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Please note that this paper was written before there was such a thing as a personal computer, and when the Internet's predecessor, the ARPANET, was in its early developmental stages.

971 Stonehill Lane ◆ Los Angeles, CA 90049
www.jala.com

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Abstract—**In recent years, several phenomena have caused significant pressures on the traditional, centralized urban structure. These phenomena include urban sprawl, separation of business and residential areas and concomitant dependence on transportation, the absence of effective or widespread mass transit, and declining oil reserves with rising energy costs. These conditions have made decentralization more attractive to many large organizations currently located in the central business districts (CBD's) of major urban areas. The increasing availability of sophisticated communications and computer technologies may encourage the continued growth and future decentralization of "information industries," thereby producing major urban changes. The telecommunications-augmented decentralization of a traditional centralized organization to a diffused one with an intraorganizational telecommunications network is described. The key factors in this process are discussed: 1) the ability of new telecommunications and computer technologies to maintain or increase productivity for routine clerical and management functions, *2*) their availability, and 3) their costs relative to urban transportation systems. Telecommunications-augmented decentralization can have significant impacts on transportation, telecommunications, labor, and land-use policies; specific areas of impact are discussed.**

I. INTRODUCTION

URBAN and suburban sprawl during the last three decades has created, and continues to create, major conurbations linked by extensive freeway systems. Dependence on the private automobile has defeated most attempts at rapid mass transit in urban areas. However, in recent years, the costs of commuting by private automobile have risen dramatically, urban air pollution has become a major national problem, and central business districts (CBD's) have suffered from declining residential populations.

Some urban planners have recommended the development of regional business and governmental centers as an alternative to the continued expansion of the traditional, monolithic CBD.[1] Recent developments in telecommunications and information-processing technologies are providing the catalyst to introduce alternatives to transportation which facilitate new urban and organizational forms and which mitigate transportation-related problems. Large organizations that engage primarily in information processing can effectively utilize these technologies to decentralize and relocate their organizational elements within regional centers. This paper describes research at the University of Southern California that estimates the magnitude, direction, and rate of innovation of telecommunications-augmented decentralization of "information industry" organizations.

II. DEVELOPMENT OF THE DECENTRALIZATION-INDUCING ENVIRONMENT

Three factors have been instrumental in creating a favorable environment for the effective decentralization of large and medium-sized organizations.[2] These are: 1) the growth of the "information industry"; 2) the development of increasingly effective, relatively low-cost communications and computer technologies; and 3) the increasing magnitude and variety of forces which motivate organizations to decentralize.

Throughout this paper, any organization or organizational component whose primary function is the creation, manipulation, or transfer of information is considered a member of the information industry. The term encompasses many government organizations, much of the banking and financial industry, the administrative functions of most major companies, and the automated or semi-automated production of goods. Because there is a steady trend in the United States toward service functions, as opposed to the

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The author is Director, Interdisciplinary Program Development, Office of Academic Administration and Research, University of Southern California, Los Angeles, Calif. 90007.

[1] V. Gruen, *Centers for the Urban Environment: Survival of the Cities*. New York: Van Nostrand Reinhold, 1973.

[2] The lower level of organization size discussed is in the order of 40-50 employees, although for some organizational functions an even smaller number of 4—5 employees could perform effectively in a decentralized group. Several small research groups in the U. S. and Canada are now operating this way.

production of goods, the information industry is growing steadily and its members constitute approximately half the workers in the United States.[3] A typical characteristic of an information industry organization is that the workers interface frequently with computers. Currently, this interface is effected by collocating workers and computers in large structures in or near urban business centers.

Over the past decade, computer technology has become very sophisticated, permitting expanded applications and lower costs. One application is the coupling of components of large computers by means of various communications networks. This has been done on a strictly computer-to-computer scale, with high data rates being used in the transfer process, and on a more diverse scale, using time-sharing services which connect a multiplicity of remote terminals to a data-processing center.[4] Primary intermediaries in the growth of "teleprocessing" have been the telephone companies, the specialized common carriers, and teleprocessing networks like ARPANET.[5]

Our research at the University of Southern California (USC) included an investigation of the technologies required for "telecommuting." A telecommuting network has computational and telecommunications components which enable employees of large organizations to work in offices close to (but generally not *in)* their homes, rather than commute long distances to a central office. The USC researchers arrived at an important conclusion: most information-transfer functions performed in an information industry organization can be adapted to an intraorganizational telecommunications environment, using primarily conventional telephone channel bandwidths, provided suitable man—machine interfaces (i.e., properly designed terminals) are available.[6] Further, the requisite telecommunications and computer technology exists to enable organizational decentralization that is economical and societally significant.

