THE FUTURE IMPACT OF COMMUNICATIONS ON THE TRANSPORT SECTOR

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1. INTRODUCTION

This paper is based on the recognition that transport activities constitute an element of the broader concept of communication. The need to interact, i.e. communicate, in terms of messages and physical exchanges is a fundamental prerequisite for the functioning of most societies. Differences between societies do not exist with respect to the concept of communication, but with the intensity and the type of interaction that is desired and achieved. It is probably only a slight simplification to state that the degree and type of communication (i.e. exchange of goods and messages) is a valid indicator for the level of sophistication of a society's social and economic structure. In this paper we will attempt to trace some developments in communications as they have affected and most likely will affect the transport sector, mainly of industrialized countries.

2. COMMUNICATIONS TECHNOLOGIES AND THE TRANSPORT SECTOR

Western societies are moving at a rapid pace towards information societies (Porat, 1978). The information flow required per person in our personal life styles, in research, in administration, in all service industries, etc. is increasing dramatically. All aspects of daily life and of society in general are affected by this acceleration in the exchange of information. Few households are without telephones or televisions. Banks and travel agencies without computers are rare. Governmental recordkeeping would be virtually impossible at the present scale without the extensive use of electronic devices (Lee and Meyburg, 1981).

Transportation and communications are closely related infrastructural elements of our society (Memmott, 1963; Nilles, et al., 1976; Stanford Research Institute, 1976). These modes are used to enhance and facilitate exchange in the national and international economies, and to increase the level of human interaction. As societies move toward information economies, the need for exchange of goods, defined in a very broad sense, is being replaced by the need to exchange information. This evolution is changing the nature of demand for these services.

In some instances communications may substitute for particular transportation needs. In other cases, they may be complementary or enhancing. Patterns of telephone usage serve as an example of the substitution potential of communications for transportation. Telephone communications have reduced the need to transport various kinds of messages and also the need to travel personally to communicate. Complementary relationships develop in situations where communication activities affect the operation, safety, efficiency and effectiveness of transportation services. One can talk about enhancement in situations where communications make travel more convenient, pleasant and useful.

This paper is concerned with the implications of transportation-communication tradeoffs as opposed to the technological details of specific communications techniques. In order to avoid confusion about the distinction between the substitutive and complementary relationships, which is at times difficult to maintain, substitution analyses will be confined to those situations in which a trip is entirely replaced by communications. Discussions of examples for the complementarity aspect can be found in Meyburg and Thatcher (1978 and 1979).

Several studies have considered the substitution potential of communications for transportation (e.g. Gray, 1974; Nilles, et al., 1974; Lathey, 1975; Dickson and Bowers, 1974; and Harkness, 1973). Most research has dealt with technologies to reduce personal travel needs. Two technologies which seem to be particularly promising candidates to influence future travel demand patterns are the videophone and the teleconferencing unit.

The video telephone adds a visual dimension to the telephone, allowing transmission of pictures of the communicating parties or conveyance of visual information (Dickson and Bowers, 1974). Communication of graphic data could, for example, facilitate consumer decisions regarding purchases by telephone and also allowing security monitoring. The motivation behind the development of this technology lies in a desire to enhance the performance of traditional voice communication systems to a degree that they are attractive alternatives for satisfying some traditional personal travel needs. The potential for augmented audio communications and the possibility of viewing textual and graphical material are considered to be the principal advantages of the technology. The potential benefits of this technology have not been realized fully due to the lack of development of a suitable market. While at the present time consumers have not perceived a sufficient increase in utility to justify purchasing and using this expensive equipment, demand is expected to grow in the future. In the U.S., the videophone, developed by Bell Laboratories of the Bell System, is known by the trade name Picturephone.

Teleconferencing services are essentially an extension of the videophone capability. They are designed to reduce personal travel needs to attend meetings. Also, these services could have a substantial impact on the character of work trips. It is feasible to decentralize office locations by using teleconferencing services. Such workplace location decisions are significant since, for example, in the U.S. people working in the Central Business District travel twice the distance and have approximately 2.25 times longer trip times than those persons with suburban employment. Obviously office or workplace locations in different cities can be connected by means of teleconferencing technology, thus reducing the need for intercity business travel.

3. ELECTRONIC MESSAGE TRANSFER

New electronic message transfer technology now under development and testing offers the potential to alter transportation demand in a significantly different fashion. Innovative electronic systems which transfer both messages and information can reduce needs to transport paper-based media. This discussion will sketch the rudimentary features of such systems and then consider some of their implications.

