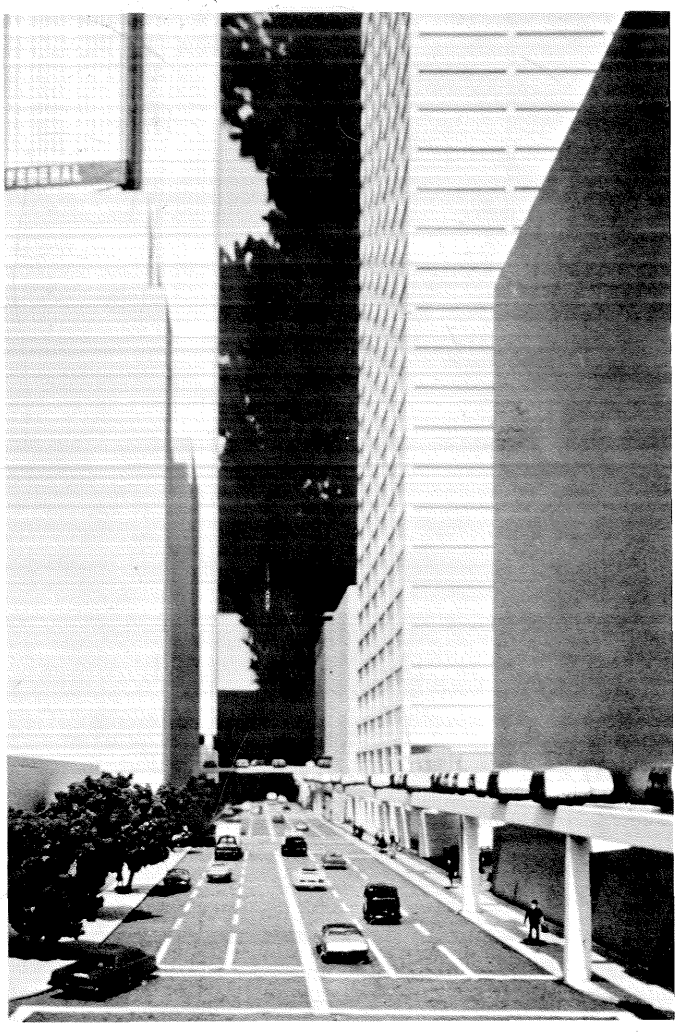


Mass transit along Grand Street in Los Angeles could look like this in 2020. With the Personal Rapid Transit (PRT) guideway installed over the curblines, neither sidewalk nor street need be cluttered with tracks, trolleys, or buses. Small PRT cars, automatically routed, would take a person or party to within walking distance of his destination with no intermediate stops.

Go or Tell:

The Future of Communication and Transportation

JOHN R. PIERCE

Without human communication we would be ignorant, lonely individuals. We would have neither the inspiration of accumulated skills and knowledge nor the support of society.

Without transportation we would be without the wealth of the world. The ivory of Africa, the tea of the East, the oil of Araby, the copper of South America, and the arts and culture of all continents could be no more than fabulous tales.

Without communication there would be no intellectual world. Without transportation there could be no real sharing among men. Communication and transportation are essential to the human condition. How will they evolve and interact in the future? Will they advance or retrogress? Will one displace the other? What can we say of the networks of communication and transportation in the year 2020?

In some sense, men of the past could envisage mechanical travel and electrical communication, but they did not and could not have envisaged the nature of the scattered yet unified life that the automobile, freeways, the telephone and television have created. Men of the past could envision human flight—usually birdlike—but they could not and did not envisage flight as all but completely replacing long-distance surface travel over land and sea.

We cannot foresee the future because it will be shaped by society, by human responses, by political and social actions and constraints—and by the potentialities inherent in discoveries and inventions. For instance, in some senses the United States, Japan, the Soviet Union, and India exist in the same age of science and technology. Yet life is very different in these countries. The use and impact of science and technology differ in each of these nations in ways that are very complex.

Thus, I shall not try to predict the future of communication or transportation in our country, let alone in our world. Rather, I shall say something about past and present trends, and indicate where I think we may be going in the short run.

Let us take as an example the rise and fall of a technological service—telegraphy. Telegraphy came into a world of slow travel and abundant labor, and it cut

drastically the time to deliver a message. In those days, the message was really delivered, right to the home and hand of the recipient. But if the telegraph was so successful, why did its use decline? Clearly, the invention of the telephone had something to do with this. We can say that the telephone is more convenient for some purposes. But basically the telegram declined because the telephone is cheaper.

