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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Reduced Communications Costs Through Centralized Management Of Multiplex Systems

Government communications circuits have proliferated because individual agencies obtain circuitry for their exclusive use. If circuit requirements are consolidated and available technology is exploited, significant savings are possible.

The Department of Defense and several civil agencies have developed multiplex systems to replace numerous individual circuits. The multiplex systems have resulted in significant cost savings and service improvements.

This report contains recommendations to the Director, Office of Management and Budget, to establish a policy, organizational arrangements, and implementing regulations to ensure that multiplex technology is exploited on a Government-wide basis.



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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This report describes the Government's existing arrangements for use of multiplex technology and the potential for increased exploitation of the technology to reduce the Government's long-distance communications costs.

We made this review to followup on our 1973 report on multiplexing and to again demonstrate the greater economic and operational benefits achievable through centralized Government-wide management rather than through existing fragmented management arrangements.

We are sending copies of this report to the Secretaries of Defense, Commerce, Justice, the Interior, and the Treasury; the Director of the Office of Management and Budget; and the Administrators of the General Services Administration and the National Telecommunications and Information Administration.

A handwritten signature in black ink, appearing to read "James B. Stacks".

Comptroller General
of the United States

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AGC 00027
DLG 03345



D I G E S T

Significant savings and improved service can be achieved through centralized management and increased use of multiplex systems to satisfy Government communications requirements.

Multiplexing, a technique in which electronic devices at each end of a single circuit simultaneously transmit a number of messages, eliminates the need for numerous individual long-distance circuits between terminal points.

The Department of Defense (DOD) and several civil agencies have developed multiplex systems, but not on a centralized Government-wide basis.

The maximum economic benefits of a multiplex system are realized when all of the channels of the system are being used. Because one Federal agency seldom has enough requirements to fully use a system's capacity, spare channels exist. If two Federal agencies could agree to share their multiplex systems under either joint or single management, the opportunities for economic benefits should increase. If all Federal agencies could agree, the opportunities for economic benefits should be maximized.

FINDINGS

The cost of data communications resources of Federal civil agencies was not readily identifiable, but estimates range from \$100 to \$200 million annually, with an annual growth rate of 10 to 25 percent.

DOD and several civil agencies have significantly reduced costs by creating multiplex systems to replace redundant individual circuits.

These savings have been achieved without impairing the quality, reliability, or security aspects of the transmissions.

The DOD systems were developed by one management activity charged with satisfying all applicable military circuit requirements. Civil agency systems were developed to satisfy particular interests of individual agencies.

DOD has 643 multiplex systems operational. The systems were initially justified on the basis of economy. Annual cost savings information is no longer maintained.

Civil agencies have 240 multiplex systems. Three selected civil agencies using multiplexers achieved annual savings totaling over \$1.2 million. (See pp. 7 to 9.)

Potential cost savings from centralized Government-wide development of multiplex systems cannot be estimated. However, about 8,500 individual circuits operate directly between 39 geographic locations. GAO believes about 7,650 of these circuits are candidates for multiplexing. (See p. 10.)

GAO demonstrated potential cost savings by creating theoretical multiplex systems in place of existing individual circuits between Washington, D.C., and five metropolitan areas. The analysis showed the following:

--One hundred and five high-speed circuits had potential for multiplexing. GAO estimated that the resulting systems could reduce annual costs from about \$1.54 million to \$892,000, or a net savings of 42.2 percent. (See pp. 10 to 12.)

--Two hundred and ninety three low- and medium-speed circuits had potential for multiplexing. GAO estimated that the resulting systems could reduce annual costs from about \$1.96 million to \$614,000, or a net savings of 68.8 percent. (See pp. 12 and 13.)

The cost effectiveness of existing multiplex systems can be improved if the spare (unused) capacity of one user's system is made available to other users. Multiplex devices are manufactured in fixed capacities (the number of circuits that can be handled), so users often acquire a device with more capacity than needed for their immediate requirements.

In 1974, as a result of GAO's 1973 report on multiplexing, the Defense Communications Agency and the General Services Administration (GSA) executed an agreement for joint use and sharing of multiplex systems. As yet, GSA has not forwarded a civil agency requirement to the Defense Communications Agency. GAO's analysis of military systems linking Washington, D.C., and four geographic areas disclosed that, of 78 spare channels, 46 could be used to satisfy civil agency requirements. If placed on the military systems, present civil agency annual circuit costs of about \$331,600 could be reduced to \$153,200, or a net cost reduction of 53.7 percent. (See pp. 13 to 15.)

CONCLUSIONS

The economic benefits of multiplexing data communications requirements are widely recognized and have already produced significant cost savings for DOD and selected civil agencies. GAO has demonstrated the potential for further significant cost savings if (1) Government-wide policy is established requiring use of multiplexing where economically and operationally feasible and (2) a central management entity is established with the authority, necessary information, and adequate resources to develop and manage multiplex systems for the entire Government. (See p. 19.)

RECOMMENDATIONS

GAO recommends that the Director, Office of Management and Budget, in coordination with the National Telecommunications and Information Administration, GSA, DOD, and other Federal

agencies develop a policy, organizational structure and implementing regulations to ensure that the Government is achieving the maximum benefits from multiplexing.

The policy should require the use of multiplexing where economically and operationally feasible on a Government-wide basis.

A single entity should be assigned responsibility for developing and managing multiplex systems for the entire Government. This entity must have the authority, necessary information, and adequate resources to fulfill the Government-wide management function envisioned.

Implementing regulations should be designed to require compliance with the policy and to provide procedures that will ensure maximum benefits to the Government from multiplex technology. (See p. 20.)

AGENCY COMMENTS

Agencies involved agreed that use of multiplexing could reduce Government long-distance communications costs. They stated that centralized management results in management and operational problems and that better coordination could achieve the same result at less cost.

GAO agreed that greater savings could result from increased agency coordination. Pointing to past failures to coordinate, however, GAO demonstrated that management and operational problems are not insurmountable and that savings would be maximized under a centralized management entity having the authority, necessary information, and adequate resources to perform this function on a Government-wide basis. (See pp. 20 to 25.)

