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# TECHNICAL ANALYSIS FOR TELECOMMUNICATIONS

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## 3.7. TECHNICAL ANALYSIS FOR TELECOMMUNICATION

### 3.7.1. Project Background

#### 3.7.1.1. Satellites as Appropriate Technology for Rural and Remote Communications

Communication planners working in the developing world have struggled for years with the physical and economic problems of providing communication capability to remote rural areas. Many have acknowledged that, given the constraints of ground-based communication systems, it will be years before even basic telephone service can be extended into the more accessible areas. For many rural areas, especially those in more remote locations or separated by rugged terrain, satellite communications may be significantly more economical and technologically feasible than terrestrial alternatives. The least-cost solution to communication problems in rural areas may involve hybrid systems combining satellite and terrestrial technologies such as rural radio telephone.

The general characteristics of communication satellites make them ideal for thin-route applications when technical specifications appropriate to those applications are selected. The greatest advantage of a satellite-based system is that it costs virtually the same to reach the most remote communities as it does to reach those nearby. The system can thus offer priority communication service to remote areas of greatest need where travel expenses are highest, rather than installing service first in communities nearest to existing facilities, as terrestrial systems usually do. This flexibility allows for the installation of a communication system well coordinated to suit the specific needs of rural development projects.

Satellite systems are also likely to be more reliable, more durable, and easier to maintain than terrestrial systems, an important consideration in rural areas and especially for mountainous, jungle, or desert terrain. The space segments of satellite systems have proven highly reliable in orbital locations with no access to repair services. Moreover, the ground segments of the system are located near the human settlements they are intended to serve and therefore have greater access to maintenance and repair than do the remote repeater sites necessary for many terrestrial communication systems.

Because any earth station can reach any other point in the network in a single "hop" through the satellite, reliable interconnection depends solely on the two stations involved. Terrestrial systems, in contrast, depend on a series of sequencial links, the failure of any one of which can disrupt the connection. As such, the satellite system is much more dependable, since a failure in any earth station affects only that location and has no negative impact on other parts of the satellite system.

Satellites also permit a much greater degree of flexibility with respect to capacity than do terrestrial systems. Earth stations can be installed to provide as little as a single-voice channel of service, using single channel per carrier (SCPC) equipment. Capacity can be installed in additional locations as demand develops. Other services, including data transmission and radio and television reception, can be added incrementally to the same basic earth station and can be installed in additional locations as necessary. In contrast, a terrestrial microwave system must be designed at the outset to provide maximum capacity to a specified number of locations, and a terrestrial open-wire system cannot be expanded significantly in remote areas without incurring major costs to the entire system.

The potential applications of satellite communication for rural development are virtually unlimited. Access to telephone use provided through satellite communications can help planners to supervise field staff and to gather feedback from development projects in rural areas. Conference calls can be easily arranged by satellite without complex networking, simply through the assignment of a common frequency. Radio programs can thus be delivered simultaneously to many sites, allowing participants both to listen and interact in consultations. Physicians at the main hospital can advise rural health workers in outlying areas. Conferencing systems can aid emergency relief activities, provide in-service training for rural development workers, and furnish market information for farmers. Specially designed programs can teach basic skills to children, offer in-service training for teachers, and provide continuing education courses for adults. Tutorials can be arranged for individual assistance. Finally, radio programs can be used to reach special target audiences, such as mothers of young children or illiterate adults.

Commercial telecommunication use has burgeoned on a massive scale throughout the world. More than 100 countries now have INTELSAT satellite earth stations; over a dozen use leased INTELSAT capacity for internal domestic communications, including seven African countries : Zaire, Algeria, Nigeria, Sudan, Niger, Libya, and Morocco. Cameroon, Angola, Mauritania, and Mali reportedly plan to implement such systems in 1984. The U.S., Canada, Europe, India, and Indonesia operate their own commercial communication satellites, and other countries and regional groups, including Iran, the Arab Gulf States, Colombia, Brazil, Australia, and Mexico have decided on that approach. A series of studies of domestic or regional satellite services is underway in Africa, and a regional system for the continent is expected to be in place before the end of the decade. Development planners should be aware of these activities and endeavour to assist countries in choosing the most appropriate systems and in using new communication facilities to best advantage.

