EURO-CARTO I*

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ABSTRACT

Euro-Carto I was a small (60 strong) scientific seminar held in New College, Oxford, from 13-16 December, 1981, under the aegis of Commission C (computer aided cartography) of the International Cartographic Association and with the support of the Royal Society. Euro-Carto II is planned for Oslo in March 1983. The paper describes the broad aims of the seminar and discusses some aspects of its scientific programme - hydrology, vegetation mapping and computer science. Each of these subjects seems to open new perspectives to cartography beyond the function of "mere map making" and into the uncertain but inevitable territory of geographical information systems.

Of the 750 participants in Auto-Carto IV in 1979 at Reston, Virginia, only about a dozen came from European countries. There is no doubt of the wide American interest that the Auto-Carto meetings generated during the 1970s both in the surveying and mapping community and also among those for whom cartography is at best only a subject of secondary interest - e.g. the US Public Health Service. I pay tribute to the continued success of these meetings.

The case for organising somewhat similar meetings in Europe was attractive because of the width of European cartographic experience, because of high levels of European technology in hardware and even more in software, and because of some Anglo-Saxon claims to have originated the notion of automated cartography at the ICA meeting in Edinburgh in 1964.

The plans for Euro-Carto I quickly took on their own idiosyncrasies. In the first place the meetings were to be on seminar lines with a maximum of audience participation; in the second place meetings were to address the sharp end of the subject - i.e. research - and to be more concerned with what we ought to be doing than with our current practice. And implicit from this was the need to keep meetings small and select (about 50). The intellectual nature of the discussions was underlined by holding Euro-Carto I in the rigorous atmosphere of a 14th century Oxford college in mid-December 1981 - it turned out to be the snowiest December for a hundred years.

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In the event - and despite both the snow and the pressures of recession on travel budgets - we had rather more than our ceiling of participants, and about half came from abroad*. Each of the chairmen of our four sessions were internationally well known - Joel Morrison of Wisconsin University and a vice-president of ICA, Hans Liebscher of the Federal Institute of Hydrology in Coblenz, Duncan Poore of the Dept. of Forestry at Oxford and formerly Director of the British Nature Conservancy, and Stein Bie of the Norwegian Computing Center. The proceedings of the seminar are currently in the press and will be published in October; they contain the "core papers" distributed six weeks beforehand to those attending the seminar - plus those papers presented at or after it. Publication - at $7.00 - is by the Canadian organisation Cartographica who will by this gesture have gone some way to making up for the absence of Canadians at the Oxford meeting.

Euro-Carto II is scheduled for 1983 and in Norway with Dr. Bie in the lead role - and already there is talk about Euro-Carto III. In a sense these cries of "encore" are gratifying; on the other hand there are dangers in the event becoming institutionalised into a kind of "club" and losing the stimulus of innovative scientific drive. Doubtless these issues are all too familiar to the organisers of nearly a decade of Auto-Cartos.

SCIENTIFIC PROGRAMME

I referred earlier to the idiosyncrasies of Euro-Carto I and have briefly described some of the administrative ones. Another idiosyncratic element lay in the subjects selected for discussion - hydrology, vegetation mapping, and computer databases. In selecting them we were concerned to emphasise the relevance of three scientific disciplines - hydrology, ecology and computer science - to surveying and mapping, and especially to the architecture of national databases or geographical information systems from which all kinds of maps - topographic and thematic - can be derived. The Oxford meeting placed unusual emphasis on the need for dialogue between cartographers and specialised scientists so that digital topographic data accumulating in databases can be structured to enable it to be used for more than "mere map making", and at the same time to improve the content and logic of maps. Our three subjects were of course only intended as examples of the interface between disciplines that environmental science demands: many others would have been just as appropriate. Our meeting was essentially for those with an appetite for geographical information systems.

Let us look in more detail at the three subjects that we selected for discussion.