Although necessary, the above factors are insufficient to motivate many business and governmental organizations to decentralize. Other conditions, however, present tangible inducements. One persuasive factor is the increasing cost of transportation in urban areas. Our research results showed that the costs of commuting to work, for a typical employee of an information industry organization, are comparable to the operational and amortization costs of a telecommunications-computer network that would allow the employee to telecommute.[7] When an information industry organization is located in an urban CBD, at least some of the transportation costs are borne by the employer, if only indirectly. For example, the CBD employer must offer higher wages and additional fringe benefits. These costs, including higher office rental costs, can be as much as three times the cost of telecommuting for the employer. Finally, the unavailability of gasoline and/or higher gasoline prices and the consequent inability of workers to commute long distances, can accentuate this factor in the decision to decentralize.

Organizations also decentralize on a national scale. Again, the increasing effectiveness and decreasing cost of computer-augmented communications and, in some cases, teleconferencing, can enhance the attractiveness of conducting business meetings using telecommunications, rather than transporting the participants to a meeting location.[8,9,10] We anticipate increased use of telecommunications by information industry organizations, particularly of teleconferences supplemented by periodic face-to-face meetings.

The accessibility of new labor pools is another major impetus to organizational decentralization. In many CBD's, particularly in older cities, local labor sources have been depleted; consequently, the residential origin of the workers employed in the CBD has been steadily increasing in dis-

[3] In 1970, professional, technical, clerical, and sales workers, managers, officials, and proprietors constituted 48.3 percent of the U. S. labor force, with an average annual growth rate, from 1960 to 1970, of 1.6 percent (U. S. Department of Labor, *Manpower Report to the President.* Washington, D. C.: Government Printing Office, 1973). The 1960 to 1970 growth rate extrapolated to 1975 indicates that these workers might constitute 57.2 percent of the work force. Although some of the technical workers, professionals, and proprietors are not strictly information industry workers, most are.

[4] An estimate has been made that by 1980, 2.5 million terminals will be in use, with 32 billion data calls. "Crisis in data-communications: Some projections of growth," in *Comput. Deciaion,* p. C 7, Nov. 1970.

[5] 'These networks can offer both sophisticated and routine data-processing capabilities. For example, through research performed at the Institute for the Future (IFF), ARPA has been instrumental in developing new software for teleconferencing (i.e., the use of a computer to provide a sophisticated store-and-forward system which permits geographically dispersed participants to communicate with each other over long distances via computer terminals). IFF's system is becoming available on at least one commercial time-sharing service under its new name: CONFER.

[6] J. M. Nilles, F. R. Carlson, P. Gray, and G. Hanneman, "Telecommunications-transportation tradeoffs," Univ. Southern California, Los Angeles, Calif., Rep. No. NSF-RA-5-74-020, prepared for the National Science Foundation, RANN Program, 1974, pp. 47—48.

[7] *lbid.,* pp. 80—109.

[8] The following organizations have been engaged in research in the effectiveness of teleconferencing: the Communications Study Group, Joint Unit for Planning Research, at the University College London, where extensive work has been done on the psychological aspects of telecommunications; Human Sciences Research Institute at McLean, Va.; the Business Planning Group of Bell Canada; Stanford Research Institute; and the Metropolitan Regional Council (MRC) in New York City.

[9] Some major national corporations already have video conferencing networks connecting regional offices. Several federal agencies, NASA and DOD among them, are increasing their uses of teleconferencing to reduce intercity travel. Video teleconferencing has generally been less enthusiastically received because of its high cost. Innovations like fiber optics transmission lines may make this option considerably more attractive by materially reducing the transmission costs that are the major cost element in long distance video conferencing.