### 3.7.1.2. Photovoltaics as Appropriate Technology for Powering Rural and Remote Communication Equipment

A reliable electrial power source is vital to an effective communication system. A photovoltaic system is an especially attractive alternative for remote areas, where conventional powerlines are unavailable and engine generators are impractical owing to erratic fuel delivery and a lack of trained mechanics. Photovoltaic systems, such as the U.S. Forest Service fire lookout towers in Northern California, have been operating in remote areas for over five years, and require little or no maintenance. In the remote West African village of Iangaye, Upper Volta, a 3.6 KW peak photovoltaic-powered grain mill and water pump is in its fourth year of operation. Such systems are generally cost competitive with conventional utility powerline extension or diesel generators for an annual energy consumption of 6000 kilowat-hours or less. Current designs for the remote earth station project annual requirements well within the range. As conventional power and diesel fuel costs increase, moreover, photovoltaic power system costs are expected to decrease. The low maintenance and repair costs of photovoltaic systems compared to those of engine generators make the former especially attractive for isolated communities. Experience with a photovoltaic village power system in the Papago Indian Village of Schuchule, Arizona has indicated that outage rates are lower than those of conventional utility systems.

Because it is common practice to equip earth stations with a backup power system, engine generators are included in photovoltaic systems. The system design should be flexible to allow the engine generator either to charge the batteries in conjunction with the photovoltaic array or to power the earth station directly. Another attractive characteristic of photovoltaic systems is modularity. The system can be enlarged to accomodate increased power requirements simply by adding more photovoltaic panels.

### 3.7.1.3 The AID Rural Satellite Program

The OMVS Rural Satellite Project is intended to be a major contribution to the AID Rural Satellite Program, a worldwide effort aimed at demonstrating that a relatively new technology based on communication satellites can provide reliable, cost effective communication services throughout the developing world. Central to the AID program is the premise that carefully planned and systematically applied communication technology constitutes an appropriate tool for achieving fundamental development objectives. The program signifies AID's commitment to help developing countries build skills and experience that will enable them to strengthen their own communication capabilities and improve social services for rural populations.

The objectives of AID's Rural Satellite Program are as follows:

- to establish reliable rural communications, through satellites and appropriate ground equipment aimed at providing services and information to support rural development programs;
- to demonstrate, through specific projects and test models, the usefulness of satellite communications in supporting:
  - economic activity in rural communities,
  - delivery of social services, including health care and agricultural information,
  - education and training,
  - participation by rural people in making decisions that affect their own welfare, and
  - rural development administration.
- to develop appropriate combinations of hardware and services on a pilot scale to demonstrate to suppliers the market potential of technology and applications, and to reduce costs of operational systems on a larger scale;
- to demonstrate the viability of satellite communication systems in the rural setting to rural development donors and investment planners;
- to encourage national participation in integrating rural satellite communication capability in future national development plans.

To meet these objectives, the program includes long-term pilot projects; assistance in software development; evaluation; policy analysis; liaison with domestic and international agencies; training and information activities geared towards networks of key decision-makers; support of the transfer of technology; and information dissemination.

AID's decision to embark on a five-year Rural Satellite Program directed towards meeting the needs of rural development comes at an appropriate time. Experience gained from development work in the past two decades points to a need to provide appropriate technology aimed at helping rural people know to solve their own problems. Access to reliable communication and information can play a vital role in that problem-solving process.

It is important to recognize that the role of effective communication in facilitating development activities and developing the technical capability to provide relable and affordable communication to rural areas are the two fundamental principles of - and justifications for - the AID Rural Satellite Program and its accompanying pilot projects.