Hydrology

An introductory paper for this session drew attention to the significance of the stream network (and its associated elements such as lakes) in topographic mapping: this has been assessed as being about 20% of the entire information content of the map. Furthermore rivers possess a high degree of internal topological organisation, and unlike many other line work elements in topographic maps are in reality a

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*Attendance figures were (a) Foreign: France 3; Finland 1; Germany 5; Italy 1; Netherlands 2; Norway 5; Poland 1; Spain 3; Sweden 2; Switzerland 1; USA 3; (b) UK: Academics 14; Commerce 6; Nature Conservancy/Soil Survey/Water resources 5; Natural Environment Research Council 4; Ordnance Survey/Military Survey 3.

highly structured entity. Despite this structural regularity inherent in river networks, the majority of applications of automated cartography treat rivers as if they were completely non-structured arrays of lines. Typically, digitised rivers have in the past been coded simply to show that they are rivers; they are generally discontinuous under bridges; and the direction and sequence of the digitising of individual stream links is often quite random. The cartographic approach to storing digitised river data as "spaghetti" can to some degree be defended as being adequate for straightforward map making; but such a disregard for structure makes it much less easy to re-use this topographic data for many specific tasks important to hydrologists, e.g. fast retrieval of all lines upstream of a particular stream link. In addition the incorporation of hydrological data in a structured fashion can make maps themselves more objective and consistent; the omission of rivers on smaller scales can, with this kind of forethought, be rapidly and rationally retrieved. The kinds of incidental inconsistencies that do occur at present between scales, even in high grade topographical map series, show up in variations in stream lengths or in the rationality - generalisation rules if you like - for omitting rivers at smaller scales.

In many countries there are already available several criteria which can provide more informative large scale maps and be the basis for a consistent and objective generalisation for smaller scales. One set of criteria relates to discharge characteristics as measured at gauging stations (thus mean flow, peak flow, specified recurrence interval, exceedence flows). Another set of criteria relates to biological and chemical aspects of river systems and to data on water quality - a matter of considerable environmental significance. A third set relates to morphological characteristics of the rivers involved (width, depth, profile downstream, capacity, stream order, area of catchment basin). Of these criteria the biological and chemical data are not as yet very widely sampled; however data on discharge does seem to exist, e.g. for most of the main rivers of Europe, though not for small streams - but even here measurements of precipitation can be linked with morphological characteristics to provide estimates of discharge. And many of the morphological characteristics are direct derivatives from the topography and the hydrologist generally has no alternative source than the topographic map from which to obtain them. These criteria all produce attributes that can be associated with digital segments (links between nodes) of the river system - and when associated can be used for example to extract all the network above or below a particular point at which a pollution event has taken place.

One method demonstrated by a British firm - GDC - is illustrated in Fig. I. The river patterns were digitised ensuring their continuity beneath bridges and producing a continuous link and node system in a straightforward manner. (It is convenient if all links do run in a consistent direction - up or down stream - but operational conditions, editing-in of revisions etc., sometimes make this difficult, nor is it essential at this stage.) Such data were then automatically structured and coded by climbing up the network within the computer - a powerful CDC one. A start is made from a specified point - e.g. the mouth of a river, and at any junction or confluence the search process turns right allotting a new code until it reaches a node with no other link than the one along which it has moved. It then does an about-turn and proceeds as before but noting those segments along which it has already passed and to which it has allocated unique codes. By a process of keeping track of code numbers allotted this programme can produce a plot on which every link has its own unique logical code number plus