Electronic transmission services already play a large role in information exchange (e.g. telegram, Telex, banking networks, data transmission). The introduction of innovative electronic message transfer technology will have further impacts on the volume of people and goods movements. Some of the impacts pertain to the use of conventional transportation systems in terms of vehicle requirements, network use, labor requirements, and fuel use

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(Meyburg and Lee, 1981 and 1982)

Emerging electronic message and information transfer systems include a range of newly developed technologies that could have a dramatic effect on the volume of discretionary travel demand such as shopping, social-recreational, educational, human interaction, personal and business travel needs. One such technology is known by the generic term as viewdata, and by the trade names Prestel (U.K.) and Bildschirmtext (Federal Republic of Germany, ASA, 1981), among others. Essentially it consists of modified telephone and television units which allow subscribers to gain access to complete libraries, newspapers, mail-order catalogues, entertainment information, electronic games, home computer services, news, sports, and weather information. The number of potential services is only limited by the willingness of information suppliers to make their products available to subscribers.

These systems offer primarily information retrieval, interactive gaming, or teleprocessing capabilities. Data are accessed by telephone lines from a central data storage bank and displayed on modified television receivers. At a somewhat more sophisticated level, this operational technology could allow subscribers with modified television-keyboard units to generate and exchange personal messages. Such systems could stimulate changes in methods of distributing books, publications, newspapers, etc. These practices could affect transportation, energy and paper requirements.

A second objective of evolving electronic message transfer technology is to facilitate the exchange of person-to-person communications which are graphic or alphanumeric character-oriented and digitally encoded. Such services convey messages electronically but may at some stage produce and transfer paper copy by convenient means. Postal services and private corporations in several countries (e.g. Germany, Sweden, United Kingdom, United States) are presently evaluating the operational and economic feasibility of electronic message transfer services. The private sector is concentrating primarily on terminal-to-terminal systems.

The U.S. Postal Service (USPS) has been developing a nationwide system which integrates conventional postal operations with electronic techniques. The USPS has been developing this hybrid electronic message transfer system design for over two decades. The current design will provide a nationwide service with next day delivery for 95 percent of messages entering the system by 5 p.m. on the previous day. Plans are also being made to provide a priority service (i.e. 1-2 hour transfer of messages) at a premium price. Both the overnight and priority service will use the conventional postal collection and distribution system along with new electronic equipment under development.

The implications of large-scale introduction of electronic message transfer are numerous, including reductions in communications cost and resource requirements and increases in speed of communications. Specific examples would be the reduced resource requirements including specifically vehicles, fuel and labor for the postal services, once a large proportion of first-class mail is moved by electronic mail. These implications are particularly significant for countries with large geographic size and large message exchange volumes.

RCA (1978) and others have made projections of the U.S. market potential of the hybrid electronic message transfer system. Table 1 reveals that almost 35 billion first-class items are considered susceptible to electronic transmission. This projection does not include check-related payment items since Electronic Funds Transfer systems may handle this traffic. Based upon these estimates, the first-class mailstream can be expected to offer between 11 billion and 35 billion items to the total potential electronic message transfer volume depending upon implicit assumptions. If check-related items are also carried on this system, the first-class contribution will be even larger.

Table 1. Projected USPS Message Volumes for USPS Hybrid System Alternatives Susceptible to Electronic Message Transfer.

Source and Letter Category	First Class	Third Class
Businesses:		
Transactions	18.8	
Correspondence (Individual)	8.7	
Priority (Alphanumeric)	0.4	
(Graphic/FAX)	0.8	
Advertising (Alphanumeric)		5.7
(Graphic)		7.3
Individual Households:		
Correspondence to Business	3.0	
To Other Households	3.1	
TOTAL (Billions of Letters)	34.8	13.0

Source: RCA Government Communications Systems, Electronic Message Service--System Definition and Evaluation, Washington, DC: NTIS, 1978.

Intracompany mail will be a second source of electronic message volume. Assuming that one-third of the estimated 70 billion pages continues to move in the first-class stream and also that more than one-half of the remaining volume continues to move via conventional company mail services, then as many as 20 billion messages may travel over electronic systems. Of course, if electronic services become much cheaper than conventional transfer, this diversion can be expected to be somewhat larger.

