Outstanding Hardware Problems Panel

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Boyle: This year interactive graphics editing is moving out of a development phase into users' hands. Also for the first time, professional digitization is not only available, but available on a relatively low-cost contract basis. One of the reasons that I asked Peter Wohlmut to be on the panel is because his company, i/o Metrics, is starting professional contract digitization. Many companies are working in manual interactive contract digitizing.

Important aspects of the state of the art that are still being developed are CRT lightheads for x-y drafting units, interactive geographic information systems, and laser-dot storage disks. The CRT lightheads for x-y drafting units provide enormous flexibility. The range of symbolization of lines, areas, etc. is important. Howard Carr and I are involved in this work and have great hopes for its future. I am pleased to get away from the optical-mechanical system that has served us so well for 10 yr.

The extension of interactive cartographic editing to a full interactive geographic information system should make it possible to analyze the cartographic data associated with various data formats.

The most important development is the laser-dot data storage disk. To me this disk is the true digital map. We were talking yesterday about the large amount of data for World Data Bank III; my calculations indicate that we could get 10 of these banks on one disk. All of the Hydrographic Service information for Canada would go on one disk. But people are becoming worried about confidentiality when you can put all the data for your organization in your pocket. Advantages, however, are great: access time on any disk is about 0.1 sec, and cost is low, about $25,000 for the playback unit. I am advertising for the companies that make the disk unit because I don't want them to be too commercial. Cartographic and geographic information systems need the archival storage that these disks offer.

Carr: Opto-acoustical modulators will soon be competing strongly with cathode ray tubes as drivers for various laser systems. They too have

the ability to randomly move a point of laser light in order to draw lines. In the near future it is conceivable that a head will operate as a no-moving-parts plotting device or be capable of mounting on a large precision plotter, such as a Gerber plotter. The absence of mechanical movements will mean higher speed operations. Solid-state, self-scanning arrays offer great potential in image digitizing systems, and we can expect to see them in mapping applications in about 5 yr.

One of the more interesting problems that concerns us today is how to store all of the information that we are currently digitizing. We have considered using the Electron Beam Recorder (EBR) for writing. We are also very interested in the optical data recording device developed by i/o Metrics, which is being demonstrated during this conference. These devices can optically store data in archival form at densities of 10^{10} bits/record. Magnetic tapes have problems retaining information over long periods--there is much print-through and loss of data. They are also relatively expensive compared to film and considerably more bulky for storage and mailing.

We have a great deal of hardware under development, but the software packages are just the tip of the iceberg. The newer output or drafting devices are similar in some repects to general-purpose computers that process many kinds of data. For instance, the EBR currently under development at ETL will be capable of drawing linear data in either vector or raster format, producing high-quality continuous-tone photographs, and writing optical digital data as binary bits.

Rhind: In a sense we are regressing in automated cartography by using special-purpose hardware because many of the first developments in automation were on/off machines made to do specific jobs, many of which didn't work too well. One name placement unit, which cost 10,000 pounds, was sold for scrap for 20 pounds without ever being used seriously. This example is bad and times have changed, but building on/off equipment can still be dangerous and expensive. However certain special-purpose hardware could be useful now to reduce effort. For example, with some line-location equipment, hardware rather than software is used to find a feature in the data base and considerably reduces access time. Extending this application makes it possible to think about hardware for polygon overlay. It is equally possible--indeed it exists already--to use hardware for rotation of block diagrams. Many other examples could be given, such as acoustical code entry, which allows digitizing on a semiautomated basis; the operator voices the numbers while digitizing, and the machine decodes them into binary numbers--a nice way of tying in attributes with geometric information.

Apart from yesterday we have discussed only large-scale systems. In universities we have very different problems. They may not be important because there are few cartographers in universities compared to the number in the outside world, but whether important to you or not, we do have problems. They stem almost entirely from the ready availability of computer power: we usually have very limited graphics input and output facilities. In addition, our requirements are more on/off than those of defense mapping agencies. Thus we have a more intractable problem. University cartographers must have a display on which they can compose maps at about the same scale and cost and in the same way that they always have. Thus the role of automated cartography in universities is more limited than it is in defense or civilian topographic mapping agencies.

Bockes: My organization has many field offices, and I am not sure if each one can be equipped with the sophisticated map editing terminals or map editing systems shown at this conference. We will have to consider computer terminals that can display maps and imagery in the same way that our present computer terminals display alphanumeric information in tabular form. Thus, I am considering a system with a large host computer that has a data base available to many local users. Each user normally will use only a very small portion of the data base, but all users must have all data available to them.