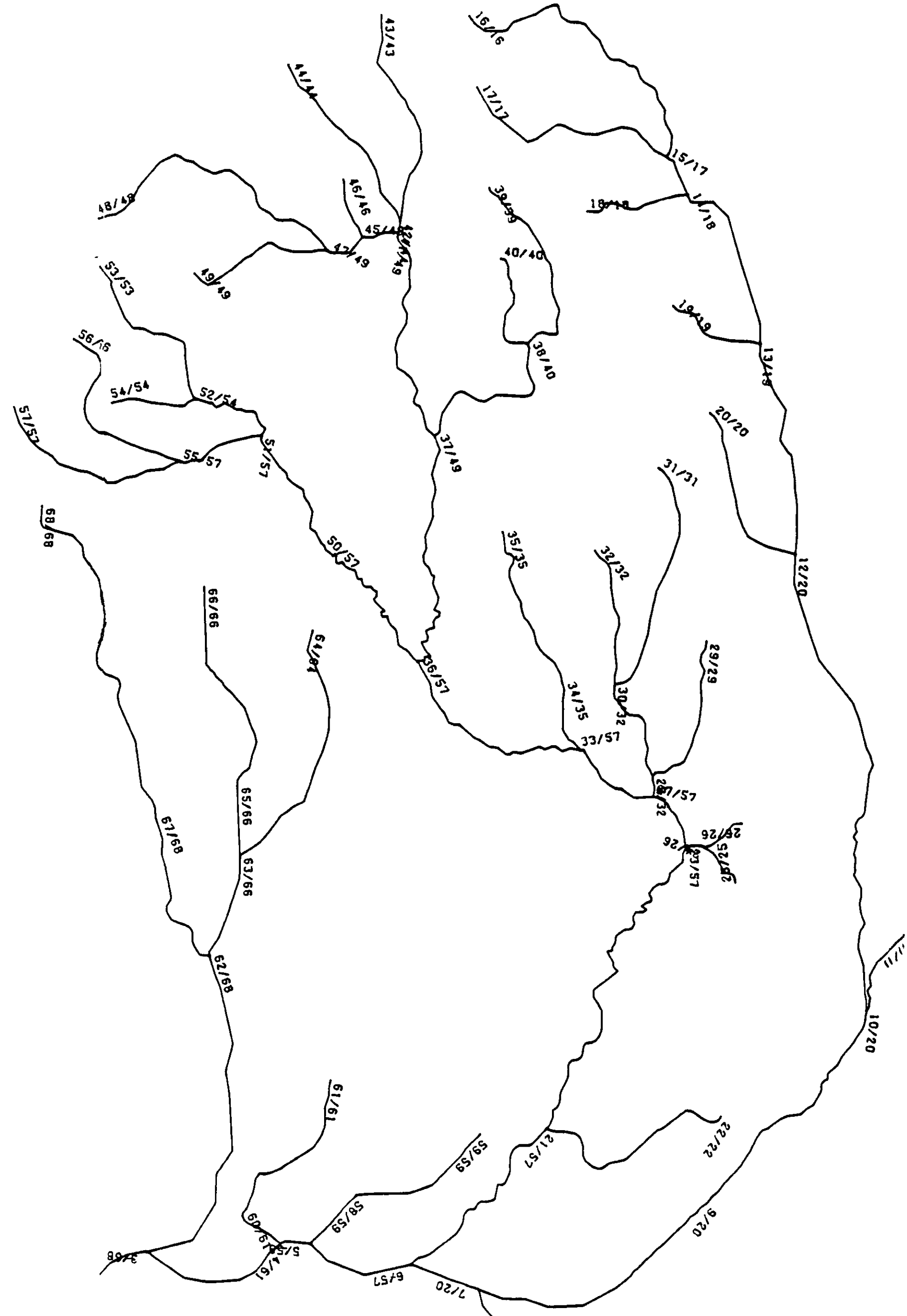

Fig. I

Stream Numbering by climbing up river network inside computer (Wyre Catchment, England. Scale 1/50k) the total of the links in the system. Granted such a labelled set of links and nodes, digital data about stream flow or biological characteristics can be easily added to the system. And of course first order, second order etc. streams can be identified (and may be useful for subsequent generalisation).

