digital landscape model. The problem is to find a way to visualization which does not require too much from computers and is cheap to produce. This article gives an overview about different techniques and shows some examples about visualized models.

1. DEFINITIONS

A TIN model in this presentation is a model which consists of irregular triangles the nodes of which are produced from measured spot heights, contour lines or other known heights.

A grid model in this presentation is a regularly spaced matrice which is produced from measured spot heights, a TIN model or from stereoimages.

A digital elevation (or height) model is a model (either TIN or grid) which has only the elevation information about the landscape. Buildings or vegetation are not included in this model.

A terrain model is a model which has not only the elevation information, but also the existing buildings and vegetation or planned new buildings and roads.

A landscape model in this presentation is a terrain model linked with a GIS. A landscape model is a scale model over the existing or planned landscape. It also works as a graphical user interface to a GIS.

2. DATA COLLECTION

The height and feature information for elevation or terrain models is often collected from existing maps by digitizing or by vectorizing scanned rastermaps. This is not the best way, because on those maps the only elevation information is usually the contour lines, which are always derived and/or generalized information. Better way to gather the elevation information is to measure spot heights and break lines (either natural or constructed) with tacheometers or with analytical plotters straight from the stereoimages and after that produce a height model. This is the way where the model itself is produced first and the maps are the two-dimensinal documents of the model.

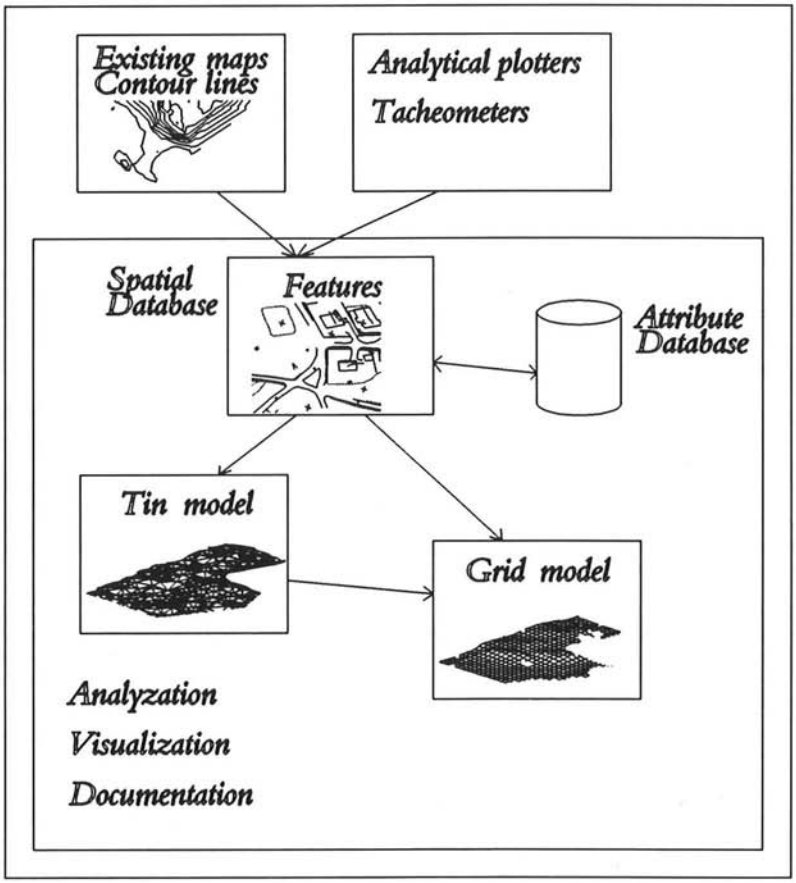

Figure 1. Data collection, model constructing and data utilization.

3. DIFFERENT METHODS OF VISUALIZATION THE ELEVATION MODEL

3.1 CONTOUR LINES

Contour lines are the traditional and in many cases the best way to display the height information on top views. However if the model is rotated for example to an isometric view the height affect of contour lines is usually lost /1/.

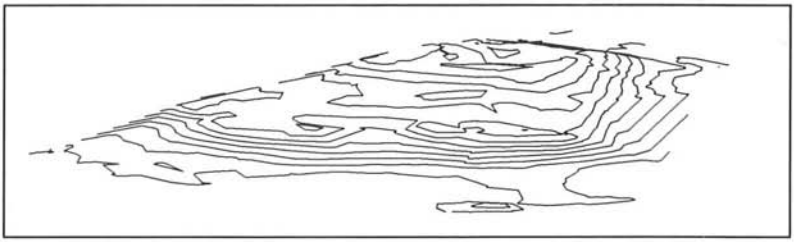

Figure 2. An isometric view to a model with contour lines.

3.2 IRREGULAR TIN MODEL

TIN model consists of triangles which all have "exactly correct" points on each edge. The area inside the triangle is planar and so it is only an estimation about the real surface. A TIN model can simply be visualized as a wireframe, filled triangles or a shaded relief where every triangle has its own colour depending on the angle and the azimuth of the sun. The height information can also be presented colourcoded, where different colours visualize the height zones.

TIN model is a good and an exact way of presenting the surface, but for a computer it is rather heavy to produce and takes a lot of space from the disk and memory, because all known height points have three coordinates. The topological data structure of the implementation is also heavy.

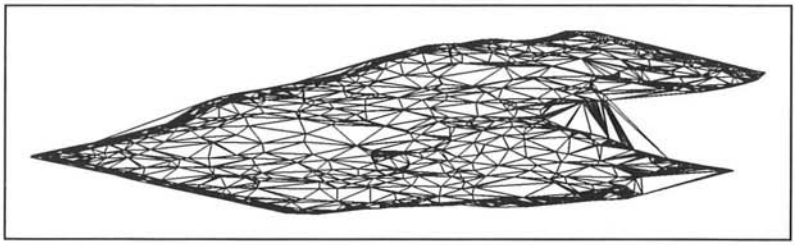

Figure 3. An isometric view to a model with irregular triangles.

3.3 REGULAR GRID MODEL

Grid model is a regular matrix where each corner of a square has an individual height. The heights of edges are not "exactly correct" but they are as near as possible to the same height as the orginal triangles or spot heights depending on

the method used to produce the squares. The smaller the squares are the better the height information is but at the same time the size of the matrix increases. The filesize of the matrix is usually smaller than the size of the TIN model, because the matrix has information only about the starting and ending xy-coordinates of the grid and the data can be compressed efficiently /3/. The xy-coordinates of the grid are calculated from the start to the end by knowing the size and the angle of the square.

A grid model can simply be visualized as a wireframe, filled squares or a shaded relief where every square has its own colour depending on the angle and the azimuth of the sun.

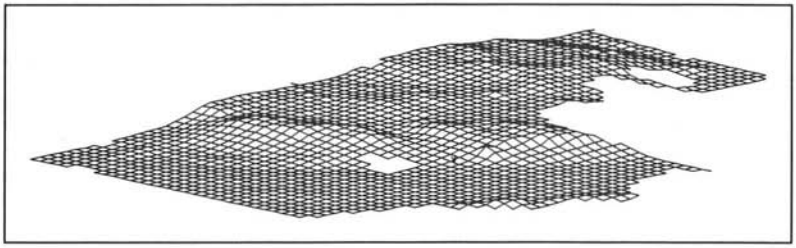

Figure 4. An isometric view to a model with regular grid.

3.4 PROFILES

As a matter of fact profiles are just "half of a grid". Either rows or columns are left away from a grid and the result is profiles. Profiles are a very light and easy way of visualization for both computers and users.

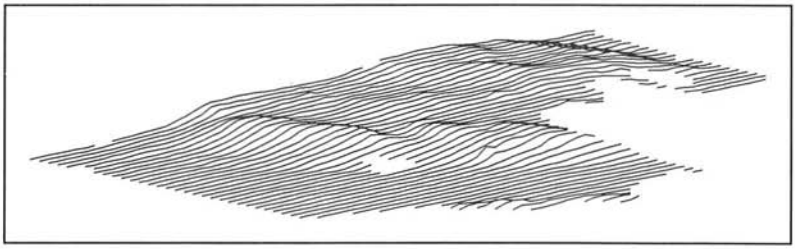

Figure 5. An isometric view to a model with profiles.

This technique can be compared with the Kitiro Tanaka -method /1/.

3.5 SHADED RELIEFS

Shaded reliefs are models (TIN or grid) in which the surface is shaded depending on the angle and azimuth of the sun. The result is a continuous surface. In spite of the "beauty" of the shaded reliefs they are "exact" models which can be used for analyzing the model e.g by measuring an exact x,y -point. If the position of the sun is changed a new shaded relief must be calculated from the model - this is why shaded reliefs are not very suitable for dynamic modelling. Shaded reliefs are best for the final visualization, not for viewing and analyzing the model.

3.6 COLOURCODED MAPS

On colourcoded maps heightzones are visualized by colours. Colours can get darker on deep and lighter on high or on the contrary. Colourcoded maps are good mainly at top views and they are very critical with choosing the right colours and tones.

3.7 DRAPING RASTERIMAGES OVER THE MODEL

One way of visualization is to project a raster image (a satellite image or rasterized aerial photograph) on the height model. The problem in this is between the aerial photograph's central projection and the parallel projection of the map or model. So it seems that draping raster images is useful for small scale maps (1:50000 ->) (with satellite images), but not excellent for large scale maps (1:500 - 1:5000). Also other raster images such as rasterized maps with land use areas or other themes can be projected on the model.

4. VISUALIZATION FACTORS

4.1 COLOURS

Colours can be chosen continously from lighter to darker or each height level can have it's own typical colour varying from deep green on the bottom to brown on the top of the model. By increasing the contrast between the light and shadow areas the height differences can be highlighted.

The problem with colours is to find those expressing the natural colours of landscape. Mountains do not usually have red tops and valleys are not always green. The colours should be as near as possible to the real colours of the nature. Using natural colours causes difficulties especially with very small scale maps because of the lost of colours and details when going higher and higher from the earth.

On shaded reliefs the colour of the shadows should be grey or blue-grey depending on the colour of the earth. On snow or glaciers the shadow should be near blue /1/. On the other hand on continous tone shaded models the shadows can simply be darker than lighted objects.

Visalization of different themes with the height information causes troubles with finding equally toned colourscales /5/.

4.2 SCALES

Sometimes the z-scale is multiplied to make the differences in the height values easier to determine. Anyway on large scale maps one should use the real z-scale, because using different scale on z causes troubles with the reality of detail plans. On the other hand small scale maps demand larger z-scales (in Finland and other "flat" countries) because of the small differences on height. By emphasizing the z-scale larger areas can be presented three-dimensionally.

4.3 DENSITY

In this presentation density in grid models means the resolution of the grid and in TIN models density means the number of spot heights per area in the model. Density of the model depends on what is going to be the use of the model. The more dence the model is the heavier it is for the computers and the better the image is. However if the use of the model is for large scale planning on large areas the dence must be rather thin to get the filesizes reasonable.

Because the data collection from the field is rather expensive extra height values have to be interpolated in regions where no height values are avaible to get the model dense enough.

4.4 LIGHTNING

The direction of lightning is often chosen to be from northwest to get the impression of positive heights. If the light comes from south one can feel the heights get negative /1/. This is true on top view maps. The only difficulty is that the sun really never shines from northwest. The azimuth of the sun should therefore be chosen to come from southwest or south to get the model lighted correctly. As a matter of fact the model should always be shown at least in two different lightning conditions to get the right impression. Time of the day and on the other hand time of the year affects the model strongly. In most cases the model is shown in lightning conditions which give the most beautiful result instead of reality.

The angle of the sun from the horizon must be the greater the bigger the height differences are to get the shadows

reasonable. The flatter the area is the smaller the angle should be to get at least some shadows. On the other hand the angle should be chosen to be as real as possible. The problem is the same as it is with the direction of the sun.

4.5 OBSERVATION POINTS

The most common view to three-dimensional models is an isometric view to the model. We are used to look models like that and there is nothing wrong with it, but sometimes it would be better to examine the model from other perspectives too. We rarely examine the real world from the sky. As a matter of fact we usually "walk inside the model" and therefore we should visualize and examine the model from the inside by separate points or by free routes which are visualized on the workstation's screen or by videos.

4.6 DATA CONTENTS

The main difference between a height model and a terrain model is the visualized data on the model. The main data contents of a terrain model are buildings and vegetation. The existing constructions such as buildings, roads and bridges and vegetation are usually rather simple to visualize as far as someone has modelled them. Separate trees or buildings are quite easy to produce as cells or blocks from existing maps by streching them as three-dimensional elements. Much more complicated is to produce a nice forest consisting of huge amount of trees or to make a gravel look rough and at the same time to try to keep the model as light and small as possible.

Planned buildings, roads etc. need some tools to be projected on the model. The coordinates of a new building are not always known, so it must be possible to "drop" buildings on the model. On the other hand the plan itself may demand to change the existing height information so the elevation model must be flexible.

4.7 BACKGROUND

Rasterized photos or stillvideos can be used as a background for a view to a model. The problem is that photos are not dynamic and so if the model is rotated photos taken from one obstruction point are useless.

4.8 DOCUMENTATION

Once the model has been done and it is rotated in a good position with nice lighting there still is a problem about taking hardcopies from it.

Colour plotting of large images with big raster plotters is

rather expensive. An other problem is that the colours on the workstation's screen do not usually appear exactly the same on paper because of the different coloursystems and colour spaces /4/.

An easy and cheap way of producing hardcopies from images is to take photographs straight from the screen by ordinary amateur cameras.

Animations made on videos from models are heavy to process but the result may be one of the best ways of documenting models.

5. PLANNING BY USING THE TERRAIN MODEL

Nowadays the model is constructed by surveyors and then delivered to land use planners.

The problem is the coordination between the planning process and model construction. The construction of a model shoud be a part of the planning process. A model's visual appearence should be as flexible as possible and it should contain all the features and geographical information that are needed for planning. The planner himself should be able to modify the model due to the effects of the planning.

Using a digital terrain model for planning causes changes to the conventional planning process and planning tools. It is obvious that the planning itself must be done with digital tools using the best techniques avaible to get all the advantages of digital modelling.

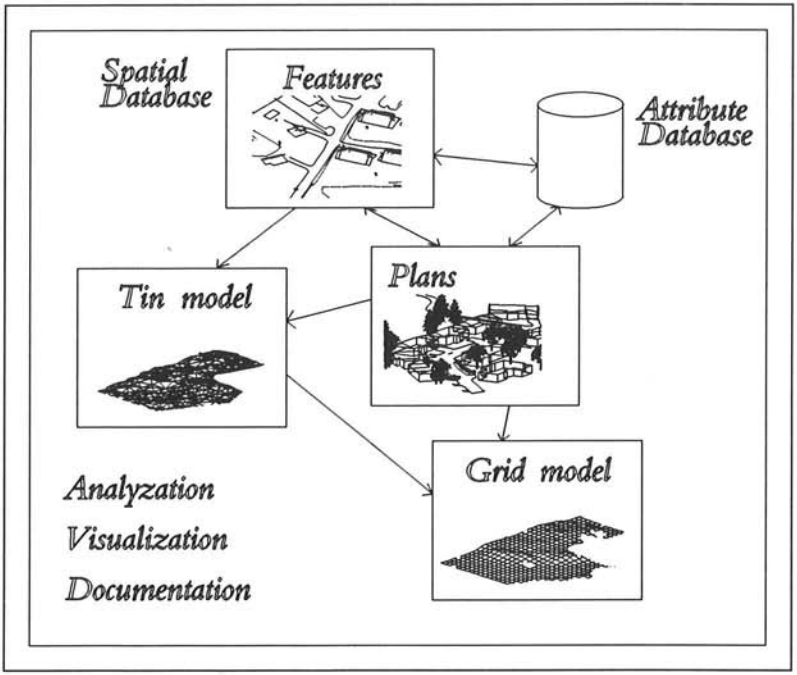

Figure 6. Modelling as a part of planning.

The result of the plan is best if planning can be done in the same environment as modelling itself because of the easy feedback to the existing world. Using the same tools for planning as for creating the terrain model guarantees the homogeneousity of the geographical information system.

6. CONCLUSIONS

As a part of digital landscape models terrain models can be visualized in many different ways starting from rough contours to smooth shaded reliefs. Depending on the power of workstations and the needs of the designer more and more realistic models can be made. Anyway the base is height information dence enough to produce models and a good GIS with it. The difficulty is to find a cheap tool for planning and modelling which is at the same time easy to use.

The importance of choosing the right techniques, colours and lightning conditions for visualization means that experienced cartographers and designers are still needed.

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Session 7

Knowledge-based Mapping Systems

Chairman:
J. Morrison, U.S. Geological Survey (Reston, USA)

A knowledge-based thematic mapping system – the other way round

E. Hutzler, E. Spiess (Zürich, CH)

Abstract

The development of knowledge based systems in various fields has nourished hopes that they may also be an answer to the wide range of design problems in thematic cartography. When the data are fed in and the user requirements formulated, the system guided by the rule-base performs all necessary steps without any further intervention. Such a procedure would be in full contrast to the interactive design mode, that progresses under full control of an experienced operator with cartographic skill. Being aware of the complexity of the problems, some guidance and support by rules is certainly welcome. Rules may also be helpful, where steps of the same kind are often repeated. Instead of striving for a huge expert system that offers global solutions, but seems unrealistic, because thematic maps in their great variety are much too complex for this purpose, the strategy presented in this paper is to gradually develop expert modules, in parallel to the interactive modes. The design structure of a few components of an prototype is explained and illustrated.

Expert systems for thematic cartography; description and discussion

Expert systems and artificial intelligence are the keywords in nowadays research. Researchers feel that such systems ought to play also an essential role in changing the excessively (?) intuitive character of map design towards more objectiveness and generally accepted expertise.

PUPPE (1991) [1] elaborated that an expert system is supposed

- to understand the problem, (what means in cartography, to analyse which of the data are essential, what kind of regional distribution is most striking or revealing to the map users etc.)
- to solve the problem, (what is in cartography to find the best construction and graphic representation etc.)
- to explain the given solution, (that is to explain the representation laws or the parameters applied, eventually also to interprete the distribution found)
- to survey neighbouring areas, (concepts in planning, in geography, demography, politics and economics)
- to assess its own competence in problem solving, (discover lacunes in the framework of graphic rules and laws, estimate the amount of ambiguity in the decisions made etc.)
- to acquire further knowledge and structure it, (in cartography e.g. by automatically testing the constructed maps on image density, overlaping or hidden symbols, but also by incorporating the results of human evaluation of the maps produced in the system).

It is generally accepted that the greatest difficulties must be expected in the very beginning of the process, when the system tries to understand the problem, i.e.in the case of mapping to select the most relevant data for display and to make decisions on their representation in map form. Experiences in areas other than mapping indicate that changing the rules for the moment being works only on feedback from users but not within the system itself.

So far, however, there is few evidence of operational expert systems in cartography. Intentions and ideas for initial work have been reported here and there. We may quote e.g. the model described by BOLLMANN (1989) in [2] for an automatized design of thematic maps, whereby the source data are analysed and evaluated, attributed by design and construction rules and transfered into a digital map model, which has to be tested (by another set of rules) for visual defects and corrected for final modelling. Every correction made is registered and those that are found by the system to be significant on a longer-term basis are used to change design and construction rules. This system is described as an example of a self-regulating optimization of the map design process. Other researchers might call the properties of such a system artificial intelligence.

For an experienced map designer it is hardly imaginable, that all what he undertakes in checking, in individual and global assessments and in carefully weightened decisions during a map design process may be equally seriously performed by such a program system, the complex it may be. A recipe that works fine in one case fails in the next one. Almost every new constellation of space and data claims for an individual, often even unique solution The ability of the graphically educated map editors to unravel and clear densly woven image configurations, so that they may become legible and understandable for the map user, can be reproduced by an expert system only with absolutely excessive efforts. We have to consider also the fact (KEATES, 1982) [3], that the combination of map contents and representation methods creates an infinite variety of solutions, whose effects on the user side can not be anticipated with certainty, a statement that makes it extremly difficult to provide the system with an adequate decision making processor.

Advantages of expert systems in cartographic design and production are expected much more in widespread decision networks, were one tends to loose track of consequences. The program in this case can make use of an abundance of rules, can organize them accordingly and is structured to influence decisions in the direction of the optimal solution. The solution is no longer the result of a sequence of individual decisions, but is based on a space of interrelated decisions and constraints.

But again on the other hand the field of thematic mapping is extremely wide. Furthermore we are confronted with a large variety in requirements of various user-groups. Often solutions may be completely different with scarcely any connections in between. In view of this two-directional complexity a global solution with a comprehensive expert system for the design of all kinds of thematic maps is virtually impossible to realize. A realistic approach will have to concentrate on some restricted and individual application oriented branches. Questionable as well is the proposed automated feedback to the knowledge-base derived from a graphic result. A generalization process e.g. may create a certain graphic constellation, which is subject to the final assessment. Such measures are irreversible and there are no means to reconstruct from this observation a higher order concept that will guide future processes.

Knowledge-based systems; description and discussion
An intermediate solution in developing expert systems are knowledge-based systems. They bring problems in a closed process to a final solution, starting from user requirements and source data, monitoring decisions on the basis of a large amount of expert knowledge that has been incorporated in the system. They are less pretentious than expert systems in so far as they operate within the existing knowledge and work straight on towards a solution. They do not care for external information, for self-critisism and for self-modification of their knowledge. On the other side they compete with primarily interactive procedures, whereby the operator initiates and monitors every single step.

If we accept that in cartography conceptual and graphical decisions are based not only on intuition, but are made according to solid and scientifically based rules, the conclusion is evident, that for a significant number of these rules that guide the editing process, algorithms can be developed. This so-called expert knowledge is one of the essential components of knowledge-based cartographic systems.

Initially the enthousiasm about such future systems will certainly be great with all those map makers that lack experience in design. This may seem to them a unique opportunity to obtain results that obviously compete with those of top experts, as the latter after all have fed the system with their entire knowledge. All what the operator would have to do, is to load a complete and consistent data set and answer a few questions. Provided the system has enough expertise and is well conceived, he will get a good result out of it, a solution that is conform to the initial requirements and to the given random conditions. As he has no notion of the large variety of possible solutions, he may be entirely satified at the beginning with what he has got. But how can one avoid that he will develop more and more a lack of interest in these sets of uniform maps, having no real chance to intervene, once the process is started, and not knowing what conditions the specific result?

Comprehensive automated rule-based systems versus intuition and interaction
For practical applications one can choose among two concepts:

With future comprehensive knowledge-based systems, one could produce on the basis of requirements, deduced from the mapping purpose, automatically an optimized map, when the system has been fed with a huge amount of expert knowledge about construction and graphic rules, that is periodically subjected to amendments.

The alternative is to apply for map design and production an interactive system, provided with a user-friedly surface, predefined forms, that make use of some basic rules, and offer besides certain default values for parameters and a large amount of variability. In this case a graphically well-trained cartographer is needed with all his skills and defects. No doubt, within certain limits rules may be very useful. They prevent people from producing absolutely useless maps. Also, the operator can be released from repetive and similar decisions and gross errors are avoided. But whether all these decisions could be left to a sophisticated controlling system, is an open question. May we quote in this context IMHOF (1968), who stated in [4] that to gain control over the graphic texture of intricate maps, demands human decisions on practically every square centimetre!

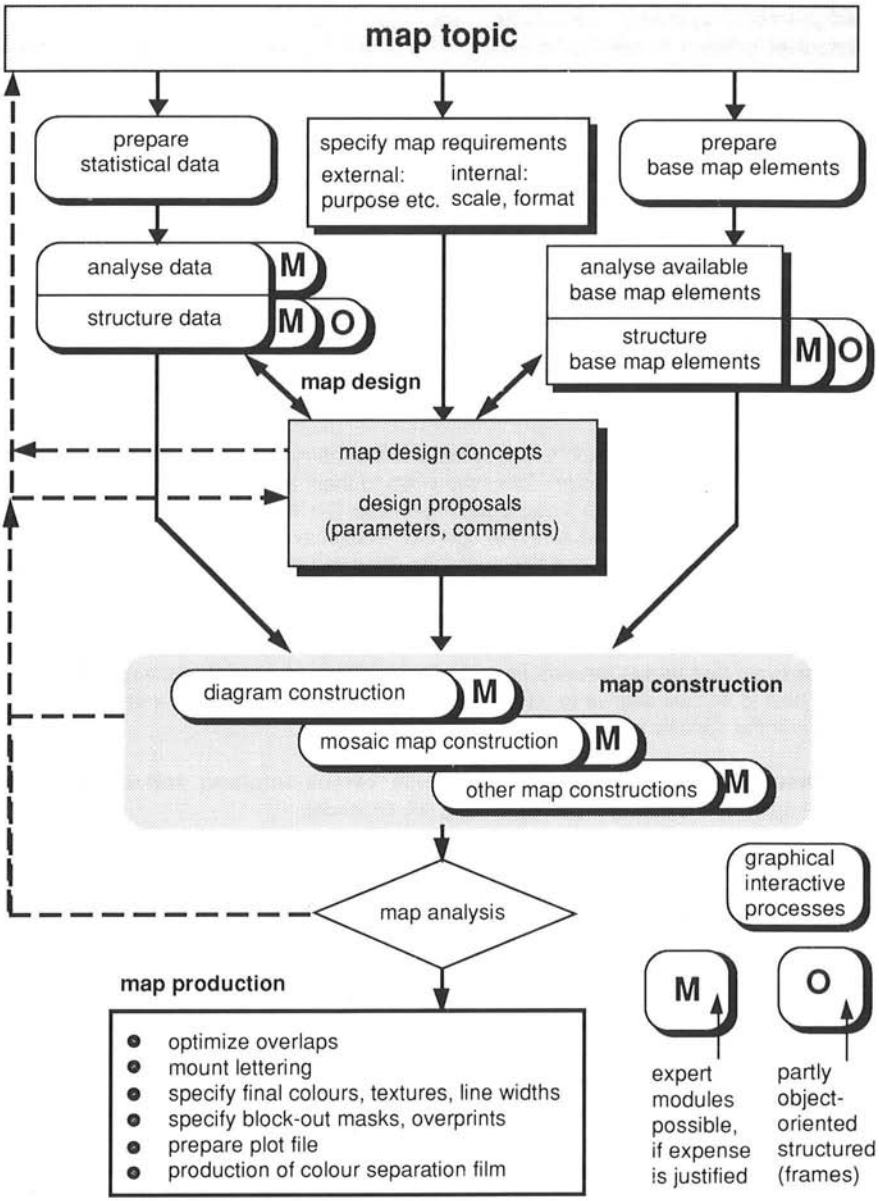

Fig.1: Flow chart of the production process for thematic maps

We have the impression that on a long-term basis this alternative concept will prove to be more fruitful. We should make use of the cartographer's specific abilities, of his sound self-critisism, his socio-cultural integration, his sensivity for continuing changes, his adaptability, his originality and imperfection, in order to keep cartography attractive and vital.

Description of an open-ended knowledge-based system with expert modules
In conclusion of the above considerations we are in favour of open-ended, operator-controlled systems with embeded rule-based and object-oriented modules, whereby step by step commented variants are presented for selection. Based on former experiences default values may be set for the parameters. The various proposals can be presented in form of legend specimens as well as alphanumeric lists of parameters. The system will react with a message or warning if initial requirements or graphic rules are violated, but leaving it to the operator, if he wishes to continue nevertheless. The whole production line has to be fragmented into a number of construction or modelling steps, each of them allowing to intervene and react on the interim result.

The production process for thematic maps with such systems may be described by fig.1. When the map topic has been given or chosen, field surveys or statistical data, which are relevant in this context, have to be gathered. On the other hand base map elements must be prepared. In this initial phase the map purpose is formulated in view of the anticipated questions of potential map users. Map scale, map format and region mapped depend on each other. As long as two of them are not yet fixed, we have to consider them as free parameters. Other external considerations may influence these decisions, as e.g. expected cost or production time.

With this conception in mind the given thematic data have to be analysed, preferably in an interactive mode, that allows to visualize results and specify supplementary queries. Plausibility tests also have to be included. Thereafter data may be structured accordingly. The base map elements as well are analysed and structured. Which other element e.g. can be combined with the administrative boundaries? What degree of generalization must be applied in the case of a combination of the river network with such boundaries? If the expense can be justified, we see an advantage to handle these processes by rule-based expert modules. Letter "M" in fig.1 indicates in which processes such modules seem to make sense and where they may be partly structured in frames ("O" = object-oriented).

The decisions to make are preferably guided by forms (fig.2 and 4) that serve as checklists, as records of parameters and constraints and for error and warning messages. The latter may include an optional help and teach function for inexperienced operators, giving advice on how to use the form in certain cases or explaining why certain constraints cannot be avoided. These features seem to be especially useful to make the semi-automated decision process more transparent and acceptable compared to the black-box of an expert system. The procedure seems to be favorable also from an educational point of view, occasionally even for training experts!

The form "Structuring of Statistical Data" (fig.2), part of an object-oriented module, gives an idea, how a limited amount of data (12 variables) may be extracted from a larger source data set (38 variables). Value d3 will be expressed as the percentage of the increase in people employed in the period 1985-1991, based on 6 source values.