### 3.7.2. Recommendations

Based on the requirements recognized by the development and private sectors and on an analysis of the existing system, we recommend three sets of actions by USAID and OMVS, outlined below. The objective of these recommendations is to provide reliable telecommunication service to support the river region development and to guide the development of a long-term overall donor investment portofolio.

- Encourage OPT (Postal and Telecommunications Office), Mauritania, Mali, and Senegal to seek donor support for upgrading existing telecommunication systems as soon as possible.

- Conduct a pilot project serving one of the five zones of the IDP in the Senegal River Basin (SRB) sponsored by USAID. This project should demonstrate and test the benefits of telecommunication support for program management, planning, and implementation; in-service training; data collection and monitoring; technical information dissemination; and private and commercial sector activities. In the proposed pilot project, two satellite earth stations would link Bakel to Saint Louis and three VHF links would extend the network to surrounding sites. The project would introduce photovoltaic power sources, an intensive on-the-job training program, and the design of simple modular and easy-to-maintain system components. It would also provide an initial institutional back-up service contract. The project should be designed to overcome existing problems and test an appropriate rural communication systems model that could be replicated throughout the region, at a minimum cost to the other four projects areas. The plan should include networking requirements for rural radio broadcasting to ensure coverage of the SRB area.

- Undertake a telecommunication policy study aimed at designing a system supporting the SRB development objectives of the OMVS and its member States and defining a regional telecommunication plan to serve Mauritania, Mali, and Senegal. This study should analyze the telecommunication requirements of the region; project and identify economic, institutional, and social development benefits; develop a regional system design (with inputs from the pilot project); identify funding and revenue-sharing procedures; and outline actions and milestones necessary to implement such an SRB-wide telecommunication program.

### 3.7.2.1. Needs

Recommendations for the proposed project activities are based on review and analysis of AID plans and activities in the Fleuve region. Findings, outlined below, are based on interviews conducted with USAID/RBDO, members of the IDP design team, OPT, Telesenegal, ORTS, and SERST (Secretariat d'Etat à la Recherche Scientifique et Technique). The findings on the communication requirements of the development projects in the Fleuve region can be summarized in the following way.

1) Telephone communication: Virtually all interviewees affirmed the need for reliable and basic telephone service among the OMVS main offices, country offices, RDA's, and principal seats of the five project areas. They also considered telephone connections between the national capitals and among the three agricultural research centers in Mauritania, Mali, and Senegal to be critical in linking the main data collection sites of the OMVS/USAID Groundwater Monitoring project. Improved telephone service could aid significantly in the following tasks:

- assisting IDP implementation, agricultural research, and the groundwater projects by providing timely feedback for testing data collection and monitoring instruments and encouraging consistent reporting;
- advancing decentralization of government activities in the Fleuve region by providing better communication for more reliable decision-making and more immediate access to maintenance support and supplies in the field;
- improving budget management efficiency of field operations by expediting release of funds from local accounts at the perimeter level to purchase necessary goods with minimum delay;
- supporting the coordinated collection, efficient analysis, and timely dissemination of critical environmental information in the long-term, such as planned for under the AGHRYMET program, by allowing timely access to the data analysis facilities;
- supporting the efficient monitoring of groundwater levels (AID Groundwater Monitoring Project) and health care conditions (IDP) by providing ready access to field data from central data collection and analysis facilities;
- supporting river transportation and water management in the long-term by coordinating water release from the Manantali Dam with perimeter operations, for example, or by routing transport vessels for cargo delivery and pick-up;

- providing reliable administrative and technical support to the newly developing finance system in the region;
- encouraging closer coordination among the major agricultural research centers in the region by permitting telephone conferences, access to documentation centers, joint planning of research projects, and discussions of progress and results;
- developing closer linkages between agricultural research and agricultural extension and planning;
- improving conditions for the private and commercial sectors in the Fleuve region through reliable access to stocks, supplies, markets, and market information.

The development organizations and the private sector in the region expressed not only a need for improved communications, but a willingness to pay for such services.