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ABBREVIATIONS

CMIS	Communications Management Information System
DCA	Defense Communications Agency
DOD	Department of Defense
GAO	General Accounting Office
GSA	General Services Administration
OMB	Office of Management and Budget
OTP	Office of Telecommunications Policy

CHAPTER 1

INTRODUCTION

The Government uses communications services--both local and long-distance--to process administrative data between user locations, to make computer inquiries, and to make high-speed bulk transfers of data between user locations. As the result of our earlier report, the Department of Defense (DOD) now centrally manages its administrative data circuitry. However, because no overall management of Federal civil agency data circuits is evident, circuits proliferate in an uncoordinated fashion.

The cost of data communications resources of civil agencies was not readily identifiable, but estimates range from \$100 to \$200 million annually, with an annual growth rate of 10 to 25 percent.

To hold down the cost of circuitry, while attempting to increase efficiency and effectiveness, DOD and several civil agencies have developed transmission systems using multiplexers. Multiplexing is a means of sending two or more messages simultaneously over a single circuit. Multiplexing is more economical to use than separate circuits because the cost of leasing a number of separate (usually long-distance) circuits exceeds the cost of acquiring a multiplexed circuit. The latter cost includes the lease cost of one circuit to be multiplexed, the multiplexer with associated equipment and services at each end of the circuit, and short-distance circuits between the user location and the multiplexers. (See app. I for illustration.)

The maximum economic benefits of a multiplex system are realized when all of the channels of the system are being used. Because one Federal agency seldom has enough requirements to fully use a system's capacity, spare channels exist. Also, since communications requirements frequently change, channel assignments often must be changed, which results in reconfiguration of old systems or configuration of new systems. If two Federal agencies could agree to share their multiplex systems under either joint or single management, the opportunities for economic benefits should increase. If all Federal agencies could agree, the opportunities for economic benefits should be maximized.

This report discusses the successful application of multiplexing in the Government today; the potential for greater use of multiplexing, especially by civil agencies; and the obstacles that inhibit greater exploitation of multiplexing.

GOVERNMENT COMMUNICATIONS
RESPONSIBILITIES

The Office of Telecommunications Policy (OTP), in the Executive Office of the President, was established in 1970. Its duties included helping to formulate policies and to coordinate the vast operations of Government communications systems.

In March 1978 OTP was abolished and its functions were dispersed to several organizations. The Office of Management and Budget (OMB) was assigned responsibility as the President's principal advisor for procuring and managing Federal communications systems and for developing and establishing policies in the same area. The National Telecommunications and Information Administration, Department of Commerce, was assigned responsibility for advising OMB on the development of policies relating to procurement and management of Federal communications systems and for coordinating communications activities within the executive branch. Also, other responsibilities were assigned to the National Telecommunications and Information Administration, the National Security Council, and the Office of Science and Technology Policy.

Section 201 of the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 481) and section 7 of the act of June 14, 1946 (40 U.S.C. 295) gave the Administrator of General Services the basic responsibility for procuring and supplying communications services for Federal agencies. To carry out this mission, the General Services Administration (GSA) established guidelines that prescribed policies and methods governing the use of communications services by the Federal organizations. These guidelines are set forth in the Federal Property Management Regulations, subchapter F, part 101-37, and apply to all executive agencies, except for selected operational communications services and facilities of the Federal Aviation Administration, National Aeronautics and Space Administration, Veterans Administration, Bureau of Prisons, and Tennessee Valley Authority.

In addition, GSA has delegated authority to DOD to procure and operate its own communications. Also, GSA has granted authority to numerous civil departments and agencies, on a case-by-case basis, to procure and operate some of their own communications.

DESCRIPTION OF MULTIPLEXING

Multiplexing, a technique in which electronic devices at each end of a single circuit simultaneously transmit a number of messages, eliminates the need for numerous individual long-distance circuits between terminal points. The technique was perfected in the 1870s and has been employed for many years by the telecommunications carriers. However, the carriers' tariffs prohibited the customer from attaching multiplexers to the carrier's system within the United States until June 1968, when the Federal Communications Commission ordered removal of restrictions on the use of interconnect devices not furnished by the carrier.

Multiplex devices range in size from a briefcase to a small file cabinet and are available for lease or sale from numerous commercial sources. The devices cover a broad range of capacity and method of operation.

Following is a brief explanation of the different multiplex devices for improving circuit utilization:

--Frequency division multiplexers combine the data from up to 24 low-speed 1/ circuits or terminals into a single higher speed circuit by dividing the circuit into discrete frequencies. The individual frequencies or channels are assigned to a specific terminal for its exclusive full-time use.

--Time division multiplexers combine data from low-speed circuits or terminals into a single high-speed circuit by allocating a very short specific time element of the high-speed circuit to each terminal. These time-slots or channels are assigned to a specific terminal for its exclusive full-time use.

--Statistical multiplexers are sophisticated time division devices which allocate timeslots or channels to users only when the users are sending data. Studies have shown that a typical data terminal is idle 95 percent of the time. Because of the

1/For the purpose of this report, circuit speeds are expressed in terms of modulation rates, or the technical term "baud." A low-speed circuit is 300 baud or less, a medium-speed circuit is 300 to 1,200 baud, and a high-speed circuit is over 1,200 baud.

intermittent nature of data transmissions, statistical multiplexers can accommodate up to 100 slow-speed terminals.

--Concentrators are devices which consolidate data by collecting the intermittent data from users' terminals. The concentrators then retransmit data at a uniform rate. Some concentrators can also store data in memory and compress and reformat data to bring about additional savings.

--Channel-packing is a technique which consolidates low-, medium-, and high-speed circuits into a single voice grade circuit by using additional modulation techniques. In its more common form, channel-packing permits four 2,400 baud data grade circuits to be consolidated into a single voice grade circuit.

OUR PRIOR REPORT

In our January 1973 report, "Reduction of Communications Costs Through Centralized Management of Multiplex Systems" (B-169857), we discussed a number of situations where cost savings were possible if DOD centrally managed its multiplex systems. We recommended that the Director, OTP, establish a policy that departments and agencies identify their communications requirements which are susceptible to multiplexing and that the requirements be satisfied by multiplexed facilities where economically and operationally feasible. OTP agreed that the Government should take advantage of the benefits of multiplexing where appropriate and that a policy would be established in this area. OTP was abolished in 1978 without establishing a multiplex policy for the Government.