In this kind of system we do not need to produce x-y table coordinates or x-y map coordinates. Perhaps we need hardware chips to translate table coordinates into ground coordinates because of the curvature and convergence built into the maps being scanned. Conversely, we need a hardware chip that will turn ground coordinates into the kind of mapping coordinates that the user requires.

Diello: By and large, the developments that we want are in some way or another pursuable. Certainly we must work on input devices, like interactive editing devices, which are largely manually guided and driven and still quite accurate, reliable, and economical. These characteristics are very important if we are going to develop and produce data banks in in the desired quantities. But we should not discount some assistance in line-following to expedite the process. Probably some specialized input devices are worthy of consideration.

Auto-litho scanning recognition equipment should be developed because the lithomap is still the principle source of our data files and is more effective and efficient in exploiting photography. We are automatically using some highly reliable recognition techniques in the process.

Finally there is too little interactive compilation equipment available. We have emphasized too much the interactive rates demanded of this equipment. We can settle for a far less rapid display system and still have an effective compilation capability if we expand the size of the displays, the color renditions, etc.

Very briefly in response to a point Rhind raised--we are presently implementing a promising voice header entry capability on one of our digitizers to reduce this time-consuming portion of digitization.

Wohlmut: Much thought can be given to decreasing digital storage. The useful result will depend on a combination of visual and digital storage. Combinations can be effected that will minimize the total amount of data to be stored and that will be effective and efficient in a running operation or in revising data. Also there may be a way of automating the original surveys. The laser beam deflection systems are so accurate that one can hit an 8-in spot at 400 mi. Maybe a deflection system with a small computer can be put on airplanes or satellites for triangulation purposes.

Broome (Bureau of the Census): For years I have been fascinated with the idea of a cartographer's drafting station with all the resources of a data base at his command--particularly, if it can be in front of him, like a table, and if he can work with instruments that he is used to, similar to a pen. I'd appreciate further comments on this idea since I know that one of the panel members has already discussed its design and possible cost.

Rhind: The drafting station is a problem not so much in hardware, but in user acceptance. The hardware mentioned by Diello is available almost in its entirety for constructing a digital working station analogous to the draftsman's table. Thus availability is not a great problem from what I've seen and heard so far, but convincing people to use it is a different matter. Education is as important as hardware.

Moritz (PRC/Information Sciences Co.): In some ways you can say that the hardware is available, just as you could say 10 or 15 yr ago that computers were available for a price. New developments, such as the i/o Metrics device, and new capabilities in thermal plastic, laser technology, and silicon storage tubes reduce the cost of these theoretical compilation stations. We're now studying the hardware developments required to enable a man to sit at a compilation console and get the data he needs in the formats he needs. In addition to storage, we are also concerned with the display capabilities and the manipulative operations involved. It is still a big guy's system. We're watching very closely to see how soon it might be possible to have such systems available, even on a time-share basis, for the smaller user.

Rockwell (Dept. of Community Affairs): Right now microfilm plotting is a quarter million dollar game with most of the good hardware. It seems possible to build a machine that with slightly less accuracy could give the advantages of microfilmed vector plotting for a tenth of the price. Similarly, better data management is possible--Harvard is attempting to run large programs using a small amount of core so that they can be run on a minicomputer. The opposite process is also possible--increasing the capacity of small processors with the specific notion of processing geographic arrays.

Thompson (USGS): Wohlmut's last suggestion about automating the original surveying procedures is indeed beyond the "perhaps" stage. Several systems are being investigated, and one system, called Auto-Surveyor, which is a further development of the Position and Azimuth Determination System, is being tested this week. This vehicle contains a payload with inertial navigation devices, accelerometers, velocimeters, lasers, etc. Since this system is approaching the accuracy needed in our surveying operations, I agree, Peter, with your suggestion that it is actually in the operation stage.

(Unidentified speaker): Somebody asked a question about the economics of an interactive station. The hardware and software for a small intelligent stand-alone compilation station would cost about $100,000.

Ryan (Calspan Corp.): The oil industry is also interested in such systems. One system currently under development depends on a geophysicist or geologist to interpret seismic data, make maps, and draw conclusions from the basic survey information. Concerning special-purpose hardware, I had expected someone to talk about the "star" and its applications to the cartographic problem.