Groups interviewed expressed a significant interest in exploring technologies that would allow the transmission over telephone lines of hardcopy of printed materials, order forms, and the like. They also regarded teleconferencing as a potentially valuable management support tool.

2) Radio Broadcasting : Inteviewees voiced almost unanimous support for radio broadcasting technologies to serve the following applications:

- imparting new agricultural techniques, technologies and information to farmers, through extension courses according to the work and schedule of agricultural and credit extension in the field;
- disseminating information on preventive health care measures in connection with public health efforts such as the anti-malaria campaign and raising public awareness of OMVS and IOP goals.

The Training section of the project paper discusses further radio broadcast applications and requirements.

### 3.7.2.2. Existing Infrastructures

A high-capacity microwave system established in 1978 extends on the Senegal side of the Senegal River from Dakar to Saint Louis and Richard Toll to Bakel. Unfortunately, unreliable power sources and shortage of funds and spare parts have prevented the system from functioning

all the way to Bakel. The Panaftel system will soon link Dakar via Kidira to Kayes to Bamako. An older telephone network exists from Richard Toll to Nouakchott. Internal telephone communications in Mauritania and Mali are more limited than in Senegal, but both have approached INTELSAT for future lease of satellite capacity for the internal domestic telecommunication system. Mauritania is also a member of the ARABSAT satellite consortium, which will launch its first satellite in 1984.

Responding to the unsatisfactory telephone system, a number of regional institutions as well as private donors have established or planned private telecommunication networks. These plans include a SAED project, a Canadian-funded study on "ports et escales", an agricultural livestock project in Bakel, a Dutch-financed project outside Podor, the AGHRYMET program, and various efforts in Mali and Mauritania. These projects use HF radio technology, an inexpensive and flexible means of meeting the immediate demand for delivery of short messages. As these systems are private, limited-access networks, however, and as they are neither reliable, of good quality, nor easily interconnected with the national telephone network, they are of limited use in the long-term. Investiments in such systems are not only costly to organizations in terms of capital and operating expenses, but they divert revenues and demand from the expansion and operation of the national telephone service. At present, these relatively costly private systems are flourishing while a more reliable, and ultimately less expensive, public system is underdeveloped. Reliance on private systems has also been detrimental to the private sector and particularly to smaller firms, which must either finance their own radio systems or suffer the consequences of isolation from markets and suppliers.

### 3.7.2.3 Institutional Arrangements

SERST would have prime responsibility for the design, implementation, operation, and evaluation of the pilot project for Senegal under the 1980 U.S.-Senegal Science and Technology Agreement. This organization has access to and responsibility for coordinating all necessary inputs and internal agreements with other Senegalese technical institutions such as OPT, Telesenegal, and ORTS.

OMVS would administer the policy study, and appropriate organizations in the member states and donor organizations would participate.

We propose that all USAID inputs to the development of this component of the OMVS program be carried out by a contractor.

### 3.7.3 Project Description

#### 3.7.3.1. Introduction

An analysis of the key activities of USAID River Basin Development Office (RBDO) shows that reliable telephone service can play a significant role in achieving the objectives of the IDP, the OMVS Agricultural Research Project Phase II, and the Groundwater Monitoring Project. Coordinating and managing development planning, project implementation, and monitoring of effects and side-effects are central to OMVS activities, as is encouraging the participation of the private industrial and commercial sector in SRB development. Although telephone service alone cannot solve policy, input, training, or transportation problems, it can play a significant role in supporting national and regional development activities.

The following proposal is aimed at designing a telecommunication component to complement regional development activities. Too often in the past, major development activities and telecommunication systems have developed independently, with no integration of the two sectors. As a result, development managers, confronted with a lack of vital communication linkages to administrative, supply, or marketing centers, have installed their own networks, which are inherently limited, costly, and proned to failure in the long-term. These systems are inefficient in terms of management and transport substitutions and do not promote the potential productivity of the private commercial sector in the region. At the same time, the telecommunication sector has consistently found investments in rural (i.e. low-traffic density) areas to be unprofitable, with limited revenues and high capital, operations, and maintenance costs per subscriber.