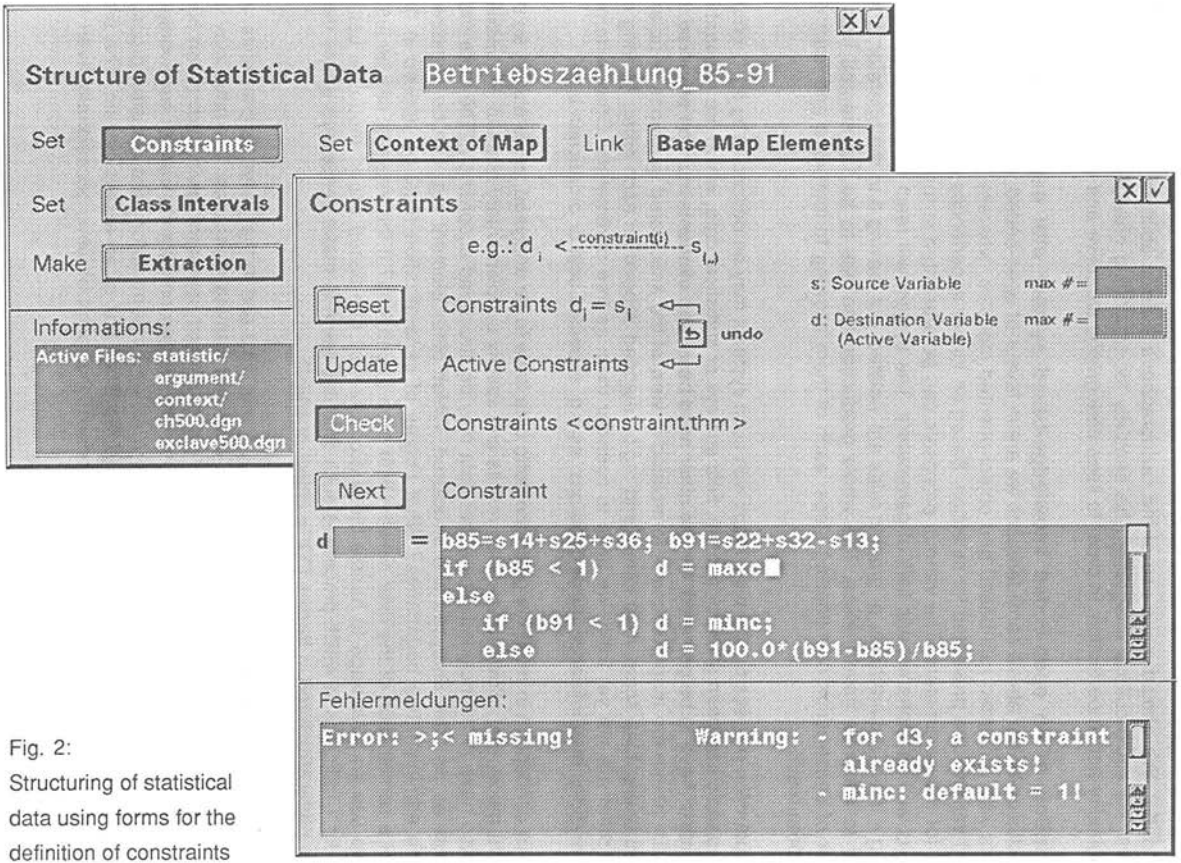

Fig. 2:
Structuring of statistical data using forms for the definition of constraints

This way prepared and fed the rule-based module develops a proposal for the design of the map, chooses the best suited graphic variables and graphic construction, calculates optimal parameters and provides them with pertinent comments. The map compilation process ends with a solution in a certain map type, a complete construction of the whole map, to be visualized on the display in every detail and as a whole. If the cartographer is not satisfied at all, he turns into a loop to start the whole process again with slightly different parameters or with a change in the concept that may end in another map type. If the solution is somewhat satisfactory a thorough map analysis may be undertaken as a final test of the design concept before continuing into map production. This last stage includes work steps like clarifying any overlap,

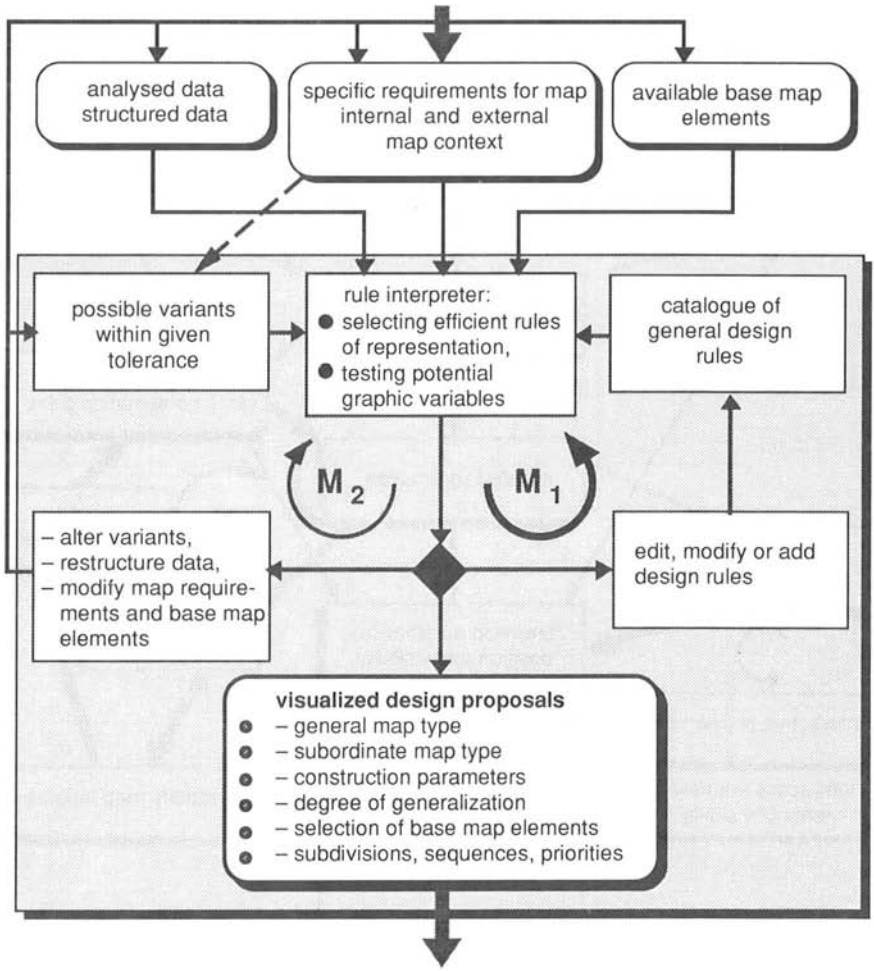

Fig.3 : General map design procedure to obtain proposals for subsequent map construction

lettering, final specifications for colours, textures and line widths. Provisional specifications may have served in the design process.

Rule-based design modules

Fig.3 describes in more detail the map design part of fig.1, the general procedure to come to a map design proposal suitable for the subsequent map construction. The rule interpreter or inference machine is fed with the data analysed and structured in the preprocess and with the initial requirements. It selects pertinent rules from the catalogue of general design rules and tests all possible graphic variables against the input data. The result of the evaluation of the proposal may be to subject it to a coarse adjustment loop, a module in which the design rules may be modified. This done, in a second run a fine adjustment may be needed on the side of the data parameters. Usually it will be sufficient to look for a variant within a given tolerance without restructuring the data. In certain cases a need to go back to the input level may arise.

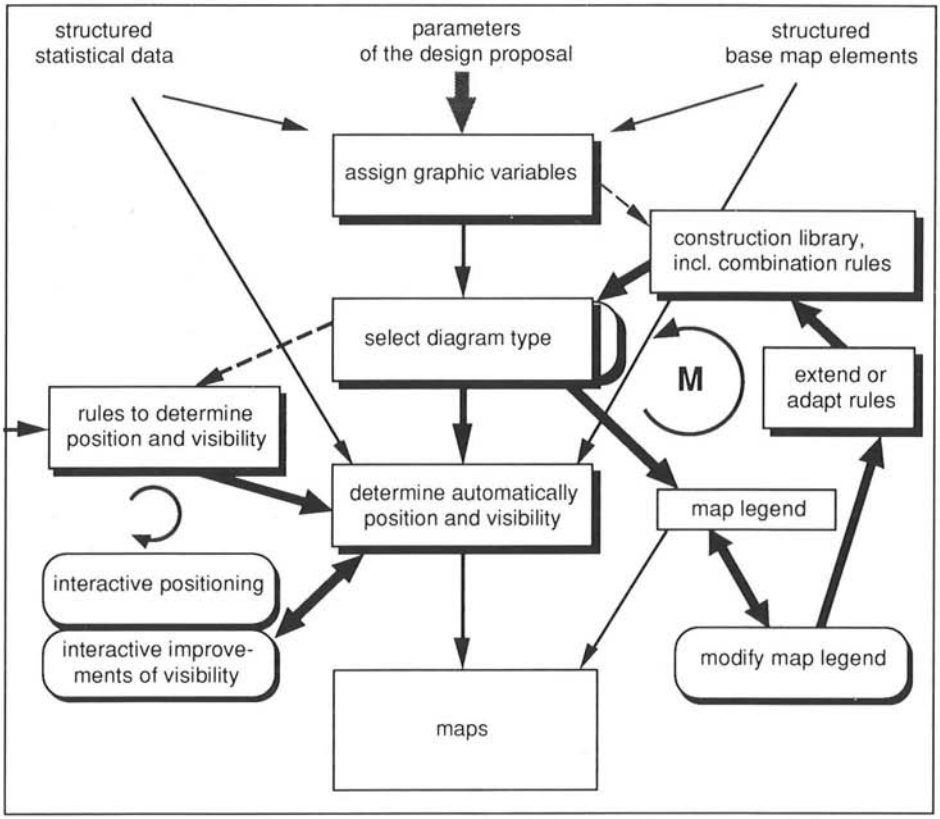

Fig.4: Construction scheme for diagram maps

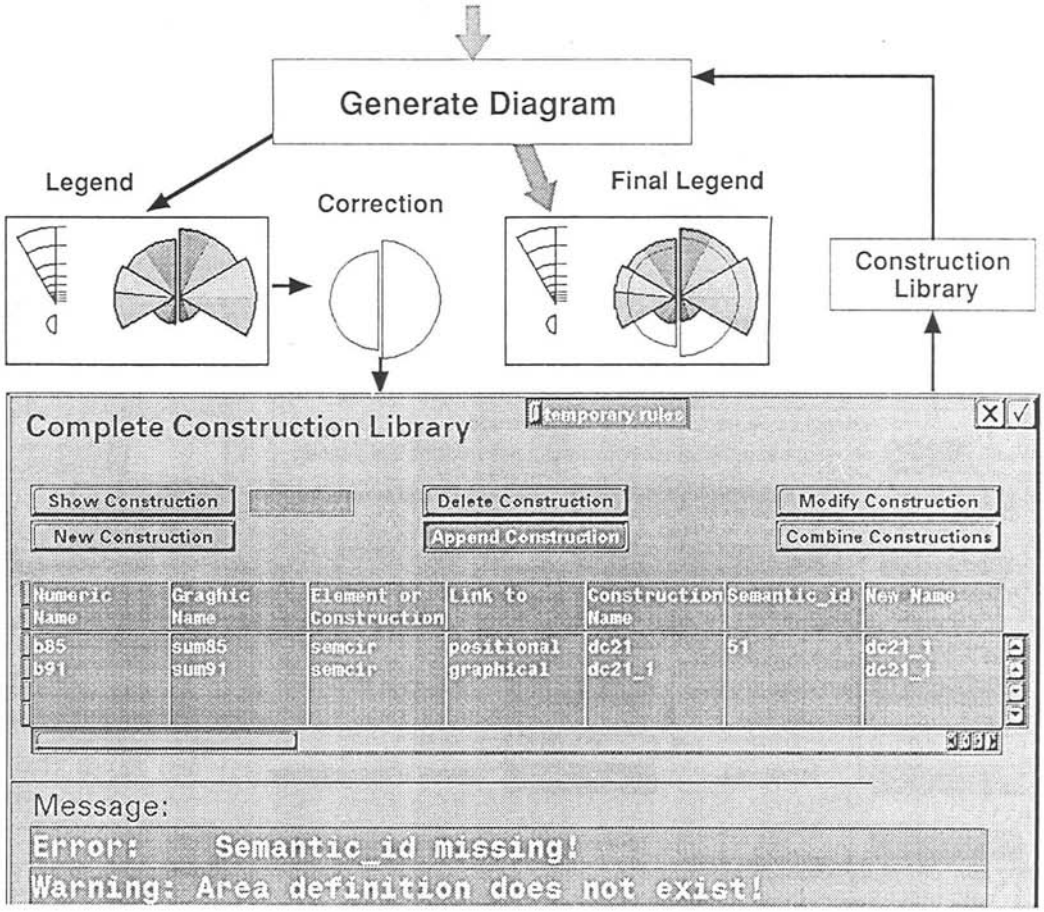

Fig. 5:
Modifying the legend by adding a pair of semi-circles, using forms to complete the construction library

Wing Diagrams

Date and time of last change in the argument table: Tue Oct 15 09 : 22 1991

Version of the argument table: 3

Coordinate file name: fgz0982.asc

Statistical file name: chbas.asc

Map scale: 1 : 200 000

Map frame X 865 000 Y 302 000

National coordinates in m

430 000 X
82 000 Y

or image coodinatesin mm

Symbols in the legend: 6 < = 15

0:	maximum	5:	1000	10:	0
1:	20 000	6:	500	11:	0
2:	10 000	7:	0	12:	0
3:	5000	8:	0	13:	0
4:	2000	9:	0	14:	0
				15:	0

Title of the map:

Employment in Industry in 1985

Number of values to be represented: < 101 6

Multiplication factor: 0.08 (0.00 < a)

Radicand: 2 (1.0 < b)

Line width of outline in mm: 0.10 (0.02 < d < 1)

Angle of zero line (clockwise α < 0°): 0 (-180° ≤ α < 180°)

Thresholds calculate new mm values upon changes of a,b

No diagram is drawn if value < 100

or radius in mm

Diagram is not subdivided if value < 800

Sectors are suppressed if the chord of the sector's arc is < 0.7 mm

In this case the suppressed values are distributed as follows:

If one sector contains more than 50 < x 51 it is shown as **100 %**

added to sector no.:
proportional on all sectors
summarized in add.sector
added to sector no.: 6

Interval scale ≤ 5

Number of intervals: 2

Class limits as values

or as radius in mm

c1 > c2 > c3 > c4 > c5

Class limits:	Interval represented by:
500	
300	370
0	200
0	0
0	0
0	0
0	

Important hints:

Fig.6: Form for the construction of one type ofdiagram with all the parameters in the interactive mode

Decision making by the operator is essential. He may decide on the basis of a first proposal visualized on the display, that shows the proposed map type, with construction parameters, with a legend figure, with indications on the degree of generalization and the chosen base map elements. When he finds it necessary to modify certain graphic rules, in general or for this specific map only, he will gradually improve and extend his catalogue of design rules or his descriptions of possible variants.

When the proposal is accepted, one can proceed into the map construction module. Fig.4 illustrates the conception of such a module for the whole group of diagram maps. Graphic variables according to the design proposal are assigned to the data and the diagram type is selected. The editor is provided also with a proposal for the map legend, which he may now modify and shift around in his layout. His expertise may allow him to extend or adapt the rules in the construction library, whenever he has developed an improved or new solution. Inevitably one will wish to improve on the relative positioning of those diagrams that overlap, compete with or disturb each other. In this case, however, we do not believe in an automatic feedback.

The form "Complete Construction Library" (fig.5) indicates that in this diagram map with devided wing diagrams another pair of semi-circles is superimposed and appended to the diagram position. The idea is to allow also for a comparison of the total number of the left side with the one on the right side. The warning indicates that the actual definition creates only the outlines of the semi-circles and that no filling will be possible, what of course makes sense in this combination. This proposal is added to the construction library and will allow in future tasks to include this item in the generation of the diagram whenever the user requires also these sums.

In contrast to such construction modules fig.6 gives an example of a comprehensive form as it is used in the interactive mode. The underlying construction program requires a full set of parameters. Most of them have been chosen already in the conceptional phase. Each time when a new variant is to be constructed, the whole set of parameters has to be reconsidered and eventually adapted. In comparison, when using the above expert module for the construction of the diagrams, only those forms with the parameters that are supposed to be changed are opened. If minor adjustments in the rules have to be made, the respective parameters in the construction library are opened and modified. In both cases extensive plausibility tests are installed in the programs.

Final remarks

The approach to design and produce thematic maps using rule-based design modules may be seen as a knowledge-based mapping system, the other way round. With a knowledge-based system one goes the straight and fully automated way from the initial requirements and data through the black-box of rules to a final result. No doubt that one will look forward to the result of this procedure in any case with excitement, will then be surprised, sometimes in the positive often in the negative sense, because the product may not meet the expectations of the operator. Too much depends on the initial conceptual input, on which the operator has scarcely enough information and therefore bad control. On the other hand an all-embracing questionnaire to start the whole process with, may be too sophisticated for the normal user.

The other way round means that the decisions in each step are based on the full knowledge of possible alternatives and options. On demand the rules that guide a certain choice can be listed and even explained. A further advantage is that the user can amend the rules, based on his own judgment and experience. Map variants are not found at random but based on some analysis of possible alternatives.

The plans are to continue to realize the described modules step by step, starting to automate them in those areas where the interactive methods provide us with proven rules. In all cases the interactive path will still be offered besides the rule-based decision. The spectrum of solutions will be much wider, what has a positive impact on the general interest in these maps. Expert system advocates probably refer to similar possibilities along the way a design problem comes to its solution. We feel however that cartographers ought to play a more active role in their primary field of activity.

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Tactile location maps from commercial geographic information systems

M.R.C. Coulson (Calgary, CDN)

1. Introduction

There are four key parameters that frame the scope of the research project presented here. They are, geographic information systems, public meetings, tactile maps, and location maps. The essential question asked is, can blind persons understand location maps produced by geographic information systems and presented to them in tactile form? And, secondarily, if not, what is the scope of the modifications necessary to overcome the problems?

This initiative is part of a larger, funded research project, *Evaluation and Design of Cartographic Output from Geographic Information Systems.* [1] The general objective of the project as a whole is to evaluate and provide improved design specifications for a wide variety of cartographic output from Geographic Information systems: screen, hard copy and tactile images.

A number of geographic information systems (GIS) are available to us, for the project; all have a North American origin. They vary in the scope of analytical functions included and the market to which they are addressed. However, they share the common characteristic that they are

sold commercially and therefore, are likely to underpin proposals to be evaluated in public meetings. It should be noted that the report has two parts. In this written paper the objectives, procedures and problems are set out. Part two, the presentation of experimental results to date, will be the oral report during the 16th International Cartographic Conference.

2. The Study Parameters

Our interest in *Geographic Information Systems* focuses upon the capability for map display of each system. The power of GIS for the analysis of problems with a spatial component is rapidly being realized. Even though there is a high initial cost, such systems are fast becoming the norm for management and planning in forestry, utility companies, urban and rural municipalities, and parks and wilderness agencies. For the most part, GIS may be perceived as a within-agency technology for such applications. However, one of the most powerful capabilities of GIS is in the 'what if' scenario - in other words, spatial planning for the future, whether it be for site locations, visual impacts, access alignments, and many other planning challenges. These typically require some presentation to the general public, whether it be for information or formal decision making. It is on these public meetings that we focus.

We are envisaging a *Public Meeting* as an interactive discussion, in which the preferred proposals of professionals can be tested against alternatives raised in a meeting. This is a radical alternative to current standard procedure in such meetings. Too often an early decision has been made to favour one of the many possible alternatives, this is the only alternative developed and it is then boosted as "the solution". We argue that by its very nature, GIS allows the pursuit of many alternative scenarios, even within a limited budget, and that the implications and potential of many suggestions from citizens can be tested and demonstrated during the meeting itself. This, of course, requires almost instantaneous output (screen or print) - another inherent capability of GIS. For the blind, this means maps that they can 'read'.

In western societies we are seeing a growing resistance to the marginalization of the handicapped. It is now recognized that a lack of sight, hearing or a limb does not equate with mental limitations, nor with limitations of spatial awareness.[2] Thus, as technology develops to encourage

a freer interchange of ideas between the professional and the citizen, provision must be made for the participation of those with visual impairments.

Over the years, a variety of production techniques have been developed for *Tactile Maps,* that is maps interpreted through touch. Each technique has its particular value and they have been well summarized by Turner and Sherman. [3] Our immediate need is for a technique that will provide near-instantaneous copies, and that can be achieved using microcapsule, or swell paper.

Microcapsule paper is available from manufacturers in Sweden and Japan.[4] It comprises a coating film of poly-vinyl chloride containing alcohol-filled microcapsules bonded to paper. A copy of the map or diagram is photocopied on to this special paper and is then subjected to a heat source. Variations in levels of heat absorption cause the alcohol under the black image to 'boil' and this portion of the image to raise.[5] From printer-copy to tactile map is no more than a few minutes. Although the heat source (usually an infra-red lamp) must be carefully controlled, there is no necessity for cumbersome special equipment. A further advantage of microcapsule tactile maps is that the map has a visible black image. This is very important because a large proportion of blind persons have some residual sight and wish to use it. In addition, such maps are also interpretable by sighted persons who may be part of a discussion group.

A complementary tool to microcapsule paper is NOMAD,[6] an interactive audio-tactile graphics processor. In essence, NOMAD, which looks like a digitizer, allows one to assign messages, stored in a computer file, to coordinate positions on the map. By pressing on such a location on the map, while it is mounted on the NOMAD board, the reader receives the message through a voice synthesizer. While there is a time delay, as the messages are entered, in the preparation of NOMAD applications, this is not a problem with materials prepared before the meeting and provides an important alternative for those who are not proficient in Braille. NOMAD is an important tool in the research project.

Current research focuses upon *Location Maps*, that is GIS products that identify the location of the study area on the earth's surface and provide information on physical and human features on the landscape. The analogy is to a topographic map and indeed such maps may be used as supplementary sources. Nevertheless, the GIS database should contain the essence of such information. Location map output is the product of combining a variety of data layers from the GIS

database and will be a standard product from most systems. It is planned to expand research to other thematic map output topics in the future.

Thus, in summary, we are working with location maps output from GIS and produced in tactual form. One sphere of application is anticipated to be public meetings on planning proposals (of a wide variety). In proceeding with our investigation, we now turn to two general questions; first, what is the cartographic capability of GIS and second, can the blind person interpret such output in tactile form.

3. "Map" Output From GIS

The existence of cartographic output from GIS may seem self-evident to many people. In fact, some researchers in the GIS community have expressed concern at the over-emphasis on cartographic output. At the same time, there are many cartographers working with GIS who are distressed by the poor quality of such output and would prefer to use the term graphic rather than cartographic for such output. It is not the intent of this paper to develop or resolve such arguments, very real though they are. Some of the elements of the issue, however are central to tactile map production.

The essential function of the GIS is to provide analytical processing for spatially referenced data. The essential function of the computer-based cartographic package is to provide a well designed map product for spatially referenced data. The importance of the difference between these functions has been too often overlooked.

For the GIS, graphic output is an ancillary function and being itself a large package, cartographic options tend to be limited. When in use within the office confines by the project group of professionals, elaboration of display options may seem unnecessary. Many images are short lived in the evolving analysis and paper copies may never be produced. The professionals themselves are very familiar with the study area and source documents, including maps, are likely to be present in the work area. For a public presentation however, the absence of basic cartographic design elements is a serious deficiency.

Many citizens attending a public meeting will be unfamiliar with maps; at least that is likely to be the case in North America. In any event, they will require cues to the map scale, orientation and content. These needs will be accentuated if copies are distributed rather than displayed and when

new products are generated during the course of the meeting. Some success can be achieved by the inclusion of well-known features, clearly named and well distributed across the map image (analogous to control points). At best, however, these are a weak substitute for the basic elements of title, scale, source, identification of orientation, legend, and normally a border. To these may be added questions about the range of symbolization available.

In most GIS the range of selection and flexibility of location on the map remain quite limited. To compensate, SPATIAL ANALYST, for example, uses AUTOCAD for all its graphic displays. A parallel alternative is to seek file format compatibility with a specifically graphic or cartographic programme, but this requires double processing of the information, familiarity with a second programme, and is generally considered overly cumbersome. We shall examine only the display capabilities of the GIS themselves, with specific reference to tactual requirements.

In this particular paper reference will be made to four geographic information systems. IDRISI [7] was developed by Dr. Ronald Eastman at Clarke University, U.S.A., originally as an educational tool for DOS microcomputers. It is now also widely used in developing countries for national and regional planning. MAP II[8] is the most widely used MacIntosh-based educational GIS, and was developed by Micha Pazner (now of the University of Western Ontario) from Dana Tomlinson's "Map Analysis Package". These two GIS were the basis for our original exploratory studies.[9] The other GIS are specifically for commercial applications. TRANSCAD is a GIS for "planning, management, operation, and analysis of transportation systems and facilities."[10] MAP/INFO is a "desktop mapping system that lets you display and analyze data geographically."[11] It seems best suited to large scale data sets and is often used for applications in the real estate industry.

4. The Tactile Map User

Tactile map users rely on their fingers to sense the information present. They do not see the map as a whole, but must scan it to get a sense of that whole. The developers of NOMAD recommend the inclusion of a small inset map to assist the tactual user. The finger is not as sensitive as the eye to the recognition of changes in symbols and, in general, thicker lines, coarser patterns, and

a reduced set of information are recommended for tactile map design, than for a comparable map using visual interpretation.

"A significant number of research studies have been published on the requirements of tactile maps. Many of these are specific to a particular production technique, but in general they address all of the basic elements of map design.[13] The absence of a comprehensive review does not signify a lack of interest in such literature, but rather that our present focus is upon standard GIS output. If this is found to be unsatisfactory, then recommendations for special output modules will be required and will be based upon that literature.

The tactile map user begins with major disadvantages. He/she cannot see a map image; nor, for location maps, relate the map to the previously viewed real world. "Thus, visually impaired persons will have more difficulty structuring and conceptualizing complex real world environments than will persons with normal vision."[12] Nevertheless, research supports the contention that blind persons, even the congenitally blind, can have a well developed spatial awareness and can make effective use of maps. For the purposes of GIS, however, they have two further disadvantages: first, screen images are not usable; second, colour cannot be utilized although it may play a supplementary role for those with residual sight.

5. Tactile GIS Output: The Potential

Textual content plays a very important role in the map. It included title and source and other locational and explanatory information. In the GIS it is often an option - do you want it? When invoked, it is often limited in scope and location. Characteristically, it results in reduction of the scale of the map (IDRISI) and occurs in a fixed location (IDRISI). In contrast, it may appear on the face of the map (TRANSCAD) obscuring part of the information although with flexibility of location. Characteristically, supplementary information, such as "source" may have to become part of the title.

In maps for tactual use, some of the design subtleties of the text are lost. Braille is essentially a single font of fixed point size and lacking such variations as 'bold' or 'italic'. To the best of our knowledge, no GIS includes Braille as a type option. It must therefore, be added to the printed map before conversion to its tactual form.[14]

This is not without its advantages, since the option without title can be chosen and then the text can then be added in an empty or low priority portion of the map.

Scale and *Orientation* are essential for all maps, but do not seem to be seen so within GIS. TRANSCAD has a bar scale with choice as to its location. In IDRISI, however, no map display scale is provided. That must be obtained by searching the documentation file for size of pixel and numbers of row and column pixels. INFO/MAP expresses the screen width as a number of miles, but this is not included in any print out. We have yet to find symbols for map orientation on GIS cartographic output.

In tactual form, problems of scale and orientation may be incorporated within a separate legend sheet - having obtained the information from general documentation on the project. The necessity of such cumbersome procedures detracts from the cartographic quality of GIS output, whether the user be blind or sighted.

Most GIS provide some capability to display a *Legend* but boxes within the legend seem to always have been predetermined and to be too small. Sufficient amounts of each symbol should be shown in the legend to establish the pattern. Some problems are even encountered with solid colours and this becomes serious with patterns. In MAP/INFO, the legend box increased when text was added, but the symbol boxes did not change. Neither did they change when the zoom function was invoked to produce a larger scale map. IDRISI has a fixed location to the right for its legend: MAP/INFO and TRANSCAD allow flexibility of location and shape (but not area).

For tactile maps it is common to print the legend on a separate sheet. This reflects the limited size of microcapsule sheets and the use of space consuming Braille for text. However, so far we have not found one GIS where an adequate legend could be printed from the screen image. A combination of small symbol boxes with coarse patterns is unsatisfactory. Our strategy for the present is either to treat the legend display as a separate data set, or to use a natural legend, modifying one print-out for use as a legend with Braille overprinting.

Symbols are the essence of the map representing real world features. Here we can address the full range available in a GIS as substitution of tactile reproduction in a particular map is relatively straightforward. However, the range of symbols is often very limited. MAP/INFO uses a multiple of three for dots, parallel lines and cross-hatch and types of line pattern and size of circles and approximately twelve point symbols. TRANSCAD has a great variety of line widths but limited

other symbolization. Many of these seem unlikely to be satisfactory for tactual use. As a potential solution we enlarged the map scale, but the programmes enlarge only the boundary files and then add the standard fill. A photocopy enlargement is an alternative, but this also thickens the pattern elements.

IDRISI allows display and printing of ASCII files and this was one of our first experiments, reported in our 1991 paper[9] Some sixty were judged as having potential, but the results were disappointing. It was difficult for subjects to discriminate between even four area fill patterns. In the same set of experiments, coarse, dot, line and cross-hatch patterns, created with MAP II, performed quite well, and hold distinct promise.

Unfortunately, most producers of GIS have focused their improvements upon the improving colour capabilities of microcomputer displays. Thus for example in IDRISI (version 4.0), the COLOR module not only provides options on the colour sequence used, but a variety of tools for referencing pixels, windowing and overlaying vector outlines. In contrast, black and white images remain largely unchanged from early versions and are limited to either ASCII symbols, graduated grey dots, or a numeric display of pixel values.

6. Looking Forward

At the time of writing, most of the experimentation lies before us. Equipment and GIS programmes are available and a laser printer replaces the dot matrix machine used in our earlier work. We also have the added dimension of NOMAD to explore. We are moving beyond the conceptual framework previously developed [15] into applied studies.

We are proceeding with a small group of visually handicapped subjects, all of whom are familiar with maps. They are using standard GIS output, but we also are taking advantage of the layered data storage to vary the complexity of the maps examined. In many ways, the project will continue to be an exploratory one. We are beginning with location maps, but there is a great variety of maps to explore. Further, GIS themselves are evolving with most presenting new versions each year. It is not our intent to review individual GIS systems, but rather to explore tactile map specifications that will allow the visually impaired to play an active role in planning their local environments.

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Graph Theory and Network Generalization in Map Design

K. Beard, W. Mackaness (Orono, USA)

"And the quaint mazes in the wanton green
for lack of tread are indistinguishable."
A Midsummer's Night Dream Act II, scene 1.

