ORGANIZATIONAL NEEDS FOR TECHNOLOGICAL ADVANCEMENT

The parenthood of autocartography revisited

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IF WE LOOK BACK on the introduction of computer-assisted cartography in Europe, it appears only as a response to a cartographic problem. With the dismantling of the European colonial states in the 1950s and 1960s, names changed and Oxford University Press had to update all its maps. This is history now, but it is a saving grace that twenty years of technological onslaught on works of art have yet to mechanize all but the most simple and trivial aspects of map production.

Autocartos are meetings for technological intoxication and it is right and proper that we who make the systems are enthusiastic about them. But it is beyond doubt that the overwhelming proportion of maps made in Europe are still made by hand, that the maps made by machine are of inferior cartographic quality and that the digital data bases we proclaim are small and ineffective. It is also hard to swallow for countries like my own that computers in the map industry have not eliminated the tedious tasks, not soothed muscles strained in monotonous map construction instruments, not expanded the scope of the individual cartographic worker, not made very many happier map people.

I believe that the main reason for this is that the driving force behind autocartography has been largely irrelevant to map production. Throughout the last 20 years autocartography has been technology driven. Technology developed in other fields, usually engineering, has been adapted to map making. The general computer is a *general* computer, the cartographic computer has yet to be invented. The flatbed plotter has its origins in the shipyard, the drum plotter in the machine tool shop, the laser plotter in the chip and water electronics world. The digitizing table may have been a cartographic true-born but its further development is due to the construction engineers. The most obvious evidence of the origins of the autocartographic species is the near-absence of cartographers among autocartography vendors.

The inherent danger in a technology-driven modernization of an ancient craft is that the technology only addresses a small part of the total production process. In cartography this has meant replacing the hand with machines but in the process of systems design leaving out the skills of compilation, the implicit rules

of generalization, the ambitions of the craftspeople, and the established logistics of an organization. Unlike what has happened in other aspects of human life facing computers the mapping institutions have not given up their traditional set of graphic quality values. Their graphics standards are so severe that a mechanization of only a part is bound to fall short of acceptance. Similarly, the users have maintained their standards.

In this respect cartography is only an example of less-than-expected success of computerization. In so many other activities society has accepted capital letters only, written by jumpy lineprinters on exhausted ribbons, or life behind a word processor screen so vastly inferior to the contrast offered by ink or paper. Cartography – and other sections of the graphics industry – is just about the last white hope in an industrial world where expediency seems to outweigh everything else, and bosses and workers lose their common sense and craft traditions.

That cartography has not succumbed offers a splendid case study. There is no reason why modern computer technology should not be expected to achieve the quality standards set by manual cartography, and there is every reason not to relax the standards so that the manufacturers can relax.

The design of autocartography systems seems to centre on the following:

1 automate data capture;
2 allow efficient editing of data;
3 mechanize the draughting process.

All participants in Autocarto are well aware of the technology involved and much is on show in the exhibition rooms. We have recently completed a survey of the introduction of digital map-making methods in Norway. The equipment used is among the most modern – Norway has an active autocarto industry with Kongsberg draughting tables, SysScan integrated systems and Simrad hydrographic mapping systems competing with imported hardware and software. But Norway has something North America has not got to the same extent, viz., legislation on the working environment with emphasis on worker participation in the introduction of new technology, safegards against monotonous and boring tasks, and demands for job content to ensure that each worker can influence the production process and have some opportunity to adjust it to fit into individual working preferences and ambitions. Furthermore, Norway has government mapping agencies genuinely wishing to implement both the letter of the law and its intentions, organized labour watching carefully and private mapping industry being concerned, trying to find alternative ways to make autocartography productive.

Firstly, we looked at the operations of photogrammetric stereo-instruments in the private mapping industry. There are traditional construction instruments of types Wild A8, A7 and B8 now fitted with digital output devices to act as data capture instruments.

Of the approximately 40 respondents to the questionaire, 70% had spent more than 80% of their working time behind the instruments. 55% of the operators had spent more than 5 years behind the same instruments, the average being 9 years. Asked to characterize their work they described it as quite varied, interesting, independent and responsible. These are terms that are normally associated

with positive motivation and job satisfaction. However, asked if they had complaints in eyes, neck, shoulders, legs or feet or had headaches, a total of 81% said they had some or all of these from time to time. Significantly *all* operators associated this with their work.