We also recommended that the Secretary of Defense, in accordance with his responsibilities as Executive Agent, National Communications System, develop specific procedures for coordinating civil and nontactical military communications which are susceptible to multiplexing. In 1974 GSA and the Defense Communications Agency (DCA), the central manager for much of DOD's nontactical communications, signed a "Memorandum of Understanding on Multiplexing."

The memorandum stated it was "desirable to establish efficient and effective policies and procedures for the multiplexing of Federal Government communications requirements." Specifically, the memorandum provided:

- Existing spare capacity on Federal multiplex systems would be available for the telecommunications of any Federal Government agency to ensure minimum overall costs to the Government.
- Periodic joint reviews of GSA and DCA leased data circuits would be conducted to identify candidates for multiplexing.
- New or major expansion of multiplex systems would consider all applicable requirements of the Federal Government.

PRIVACY AND SECURITY CONSIDERATIONS

In March 1977 we reported on the "Vulnerability of Telecommunications Systems to Unauthorized Use" (B-146864). The report concluded the vulnerability of telecommunications systems to unauthorized penetration depended upon administrative control, competence and integrity of telecommunications personnel, physical and technical security, and the technical knowledge and financial resources of the perpetrator. Telecommunications carriers and Government officials agreed that the users should have the ultimate responsibility for determining and providing security for their communications.

By interleaving a number of signals into a single data stream, multiplexers increase the degree of difficulty to understand an intercepted transmission. However, multiplexing is not a substitute for organizational security measures.

DATA CIRCUIT INFORMATION USED IN THIS REPORT

We developed the circuit information used in this report from GSA's computerized inventory of agency data circuits. This inventory, known as the Communications Management Information System (CMIS), was initiated in 1976 to (1) encourage telecommunications sharing, (2) improve telecommunications systems planning, and (3) consolidate circuits and equipment. The CMIS is derived from information submitted to GSA by those executive agencies not exempted by the Federal Property Management Regulations. This inventory is the only known Government single-point data base of civil agency data circuitry.

In April 1979 CMIS contained information on 22,779 data circuits, with an estimated 18 million miles of circuitry,

operated by 57 civil agencies or identifiable Government organizations. GSA officials are aware that CMIS contains inconsistencies, such as erroneous data and omissions of data elements. Under current procedures, GSA cannot ensure the data base reflects changes that occurred after initial input, nor can it determine the existence of unreported circuitry.

SCOPE OF REVIEW

We interviewed officials and examined pertinent documents at 28 civil departments, agencies, or bureaus using data transmission facilities. (See app. II for listing.) We also interviewed officials and examined pertinent documents at DCA. Further, we interviewed officials of three principal organizations concerned with Federal telecommunications policy--OMB, GSA, and the National Telecommunications and Information Administration.

Since GSA's CMIS data base, as structured, could not provide the information needed for this review, we used available commercial computer routines and developed necessary software programs, and thus manipulated the CMIS information into a form suitable for our analysis. These computer programs were subsequently made available to GSA management. Despite the known shortcomings of CMIS, we believe the information is sufficiently reliable for analyzing circuit concentration points and routing patterns to demonstrate the potential for multiplexing selected civil agency data circuits.

We verified the reliability of CMIS information at selected agencies and in geographic areas as appropriate. The period covered by our examination was May through August 1979.

CHAPTER 2

SAVINGS ACHIEVED BY GOVERNMENT

THROUGH USE OF MULTIPLEXERS

By establishing multiplex systems to replace redundant individual data circuits, DOD and several civil agencies have significantly reduced costs. These savings were achieved without impairing the quality, reliability, or security aspects of the data transmissions. The DOD systems were developed by one management activity charged with satisfying all applicable military data circuitry requirements. GSA had not taken similar action. However, under delegation of authority from GSA, civil agency systems were developed independently to satisfy particular interests of the user.

CIVIL AGENCY MULTIPLEX SYSTEMS

Only 55 of the 1,589 reported civil agency data networks in CMIS use multiplexers. These 55 networks involve 240 multiplex systems. An examination of three civil agencies and/or departments using multiplexers disclosed significant cost savings are achieved without a decrease in the quality of service. The selected applications are discussed below.

Bureau of Reclamation

The Bureau of Reclamation, Department of the Interior, has a large data communications network consisting of 22,000 miles of circuitry. This network serves seven Department of the Interior bureaus, seven other Federal agencies, and six non-Government organizations. The non-Interior activities provide their own short-distance circuits to connect to the Interior multiplexers. Interior does not charge these activities for the use of the network's capacity. The slight additional cost for circuit connection at the multiplexer is not considered economically recoverable.

The network connects over 700 terminals, located in 70 different cities, with the Bureau's computer center in Denver, Colorado. About 500 of the terminals on the network are serviced by multiplexed circuits. The network uses 40 time division multiplexers, 4 statistical multiplexers, and 28 channel-packing devices. The multiplex devices are located on Federal facilities.

We estimate this system reduces costs by about \$400,000 a year and eliminates the need for about 85,000 miles of circuitry. This saving represents a 53-percent cost reduction

when compared to an unmultiplexed system providing equal service capability. According to Bureau officials, the multiplexed service is as good as the service it replaced.

Federal Bureau of Investigation

The Federal Bureau of Investigation recently began channel-packing selected high-speed data communications circuits on its National Crime Information Center network. Before channel-packing, the network consisted of 72 high-speed circuits connecting major State and city law enforcement agencies with the Center's computer in Washington, D.C. By installing 20 leased channel-packing devices, located on commercial vendor premises, the Bureau decreased the network mileage by 35,302 miles and reduced communications costs by about \$156,000 a year. This saving represents 24.5 percent of the Bureau's cost for high-speed service on the network. Bureau officials stated the multiplexed service was better than the service experienced with individual circuits. The Bureau is studying the feasibility of establishing additional channel-packing facilities.