Abstract
In line with advancing mapping technologies, solutions have been sought to the intelligent automation of map design. The selection and degree of application of various generalization techniques depends on the behaviour of the map objects and their interaction, theme, scale and intended use. In order to convey the attributes of features it is first necessary to capture their nature. One of those attributes is connectivity and association. Graph theory is a branch of mathematics concerned with connectivity and the generalization of relationships. Intuitively it seems appropriate to use graph theory to aid in the generalization process. This paper reviews some of the areas of generalization to which graph theory can be applied and shows through examples how graphs can be used to generate strip maps, generalize networks, identify components in the form of subgraphs, and influence symbology. Various parameters of graph theory can also be used to summarize the descriptions of graphs; such information can be used to retain the characteristics of a feature during generalization. The paper begins with a very brief overview of graph theory.
Keywords: graph theory, network generalization, digraphs, automated map design.

Introduction

The literature on graphs is vast and excellent introductory texts numerous, among them Ore (1963); Hartsfield and Ringel (1990); Chartrand (1977). Graph theory has branched into areas such as directional graphs (Robinson and Foulds 1980), hypergraphs (Berge 1976), and fuzzy graphs (Dubois and Prade 1980). There are a number of excellent texts that look at graphing algorithms, including Preparata and Shamos (1985) and Sedgewick (1983). Graphs in general have many properties and many algorithmic solutions have been devised for measuring and predicting the behaviour of graphs (James et al. 1970). The range and diversity of applications is equally broad and makes fascinating reading:- efficient traveling paths, efficient circuit board design, minimum spanning networks, minimum vertex coloring, modelling markov chains, labyrinths (Konig 1990), enumeration of chemical molecules, linguistics (Busaker and Saaty 1965), network flows and scheduling or critical path analysis.

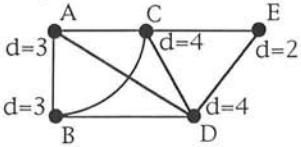


Figure 1. *A graph and its degree*

Let us briefly review some terms. A graph is made of vertices (A, B, C, D, E in Figure 1), and edges ($\overline{AB}$, $\overline{AD}$, $\overline{CD}$, $\overline{BC}$, $\overline{DE}$, $\overline{CE}$, $\overline{BD}$, $\overline{AC}$). The degree of a vertex is the number of edges that have that vertex as an endpoint (for example vertex D is of degree 4, having edges $\overline{AD}$, $\overline{CD}$, $\overline{DE}$, and $\overline{BD}$). The degrees for each vertex are shown in Figure 1.

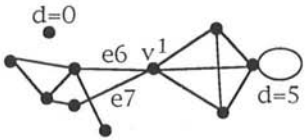


Figure 2. *Articulate and isolating vertices and loops*

Figure 2 looks at other attributes of graphs (in which not all the vertices, degrees and edges are marked); the isolated vertex is shown with degree 0 and an example of a loop (note the degree number for that vertex is 5 not 4). A 'disconnected set' of a connected graph G, is a set of edges whose removal disconnects G. In Figure 2, the disconnected set is e6 and e7. A 'separating set' is similar to a disconnected set, but applies to vertices; if the vertices of a separating set are removed, the graph G becomes disconnected. If a separating set contains only one vertex, it is called the cut-vertex or articulation vertex. In figure 2, v^1 is an example of an articulation vertex. Finally, we can state that if a connected graph contains a cycle – that is, it is possible to visit the same vertex from different adjacent vertices – then removing an edge from the cycle will not disconnect the graph.

Directional Graphs (Digraphs)

Directional graphs or 'digraphs' (Robinson and Foulds 1980) can be used to indicate flow, or hierarchical orderings. This enables the modelling of capacitance and flow constraints such as in electrical and hydrology systems (Bollobas 1979). Direction through graphs can also be used as a basis for generalizing graphs (called reduction - Hecht and Ullman 1972), and this has apparent applications in anthropogenic and natural geographical networks such as one way road systems and river networks.

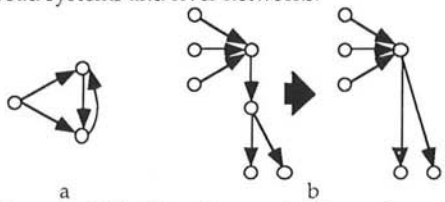


Figure 3. *Reducible and non-reducible graphs*

For example Figure 4, a) shows a graph which cannot be condensed further – it is *non-reducible*. Figure 3b **is** reducible – A digraph is reducible, irrespective of the size, direction and complexity of the graph, if the in-degree of a vertex is 1 (figure 3b). Reducing graphs is an irreversible process in the sense that many different initial graphs have the same end product when reduced. From a Geographic Information (GIS) database perspective this would not be a problem if the data were stored at a high resolution and lower levels of detail were then derived through reduction.

Parameters of graphs

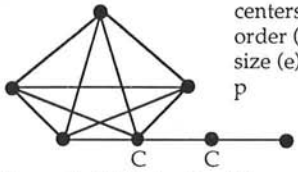
As itemized by Cliff et al. (1979) there are a number of parameters that can be use d to describe the nature of graphs. In the table below, n and m denote the number of vertices and edges respectively in G, and S_{ij} denotes the length of the shortest path from vertex i to vertex j.

Parameter	Bounds on parameter	Interpretation
$\beta = \frac{m}{n}$	$\frac{1}{n}(n-1) \le \beta \le \frac{1}{2}(n-1)$	ratio of the numbers of vertices and edges.
$\mu = m - n + 1$	$0 \le \mu \le \frac{1}{2}(n-1)(n-2)$	Cyclomatic number of G, giving the no. of fundamental circuits.
$\alpha = \frac{2(m-n+1)}{(n-1)(n-2)}$	$0 \le \alpha \le 1$	Ratio of fundamental circuits to the maximum possible.
$\gamma = \frac{2m}{n(n-1)}$	$0 \le \gamma \le 1$	Ratio of the number of edges to the maximum possible.

$H = \max_{i,j} e_{ij}$	$0 \le H \le \frac{1}{2}n(n-1)$	The height of a graph.
$\delta = \max_{i,j} s_{ij}$	$1 \le \delta \le n-1$	the diameter of G
$\kappa_i = \max_{j \ne i} s_{ij}$	$1 \le k_i \le n-1$	the Konig number of vertex i
$D = \sum_{i,j} s_{ij}$	$n(n-1) \le D \le \frac{1}{2}n^2(n-1)$	the dispersion of G (measure of connectivity).
$A = \frac{1}{n(n-1)} \sum_{i,j} s_{ij}$	$1 \le A \le \frac{1}{2}n$	the average path length in G

Table 1. some parameters of simple graphs (Cliff et al. 1979, p. 301).

Even though these parameters do not describe all the differences between graphs, they are able to summarize some of their characteristics. For example a graph representing a transport network of high connectivity would generate low values for δ, κ, D *and* A. James et al. (1970) suggest a more discerning technique, the measurement of which depends on an analysis of the frequency distribution of the lengths (weights) of the edges. Other measures include measures of complexity (see Temperley 1981). Figure 4 shows a graph and the values for some of the parameters of table 1.



Parameters of this graph:

centers	C	$\delta = 3$
order (v)	7	$\mu = 6$
size (e)	12	$\beta = 1.71$
p	1	$\alpha = 0.400$
		$\gamma = 0.571$

Figure 4. *Attributes describing a graph*

In addition to the parameters listed above, it is also possible to identify the center(s) of a tree (*min* δ), shown as 'C's in Figure 4. The *eccentricity* of a vertex is the distance from a vertex to the furthest vertex and we can use this definition to define the *center* of a graph as being the vertex with minimum eccentricity. It is also possible to define the *radius* (not necessarily half the diameter) of a graph (Deo 1989) as well as its *capacity* (Bollobas 1979). Using such descriptions, it is possible to model features and their relationships and describe their preferred properties.

One parameter of note is the value of γ, which is a measure of completeness (Figure 4 is 57.1% complete). A graph is said to be complete if, for any simple graph, every pair of distinct vertices are adjacent. We can calculate the number of edges of a complete graph if we know the number of vertices making up the simple graph. If n is the total number of vertices, then the number of edges is exactly $^1/_2$ n (n-1). Such an index can help describe the level of connectivity in a graph. Consider Figure 2, where, if it were complete it would have 36 edges. Ignoring the loop, it has 12 edges and is therefore 12/36 or 33% complete.

Graphs, Geography and Cartography

Graph theory is a branch of mathematics which enables the modelling of relationships between objects, and since this branch of mathematics has emerged several geographers have discussed its potential (for example Robinson and Foulds 1980; James et al. 1970). The problem of the Konigsberg bridge is frequently cited (Figure 5), the problem being to commence a walk, cross all seven bridges just once and return to the same point.

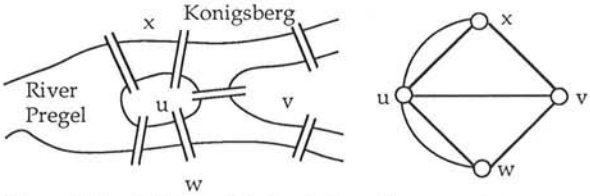


Figure 5. *Konigsberg and its graph theoretic representation*

Graphs can be used to represent geographical features such as road and river networks and other types of relationships (such as symbiosis or contiguity). Cliff et al. (1979) demonstrate its use in transport network growth and comparison, and in modelling river regimes.

In cartography, graph theory has been used to solve the coloring problem: namely what is the minimum number of colors required to color a map and not have two contiguous regions the same color. The number of colors is termed its chromatic number and it has been shown that for simple polygon division, the number is four or less. But there are some more intriguing ways in which we can use graph theory to aid in map generalization. From a generalization point of view we wish to capture the essence of an object and its properties and preserve these qualities during the generalisation process. We are therefore interested in the connectedness and shape of features and can use graph theory to capture and quantify (such as in Table 1) some of these qualities.

Graph Theory and Map Generalization

Generalisation is more than a set of operations applied wholesale to groups of features classified according to data type. The subtleties of map design mean that generalization techniques are applied both **within** classes of objects and **between** different classes of objects. This reflects the fact that objects have their own behaviour which varies according to several factors, but principally map task, scale, theme, symbology, and contextual content (Mackaness 1991).

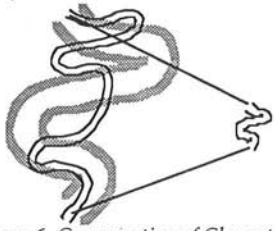


Figure 6. *Conservation of Character*

For example the inclusion of a feature in a map is a compromise between many competing factors such as map real estate, relative importance, a user's knowledge as well as their powers of interpretation. Though generalisation operators are applied based principally on an analysis of space, a map is as much about the communication of spatial concepts.

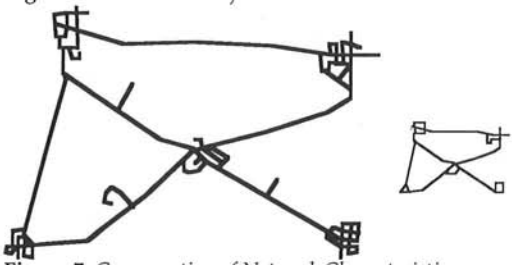


Figure 7. *Conservation of Network Characteristics*

What governs good design is the success with which we convey the nature of space and facilitate its interpretation. When we generalize an object we wish to capture the essence of its characteristics and preserve them in its generalized form. Thus a hairpin road has fewer bends but is exaggerated at reduced scale (Figure 6). One of the geographical characteristics of space is the connectivity that exists between objects (both physical and logical). Typically we wish to convey the clustering of roads that belie a town or its remoteness. We also wish to convey the notion of the relatively sparse, long road sections between those towns (Figure 7). Describing these clusters using graph theoretic

techniques is discussed by Zahn (1971). Since graphs can be weighted and directed to convey these notions, it would appear that they can be used to describe the relationships between objects on a map. The description of relationships between objects is a prerequisite to the utilization of knowledge based map generalization systems (Muller 1989; 1991).

Generalization of Networks and Component Analysis

As mentioned in the overview, digraphs are reducible and can also be used to identify lower limits of information. Surprisingly there are few situations where directional graphs need to be used in order to facilitate generalization. Roads are, in principal, bi-directional, and whilst hydrological features have flow, it is not a characteristic that is used to help in their symbolization (though it has been used to aid image interpretation (Paiva et al. 1992) and directional graphs have been used to facilitate contour labeling (Wu and Mackaness 1992), and algorithms exist that determine shortest paths through directed graphs (Tarjan 1983). An algorithm that determines shortest paths would have application in dynamic generalisation; for example in in-car road navigation systems where it was necessary to identify and highlight an efficient route across town through a one way system (White 1991).

Digraphs in Map Generalization

As discussed earlier, digraphs can be used in the generalization of networks, for example in one way road systems in towns (for discussion see Ore 1963).

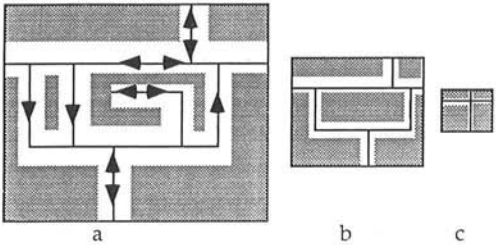


Figure 8. *Three states of generalization of a road network,*

Various algorithms have been developed to reduce the number of edges in a directed graph whilst still ensuring that it is feasible to travel from any one vertex to another (Figure 8). Note that in Figure 8b, the small cul-de-sac (which can be identified as the disconnected set of a vertex of degree 1), is not critical to the preservation of overall connectivity and has therefore been removed.

Chapter 2 of Robinson and Foulds (1980) shows how digraphs can be condensed by component analysis. The components are identified based on their directional behaviour and the 'outreach' from a given vertex (which vertices it is possible to travel to from a specified vertex). It is then possible to group vertices together into 'component subgraphs' (Robinson and Foulds, 1980, p.51) and these components can then be reduced to single vertices - thus condensing the graph but maintaining the connectivity between the subgraphs.

Weighted Graphs used to Mimic the Generalization of Networks

Using weighted graphs, we are able to generate minimum trees. Weights can be assigned to each edge of a graph so as to indicate factors such as distance between features or capacities. Indeed each edge might have a number of weights according to the number of attributes associated with each edge. In Figure 9a, depicting part of a stream network, the numbers have been assigned on the basis of Strahler's (1960) stream ordering principle. The graphs of 9a and 9b are also shown. Such weighting has immediate and apparent use in network generalization (Rusak Mazur and Castner 1990), as well as in symbolization (as illustrated under the graph of 9a). Figure 9b shows the same network but with only stream order 3 and 4 shown. Numerous researchers have highlighted problems such as the one illustrated in Figure 9b whereby the

lakes have become 'detached' from the network because part of the 'core' path was comprised of a section of lower stream order.

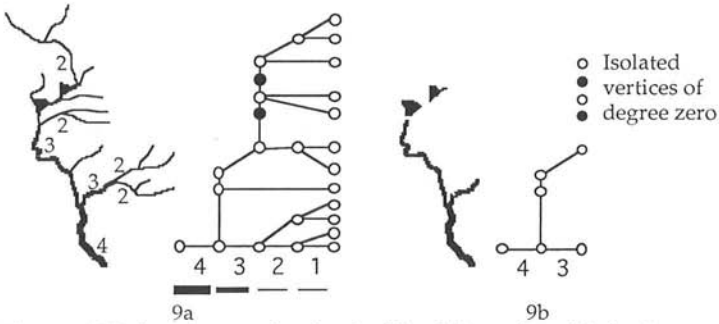


Figure 9. *Weight assignment based on Strahler, their graphs and isolated vertex*

Most human cartographers would extend the line to 'catch' the lakes. This can be similarly achieved through the application of graph theory by inspecting the graph before and after generalization. We can identify lakes that have become isolated as well as the disconnected set (the set of edges) that isolated the lakes. Given the graph for the stream network, we can issue the following instruction to reflect the more subtle application of generalization techniques: Remove all edges with a 'weight' less than three unless that edge is the disconnecting set for vertices labeled 'lake', in which case retain it. Finally we should also observe that such a rule is applicable only for a range of scales, and that such a rule could be further refined, for example to control the elimination of lakes as an alternative to retaining the disconnected edges.

Minimum spanning tree algorithms and the reduction of information

Potentially minimum spanning trees (MSTs) have many uses in generalization. This section reviews their use in reducing map content in networks and associated information but MSTs can also be used to identify groups of points in proximity. Identification of clusters of features on a map is prerequisite to a number of generalization operations including selective removal, displacement, exaggeration or scale change (Mackaness 1991). For an excellent discussion of MSTs in Euclidean space and their relationships with Voronoi diagrams the reader is referred to Chapter 6 of Preparata and Shamos (1985).

Kruskal's minimum spanning tree algorithm can be used to generalize networks and control the reduction of information in maps at smaller scales, assuming that the network is in the form of a finite weighted graph. The resulting graph, coupled with parametric information (such as in table 1), can be used to control other information associated with the graph such as town names. An implementation of Kruskal's algorithm was used to generate the results shown in the following graph. An important cartographic condition is that at certain small scales, there is not enough space to show every class of road and link between towns. An overriding objective remains that we need to convey the notion of connectivity that exists between features, in the following example, towns. In the example below the graph has been weighted according to the distance between towns, but other factors could be used (for example time). The shorter the distance, the lower the weight. We can use Kruskal's algorithm (also known as the greedy algorithm), to find the minimum weight spanning tree (MST) in a connected graph (for a description of this algorithm see Aho et al 1974) – one that connects all vertices using the least number of edges of the lowest weights. This minimum spanning tree is acyclic - being a graph that has no circuit.

The advantage of such an approach is that irrespective of the magnitude of weight given to an edge, no vertex becomes isolated (of degree 0). Thus if a map contains a town connected solely by a minor road, it will be retained using this algorithm, thereby preserving the connectivity of that town with other towns. The distances shown on the graph came from Rand McNally (1991).

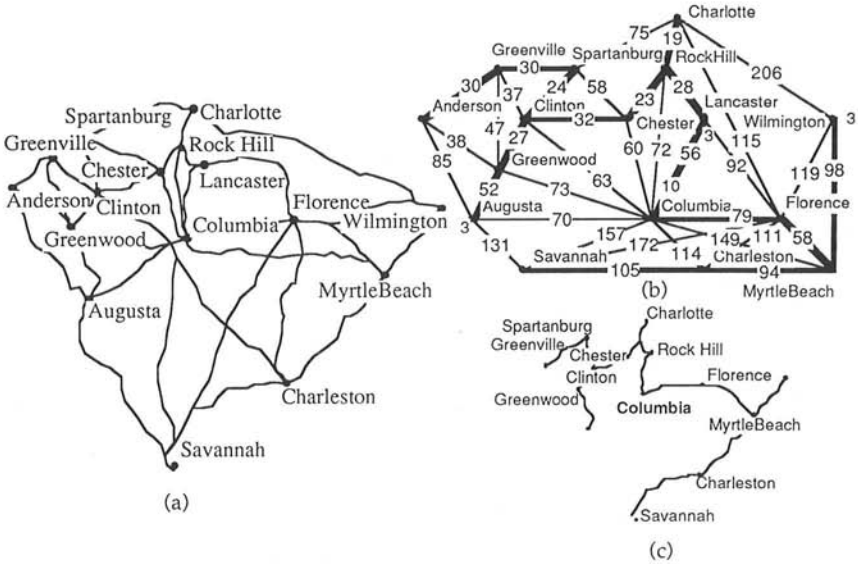


Figure 10. a) Major towns and roads in South Carolina, b) its graph, c) its generalized form.

Figure 10 shows the major roads and towns for South Carolina, on the eastern seaboard of the USA. The graph of that map is shown in Figure 10 (b). Kruskal's algorithms has been applied to the graph to determine the minimum spanning tree and this is highlighted in the graph of Figure 10 (b). Those vertices of degree three are also labeled. Using only the information in Figure 10 (b), the map (c) was derived. The graph has been used to reduce the amount of transportation network shown, reduce the amount of text and highlight towns of special importance. This was done by removing all edges not belonging to the MST, removing text associated with vertices of degree less than four and making bold any vertex with degree greater than seven (in this case the town of Columbia, which is of degree 10).

If we had used time instead of distance, the graph generated would tend to choose fast roads (such as motorways or interstates). The calculated degree of completeness (γ), for Figure 10a and 10b is 30% and 12% respectively. Thus we can vary the content from 30% down to 12% with the knowledge that we have retained the notion of connectivity. In a situation where the percentage difference was great, we might assume from a cartographic perspective that we had lost too much of the context of connectivity and revisit the graph, adding edges of lower weights until the percentage difference fell within some pre-defined tolerance. For example Figure 11 shows the same map at 24% complete (edges have been successively added to Figure 10c). As stated previously, a features inclusion in a map is a compromise between many competing factors, and is not a crass decision based solely on scale, or that one feature type stays at the expense of another.

Figure 11. *South Carolina - 24% complete*

If there was a need to reduce the content below 12%, this would indicate the need to also reduce the number of vertex features (in this case cities or towns). This form of content reduction acknowledges the role played by various features in creating a gestalt of woven information – each feature contributing to the nature, and reflecting the behaviour of, other features on the map. The degree of completeness is one approach to measuring map content that enables the measurement and selection of objects for removal.

In a separate application of MSTs, Zahn (1971) shows how they can be used to detect different types of clusters. Geographical features can be identified based on a taxonomy by clusters (dense roads denote towns, clusters of islands an archipelago, groups of trees a forest), and such information is critical to the successive generalizations of objects at smaller scales.

Connectivity Influencing the Likelihood of Inclusion in a Map

Knowledge of feature connectivity can govern the inclusion of other features. For example where a remote town was accessible only on foot or by river, these routes of access are likely to be shown on a map, even where the scale would normally preclude their inclusion. Using graph theory they can be identified as the disconnecting set. Thus graph theory can be used to secure the connectivity context of features when generalization techniques are being applied.

Corridor Maps

We can also use such graphs to derive corridor maps by first identifying an intended path through a graph theoretic representation of a topographic map (for example a railway map or walking map of the Pennine Way in England). The features local to the route can be identified by identifying edges and vertices adjacent to the path. This would create a graph that represented a 'corridor map' (or strip map) which in effect would show local towns and amenities.

Some Preliminary Rules

We summarize this paper by listing a selection of rules that can be formulated in a graph theoretic form and could be used in a rule based system to control the selection and degree of application of various generalization techniques. Some of the example rules are compound and would require additional analysis through the application of theories other than just graph theory.

'A feature with degree 0 is an isolated feature.'

A feature can have additional prominence by virtue of its isolation. This fact coupled with the use of Euclidean Minimum Spanning Trees (EMSTs) can thus be used to preserve features in culturally sparse areas (for example a mountain refuge hut).

'Where a cycle exists, edges can be removed on a hierarchical basis without isolating a feature'

This is the basic premise under which MSTs were applied to generalize networks whilst maintaining connectivity.

'A feature with degree 1 is a terminus in a network'

Sometimes we wish to preserve terminus features, for example where they represent an 'outpost'. Alternatively they may represent cul-de-sacs (figure 6), in which case they can be omitted. Again the use of EMSTs would help differentiate between outpost and cul-de-sac.

'A feature with proportionately high degree compared with the mean degree of the graph, has hub like qualities'
When a feature is common to a high number of other adjacent features, that feature becomes important because objects traveling through the network will travel 'via' that feature. For example the city of Columbia had degree 10, and this fact was used to control its symbology (Figure x).
'A feature that is the sole member of the disconnecting set is more important than features not serving this task but of a similar type'
This was the underlying rule used to prevent the isolation of two lakes connected to a river network (Figure x), but could have been applied in any situation where the connectivity between features needed to be preserved.
'An articulate feature displays hub like qualities and additionally provides unique connectivity between features'
Those traveling across a network will be forced to route via an articulate feature, and so that feature will have raised importance. For example, Calais is a small fishing port in France, but has elevated importance as one of the main cross channel ferry terminus connecting the UK with France.
'Where edges of different types meet, the vertex has raised importance'
Where there is a change in mode of transport, (from ferry to road, or rail to float plane), the feature (such as a town), has the quality of 'connecting' terminuses of different types, and again has a raised importance. Again this describes one of the discerning attributes of a town, where typically you find rail, bus and river terminus.

The above list is by no means exhaustive and does demonstrate the need to gather additional information in order to determine the appropriate generalization technique. The use of these rules can help to more finely select features based on their attributes and their role in the map. For example, if we assume we knew many of the spatial and non spatial attributes of a set of towns, we could prioritize them based on which of the above rules applied.

Conclusion

This paper has shown how graph theory can be applied to help with a number of design problems; in the first instance, weighted graphs and/or directional graphs can be used to hierarchically omit or delete classes of features (for example the river network of Figure 9). Whilst different cities, towns and villages will have different mean degrees and completeness, graph theory can be used to prevent the road network of a town falling below a level at which the towns become disconnected. Whilst this would have the effect of de-emphasizing the difference in urban street complexity between towns (and therefore by inference its size), the authors consider that it is equally important to represent the connectivity between features as it is their difference in size (especially as there are other ways of showing size difference through use of symbols and text). Whilst its obvious application is in identifying remote features as well as maintaining connectivity between features, graph representations can also be used to help select features in general proximity to other features. Thus it is possible to create 'strip' maps. Not only can it be used to identify remote features, but also key links between features, such as a minor road that crosses over a pass, linking two remote mountain villages.

Almost irrespective of the theory applied, the authors have argued a course that requires a 'rich' database; at the point of data collection (the first abstraction) it is necessary to collect additional non-spatial attributes so that links (both spatial and non-spatial) can be identified and values assigned. If we wish to apply generalization techniques in the same subtle way that they are applied in human map design (in order to convey ordering, distinction, comparison,

combination, and recognition of relations) then this additional information is required. No amount of second level processing will bring back what was not collected at the first abstraction. The interpretation of a feature is itself dependent on a context provided by other features. Thus a features inclusion or exclusion from a map graphic is not solely based on theme and scale, but also its interaction with other features, and the competition for space. The application of graph theory enables us to formalize some of the relationships that exist between these features and thus gain a better insight into how features interact and in turn help us to make better decisions in map design.

Acknowledgments
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Generalization of digital surface models

J.T. Bjørke, T. Midtbø (Trondheim, N)

Abstract

This paper demonstrates how information theory can be applied to the estimation of parameters for contouring from digital surface models. The optimum amount of variation in a contour map is defined to correspond to the maximum value of the useful information, i.e. the channel capacity.

The generalization of the surface model is based on a triangular irregular network (TIN). The TIN is constructed in an adaptive manner which provides models of various accuracy. Various parameters for the method are discussed.

The paper also includes a short discussion on the handling of nationwide models by block-based triangulation.

1 Introduction

The use of TIN (Triangular Irregular Network) as data structures for terrain surfaces has increased in extension recent years. Surface modelling is very often based on huge data sets, using models that have to be efficient in terms of time. For example navigation charts cover large areas, and the surface model of the bottom of the sea has to be very efficient when a ship is under way.

Delaunay triangulation is definitely the most used technique for the triangular modelling of terrain surfaces. This method is based on achieving a well proportionated triangular geometry between the horizontal projections of the data points. By using the incremental method for Delaunay triangulation [LS80] and [GS85], it is possible to determine the contribution a point will make to the model, *before* the point is included in the network. This process is named "qualified selection of points" in Section 2, and leads to the efficient generation of models with various degrees of accuracy.

A problem in the map generalization of a surface model is the selection of an appropriate dimension for the parameters which control the amount of detail. We have carried out an experiment in this field based on information theory.

A sub division of the areas into blocks is required for the efficient triangulation of large areas. Section 4 gives a brief discussion of this.

2 Surface generalization by qualified selection of points

Cartographic generalization consists of several sub-processes according to [Aas92] and [SM89] among others. The qualified selection of points is in fact a simplification, which probably is the most important sub-process. However, the qualified selection of points is not primarily used for cartographic simplification, rather to simplify the surface model. We have consequently chosen to refer to the process as the generalization of the surface model.

The basis for the triangulation by the incremental method is a set of points in the 3 dimensional space covered by an initial network. The points are included in the network due to their contribution, and the edges are subsequently reorganized until the geometrical condition of Definition 1 are met for the whole network.

Definition 1 *A Delaunay network in two dimensions consists of non-overlapping triangles where no points in the network are enclosed by the circumscribing circles of any triangle.*

A triangle formed by three points represents an exact description of a plane in space. When candidate points that lie inside the horizontal projection of the triangle fall in the triangle plane, these points will make no contribution to the model.

Example: When a sea surface is represented by a grid model, a lot of redundant data are stored. In the TIN model the surface is represented by large triangles "rooted" on the shore.◇

It is possible to extend this algorithm to ignore "almost redundant" points as well. This means that a point might not be included in the triangular mesh if it lies close to one of the triangles. Consequently it is possible to establish surface models with various degrees of accuracy. The accuracy is set by a predefined threshold value for the point inclusion.

When a generalized surface model is required, it is an advantage that the selected points give the best possible description of the surface. During the insertion process in the incremental algorithm, a *split point* is chosen from the points that are enclosed by the present triangle. Usually the most distant point in each triangle makes the most significant contribution to the model, and is consequently chosen as the split point. After the triangle is split and surrounding edges are reorganized, every triangle that is influenced by the reorganization will have a new split point. When all the points lie closer to the triangle than the predefined threshold, λ, no more points will be included inside that triangle. The triangulation for the entity area is terminated when every point, that is not included in the network, is closer to a triangle than λ.

The triangles to split can be chosen in random succession. This is simple, efficient, and experiments show that the results are quite good. However, the surface models do not necessarily become identical when one data set is processed twice

when the point succession is changed. As the variation is small, the precision of the surface model will still be the same. It is possible to avoid this "problem" by getting the triangle to split in a more sophisticated way. During the triangulation we can, for example, always split the triangle which has the most distant point. In this case variations caused by different point succession only occur when we have to choose between two (or more) triangles with equal distances to the most distant point.