Chrisman (Harvard Univ.): How effective will associative processors and star matrix operators be in present layouts? The big Central Processing Unit hardware still seems oriented towards matrix operations. I haven't seen it handle interactions between spatial entities. That development in hardware design is in the future. A spatial model will have to be provided through software.

Moritz: The $100,000 figure for a small system is not unrealistic, but

people from government circles ought to be aware of the economics of manufacturing. If 30, 40, or 50 potential users are unable to agree, no manufacturer will risk providing the equipment necessary for the money that you have to spend. I'd like to see more communication between the different users. The only way that we're going to reduce the cost of hardware is through bulk economy.

Various polygonal descriptions have been compared with the highly accurate requirements of the Defense Mapping Agency Aeronautical Center. When plotting two points, it doesn't make any difference whether we call the path a line, a straight vector, a squiggle, or a piece of macaroni--we're still going from one point to another. The longer that distance becomes, the more obvious our problem, if we need to go through geographical coordinate frames for commonality on a global basis. For example, because a straight line is in transverse Mercator, it is not necessarily a straight line in elaborate conformal if you're coming back again. Those things that laid nicely right in front of the schoolhouse no longer do so in a different projection system.

While we need high, accurate, and consequently expensive, storage densities, State and local people don't have to worry about geographics because they're in a grid system. Again we're faced with a dichotomy of use--requirements for different storage systems and different digitizing systems. It would be helpful to catalog the requirements of different groups so that maybe the hardware people could develop products for $100,000 that would meet these requirements. However, it would be difficult at this time to include the highly accurate Defense Mapping Agency requirements in such a system.

Regarding Chrisman's point on the associative processor--the star machine has been used very successfully for spatial relationships like weather prediction or atmospheric modeling. Time and time again the machine's intrinsic parallelism, the ability to treat an entire space or entire net of points simultaneously, has proved valuable. You don't have to address the data structure itself; its representation is built into the structure. Although cost savings aren't obvious yet, the star will indeed be a significant time-saving device.

Carr: I would like to go back to Broome's dream of having access to all of the necessary data at one station. The requirement, "all of the necessary data," presupposes a tremendous data bank. So far this discussion has been bouncing back and forth between software and hardware, and we must all be aware that software is dependent on hardware and vice versa. We must have a particular kind of hardware to access a large data base. We can't access what doesn't exist. In the next few years we should consider a modular data base that is used for different purposes. We shouldn't be mixing apples and oranges in these data bases. The commands that tell a plotting mechanism to move to a certain position and to put down a symbol are hardware commands. They can be stored, but they shouldn't be mixed up in a data base that has information for answering questions about soils and climates. The type of data base will affect the type of hardware used to produce a graphic of a certain quality. About 10 yr ago we had to choose between buying a plotter that would produce a quick and dirty copy or buying a more expensive one that would produce more precise graphics. Today since devices, such as the Electron Beam Recorder demonstrated by CBS labs, have the capability of producing both a very quick and a very good product, the speeds for the quick and dirty graphic are now the same as those for the precision and high quality graphic.

Bockes: Many of the comments relate to my suggestion of a cheaper terminal. Concerning Broome's question about an editing station, there are at least three on display this week that are in that category. They may not be optimized for the traditional cartographic draftsman, but they can be. Dr. Rhind's suggestions indicate the need to standardize some of the cartographic procedures. As Chrisman suggested, for a long time some standard cartographic feature capabilities will be in software. I suggested a few standard hardware procedures available now, such as the mathematical translations from table coordinates to map coordinates and back again. I'm not sure whether this firmware will be located at a front-end processer on a host computer so that anybody with a terminal can run through them or whether they will be little chips in their own terminals.

Rockwell: We've heard again and again that there are several different kinds of requirements, but they seem to depend on: first, the output, whether you're interested in high-precision, one-time maps or in many iterations with perhaps slight modifications of output, approaching an interactive line of thinking (analytical geography or whatever purpose), and second, the purpose, whether for example you're concerned with State planning use or environmental design.

Hardware people can't design a machine for a nonexistent market. We must assemble a group of people to nail down the two and three major markets for automated mapmaking. Maybe certain existing hardware with minor modifications would meet needs that haven't yet been articulated. There may be many potential meshes that we haven't discovered because we have not seen how many of our needs overlap. Maybe what we really need is more work in defining goals; perhaps a recommendation of this conference should be that we assemble a group to do just that.