U.S. Customs Service

The U.S. Customs Service has an extensive data communications network called the Treasury Enforcement Communications System. This system has 1,200 terminals located at ports-of-entry, international airports, and selected preclearance facilities in Canada, Bermuda, and the Bahamas. The terminals are connected to a computer center in California through a series of high-speed circuits. The circuits for about 700 of the 1,200 terminals are frequency division multiplexed. Even with this arrangement, Customs officials were concerned with the cost of the communications lines and installed concentration devices in Washington, D.C., Boston, Miami, and Houston.

Customs ultimately reduced the circuit mileage by 90,000 miles and saved \$600,000 a year. According to a Customs official, the quality of service provided by the concentrators was an improvement because of the availability of backup equipment, alternate circuit paths, and fault diagnosis. Customs is very satisfied with the concentrators and is studying the feasibility of installing additional concentrators in Chicago and Seattle.

DOD MULTIPLEX SYSTEMS

DOD has recognized the advantages and cost savings of multiplexing and has extensively used the technique. The Department has 643 different military multiplex systems.

System users are charged a prorata share of the applicable system costs. The systems range in complexity from those using simple frequency division multiplexing to sophisticated high-speed systems using satellites. According to a DCA official, most systems were initially justified on the basis of economy.

Annual cost savings reports are no longer maintained; however, DCA officials estimate annual savings of \$1 million have resulted from establishment of multiplex systems in accordance with recommendations in our 1973 report.

DCA officials state it is quite common for multiplex users to experience an increase in service reliability and improvement in the quality of transmission. These improvements result from error detection techniques incorporated into the multiplexers and the reduction in the number of circuits in use; circuits are usually the most unreliable part of any network. However, a user's experience will vary depending on the geographic location and the particular commercial carrier providing the circuitry.

As discussed in the next chapter, significant potential cost savings exist in the Federal civil agency sector if shared-use multiplex circuitry could be developed between geographic areas containing a high concentration of individual long-distance data circuits.

CHAPTER 3

POTENTIAL FOR GREATER USE OF MULTIPLEXING BY GOVERNMENT

The cost savings from centralized Government development of multiplex techniques to satisfy administrative data circuit requirements cannot be estimated; information to develop such estimates is not maintained anywhere in the Government. To demonstrate potential cost savings, we developed several theoretical applications of multiplexing in place of existing individual civil agency data circuits. Also, to further demonstrate potential cost savings, we theoretically used spare capacity of existing DOD multiplex systems in place of existing individual civil agency circuits.

POTENTIAL FOR DEVELOPING NEW SYSTEMS

Our analysis of GSA's CMIS inventory of civil agency data circuits shows the circuits are highly concentrated. For example, 69 percent of the reported 22,779 circuits originate and/or terminate in only 39 metropolitan areas. Furthermore, 8,500 of the circuits operate directly between these 39 metropolitan areas. On the basis of the reported speed characteristics of the circuits, it would appear that about 7,650 of these are candidates for multiplexing. This multiplexing may be accomplished by either developing new multiplex systems or improving the use of existing systems.

To demonstrate the potential for developing new multiplexing systems, we analyzed the circuits between Washington, D.C., and its vicinity and the following cities and their vicinities: Los Angeles, San Francisco, Denver, Kansas City, and Chicago. Incomplete technical information in the CMIS severely limited our identification of potential circuits. Also, the absence of traffic data in the CMIS records caused us to make selective judgments on candidate circuits and limited our considerations to channel-packing and time division multiplexing techniques. Even with these restrictions, our analysis clearly shows that multiplexing can substantially reduce data telecommunications costs.

Example of channel-packing

We identified 105 high-speed circuits between Washington, D.C., and the five selected cities with potential for multiplexing using the channel-packing technique. We developed

40 theoretical channel-packing systems that would save about \$651,000, or 42.2 percent, of the estimated present annual costs associated with the 105 circuits.

In developing each of these systems, we determined the requirement for channel-packing devices, associated equipment where necessary, service connections, and long-distance circuitry between the channel-packing devices, and, where necessary, short-distance circuits between the channel-packing device and the user terminals.

The equipment and connection charges were costed at standard tariff rates. Circuit costs were priced using standard airline mileage and the rate currently used by GSA for circuit mileage charges. The channel-packed costs were compared with the costs of equipment, connection charges, and circuits (similarly priced) for the existing circuits.

The following table summarizes our analysis and shows how channel-packing can substantially reduce communications costs at the five selected locations.

Theoretical Channel-packing Applications

	<u>Before multiplexing</u>		<u>After multiplexing</u>		<u>Reductions</u>	
	<u>No. of circuits</u>	<u>Costs per year</u>	<u>No. of circuits</u>	<u>Costs per year</u>	<u>No. of circuits</u>	<u>Costs per year</u>
Between Washington, D.C., and:						
Denver	27	\$ 330,444	9	\$196,092	18	\$134,352
San Francisco	30	562,320	12	326,400	18	235,920
Los Angeles	27	478,476	11	253,044	16	225,432
Chicago	10	70,920	4	52,632	6	18,288
Kansas City	11	100,872	4	63,912	7	36,960
Total	<u>105</u>	<u>\$1,543,032</u>	<u>40</u>	<u>\$892,080</u>	<u>65</u>	<u>\$650,952</u>

These applications result in a 61.9-percent reduction in the number of circuits and a 42.2-percent cost reduction. The principal factor in the cost reduction is the decrease in leased circuit miles from 191,327 to 75,233, or 60.7 percent.

Example of time
division multiplexing

We also identified 293 low- and medium-speed circuits which had potential for simple time division multiplexing between Washington, D.C., and the five selected cities. We incorporated these circuits into 40 time division multiplexers and then applied channel-packing, where feasible, to reduce the number of long-distance circuit requirements to 13. For example, low- and medium-speed circuits from Chicago to Washington were first incorporated into 12 time division multiplex systems, which in turn were incorporated into 3 channel-packed circuits.

These theoretical systems would save about \$1,351,000, or 68.8 percent, of the estimated present annual costs associated with the 293 circuits.