2.1 Threshold for point inclusion

The threshold for point inclusion depends on the problem to be solved and will vary in type and size. Figure 1 shows a typical threshold, λ_p. Every point that is closer to their enclosing triangle than λ_p will not be included in the mesh. The

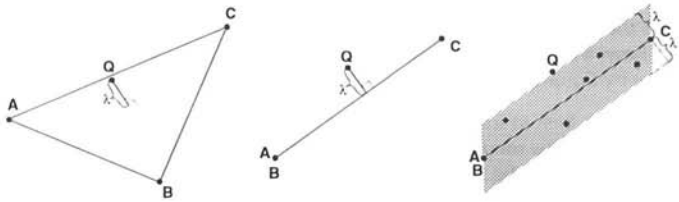

Figure 1: (a) Threshold value, λ_p, for the perpendicular distance. (b) A cut through the triangle. (c) Region inside the threshold value.

threshold in Figure 1 is designed for the perpendicular distance from point $P_Q(x_Q, y_Q, z_Q)$ to the triangular plane, $\triangle ABC$, calculated by Equation 1

$$dist_p = \frac{ax_Q + by_Q + cz_Q + d}{\sqrt{a^2 + b^2 + c^2}} \tag{1}$$

When we are searching for the most distant point from a triangle, it is less time consuming to only compare the numerators of Equation 1. The denominator is equal for all points enclosed by a triangle. Consequently the split point is determined by Equation 2.

$$s_p = \max |\, ax_i + by_i + cz_i + d \,|, \quad (i = 1, 2, .., n) \tag{2}$$

n is the number of points enclosed by the horizontal projection of $\triangle ABC$.

A closely related method is to look at the vertical distance between the point and triangle plane. The point related to s_v of Equation 2 is chosen as split point when we use the vertical distance.

$$s_v = \max |\, z_i + \frac{d + by_i + ax_i}{c_i} \,|, \quad (i = 1, 2, ..., n)(c_i \neq 0) \tag{3}$$

A common feature of both methods is that it is indifferent which side of the triangle the most distant point is situated. A point above the triangle represents a peak while a point below represents a trough. For certain tasks it may be advantageous

to keep separate threshold values for each side of the triangle. The threshold value can also depend on where the point lies in the model. Some areas may be more important than others and we will have:

$$\lambda = f(x_{global}, y_{global}) \tag{4}$$

Similarly the threshold sometimes might depend on the z value:

$$\lambda = f(z_{global}) \tag{5}$$

Example: For maritime charts it is important to include all peaks that can be dangerous for navigation. Consequently the threshold value above the triangles are very important and should be rather small, maybe even zero. Bellow the triangles, size of λ is of minor importance and can be much greater. For certain areas, for example through a fairway, it might be interesting to maintain a higher level of accuracy. In that case the threshold is set by Equation 4. Further, maritime charts have to keep a higher level of detail in shallow waters. The threshold is consequently set by Equation 5 where λ grows when the depth is deeper.◇

In many cases it is best to include maximum and minimum points (extremal points) for the surface in the model, even if these points are closer to a triangle than the predefined threshold. To be sure that such points are included in the mesh, all points below the lowest z-value or above the highest z-value in the triangle are included in the network. Figure 2 shows a cut through a triangle and the areas

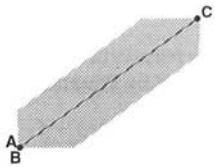

Figure 2: A cut through the threshold zone for λ_p and λ_v when extremal points are included.

that are inside the threshold. During the triangulation it is also possible to include an extremal point rather than the most distant point. However, when using the threshold zone in Figure 2 it is necessary to check the inclination and orientation of the adjacent triangles. This is because there will not be an extremal point between two subsequent triangles in the same slope.

The methods for incremental Delaunay triangulation and qualified selection of points are in [Mid93] extended to be valid in three dimensions. The result is adaptive data modelling by tetrahedral irregular networks.

Example: A lot of temperature measurements have been sampled for a sea area. If the sampling of data is easy, most of the measurements are probably redundant. For each sample x, y, depth and temperature are measured. A tetrahedral data structure may be generated to store the information. If the temperature of some samples inside a tetrahedron can be calculated from the four vertices of the tetrahedron, it is not necessary to store these samples in our data structure.◇

3 Information theory

A problem in the map-generalization of a surface model, is the selection of an appropriate dimension for the parameters which control the amount of detail.

An obvious question is: "How can parameters of a generalization algorithm be optimized?". The answer is not obvious as we must decide what is the meaning of optimization.

We turn the question another way and ask: "What is information and how can information be measured?".

Information theory, as given by Shannon and Weaver [SW64], is a fruitful point of view for our problem formulation. According to information theory the useful information in a message is defined as:

$$R = H(X) - H_Y(X) \tag{6}$$

where $H(X)$ is the entropy of the information source and $H_Y(X)$ is the so-called equivocation.

If the transition probabilities are known, the useful information can be calculated as:

$$R = -\sum_i \sum_j P_i \cdot p_{ij} \cdot \log \sum_k P_k \cdot p_{kj} + \sum_i \sum_j P_i \cdot p_{ij} \cdot \log p_{ij} \tag{7}$$

where P_i is the probability that message i is sent and p_{ij} the probability that message i is interpreted as event j. The messages are assumed to be independent.

A cartographic application of this concept is to select a generalization which maximizes the useful information. This value of R is termed the *channel capacity*. When we talk about the optimized values of generalization parameters, we mean the parameter values corresponding to the channel capacity.

The theory is based on discrete, independent events. Geographical data does not consist of discrete, unconnected items of data, but instead, positionally related items or continuous surfaces. Therefore, information theory has a limited application in cartography and it is not obvious how to apply the theory. Despite of this defect, we will try to demonstrate an application of information theory in contouring from digital surface models.

3.1 The useful information of a contour line

We assume a vector representation of a contour line, and we ask the question: "How can the entropy of the contour line be calculated?"

In our approach we select a strategy proposed by [Bjø91] and [Bjø92]. These papers propose using the angle of the break-points as events in the entropy computation. The underlying philosophy of this choice, is that we regard the breakpoints as the information carriers. Since a contour line is a continuous phenomenon, one should be aware of this weakness in our information model.

A digitized line is made up by a consecutive order of points, like for example:

$$(x_1, y_1), (x_2, y_2) \ldots\ldots (x_{i-1}, y_{i-1}), (x_i, y_i), (x_{i+1}, y_{i+1}) \ldots\ldots (x_n, y_n)$$

Angle α_n is defined as the angle between the two lines $L_{i,i+1}$ and $L_{i,i-1}$.

Since α is a continuous value, P_i cannot be calculated by simply counting the number of different events. Therefore, we classify the angles into a limited number of classes and choose these classes as events. However, if the probability density distribution $p(\alpha)$ of α is known, the entropy of the line can be calculated according to:

$$H(X) = -\int_0^{2\pi} p(\alpha) \cdot \log p(\alpha) d\alpha$$

The computation of the equivocation is also based on a model proposed by [Bjø91] and [Bjø92]. Since the equivocation is dependent on the visual separability of the elements which make up the line, we have to choose a model which describes the visual separability of the events.

A circle with radius T, hereafter termed the *coincidence unit circle*, is the parameter of the selected model. The computation of the transition probabilities is done as:

If $3T \leq S_{ij}$ then $p_{ij} = 0.00$
If $2T \leq S_{ij} < 3T$ then $p_{ij} = 0.06$
If $T \leq S_{ij} < 2T$ then $p_{ij} = 0.25$
If $0 \leq S_{ij} < T$ then $p_{ij} = 0.50$ (the events cannot be separated)

where S_{ij} is the the Euclidian distance between the break-points i and j, and p_{ij} is the probability that the angle in break-point i is interpreted as the angle in break-point j.

Since we have a method to calculate both the entropy of the line and the equivocation, the useful information can simply be computed as the difference between these two.

The value of T is of course very significant to the value of R. Therefore, T must be selected carefully, the actual graphical device considered.

3.2 The useful information from a set of contour lines

The selection of the equidistance in contour maps is a critical step. The following model is only a proposal and we have yet not implemented it. Our proposal is:

1. Select the contour lines themselves as events.
2. Compute the probabilities as a function of the length of the contour lines: $P_i = f(S_i)$.
3. Compute the transition probabilities as a function of the length of the conflicting areas $p_{ij} = g(s_{ij})$.
4. Use the previous steps to compute the equidistance corresponding to the maximum useful information.

This model does not consider constraints such as the equidistance being a number which is easy to memorize. If the application requires such constraints, the entropy-computed equidistance can be used as a starting point for a modification.

3.3 Model to estimate parameters in surface contouring

This discussion has led us to propose the following method to estimate parameter values in surface contouring:

1. Compute the value of the generalization parameters corresponding to the optimum variation of the contour lines.

2. Compute the optimum equidistance.

3.4 An example

The previous theory is applied to a triangular surface model covering part of Norway. Figure 3 shows the experiment. The map scale in the figure is 1:250.000 and T is given the value 0.2mm. From the figure it can be seen that R has its maximum when the generalization parameter λ has the value 150m. It is important to notice that the theory is applied to the contour lines while the surface model is generalized, i.e. the surface model is generalized, not the contour lines.

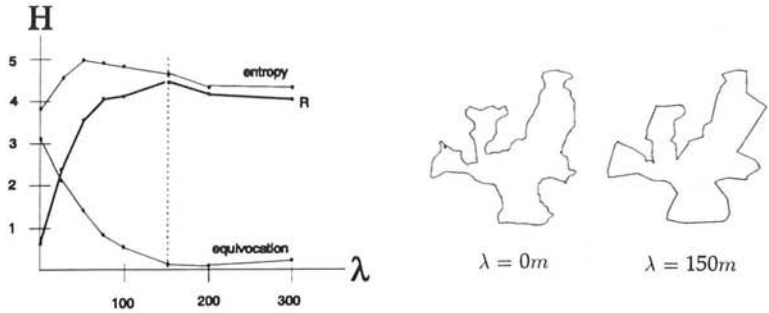

Figure 3: Information theory applied to a single contour line. Map scale 1:250.000, parameter $T = 0.2mm$. I this case R has its maximum when $\lambda = 150m$.

4 Block-based management of the surface model

Data sets for surface modelling very often consist of a huge number of points, particularly for terrain surfaces. When the surface model is used for a practical purpose, only parts of the set may be necessary for computer processing. When new parts of the data set are required, a procedure for merging two adjacent triangular meshes is useful. If there are proper routines for merging triangular meshes, this means that we can handle data sets with an endless number of points. When the requested calculations are completed in certain areas, this part of the network is removed from the computer memory. New areas can then be merged to the network and the surface model will behave like a seamless model. It also means that large data sets can be handled by small computers, where memory is a serious limitation.

The basis for the triangulation is a set of points which is situated on the surface we want to describe. Before doing the blockwise triangulation, the data set has to be divided into smaller subsets. It is best to manage the blocks such that they are based on an equal number of points.

Each block is triangulated as an independent operation, with or without the qualified selection of points. The blocks are subsequently merged. A merging method where invalid boundary edges are removed, and new edges connects the neighbouring meshes, is described by [LS80]. [Mid93] describes two other merging algorithms where invalid edges along the boundaries are reorganized due to the merge operation.

Various advantages of the block method can be listed:

Nationwide models. A division into sub-models is required for nationwide models. Working on an area divided into blocks is much faster than handling large, heavy models in one operation.

Algorithm complexity. The theoretical worst case behaviour of the incremental algorithm is $\mathcal{O}(n^2)$, while practical tests show a running time of $\mathcal{O}(n \log n)$ [Hel90]. But the importance of the complexity will decrease when using smaller blocks. [Mid93] shows by experiments that the optimal block size is about 15-40 points.

Computer memory. UNIX systems can perform swapping of the memory to disk when necessary. When the blocks are well adapted to the memory, less disk swaps are performed by the computer.

Triangulation in parallel. The block methods are well suited for triangulation on parallel computers. The triangulation becomes very efficient when the blocks are triangulated in parallel in different processors, and subsequently merged two and two, also in parallel.

When fast access to a huge model is essential it is advantageous to store the TIN structure in blocks on disk. Consequently a proper addressing system is required to give the triangles a global reference. [Mid93] proposes block division by a quad-tree method and the use of Morton indexes. The Morton index will form a global address for the triangles together with the local index for each triangle.

5 Concluding remarks

Models of various accuracy can be constructed when using the qualified selection of points. This method has made it possible to make simple surveyable models where only the distinctive surface characterizations remain. Models of higher resolution can be generated by the refinement of the simpler model.

It is demonstrated how information theory can be used to estimate the values of generalization parameters in surface contouring. Unfortunately, it is very hard to imagine that information theory will provide a model for all the aspects of generalization. Therefore, we assume information theory is one of several techniques in quantifying the efficiency of transmitting cartographic data. Further research in this area is recommended. Attention should be paid to the fact that information

theory is based on discrete, independent events, while geographical phenomena are usually continuous and spatially correlated. Our experiments show information theory is used for the contour lines while the surface model is generalized. The next step will be to use the information theory directly on the surface model.

Block-based triangulation seems to be an efficient method for the modelling of huge areas by TINs. Heavy operations on large areas become much simpler in a smaller model.

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Treating of area features concerning the derivation of digital cartographic models

M. Beines (Bonn, D)

Summary: Methods for implementing individual generalisation procedures are examined as part of a concept for a computer-assisted generalisation system to be used for creating Digital Cartographic Models (DKM) as part of the ATKIS project. The paper will give particular consideration to the scope and content of selection and combination within the generalisation process and propose a computer-assisted solution for combination.

1. Introduction

The State Surveying Offices of the individual Federal States in Germany are currently creating ATKIS (Authoritative Topographic-Cartographic Information System). It consists of Digital Landscape Models (DLM) and Digital Cartographic Models (DKM). The DLM are used to store topographic information relating to the Earth's surface to which the DKM then allocates cartographic symbols. The feature catalogues (OK), which contain the definitions for the capture or acquisition of landscape features, form the basis for the DLM structure. The rules governing the creation of map features in the DKM and their symbolisation are stored in the symbol catalogue (SK). Because DLM and DKM are separate models, the digital cartographic data must be derived from the DLM.

At present the data for digital landscape model DLM 25 are being captured in the first project implementation stage which will run until 1995. Since this data capture process is now well-advanced - in North Rhine-Westfalia, for example, more than 50% of the area has already been captured - the problem of creating a digital cartographic model with a scale of 1:25000 (DKM 25) is becoming increasingly important. The derivation process used for data transition from DLM 25 to DKM 25 comprises several operations, including, in particular, computer-assisted generalisation. Since DLM 25/1 consists mainly of linear elements and areas and since land usage is to be fully defined for the whole surface area within the topographic model, the treatment of area features is of particular interest. The selection and combination procedures of generalisation are especially important.

This paper will report on work carried out on the generalisation of area features at the Institute of Cartography and Topography at Bonn University. The treatment of selection and combination necessarily overlaps with other generalisation procedures,

particularly with simplification and displacement.

2. Generalisation in ATKIS

Depending on application, generalisation can be divided into feature and cartographic generalisation. This terminology, which also applies to conventional map production, needs to be expanded due to the digital derivation of a DKM from a DLM. As Fig. 1 shows, the feature generalisation is divided into two areas: Feature generalisation according to OK and feature generalisation according to SK. OK feature generalisation occurs during transition from a landscape or other original model, i.e. aerial photographs, to a digital landscape model in which the data capture rules as defined in the OK have been taken into account. During the first derivation from the DLM of an initial cartographic ungeneralised digital cartographic model, also called a raw-DKM, pre-defined selection criteria in the SK are used as a basis so that one can speak of feature generalisation according to SK. Via digital intermediate models (DZM) which are created during further processing, and which occur after each application of a specifc generalisation procedure, one finally arrives at the end product, a complete cartographic, generalised DKM.

Structuring cartographic generalisation into fractional steps is carried out in accordance with Hake, who distinguished between seven elementary procedures (Hake 1982): simplification, enhancement, displacement, combination, selection, classification and emphasising.

These cannot be viewed as separate units, since they interact with one another. Cartographic generalisation therefore presents itself as a highly complex process.

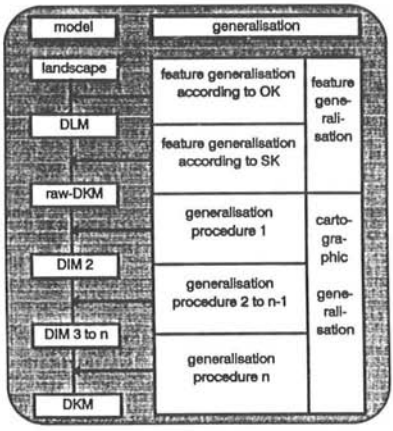

Fig. 1 - Generalisation in ATKIS

3. Problems of area generalisation

3.1 Generalisation procedures in the treatment of areas

In ATKIS all map features are allocated to seven feature areas: fixed points, settlements, traffic routes, vegetation, waters, relief, and regions. 46.3% (129) of all map feature classes are area features. A large part of these is classified as settlement feature fields. However, numerous area features also occur in the vegetation and waters fields; 2/3 of all vegetation features are area map feature types. The division into area features in the map image was researched using a variety of map sheets, urban districts (UD), cultivated lowland areas (CL) and cultivated highland areas (CH). This research shows that the proportion of settled area ranges between 40% and 60%. As expected urban areas show the highest value. The highland area is mainly characterised by vegetation (57%/28% in UD). These areas are mainly bordered by traffic routes or waterways. The examined urban areas showed, for example, that 64% of settled areas and 73% of the vegetation areas were completely bordered by other linear features (traffic and waters), whilst in the cultivated highlands this applied to only 30% of the settled areas and 49% of the vegetation areas.

If we consider the individual generalisation procedures for area treatment in greater detail, then we can conclude the following:

The classification problem faced by ATKIS was already tackled during the compilation of the detailed keys for map features in the symbol catalogues.

As far as simplification is concerned, it can be said that the treatment of areas mainly means outline simplification. If traffic and waterway networks have already been processed, then they must, if they border area surfaces assume the area outlines. As far as any other area perimeter representation is concerned, the same principles can be applied as already apply to linear simplification. Practical surveys of various map examples have shown that linear features, such as roads, railway lines, waters, contribute to area formation by up to 50%-70%. The major proportion of the linear networks is formed by roads and paths (50%-60%).

As far as selection and combination within the generalisation process are concerned, special attention must be given to the fact that in ATKIS all map areas are defined according to usage type. There are no longer any undefined open spaces or white map areas. Areas for which no presentation is foreseen in the DKM must be allocated to other areas; the same applies to areas which are smaller than the minimum area sizes defined in the SK. Whilst ATKIS has solved some of the selection problems by providing appropriate selection criteria in the symbol catalogue, computer-assisted solutions will have to be developed for combination. Buildings require separate treatment. As they are not included in DLM 25/1, they were initially ignored for the purposes of our research.

3.2 Special treatment of selection and combination

3.2.1 General remarks

The selection step in the generalisation process always serves to reduce the number of features in a map. All that remains are features which serve the purpose or topic of the map and which can still be clearly represented in the respective scale. Selection becomes necessary when map features are oversized and, at the same time, the available space is reduced due to the choice of smaller scales. If an area is no longer selected for representation due to its small size, a decision must be made as to what is to be done with no longer defined space. If empty spaces are to be avoided, then the affected area has to be allocated to its adjoining areas. This demonstrates the close connection between selection and combination. An example is given in Fig. 2.

Combination as a cartographic generalisation procedure is generally seen as graphically combining adjoining homogenous features. Characteristic structures in which areas are allocated to each other must not be lost. Basically the individual process is only applied if the distance between two features is smaller than the minimal dimension (0.2mm as according to HAKE). However, combination is not permitted over other topographic features. Fig. 2. also shows the combination of vegetation areas in which several isolated small woodland areas are combined to make one larger vegetation area.

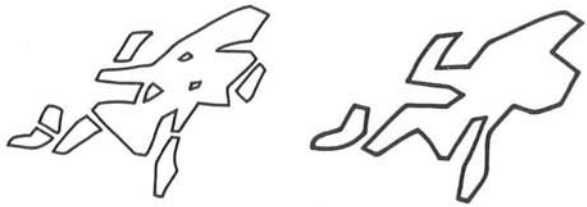

Fig. 2 - Omission and combination of small areas to make one large area (as: SGfK, 1980)

3.2.2 Scope and content

The scope of generalisation measures depends, among other factors, on the given area criteria. In SK 25 such given values are listed as selection and combination criteria for each map feature class. If the features fail to meet the criteria, then they can be omitted or possibly combined with others. In the case of area features the criteria are mostly defined as minimum area sizes. They must be carefully aligned to comply with the map scale. If one chooses too small a value, a highly-differentiated raw-DKM results in which extensive generalisation measures become necessary. On the other hand, if ceiling values are too high, areas will be omitted which could easily have been independently

represented. Both cases result in less than ideal information content.

Mention is made in Chapter 3.1 of an analysis of map sheets representing various landscape types. The survey of these map sheets also served to give a general overview of area constellations in map image and the scope of generalisation measures, especially of combination. The basis was formed by plots of the DLM 25/1 data capture onto which the area features had be defined. Each area feature was examined with regard to the possibility of combining it with adjoining areas.

In accordance with SK 25 criteria, the following results were achieved.

(a) As shown in Table 1, urban districts (UD) in particular lead to the existence of many small areas (48%), meaning that such areas do not fulfil the selection and combination criteria and are therefore not represented. In contrast to cultivated areas, only very few combination possibilities exist in the UD because a large proportion of area features are bordered by other elements which delimit a feature (e.g. roads, railways, rivers). Unsolved cases in the examined areas remain in small settlement areas only. The selection and combination criterion for this in SK 25 has been defined as 3 hectares. If, for example, this criterion were reduced down to 0.5 hectares, a size which can still be easily represented, then the proportion of small areas would be reduced drastically.

test sheet	total number of areas	small areas (sma)	sma with the possibility of combination	adjoining areas = 1	cases solvable by cp	unsolved cases (taking the criteria in SK 25 into consideration)		change of settled area criteria => 0,5 ha		
								sma	unsolved cases	
						number	%	number	number	%
UD	159	77	30	22	8	47	61	6	1	17
CL	76	33	23	15	8	10	30	6	0	0
CH	97	36	24	19	5	12	33	14	5	36

Table 1 - Evaluation of the survey of area combination for small areas (sma) (cp = combination priority)

(b) During data capture of area features in OK 25 pre-defined data capture criteria are given. It is noticeable that the prescribed ceiling values of vegetation areas in particular often failed to be reached. This means, however, that with complete adoption by the DKM, even very small areas would be represented, if they were not recognised and treated accordingly. There are though also some special cases in which minimum area sizes must be ignored, in order to prevent small gaps in the data set. This applies, for example, to small vegetation areas at motorway intersections.

(c) Apart from such areas, the test areas also showed some features for which no map feature classes have been defined in

SK 25: these include sports grounds and greens as well as car parks. Their omission would result in empty spaces in the map image. Since the aim is to achieve complete usage definition, a solution should be found for these areas within the framework of combination or new map feature classes should be defined in SK 25.

Based on these survey findings, it is possible to divide area generalisation into the following problem areas for combination:

(A) Combination of small areas
Small areas can no longer be represented due to their small size or do not fulfil a pre-defined minimum area size. See Fig. 3.

(B) Empty spaces
They occur when feature classes in OK 25 are not defined as map feature classes in SK 25. (Fig. 4) Since the aim is to achieve a complete area usage definition, these areas must be allocated to another map feature class.

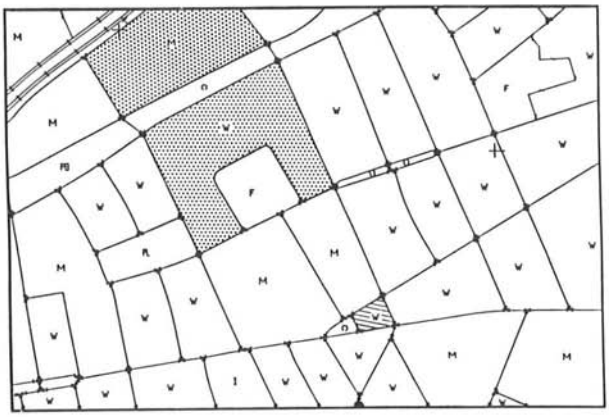

Fig. 3 - Small areas in an urban district (Duisburg)
No. of small areas:
a) at > 3 ha all areas with the exception of dotted areas
b) at > 0.5 ha only hatched areas

(C) Combination of two areas because intermediate features are omitted in the target scale. This does not occur with the 1:25000 scale, although it becomes increasingly important as the scale is reduced, if a greater selection is chosen for the road and waterway networks.

(D) Small distance between two areas
The distance between two separate areas is so small that they have to be combined. The feature between the areas shows a small area which can no longer be shown on the map. Two treatments are possible: Enhancement of the middle area or combination with an adjoining area. This problem rarely occurs with a scale of 1:25000.

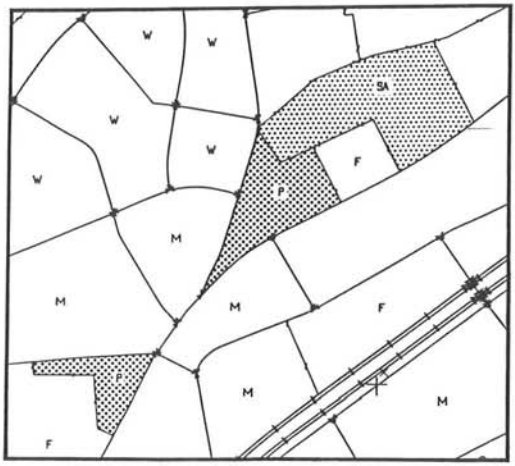

Fig. 4 - Empty spaces
(Extract from the city of Duisburg)

3.2.3 Computer-assisted solution

Pragmatic solutions for some of the above described problems were conceived and programmed at the Institute of Cartography and Topography (IKT) at Bonn University. Priority was given to the treatment of small and empty spaces.

The work was based on the DKM data catalogue described in the general documentation to ATKIS and implemented in the raw-DKM derivation. Fig. 5 shows the rough flow chart for the treatment of small areas which will be presented here by way of example.

During the derivation of raw-DKMs, that is within the frame of feature generalisation, small and empty spaces are already marked accordingly so that their selection in the raw-DKM will be easy. After a small area has been identified, its adjoining areas are determined. At the same time a check is run to determine bordering features (roads, rivers, ...) over which combination is not possible. If only one adjoining area is found, then the two are combined.

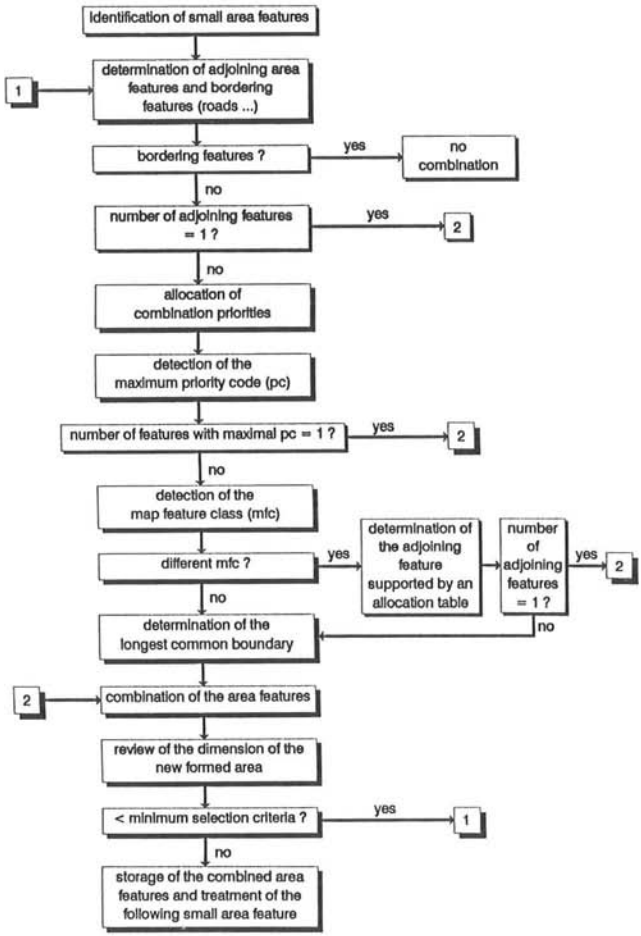

Fig. 5 - Flow chart showing the treatment of small areas

If several areas border on the treatment area, then it must be decided which feature allocation is to be preferred. Here, a feature with the most similar characteristics possible should be selected. Depending on the type of adjoining object, combination priorities can be applied which correlate to the structure of the features in the OK. The adjoining areas can be given the following priority codes:

100	same map feature class
90	same feature group
80	same feature field
10	different feature fields

Adjoining features with the highest combination priority are filtered out. If only one object exists with the highest priority code (pc), then the solution is clear. If several objects exist with the same code, more decision-making aids are required. Additionally for this purpose map feature classes are checked for these areas. If the adjoining areas have a similar combination priority but differing map feature classes, then an allocation list is used as a decision-making aid.

For example, if all the surrounding features belong to the feature group 2100 (built-up areas), then the allocation list may be structured as follows:

General and light industrial area (202)
Area of special use (204)
Mixed zone (203)
Residential area (201).

The allocation algorithm works alternately with the initial position, resulting in the following allocation hierarchies:

Basic area	Hierarchy of adjoining areas
Residential area	203, 204, 202
Mixed zone	201, 204, 202
General and light industrial area	204, 203, 201
Area of special use	203, 202, 201

If two or more features occur with the same map feature class, then the feature with the longest common border is determined and then combined. This procedure was selected as it helped to avoid the creation of short sides and areas with angular shapes.

The compilation of lists can easily result in decision conflicts. Under certain circumstances pragmatic definition may be necessary.

If an area has been determined for combination on the basis of an allocation list, then combination is carried out and the area size of the newly created area is itself checked. If the area criteria are still not fulfilled, then the adjoining features are examined again. Finally, the processed areas are marked as such. Fig. 6 presents a clear example with an extract from the raw-DKM and the corresponding, generalised DKM extract.