[10] E. M. Dickson and R. Bowers, "The video telephone," Cornell Univ., Ithaca, N. Y., June 1973.

tance from the OBD. Decentralization enables an organization to establish subunits in locations closer to the desired work force. For example, a company studied by the USC research team is beginning to decentralize. largely because it can attract higher quality clerical staff at locations removed from the CBD. The company is interested also in attracting part-time workers, including handicapped persons, students, or housewives who, although otherwise qualified, would be unable to commute to the downtown location. Finally, the increasing emphasis on equal job opportunity is causing employers to consider locating organizational subunits in minority areas where public transportation is often poor or unavailable. None of these options is effectively open to a firm unless quality communications are possible between the scattered subunits.[11]

III. OTHER INFLUENTIAL FACTORS

A crucial question in telecommunications-augmented, organizational decentralization is whether productivity can be maintained or improved when information industry workers use computer terminals.[12,13] Research on this question is just beginning, but it appears, from our own research and that of others, that most clerical and routine administrative functions can be effectively performed using commercially available computer terminals. Initial tests at a company studied by USC indicate that productivity is increased in this mode as compared to the traditional mode. However, it is too early to determine if there is a "Hawthorne" effect (i.e., whether the uniqueness of the situation is spurring workers to increased effort). On the other hand, the feedback properties of the computer terminal, when equipped with appropriate software, may provide precisely the productivity-increasing operant reinforcement that was observed in the most noted experiment at Hawthorne.[14]

Some corporations have experienced adverse effects on productivity when computer terminals were introduced to portions of their work force. The primary reason appears to be that the human-factors aspects of the problem (i.e., the psychology of introducing new methods or the development of effective operating interactive software) were not considered fully before introduction of the new operating mode.[15]

The question of effectiveness of management functions in the telecommunications mode is more complicated, primarily because of the greater complexity and variety of management tasks. As the level of management increases, so does the tendency to insist on face-to-face meetings between the manager and his peers or subordinates.[16] Although managers feel diminished confidence in decisions made using various telecommunications systems, compared to their confidence in decisions reached after face-to-face meetings, researchers have concluded that the actual decisions are the same in both cases.[17] The key point seems to be that the optimum management use of telecommunications in a decentralized organization is through occasional face-to-face meetings to renew confidence in verbal cues, perceptions of attitudes, and similar imponderables not easily transmitted through a telecommunications system, supplemented by the use of telecommunications in the interim periods. An important element in the managerial use of telecommunications appears to be the availability of some form of graphic-display capability (not necessarily transmitted at video bandwidths) so that data, curves, line drawings, etc. can be transmitted. Either a CRT display or hard copy would suffice for this purpose.[18,19]

One factor influencing the extent and rate of organizational decentralization is the operational availability of adequate communications networks and components. A reliable baseline network, the telephone system, already exists. A substantial and rapidly growing industry is engaged in the development and production of computers, terminals, software and interconnect systems. However, commitment by a decentralizing company to a customized, self-owned telecommunications system design, hardware,

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[11] As a case in point, one firm was studied during the research because it is *re*centralizing from a set of six locations dispersed around the Los Angeles CBD. The newly centralized location will be more than 60 miles from the CBD, although a CBD headquarters office will be maintained. One major reason given for the recentralization was poor communications quality between the dispersed offices. The firm did not use sophisticated telecommunications technology.

[12] J. M. Nilles *et al., op. cit.*

[13] J. W. Lawrie *et al.,* "Terminals and their impact on employee motivation," *Datamation,* pp. 59—62, Aug. 1974.

[14] H. M. Parsons, "What happened at Hawthorne?," *Science,* vol. 183, pp. 922—932, Mar. 8, 1974.

[15] For example, the management of one company interviewed by G. Hanneman during our research experienced severe difficulties in introducing terminals to the clerical staff. These problems were attributed **to** feelings of fear for job security resulting from an abrupt and arbitrary introduction of the new system. The problem was particularly severe among older clerical personnel, some of whom went to the extent of trying to sabotage the system.

[16] "People contact counts more than computers," *Business Week,* pp. 80—81, May 4, 1974.

[17] A. A. L. Reid, Head, Long Range Studies Division, British Post Office Telecommunications, statements made during the National Conference on Telecommunications Policy, Airlie House, Va., Apr. 1974.

[18] **A.** E. Casey-Stahmer and M. D. Havron, "Planning research in teleconference systems," Human Sciences Research, Inc., McLean, Va., 1973.