In developing each of these systems, we determined the equipment required and costed all elements of the systems using methodology discussed in the prior example of channel-packing.

The following table summarizes our analysis and shows how time division multiplexing can substantially reduce costs at the five selected locations.

Theoretical Time Division Multiplex Applications
(channel-packing applied where feasible)

	<u>Before multiplexing</u>		<u>After multiplexing</u>		<u>Reductions</u>	
	<u>No. of circuits</u>	<u>Costs per year</u>	<u>No. of circuits</u>	<u>Costs per year</u>	<u>No. of circuits</u>	<u>Costs per year</u>
Between Washington, D.C., and:						
Denver	30	\$ 205,152	2	\$121,269	28	\$ 83,883
San Francisco	38	411,768	2	143,321	36	268,447
Los Angeles	103	906,108	4	161,953	99	744,155
Chicago	110	380,688	3	138,990	107	241,698
Kansas City	<u>12</u>	<u>60,648</u>	<u>2</u>	<u>48,314</u>	<u>10</u>	<u>12,334</u>
Total	<u>293</u>	<u>\$1,964,364</u>	<u>a/13</u>	<u>\$613,847</u>	<u>280</u>	<u>\$1,350,517</u>

a/Composed of 40 time division multiplexed circuits; 36 of which were then channel-packed into 9 circuits--for a total of 13 circuits.

These applications result in a 95.6-percent reduction in the number of circuits and a 68.8-percent cost reduction. The principal factor in the cost reduction is the decrease in leased circuit miles from 449,782 to 24,362, or 94.6 percent.

POTENTIAL FOR IMPROVED USE OF EXISTING SYSTEMS

The Government operates 883 multiplex systems (643 Defense and 240 civil). The cost effectiveness of these systems could be improved if the Government used all spare (unused) capacity in the systems. Multiplex devices are manufactured to fixed capacities (the number of channels that can be handled), and the users may acquire a device having more capacity than is needed to meet immediate requirements. The spare capacity of one user's system can be used to fill a requirement of another user, thus reducing the Government's communications costs.

There are no known formal interdepartmental agreements to make spare capacity of one civil agency's system available to another civil agency.

As noted on pages 4 and 5, DCA and GSA entered into an agreement for multiplexing of Government communications requirements in May 1974. During our review, DCA advised us that GSA

has never requested a civil agency data circuit be placed on a military multiplex system, nor has DCA made comparable demands on GSA under the terms of the 1974 agreement. However, there were three exceptions:

--GSA started using capacity on a DOD satellite link between California and Hawaii in September 1979 under a separate agreement.

--At our suggestion, GSA assumed Government-wide management of DATACOM in October 1979. This is a multiplexed service offered by a common carrier between specified locations which had previously been leased by individual agencies. DOD currently has nine circuits in this GSA-managed system.

--DOD provides insignificant capacity to eight non-DOD activities on its systems in this country. These eight non-DOD activities, such as the Supreme Headquarters Allied Powers Europe and the State Department, are not required to go to GSA for the services provided.

GSA said its analysis revealed DOD and civil agency requirements and systems are not colocated, a factor considered a necessity for effective joint sharing of multiplex systems.

We agree that most DOD and civil agencies are not colocated, but this fact does not summarily exclude from consideration all requirements or systems in a given geographic area. For example, as of August 1979, DCA had 925 spare channels on its multiplex systems. While many of the spare channels are at DOD installations not located near civil agencies, short-distance circuits can be provided from the civil agency to connect with the DOD multiplexers.

Our examination disclosed spare capacity exists in both DOD and civil agency systems that might fulfill other Government agency needs if its existence was known.

Spare capacity in DOD multiplex systems

Our analysis of spare DOD multiplex channels and civil agency data circuit requirements between Washington, D.C., and four metropolitan areas disclosed the Government theoretically could save \$178,368 a year (\$153,240 versus current costs of \$331,608) by using the existing DOD spare multiplex

channels in place of continued leasing of nonmultiplexed circuits by civil agencies. The savings consist of the eliminated civil agency circuit, connection, and equipment charges, offset by the added costs of equipment, connection, and short-distance circuits to connect the civil agency user to the DOD multiplex equipment. Pricing was the same as described in the previously discussed channel-packing applications.

The following table shows how the Government can save by using the existing DOD spare multiplex channels:

	<u>DOD channels</u>		<u>Compatible</u>	<u>Net</u>
	<u>Total</u>	<u>Spare</u>	<u>civil agency</u>	<u>cost</u>
			<u>requirements</u>	<u>savings</u>
Between Washington, D.C., and:				
Los Angeles	12	3	3	\$ 22,524
San Francisco	169	54	34	131,064
Denver	4	2	2	12,792
Kansas City	<u>50</u>	<u>19</u>	<u>7</u>	<u>11,988</u>
Total	<u>235</u>	<u>78</u>	<u>46</u>	<u>\$178,368</u>

Spare capacity of civil multiplex systems

The actual spare capacity of civil agency systems remains known only within the operating agency. No requirement exists for reporting spare capacity to a central Government source. There are no interdepartmental procedures among civil agencies to ensure effective use of spare capacity in the 55 multiplex networks (240 systems) identifiable in the CMIS. While CMIS data is sufficient to identify installed multiplex devices, many specific details needed to determine actual spare capacity were either missing or questionable. Within these constraints, it appears 23 of the 55 reported networks may have spare capacity available.

The Department of the Interior provides an excellent example of how spare multiplex capacity can be effectively managed. Recognizing the importance of using the full capacity of the systems, Interior formally established an Inter-Bureau Data Communications Committee in October 1977.

Interior's goal is to provide data communications using the most economical methods available, even though such arrangements may increase the costs to an individual user. Since shared arrangements are based on the lowest cost alternatives that satisfy each specific need, total Department data communications costs are reduced.

We noted, for example, the following situation as one result of Interior's shared use of facilities. The Bureau of Land Management was leasing a data circuit from Montrose, Colorado, to Denver at a cost of about \$2,260 a year. The Bureau of Reclamation had spare capacity in a multiplex system between these two points. By installing short-distance circuits to connect with the multiplexers and using the spare long-distance channel, the Bureau of Land Management saved about \$1,100 a year on this 173-mile circuit. To realize additional savings, the Bureau of Reclamation and the Bureau of Land Management are considering multiplexing of the interconnect circuits.