When you send a telegram, you have to write or dictate the text. Someone has to count the words, make out the bill, and charge it or collect the money. Someone else has to key the message in for transmission by means of a teletype machine or other device. And, at the far end, someone else has to deliver the message by phone or through the mail. All this labor makes communication by telegram expensive.

By contrast, the telephone is a do-it-yourself service. You dial the call, local or long distance, without the intervention of an operator. Once you reach your party, you simply talk; no keyboard operator need intervene. Billing is largely computerized and automatic.

I believe the use of public transit has fallen because, like the telegraph and the sedan chair, it uses too much labor in a day in which labor is extremely expensive. Of course, people find automobiles convenient, but also they themselves do much of the work. They drive their own cars, and they spend time and do clerical work in connection with their cars' purchase, maintenance, and insurance. People do these things partly because they don't mind doing them, and partly because, in a world of high labor costs, it's too expensive to pay anyone else to do them. Thus, we can afford telephony because it is an automatic, do-it-yourself service; we cannot afford telegrams because they are labor-intensive. Private cars, carpools, and vanpools succeed because the driver contributes his services.

Where they are not forbidden by law, jitneys that pick up and carry several passengers are cheaper and more widely used than taxis that carry only one passenger. Chartered commuter buses, which take groups of people to and from work, succeed better than public line-haul buses because they carry a full load. Airplanes are more economical than trains because fewer man-hours are required per passenger mile.

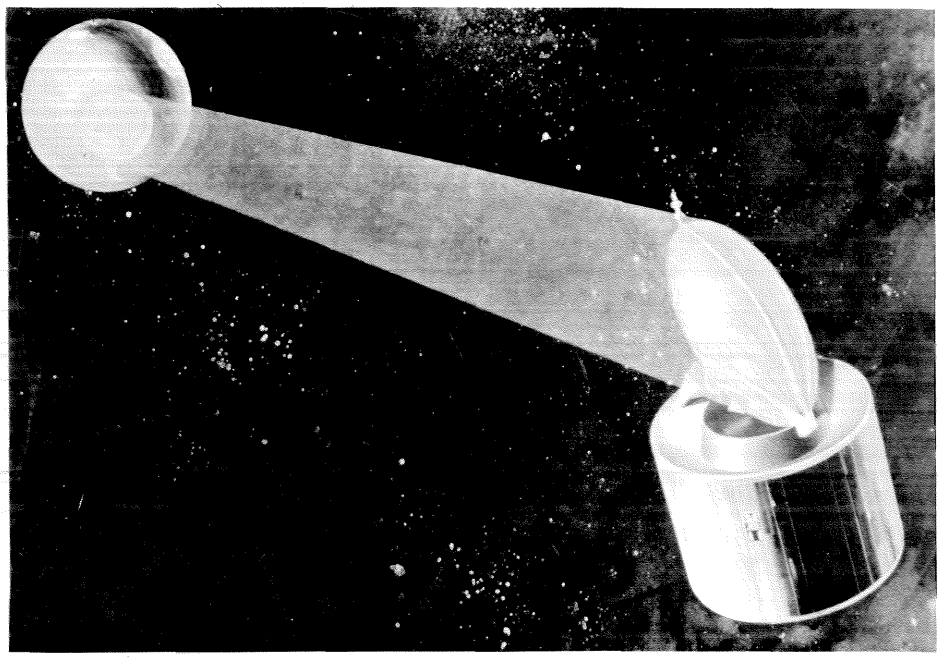
A reversion to a less even distribution of wealth, the creation of a servant class, or drastic changes in our tax structure might create a new pattern of services. But unless our governmental and social structures change drastically, we will continue to be unable to afford the labor of others.

Looking ahead, we must ever keep the cost of labor in mind as we consider what is either plausible or desirable. And we must keep in mind new technological potentialities that may provide more or better services without excessive labor of others.

One example of such potentialities is the new field of data communication and processing. Data—alphabetic and numeric—is written rather than spoken information. It is akin to telegraphy rather than telephony. But, unlike the telegram, the transmission and processing of data can be automated. Thus it is reasonable to expect greater use of data communication and processing when certain technological limitations are overcome.