[19] My discussions with various users of video telephone systems have tended to support this conclusion. After a user of the video telephone system becomes accustomed to it, he tends to concentrate on seeing graphical material displayed rather than on facial expressions. One of the most common criticisms of AT & T's Picturephone® (registered service mark of the American Telephone and Telegraph Company) has been its insufficient ability to transmit graphic and textual material. Since much of the unwillingness of managers to buy video telephone services has been due to their high cost, for the small increment in effectiveness, it has become increasingly evident that systems providing quality graphic displays and using lower bandwidth technologies (and hence, providing information at lower costs than video telephones) are probably quite adequate for the majority of management functions that would utilize telecommunications media.

and software could require a significant initial investment and long-term planning to ensure system effectiveness.

IV. MODES OF ORGANIZATIONAL EVOLUTION

As part of the USC research, the evolutionary phases of information industry organizations were defined in the context of telecommunications-augmented decentralization. Four evolutionary phases can be described: 1) centralization, 2) fragmentation, 3) dispersion, and 4) diffusion (Fig. 1)

A. Centralization

Centralization represents the current mode. All administrative operations are located at a single central site, with workers divided into functional groups according to their primary information product. Where national organizations divide into regional offices, the regional home office replicates this monolithic structure. Both corporations *A* and *B* are centralized in Fig. 1(a).

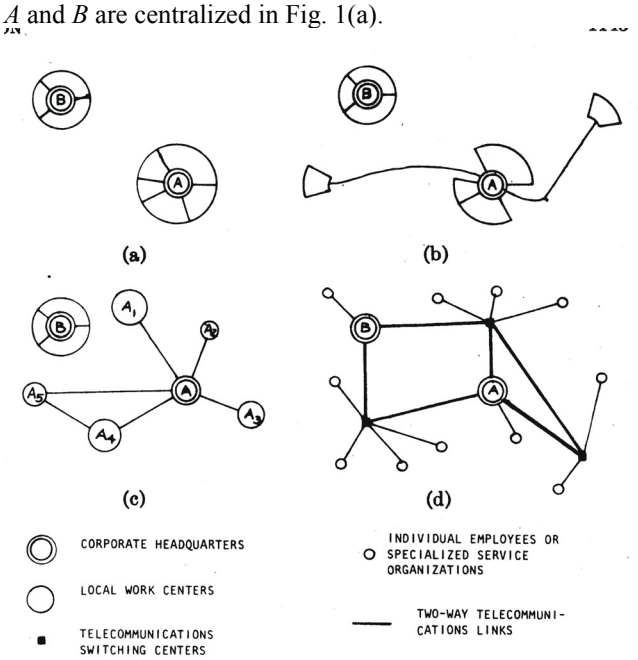

Figure 1. Organizational evolution: two cases, Corporations A and B. (a) Centralization. (b) Fragmentation. (c) Dispersion. (d) Diffusion.

B. Fragmentation

In this phase, coherent subunits of the central organization separate and relocate elsewhere. The communications boundaries of the organization are stretched and replaced by telecommunications or mail, but the communications within the unit remain intact. Two common variations of fragmentation are *branching,* such as occurs in banks, where the fragmented unit is a miniature replica of the parent, and *segmenting,* where functional units such as data processing, accounting, or marketing are separated from the central organization [Corporation A in Fig. 1(b)]. Unfortunately, fragmentation often increases commuting. This can be seen from the experience of many cities (e.g., Atlanta, Ga., Boston, Mass., Washington, D.C.) where a beltway has been built around the city. New commercial centers are built along the beltway, particularly at the intersections with freeways that lead to the downtown. People who live on one part of the perimeter tend to work, by the perversity of nature, on another part of the perimeter. Furthermore, many people who live inside the perimeter travel through downtown to reach their place of work at the perimeter. The net effect has been to increase the downtown traffic congestion beyond that which would result from the growth of downtown office space, because of the large number of people who pass through the downtown. In Los Angeles, for example, the City Traffic Engineer states that only 42 percent of the people who travel into the downtown freeway interchanges actually stop in the CBD.[20]

C. Dispersion

The third stage of decentralization is dispersion. In this stage, the firm establishes a number of work centers at locations throughout the city. Employees report to the center nearest their homes, irrespective of the organizational subunit in which they work (Corporation *A* in Fig. 1(c); Corporation *B* is still centralized). Employees obtain their information through the "central" computer, which can be physically located anywhere in the network. Supervision and coordination activities often use telecommunications rather than line-of-sight surveillance, although there would be general supervisors at each location. In dispersion, executives who require many face-to-face contacts to perform their jobs may still travel frequently to a central location to permit such interaction, but the majority of clerical workers would be able to achieve substantial reductions in their commuting. Dispersion would also permit firms to tap labor markets that are not available currently to them; for example, housewives working while their children are in school and high schoolers in the later afternoon.

