Computer as Horseless Carriage: Transportationists for the 1990s and Beyond

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Individuals and organizations active in a particular technology form are often unable to perceive the direction and magnitude of change in their area when the impetus for the change is external to their technological (or disciplinary) area. An analogy between the impact of the evolving characteristics of computer systems and the development of the automobile is developed with respect to their impacts on transportation. The near future character of computer systems is examined with respect to the manner in which each characteristic is likely to impact the processes of transportation and traffic engineering. Three examples of probable impact areas in transportation engineering are discussed: (a) traffic control safety by using the principles of positive guidance control, (b) site analysis for traffic environment effects, and (c) data base development and manipulation. Lastly, and most importantly, the capability of the computer to integrate the fragmentation of specialized talents with transportation practice is discussed. This probable and most significant effect of computer-aided communication in transportation suggests that a new focus, distinct from and more broadly based than the current paths to practice will develop; i.e., the transportationist.

The appearance of the automobile early in this century produced at least three viewpoints. The first saw the automobile as a meaningless and doomed fad. The second saw the automobile as merely an engine-powered (i.e., horseless) carriage. The former view simply misjudged the utility and impact of the invention; the latter view saw the potential for change, but perceived the automobile to be merely a linear extension of extant technology. A third, uncommon view, foresaw that the automobile would remake all industrial societies in its wake, as in due course, the automobile did change the way people live, work, and seek recreation.

The computer can be seen in analogous terms. Tracing the thread of recent U.S. history (in general terms) for those who perceived the automobile in these three terms may provide instruction on how a failure to properly respect today's computer may affect transportation professionals. A few selected examples of current interest will be examined.

THREE VIEWS

Meaningless and Doomed Fad

When the automobile was invented and fledgling tinkerers began to build these contraptions for sale, many individuals scoffed at both the invention and the would-be entrepreneurs. Cynics looked at the invention and saw only its limitations and failures: It could not swim a stream like a horse; it required that cans of messy fuel be carried; when it threw a wheel (as a horse was apt to throw a shoe) several strong people were needed to push it home, but a horse could walk; and, of course, if God had intended people to ride that fast He would have created them without legs!

It is rather humorous to read some of those accounts today; however, does a parallel exist in the transportation engineering field (education, training, operations, design, and analysis) with respect to computers? How different is the attitude of the supervisor of an engineering office who views the computer as a device that permits employees to make more mistakes faster? How realistic is the engineering office manager who thinks a computer is for computations and an electronic typewriter with memory is for word processing, thereby failing to realize that the computer function is the same on a machine equipped to do both? What is the depth of technological vision of a traffic engineer who regards traffic signal timing as a closely guarded art and fails to see in computer graphics stick drawings the precursor to a media format by which a technician with one-half the engineer's education can determine optimum signal timing settings?

Engine-Powered (Horseless) Carriage

People who looked at the embryonic stage of the automobile industry as the carriage with a mechanical device to replace the horse were correct initially. What they saw were the efforts of mechanics to get engines to operate reliably. These engines were the focal point of the mechanics' interest and were attached to convenient buckboards, surreys, or whatever was available. These people thought that the ways a horse and carriage were used were the ways in which an automobile would come to be used. Because speed and power had always been sought in horses, it was reasonable to assume that automobiles would be improved in the same manner. However, persons thinking of a horseless carriage did not envision the impact that environmental protection of the occupants and cargo could bring, thus opening the way for frivolous uses of transportation. Even today, many engineers think of the automobile as a utilitarian unit of transportation. Psychologists, sociologists, and marketing analysts have long known that the automobile's utilitarian function is often secondary to other images and values attached to it.

Where lies the parallel in the computer age in 1983 through 1990? Some technologists and social analysts regard the modern computer as a linear extension of the familiar and uncomplicated hand calculator. Such an image of the very small but highly sophisticated devices coming on the market creates a smaller-but-same mind set, thus limiting their vision of microcomputers. A similar error occurs at the opposite pole when people think of a computer as only the large-capacity mainframe unit with high-speed printers, numerous disc and tape drive units, and several people hovering over the system day and night. The smaller-but-same perspective prevents a person from envisioning the way communication of people in expressing their creative thoughts may be enhanced by one-on-one interaction with the computer, as opposed to the at-arms-length interaction associated with mainframe computers.