The potential for expanded use of multiplexing is evident, but as discussed in the next chapter, the Government cannot fully exploit this technique without some form of centralized management.

CHAPTER 4

OBSTACLES TO FURTHER EXPLOITATION

OF MULTIPLEXING

The Government cannot fully realize the economies of multiplexing because (1) there is no Government-wide policy requiring the use of multiplexing where it is the most economical way to satisfy operational requirements and (2) adequate organizational arrangements and procedures have not been established for effective coordinated or centralized multiplex management.

NO SPECIFIC POLICY TO EXPLOIT MULTIPLEXING

Although OTP agreed with the recommendation in our 1973 report (see p. 4) that a policy requiring use of the multiplexing technique should be established, neither OTP nor its successors has established such a policy. As a result, data circuits have proliferated in an uncoordinated fashion.

UNCOORDINATED DECENTRALIZED MANAGEMENT

GSA has delegated authority to other agencies, including DOD (which has about 80 percent of total Government communications), to procure and manage their own communications. Thus, management is decentralized and procedures have not been established for the coordination necessary to fully realize the economies of multiplexing throughout the Government.

GSA

GSA has not established an organization or procedures to manage (identify new and existing candidate circuits, configure new systems, and reconfigure old systems) communications susceptible to multiplex technology.

Also, GSA's computerized inventory of data circuits-- or CMIS--does not include DOD circuits nor does it include all civil agency circuits. Furthermore, circuit information included in the inventory data base is not completely accurate and current, and software programs have not been developed to retrieve the data in a form necessary to plan, develop, and manage multiplex applications.

As a result, with the exception of the DATACOM service referred to on page 14, GSA has not established a single shared-use multiplex system, although we have demonstrated in chapter 3 several examples of the potential for economies through use of multiplexing.

Other civil agencies

As noted in chapter 2, individual civil agencies are using multiplexers on some of their data networks and information relating thereto has been reported for inclusion in GSA's CMIS. However, specific operational characteristics of these systems, such as spare capacity, were not included and are known only within each individual agency. Furthermore, these individual agencies have not developed procedures for sharing of multiplexed systems with other agencies except on an ad hoc basis.

DOD

In March 1973 the Secretary of Defense assigned to the Director of DCA the function of centralized management and engineering for all DOD nontactical, off-base multiplex. DCA was given the authority and responsibility to place new data requirements into existing multiplex systems, to establish new multiplex systems, and to reconfigure existing multiplex systems.

All new data communications requirements ordered by DOD's central leasing activity are first reviewed by a multiplex management group. This management group decides if the requirement can be satisfied within the spare capacity of the existing multiplex systems. If so, it is placed on an existing system. If not, it is leased as a separate circuit. In both cases, detailed information is entered into a computer data base that is readily available to the multiplex management group for use in developing new systems or reconfiguring existing systems. Any changes to existing circuits are processed the same as a new requirement.

Thus, within DOD, DCA has been established as the central manager for nontactical multiplex. DCA has effectively assumed this responsibility and has developed the necessary accurate and reliable data base and appropriate procedures for operation and administration. As a result, DCA has substantially increased exploitation of multiplexing within DOD since 1973.

GSA/DOD multiplex system sharing agreement

The GSA/DOD 1974 agreement required the establishment of policies and procedures for Government-wide sharing of Federal multiplex systems. (See pp. 4 and 5.) However, no procedures have been established for the continuous coordination necessary to implement the agreement.

CHAPTER 5

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

AND OUR EVALUATION

CONCLUSIONS

The economic benefits of multiplexing are widely recognized and have already produced significant cost savings for DOD and selected civil agencies. Our review has demonstrated the potential for further significant cost savings.

Our review has also disclosed that there are obstacles to further exploitation of multiplexing. In our opinion, maximum benefits through use of multiplexing can be achieved only on a centralized Government-wide basis. However, there is no specific policy requiring the use of multiplexing where economically and operationally feasible. Procedures do not exist for coordinating civil and DOD circuit requirements to develop new multiplex systems or for interagency use of spare capacity on existing systems.

DOD has established a centralized management organization with the authority and resources to effectively manage multiplexing within the agency. No comparable organization exists for civil agencies, and the GSA/DOD agreement on multiplexing has not been implemented.

We believe that a specific Government-wide policy requiring the use of multiplexing where economically and operationally feasible is essential to increased exploitation of this beneficial technique. Also, although increased coordination between all Government agencies should result in additional benefits, we believe that maximum benefits can be achieved by establishing a mechanism for centralized management with adequate authority and resources to see that optimum use is made of multiplex technology on a Government-wide basis. Such a management entity (and we look upon the existing DOD multiplex management organization as an acceptable model) would have the necessary information on all Government circuits susceptible to multiplexing and of existing multiplex systems, and could thus configure new systems and reconfigure old systems with maximum Government-wide effectiveness.

RECOMMENDATIONS

We recommend that the Director, OMB, in coordination with the National Telecommunications and Information Administration, GSA, DOD, and other Federal agencies develop a policy, organizational structure, and implementing regulations to ensure that the Government is achieving the maximum benefits from multiplexing.

The policy should require the use of multiplexing where economically and operationally feasible on a Government-wide basis.

A single entity should be assigned responsibility for developing and managing multiplex systems for the entire Government. This entity must have the authority, necessary information, and adequate resources to fulfill the Government-wide management function envisioned.

Implementing regulations should be designed to require compliance with the policy and to provide procedures that will ensure maximum benefits to the Government from multiplex technology.