Today we have no keyboard or display in our homes to

The home communication center of the year 2020 could have a wall-sized TV screen; and news, entertainment, and educational courses would be available as they are now. The handy chairside remote control keyboard would not be simply for switching channels without getting up, but for asking for more detailed information, either spoken or written. Telephones will be both audio and video, and the Gra-Flash will be a convenient and quick source of information and instruction and a means for transacting business at a distance.



Today satellites beam signals to continents. By 2020 sharper beams will be used between city and city. Thus, bandwidths of the same frequency can be used over and over. Switchboards in the sky will provide an almost unlimited amount of cheap long-distance data, telephone, and video communication.

link us to a distant computer, and so we don't use that device to perform computations, to make reservations, to order goods, to retrieve information, or to learn lessons. Instead we use hand calculators and old-fashioned typewriters. We read books. We call people on the telephone, and we go to see them. A secretary doesn't use a computer to edit manuscripts and get fresh, corrected, repaginated copies. Instead, she either retypes manuscripts completely, adding a few new errors as she removes the old, or she patches up the pages with the aid of a white, opaque fluid. When the manuscript goes to a publisher, there is a whole new keyboarding operation before it appears in print.

Why can't we make large-scale integration and data communication do our bidding? They are cheap, but the command chain isn't. To send and receive information costs so much that it really isn't worthwhile.

All the things one asks of a computer terminal have been done, some experimentally, some even commercially. Computers do edit manuscripts and make fresh, corrected, repaginated copies. In the process they produce magnetic tapes or other machine-readable records. With a little further editing, these same records can operate typesetting or photocomposing machines—or the material on the tapes can be transmitted from office to office over a data circuit.

Computerized reservation, ordering, and information-retrieval services are available. People do learn by computerized instruction. But these things are not yet in most offices or in many homes.

Until we have suitable terminals, data communication systems and computers will not be fully exploited. Yet I believe that the problem of cheap, attractive, flexible data terminals will be solved. In the not-too-distant future we will have them in most offices, and they will begin to enter our homes. Some day we will use automatic services to make reservations, purchase goods, acquire information, add to our knowledge, and learn skills.

But there is more to the future of communications than data communication and processing. Telephony itself is still incomplete in two ways. We have no mobile telephone service. And we can't see as well as hear on the telephone.

Our lack of effective mobile telephony is partly the result of a longstanding government bias toward mass communication as opposed to personal communication. Partly, however, it is because an electronic art based on vacuum tubes, or even on individual transistors, is simply too difficult.

Thus, an effective mobile communication system requires complex equipment in vehicles and an even more complex system on the ground—to set up calls, to monitor location or signal strength, and to transfer a call from one base station to another. Effective mobile telephony, indeed, requires all the complexity of present telephony—and a great deal more. Someday we may have it, or we may not, for mobile communication is the toy of those who allocate frequencies. Technology opens up potentialities, but governments increasingly control what we actually have.

Aside from mobile communication, the most serious limitation of the telephone would seem to be that we cannot see as well as hear. At present the dominating

problems are those of terminal and transmission costs. Continuing advances in integrated circuits should lead to cheaper, better terminals, which could well include coders and decoders for economical digital transmission of video and audio signals. Such terminals could be sold rather than rented, and they could be compatible in some way with the standard TV format. They might gain added appeal through providing high-definition intermittent transmission of detailed documents and pictures.

Widespread video transmission also calls for cheaper transmission, and happily there are two assured approaches to it. One of these is optical fibers. The production of uniform, low-attenuation optical fibers in large quantities has not yet been attained. Problems of assembling fibers into cables and of splicing and connecting have still to be solved. While the life of photodiodes and light-emitting diodes is satisfactory, initially the life of semiconductors in lasers necessary for single-mode operation was low. Happily, now some such lasers have been developed that have lasted several thousand hours.

Tiny glass optical fibers, which transmit high-speed signals with less loss than copper wires, will become important communication pathways.

The eventual overwhelming success of optical fibers seems assured, but it must evolve through applications, the earliest of which may be simply to provide more trunk circuits between nearby telephone central offices. Or fibers may be used to replace complicated, heavy, fallible wiring harnesses in spacecraft and aircraft. Whatever the evolutionary course of optical fibers, by the year 2020 they will be used widely for both short- and long-distance communication. And this use of optical fibers will reduce profoundly the cost of broadband transmission.