Comparing the findings on stereo-operators with other groups of workers, we find that complaints are similar to those reported by operators of video display units:

Complaints in	% stereo-operators	% VDU-operators
Head	35	45
Eyes	57	55
Neck	62	55
Shoulders	43	41
Legs/feet	15	12
Number of respondents	42	106

We should note that these are very high complaint figures.

A further finding was that of those who had spent more than 5 years at the same instrument, 74% reported job-related complaints; of those with fewer years, 34% reported complaints once a week or more.

Of the 41 photogrammetric operators 60% had experience with digital cartography, normally with digital output on their instruments. We asked them whether they thought problems would arise with the future computerization of map production:

	With experience	No experience
Yes	68%	50%
No	12%	13%
Don't know	20%	38%

Those who are experienced with digital methods are more sceptical than their colleagues.

In job studies of this kind a standard final question is to ask employees whether they would recommend their job to young people. Our experience is that even in jobs with low satisfaction ratings, workers often wish to see their children or other young people follow in their footsteps. We were surprised to discover that, of the 36 stereo-operators reporting, only 9 (25%) said 'yes', 6 (17%) said 'maybe' and 21 (58%) said 'no'. Albeit a small group, there are strong indications that a specialized job in map production performed over a long time is not a happy one, and adding a computer does not mean a radical change.

Next we studied operators of digitizing tables. In contrast to the stereo-operators who were nearly all men, these were women, all untrained in computers at the onset. From other experience we had understood that digitizer operators had a tough life. We had noted foreign reports of high turnover of digitizing staff.

The organization we investigated was the Institute of Land Inventory of the Ministry of Agriculture. They operate six digitizing tables. We found a happy crowd, with very low turnover of staff, low sickness rates and apparently harmonious staff-management relations. And this was their recipe for success.

Whilst management had the overall responsibility for production targets and production speed, the medium- and short-term planning of work was done by the operators. They had divided the day into 4 periods, the two first periods of approximately 2 hours, the two latter ones of slightly shorter duration to compensate for increasing fatigue. Two operators shared one table. Map preparation and digitizing were both the responsibility of the operator, allowing a rotation of one period preparation, one period digitizing, one period preparation and one period digitizing. Thus no one spent more than 2 hours in one stretch on a digitizer.

The main problem facing the staff was the poor quality of the incoming documents. This necessitated frequent contacts with the local authorities supplying the manuscript maps. For many cartographic institutions this would have been a drawback, but the Land Inventory had turned it into an advantage: the solving of error, inconsistency and illegibility problems were left to the operators, who spent part of their preparation time in direct contact with the local authorities, by telephone or (occasionally) by letter. Many of the operators reported to us that this problem solving was a most atractive part of their job. A map organization that can turn bad manuscript maps into a production advantage deserves praise.

The Institute of Land Inventory has also spent much effort on adjustable tables, five-legged chairs (how many digitizer operators have fallen off four-legged ones?), non-reflecting lighting, situating the digitizing rooms to the Northwest, and sound proofing. Much thought has gone into the design of the computer dialogue, giving the operator a correct amount of feedback at useful intervals on the progress of the digitizing work through screen terminals mounted next to the digitizing tables.

Many reports on the quality of the working environment focus on the ergonomic, and physical aspects with the result that management sometimes see these as the most important in planning a production process. With these two case studies, of the photogrammetric stereo-operators and the digitizer operators, there is an alternative, clear message emerging from digital map production in Norway:

- Job specialization, long working periods and limited tasks create problems;
- Varied manual/digital jobs, with wide individual responsibilities for maintaining product quality create good job environments and high productivity;
- Ergonomic considerations are also important.

Here emerges the most important point of my paper. We have had a technological development leading to specialized and high-cost cartographic computer terminals and systems. To obtain high productivity and, if possible, economic return on investments, many organizations have chosen to specialize their staff on one instrument. Thus we have got the stereo-operator, the digitizer operator,

the map editor with her or his graphics screen, the draughting machine operator, the reproduction department, the map printer.