Remaker of Society

Those who saw the automobile as a catalyst for change were opportunists. Some sought a fortune in finding oil to produce fuel to power a future fleet of automobiles. Some chose to create an empire by providing the automobile in a variety of dimensions. Some aspired to acquire an automobile for personal use to increase access to potential mates, to potential jobs, to health care, and to a view of different terrain.

In the computer age those opportunists also exist. The computer has already begun remaking industrial societies as completely as did the automo-

bile. The reasons for and the importance of this reality must be understood. More specifically, everyone working in the field of transportation should know what this scenario bodes for transportation activities; this is the topic of this paper. The question raised is the extent to which the current structure of the academic world prepares its clients to be problem solvers of the sort that will be needed. Currently the nature of education (in the United States particularly) engenders a form of tunnel vision that focuses on disciplinary issues. This focus may be producing a trained incapacity on the part of students who graduate from such a curriculum.

COMPUTER AS A THING IN ITSELF

The computer is not merely a linear extension of the hand calculator. Rather, the computer has already begun to manifest abilities that will render moot the artificial intelligence (AI) debates of the past two decades. Who really cares whether a machine thinks if the machine is capable of making decisions within limits set by the owner and over which the owner needs to perform no oversight? The question of whether machines think or reason is not a question asked by those in the trenches. As a case in point, the first traffic signal in the United States was changed manually by a policeman who exercised his judgment as to timing and sequence. Much later detectors and analog computers were employed for the same purposes as microprocessors are today, namely the control of sequence and timing. Whether the microprocessor thinks is irrelevant, for it performs a formerly human job much faster and with near-perfect reliability.

The most important power of the computer, relevant to transportation, may be its capacity to diminish the number of tasks. That is, it can integrate formerly divergent activities. The computer does this by virtue of its strengths--speed and power.

The slowest microprocessor circuits still perform repetitive tasks with a speed and accuracy unthinkable only a generation ago. The telescoping of time perception that occurs among computer users, happily, tends to render such terms as slow and fast obsolete.

Computers possess almost fantastic powers to sort and perform decision making based on predetermined criteria. A newly marketed Japanese ship can be operated with a single person on the bridge who communicates with the computer by speaking English. The sheer size of memory in modern computers is virtually the only limitation on the analytical tasks to which they can be assigned.

The merger of video and digital discs with computers will effect changes in information access that will equal Guttenberg's contribution of inventing movable type. An example of the potential changes that the new technology will accomplish can be found in the present practice of photologging, where a time-lapse movie camera synchronized to the speed of an automobile photographs a roadway (1). The resultant filmstrip, showing the roadway in measured intervals, can be used to study the number of driveways, advertising signs, and bridge approaches during a period of time. By using videodiscs, the filmed information could be transferred to the discs and accessed with multiple video machines controlled by a computer to show any single section of roadway during any period of time without any time lag due to reel switching. Furthermore, the useful life of the videodisc would theoretically be longer than the life of the roadway. At some point all similar bridges could be seen in sequence or safety ideas from other sites could be examined by comparison with a problem site.

All this could be done without leaving the office. The U.S. Department of Defense is using prototypes of this sort of video-computer interface to train tank drivers and has a cruise around San Francisco Bay test version that has been demonstrated publicly.

Range

Unlike humans, the range of tasks that a computer can undertake is almost limitless, from the numbingly boring tasks performed by industrial robots to tasks done by home computers that operate lighting or automobile cruise controls. The cruise-control microprocessor replaces mechanical servomechanisms of a generation ago. It constantly monitors speed and relays correction commands to engine operations. At the opposite extreme would be the elaborate aircraft simulators operated by United, American, and Lufthansa airlines. In these the number of variables simultaneously manipulated by the computer is enormous.

Friendliness

In the jargon of computerists, friendliness refers to some combination of intimidation factors and transparency of the operating system. At a more abstract level it can refer to the tendency of computers to produce interactions with human beings in a format that is easier to digest than were the esoteric initial outputs. For example, those doing research quickly find that reams of printouts containing tables and correlation matrices may mask rather than enhance significant findings. The newest computers, by using sophisticated graphics and plotting tools, can put statistical data into physical forms that allow the researcher's intuition to reenter the research process. Computers also are beginning, through natural language programs, to literally speak our language. Beyond the computer-piloted ship already mentioned, speech-to-text and text-to-speech computers hold the promise of forever altering our relation to the printed word.