The second approach to cheaper transmission lies in domestic communication satellites. The technology of satellite communication is excellent, and it is advancing rapidly. Satellites using very short microwaves could provide cheap, high-volume communication between cities. Such communication could make intercity video communication attractively cheap. Whether this will come about depends on whether the regulatory and economic problems can be solved.

The regulatory problem is that of licensing some organization that has the resources to build a technologically advanced, high-frequency system to carry volumes of traffic between city centers and also somehow develop increasing volumes of traffic. Some organizations have now been given permission to build domestic satellite systems, but not the very high frequency system that could have a truly revolutionary effect. The economic problem of domestic satellite communication is to find a means of pricing—introductory and continuing—that will lead to the full and economical utilization of a large-capacity satellite system.

It appears that video telephony can be an inevitable outcome of technological advances, in terminals and in broadband transmission. Thus, perhaps by the year 2020 we can expect to have the universal home communication center that many have dreamed of. Data, video, and voice will provide us with services, and entertainment too, far beyond anything the world has seen. This will come, but technological, regulatory, and social constraints lie in the way.

The idea that communication may eventually take the place of travel is an intriguing one. If we eventually have very cheap, very good long-distance video, audio, and graphic communication, we may someday confer electronically rather than fly to conferences.

Will we actually someday work at home, attached to an office by wire? Or will we, instead, have neighborhood offices, linked together by communication? This depends not only on communication itself but on a host of other factors, including zoning, the nature and amount of taxes, the quality and nature of living conditions, and the attitudes of business management.

Communication has already made possible a great deal of decentralization of highly integrated industries and activities. But our areas of interest and action are also spreading over larger and longer geographical areas. The number of local telephone calls per person per year, for example, is rising slowly. But long-distance calls are increasing rapidly, and overseas calls more rapidly still.

Most air travel is over considerable distances, and overseas air traffic increases at about the same rate as domestic air traffic. Both have nearly tripled in the last ten years. Beyond this, the communication to and from, and the travel to and from, urban areas appear to go hand in hand. On a large scale, at least, we may expect the future to bring increases in both communication and transportation.

In long-distance travel presumably we will use jet aircraft, supersonic aircraft, and—eventually—ballistic, suborbital rocket vehicles. Will the automobile disappear in local travel? I think not. Rather, we will have lighter, more economical cars that are smaller outside if not inside, and they will be propelled by more economical engines. As more effective batteries or other energy storage means are developed, some will be electric.

What of mass transit? Taxis will persist, and jitneys will triumph where they are not forbidden by law. Buses and demand-responsive buses will continue to provide an essential but costly service. Subways and conventional rail systems will be built by communities that love dinosaurs and will have them at any cost. Mass transit that is successful in any reasonable sense of the word must be automated, for that is the only way it can escape the economic disaster of increasing labor cost.

Can automated mass transit succeed? An automated system at Morgantown, West Virginia, has been a financial disaster. BART, the Bay Area Rapid Transit System in northern California, has had troubles. Such difficulties should not be overemphasized; automatic elevators are a form of mass transit that is an unqualified success.

Automated mass transit is a new and difficult field that must be explored experimentally before it can succeed commercially. In the cases of Morgantown and BART, an effort was made to provide service with untried vehicles and control techniques. The canny Japanese are building two and a half miles of track and 80 vehicles simply to *experiment* with automatic mass transit. Perhaps we can learn from them.

What, then, does lie ahead of us? In part we will have more of the same—more telephones, more long-distance and overseas calls, more cars and freeways, and more and longer travel by air. We may even have super-fast, guided surface vehicles.

At opposite ends of today's automobile spectrum—the Honda and the Cadillac. Automobiles will not disappear by 2020, they will merely become smaller and more economical in terms of fuel consumption.

In part we will have more and better communication. We will have more data communication; we will have mobile communication and, eventually, video communication as well.

We may have new forms of transportation that are as do-it-yourself as automobiles, telephones, and automatic elevators. What we will not have, unless our world changes drastically, is much costly, labor-intensive transportation like sedan chairs and present forms of mass transit.

We may see new patterns of life and work in which we do not travel so far to earn our living. Perhaps, as communication is perfected, travel will no longer grow hand in hand with it. In fact, easy communication may ultimately substitute for arduous travel.

As ever, the future remains a closed book. How radically the world will change by 2020 depends on technological and sociological forces beyond my comprehension or ability to evaluate. □