This process of structuring topographic river data has been demonstrated by examples published in the proceedings of Euro-Carto I: admittedly it demands a computer powerful enough to hold all the segments of a network in core. Beyond this of course it demands complete river systems in digital form (or at least upstream of the starting point if this is not the mouth of the river). Topographical map sheets are of course liable to include segments of different river systems and not to include all the segments of any one river system, so the process of automatic structuring/coding has to be applied to blocks of maps that have already been digitised. Other practical complications are in the treatment of double line rivers and the need to obtain a structural centre line in addition to both banks.

These small examples help to focus on issues that could at minimal cost increase the potential of the cartographic database and furnish usable information of relevance to specialised hydrologists. The information that topographers gather has uses - and even markets - beyond map making if structured with such logic in mind. So do we not need to escape from our present tendency to produce digital spaghetti? This is not perhaps an entirely academic issue. There seems over the last six months since the Oxford meeting to have been some recrudescence of proposals for digitising the river systems of Britain for the separate Water Boards that are the official authorities for rivers. The scale suggested is 1/50k though there is some case for using the more complete stream pattern from the 1/25k series. If schemes of this kind move ahead how do they relate to the work of topographic surveying carried out in Britain by the Ordnance Survey and generally at much larger scales (1/1.25k, 1/2.5k, 1/10k). These questions have not of course been answered - but it is important that they should at least be asked.

And the desirability of structuring river networks provokes related questions some of which were demonstrated at Euro-Carto. Many hydrologic problems need other elements of the topography such as contours to define catchment boundaries, or land cover as a factor in run off. As hydrology becomes increasingly computer based so the demand for digital cartography will grow if topographic data is structured and organised for both map making and use by other scientific disciplines. There is also a growing EEC interest in ecology and in attempts to control chemical pollutants in the rivers: at whatever scale this problem is considered it is likely that the digitising and structuring of river data will be involved. A separate point was covered by a Swiss demonstration plot - part of a 1/500k database of that country - which drew attention to the fact that administrative boundaries often coincide with rivers - and even banks of rivers - and often require defining and mapping at larger scales. For the cartographer river importance, traditionally expressed by thickness of line, is based on many factors of which mean flow is one.

<u>Vegetation mapping</u>
In this session it was evident that rather the same kind of overlap of interest between topography and hydrology also seems to exist between topography and ecology. All topographic maps find it necessary to display "vegetation", partly because they help the map user to see

where he is and partly because they help to characterise landscape. Vegetation maps by contrast are often the work of specialised botanists using very detailed classifications which relate little to the topographic categories which they overprint. A wide new interest in natural habitats, in competing land uses and in change in the landscape seems to be developing. The new class of map user, the "land manager", seems likely to need rather more professional definitions of vegetation than he finds on topographic maps - and, by implication, will find in a cartographic database. We were again concerned that some growing together of these two disciplines is desirable, and in passing we observed that a computer database can obviously accommodate a very detailed classification structure from which it can easily and rapidly amalgamate classes - e.g. on an hierarchical basis - where such generalisation is required. The present situation where the topographer's definitions of vegetation - e.g. of marsh - are often unrecognisable by botanists and ecologists seems at best untidy and a potential source of confusion in a national database.

The discussion of this issue at Euro-Carto was illuminated by Swedish examples of vegetation mapping at 1/100k and 1/50k scales from Prof. Wastenson whose work at the University of Stockholm is funded by the Swedish Environmental Protection Agency. In his work he employs the full range of contemporary technologies from Landsat interpretation to automated cartography. Encouraged by this, a joint British/French project - an "Eco-topographical" experiment - has been undertaken. This uses the results of soil mapping interpreted to provide 72 vegetation classes on a phyto sociological basis and capable of generalisation (i.e. collapsing) into 18 groups in Britain. The classification is based on 20 years' work in the Soil Survey of Scotland. The experiment also takes particular topographic patterns from the OS 1/50k series such as rivers, contours, boundaries, built-up areas and communications. Both topographic and soil/vegetation patterns have been digitised by the raster system at IGN Paris - the System Semio - which has many common elements with the raster system e.g. at USGS. The result of this project seems to have induced some re-awakening of interest in ecological mapping in Britain - partly at least because of dramatically lower costs from the raster system and partly because of a whole range of area manipulation or "overlay" procedures which are easy to perform by raster working. The ability to measure the areas of particular vegetation types within a Nature Reserve and on a slope of over 12° - and doing so instantly and cheaply - provides a quite new flexibility for the scientific map user. Their very cheapness does seem to give promise that they may actually be used.