The next step in simple technology such as traffic control devices may be the abandonment of unique and convoluted adjustment and reprogramming procedures now employed by every manufacturer. At some point in the future a policeman with proper codes may speak into a microphone on a traffic signal pole and tell the computer to alter sequences and timing to conform to some special event or emergency. Expensive training to manage special events and dangerous errors in adjustment would disappear.

REMAKING THE TRANSPORTATION FIELD

The power of the computer to integrate tasks will be as obvious in the field of transportation as in any other. More specifically, what it will offer to the next generation will be the opportunity to bring under one umbrella tasks that were separated only because of the technology and customs of earlier times. The number of possible examples are many and varied; some obvious ones are described in the following section.

Beyond Positive Guidance Control

The traditional positive guidance control (PGC) method is likely to become, at some time, merely a subcategory of an integrated computer graphics and videodisc method. By using PGC, engineers or safety analysts currently draw up an accident history for a

problem site and generate a checklist for potential driver confusions that could occur relating to signs and road stimuli. From this a recommendation is made as to changes short of rebuilding the site. PGC, a combination of human factors and traditional engineering tasks, may become more technically independent if the computer is put to work in currently available ways. First, the site could be analyzed item by item by using computer analysis of stored categories of signs, stimuli, and frequency factors. Actual changes could be programmed into graphics displays for testing with volunteer subjects, with the computer controlling the addition and subtraction of elements until an optimal solution is reached. Videodiscs could be used on isolated sites where sign changes and stimuli removal could be made via computer graphics overlays to the video image. After sufficient trials under these standardized conditions, certain stock answers would be obvious, whereas today each intersection or site tends to be dealt with idiosyncratically. Thus, the tasks of the human factors specialist and the civil engineer may be blended into a more integrated and functional role.

Site Analysis

The expanded PGC procedures described can also be applied to site analysis for the construction of bridges, roads, and buildings. The computer graphics and videodisc technology will one day permit the videotaping of a site and the conversion of those images into a realistic graphic display, with the result that elements can be almost infinitely put in or taken out in order to study the overall effect. Coupled with already extant analysis programs that provide running tallies of materials stresses, fatigue points, and costs, such analysis would again represent an economy and integration of effort. The computerization of movie backgrounds (i.e., sets) suggests that the geometry of fixed site parameters could easily be digitized. The site development could be tested in much the same manner that a computer-generated cartoon is created so the nonengineer can see the impact of proposed developments.

Considerable improvement could be shown in the design and placement of such ordinary structures as parking lots, parking garages, and simple entrances and exits. By using the techniques suggested here, substantial improvement could be made in trying out various solutions to problems at low cost.

Data Representation and Interpretation

The sheer volume of data now being generated is a substantial problem. Many of our colleagues ask whether anyone is reading the data we are grinding out. Unfortunately, the answer is often a resounding no. Even professionals often are no longer willing to wade through a maze of summary statistics generated on even small research and traffic analysis studies. The reason for this problem is that it is thought that, once generated, the data should be shared, although many would appreciate less rather than more generosity.

One likely development is the creation of better visual representations of data. More important, the analytic power of the computer must be put to work to generate something that transcends simply faster computing than can be done by humans (beyond the horseless carriage). There often turn out to be what one sociologist referred to as deep structures--large-scale forces or processes not evident from superficial analysis (2). For example, typical correlational analysis of driving behavior does not usually verify patterns of automobile use that we all know are evident, including social class and cultural differences. What transportation badly needs is knowledge of what other hidden factors are at work in perception, attention span, and other human-factor problem areas. As soon as users know the proper questions, the technology of modern computers will permit better answers.

In the area of effects and applications, transportation does a poor job of representing itself to laymen and nontechnical publics. Particularly, nontechnically trained persons in decision-making positions (e.g., legislatures and executive offices) tend not to respond to the kind of technically satisfying presentation found in most transportation analyses. A case in point is the difficulty recounted by Hochstein (3) with regard to the Westway freeway and one comment his article elicited (4). Nontechnically trained decision makers need to see the projected or potential effect of Policy A as opposed to Policy B and to see it in a scenario format that would permit rational rather than intuitive selection.

There is need for more detailed but generalized methods of data representation. In philosophical terms, what we often find when we do research is the proximate cause of an event when what we want is the remote cause, which is more deeply rooted. Forms of such analysis might include currently infant methods such as surface analysis.