D. Diffusion

The ultimate stage in this telecommunications-augmented process is diffusion. In diffusion, firms would maintain a relatively small core staff which may be dispersed. Peaks in work load would be handled by individual workers who would offer their services through a telecommunications network to several different firms or clients [both corporations of Fig. 1(d)]. This could be done by workers in their homes, in the totally diffused case, or by a variant of dispersion in which workers with the same groups of capabilities would report to offices near their homes. This particular phenomenon is beginning to appear in the form of companies that offer temporary secretarial services and, of course, is common in the professions such as law. A significant difference is that diffusion requires the widespread availability of switched data networks, either between regional centers or, in its ultimate form, between centers and home, rather than small private networks or leased line

[20] Los Angeles City Traffic Department, Transportation Planning Division "Staff report: Home-to-work trip making characteristics of vehicle drivers and bus passengers for the 'cordon count' area," Los Angeles, Calif., June 20, 1973, p. 7.

systems. For a variety of reasons, it is unlikely that the diffusion stage of decentralization will be acceptable to many large organizations in the near future. However, the possibilities of this mode of work will become increasingly attractive to those smaller, service-providing organizations which constitute a growing portion of society.

V. SOME SOCIETAL IMPACTS

A. Transportation and Communications Systems

If large numbers of organizations disperse their operations because of the increased capabilities of telecommunications and computer technology, some significant impacts on societal structure may occur. The most immediate physical impact will be on the design and operation of both transportation and telecommunications systems. For example, since a large fraction of the activities occurring in major urban business districts are information industry related, a substantial displacement of these workers to outlying regional business centers could alter completely the. design of transportation systems which are currently commuter oriented.[21] Different forms of mass transit would be required that would be oriented more toward bringing employees relatively short distances to local work centers.

The enhanced possibility of collocating information industry workers in a discrete number of regional business centers within a conurbation invites new ideas in telecommunications system design. For example, the development of a new specialized common carrier service, either by existing telephone companies or by others, becomes an increasingly real possibility. Such a service would provide a broad-band communications capability linking all the regional business centers within a conurbation, either through coaxial cable or, ultimately, through fiber optics transmission lines, leasing its communications capabilities to organizations in each business center. This would allow each organization to operate their private communications without going through the conventional switching system provided by the telephone company. The intriguing feature of a specialized local service, if it were to be provided by other than a telephone company, is that the carrier would not be engaged in interstate commerce in most areas and, since it would not use broadcast transmission of any sort, its operations would not fall under the regulatory jurisdiction of the Federal Communications Commission. Such a network could be regulated as a public utility by state or local government, but many state, and many more local governments, do not have suitable regulatory policies to deal with this type of service.

The impact on the telecommunications and computer manufacturing and service industries would also be pronounced. Requirements for more versatile, reliable, and/or lower cost computer terminal capabilities, coupled with an increasing market potential, should lead to significant developments in terminals, minicomputers, and their accompanying software packages. These developments will make standardization of some aspects of teleprocessing technologies more urgent if compatibility between systems is to be achieved without simultaneously stifling innovation.

B. Labor Force

The possibilities for greater involvement of presently underutilized components of the national labor force have already been mentioned as direct consequences of organizational decentralization. Training, by both school and information industry organizations, may be necessary to prepare workers for the new work mode. On a larger scale, federal policies regulating labor should be reviewed. Right-to-work laws, fair employment practices, unionization policies, and other externally imposed constraints can be potent factors in the decision to decentralize. Organizations involved in or concerned with the regulation of the labor force should anticipate and evaluate the possible impacts of telecommunications-associated decentralization.