The benefits of reliable telephone services should not be measured exclusively in terms of financial returns, but, as with other infrastructures, should be viewed in terms of larger economic benefits accrued, such as more effective project implementation and greater support for private sector activities in the long term. The development of rural telecommunications should be viewed as a cross-sectoral concern, since its benefits are most evidently outside the sector investing the resources.

A rural telecommunication support system should be consistent with the resources, investment level, and conditions of the area. For example, attempting to replicate an urban telecommunication system would be fruitless given the demographic and socioeconomic constraints of rural areas. The rural telephone system proposed, therefore, is designed to serve the two sectors that affect economic development most significantly - the development institutions and the business and commercial sector.

### 3.7.3.2. OMVS Development Focus

In general, the global focus of all three programs and other donor activities is to support the agricultural exploitation of the SRB through irrigation agriculture by expanding perimeters; introducing new crops or techniques; coordinating field-level needs and agricultural research; monitoring changes in SRB ecological and health conditions; strengthening the commercial supply, credit, and marketing systems; and establishing an effective and viable regional and national monitoring and management information and control system. Critical to this program is the construction of two dams and the subsequent development of irrigated rice cultivation and water transportation.

### 3.7.3.3. Statement of Work

The design challenge of the telecommunication component of the IDP is to satisfy the short-term telephone requirements for the implementation of RBDO programs, as well as the long-term telephone requirements of OMVS, RBDO programs, SAED, parallel organizations in Mali and Mauritania, and private sectors activities including commerce, transport, banking, goods processing, maintenance, and repair.

The design objective is to address all of these requirements in modular form. The objective for a minimal pilot project (i.e., covering one of the five zones of the IDP project) would be to satisfy the most immediate and direct communication requirements, which in Senegal's case would be reliable links between Saint Louis and Bakel and between a few selected surrounding village centers. The aim of the proposal is not to develop a telecommunication project, but to design a communication component to support the OMVS development project. Depending on desirability and funding, this system could extend to the sites of the other four IDP zones at Podor, Kaedi, Selibabi, or Kayes, as well as Matam or other principal towns in the Region. The purpose of the pilot project would be to demonstrate how telecommunication can support rural development activities. The system can be expanded and replicated in the other zones of the SRB once funding becomes available.

A needs analysis of the system's uses for management purposes strongly suggests the need for reliable telephone service as well as a component to send hardcopy of order forms, approvals, directives, or announcements. Facsimile machines can serve this function. Any basic system for Senegal must provide a link to Ross Bethio, SAED's Industry Division, because of its strategic position in regard to maintenance and supplies. The Dakar to Saint Louis link is presumed to be satisfactory; we recommend that if funds are available for a third earth station, they go toward construction of a site at Podor, Kaedi, or Selibabi, all of which have urgent needs for telecommunications.

Senegal is a logical choice of site for the initial pilot project, as the Government of Senegal identified the development and testing of appropriate communication satellite technology for rural development as an area of cooperation in an agreement with the U.S. Government in 1980. The overall telecommunication support program, however, will be designed to serve the whole river basin, drawing on information and experience from the pilot project for the express benefit of all OMVS member states. It should be noted that both Mauritania and Mali have approached INTELSAT to explore the lease of satellite capacity for domestic communications, planned for 1984.

As part of the total OMVS/SRB activity, a regional study would be undertaken in the near future to identify the needs and requirements of the development agencies and the nascent commercial and industrial sectors of the region. Such an OMVS-wide perspective will help communication planners to inaugurate three national domestic satellite services that optimally serve regional linkages and requirements.

The scope of this telecommunication component is thus twofold:

- to analyze, implement, operate, and evaluate in a pilot project the developmental, managerial, and economic benefits of an appropriate rural satellite system; and
- to analyze and develop regional requirements and recommend technical, financial, and institutional solutions to an appropriate telecommunication system designed to support the development objectives of the OMVS states.