Tsao (Dept. of Natural Resources, Montana): We have a land-use planning group that defines goals and makes suggestions. About 5 to 10 years ago the land-use planners tried to adapt their own methodology to the existing hardware. For example, the printers used the grid system. We made many mistakes because we didn't have design specifications for all purposes. Now we do. Even in the land-use planning group, we have different types of requirements. While local planning requires a very detailed, accurate scale, State-planning accuracy is not as critical, within 40 to 160 acres. Many format specifications within each group already exist; they just need to be cataloged. Since land-use planning specifications have been available for several years, the people just need to get together and not search blindly.

(Unidentified Speaker): Our thinking is still very provincial. We're looking for equipment that effectively allows us to compose maps faster, but with much of the same methodology that we've used for years. Perhaps we need less professionalism. We shouldn't make a drafting station just to satisfy a professional cartographer's whims. We should be developing a process that uses the available tools more effectively. Certainly, some tools should be improved upon, but we should take advantage of what's here. We could do a great deal right now.

Rhind: I certainly wouldn't disagree that hardware is important from all points of view, and I tried to suggest earlier that we should have hardware for polygon overlay and the like. In the final analysis, however, not the capabilities but the people who use them are really important. London has 8,000 land-use sheets. These are updated periodically by different systems throughout the city's boroughs. Some are updated in,

5-yr intervals, some are updated when the people feel like it, and some are updated when an answer is required. If they want to be really sure, do they turn to their geographic information system? No, they send a guy out on a bicycle to check--that way they can rely on the information. A geographic information system is too expensive for them now, with the present technology and the effort that they would have to put into it. Land-use planning is critical and valuable, and theoretically it can be an ideal market for the techniques that we've been hearing about. But on the other hand, you must recognize that even with perfect information, they won't actually use the techniques even if they have the money. In the long run, the human element is a much more serious problem than the one that you've been discussing today.

Finnie (Private consultant): I don't know how the cost of hardware and software is influenced by the requirement for high-quality standards, but it's been a long time since a Class A product has been able to satisfy the metric accuracy requirements for military operations, whether on an intercontinental basis or in a very small area. Military operations require local measurements for tactical purposes, just as a county surveyor does. We have developed formats other than maps or charts for satisfying these accuracy requirements. As an engineer, I found that in mountainous regions I didn't need quite the degree of accuracy of the USGS Class A 1:24:000 maps; on the other hand, in heavily cultured areas I needed greater accuracy. We have systems for acquiring data, for manipulating photography in relation to this data, and for recording this data digitally so that we can provide military or civil customers with highly accurate input, separate or as a product companion. Rather than beginning the studies with hardware, maybe we ought to study accuracy requirements for the products and consider how variations in accuracy requirements influence the cost.

Bockes: It is as dangerous to refer to land use in a general sense as to refer to a map user in a general sense. Regional land-use planning requires one map scale and one accuracy, while local land-use planning requires a much larger scale map and more stringent accuracy. We do not have a definition of the digital accuracy requirements, and we are not producing maps that meet map accuracy needs.

Schweitzer (Bureau of the Census): Our agency has a particular need not so much for highly accurate maps but for current maps. We ought to consider data acquisiton. Wohlmut suggested some automated surveying techniques, and there are other similar techniques that even I used years ago. But we need some way of capturing the synoptic view so that we can tell if change is occurring in, for example, remotely sensed, multispectral data from different passes of a satellite like ERTS or something with a finer resolution. We need to be able to match these data to the same geographic area within the computer and to internally remove image transformation, rotations, and distortions so that we can isolate only those areas of change. Suspicious changes may require some human judgement; someone may have to go to another data source, such as high-altitude infrared photography, to determine the nature of the change. The revised maps may not be highly precise in position, but they are correct concerning what is there, and we need currency. We have been considering output, but we need to consider input if we are to solve this problem.

Diello: Schweitzer is alluding to highly sophisticated systems that provide the ability to detect change through correlation with a new record from another day or with some rigorously controlled data base. A wealth of technology is probably available to provide these capabilities,

but much like the digitizing tables, we really can't afford many of them. They are extremely expensive, and probably we should be providing more effective tools to do the job manually. We certainly sympathize with the view and the need, but I don't think that these capabilities will ever be used widely or effectively.

Rockwell: Dr. Wohlmut, can you say something about the mass storage medium that you described Monday?

Wohlmut: It is a packet with a 10^{10}-bit storage on it. I have one that I can show you after the sessions. A light source shines through this film, the film rotates at a fixed rate, and then a mechanism drives ahead, back and forth. You access any part of the disk in about 0.1 sec.

Rockwell: It is completely random then.

Wohlmut: Yes.