C. Land Use and Urban Growth Patterns

Potentially conflicting, communication-related pressures can be foreseen in the area of urban growth. Some of these forces encourage greater concentration within the cities, while others could increase urban sprawl. Goldmark is conducting experiments oriented toward development of "new rural communities," located in areas of low population density.[22] The inhabitants of these communities use telecommunications to communicate with each other and to perform their work; as a consequence, they enjoy lower crime rates, decreased pollution, and other benefits of rural living. However, I feel that the "rural city," which mixes the familiar downtown business area and suburban living, is a more likely near-term consequence of telecommuting.

One anticipated outcome of telecommunications-augmented decentralization could be that future regional business districts (or, more properly, activity centers) will no longer have their present single-use characteristics. Instead of monolithic buildings devoted solely to office use, activity centers may contain a mixture of offices, living quarters, and entertainment facilities. This has already occurred, to some extent, in downtown Chicago. Suburbanites would have some advantages of small town living, in that they would live and work in the same general area, thereby developing a greater sense of community and lessening many of the urban problems, while enjoying the cultural advantages and activities of a major metropolitan area.

As with all cases of increasing freedom of choice, freedom may become license, producing the urban growth

[21] J. M. Nilles, F. R. Carlson, P. Gray, and G. Hanneman, "Telecommuting—Telecommunications or transportation," in *Proc. TRANSPO LA: The Future Is Now!,* Los Angeles Council of Engineers and Scientists, American Institute of Aeronautics and Astronautics, Oct. 1974.

[22] P. C. Goldmark, "Communication in the new rural society," Department of Communication Arts, Cornell University, Ithaca, N. Y., paper presented as part of the 1973 University Lecture Series.

equivalent of the "tragedy of the commons."[23] Clearly, one of the potential results of the greater ability to relocate because of improved and less expensive telecommunications technology is that people will move to areas of great scenic beauty or recreational potential in such numbers as to destroy the resource they have moved to be near. The choices are to risk the destruction of such major natural resources through inadequate planning for this possibility or, through careful planning, including deliberate limitation of transportation facilities and rigidly enforced zoning restrictions, provide scenic and recreational areas in the cities.

VI. CONCLUSIONS

Although it is too early, at this point, to predict the rate and extent of telecommunications-augmented decentralization, it is clear that favorable conditions exist for such decentralization. Growing numbers of information industry organizations and increased availability and sophistication of computer and telecommunications technologies allow unprecedented opportunities for increased flexibility in organizational development and diversity.[24] Information industries are particularly amenable to telecommunications-augmented decentralization, since the majority of their employees perform routine clerical or middle management tasks that can be adapted easily to a telecommunications mode. In many cases, computer and telecommunications technologies allow organizations to perform at least as effectively as they do now and may increase productivity if care is taken to satisfy human factors requirements and to provide software that permits a positive man-machine interface. Telecommunications-augmented decentralization represents an important alternative to current patterns of organizational and urban structure. Consequently, public planners and policy makers on all levels of government should investigate possible impacts of these technologies and formulate the requisite policies to maximize the positive benefits and to minimize any negative impacts.

Jack M. Nilles had 18 years of military and industrial experience prior to 1972. During the latter part of this period, he was responsible for initiation, development, and direction of civil systems programs at The Aerospace Corporation. These programs were in the areas of transportation, resource management, communications, law enforcement, and medical engineering. Prior to this experience, he was Director of Advanced Planning operations for several military space systems at The Aerospace Corporation, TRW Systems, its predecessor, Space Technology Laboratories, and the U.S. Air Force. Since 1972 he has been with the University of Southern California, Los Angeles, where he is currently Director of Interdisciplinary Program Development, responsible for the development of interdisciplinary research programs on a university-wide basis. Particular emphasis is placed on programs that involve significant business and community participation and involvement. One of these programs is the NSF-sponsored program discussed in this paper.

[23] *G.* Hardin, "The tragedy of the commons," *Science,* vol. 162, pp. 1243—1248, Dec. 13, 1968.

[24] R. Bretz, "Two-way TV teleconferencing for government: The MRC-TV system," RAND Corp., Santa Monica, Calif., Rep. R-1489-MRC, Apr. 1974. The MRC system permitted interagency coordination to occur where it has rarely occurred before. The use of teleconferencing to enable an organization to have better (or any) access to a scarce resource (e.g., specialists, information, labor markets) can allow greater operational flexibility.