### 3.7.3.4. Project Objectives

The overall telecommunication project objectives for the OMVS program are as follows:

- to support Senegal River Basin development by providing reliable telecommunication services to RDA's and for the private and commercial sectors;
- to demonstrate and test in a pilot project the developmental benefits of reliable telecommunication services for the management and functioning of select rural development projects;
- to demonstrate and test the performance and costs of thin-route satellite earth stations, terrestrial secondary links, and peripheral equipment, all specially designed to meet the conditions of rural regions characterized by unreliable power supply, lack of trained technical staff, or difficulty of access;

- to support the OMVS objective of moving toward regional economic integration by presenting an SRB-wide telecommunication plan based on institutional and commercial linkages, including plans for financial and institutional arrangements, system scenarios, and implementation schedules.

The particular goals of the rural satellite pilot project are the following:

- to provide OMVS/SAED/AID with an effective telecommunication link to an important, but remote and often inaccessible project site for project development business as well as for the private and commercial sector;
- to furnish OMVS/SAED/AID with the necessary training, planning, implementation, and operational experience as well as the evaluation data to exploit fully and successfully the resources of a telecommunication system for effective project management and implementation of development goals;
- to promote the development of integrated, shared use of telecommunication facilities in the project area;
- to assist the parties concerned in identifying and developing the necessary institutional arrangements and staff resources to make effective use of such a system;
- to encourage the governments, telecommunication carriers, and donors concerned to provide telecommunication services for the Senegal River Basin region by identifying costs, revenues, and wider economic benefits of such a system.

The particular goals of the policy study are as follows:

- to provide OMVS with a tool to carry out its mandate of regional planning and coordination of inputs;
- to assist the parties concerned in identifying and developing the necessary institutional arrangements and the staff resources to make effective use of such a system;
- to promote the development of integrated, shared use of telecommunication facilities in the project area;
- to encourage the governments, telecommunication carriers, and donors concerned to provide telecommunication services for the Senegal River Basin region by identifying costs, revenues, and wider economic benefits of such a system.

### 3.7.4. Application Analysis

Assuring a smooth flow of information between the farm level and the OMVS planning level is a critical objective of the IDP. We believe the telecommunication system can contribute greatly to the effective management and handling of this information flow. A well-planned telephone service can serve many other purposes besides conveying messages and permitting the exchange of discussions and advice. For example, through the transmission of hardcopy pages, this system can facilitate the ordering of and the quick relay of policy directives and announcements; it can also be an instrumental component of regular data collection and monitoring activities. For example, it can transmit locally collected health care statistics or monthly expense vouchers reliably and quickly to the processing location, or allow signatures required prior to funds dispersal to be obtained more easily.

The system's special teleconferencing feature can help managers more regularly or more easily conduct staff meetings with dispersed personnel, discuss new directives, and obtain feedback from the field. Effective communication can aid planners in such projects as the Agriculture Research Project to coordinate their activities by organizing regular teleconferences among the researchers or between researchers and development agencies. Or course, not all personnel meetings can or should be substituted by telecommunications; a suitable mix must be attained. Monitoring project progress or responding to particular questions are examples of activities that can easily and readily be carried out through telephone calls rather than through personal visits.

The Groundwater Monitoring Project will require effective communication. Although the multitude of data gathering locations prohibits, cost-wise, a direct link between the information collection and analysis sites, the regional collection and dispatch of these data (such as in Bakel) can help organize and expedite the process. The same process could be applied to monitoring activities involving health conditions, vector habitat, or other issues.

As stated earlier, the goal of the pilot project is to provide a quantitative measure of the effectiveness and value of a telecommunication system. The applications to be tested in the pilot project are representative of the kinds of uses that could be made of a larger regional system. The information and data to be collected, therefore, will be representative of the costs and benefits of a system.