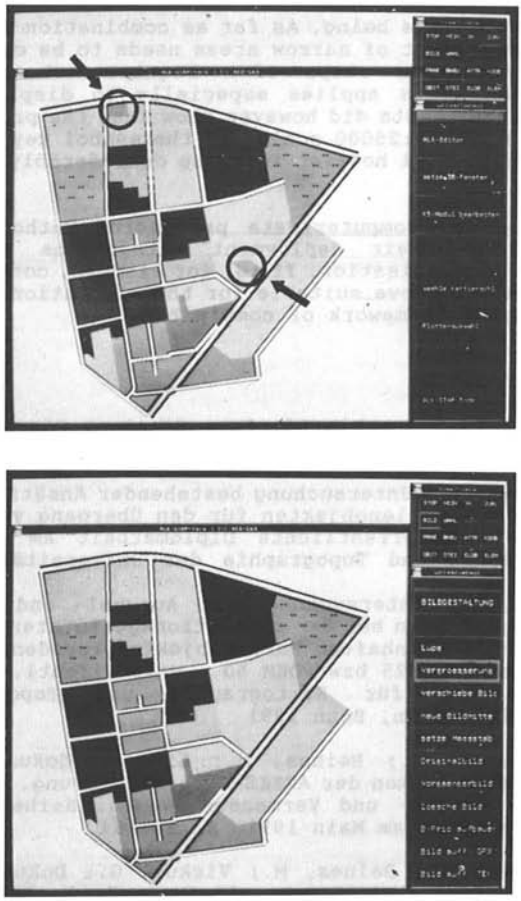

Fig. 6 - DKM 25/1 - Extract from Büderich-Nord sheet

4. Outlook

By gathering research findings on combination as a generalisation measure, a considerable step has already been made towards achieving a DKM. Practical tests at the Institute for Cartography and Topography have proved the suitability of this approach, although priority was given to the treatment of the area problem. Buildings were not given consideration in the surveys. They are not intended as part of DKM 25/1, and will therefore not be

included for the time being. As far as combination is concerned, work on the treatment of narrow areas needs to be continued. But other generalisation steps also require not insignificant research funds. This applies especially to displacement. The research of test sheets did however show that the problem remains manageable for the 1:25000 scale, if the symbol key is retained. The difficulties will however increase considerably as the scale is reduced.

However, also new computer/data processing methods should be examined as to their deployment within the framework of cartographic generalisation. It is, for example, conceivable that *Fuzzy Logic* might prove suitable for the allocation of adjoining areas within the framework of combination.

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Session 8

Maps for Protection and Disaster Preventation

Chairman:
A. Papp-Vary, Ungarn Nation. Com. of ICA (Budapest, H)

Principes d'une cartographie globale des risques naturels et technologiques

J. Steinberg (Alfortville, F)

La fragilité de notre environnement et les atteintes qui lui sont portées par notre civilisation à haute technologie rendent plus que jamais nécessaire une démarche de préservation et de prévention contre les nuisances et les risques majeurs. C'est ainsi qu'en France, les documents d'urbanisme doivent désormais "prendre en considération l'existence de risques naturels prévisibles et de risques technologiques", selon la loi du 22/07/1987 modifiant le Code de l'Urbanisme.

La cartographie et les nouvelles techniques associées (infographie, télédétection entre autres) sont susceptibles de contribuer à la connaissance des risques et de faire office d'outils d'aide à la décision pour l'Etat et les collectivités locales concernées. Le grand essor actuel des Systèmes d'Information Géographiques peut en outre permettre de rationaliser cette entreprise.

Depuis quinze ans en France, quelques travaux ont été entrepris, en particulier les cartes ZERMOS sur les mouvements de terrain, qui furent les premières cartographies systématiques. Cependant, la cartographie des risques se développe surtout depuis les cinq dernières années, avec la mise en oeuvre des Plans d'Exposition aux Risques, issus de l'application de la loi du 13/07/1982, relative à l'indemnisation des victimes de catastrophes naturelles, et qui sont établis à l'échelon communal.

Il est reconnu par les spécialistes qu'une cartographie globale, à moyenne échelle, combinant tous les types de risques majeurs pouvant éventuellement survenir sur un même site, présente un intérêt indéniable: en effet, elle permet d'une part d'ouvrir la voie à des représentations plus détaillées et plus fouillées concernant par exemple une nuisance ou un risque particulier, d'autre part de sensibiliser les responsables, élus notamment, à ces problèmes.C'est dans cet esprit que nous présentons les cartes qui ont été réalisées à l'échelon de l'Ile-de-France en 1991 et 1992 ,au 1/25 000 et au 1/50 000.

I. Les fondements de la cartographie:

1) La prise en compte des risques naturels et technologiques;genèse et types:

C'est en 1981 que fut créé en France un Secrétariat aux Risques Majeurs, devenu ensuite la Délégation aux Risques Majeurs, insérée dans le Ministère de l'Environnement. Le titulaire du poste fut jusqu'en 1986 M. Haroun TAZIEFF, qui est depuis longtemps sensibilisé aux problèmes de sécurité civile et d'information du public sur ce thème. La charnière des années 70-80 coïncida par conséquent avec une prise de conscience consécutive à une série de catastrophes du type de la marée noire de l'Amoco Cadiz ou de l'émission de dioxine à Seveso, auxquelles s'ajoutèrent malheureusement par la suite celles de Bhopal, Mexico et bien entendu Tchernobyl.

Une classification des risques a alors été établie et reste généralement admise aujourd'hui. On a donc coutume de distinguer les risques dits "naturels", bien que beaucoup d'entre eux soient aggravés, si ce n'est provoqués par l'homme, et les risques technologiques.

a) Les risques naturels comportent les catégories suivantes:

- les séismes et les éruptions volcaniques;
- les inondations;
- les mouvements de terrain;
- les avalanches neigeuses;
- les incendies de forêts.

b) Les risques technologiques comprennent deux types principaux:

- la fabrication et le stockage de produits dangereux (chimiques, radioactifs, inflammables);
- le transport de ces produits par voie terrestre,fluviale ou maritime essentiellement.

Parmi les produits considérés comme dangereux, on distingue principalement les substances radioactives, énergétiques ou chimiques. Elles sont susceptibles de provoquer des incendies, des explosions et des dégagements de gaz toxiques ou de radioactivité.

2) Cartographie de l'environnement et cartographie des risques: une filiation certaine:

On connaît les travaux cartographiques élaborés sous l'égide du Professeur André JOURNAUX et auxquels nous avons nous-même participé. Il s'agissait alors de représenter les atteintes à l'environnement sous la forme de pollutions et de nuisances affectant l'air; l'eau ou le sol. La question est de savoir s'il y a véritablement une différence fondamentale entre l'"environnement" et les "risques", et pas plutôt une différence de degré: à partir de quel moment en effet une pollution chimique

ou radioactive devient-elle une catastrophe écologique ou industrielle ? Le problème des inondations a été traité par la cartographie de l'environnement et repris par la cartographie des risques: en France, il y a belle lurette que les zones inondables figurent dans les POS. De même, le poste "dégradations de la surface de la terre" de la légende Journaux correspond aux mouvements de terrain accidentels: écroulements, affaissements, glissements par exemple.

On peut par conséquent parler de filiation entre l'une et l'autre, même si le contenu et la légende divergent notablement. Il s'agit souvent d'appréhender une même réalité sous deux angles différents: les pollutions et les nuisances sont plutôt envisagées selon leur caractère permanent ou chronique (cf la pollution automobile en zone urbaine), alors que les catastrophes sont par définition brutales et généralement imprévisibles, un séisme par exemple.

Ainsi, nous n'avons pas plus trouvé de solution entièrement satisfaisante en ce qui concerne la représentation cartographique de la diffusion de la pollution autour de la source émettrice que pour celle de la zone soumise à un danger d'explosion ou de toxicité en cas d'accident industriel, les conditions météorologiques locales et à un moment précis jouant alors un rôle majeur.

3) Nécessité d'une cartographie réglementaire et opérationnelle:

En France, les Plans d'Occupation des Sols, qui sont les plans d'urbanisme communaux, contiennent depuis leur création , il y a 25 ans, des informations cartographiques sur certains risques naturels: inondations et mouvements de terrain. Il est désormais prévu de systématiser ces informations sur les risques majeurs dans les futurs POS. L'article L 121-10 de la loi du 22/07/1987 prévoit en effet que "la prévention des risques naturels et technologiques figure parmi les objectifs que doivent prendre en compte les documents d'urbanisme".

Les documents graphiques du POS doivent notamment faire apparaître "toute zone où...l'existence de risques naturels... ou technologiques justifient que soient interdites ou soumises à des conditions spéciales les constructions ou installations de toute nature..." (article R 123-18 du Code de l'Urbanisme).

Il existe ainsi un certain nombre de servitudes d'urbanisme liées aux risques. L'article R 111-3 du Code de l'Urbanisme prescrit notamment la délimitation par arrêté préfectoral des zones exposées à des risques tels que l'inondation, l'érosion ou les avalanches. Les Plans de Surfaces Submersibles (PSS) doivent permettre à l'Administration de s'opposer à toute action ou ouvrage qui pourrait faire obstacle au libre écoulement des eaux ou réduire de façon nuisible le champ des inondations. Le projet d'intérêt général (PIG) impose des servitudes d'utilité publique dans le cas de projets ou installations existantes de grande taille,

aussi bien en matière de risques naturels que de risques technologiques. Enfin, nous verrons plus bas l'importance des Plans d'Exposition aux Risques, qui cependant ne concernent encore qu'un nombre limité de communes.

II. Les cartographies existantes:

Elles concernent presque exclusivement les risques naturels.

1) Les cartographies analytiques, scientifiques ou pré-opérationnelles:

A partir de la fin des années 70 ont pris naissance des cartographies établies pour chaque type de risque naturel ou assimilé. Voici les trois plus remarquables concernant la France.

a) Les cartes ZERMOS (Zones exposées à des risques liés aux mouvements du sol et du sous-sol): il s'agit de la première couverture cartographique d'un type de risque en France. Etablies entre 1975 et 1982 par le Bureau de Recherches Géologiques et Minières (BRGM), leur échelle est en général le 1/25 000. Elles comportent un zonage des terrains en trois niveaux de risques (élevé, moyen ou nul) et un recensement des phénomènes ponctuels déclarés ou potentiels. Par leur caractère pionnier et la rigueur scientifique de leur élaboration, on peut dire que les cartes ZERMOS ont marqué une étape importante de la cartographie des risques.

b) Les cartes des zones inondables: il s'agit du risque naturel le plus fréquent et le plus répandu en France, puisque 70% des communes sont concernées. Les années 80 ont vu le développement de la méthodologie cartographique qui y est appliquée: l'IGN y joue un rôle moteur, notamment par la fourniture d'images de télédétection et leur exploitation, mais le Service Technique de l'Urbanisme et le Ministère de l'Environnement participent activement aux travaux.

c) Les cartes de localisation probable des avalanches (CLPA): suite à la catastrophe de Val d'Isère en 1970, le Centre National du Machinisme Agricole du Génie Rural des Eaux et Forêts (CEMAGREF) a entrepris une couverture systématique du massif alpin, en collaboration avec l'IGN. Les cartes répertorient d'une part les avalanches constatées par enquête sur place et examen des archives, d'autre part, par photo-interprétation, les couloirs susceptibles de correspondre à des sites d'avalanches possibles.

2) Les cartographies opérationnelles; les Plans d'Exposition aux Risques:

Les PER ont été institués en application de la loi du 13/07/1982 relative à l'indemnisation des victimes de catastrophes naturelles. Cette loi affirme la nécessité de prendre en compte les risques dans l'aménagement et institue pour les citoyens un droit à l'information sur les risques auxquels ils peuvent être soumis.

Les PER sont élaborés à l'échelon communal sous le contrôle de l'Etat et ont valeur de servitude d'utilité publique. Ils sont opposables à tout mode d'occupation ou d'utilisation du sol. Les documents d'urbanisme de type POS doivent respecter leurs dispositions et les comporter en annexe. Comme eux, ils contiennent trois types de documents:

- un rapport de présentation des risques existant sur la commune;
- un ou plusieurs documents graphiques (plan de zonage) au 1/ 5000;
- un règlement contenant les mesures de prévention obligatoires.

Dans le département du Val-de-Marne,au sud-est de Paris, trois communes seulement ont été, pour le moment , soumises à cette procédure: Ablon, Villeneuve-le-Roi et Villeneuve-St-Georges, qui sont considérées comme particulièrement sujettes au risque "inondation".

L'une des dispositions les plus importantes des PER est la subdivision du territoire en trois zones, en fonction du risque encouru:

- la zone rouge, où le risque est élevé, est déclarée inconstructible;
- la zone bleue correspond à des secteurs moins exposés, dans lesquels des mesures de prévention sont possibles;
- la zone blanche, où le risque est faible ou nul.

La détermination des zones passe par la confrontation de deux types de documents cartographiques:

- la carte d'aléa, qui définit le risque, en fonction de sa fréquence, de son importance et de sa durée;
- la carte de vulnérabilité, qui présente la répartition de l'occupation du sol et de la population éventuellement exposée aux risques.

III. La cartographie de synthèse en milieu urbain:

1) Sa place dans l'éventail des cartes existantes ou en cours de réalisation:

Elle se justifie par les éléments suivants.

a) L'adjonction de la représentation des risques technologiques:

Comme on l'a constaté en II, ce type de risques n'a guère été pris en compte jusqu'à présent. Les raisons en sont certainement d'ordre politique (le sujet est explosif à tous les sens du terme !), mais également d'ordre technique: difficulté, comme nous l'avons vu, de représenter le mode de diffusion du phénomène catastrophique, recensement plus ou moins exhaustif des sources de danger (stockage de produits toxiques en particulier), etc.. Comment figurer les risques liés au transport de matières dangereuses ? Cependant, il devient de plus en plus

nécessaire de bien connaître les localisations de ces types de risques , pour une planification raisonnée du territoire. Des prises de conscience récentes, notamment dans les medias, incitent également à s'en préoccuper.

b) L'apport de la synthèse:

La synthèse ne constitue pas ici une simple addition ou accumulation de données concernant un même territoire; il s'agit bien plus d'appréhender l'effet multiplicateur de danger résultant de la coexistence en un même lieu de risques différents, naturels et technologiques. Imaginons, comme cela peut se produire, hélas, dans le Val-de-Marne, les conséquences qui pourraient résulter d'une catastrophe sur un site industriel de la vallée de la Seine, à un moment où le secteur subirait une inondation du fleuve. C'est là que réside la vraie justification de l'étude synthétique.

Dans cette optique, la Délégation aux Risques Majeurs a engagé la réalisation d'une cartographie départementale, sous la forme d'Atlas au 1/50 000 destinés essentiellement aux responsables et décideurs locaux. Un prototype en cours d'achèvement a été réalisé sur le département des Hautes-Alpes, considéré comme exemplaire du fait de la multiplicité des types de risques susceptibles d'y survenir. Les cartes renvoient à un répertoire des études existantes et des événements importants recensés.

L'intérêt de la synthèse se situe également dans la possibilité de délimiter des"bassins de risques" (G.GARRY), à partir de l'examen desquels on pourrait lancer des études détaillées sur telle ou telle zone ou tel ou tel type de risque. La synthèse représente par conséquent aussi bien un point de départ qu'un aboutissement des investigations.

c) Reprise des notions d'aléa et de vulnérabilité:

Cela correspond à la superposition sur une même carte des éléments suivants: type de risque, naturel ou technologique, fréquence et intensité du risque (aléa), impact sur l'urbanisation environnante et sur la population résidant à proximité (vulnérabilité). Cette dernière information est, on s'en doute, particulièrement importante dans un milieu urbain, où les conséquences des accidents ou événements peuvent se révéler catastrophiques.

2) Son contenu:

a) L'exemple du département du Val-de-Marne:

Ce département peut être considéré comme exemplaire dans la mesure où il concentre malheureusement plusieurs facteurs de déclenchement ou d'aggravation des catastrophes naturelles ou technologiques.

Il s'agit tout d'abord d'un secteur d'urbanisation ancienne et à population dense qui a profité des larges espaces dégagés par la confluence de la Seine et de la Marne, aussi bien pour la résidence que pour l'industrie. D'où une vulnérabilité très importante vis-à-vis des facteurs éventuels de danger.

Il est vrai que certains types de risques naturels sont complètement absents, ou peu s'en faut, de cette partie de l'Ile-de-France: nous pensons surtout aux séismes et aux avalanches. En revanche, d'autres sont très présents: le Val-de-Marne est en effet particulièrement concerné par les risques d'inondations de la Seine et de la Marne, et il en a beaucoup souffert, notamment lors de la dernière grande crue centennale de janvier 1910. Par ailleurs, les carrières souterraines dont son sol est truffé, notamment au nord-ouest, à proximité de Paris, en raison de l'exploitation des calcaires grossiers et des gypses pour la construction, posent des problèmes de stabilité des sols en maints endroits.

Quant aux risques technologiques, étant donné l'ancienneté et le développement de l'industrialisation du département, il est inévitable qu'ils comptent parmi les plus préoccupants de tout le territoire français. Qu'il s'agisse des centrales énergétiques, des réservoirs de combustibles liquides ou gazeux, des industries chimiques ou des laboratoires nucléaires, il y a là une accumulation remarquable sur un espace restreint: 27 installations classées à plus haut risque , dont deux soumises à la Directive Seveso. A cela, il convient d'ajouter le transport de matières dangereuses par route ou voie ferrée.

La cartographie a été réalisée en 1991 , à l'échelle du 1/ 25 000, afin de correspondre au fond IGN et à la carte des Modes d'Occupation des Sols de l'IAURIF. Trois planches format A 3 ont été établies à titre de prototypes; elles couvrent les trois quarts du département et on y trouve la quasi-totalité des types de risques existant dans le Val-de-Marne. Le principe consiste à affecter une couleur par type de risque: bleu pour les inondations, orange pour les mouvements de terrain, rouge pour les risques technologiques. En superposition apparaissent, en textures points ou traits noirs, les principaux types d'occupation du sol en tant qu'éléments de la vulnérabilité: habitat collectif et individuel, zones d'activités, espaces non urbanisés.

Pour les inondations, on a distingué l'extension de la crue centennale de 1910 et celle de la dernière crue dite "trentenaire", bien qu'elle remonte déjà à 1924. Les zones de carrières ont été représentées en traits barbulés orange, avec la mention des accidents ponctuels répertoriés par l'Inspection Générale des Carrières de Paris. Pour ce qui est des établissements dangereux, on a synthétisé les informations provenant de la Préfecture (carrés rouges) avec celles des Sapeurs Pompiers de Paris (triangles rouges). On a en outre figuré autour d'eux des zones circulaires d'un kilomètre de rayon, correspondant

aux secteurs les plus exposés aux accidents éventuels. Enfin, au titre des voies de transport, on n'a reporté que les autoroutes pour ne pas surcharger la carte.

Les cartes montrent bien notamment la concentration des risques dans la vallée de la Seine et, dans une moindre mesure, celle de la Marne (inondations plus industries), ainsi que les problèmes liés aux carrières , essentiellement dans la couronne la plus proche de Paris, au nord-ouest.

b) Le Système d'Informations Géographiques Régional de l'IAURIF:

Nous avons dirigé, au cours de l'année 1992, un stage de deux étudiantes d'urbanisme, réalisé dans le service de M. Alain LE SAUX à l'IAURIF (Métropolis-Risques majeurs). Il s'agissait d'intégrer au SIGR des données relatives aux établissements industriels dangereux de la Région Parisienne, le système permettant ensuite d'effectuer des sorties cartographiques, superposées éventuellement à d'autres éléments déjà existants dans la base de données , notamment l'occupation du sol.

Les enquêtes menées au cours du stage ont permis de recenser 285 établissements à risques élevés sur l'ensemble de l'Ile-de-France, dont 21 particulièrement dangereux, qui relèvent de la Directive européenne Seveso. On connaît pour chacun d'entre eux sa raison sociale, son adresse, son activité, le type de produits stockés, le type de risque engendré (incendie, explosion,etc..), le type de pollution (air, eau, déchets), enfin le classement juridique (Seveso, PIG, etc..).

Le document présenté ne constitue pas une véritable cartographie de synthèse, dans la mesure où les risques naturels n'ont pas été pris en compte, mais ceux-ci sont déjà intégrés au SIGR et la synthèse semble d'ores et déjà réalisable. Cependant, la carte au 1/50 000 montre, à l'échelon d'un département, les Hauts-de-Seine, à l'ouest de Paris, et sur un fond comportant la Seine et les grandes voies de circulation, la localisation de 38 établissements à risques, différenciés selon leur nature d'activité (en couleur) et leur type de pollution (en hachures superposées). On constate la concentration de ces établissements dans deux secteurs, en premier lieu la boucle de Gennevilliers au nord, et la commune de Nanterre à l'ouest. Le sud du département, beaucoup plus résidentiel et boisé, ne comporte que très peu d'industries dangereuses.

Conclusion:

La cartographie des risques naturels et technologiques a été relancée depuis quelques années par la mise en oeuvre des Plans d'Exposition aux Risques, et aussi par le lancement des Atlas départementaux, dont les Hautes-Alpes constituent le prototype. La nécessité de réaliser des synthèses ne semble plus faire de doute, dans la perspective

d'études pré-opérationnelles destinées aux décideurs locaux.

Les cartes réalisées dans le milieu urbain de l'Ile-de-France se situent dans ce cadre d'information et de sensibilisation au problème des risques. Elles devraient trouver des prolongements, notamment en ce qui concerne la représentation précise des sources et formes de danger dans le domaine technologique qui, jusqu'à présent, nous l'avons vu, n'a pas eu droit au même sort que le domaine naturel. C'est à cela, entre autres, que devront répondre les études plus approfondies et à plus grande échelle qui nous paraissent nécessaires dans un milieu aussi vulnérable, en raison de sa densité de population.

On devrait ainsi aboutir à la mise en oeuvre de véritables systèmes d'informations géographiques sur l'environnement et les risques, régulièrement mis à jour. C'est certainement l'une des conditions essentielles à un aménagement rationnel de l'espace qui, jusqu'alors, n'a guère été satisfaite, pour des raisons techniques, mais aussi, il faut bien l'avouer, politiques. Mais sans doute tolérera-t-on de moins en moins la présence de véritables poudrières implantées en pleine zone densément peuplée, ce qui sera de nature à favoriser la transparence de l'information dans ce domaine.

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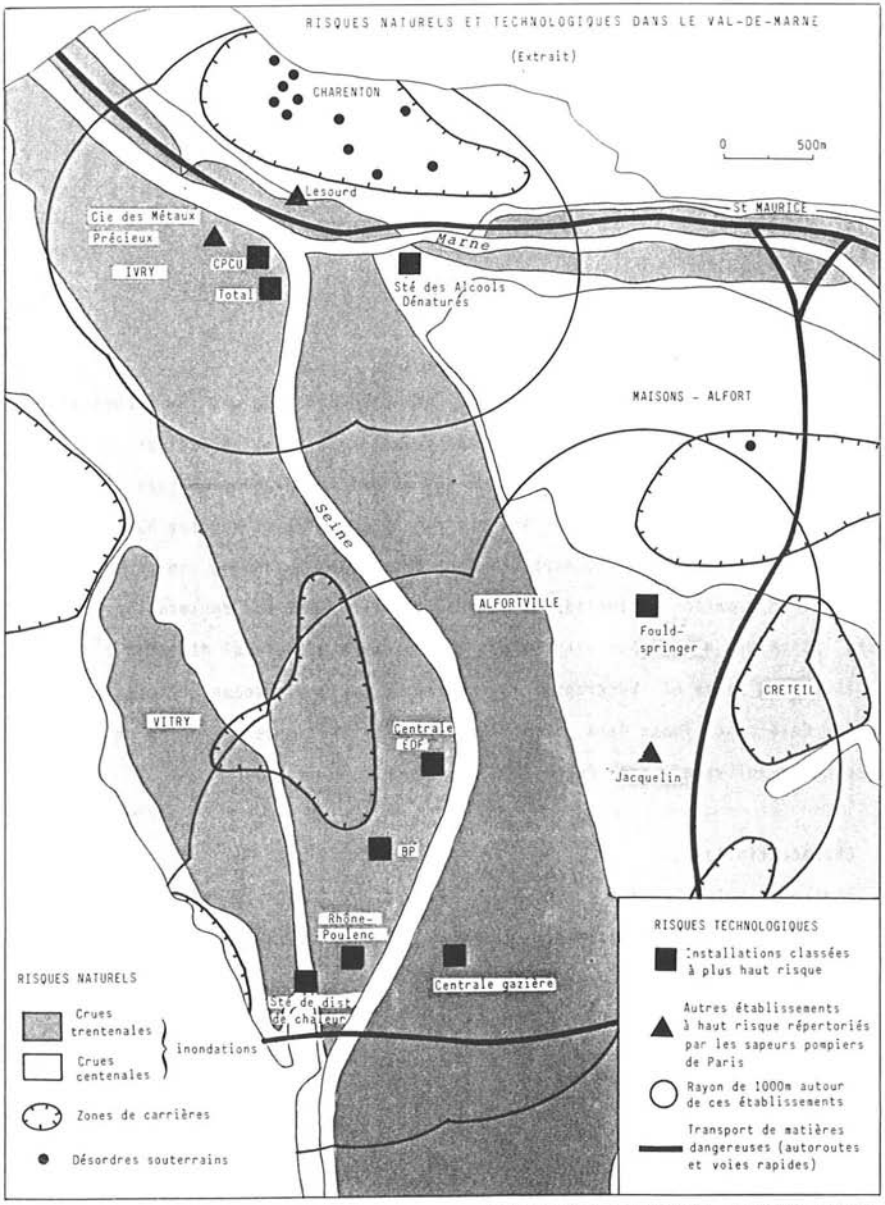
ABSTRACT

The fragility of our environment and the attacks which are told to it by our high technology civilization require to fight against pollutions and major hazards. In France, urban planning texts must "take in consideration natural and technologic hazards", according to the law of 22/07/1987.

Cartography and new associated techniques (infography, remote sensing) may contribute to the knowledge of hazards and are able to be tools for help to decision for the State and the local communities. The great development of the Geographical Information Systems may rationalize this task.

For fifteen years in France, some works has been made, in particular ZERMOS maps upon landslides, which were the first systematic cartographies. However, hazards cartography has been developed for the five last years, with the creation of the Plans d'Exposition aux Risques, born in application of the 13/07/1982 law , which concern natural hazards.

The specialists think that a global cartography, at a mean scale, gathering all major hazards which are able to occur on a same place, have a great interest, because it makes the persons in charge sensitive to these problems, and it opens the way to cartographies at a great scale upon a particular pollution or hazard. We are presenting in this perspective the cartographies realized in the Ile-de-France region, in 1991 and 1992, at the 1/25 000 and 1/50 000 scale.



Cartographie : Jean STEINBERG - Véronique JARA-RON

Mapping systems for disaster preventions

M. Tsuzawa, K. Haraguchi, Y. Inazawa (Tsukuba-shi, J)

1. Introduction

The Ministry of Construction of Japan has been carrying out the Technical Project about developement of "Hazard and Disaster Information Systems".

One sub-theme of this project, which was shared by the Geographical Survey Institute (GSI), was developement and experiment of "Digital Mapping Systems for Disaster Preventions" to support for protection planning in normal time, for information collecting in outbreaking time, and for restoration works' planning at various prevention work offices of natural disaster .

These are kinds of geographical information systems composed of digital mapping data-base, image data collecting system by helicopter, mapping or calculating softwars, and PC or EWS data processing system.

2. Characteristics

"Digital Mapping Systems for Disaster Preventions (DMsDP in this paper)" have the following charactaristics compared with existing hazard maps.

1) Consistent Managenent

This digital mapping data-base could contain consistent information for each kind of disasters, each area, and each sequence of disaster prevention management.

2) Prompt Information

Hardware of DMsDP is composed by PC or EWS and its circumference instruments. They bring various functions to more prompt than existing systems for data reference, processing, and communication .

3) Various Representation

Mapping softwares of DMsDP support various kinds of presentation; required data, required scale, and required expression.

4) Circumstantial Information

When natural disaster is outbreaking, Image Data Collecting System by helicopter and Data Processing System bring circumstantial informations about damaged area, any refuge routs, stock of rescue materials, etc. for restration works.

3. Basic Datas

1) Standard Mapping Data Base

This cartographic data base has been made by the GSI for large-scaled digital mapping. It is composed of Positioning Data and Configuration Data. Positioning Data was directly digitized by photogrammetry with original precision. Configuration Data was reproduced from Positioning Data applying geometrical models of planimetric feature or symbolized figure. This data base is used for basic data to representation or clculation on DMsDP as follows;

① Positioning or Morphological recognition.

② Mesuring distance, extention, or area.

③ Judgement of duplication or inclusion.

④ Network analysis.

⑤ Extracting geographical influenced area.

2) City Planning Data Base

This cartographic data base has been made by the Ministry of Construction to be used for city planning. Its data , which contain of administrative boundaries, buildings, and coast lines, were digitized from National Large-Scale Map by GSI or City Plan by local government.

4. Structure and Functions

1) Structure of Systems

DMsDP are kinds of geographical information systems composed of digital mapping data-base, image data collecting system by helicopter, mapping or

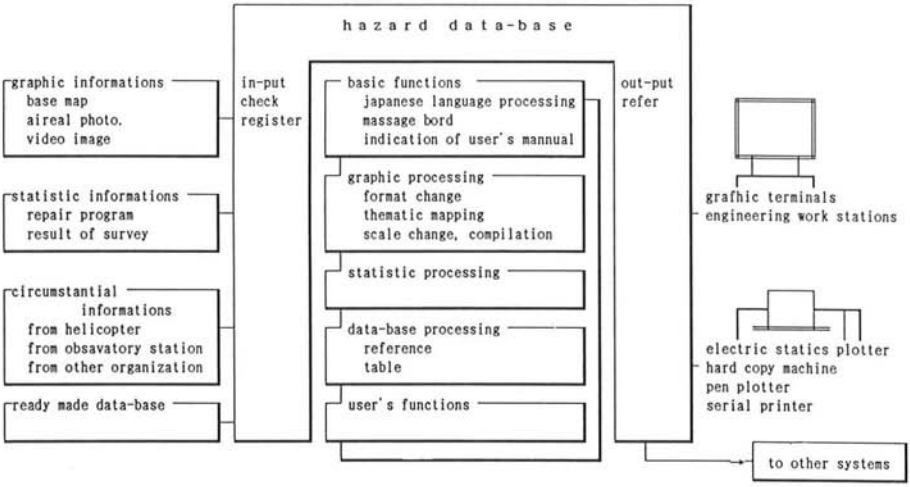


Fig.1. Structure of Mappping Systems for Disaster preventions.

calculating softwars, and computer aided processing system.

① Hardwars in Office

There are two processing forms by computer system. One is concentration form, the other is dispersion form. Both have merits and demerits respectively. In the case of DMsDP, dispersion form is suitable for the reason that each terminal is demanded to prepare different function or capacity from characteristics of each site or each disaster.