Another area in which new approaches might be of use is traffic analysis of route and time factors. The standard approach involved developing algorithms for linear programming models for minimum time paths. Simulated traffic could then be loaded onto the network of minimum time path trees according to various logic patterns regarding the interaction of traffic with the network characteristics. Charnes (5), in contrast, was developing another approach that considered each originating unit for traffic (household or traffic zone) and the application of that unit's traffic to the network. The mathematical formulation simultaneously balanced the traffic-to-network interaction that resulted from building up a data base when each succeeding traffic unit formed a copy (or a layer).

Charnes' approach was seen by many researchers as impractical and difficult, yet it can, in retrospect, be seen to have some virtues. First, borrowing from the field of organizational efficiency and effectiveness, uncertainty theory (6) holds that the goal of organizational participants is to minimize uncertainty--those situations where behavior is undefined or goals are unsure. Inventions such as the left-turn penalty and volume-to-capacity restraint functions were instituted in order to compensate for the need for real-world uncertainty, but the standard approach still lacked data generated from the grassroots (i.e., in practical application it was based on aggregated data set characteristics). Similarly, Simon's (7) Nobel Prize in the field of economics was largely based on his contributions to decision theory, one element of which said that decisions are not made in organizations on the assumption that there is one single, best solution to any question. Rather, says Simon, people in organizations optimize, which is to say that they stop looking for solutions when an acceptable alternative comes along.

Relating these ideas to transportation, there is reason to doubt that statistical models of time minimization and similar maximizing solutions contain enough real-world aspects to be useful in prediction of behavior. Perhaps in retrospect, Charnes' approach, wherein the decisions of individuals can be built into aggregated data sets, may be more representative than those approaches derived

from theories based on questionable econometric assumptions and statistical distributions. Modern computer graphics with computing power makes the approach of Charnes not only easily implemented but potentially more powerful.

TRANSPORTATIONISTS FOR THE 1990s

By 1990 the functions of the transportation planner, researcher, traffic engineer, and technician will begin to be integrated. The integration of these functions will occur because of the capacity of interactive computer-video devices to process and sort vast amounts of information rapidly. The new role may come to be called that of transportationist. This new name suggests that the person who fills that position will be a problem solver dealing with transportation. This, in many respects, is what motivated many individuals to enter their fields in the first place and exactly what policymakers and planners often think they are getting when those persons are hired. Let us hope that expectation and reality come to be more closely aligned. A few writers have recently begun to consider the shape of transportation in a resource-scarce era (8,9); however, few have tried to deal with it universally.

The microcomputer and advanced computer graphics in existence in January 1983 permit some of this diffusion of technological disciplinarity. The FHWA computer system for testing traffic signal timing, NETSIM, has the capability, through time compression of the graphic output, to make the mathematical models completely transparent to a person testing a signal timing plan. Therefore, a person can evaluate the goodness of the signal timing intuitively as well as examine numerical criteria. Furthermore, it is possible to relate the numerical engineering data to the visual feel of the network operation. This is a new communication capability.

The accounting spread-sheet programs (such as Visicalc) are being recognized as a convenient and rapid means of organizing and carrying out the computations previously done by hand with a slide rule or calculator or by a mainframe computer program for selected engineering analysis techniques. Two such examples are the development of the velocity profile for operation of a train on railroad grade and the analysis of a truck escape lane (arrestor bed) on a highway grade. Perhaps it is easier for the engineer and the policy analyst to understand each other when a bookkeeping device handles the calculations and a computer graphics display unit presents a diagram of the results.

One final example from highway signing is suggested. In urban areas where sign control ordinances govern both private and public signage, the application of the Manual on Uniform Traffic Control Devices (10) and the application of outdoor advertising principles often conflict with the local ordinance application. Computer graphics offer a means for comparing technical requirements with aesthetic requirements and economic requirements simultaneously or for examining each in turn in short intervals. If engineers, especially traffic and transportation engineers, are to be effective during the 1990s in planning, designing, operating, and maintaining the transportation system, they must become more capable in graphic art design, more articulate in visual and verbal communication, and more adept at extending their minds beyond benefit/cost ratios and sketch plans via computer-enhanced communication.

Therefore, the logical result of this process is that the educational activities related to the fields of planning, transportation engineering, and allied disciplines must become more integrated rather than more discipline-oriented. Our experience in doing funded research across discipline, college, and departmental lines suggests that no mechanism currently exists in the education industry to cope with the need for the integration of these functions. This must be the important first step in the integration of roles that is to come.

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