In Norway there is growing concern over this model. Cartographic skills become increasingly black-boxed, and with specialization there is decreasing knowledge and skill-exchange between the various stages in the map production process. Suppose this is not the map production model most suitable to industrialized countries. Suppose that the indications I have reported point to the need for production integration, for each map maker to follow her or his map a long way during the production process. Suppose that the optimum is the recreation of the environment of the classical cartographer who followed the map from data collection to the printing plate, and who signed it with his (normally!) name and had the law protect it as a work of art. If this is the way that cartography can flourish then the current digital technological development in cartography has got it wrong.

It was our *sociological* research on the introduction of digital cartography in our map production agencies in Norway that stimulated the design of a prototype of a 'complete mapping machine'. We wished to create a low-cost machine that could remove the drudgery of line following, the strain of normal photointerpretation, the hopeless *ad hoc* design of application modules, the heavy load of program maintenance, and the dependence on other parts of the system to have done its bit. In short, we wished to recreate a digital but classic cartographic workbench where one operator can follow the map from beginning to end at her or his own table.

This is the MIKADO-concept, a joint project between the Norwegian Research Council on Science and Technology and the electronics firm Simulation Excel (or Sim-x) of Oslo. The Norwegian Computing Center is responsible for methods and programming, Sim-x for the hardware and the Research Council for half the money. The prototype is due at the end of this year (1983).

The design centres around a pipe-line graphics processor with up to 6 MBytes memory, plus auxiliary disc/magnetic tape (videodiscs will come), a high resolution screen, a laser input scanner with variable resolution for automatic map and photodigitizing and a laser output scanner for producing film or directly burning the printing plate. There is no need for a host computer. Software is written in the very high-level language SIMULA, the graphics processor has a SIMULA compiler. The basic concept is for a number of data generating procedures to create a common data base on which all other application programs work. The data base is the reflection of a mathematical description of a model of geographical data. The model may be 'viewed' in a wide variety of ways: as a static image on the graphics screen, as the map printing plate, or as a perspective model in which we can travel in real time as in a flight simulator.

The main point is that this is *one* work station, standing alone or linked in a local network to other such MIKADO stations and possibly sharing peripherals or computing resources. It contains automated digitizing, including character and symbol recognition from existing maps; it also contains automatic stereocomparation (although this will not be fully implemented in the 1983 prototype), it has digital terrain modelling, it has interactive screen editing, it has highest

quality plotting facilities. It can all be operated by one person – preferably someone from the dying breed of general map people, a breed we think should be encouraged to rise from a period of technological one-mindedness.

Further, we believe that a list price for it all should be around US$150,000 ($200,000 CDN). The price of the input/output scanners that may be shared constitutes around US$100,000 of this.

Finally let me return to the opening statement of digital technology in cartography arising as a response to a cartographic problem. We have now had 20 years of introduction of digital technology into map production agencies. We have seen no dramatic breakthrough and no evidence of widespread favourable cost benefit ratios. Monitoring production environments on the Scandinavian scene, it appears that the problem is a profound mismatch between the technology introduced, the organizational structures of long-established mapping agencies, and the growing ambitions of our individual staff members to influence a greater part of the map production process from which they derive their money, their intellectual fulfilment and – ultimately – their pride.

The user environment has yet to establish strong claims to new products in autocartography. In the cartographic community we have tried to supply them with ideas, but the new market is growing slowly. In any case, this new market will require data collection and manipulation procedures very similar to those experienced in present-day map making.

To me the challenge lies in the evolution of a machine that can be a valuable tool in the *whole* production process of a map. Underlying this is the growing awareness as a cartographer of map making being very different to engineering drawing. The next stage in our conceptual model of a new generation of autocartography tools may lie in the 'expert system', with formalized and non-formalized aids to the production of better maps and better digital geodata. But the 'expert' in a map production environment is a generalist, not a specialist. Thus much of the technology we see in use in our mapping agencies and on display here represents what I believe is technically and economically a blind alley. However, some of it may be modified to suit the concept of a complete mapping machine. But then the starting point in systems design must be the map production institution, its tasks, and the ambitions of its individual staff members. Not because it represents blue-eyed Scandinavian naivety, but simply because it may be the most effective way to produce maps.

ACKNOWLEDGEMENTS

Much of the social research on which this paper is based has been performed under a grant from the Norwegian Ministry of Environment. I am most grateful to my colleagues Arne Pape, Asbjørn Ekenes, Tron Espeli and Truls Kjølberg for their contribution.