Electronic message services are not likely to be direct substitutes for any current message services because the products are dissimilar. However, electronic services have some combined characteristics of both conventional and telephone services (e.g. speed, hard-copy), suggesting that some consumers may view electronic message systems as desirable alternatives to the telephone for certain communication needs. At the same time, it is probably reasonable to expect that the telephone will continue to be the overwhelming communications carrier. As a substitute for the written word and for otherwise necessary or desirable travel it has affected business and personal life most profoundly.

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Since annual telephone message volume is expected to reach 465 billion calls in the U.S. before the end of the decade, a mere one percent migration could represent a potential volume of more than four billion messages. If electronic message and telephone service rates ever reach parity then a diversion of even a few percent will result in a significant message volume.

Annual electronic transfer volume could reach between 35 billion and 59 billion messages within the next decade. But limitless possibilities exist for new uses. If new uses prompted by new technological capabilities raise message volumes by 10 percent, total potential traffic over end-to-end and hybrid systems may reach 65 billion communications annually by the end of the decade -- hardly a trivial volume. In terms of scale, this estimate is almost 20 percent larger than the current first-class mailstream. A growth in electronic message volume of this magnitude will have a significant effect on postal operations.

While the implementation of a hybrid system will have significant impact on a number of areas in the public and the private sector, the direct effect on personal travel most likely would be minimal.

The end-to-end system gives rises to a more futuristic, yet not unreasonable scenario. The fully electronic home and office are definitely on the horizon. In this scenario virtually all communications and interactions necessary for the conduct of business and of our personal lives can be performed within the home and the office. Some elements of this electronic future exist already. For example, we will be able to pay bills, do shopping, send letters, and select entertainment directly by means of a home terminal. The electronic office, possibly also located in the house, could have as added features the videophone, the word processor, teleconferencing capabilities and, of course, easy availability of computing facilities.

The end-to-end system scenario could change our life and business conduct to a rather substantial degree. Since life-style changes are very much related to the need and propensity for travel, the transport sector could be affected. Fewer work trips, personal business and shopping trips would be the obvious consequences of being able to fulfill many functions at home or in the home office that conventionally would require travel activities.

The degree of market penetration of such technologies is dependent, in part, on the economic well-being of a sizeable segment of society and business, and on the acceptance by the potential users (probably a function of the "salesmanship" of the hardware, software, and information providers). Another aspect of the likelihood of a sizeable market penetration will be whether the use of new communications technologies becomes necessary, for example, for a business to remain competitive and efficient and for a household to cut household expenditures in the long run. If the home-based electronic technology constitutes merely a convenience and hence an additional option as to how one might want to conduct one's business and social activities, the impact on travel intensity and patterns is likely to be minimal. Support for this projection can be found in the U.S., for example, with respect to the use of entertainment options via home box office and home videorecorder. While the use of these two means of in-home entertainment has increased substantially over the last few years, the attendance at and travel to conventional movie theaters has increased significantly during the same time. This result is possible because people obviously perceive an enhancement in their entertainment options rather than the creation of substitutes for traditional entertainment modes.

In projections of future travel demand and travel characteristics the potential impact of communications technologies as either substitutions of or complements to travel typically are completely overlooked and ignored (e.g. U.S. DOT, 1977; Bayliss, 1981; Hartgen, 1981). The reason could be unawareness of the communications-transport tradeoff. Another explanation could be that impact and tradeoff are considered too negligible to warrant discussion. Careful analysis of these relationships suggests that these relationships are real and that the impacts are likely to be all but negligible.

4. SOME COMPLEMENTARITY EFFECTS OF COMMUNICATIONS

Many uses of communications technologies are in existence that complement transportation system operations. The major motivations behind their use typically lie in the areas of efficiency, safety, and control. In many countries two-way radios are standard equipment for taxi and urban goods pick-up and delivery systems. Demand responsive public transportation systems are dependent on in-vehicle communications capabilities. Modern subway, commuter train and intercity rail services are unthinkable without the use of electronic services for control, safety and operational efficiency. The most sophisticated communications technologies make the orderly and safe operations of the world's air carriers possible. The impact of communications technologies in these transport systems were and are significant. The future will bring some incremental additions, improvements, and changes in these technologies without dramatically changing the character and performance of the transport operations. Automatic vehicle monitoring systems undoubtedly will become more common in the future as will be the use of changeable message signs about recommended speeds and routing on expressways.