② Softwares

There are two types of software on DMsDP. One is Software for Data Management : Collecting, Registration, Renewal, and Keeping Security. The other is Software for Data Using : Processing, Out-putting, or Data Offering to other systems.

③ Helicopter

Ministry of Construction possesses a helicopter "Aozora" to be used for natural disaster prevention works. Main payload of this helicopter is Image Data Collecting and Informing System (Table 1).

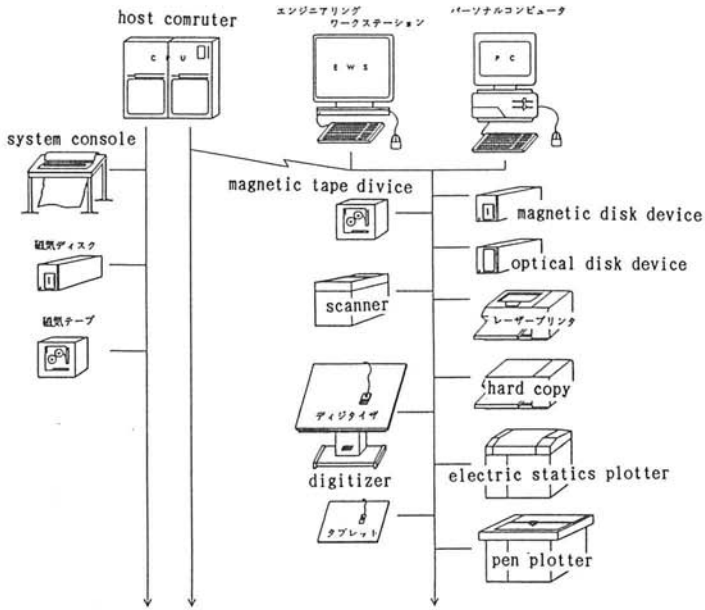


Fig. 2. Structure of Hardware.

Table 1. Capacities of the helicopter "Aozora".

Type:	Twin-engined rotorcraft
Model:	Bell 214ST
Nationality Mark and Registration Mark:	JA9683
Owner :	Minister of construction
Dimensions, External	Length overal: 18.95 m
	Width overal: 2.88 m
	Hight overal: 4.84 m
	Diameter of main roter: 15.85 m
Engin:	2 × 1625 SHP General Electric CT7-2A turboshaft engine
Max T-O Weight:	7938 kg
Paylord:	2044 kg
Service Ceiling (at max T-O weight):	3030 m
Max Range:	1080 km
Navigation and Communication:	VOR,
	Radio altimeter,
	Weather rader,
	ILS,
	Airtrafic control transpondernt,
	Encoder altimeter,
	Omega Navigation system,
	GPS,
	R-NAV,
	VHF/AM,
	HF,
	ELT
Imaging Systems:	Swivel infrared video camera (INFRAVISION 214AH-20)
	Perpendicular stereo camera (2 × MK-70)

2) Basic Functions

① Mapping

This function is required to represent large amout of data and to scroll rapidly.

② Reference

This function is demanded to refer from helicopter's position or sourse of information to coordinates or areas of objective site.

③ Measuring

Measuring distance, extension, area, or volume.

④ Topological Calculation

Looking for objective institution in a polygon. Searching for the nearest life-line from objective site. Setting up the influence area from outbreaking site. Calculation "and""or" to know the suffered population. etc.

⑤ Statistics

Total. Cross checking. Correlation.

5. Objectiv Informations for Each Disaster

1) In Case of Fire in Built-up Area

① Fire by Earthquake

In Japan, the most conciderable disaster by large earthquake is fire in built-up area. Because of the 1923 Southern-Kanto earthquake took heavy fire disaster to built-up area of Tokyo and Yokohama where most of houses were built of wood or other inflammable materials. Nawadays, there are still many inflammable houses, in spite of the fire-proof in a city has been intensifyed,

② Case Study

Nagoya is the provincial metropolis of Tokai region and also the third big metropolis in Japan. Large earthquake is presumed in Tokai region, provided from geophysical and geological investigations. Most of local governments in t his region prepare advanced plans for disaster prevention. Case study was enforced by using such plan.

③ Objectiv Information

see Table 3.

④ Mapping

It was attached inportance to indicate the symbol of helicopter's locatition with basic or circumstancial informations' map on graphic display. Scene could scroll cynclonyzed with helicopter's movement.

2) In Case of Mass Movement on Mountain Slope

① Mass Movement by Heavy Rainfall

More than 60% area of Japanese Archipelago forms mountain slopes, and most of mountain slopes have steep degree with fragile soil. Prevention works from mass movement disaster by heavy rainfall in Baiu or Typhoon season has been one of important activity of the Ministry of Construction.

② Case Study

The 1982 Nagasaki Heavy Rainfall Disaster, when it recorded the largest amount of precipitation, 187mm/hour, in all history of meteological observatory on Japanese Archipelago, brought many wretched disasters by land-slide or debris flow on suburban area of Nagasaki city. Case study was enforced by using restoration reports of this disaster.

③ Objective Information

see Table 3.

④ Mapping

In this study, indication method of helicopter's locatition on base map was linked with the Global Positioning System.

3) In Case of Flood on Alluvial Plain

① Flood by Heavy Rainfall

Most of residential or industrial districts are located on flood plain in Japan. The more people's activities are concentrated on flood plain, the larger potential of flood disaster is resulted. Swift land use alternation cancels the efficacies from advanced flood control works.

② Case Study

The Kokai River is one of branch stream of the Tone River on Kanto plain. In 1980s, flood water struk twice to residential districts and paddy fields on the alluvial plain along this river. Case study was enforced by using restoration reports of these disasters.

③ Objective Information

see Table 3.

④ Mapping

In general case of flood on plain, people could have enough time to be warned and to take refuge before outbreaking of disaster, however any after-effects of disaster would remain enough. In time before outbreaking, it is effective for warning that DMsDP draw the water level at every moment on cross-section of river embankment with river maintenance plan or dangerous zoning. In time after outbreaking, DMsDP show any life-lines for rescure, public facilities for relief and safety, or material list for resoration activity.

6. Utilization

1) Conditions

① Normal

DMsDP could be used as basic information systems for any administrative works on normal time. Objective works are, for example, prevention planning, publicity about disaster preventions, fire fighting, etc.

② Outbreaking of Disaster

This is the principal condition of DMsDP. They are used to indicate damaged position, sphere, and grade, to support planning for prevention of water spread or refuge of people, etc.. On this condition, circumstantial data are gained and informed from helicopter or other communication networks.

③ Restoration

On this condition, DMsDP could be used as basic information systems for any restoration activities.

2) Classification of Objectiv Information

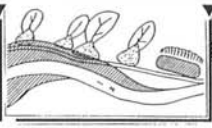
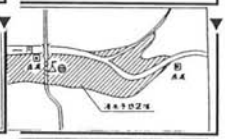
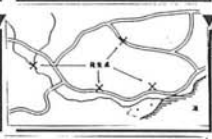
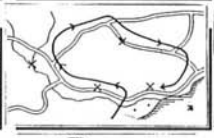
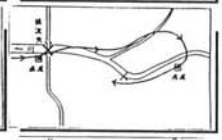
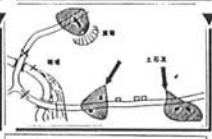
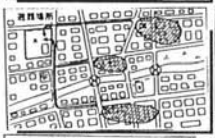
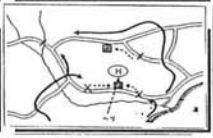
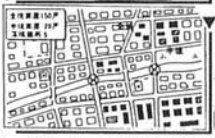
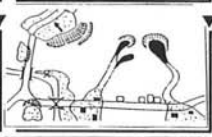
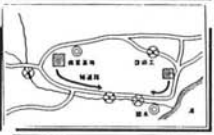
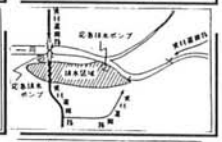
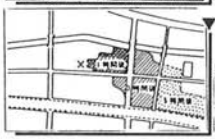
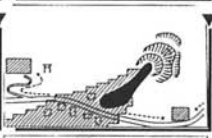
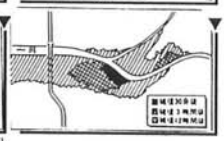
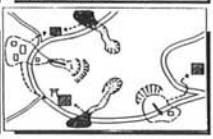
There are two categories of objective information. One is a common information for every disaster, and the other is a specific information for each disaster. Specific information is further classified to basic information to be in-put to DMsDP beforehand, and circumstantial information to be in-put at every moment.

Table 2. Objective Informations for Mappping Systems for Disaster preventions.

(Simplifyed from Tsuzawa, 1992)

common information for every disaster	*base map*	topography [conter line, cliff] hidrography [river, coast line] roads railways land use administrative boundaries establishments houses and buildings
	common information	organizations & public facilities heli-ports press organizations dangerous materials dangerous pobject dealers
specific information for fire by earthquake	*basic information*	establishments for fire fighting inflammable houses others
	circumstancial information	from helicopter from communication network
	restoration plan	burnt district burnt object
specific information for mass movement disaster	*basic information*	establishments for sabo works historical damaged sites regulated area by law micro landforms on mountain slope others
	circumstancial information	from helicopter from radio communication
	restoration plan	transformated land damaged establishment life-lines prevention of epidemics
specific information for flood disaster	*basic information*	establishments for food control historical flooded area regulated area by law micro landforms on alluvial plain others
	circumstancial information	from helicopter from radio communication
	restoration plan	flooded area damaged establishment life-lines prevention of epidemics

Table 3. Utilization Diagram of Mappping Systems for Each Disaster

sequence of disaster prevention	mapping themes	mapping models in case of fire by earthquake in built-up area	mapping models in case of mass movement disaster on moutain slope	mapping models in case of flood disaster on alluvial plain
warning sequence	base-map dangerous zonning			
outbreaking and confusion sequence	prompt information			
	operation plan of helicopter			
refuge and rescue sequence	circumstancial information			
	refuge plan			
restoration sequence	distribution of disasters			
	restoration plan			
secoudary warning sequence	simulation map			
	dangerous zonning			

3) Cost Performance

Hardware :

Personal Computer [40MB. adding Data Processer, 4MBRAM, Mouse, MS-DOS] .....9600us$.

Imaging Processer [16MB].....131900us$.

Graphic Display [20in. on Imaging Proceser].....4700us$.

Graphic Display [14in. on PC].....1400us$.

Hardware's Total.....147600us$.

Software :

Basic Software.....15000～150000us$.

Application Software

.....150000～400000us$/each sort of disaster.

Software's Total.....appproximately 400000～800000us$.

Data In-put :

Scanning [A3.8dots/mm].....24us$/sheet.

Digityzing [A2].....15000us$/sheet.

R-V conversion..... ≦ approximately 700000us$.

Whole System's Total..... ≧ approximately 600000us$.

7. Conclusion

These experiments result the optimum mapping systems for each disaster prevention activities in multiple condition. The case studies were enforced on tracing known past disasters or on theoretical plan. It need for these systems to work experience of practical using.

Acknowledgement

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Maps for the protection of the public during a technological disaster

U.J. Dymon (Kent, USA)

ABSTRACT

Maps play a critical role in coordination of successful emergency responses during a technological disaster. Actions and information flows critical for effective emergency management are based on knowledge of spatial relationships and are best presented through the medium of a map. By detailed mapping of a community, areas of potential risk can be identified and mapped.

Once an emergency arises, managers have two simultaneous efforts to coordinate: control of the physical agent (the disaster) to prevent worsening conditions and care for the public at risk. Immediately, maps offer a visual tool with which to measure the extent of areal impact allowing for speedy notification of all utilities and institutions affected. They also provide emergency managers with basic knowledge of the key spatial aspects of the disaster needed to attempt to control the physical agent(s) causing the crisis.

The utilization of maps can provide the essential spatial information to evacuate the "at risk public" from the danger zone. The "at risk public" often includes the sensitive publics who require special attention and care during an evacuation. By correlating a list of persons with special needs with a color-coded emergency map, workers are able to target these persons for individual help during an evacuation. This paper describes the pre-disaster preparation of emergency maps, both their content and their design, and it also describes the effective use of these maps during a technological disaster. How emergency mapping provides emergency managers with essential means to respond effectively during the time of crisis is addressed.

INTRODUCTION

Over the past decade, accidents and disasters necessitating evacuation of large numbers of people have grown rapidly. In the United States during the 1980s, emergency evacuations caused by technological accidents appeared much more frequently than in the past (Sorenson and Vogt 1987), and the assumption can be made that the number of evacuation will continue to increase in the next decade (Dymon and Winter, 1993). On-site or in-transit disasters involving hazardous materials have the potential to affect just about any community in the United States. These incidents can occur in rural as well as in heavily populated areas and provide a major challenge to emergency managers. Businesses and industries storing or transporting hazardous materials are required to report to the local government the quantities of such hazardous materials that are being handled within the communities. In most communities there are Emergency Planning Committees formed in accordance with this law.

These planning committees are responsible to provide quick and safe evacuations to the public at risk when a accident or disaster occurs. Any evacuation is the most massive, costly and disruptive community response, and most evacuations can be grouped into two basic action 1) pre-impact evacuations, and 2) post-impact evacuations. While both vary considerably in their duration and complexity, they still require careful coordination of emergency efforts. An addition, emergency managers have to coordinate the control of the physical agent (the disaster) to prevent worsening of the conditions while taking care of the public at risk.

EMERGENCY MAPS

Well-integrated emergency planning maps offer a visual tool during a disaster with which to measure the extent of the spatial impact allowing for speedy notification of all utilities and institutions affected. They also can be used as key devices in communicating and promoting inter-departmental, inter-agency and cross-jurisdictional coordination of emergency response efforts before, during and after a technological disaster. Under the time constraints of an emergency situation, emergency managers have no time to read lengthy text, well designed emergency maps therefore can provide emergency managers with a comprehensive view of the situation at hand. In spite of the critical role maps can and should play in planning for disasters, many communities are ill prepared to deal with an unexpected emergency and map resources are often scarce or not existing at all (Dymon and Winter, 1991). Part of the problem is the way local governments perceive natural or technological hazards. They often pay little attention to emergency management (Cigler, 1988). Because of it, there is a dearth of emergency mapping on the local level causing emergency managers to make evacuation decisions without the spatial information on maps. This study describes how one community with its scarce resources was able to prepare a set of well integrated emergency planning maps which were used during a technological disaster providing pertinent information to emergency managers to evacuate nearly one thousand people.

THE EMERGENCY INCIDENT

Town setting

Marlborough, a city of about 31,000 people population is a closenet community with a large number of French-Canadian and Portuguese people living in the city. The city is part of the high tech industrial belt located about sixty miles west of Boston Massachusetts. A network of major highways makes the city easily accessible from two major urban areas. These areas provide a labor force within commuting distance of Marlborough. The majority of persons working in the city's high tech industry are commuting from the nearby cities and communities. During an average working day Marlborough swells to a population of about 130,000 people.

The accident

On a saturday night during the cold New England winter a tank track delivering gasoline to a downtown gas station experienced a crack in the gas hose, spilling about 100 gallons of gasoline into the main street storm drain system. Shortly after the spill was reported, pockets of gasoline vapors set off explosions causing manhole covers to fly into the air. The fumes that seeped from the storm drain into the basement of several houses caused major explosions and severely damaged numerous houses along the affected area. The driver of the delivery tank track immediately contacted the fire department about the spill. Since the area was heavily populated, quick action had to be taken. According to emergency procedures, the local fire chief became the commander in chief, and he had to set emergency procedures into effect. After contacting all emergency personal, he ordered immediately an evacuation of all residents within the area. In spite of the severity of the

accident, there were no major injuries reported. Next morning, after the vapors had dispersed, most evacuees were able to return to their homes except the persons living in houses affected by the explosions.

PRE-DISASTER PREPARATION AND MAPPING

In contrast to many other communities, Marlborough was well prepared for this technological disaster. A year earlier the city of Springfield, third largest city in Massachusetts, experienced a major chemical fire. Large numbers of residents needed to be evacuated. While the fire was burning, nobody knew what kind of chemicals were burning and what kind of impact the vapors had on the rest of the area. After this incident, several Massachusetts communities started active emergency evacuation planning programs. This was coupled with the passage of the 1986 Emergency Planning and Community Right-To-Know Act (U.S. Federal Emergency Management Agency (FEMA) and Environmental Protection Agency (EPA), 1986).

Marlborough designated one of the local fire fighters as the emergency manager. This person took a major interest in training himself and his fellow fire fighters in most aspects of emergency preparedness. One of his special interests was the preparation of an extensive set of emergency planning maps.

Marlborough, like many other communities, had meager resources available for their emergency planning program. However, this did not stop the emergency manager from preparing a set of useful and perhaps lifesaving emergency planning maps.

The emergency manager went to the city's engineering department to gather several detailed base maps of the city. Some maps had utilities and services already mapped, others were zoning maps. Using these maps as a starting point, he colored in with markers and colored pencils the following:

- industries and businesses storing hazardous materials
- highways and roadways transporting hazardous materials
- listing of the hazardous materials and their effects on humans and the environment

In addition, he added a radius of one mile around each site storing hazardous materials. This method of using visual buffers could also be found along highways and other routes which were used to transport hazardous materials. These maps basically were risk maps since they pointed to the possible risk at the locations.

Another map showed the population within this area. The map showed single versa multiple housing. Each block displayed and listed by individual names of citizens the publics in need of special care, such as persons who are physically or mentally impaired, nursing homes, childcare centers and schools, both private and public. Each list which was attached to the maps was color coded according to the special needs persons had during an evacuation. One could identify at a glance what the special evacuation requirements for a specific person was.

Another map featured all schools, churches and public facilities which could be used as emergency shelters. Designated emergency shelters had special color coding and the maps indicated the areas for which the shelters were to be used. Again, simple color coding was applied to point to public versa private facilities.

A final map displayed all emergency facilities such as fire stations, police stations, utilities, hospitals, care facilities, firetrucks, buses etc. The data collected for these maps was the result of extensive questionnaires which were sent to all industries and businesses as well as all residences. These questionnaires were sent as an appendix of the city census. All maps were prepared on official city maps, and in most cases, the information was added with color markers and pencils over existing information. In order to make the maps more durable, so that they could be taken into the field when needed, the maps were laminated. This allowed managers to add information to the maps when needed. These risk maps were available to all emergency personnel in the fire station.

MAP USE DURING THE DISASTER

All actions by the incident commander required rapid decision making. Immediately, he consulted the risk maps to identify the danger zone and to make evacuation decisions. He ordered instantaneously the evacuation of all residence on both sides of the storm drain. The color coded residential map pointed to all persons who needed special assistance during the evacuation.
Shelters were established, and while the safety of all residence was of highest priority, simultaneously the physical agent needed to be controlled to avoid further acceleration of the disaster. The incident commander was able to control the disaster within several hours and the dangerous vapors started to disperse. Use of maps increased the speed of decision making for both evacuations and fighting the dangerous physical conditions.

SUMMARY AND CONCLUSIONS

Mark Monmonier and George Schnell suggest that the design of effective risk maps requires an understanding of the intended audience and its limitations. They point out that elected officials and the general public require concise straightforward, simplified presentations (Monmonier and Schnell, 1992). Emergency managers are under a great deal of pressure to make decisions which may affect the life of thousands of people, yet they have only a few minutes to analyze the situation and act. They cannot afford to make mistakes and delay safety decisions.

The maps in Marlborough clearly provided the information needed. They were simple maps and served their purpose. Partly because the mapping process identified emergency managers needs (the content was identified by the emergency manager) and partly because the simple design of the maps made them easy to understand (labels, symbols and description were next to the map content). These maps allowed for a certain readiness which could only be provided by a quick glance at the spatial situation.

In contrast many communities are not as prepared as Marlborough. There are several reasons a) there is a concern if risk maps are made public that property values drop, b) many communities are experiencing budget problems and preparation of maps which may not be needed is not on a high priority list, 3) emergency managers in a community may not think spatially and therefore do not perceive mapping as part of their emergency planning as important.

Emergency mapping is a growing and important area. Cartographers with their spatial knowledge and the adoption of new technologies such as automation and geographic information systems can make a major contribution to the field. There is a need to develop guidelines and a framework for the preparations of effective emergency planning maps.

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Design and compilation of urban anti-disaster planning atlas

L. Yanfang, L. Yaolin (Wuhan, RC)

INTRODUCTION

Cities are densely populated and constructed. There are a lot of dangerous old houses and secondary disaster sources such as combustibles, explosives and poisons in cities. Once the disasters such as earthquake, flood and fire come, they must have suffered heavy losses. So the cities are very important areas for anti-disaster planning. The ultimate objective of the planning is to reduce economic losses, and numbers of injuries and deaths to a minimum, how to take procautions before the disaster? How to take actions during the disaster? And how to put the city into normal state, that is, to rebuild the homeland and go into production as soon as possible, after the disaster? These are the problems which should be considered and solved in the planning. The key point for all those problems in what of the current anti-disaster ability of the city. So, the reasonable and effective anti-disaster planning must be based on the overall and comprehensive assessment on urban anti-disaster ability.

In the assessment on urban anti- disaster ability and planning of urban anti-disaster, cartographers can play a very important and active role. It is a major point that the paper will show.

Cartographers can well combine the mean of map analysis and map representation with the assessment and planning of anti-disaster. The maps of urban anti-disaster are basic means and basic data for assessment and planning of urban anti-disaster. And with these maps, measures of anti-disaster can be made and actions of anti-disaster can be taken in line with local conditions. Therefore, designing and compiling the atlas of anti-disaster planning is of great importance.

Based on the case study in Wuhan city, Hubei province, the paper will discuss basic contents, and structure, selection of map subjects, and major procedure of the atlas.

BASIC CONTENTS AND STRUCTURE OF THE ATLAS

An Atlas consists of a set of maps which have unified general design, complete content system, Logic system structure and well-taken technical standards. It is a complex systematic engineering of mapping in the cartography system, because it involves broad scientific contents of multi-disciplines, and has a great amount of information and complex data processing. So the scientific, logical, systematic and integrated characters of the atlas are the common features which must be considered in the general design of the atlas. However, the individual characters for different atlases must also be considered for establishing the structure of each atlas, so that the atlas can stress on specific characters based on reflecting general characters.

Therefore, whether the structure of the atlas on the subjects of maps, its dedign shoult be combined with the objectives (uses) and regional features.

Urban anti-disaster planning should begin with the assessment on current urban anti-disaster ability, find out the weak points of anti-disaster, and then according to the local conditions, especially the weak points, take a series of measures for strengthening urban anti-disaster ability (i.e., decision making).

Urban anti-disaster ability is the complex one which consists of the ability of urban anti-disaster before disasters and the ability of putting the city into normal state as soon as possible after disasters. It depends on varied factores, such as urban natural conditions, urban land use structure, road system, areas for dispersion, quality and density of buildings, and varied lifeline facilities and etc.

For natural conditions, if a city is located in a firm foundation, there is less effect of earthquake on the city. But if there exist

harmful engineering geological conditions, such as soft rock strata which are easily liquefied and subsided, and hidden faults, once the disaster comes, these conditions certainly will aggravate the effect of the disaster in the parts on the city, resulting in great losses.

For social-economic conditions, if buildings are population of the city are heavy concntrated as well as the quality of buildings is poor, the urban anti-disaster ability is so weak that it must have suffered heavy losses once the disaster comes. In addition, if roads for dispersion and rescue are narrow, road system does not completed get, and there are no any areas for dispersion, we can't imagine the results. The facilities of power supply, water supply, communication and medical treatment are components of lifeline engineering. Their anti- disaster ability and working reliability have direct influence on rescue during disaster and recovery after disaster. But if they are hit by the disaster, they will become serious secondary disaster sources which will result in fire and flood. So more attention should be paid to them in anti-disaster planning.

Thus it can be seen, the basic contents of Urban Anti-disaster Atlas must include two major aspects: 1) Factor and Factor Analysis Maps which reflect the comprehensive ability of urban anti-disaster, including physical factors and social-economic factors; 2) Maps of planning measures which are made according to the major weak points.

Disasters for cities vary with the specific geographic location. May be earthquake, or flood, or trio disaster of earthquake, flood and fire. So the maps of the atlas should reflect the regional characters, including factor maps aiming at the local major disasters and measure maps against the local major disaters.

For example, Wuhan city situated in the lower reaches of famous 'hanging river' section —— Jingjiang of Yangzi River, and the River moves across the city. This region suffered so much and so heavy flood in the past, and today it is still threatened by flood. On the whole, the city is located in the 'faults and heave' area and may have

Analysis for Current Urban Anti-disaster Ability

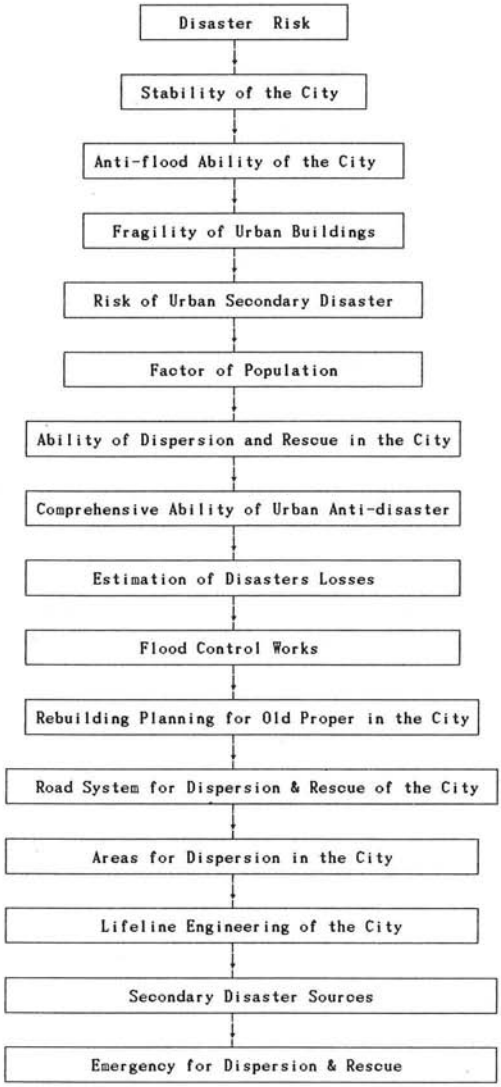

Fig 1. Structure Design of the Atlas

potential sources of earthquake. even if the earthquakes occur outside, they will have different effects on the city. In addition, the city has a long history, a very large population and much more old buildings. Therefore, the anti-disaster planning as well as its atlas in Wuhan should aim at the trio-disaster of earthquake, flood and fire.

The structure of the Atlas should be in accord with the procedure of analysing and planning step by step for urban anti-disaster ability, by using systematic approaches, from outside to inside, from one to the another, from single factor to multi-factors comprehensive assessment, having a logical sequence all linked with one another.

At first, we should regard the city as a whole in a larger regional system for analysing the risk of varied disasters, such as risk of earthquake or flood. So we can use the map of active fault to reflect the geological conditions for seism, and use the map of distribution of epicentres at the modern times to reflect the major seismic activities in history. And then, we go deep into the city to set off discussions from physical and social-economic aspects. We give systematic and overall descriptions for comprehensive anti-disaster ability of the city from maps of physical factors to maps of social- economic factors, and from maps of single factor analysis to maps of muti- factors comprehensive assessment. After that, we come to use varied planning maps to show a series of anti-disaster measueres which are taken for strengthening the comprehensive anti-disaster ability mainly aiming at the weak points, see Fig. 1.

SELECTION OF MAP SUBJECTS

The subjects of Maps should always centre on the urban anti- disaster ability.

MAPS OF DISASTER RISK

Mainly reflecting geological conditions for seism, major seismic activities and floods in history, and seismic intensity reasonalization

in the urban area (background area of the city).

—— Map of active faults, reflecting the distribution of varied active faults.

—— Map of distribution of epicentres at the modern times, including the geographic distribution of epicentres, and their occurring times and grades etc..

—— Map of seismic intensity regionalization, representing the results of assessment on the seismic risk mainly based on the above two maps. This map gives seismic backgrounds for different areas in the coming 50 years or much longer, providing the basis for anti-seism design of buildings.

MAPS OF STABILITY OF THE CITY

Mainly reflecting such factors which influence the stability of the as geomorphologic condition, geologic condition, active faults, groundwater, bad ground soil, and the results of comprehensive assessment based on these factors.

—— Map of Geomorphology and the Quaternary Geology, representing the cause and pattern of landforms, lithology and dynamic geologic features such as landslides and collapses etc..

—— Map of Lithology and Anti-seism Property, giving the results of assessment on rock and soil for anti-seism property, such as strong, weak and poor.

—— Map of Geomorphology and Effects for Seismic Damages, representing the results of assessment on landforms for effects of seismic damages. For example, pointing out the areas such as tectonic-denuded hills which are easy to collapse or slide with the earthquake.

—— Map of Distribution of Bad Ground Soil, mainly representing the distribution of bad ground soils, which are easy to be caved in or liquefied.

—— Map of Buried Depth of Groundwater, being the basis for liquefication analysis.

—— Map of Enginnring Geology for Seism, mainly representing the results of assessment on engineering geology for seism based on above data and the major features of engineering geology.

—— Map of Susceptibility of Sand Liquefication, representing the results of assessment on susceplibility of liquefication, as well as the specific, such as sand thickness.

—— Map of Seismic Microzoning in the City, representing the results of assessment on the anti-seism property of fundation for construction based on all above data, especially stressing on the dangerous areas and their major bad factors.

MAP OF ANTI-FLOOD ABILITY ANALYSIS

Mainly representing the distribution of current flood-defence works and their quality characters, as well as the prediction of floods met once in the coming 50 of 100 years.

MAPS OF FRAGILITY OF URBAN BUILDINGS

Mainly representing varied characters of buildings, one of major victims, including:

—— Map of Building Density

—— Map of Building Storey

—— Map of Building Quality

—— Map of Anti-seism Structure of Building,

representing the classification in terms of such indexes as old-new degree, height of buildings, roofing type, floor type, wall quality etc.

—— Map of Urban Land Use

—— Map of Estimation of Building Loses, representing the estimations for different kinds of buildings such as multi-storey brick house, low brick or wood house, one storey workshop or warehouse and base-frame house, in terms of different earthquake intensities.