AGENCY COMMENTS AND OUR EVALUATION

Comments on our draft of this report were received from the Departments of Defense, Justice, the Interior, and the Treasury; GSA; the National Telecommunications and Information Administration; and OMB. The comments totaled 19 pages. Because of the volume, only OMB's comments are included in full. (See app. III.) Corrections and clarifications of facts and statements in our draft suggested by the respondents have been incorporated in this final report, where necessary and appropriate. Comments received are summarized as follows:

- Justice agreed with our conclusions and recommendations and enthusiastically supported our recommendation for a specific Government-wide policy with a mechanism for centralized management, but had concern for the timeliness of responses by the centralized entity for circuit assignment and maintenance.
- Interior agreed that a Government-wide concept theoretically offered economic benefits over present methods. Interior said, however, that careful consideration needed to be given to how and at what cost a single entity could integrate

all of the diverse activities and needs into a manageable Government-wide program that is responsive to all users. Interior also said that overhead costs could negate some of the projected savings and had questions about who would budget for costs of shared systems and provision of alternate circuits for backup. Interior suggested it is more appropriate that the economic and technical feasibility of the concept should first be thoroughly investigated.

--Treasury agreed that significant benefits could be realized by sharing multiplex circuits, but it believed that a better approach than a single management entity would be to recommend that multiplex systems be the responsibility of each individual agency, that interagency coordination of circuit requirements be left with GSA, the current responsible organization, and that sharing opportunities be exploited within current interagency forums. Treasury was also concerned that insufficient emphasis was given to the need for adequate resources necessary for engineering studies and capital investment needed to implement new systems.

--DOD agreed that costs could be reduced by multiplexing but suggested a step-by-step approach in lieu of "GAO's legislated policy structure":

- a. Correct data base shortcomings and adopt procedures to keep data bases current and to ensure that information can be used for multiplexing decisions.
- b. Establish procedures with GSA to ensure that circuit requirements are examined and satisfied based on available Government multiplexing resources.
- c. Concurrently establish a single Government long-distance circuit acquisition function, of which multiplexing management would be an integral part.

--GSA generally agreed with our conclusions and recommendations and advised us that it is developing a multiplex management plan for Federal civil agencies in which GSA would act as a

clearinghouse for information on existing requirements to ensure optimum use of spare capacity throughout the Government. GSA added, however, that if a common-user system was identified, as a result of its engineering analysis called for by the plan (with no impact on privacy and security), it would be necessary to obtain advance congressional approval in accordance with restrictions contained in GSA's appropriations acts. GSA said that savings in our theoretical examples were probably overstated since operating and management costs were not considered. GSA agreed that OMB should develop a policy on this subject and that GSA should be the implementor.

--The National Telecommunications and Information Administration agreed that multiplexing could achieve savings under some conditions, but that it would be more productive to recommend improvements in technical facilities, management controls, and procurement principles for acquisition of communications services. The Agency contended it would also be more constructive to recommend improvement of personnel and organizational management competence and development of new procedures and regulations by GSA to direct all Government agencies to take advantage of the opportunities (not just limited to multiplexing) available from the new dynamic communications environment. This should be done in compliance with existing policies and regulations. The Agency also contended that using agency functions, such as accounting, billing and verification, and ordering/managing changes were duplicative in part to those functions performed by the centralized management entity and that complete analysis of these costs might yield a conclusion contrary to ours. The Agency believed that more specific guidance should be given to (1) justify, establish, or maintain a consolidated service arrangement including, among others, improved management at the agency level without consolidation, (2) operational/management conflicts between GSA and the agencies, and (3) technological obsolescence because of long-term liabilities associated with consolidation. Finally, the Agency believed that GSA's CMIS should not be corrected and redirected as we suggested because the data base does not include planning information and is therefore inadequate.

--OMB agreed that savings and improved service may be achieved, but it believed that even greater savings might be obtained through bulk purchase discounts, use of value-added services, and increased sharing of existing facilities. Furthermore, OMB believed that emphasis on multiplexing may lead to costly inflexibility and may even restrain competition. OMB stated that it fully supports the existing responsibilities of GSA and that more detailed and specific management deficiencies which have prevented GSA from exercising its authority, both generally and in connection with the GSA/DOD multiplexing agreement, should be identified. OMB said that it would reserve detailed comment on our recommendations after its review of our final report.

As noted, the comments received range from enthusiastic agreement to virtually total disagreement with our conclusions and recommendations, although all respondents agreed that use of multiplexing could reduce costs. Specific disagreement appeared to be centered on the contention that management and operational problems are associated with centralized management and that better coordination could achieve the same result at less cost.

We recognize that the savings projected in our theoretical examples do not reflect consideration of all costs, such as overhead. We also recognize that detailed studies must be made before actual implementation of multiplex systems, and that such studies would have to (1) consider all costs and (2) comply with existing policies, such as relying on private industry rather than Government ownership, obtaining competition, etc. We believe, however, that savings may be understated rather than overstated under a Government-wide management concept because of the greater economies-of-scale and use of more sophisticated multiplex devices when providing for Government-wide rather than individual agency requirements. Note that our theoretical examples in chapter 3 were restricted to simple multiplexing methods and did not consider traffic data (not available) which could result in even greater economies.

We recognize that centralized management could result in operational and management problems. We also recognize that not all circuits are susceptible to multiplexing; that is why our recommendation provides for use of multiplexing where economically and operationally feasible. However, the examples of

existing multiplex systems in chapter 2 indicate that these problems are not insurmountable and that significant savings have resulted.

We agree that better coordination should result in increased savings. However, we do not agree that better coordination would be as effective as centralized management. The lack of coordination by DOD and GSA--as called for in their 1974 multiplex agreement--and the existence of numerous spare channels on existing multiplex systems described in chapter 3 indicate that coordination would not be fully effective. Furthermore, development of new multiplex systems by individual agencies, even with increased coordination for use of spare channels, could result in proliferation of agency multiplex systems which would not take full advantage of more sophisticated multiplex methods and the greater economies-of-scale available under centralized Government-wide management.

We agree with DOD and GSA that GSA's CMIS deficiencies should be corrected and that data base information should be kept current to permit appropriate multiplex decisions. Thus, we do not agree with the National Telecommunications and Information Administration that CMIS would be worthless "because it does not include planning information." How can one manage anything without having an accurate and current inventory (data base) of what is being managed? We agree that planning should be considered, but we believe the Agency is confused in associating planning (particularly long-range) with data base details. Multiplex technology can be obtained (with competition) under month-to-month lease arrangements so that savings can be realized now without termination liability and without waiting for implementation of much more ambitious, but uncertain, long-range plans.