A rather significant growth area of communications technologies in support of transport systems is likely to be in the area of mobile communications (Meyburg and Thatcher, 1978a,b and 1979). The implementation of the so-called multi-channel trunk system and the cellular system can have a major effect on the operational efficiency, and hence on the cost of demand-responsive passenger transport and on road-based freight operations. In addition, telephone use in private cars is likely to become widespread with the introduction of such technologies.

In the multi-channel trunk system (MCTS) with automatic control, access to the several channels assigned to this system is controlled by a central computer unit; all users must request permission to transmit. Permission may be requested by voice through a dispatcher or automatically by pushing a button in the mobile unit. The capacity of trunked systems is much greater than that of dispatch-type services. Trunking allows each caller to use one of many channels available, rather than waiting for his designated channel to become free.

MCTS systems are relatively private, since each simultaneous communication is on a different frequency. It uses spectrum much more efficiently than dispatch systems because it permits steadier utilization of channels. The number of users is limited by the number of channels assigned to the system. Capital costs for this system are obviously greater than those for simple dispatch systems.

In a cellular system, a large service area is broken up into cells; within each cell is operated a sub-system functionally similar to that of the multi-channel trunked system. The cells may be from one to about twenty miles in diameter, and the MCTS transmitters in adjacent cells operate on different sets of frequencies. The major purpose of the cellular system is to increase mobile communications capacity within a given spectrum allocation. Short-range transmitters and small cell size permit reuse of allocated frequencies in cells separated by a specified distance from the cell originally using those frequencies. Moreover, small cell sizes are naturally compatible with the limited range and unfavorable propagation characteristic of the frequencies now being made available for mobile communications.

It is apparent that in addition to the basic components of MCTS, a cellular system requires facilities for locating mobile units with a precision of one cell; and for automatically switching receiver/transmitter frequencies and transmitter stations, as the vehicle moves from cell to cell.

The major advantage of the cellular system is its vast potential capacity; it can accommodate millions of users. The capacity is not only proportional to the number of channels assigned, but is also inversely proportional to cell size. As cell size is reduced, the number of cells in a given service area is increased, thus increasing frequency reuse. Additional advantages are privacy and virtually unlimited effective range.

Assuming that a cellular system would have the following capabilities: (1) vehicle monitoring; (2) increased dispatching capacity; (3) increased dispatching speed; (4) shared cost of dispatching; (5) increased range; (6) mobile-to-mobile communications; (7) privacy; and (8) interconnection with the wireline telephone system, several benefits to both present and future demand-responsive systems can be seen.

It is important to note at the outset that the distinction between benefits to presently designed operations and future systems is important to make in analyzing impacts. For example, it might be suggested that the operation of a system could be altered significantly by the new technologies, and as a result, a new set of benefits might accrue. At the same time, if the system remains in its original state of operation, a totally different set of impacts would result.

Dial-a-ride, jitney and shared-ride taxi systems as they exist now, would stand to benefit from a number of the cellular system's abilities. Vehicle monitoring and increased dispatching capacity and speed are characteristics that are highly desirable in these operations. Vehicle monitoring would aid in better routing and scheduling by providing control of vehicles. Increased dispatching capacity and speed would eliminate communications delays and overcrowding and would therefore increase vehicle utilization.

For present conventional taxi operations, increased capacity would be a major benefit but vehicle monitoring would have little immediate impact on the industry. Because the present method of conventional taxi operation does not include complex routing and scheduling of vehicles, the need for a vehicle monitoring system does not arise. Increased dispatching speed and capacity, which would result in a general decrease in spectrum congestion, would be a substantial benefit as the majority of taxis are operated in large cities where frequencies are very overcrowded.

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A benefit that would be applicable to all systems would be the lowered cost of communications equipment. Specifically, the monthly charge for cellular service would eliminate the high capital cost of equipment and enable a greater number of taxi and jitney operations to become radio-dispatched. Shared-ride taxi systems and dial-a-ride systems, which are of necessity radio-equipped would experience this benefit in the sense that it would become much easier to afford to establish these types of services. Of course, the benefit of lowered cost would depend on the level of penetration of a cellular technology which would probably determine the charge per month that would be levied. If the system were offered at or near $20/month it is likely to have widespread economic impact on all demand-responsive operations. If, however, the charge is more in the range of $50/month, large dial-a-ride and jitney services (with federal and state money available for purchase of equipment) would likely opt for the outright purchase of a communications system. Also, if a high cost were to prevail, taxi systems would probably not become cellular network users (shared-ride taxi systems would remain using conventional equipment, and conventional taxi systems would either remain totally non-radio-equipped or would continue to rely on the "all-call" form of dispatching). The only systems that would benefit from a cellular technology given a high monthly charge would probably be very small operations, for which even a $50/month charge would be more reasonable than purchasing a base station, leased line to an antenna and mobile units.