MAP OF RISK ANALYSIS OF URBAN SECONDARY DISASTERS

Mainly representing the distribution of varied secondary disaster souces, as well as ranges and degrees of their influences.

MAP OF POPULATION DENSITY

Population density is one of main factors which are influencing the comprehensive anti-disaster ability. The emphasis is on the highest density. If there exist geographic differences in such features as sex and age, these features should be reflected in the map, which are the bases for dispersion and rescue.

MAPS OF ABILITY OF DISPERSION AND RESCUE IN THE CITY

—— Map of areas for dispersion, representing distribution of dispersing areas such as green land, vacancy, sports ground, and underground civil air defence, as well as the results of assessment on their suitability in terms of accessibility, stablity and function etc.

The volunm of areas can be described by average amount of areas per person.

—— Map of Road System for Dispersion and Rescue, including grade, width, pavement and current use of roads.

—— Map of Lifeline Engineering, mainly representing distribution, function and scale of auti-disaster headquarters, life line facilities such as hospitals and fire stations, as well as power system and water system.

MAP OF COMPREHENSIVE ABILITY OF URBAN ANTI-DISASTER

Representing the results of assessment on comprehensive ability of Urban anti-disaster based on all above data, with emphasis on the areas of the poorest ability.

MAP OF ESTIMATION OF DISASTER LOSSES

Mainly representing the results of estimation on economic losses and

numbers of injuries and deaths.

MAPS OF URBAN ANTI-DISASTER PLANNING

Including two aspects: 1) construction planning aiming at the weak points of anti-disaster ability, for strengthening the ability; 2) emergency measures for dispersion and rescue.

—— Map of Planning for Flood Control Works

—— Map of Rebuilding Planning for Old Proper in the City, mainly representing the rebuilding measures such as demolishing precipitous houses, reinforcing some old houses, decreasing the densities of building and population, removing the secondary disaster sources, improving road system and opening areas for dispersion etc.

—— Map of Planning for Road System

—— Maps of Planning for Lifeline Projects.

Such as Map of Planning for Fire Control System, including disposition of new fire stations, measures for water supply, passageway and fire-fighting equipment.

—— Map of Planning for Dispersing Areas

—— Map of Planning for Reducing Secondary Disaster.

PROCEDURES FOR MAP COMPILATION

Map Compilation is an extreamly complex and compact systematic engineering. The whole procedure includes data collection ⟶ data analysing and processing ⟶ base map compiling and drafting ⟶ compiling and drafting of thematic elements. Remote Sensing and computer techniques are applied in many maps of the atlas to a certain extent, such as map of population density, map of Anti- seism Structure of building and map of comprehensive ability of urban anti- disaster etc, see Fig 2.

Problems about data quantifying and comprehensive assessment in urban anti-disaster planning are specifically discussed in another paper of the authors entitled as "Assessment on Urban Anti-disaster Ability".

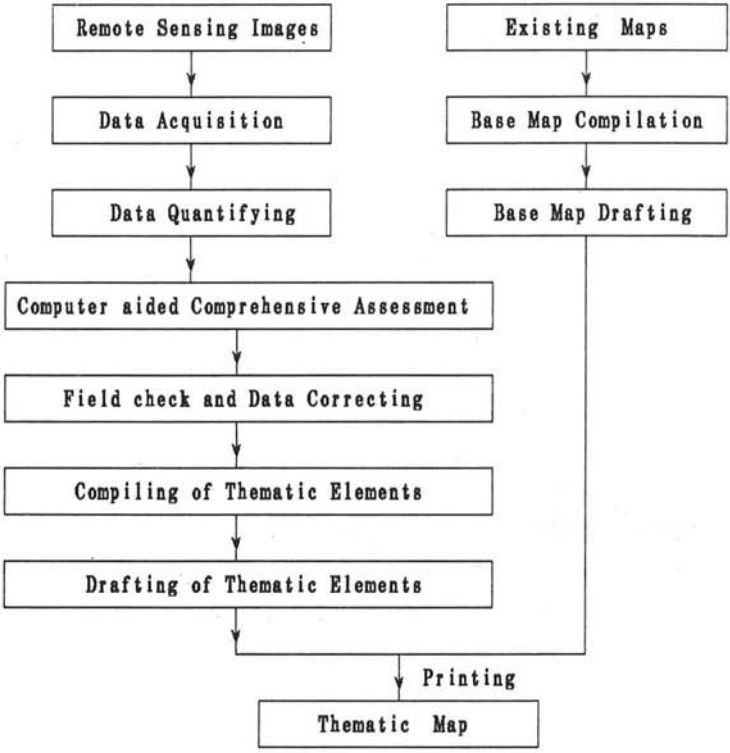

Fig. 2

CONCLUSIONS

1. The atlas is the important and scientific basis for urban antidisaster project Cartographers can play a very important part in this field.

2. The atlas is a system which consists of a set of maps and has a unified general design, complete contents, logic structure and well-taken technical standards.

The contents of maps and the structure of the atlas should be centered on the urban anti-disaster ability, from current state to planning measure, from physical elements to social- economic elements. from single analysis to multi-factor comprehensive assessment.

3. It is still worth to discuss how to select the much more expressive methods and reasonable combinations of representing methods in the atlas of urban anti-disaster planning.

Session 9

Map Based Information Systems I

Chairman:
S.C. Guptill, U.S. Geological Survey (Reston, USA)

Digital quality products of official cartography in Germany

H. Brüggemann (Bonn, D)

1. Introduction

About twenty years ago, the Surveying and Mapping Agency of North-Rhine Westfalia bought its first digital cartographic equipment consisting of a computer supporting the FORTRAN programming language, a high resolution digitizer, and a digital draughting machine with light pen. The intention was to develop first components of a digital cartographic production process. The results should be the traditional analogue topographic maps, which are to be produced by the agency. So, until 1980 a software package has been developed allowing a complete digital process from manual map digitizing to the automatic symbolisation of the digitized objects by the draughting machine using the digitized geometry of the objects and their object codes. Already at this stage we strictly separated the modelling of the real world objects from their graphical representation. No graphical attributes were stored with the objects.

The idea was to use the developed process for the simultaneous derivation of 20,000 and 25,000 scale maps from updated 5,000 scale German basic maps. Parallel R&D activities on the cartographic generalisation process at several German universities should deliver the missing components for this complicated process step. Cooperation between some universities and Surveying and Mapping Agencies within the Working Group on Digital Cartography (Arbeitsgruppe Automation in der Kartographie - AGA) led to the first standards on cartographic object classification and on cartographic data exchange.

But, soon it became clear that the state of hardware and software technology at that time did not allow to set up an economic production process. The draughting machine needed days to produce the symbols of a topographic map. With large efforts the results had to be corrected by manual methods because of the insufficient results of the cartographic symbolisation. And the few realized computer-based generalisation methods turned out as being not very helpful for the map derivation process.

Looking back from today, the courage is astonishing to start already 1975 realizing a complete cartographic production process. Now, in 1993, a lot of progress has been made but, no official cartographic institution in Germany produces analogue map series using digital production techniques including cartographic generalisation. A solution of this problem is not yet to be seen.

Instead, a new category of cartographic products has bound all forces: digital cartographic data[3]. The users needs for up-to-date information about the earth's surface have grown rapidly. Also for the official cartography the entry of our society into the information era means a new challenge. The new possibilities of the information and communication technology are to be used in time to enable a

controlled evolutionary change from the analogue to the digital world. Following its legal mandate, official cartography prepares the prerequisites of a basic geographic data infrastructure for public and private users. Therefore, we have to play a pioneer's role setting up a digital land documentation on basic geographic data covering the area of our country. Suitable geodetic and cartographic reference systems are to be provided for our own data and application oriented data as well. The users are knocking at the door asking for basic data for a variety of applications in the fields of e.g. facilities networks, traffic, environment protection, statistic, agriculture, and military.

Therefore, since 1980 the German Working Committee of the Survey Administrations of the Länder of the Federal Republic of Germany (Arbeitsgemeinschaft der Vermessungsver-waltungen - AdV) first developed the concept of the Digital Cadastral Map (Automatisierte Liegenschaftskarte - ALK) and, based on these experiences, since 1985 the Authoritative Topographic-Kartographic Information System (ATKIS), the German kernel project of official cartography. Now, e.g. for North-Rhine Westfalia about 50 % of our state area are available as ATKIS Digital Land Model 25 (DLM 25) data, and it has to be clarified how to provide these data as official cartographic products to the users. In addition, a more advanced production process leading to analogue cartographic products is being prepared, which offers the possibility of deriving a greater variety of maps than in the past.

Map and data production are seen as a public duty. In the interest of the public weal, the state gathers information relating to territory and people in official records, registers, and land registers,

- to be able to assure public order and the right and safety of the individual citizen,
- to be able to intervene with planning and control measures in the development of the community,
- to be able to provide cost-effective services to each citizen for the purposes of provision for his existence.

As a rule, the information from such records is also supplied in extracts to private bodies subject to payment of a fee, where a justified demand exists and provided careful use of the data is assured. The state adopts a very restrictive procedure with the supply of data relating to persons or affecting security interests.

Part of Surveying and Mapping is the registration, documentation and provision of information relating to the topographical realities of the national area (topographic survey), as well as the issuing of official topographical map series. The Surveying and Mapping is required to orient itself to the needs of public and private users in performing this duty, and to disseminate its results in a suitable way provided this is not contrary to public interests and the guarantee exists for proper use.

2. Traditional German cartographic quality products

2.1 Map products

Based on their leagal mandates, the Surveying and Mapping Administrations of the German *Länder* agreed on the current produced official German topographic map series. They are produced and published by the respective agencies of the *Länder* and, with respect to the small scale maps, by the Institute for Applied Geodesy. The map series are:

- German Basic Map 1:5,000
- Topographic Map 1:25,000

- Topographic Map 1:50,000
- Topographic Map 1:100,000
- Topographic Map 1:200,000
- General Map 1:500,000
- International Map of the World 1:1,000,000

In addition, some Surveying and Mapping Agencies are providing 5,000 and 25,000 scale orthophoto map series. Up to the scale 1:100,000 the maps are produced and published by the Surveying and Mapping Agencies of the *Länder*, maps at smaller scales by the Institute for Applied Geodesy.

A special class of analogue cartographic products are map separates serving as the basis for the up-dating process and as suitable combinations for the printing process.

2.2 Map quality assurance

A quality product is a product which is in conformance with its specification. To achieve this conformance, the production process has to be installed and controlled in a proper way. Quality aspects to be taken care of for maps are their up-to-dateness, appropriate accuracy, completeness, reliability, readability, and correct symbolisation with respect to the standardized AdV symbol catalogue.

All map products are following clearly defined technical specifications agreed on as AdV standards. The governments have introduced these technical specifications by administrational acts to be used by the responsible agencies based on fixed revision cycles and quality assurance rules. Large efforts are undertaken to guarantee the conformance of a map product with its specification using all available sources like aerial photographs, public registers, local surveys carried out by own staff or by other institutions. Our surveying and mapping law enables us to access all information on changed situations available from both public and private organisations and people if needed.

Parts of the cartographic updating work is done by private companies on contractual basis. They have to prove their ability that they are able to carry out the work based on well founded cartographic expertise. All delivered results are checked by experts of our cartographic department.

This production process guarantees that our users can rely on the equal quality of our map products. Fixed revision cycles harmonized by the Surveying and Mapping Agencies of the *Länder* and reliable AdV standards on the content and symbology of the maps enable the users to adapt their thematic map production years before.

2.3 Map distribution

Maps and Orthophoto Maps are directly distributed by the Surveying and Mapping Agencies to bookshops and to end users. In addition, several agencies concluded contracts with powerful private companies giving them the role of an official map distributor. These contracts include special discount rates dependent on the amount of purchased map sheets.

Finding the right price for a map sheet is a problem. Map production in Germany is seen as a public duty financed by taxes. The rules of offer and demand cannot be purely applied, because the product "map" would become too expensive for the private end user taking into consideration all the efforts undertaken including also e.g. the maintenance of the reference point networks. (In Germany only 10 % of the costs of a Surveying and Mapping Agency are covered by the sale of its products.) Map prices are agreed on by the AdV.

Map separates are sold to users who want to produce thematic maps using them as topographical background for their theme. The users buy map separates with the right of reselling the topographic information combined with their thematic information as application oriented maps. The price depends on the amount of printed thematic maps based on the topographic map separates.

3. Digital data products - today and tomorrow

Supervision of the earth's surface by traditional methods and cartographic techniques does no more fulfill the requirements of the users. Computerized methods in all application fields need digital data. The quality requirements in accuracy, up-to-dateness, reliability of the data are seriously growing because fast respond is needed on fast changing situations on the earth.
Therefore, official Surveying and Mapping is planning a standardized digital land documentation covering a country as a basis for different digital products of different accuracy and content, in addition to the traditional analogue map products described in chapter 2. Following our legal mandate we offer these data products as basic information for application oriented official and private data handling and information systems. In parallel, it is planned to replace the current map design by a modernized one using the possibilities of computer technology.

3.1 Global data concept of official cartography

Figure 1 gives a comprehensive view on the relationships between the real world itself, its digital description by suitable models and products derived from these models to be provided to the users. This concept is based on the ATKIS approach, but not identical with it.

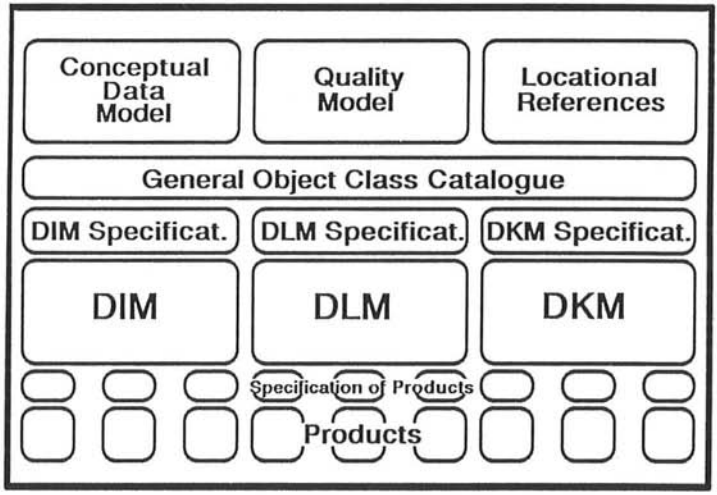

Figure 1: Global data concept of official cartography

To describe the cartographers real world the concepts of a Conceptual Data Model (CDM), a Quality Model (QM), a General Object Class Catalogue (GOCC) and of Positional References are helpful. Using these concepts, Digital Image Models (DIM), Digital Land Models (DLM) and Digital Kartographic Models (DKM) can be specified. Based on these specifications DIM-, DLM-, and DKM-databases can be realized; altogether these data are called digital topographic-cartographic geo-basic data. They form a digital land documentation on topographic-cartographic data of a country and can be used to derive market-oriented digital and analogue products following corresponding product specifications. Specifications in general are the basis for quality assurance during the production process of DIM's, DLM's, DKM's and all derived products.

Conceptual Data Model

The CDM delivers the terminology and the principles to be used to describe the objects and phenomena of the cartographer's real world in a formal manner needed for their handling by data processing techniques. It offers possibilities of modelling objects using the structural elements of the object-oriented data model. Important basic terms are "object", "object part", "complex object", "geometrical element", "vector element", "raster element", "object class", "attribute", "name", "overpass relationship", and "topological relationship". Basic principles are the planarity of the underlying graph, the assignment of topological relationships to the semantic level of object parts, the assignment of attributes to complex objects, objects, and object parts, m:n relationships between objects and complex objects and between object parts and geometrical elements, and 1:n relationships between objects and object parts. The current ATKIS CDM does not support rules, constraints, and the behaviour of objects. But, R&D projects on cartographic generalisation and on advanced up-dating procedures initiated by the Surveying and Mapping Agency of North-Rhine Westfalia and undertaken together with the university of Bonn, show the needs for adding such capabilities. (A more detailed description of the CDM gives [1].)

Quality Model

As already pointed out, quality means the conformance of a product with its specification. Basic data quality aspects to be used in a specification are the up-to-dateness, reliability, accuracy, and completeness to be achieved by a suitable production process. The quality parameters depend on the chosen CDM elements. Using the ISO 9000 standard family could be helpful assuring the intended quality. Eqivalent prodedures are being used by the ATKIS data producers.

The QM allows the definition and realisation of different DIM's, DLM's and DKM's according to the requirements of the different applications expressed by analogue and digital cartographic products. In addition, it allows the agreement on compatible quality parameters for the realisation of primary databases of official cartography and assigned secondary databases of users.

Positional references

The geometry of a spatial object and its integration into a coordinate system is its special characteristic comparing it with non-spatial objects. Therefore, this attributive information usually is subject to special conceptual considerations and agreements. The German coordinate systems are based on the Datum of the German Fundamental Control Net ("Potsdam Datum"; Fundamental Point Rauenberg, Bessel ellipsoid) and the Height reference surface NN (Amsterdam tide gage). For Europe-wide developments and applications the European Territorial Reference System (ETRS 89) with WGS coordinates can be used. For Germany, integrated lower order control nets have been measured and evaluated.

General topographic-cartographic object class catalogue

Using the terminology of the CDM, a general topographic-cartographic object class catalogue could be aggregated. This catalogue would be a list of all real world objects with all attributes and relationships

needed from the topographic-cartographic point of view, without assigning them to a specific digital description model of DIM, DLM or DKM type. Momentary, a separate GOCC is not part of the ATKIS standard; the existing ATKIS object class catalogue includes the specification of the DLM 25 with respect to chosing quality parameters and and the coordinate system, too.

DIM; DIM specification
A Digital Image Model is a seamless database storing the rectified results of remote sensing and scanned aerial photographs. It contains the spatial objects as unstructured pixel heaps. They can be identified by pattern recognition processes and could then be addressed by names and described by attributes and relationships. The CDM offers the needed structural elements. According to the resolution, DIM's of different accuracy and interpretability can be realized. This has to be fixed by the respective DIM specification, which uses the object classification of the GOCC. A DIM serves as an important basis for derived DLM's, especially for the up-dating process using image analysis techniques. Our agency is preparing DIM's according to 30 cm and 60 cm resolutions.

DLM; DLM specification
A DLM stores the real world objects classified by the GOCC as database entities using the modelling posibilities of the CDM in a seamless manner. The German AdV decided on the creation of DLM's according to the contents of the map series 1:25 000, 1:200 000 and 1:1Mio. The objects of the respective DLM's are simplified according to specified accuracies, but not cartographic generalized. There are specialized object class catalogues describing the contents of the DLM 25 and the DLM 200. For ATKIS DLM 25 data the German Gauß-Krüger projection is used, for ATKIS DLM 200 the IfAG decided to use geographical coordinates. In addition, the DLM specifications contain quality rules to be followed by the DLM production process.

DKM; DKM specification
A DKM is a cartographically generalized DLM. The generalization process depends on the space needed to represent the cartographic symbols according to a given map design. The structural elements are the same as those used for the DLM. It is planned to generate DKM databases for every map scale. The current ATKIS symbol catalogues serve as both the DKM specification and the specification of the target map. They contain DLM selection rules with references to the ATKIS object class catalogue, generalization rules and the signatures of the cartographic features. It is proposed to split the catalogue into a DKM specification part similar to the existing DLM object class catalogue and a product specification part.

There is a discussion in Germany on the suitable definition of a DKM. Some experts want to avoid a standardized abstract DKM database without executed object symbolization as described above. They propose only to create fully symbolized DKM's as raster data which can simply be used to produce map products.

The author's opinion is that both a vector based DKM without assignment of symbols to the objects and fully symbolized DKM's in raster form should be stored in a seamless manner to be able to derive DKM vector data products and DKM raster data products as well.

Concluding, the creation and maintenance of digital basic spatial data by Surveying and Mapping can be described in the following way:

A. DIM data as result of digital orthophoto production with 30 cm and 60 cm resolutions

B. DLM data for all needed accuracy levels (digital situation data and digital terrain data): DLM 25, DLM 200, DLM 1000

C. DKM data relating to the topographic map series (vector and raster data): DKM 25, DKM 50, DKM 100, DKM 250, DKM 500, DKM 1000 (and further DKM's when required)

Product specifications
The DIM's, DLM's and DKM's are no products directly to be provided to the users. They are components of the official land documentation on basic topographic-cartographic data of Surveying and Mapping and the basis for derived products to be provided to the geo-information market. The derivation of these analogue and digital products follows official specifications to be agreed on by the AdV. Digital products are specified by:

- the data content,
- the transfer mechanism,
- the transfer medium,
- legal transfer conditions,
- commercial transfer conditions.

The data content specification is the basis for the selection of DIM, DLM or DKM data and for the assignment of quality information to be given to the user. Transfer mechanism and transfer media are dependent on the possibilities of sender and receiver of a digital product; national and international standards have to be used as much as possible.

General rules are valid in Germany concerning the legal and commercial transfer conditions for both analogue and digital cartographic products. They are described in chapter 3.2.

DIM Products
The Digital Image Models with resolutions of 30 cm and 60 cm will be the basic databases for the derivation of analogue and digital image products. The AdV has set up a Working Group with the aim of agreeing on common digital DIM products for Germany. The Surveying and Mapping Agency of North-Rhine Westfalia is preparing a digital production process for orthophotos and orthophoto maps which leads first to a piece of a DIM, second the digital DIM product and third the analogue result. Currently we are producing orthophoto maps with scales 1:5,000 and 1:25,000. In the first run, a digital "orthophoto" and "orthophoto map" will cover the same area as the corresponding analogue one. As exchange format for digital products TIFF has been introduced.

DLM Products
Currently the DLM 25 and the DLM 200 are being created by the Surveying and Mapping Agencies of the *Länder* resp. the Institute for Applied Geodesy. There are different ways of providing a user with extracts from a DLM database as standardized products. The procedure depends on the application of this user.

Some important users want to create their own application oriented databases covering the whole region or large parts of it. They are to be integrated into a defined revision programme and to be served by our DLM database providing them with change only data.

The use of transfer media is limited to those supported by our data processing system. Our system is part of a wide area network maintained by the Statistical Agency of our country. It is based on the OSI standard. Interested users can directly access our data using this network.

The basic German exchange standard used for all DLM data transfer activities is the Uniform Database Interface (Einheitliche Datenbankschnittstelle - EDBS) published by the AdV. A general cost frame for DLM data is agreed on by AdV, too.

At present, the biggest problem of selling ATKIS data is that the users hardware/software equipments are not prepared to support the rather complicated structure of DLM data. First they have to prepare their own applications based on the ATKIS standard requirements. The impression is that this situation is just changing, and that we will have a lot of different applications using DLM data during the next year.

DKM Products

Extensive discussions have been started within the responsible working groups of the AdV on the future structure of products derived from DKM's. Especially the decision on a vector based DKM or a raster based one or on both will influence future product specifications. Until now, scanned datasets derived from existing analogue maps are offered as preliminary "DKM products". The demand for such data is rapidly growing because their short-term and relatively unexpensive availability and their simple data structure which allows also simple graphic systems to handle them. Based on the DKM idea, future map production would change significantly. At present, the biggest problem is to come to an efficient procedure of deriving DKM's from a DLM. This process is complicated because of unsolved cartographic generalisation problems. We try to come to a solution using our ALK-GIAP software in close cooperation with scientist of the Institute for Topgraphy and Cartography of the university of Bonn. In parallel a new design for our topographic map series is being developed by an AdV working group.

3.2 Legal and commercial transfer conditions

In principle, knowledge about the objects and phenomena on the earth´s surface is open to everybody as long as justified private or public interests are not contradictary.

Examples for private interests to be observed are:

- personal data in general (land ownership)
- personal right on privacy (high resolution remote sensing)
- inventions (industrial plants)

Partly these interests are protected by law in several European coutries. An example is protection of data privacy in Germany.

Examples for public interests to be observed are:

- militarian interests (military plants)
- protection from terrorism (endangered objects)

In Germany these objects are not shown in public maps and orthophoto maps. Basis for protection is the Criminal Code.

The above mentioned aspects limit the allowance of both information collection and its proliferation. Further aspects have to be taken into account relating to the use of existing map data and their general proliferation to anybody.

There are national and international, especially European aspects of this topic. In Germany we are convinced that, with respect to our specific situation the best solution will be to protect official data produced by Surveying and Mapping Agencies by public law as already successfully done in North-Rhine Westfalia. Besides of this public law based solutions, important other legal aspects are based on Copyright, law of competition (unfair competition), law of contracts.

The main aspects of legal protection of Geo-Information are presently being discussed within the European Community based on the "Green Paper on Copyright and the Challenge of Technology" issued in 1988 by the Commission, Directorate General III/D-4 (Internal Market and Industrial Affairs). It includes the chapters

1. Copyright and the European Community
2. Piracy
3. Audio-visual home copying
4. Distribution right, exhaustion and rental right
5. Computer programs
6. Databases
7. The role of the Community in multilateral and bilateral external relations.

From an economic point of view, the main goal must be to create a free market on Geo-Information in Europe, where the different actors, the public and private data producers, value adding service companies, data distributors, public and private data users can play their role following clear defined legal conditions as pointed out.

CERCO is preparing this Geo-Information market based on the MEGRIN concept, which allows the integration of all mentioned actors in a well defined way. CERCO is interested to develop MEGRIN together with interested partners representing the different roles of the market actors.

In Germany contacts with other public data producers e.g. the Road Administration have been started to come to agreements on the responsibilities of the different involved parties. The exclusive responsibility of Surveying and Mapping Agencies for basic spatial data collection has been fixed by governmental acts of the different states.

On the other hand private firms are involved in data capturing on contractual basis. Recently a draft contract has been developed together with a company interested in data distribution, based on a similar solution for map distribution installed since many years. The supply of data is following a nation-wide agreed cost frame with dicount possibilities dependent on the amount of ordered data.

Without doubt, a main market factor in the field of digital data exchange is the existence of clear defined and commonly agreed standards. CERCO is very active in that field, together with user groups like CNIG in France and AGI in Great Britain, with industrial partners as the main European car manufactorers and electronic companies and with the militarian standardization body for spatial data DGIWG. A close cooperation has been established in the DRIVE project Task Force European Digital Road Map, which lead to drafts for a family of spatial data standards, a Conceptual Data Model and a Quality Model. Another proposal has been prepared by CERCO dealing with a common geodetic reference system and common European coordinate systems. Further activities in the standardization field are now given to a recently established Technical Committee "Geographical Information" of the European Standardization Committee.

Without standardization spatial data exchange in Europe would cost a lot of money. Spatial data structures are very complex and transformation software development is time consuming and expensive. (See also [2])

4. Data integration aspects

Spatially related application oriented data are being produced by a lot of application oriented official institutions dealing with e.g. statistics, planning, environment protection, supervision. Their data sources are

- existing official maps and data
- aerial photographs and satellite imagery
- field survey.

Most of them are waiting for basic spatial data being produced by the official Surveying and Mapping Agencies. Established cooperation procedures based on analogue maps from Surveying and Mapping are just being supplemented by digital mapping techniques based on ATKIS data as official standardized basic spatial data products provided by Surveying and Mapping, too.

Besides of official spatial data producers, private companies are more and more engaged in the spatial data production process, a sigificant hint to the economy of this new technique. They are involved

- on contractual basis acting for public institutions,
- in order to support their own production process,
- in order to offer their spatial data products to the market.

Their data sources are

- official and private maps
- aerial photographs and satellite imagery
- field survey.

Problems will arise, if private firms will not be informed about legal restrictions on the use of official data sources or ignore them.

Official basic spatial data products should be the basis for public and private applications to guarantee

- standardized coordinate systems referred to by all participating parties,
- standardized data definitions enabling the sharing of information in different information systems and data exchange without larger problems

The above mentioned standards are parts of a family of spatial data standards being developed by CEN and integrated in the Multi-purpose European Ground-Related Information Network (MEGRIN) concept, which is to be realized by the Comite Europeen des Responsables de la Cartographie Officielle (CERCO)[4].

Integrating data and value adding services for Geo-Information will play an important role after the realization of large Geo-Information systems. It will become a main business for private companies to prepare geo-data according to the demand of the market and provide it to a lot of users. For Germany, ATKIS data products will play an important role as the basis for integrated products of a lot of applications.

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Digital geological map production in the UK – more than just a cartographic exercise

E.F.P. Nickless, I. Jackson (Nottingham, GB)

1 INTRODUCTION

1.1 Since its creation in 1835 as the Geological Survey of England and Wales, the organisation known today as the British Geological Survey has experienced many changes of title. As presently constituted, the Survey is a component body of the Natural Environment Research Council, one of five Research Councils in the United Kingdom charged with responsibility for administering and funding scientific research.

The Survey is funded from three principal sources in almost equal amounts. By a block grant from Government via the NERC, the so-called Science Budget; through commissions awarded competitively by Departments of State to undertake geological work in support of policy; and from contract work for the newly privatised industries, regulatory bodies, industry and commerce.

The Survey's mission is to maintain and to keep up-to-date the geological map of the UK. This activity, which forms the Core Programme funded by the Science Budget, is approved and monitored by a Programme Board which includes representatives of the major users of geological information. The profile of the work programme is shown at Table 1.

A 15-year programme to bring the geologically mapping of the UK up to a modern standard was begun in 1990. Surveying is usually undertaken at a scale of 1:10000 and the mapping is summarised in 1:50000-scale colour printed maps supported by descriptive memoirs. The Programme Board has set a annual publication target of an average of 21 1:50000-scale maps and 15 memoirs.

2. GEOLOGICAL MAPS

2.1 Geologists have traditionally summarised their work in map form. In the United Kingdom, one the first geologists to do so was William Smith, the Father of English geology, who in 1815 published his map at 1:313,800 scale of England and Wales. Smith, a civil engineer, was concerned to establish the practical application of his geological observations and interpretations. His maps record the practical use of the various rock formations, for example as sources of building stone, coal, brick clay and so on.

The simplicity of Smith's maps has been lost as geological theory and understanding has developed. As the information base and expertise have expanded, geologists have increasingly included more detailed interpretations of the geology. Often, this results in complex maps which are intelligible only to a professionally trained person. As a result, there has been a failure to ensure that geological information is readily available in an easy to understand form to those who need it.