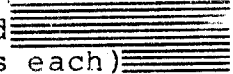
DOD's suggestion to establish a single Government long-distance circuit acquisition function, of which multiplexing management would be an integral part, is a step in the right direction. We must emphasize, however, that such an entity must have the authority, necessary information, and adequate resources to manage the function on a Government-wide basis. In this connection, we do not agree that GSA would be violating restrictions contained in its appropriations acts by planning or developing multiplex systems. We do not believe such systems are "common user shared" systems enjoined by the acts because, although the multiplex devices and the single multiplexed circuit are "shared," specific portions thereof are assigned

to each user. Nevertheless, if GSA believes any multiplex system resulting from its planned engineering analysis is such a common user shared system, it should seek the requisite congressional approval.

We agree with OMB and the National Telecommunications and Information Administration that multiplexing is not the only alternative that can be used to reduce the Government's long-distance communications costs. However, our review was limited to multiplexing and our recommendations were accordingly addressed to that alternative. Thus, we would encourage OMB to consider multiplexing and other alternatives in acting on our recommendations.

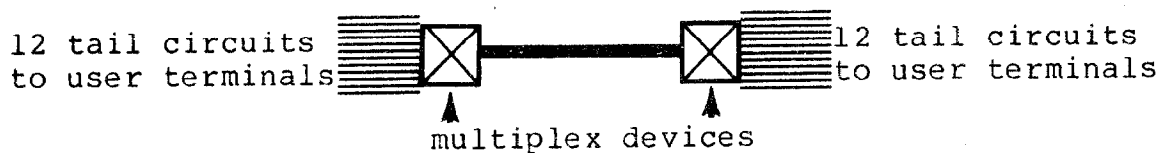
ILLUSTRATION OF INDIVIDUAL CIRCUITS
VERSUS MULTIPLEX SYSTEM

Individual Circuits

User terminals  12 medium-speed circuits (600 miles each)  User terminals

	<u>Monthly costs</u>
Circuit costs (12)	\$3,744.00
Connection charges (24)	<u>1,039.20</u>
Total	<u>\$4,783.20</u>

Time Division Multiplex System
(same 12 circuits; same distance)



	<u>Monthly costs</u>
Multiplex devices/16-channel capacity (2)	a/\$ 226.00
Multiplexed circuit cost	312.00
Multiplexer connection charge (2)	86.60
Channel cards (24)	187.20
Tail circuits (24) (note b)	312.00
Additional modems (24)	519.60
Tail circuit connection charges (48)	<u>2,078.40</u>
Total	<u>\$3,721.80</u>

Cost Comparison

Individual circuit costs	\$4,783.20
Multiplex system costs	<u>3,721.80</u>
Monthly savings	<u>\$1,061.40</u>

a/Twelve of 16 channels used; 4 spare channels available for other users.

b/Short-distance circuits (tails) to connect user terminals with the multiplex devices. Assumed distance was 25 miles for each terminal, each end of the system. Circuit mileage cost of \$0.52 per mile was used for tail circuits, the individual circuits, and the multiplexed circuit.

LISTING OF CIVIL DEPARTMENT, AGENCY, OR BUREAU DATACOMMUNICATIONS USERS INCLUDED IN THE REVIEW

Department of Agriculture
Department of Commerce
Department of Energy
Department of Health, Education, and Welfare
Department of the Interior
Department of the Treasury
Environmental Protection Agency
General Services Administration
Small Business Administration
Veterans Administration
Drug Enforcement Administration (Justice)
Economic Development Administration (Commerce)
Federal Bureau of Investigation (Justice)
Forest Service (Agriculture)
Immigration and Naturalization Service (Justice)
Internal Revenue Service (Treasury)
Maritime Administration (Commerce)
National Bureau of Standards (Commerce)
National Environmental Satellite System Agency (Commerce)
National Oceanic and Atmospheric Administration (Commerce)
Social Security Administration (Health, Education, and Welfare)
U.S. Customs Service (Treasury)
U.S. Geological Survey (Interior)
U.S. Secret Service (Treasury)
Bureau of Alcohol, Tobacco and Firearms (Treasury)
Bureau of the Census (Commerce)
Bureau of Land Management (Interior)
Bureau of Reclamation (Interior)



EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

MAR. 11, 1980

Mr. Allen R. Voss
Director
General Government Division
General Accounting Office
Washington, DC 20548

Dear Mr. Voss:

We appreciate having an opportunity to review your draft report, "Reduced Communications Costs Through Centralized Management of Multiplex Systems" (code 941173). The following comments on this report are offered for your consideration.

We recognize that savings and improved service may be achieved through coordinated management and increased use of multiplex systems to satisfy government communications requirements. However, we question why multiplexing has been examined in isolation from other means for reducing costs while satisfying communications requirements. Effective management of communications resources requires attention to all possible means for meeting requirements. Even though some savings may be achieved through increased use of multiplexing, one should not ignore the possibility that even greater savings could be obtained by consideration of other approaches and techniques, such as bulk purchase discounts, use of value-added services, and increased sharing of existing facilities. Furthermore, singular emphasis on multiplexing may lead to costly inflexibility in meeting requirements and may even constrain effective competition in some situations.

It would be helpful if your report could develop in more detail the management deficiencies which should be corrected in order to improve government communications systems. The General Services Administration has centralized authority to procure and manage government communications. If there are problems which have prevented GSA from fully exercising its authority in this area and which could possibly be resolved through improved agency coordination, then these problems should be identified in your report.

As part of this detailed examination of management deficiencies, it appears that a closer scrutiny of the GSA - Defense Multiplex System Sharing Agreement would be helpful. This agreement may ease many of the concerns which you have expressed in the report. Specific identification of deficiencies in the agreement and obstacles which have prevented its full implementation would be helpful. OMB fully supports the existing responsibilities of GSA in this area.

We will reserve detailed comment upon your recommendations until we have had an opportunity to review the final report.

Sincerely,



Jim Tozzi

Assistant Director for
Regulatory and Information Policy

(941173)





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