Quite apart from the technical interest in this Anglo/French experiment it is encouraging to see progress in international collaboration actually being realised within six months of the Euro-Carto seminar. We are not resting on our laurels in this respect.

Computer Science

The first introductory session of our seminar consisted of a paper by the Director of research of Univac - Dr. Michael Godfrey. His review of the directions that computing seems likely to take over the next five years was illuminating and especially so since he had had close connexions with my Experimental Cartography Unit during his previous academic career in London. His references to VSLI systems (very large scale integration) with c. 10^5 logical devices operating at a speed of 0.5 MIPS (million instructions per second) but only costing $200-300 were interesting. They give the prospect of very powerful processing being cheaply available and being portable enough to take to large environmental data sets - rather than the reverse. Does this imply an unprecedented decentralisation in computer cartography? Shall we find ourselves processing from basic data each time rather than storing intermediate results? Dr. Bie pointed out that it might be advantageous to abandon complex database management which requires thought and has considerable overheads in pointers or tables, to more simple index sequential - or even sequential - files which require much more processing but less storage and less initial intellectual development.

If the predicted wave of increased processing power really may alter the future architecture of cartography dramatically, so also may the development of new computer languages urged in the seminar by Prof. Bouillé. In comparison with SIMULA 67 or EXEL he regards FORTRAN and PL/1 as dinosaurs actively obstructing the development of a more elegant cartography. He points out that Japan is preparing a fifth generation of computers; it will include expert systems, it will allow sequential as well as parallel processing, will probably include fuzziness handling. A cartographic "machine" would in his view be a parallel processor, a non numerical processor dealing directly with the very high level concepts which we use - sometimes unknowingly - in cartography.

Another paper by another computer scientist - Dr. Neil Wiseman - points out that a national topographic database might run to 10^{11} bytes in size - greatly exceeding anything of which we have experience. Such a mass of data would be in itself such an expensive investment that it must assume longevity and must not be thrown by changes, e.g. in computers. Furthermore, such a database must anticipate constant updating as well as being structured to take account of other disciplines that impinge on topography. Is it not time, he argues, to address the architecture of such systems - starting not from our present practice of remaking ad hoc maps by substituting digitising for scribing, but by working backwards from what we can anticipate of the grand design of a national database.

There does seem much evidence - at least in Europe - to suggest that those cartographers who are involved in automation are concentrating only on remaking maps that are indistinguishable from their manual predecessors except in costing more. Perhaps it is this feeling that many of us are stuck in a rut of our own making that lies behind the statement "The evolution of map standards and conventions over the past several hundred years is almost irrelevant in approaching the future requirements for automated geospatial analysis". This is perhaps the new world of USGS redressing the balance of the old world of European cartography. My generation believed we were living adventurously in confronting the wailing wall of digitising; beyond that wall life now seems to become much more adventurous.

When conferences end, of course, most cartographers have to come down to earth and return to all the familiar problems of the map factory and its inexorable schedules. Perhaps an ecouraging first step would be a cost reduction in automated cartography of an order of magnitude - but in itself even that is not enough, we have to try and look further ahead. Many of the surveyor/cartographers who came to our seminar believed that their function was to "get the geometry right" and everything else would fall into place. Some of them left also believing that it was important to get the topology, the taxonomy and the structure right as well.

Long may the Auto-Carto-Euro-Carto link continue! I hope you will find time to browse in our proceedings when they are published and to ponder the scientific doubts and dilemmas we see ahead: these are the growing pains of the new cartography. And I hope next year you will invite Stein Bie from Oslo to tell you what has taken place at Euro-Carto II.