A last possible area of benefit would result from a problem now experienced in demand-responsive operations, termed the no-show problem. This refers to customers who call the dispatching center for a ride but when the vehicle arrives at the address given, the customer either delays in appearing or fails to appear at all. Typical delays incurred by customers not being aware that the taxi is waiting could be aided by the cellular system's "interconnection with the wireline network." At present, no-show problems are handled by the driver informing the dispatcher about the situation. The dispatcher then refers this to the switchboard operator who will call the person to inform them that their ride has arrived. With the cellular system, this could be accomplished through the creation of a third communications interface: the driver/customer interface.

Even if a cellular technology were not employed in the dispatching of demand-responsive vehicles, one very important benefit would still result from public use. First, customers would be able to phone in their requests without having to be at home or having to use a pay phone. The importance of freeing customers from the land-line network has been displayed by the fact that a number of demand-responsive systems employ free, direct-line telephone service at major areas of demand such as shopping centers, airports, etc.

Besides effects on systems as they are now designed, the introduction of a cellular technology could alter the actual operation of demand-responsive systems in the process of establishing benefits. For example, although no system operated today has reached the computer-controlled/digital communications (C/D) level of operation because of problems in the development of reliable computer algorithms for automated control, the potential for a C/D operation would be enhanced by the cellular system's ability to locate both vehicles and customers. Through the use of digital coding, a mobile phone could be used to relay information to and from a vehicle to a computer control center without the necessity of having a dispatcher intervene. At the other end of the system, the customer could enter a coded message giving his/her desired destination and this information, along with the customer's origin (known by the cellular systems' control center) could be fed into the routing and scheduling computer. By eliminating both the dispatcher and the switchboard operators, the operating cost of demand-responsive systems could be drastically reduced.

A second benefit that might accrue to a future form of demand-responsive operations would be the ability to integrate demand-responsive systems (as "feeder" services) into an overall transit network. Designed to service suburban areas and less densely populated areas, demand-responsive systems could be organized to provide ridership to city-based fixed-route, fixed-schedule systems. The mobile-to-mobile capability could allow drivers to communicate with each other and would make transfers of passengers much less difficult (it would also reduce the delay time between transfers). City-wide coverage afforded by the cellular network would enable demand-responsive systems to ring metropolitan areas and provide service to all fringe area residents. Obvious first-order impacts that would result from the benefits mentioned above would be:

(a) ease in implementation of systems and thus an increased number of demand-responsive operations;

(b) more efficient operation and increased vehicle productivity which would reduce the deficit per passenger;

(c) a higher level of service afforded the general public and as a consequence an increased ridership;

(d) better public transportation in suburban and rural areas, previously unable to be served efficiently by fixed-route, fixed-schedule systems.

The preceding sections have illustrated that use of new mobile communications technologies in the passenger transport sector. Naturally, a similar set of impacts can be identified for freight transport. Again, the major impact categories are those of operational efficiency, flexibility, cost and safety. The details of an assessment of the complementarity effects of mobile communications on road-based freight transport have been discussed by Meyburg and Thatcher (1978b and 1979) and will not be reviewed here.

5. SUMMARY AND CONCLUSIONS

In this paper we have attempted to illustrate some aspects of the relationship between communications and transport. Examples were provided of how both the substitution and the complementarity effects have had impacts in the past and how travel and transport are likely to be affected in the future. The role several types of new communications technologies will play in the changing characteristics of transport were assessed and projected.

It should also be noted that communication is and will be only one element that can and does influence travel intensity and type. Relative costs, time, and convenience will be important elements in transport and communications choices. For example, it is hard to imagine that in the foreseeable future, trends in automobile ownership will change as a function of developments in the communications sector. On the other hand, the use of the private auto might be affected with respect to frequency and trip purposes. Communications as a means of improving the efficiency, safety and economy of sectors in the transport industry is likely to increase. Travel; or transport, and communications are elements of the human activity set. Their characteristics and intensity are, in part, a reflection of economic activities and life styles. Careful consideration of the interplay between travel (transport) and communications will assist in analyzing and understanding better travel and transport as elements of human activity patterns.

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