Recognising this, within the last decade there has been a radical change to the map products required by some of the Survey's major customers. New series of maps illustrating one or more themes of interest to planners, developers and other potential users have been prepared. These 'applied' or 'environmental' geological maps at 1:25000-scale were first developed in the Fife Region of Scotland based on the Glenrothes area[1, 2] and included topics listed at Table 2.

2.2 Geological maps show the distribution of rock-types and their relationships but it is critical to understand that they are a two-dimensional representation of a three-dimensional structure - the uppermost part of the Earth's crust. Geological maps are thus not merely a portrayal of surface features, they are also an interpretation of rock-structures at depth. There is a second significant distinction between topographic and geological maps. Although the topographic map is subject to limitations of scale, measurement and projection, and becomes outdated in light of man-made and natural modifications to the land surface, it is based on direct observation. In contrast, the geological map attempts to represent what is largely unseen. It is based on information revealed in natural and temporary sections such as cliffs, gullies or man-made excavations, and drill holes. It is thus an analysis of both surface and subsurface information available at the time of survey. In an area of few outcrops much may be conjecture and new data, for example a new borehole or road cutting may alter dramatically the interpretation, and hence the map.

In the UK geological maps are often issued as two editions, Solid - the consolidated rocks and Drift - the superficial, unconsolidated Quaternary and Recent deposits. They are presented at a variety of scales, from the largest at 1:10000 (which have to date been released as a monochrome paper dyeline/diazo) to smaller scales - 1:50000, 1:250000 and 1:625000 - reproduced by offset-lithography.

2.3 Geological maps produced by these conventional methods have their weaknesses. Like all "fixed" paper products they are inflexible. It is time-consuming to separate chosen elements, to change scale, to integrate other information or to vary the area. Despite the production of two editions (Solid and Drift) geological maps can be complex documents, a mixture of factual and interpretive detail, and when presented in monochrome may be very difficult to interpret. Arguably, the most significant weakness of maps which are often based on the evaluation of only a few pieces of hard data, is the difficulty to update and revise. As a national repository for geological data, BGS acquires new information at a dramatic rate but its maps are amended only infrequently. The desire to arrest this progressive obsolescence was a primary stimulus for BGS to develop a digital system for the production of its 1:10000-scale map series.

3 DIGITAL GEOLOGICAL MAP PRODUCTION

3.1 *Why do it?*

3.1.1 Whilst an initial stimulus was an ambition to synthesize and update geological maps rapidly, the move to a digital system was also seen as an opportunity to create a digital geological map database as a primary BGS information resource. The overall objectives of the 1:10000-scale digital map production system were thus:

i. to establish a digital geological map database.

ii. to facilitate the continuous revision of maps by updating the digital database.

iii. to provide data in digital format to be integrated with other systems including internal and external modelling and Geographic Information Systems software.

iv. to produce high quality (and readily understood) geological maps.

v. to allow the generation of non-standard, customer-specific output.

vi. to ensure consistent standards of format and production.

The development of digital geological map production in BGS was therefore not merely seen as an isolated cartographic exercise, designed simply to provide a digital facsimile of the conventional geological map. The intention was to capture the data contained within the map, the points, lines and polygons and their **geological** attributes, to create linked spatial and non-spatial databases and deliver a variety of digital and paper products.

3.2 *Objectives*

3.2.1 There was considerable geological computing expertise already available in the Survey to achieve these objectives. Digital geological map production had been attempted in the 1970's but the available hardware and software was insufficiently mature[3, 4, 5]. Throughout the 1980's Computer-Aided Design (CAD) and Relational Database Management System were used in diverse projects across BGS. In the late 1980's digital cartographic systems were being used in the preparation of several 1:50000-scale maps and GIS was being investigated for the production of applied geological maps[6, 7, 8]. The experience from these programmes fed into the definition of the objectives and provided the basis for the development of a comprehensive operational requirement and contract specification for the hardware and software. In early 1991 a project team was assembled to implement the digital system.

3.2.2 The project aims required significant resources both in terms of capital outlay and the input of diverse skills - geology, cartography, systems analysis, database design and management, system design and procurement and GIS. A formal project management methodology was adopted to ensure effective co-ordination of what was a complex multi-disciplinary task. The project team was organised into a number of sub-projects co-ordinated by a Project Manager who in turn reported to a Project Management Board comprising 3 senior BGS managers (see Figure 1).

3.2.3 Central to the project was the desire to create a digital map database. Consequently, the data structure (modelling) element of the project was considered fundamental. The database was designed at a conceptual level (the logical model) before any attempt was made to implement it on the chosen hardware and software. There were two reasons for this. First, it was critical that the system met the specific BGS objectives. Secondly, it was crucial to maintain the scientific integrity of the data to allow future vendor independence, providing the potential to implement a system on other hardware and software platforms.

3.2.4 The tender for the hardware and software was won by Intergraph (UK) Ltd and the equipment was installed in October 1991. A preliminary version of the system was implemented in April 1992 and the final system was ready for operational production in December of that year. The system is based on the concept that the spatial data are held within the cartographic/GIS system (Intergraph's Microstation and MGE) and are linked to non-spatial data and attributes held within the corporate Relational

Database Management System (Oracle). By issuing queries against the linked databases it is possible to generate a variety of conventional geological maps or non-standard products.

A much simplified workflow, which omits quality control and map management stages is outlined below.

i. The geologist prepares manuscript geologically attributed lines master and colour models.

ii. Manuscript lines master and colour models approved by Line Management.

iii. The cartographer digitises map, generates polygons and captures attributes.

iv. Electrostatic plots of required editions generated; raster topography added at immediate pre-plot stage.

v. Plots approved by Line Management; plot files held for reproduction on demand.

3.3 The key has been to develop a system which is based on geological as opposed to cartographic attribution of the lines, points and areas on a map. Thus the system is not only capable of offering scale variation and site-centred mapping, but because the individual elements have been stored in a geologically structured way, they can be selected and combined at will to produce geologically customised products. For example, it is possible to select the areas of fill and made-up ground in a particular region and to depict their coincidence with a particular underlying solid unit. The facility to select elements of the map and plot in colour makes the maps much clearer and more intelligible than their black and white dyeline predecessors. In digital form the map may be manipulated much more readily and the ability to edit and revise will allow the maps to be updated in response to new information. A fundamental benefit is the capability to provide geological map data in digital form so that it can be readily integrated with other information by using a GIS or surface modelling software. Thus the system provides BGS with the capability to handle the large volumes of data required to digitally produce some 14 of the 18 applied geological 'element' maps drawn manually for the Glenrothes project. It is also possible to integrate the socio-economic criteria necessary to generate the Environmental Potential maps (see Table 2).

ISSUES ARISING FROM IMPLEMENTATION

4.1

4.1.1 The introduction of routine production of 1:10000-scale digital geological maps by the Survey's cartographic staff has involved the adoption of new skills and changes in long-established working practices. This has met with some resistance from staff. In part, the transition to new working methods has been made easier by the introduction several years ago of digital techniques in place of scribing in map production. The new practices can therefore be regarded as a continued evolution of that process.

Nevertheless, it has taken time and a considerable amount of effort on the part of senior management to set the overall strategy and the longer term vision of a map series derived from manipulating geologically attributed spatial data with other databases. It has been necessary to convince the cartographic staff to look beyond map production as an end in itself and to see themselves as an important part of a team engaged in database building. Some of main issues in bridging the cultural change include:

failure to appreciate the databasing content of the work and an unwillingness to undertake non-cartographic tasks, for example the addition of geological codes (attribution) to line segments;

resentment of other disciplines encroaching into 'cartographic domain';

a perception that cartographic skills have been devalued;

the need to formalise and standardise of working practices limiting scope for individual freedom of action;

the integration of cartographic and geological disciplines such that neither any longer work in isolation.

The work of building the geological map databases must not been seen in isolation but in the context of the Survey's total information strategy. BGS' aim has been to pursue an integrated, 'holistic' policy and it has expended considerable effort in the last few years identifying and cataloguing a data holding in excess of 750 individual datasets.

4.1.2 The introduction of a digital system also continues to meet with some resistance from field geologists. Traditionally an independent profession, many geologists resent the introduction of the standard specifications and dictionaries necessary to ensure the success of a national map database. A more rigorous approach to quality control has been essential - GIS do not tolerate the practice of using vague cartography to hide

geological uncertainty! There has also been a failure to appreciate that the versatility the system provides comes at a price and there is resentment of the increased effort needed to explicitly attribute to maps in order to build the database.

4.2 System and data management has proved to be a very complex area; provisional procedures are in place but a considerable amount of work remains to be done. Some of the more significant issues encountered are:

> The designed system is an integrated operation which crosses BGS divisional boundaries; new standards and procedures for data management are being devised to replace pre-existing diverse (and often ad hoc) methods. The system requires close supervision and map managers have been appointed to ensure effective liaison between the geological and cartographic divisions.
>
> Problems arise because geological maps released by BGS are regarded as authoritative documents which may be used in litigation. Conventionally the master version of the paper map carried the approving signature of the Chief Geologist but it is difficult to retain this necessary formal approval procedure and yet exploit the flexible and dynamic virtues of a digital system. For the moment BGS has opted to take a magnetic archive copy of the database following Chief Geologist approval of an electrostatic plot of the map. The problem, in essence one of version control and archive management, highlights a further difficulty, that of validating those parts of the database which are not graphically represented on the map. Checking these items will involve significant effort.
>
> The digital map system has been designed to access and display information held in BGS databases which lie outside the responsibility of the map production system (for example borehole and structural data). The independence of these databases means that effective procedures are necessary to ensure there is no conflict between the contents of the various databases and their graphic representation on the map face.

4.3 The problems associated with dissemination and release of the digital map data are considerable as in the UK data are regarded as a tradeable commodity. It has proved difficult to reconcile a cost-recovery policy necessary to sustain research and map production and yet ensure the products are available to all at a fair and affordable price. Additionally the problems of policing copyright of digital data and controlling unauthorised digitisation of BGS map holdings cannot be understated. After long discussion a comprehensive charging structure is now in place. Multi-coloured electrostatic plots of 1:10000 maps are replacing monochrome dyeline (diazo) copies and their price reflects the higher quality product and the technology used to produced them. Digital data at 1:10000, 1:50000 and 1:250000 are available in raster and vector formats. Raster data may be purchased outright while vector data are available only under licence.

4.4 The success of the development of digital mapping in the Survey and its adoption in production has depended in no small part on the commitment of senior management in identifying and protecting the project team from work conflicts and providing the significant financial resources for the purchase of equipment and software. The project has drawn staff from many groups across the Survey, on average 8 man years per year over the last 3 years, with a budget for travel and consummables approaching £30k annually. A significant challenge has been to ensure the staffing levels agreed at the beginning of each financial year are not eroded by competing demands from contract work.

The time taken to produce a 1:10000 map using digital methods is probably 20% greater than traditional methods. The advantage comes in the facility to readily update the map and the opportunity which a digital database provides to generate tailored and non-standard map products. The initial investment as data are converted from paper to digital formats is substantial but unavoidable. A small production team, initially three strong but planned to grow to five from April 1993 has been identified and targets set. The aim is that as digital map sales develop, the team should become self financing.

Although the potential of digital data in Geographic Information Systems is widely recognised, there is currently little expressed demand yet in the UK for a digital geological component. In part this may reflect a failure on the part of the Survey to inform the potential client base. The Survey strategy will continue to be to use market surveys to meet customer need.

5. NEXT STEPS

5.1 Following implementation of the 1:10000-scale system BGS is now investigating the feasibility of extending the geologically attributed approach to its 1:50000-scale series. This series is currently produced by digital means but by a cartographically structured process. The advantages established for the 1:10000-scale system retain their validity regardless of scale and extension of a similar approach to the 1:50000-scale series will more readily enable provision of national coverage of geologically attributed digital map data.

5.2 A number of the implementation team are now concentrating on the digital production of non-standard (customized or thematic) geological maps. BGS has considerable expertise in the conventional production of thematic or applied geological maps and sees the capability to generate these digitally as crucial to its future business. The first phase, the production of map variants based on map face data alone - scale and area variation, element and selection and permutation - has been successfully completed. The next phase is to refine and automate the generation of maps from

multiple datasets i.e. map-face data integrated with other digital information - for instance borehole, geochemical, geophysical, mining and quarrying, environmental and planning data.

5.3 Under the aegis of the project BGS is also investigating two systems for digital acquisition of data in the field. The first venture is using established laptop technology and a Canadian Geological Survey software package called FIELDLOG to record and build databases of geological observations e.g. lithological and structural data. The second is taking the concept further and is exploring the feasibility of using pen-based systems for construction of the field map and notes in the field. A comprehensive user requirement has been developed and a pre-prototype trial is currently taking place to establish whether the technology possesses the basic functionality.

6. SUMMARY

The development of the two-dimensional digital system is a significant advance on current conventional methods of disseminating geological map data. However, geology is a three-dimensional science and the long term goal must be to develop a system to deliver a three-dimensional digital spatial models which can more fully, analyse and illustrate the reality of complex geological interrelationships. BGS intends to build on the advances made to date which reflect a structured approach to the construction of digital databases, an acceptance of an imposed data architecture, the commitment of both staff and financial resources by senior management to the project and its subsequent implementation in map production.

Over the coming year a number of digital map products will be made available under licence. A series of 1:10000-scale maps for an area of north London were released in January 1993. The 1:250000-scale geological map of mainland Britain with cartographic attributes will be available as a series of digital files by end-March 1993. The aim is to provided this as a full geologically attributed dataset during 1993. Work is in hand to release a number of 1:50000-scale maps as digital files.

The move is towards digital data provision with the printing of maps 'on demand'. It follows that many of the maps produced in future will be ephemeral and customer specific. It is reasonable to assume that there will continue to be a demand for printed material and that for the foreseeable future the Survey will continue to provide a coherent printed map cover for the UK at the 1:50000-scale. However, the emphasis is changing to the underlying data and interpretation, and away from printed map products. Within this the centrality of the databases is assuming overriding importance and the printed map will increasingly become regarded as peripheral by many users, although we do see a continuing requirement for hard copy.

7. ACKNOWLEDGEMENTS

The Digital Map Production Implementation Project is a multidisciplinary BGS initiative and we would like to acknowledge the efforts of all the project team. This paper is published by permission of the Director, British Geological Survey (NERC).

Figure 1


Project Management Board
Project Manager
System Design And Procurement - define and obtain hardware and software
Customisation - undertake the physical implementation
Data Structure - analyze map data and design a logical data model
Conventions - establish digital map specifications and procedures
Logistics - Cartographic staff training and accommodation
Strategy - devise digitisation programme

Table 1 THE BRITISH GEOLOGICAL SURVEY CORE PROGRAMME

The programme comprises a series of long-term strategic survey and monitoring activities. There are six elements:-

- onshore geological mapping;
- offshore geological mapping;
- geochemical surveys;
- geophysical surveys;
- hydrogeological and geotechnical surveys, and
- National Geosciences Information Service, whose role is to draw together and disseminate the Survey data.

Table 2 ENVIRONMENTAL GEOLOGY MAPS RELATING TO ORDNANCE SURVEY SHEET NO 20 (based on Glenrothes in the Fife Region of Scotland)

Element maps (basic data)

1 bore sites
2 unconsolidated deposits
3 lithology of the unconsolidated deposits
4 engineering properties of the unconsolidated deposits
5 thickness of the unconsolidated deposits
6 depth to water in the unconsolidated deposits
7 sand and gravel thickness
8 bedrock geology
9 bedrock lithology
10 rockhead contours
11 shallow undermining
12 natural landslip potential
13 opencast workings
14 hardrock aggregate resources
15 limestone resources
16 brick and tile clay
17 mudstone for brick making
18 hydrogeology

Derived maps (combining two or more elements)

19 underground storage potential within 100 m of the surface
20 sand and gravel potential
21 foundation conditions
22 groundwater resources

Environmental Potential (summary maps based on the element and derived maps)

A development potential
B priority areas for on-site investigation
C^1 resources at or near the surface which might be won by opencast working
C^2 buried resources which might be won by opencast working
C^3 buried resources which might be won by pumping or mining

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Mapping supported by the national land information system in China

J. Jiang, D. Wang (Beijing, RC)

Introduction

The National Land Information System (NLIS), which is being developed by the Research Institute of Surveying and Mapping, the National Bureau of Surveying and Mapping (RISM, NBSM) since 1984, is the main information system of the NBSM and one of the sub-systems of the National Economic Information System in China.

The system includes the Map Data Base, the Geographic Names Data Base, the Geodetic Data Base, the Gravity Data Base, the Data Base Management System for both vector and raster data, and some application models.

As the first step in developing the NLIS, the 1:1M-scale Map Data Base (MDB) and 1:1M-scale Geographic Names Data Base (GNDB) over the whole China have been established. The MBD is supported by the VAX 11 series computers, ARC/INFO and some software developed in house. The data, derived from the positive films which are directly copied from the safety copies of 1:1M-scale map sheets, contain following categories indigital form: hydrography, transportation, boundary, residence, vegetation, hypsography, DEM, etc. The DEM cell size is 28″.125 X 18″.750(longitude X latitude) and the points number is 25,000,000. The GNDB is supported by the VAX computers and the RDBMS ORACLE. They are not only experimental, but also practical data bases. They have been and willbe applied to a wide range of fields of the national economy agencies in China, for example, they can be used for macroscopic retrieving and analysing nationally, or as basic data for other systems, or to reduce the time cycle for compiling and updating maps at 1:1M and smaller scales.

The MDB Development

The data of the MDB are captured through manual digitizing or scanning according to different features and their density. All data are fully topologically structured and attribute coded.

The data category and attribute codes (or feature codes) are used to describe the map features represented by a point, line or area in the MDB. The category and codes are based on the Cartographic Symbolizations of the NBSM topographic map series.

An attribute code in the MDB is composed of two distinct subfields: a category code and an identified code.

The category code indentifies the category to which the element belongs.

The category of the features has three classes. Table 1 shows the catalog of the first class used in the MDB.

1 ——————— Hydrography
2 ——————— Residence
3 ——————— Transportation
4 ——————— Pipe Line
5 ——————— Hypsography (Terrain)
6 ——————— Boundary
7 ——————— Vegetation
8 ——————— Others

Table 1. The catalog of the first class used in the MDB.

The identified code is only used to describe some major features, such as cities and boundaries with political levels higher than or equal to county, railways, main roads, main rivers. The tag in the category code indicates if there is an identified code for a certain element.

Considering relationships between features and the data structure used, the da-

ta of every map sheet are divided into 13 layers which form 13 coverages. Table 2 indicates how the layers divided and contents of each layer (the number under this column are correspondance to sequence numbers in the Catographic Symbolization of 1:1M-scale Map of the NBSM).

Feature	Layer	Contents
Contour	1	53
Other topography	2	54——66
Hydrography	3	20,21,29——31,34, 36——39,42,49——52
Hydrography(area)	4	32,33,35,40,41,43, 45,47
Railway	5	9——14,19,193
Road	6	15,16,45,60,192
Trail	7	17,18
Residence(point)	8	3——8
Residence(area)	9	1,2
Boundary	10	24——28
Vegetation	11	67——71
Other point features	12	22,23,44,72——75, 78,79
Other line features	13	76,80——82

Table 2

The layers metioned above could be divided further, or combined if necessary.

Data capturing has to meet following requirments:

1. Keep continuity for linear features;

2. Form completely closed polygons for area features;

3. When an object has 2 or more attribute codes, for instance, a boundary on a section of a river, it is only digitized once and recorded in the feature coverage which main attribute code (in this case, river) belongs to. Its secondary attribute code(s) (in this case, boundary) is recorded at the same time.

4. Sometimes, it is neccessary to add some arcs with special codes at certain place, such as the sections of roads or railways cut down by bridge or residence symbols, the section of lake bank at the mouth of a double line river, the sec-

tion of a large reservior bank at the interior side of its dam, and so on.

5. For manually digitizing, the positional error should be less than 0. 2 mm. The distance between adjacent 2 vertexes on curve line should be less than 0. 5—0. 8 mm and the bigger curvature is, the shorter such distance should be.

6. The noise came from scanning and useless data, such as too narrow double lines, too small lakes, have to be removed. The data should be transfered into a coverage, including coordinates converting from scanner coordinate system to map projection system, using certain commands. Then additional manual digitizing for part of features is usually needed.

For different features or layers, the different attribute tables have been designed. Each table consists of the item name, input-width, output-width and type. Every table has three same items: user-ID, category code and identified code. Table 3 is an example of such tables:

item name	user-ID	category code	identified code	name	subordinate basin code	navigable status	…
input width	4	6	6	20	6	1	
output width	5	6	6	20	6	1	
type	B	C	C	C	C	C	

Table 3. Attribute table of rivers
(including canals and ditches)

The items for every feature or layer can be increased depending on requirments, and existing statistic data and other source materials.

Every coverage should be seriously passed the testing of data quality control, to ensuer that data are accurate and reliable for the MDB users.

The data quality testing consists of following points:

1. Check the logical consistency and completeness.

2. Check the Position Accuracy.

3. Check the Attribute Accuracy.

After data quality control, the data are digitally edge matched to adjacent map sheets. Each edge of a coverage should be checked for positional and attribute matching along the neatlines with adjoining cooresponding coverages. For positional matching, the error allowed is 0. 2mm; and for attribute matching, no difference is allowed.

The GNDB Development

The GNDB contains about 80,000 geographic names on all 1:1M-scale map sheets over the whole China. The main items in the GNDB are User-ID, name on 1:1M map, standard name, Chinese phonetic name, 1:1M map number, geographic name category code, population, area, length, elevation, transportation status, longitude, latitude, etc. The User-IDs are the same with those of relevant objects in the MDB. Some data are come from the MDB, sucu as longitude, latitude, length, area, elevation, and so on. All other data are inputted into microcomputer based on DBASE III and CCDOS first. After checking and correcting, they are transmitted into VAX. Names in the GNDB can be added, updated, printed, and plotted in Chinese in several ways. It is in accordance with the standard of Geographic Names Information System of National Committee of Geographic Name.

The technic interface between the MDB and the GNDB is designed, so that the geographic names can be retrieved from the GNDB according to the category code or the identified code which are the same in both attribute tables of MDB and GNDB for the same object. The chinese codes geographic names retrieved from GNDB and the positional data of the same name retrieved from MDB are used for automatic annotation on output map or on screen in different Chinese lettering styles and different sizes. Of course, it is necessary to do some modification interactively.

Symbol Library Creation

The software ARC/INFO is designed in common use. Its symbol library is not enough for mapping in accordance with the Cartographic Symbolizations of different scales map of the NBSM in China. More symbols including point, line and area (pattern) symbols need to be added into the symbol library in ARC-PLOT module, such as symbols of residances, administrative boundraies at the different political levels, the symbols of different vegetation types, and so on. For symbols on maps at the different scales are not the same, symbols of 1: 1m-scale map were added first, others will be created afterwards.

Some symbols such as different types of deserts are scanned from analog patterns with high resolution (1,000 dots per inch), and are used when plotting using raster format.

Chinese Character Data Base Linking

To annotate geographic names on maps in chinese, it is necessary to link the Chinese character data base with ARC/INFO. There are several kinds of Chinese character data bases, both in vector and raster formats, on the market. The standard data base consist of about 7,000 characters and 4 or more lettering styles. Characters can be retrieved one by one according to respective code, pronunciation or other conditions. However, the data bases on the market are not enough for geographic names annotation. There are still about 1,000 special characters needed to be added into the data base.

The Chinese character data base is out of ARC/INFO v. 5. 0. 1 for its fonts are limited. A interface was developed to link the data base with ARC/INFO. It reads vector data of each character from Chinese character data base and writes it into a coverage.

Mapping supported by the NLIS

After the MDB, the GNDB and the symbol library have been developed, the well designed NLIS are satisfactory basis for mapping. It has been used and will be continuously used to produce lots of maps in different ways.

1. Generate New Version 1:1M-scale Maps

The data of the MDB and the GNDB can be used to produce 1:1M-scale maps like a copy from the source maps. But, this is not the goal for the NLIS design. It is interested in generating new version maps. For this reason, data were updated before use. The steps are:

(1). Collect and analyse all information used for updating, choose those which can be shown on maps at the scale of 1:1,000,000;
(2). Compile a set of correction maps based on stead film, on which all updated features are drawn;
(3). Digitize the correction maps;
(4). Add new data into the data bases instead of corresponding out-off-time data, then do some editing for adjustment.

Two methods were used to generate the new version maps:

One is using vector data did in RISM, NBSM. The procedure is as follows.

(1). Selecte data of all layers one sheet after another;
(2). Annotate all geographic names from the GNDB into a coverage according to perspective coordinates in the MDB. The coverage is of a line feature layer. At the same time, each annotation was geven a sertain code to assign lettering style, size and colour when plotting;
(3). Execute AMLs to create plot files, in which each class of data was assigned a sertain symbol and colour;
(4). Output plots on electrostatic plotter or pen plotter.

Another way is using raster data did in USGS. The procedure is as follows. *
(1). Execute AMLs on all coverages to assign a value to MAPITEM that represents the graphic symbol on the FEATURE attribute in cover-id;
(2). Execute AMLs to generate ARCPLOT files based on their final output colour separation. Symbol lookup tables were used to simplify changes in sym-

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* We have a coopration research with USGS in developing GIS techniques. This passage was quoted from Mr. R. Keeler's paper: " Generation of a 1:1,000,000-scale Map Product from ARC/INFO Coverages Using Automated Cartographic Techniques".

bolization;

(3). Execute Plotscitex command to convert plot files to Scitex vector format. Font tables were used to pass line, area and marker symbol information from ARC to the Scitex;

(4). Load files onto Raster Editing system. Convert data from vector to raster and apply appropriate line and area pattern symbolization;

(5). Interactively edit raster symbolized files as needed to correct unique situations;

(6). Output final color separation negatives with unique printing screens included.

2. Compile a Set of Maps at the Scales Smaller Than 1:1,000,000

A set of maps at the scales of 1:2,500,000, 1:4,000,000 and 1:6,000,000 have been made from the MDB and the GNDB. They are:

(1). The Drainage Map of the southeast part of China (1:2,500,000);
(2). The General Map of China (1:4,000,000);
(3). The Transportation Map of China (1:4,000,000);
(4). The Administrative Map of China (1:6,000,000).

The procedures for creating these maps are similar except the data selection. After selecting sertain data, convert pojection from Stand Alone Conical Conformal Projection for each map sheet into the Normal Conical Conformal Projection With Two Standard Parallels for all map sheets. Then merge data files of all map sheets one layer after another to get new 13 coverages. Generalize such data using GENERALIZE command. The rest steps are the same like those used to create the new version 1:1M-scale maps mentioned above.

3. Produce Analysing Maps from the DEM

A program package was developed for analysing the DEM. Executing this package, lots of analysing maps were plotted, such as terrain profiles, slope maps, layer style maps, 3-D maps draped by other features, etc. Supported by geographic quantity analysing, the Geomorphological Map of China at the scale of 1:4,000,000 and the Relief Amplitude Map of China at the scale of 1:10,000,000 were compiled.

4. Overlayed by Some Thematic Data to Create Thematic Maps

The 1:1,000,000 data can be seen as basic data for compiling thematic maps similar to the master maps for traditional thematic map compiling. It is easy to create some thematic maps by overlaying thematic data, such as land use map, vegetation map, soil map, and so on. the only question is data registration accuracy. It means that they have to convert into the same projection, the same scale and after overlaying the registration accuracy is good enough.

5. Produce Some Statistic Maps

Statistic map is one kind of thematic maps. Combined with statistic data, the MDB and the GNDB are used to produce some kinds of statistic maps, such as population maps, economic maps, historical disaster maps, etc. so long as the statistic unit is corresponding to any kind of polygons, lines or points in the MDB, like county boundries. For example, the Poor County Map of China at the scale of 1:4,000,000 is generated using the statistic data based on the unit of county.

6. Some other maps have been planed to produce, examples are the image maps, the Flood Status Forecasting Map of China as one of TV programs.

Conclusion

The advantages and characteristics of mapping supported by a GIS like the NLIS in China are evidently.

1. Maps can be in both digital and analog forms at the same time. The former can be easy used to spatially calculate and measure length, distance, area, slope, position (coordinates), angle, etc. instead of manual graphic measuring. The latter can be used as tranditional maps. Users can choose any one or both of them.

2. Geographic names can automatically and quickly located on maps in different Chinese lettering styles and sizes, even it is necessary to do some modification interactively.

3. Flexible change in map content, projection, scale, symbol and output form. Based on data layers and attribute codes, features can be selected by layer, any attribute items such as category code, identified code, by any polygons, by topology, or by sertain domain. These conditions can be combined to make more complex selection. The NLIS provides more than 20 kinds of projections normally used in China. It is easy, quickly and accurately to convert projection from one to another. The map scale is easy and quickly to be reduced or enlarged as well. Of course, the accuracy will be lower when enlarged, and the vertex density of curve lines will be higher when reduced. The symbol style, pattern, size and colour can be changed and the results can be displayed on the screen before plotting, allowing users to make a comparison. Maps can be drawn on paper, cartographic film, or scribed on scribecoat, or exposed on photographic film. So, it can be done to provide different maps for different users based on the same data base. It is impossible to do so in traditional cartography.

4. Reduce the time cycle for compiling and updating maps. Based on a existent data base, only changed festures need to be modified and new features need to be added. All other data, which are normally a large percentage of data in a data base, are still keeping. In this case, the time spent for compiling and updating maps can be reduced. Map updating can be made much more times than tranditional mapping. It gives us the possibility to update maps timely.

5. Four colour printing can be used for map production in analog form. Data can be output on four exposed or scribed film separately, which present colours of yellow, magenta, cyan and black respectively. They are directly used to make four printing plates. It omited several steps including reprographying, photographying processing, colour separating and retouching.

6. More new kinds of maps can be made, for example, the 3-D map with some other features or images draped on it. In anticipation, there will be more and more maps generated.

Though it has lots of advantages to produce maps supported by a GIS, there are still some problems needed to be overcome. For instance:

1. Some symbols normally used in tranditional cartography should be changed to adapt automatic mapping.

2. Data generalization technique is required when producing maps at the scale smaller than the data base.

3. High quality plotter with high resolution (such as 1,000 dots per inch or more) is needed to make good quality maps.

Reference

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