#### 3.7.4.1 Key Organizations

SRB activities in all three countries are organized along similar lines, with OMVS serving as the regional organization and the three na-

tional RDA's implementing national development activities with support from other national ministries. Each country operates a national agricultural research center. Both the bilateral AID missions and the regional USAID/RBDO offices have their respective roles vis a vis OMVS and the RDA's. A pilot project in the Bakel zone of Senegal could thus be seen as representative of the kinds of applications and uses that could be made of a telecommunication system in the other zones of the SRB.

In Senegal, the key organizations or sectors in need of a reliable link to Bakel are SAED, OMVS, and AID (other sites would include different donor agencies), as well as the private sector. Uses of this link fall into the categories of management/administration, project implementation, training, monitoring, research extension, and private sector needs.

SAED is headquartered in Saint Louis with an industrial division in Ross-Bethio and a training center in N'diaye, both near Saint Louis. The organization is divided into a series of regional divisions, such as Dagana, Podor, Matam, and Bakel, which organize second-level activities. The regional divisions are again subdivided into administrative zones. Most activities, such as collection and commercialization of the harvest, rice hulling, fertilizers, and equipment input and repair have been directed from Saint Louis. In the future, however, more emphasis will be put on local initiatives such as equipment repair. SAED is in the process of decentralizing its functions to allow more authority to its 1,000 extension agents in the field. The role of these agents has in turn been redefined to that of technical counselors to allow greater decisionmaking on the part of the rural population.

OMVS is presently headquartered in Dakar, but plans to relocate in Saint Louis. It is a regional organization charged primarily with coordination, policy, monitoring, and regional studies. The Groundwater Monitoring and Agricultural Research projects are both OMVS projects. The IDP project also is elaborated under OMVS auspices, with SAED and its two national counterparts in Mali and Mauritania serving as implementing agencies. The key IDP project sites in those countries, aside from the capital, are Kayes, Kaedi, and Selibabi.

The AID/RBDO, responsible for overall relations with OMVS, is based in Dakar, where it monitors field-level activities.

GOS agencies and departments, such as the BNDS, the Ministry of Eaux et Forêts, and the Ministry of Finance (as well as their counterparts for Mali and Mauritania), support OMVS activities. Communication with the field is vital for these as well as for the national implementing agencies.

Major distributors, banks, and maintenance/repair suppliers in the private sector are based in Dakar, Saint Louis
in Bakel are currently very limited.

Additional OMVS regional projects that could benefit in the long term from an enlarged telecommunication system are the Groundwater Monitoring Project and the Agricultural Research Project. Key sites for the Agricultural Research Project would be Fanaye near Podor in Senegal, Kaedi in Mauritania, and Same near Kayes in Mali. The Groundwater Monitoring Project will have hundreds of data collection sites along the Senegal River, where the above mentioned sites, particularly if they are IDP zone seats, can function as data collection and coordination centers.

3.7.4.2. Management Administration

The intelligent and timely acquisition and use of information is often cited as a key variable in successful program management. An effective flow of information is particularly valuable to the IDP, as project personnel and centers of decisionmaking are widely dispersed and travel and transportation are difficult, cumbersome, and expensive. In addition, inputs into the IDP from different ministries and agencies must all come together at the field level. Access to relevant and timely information will put managers in touch with the work environment of the field agents and build trust in information obtained from the field. Because of the interactive nature of the telephone system, it can play a significant role in this process as it allows managers to be in direct contract with the field.

Basic teleconferencing equipment will provide managers with the tools to conduct weekly staff meetings, monitor progress, or discuss problems. A reliable telephone service will also facilitate ordering supplies and obtaining regular and emergency maintenance and repair support, as well as contact with major donor activities in the field.

On the other hand, it is a stated goal of the RDA's to decentralize its powers and delegate increasing responsibility to field personnel. If such a transition is to be effective, field-level personnel must have access to user-oriented information that can offer advice and guidance, thus encouraging more informed and timely decisions in the field. The well-planned use of the telephone system between the central office and the field level can also help decisionmakers understand the implications of their decisions.

We propose that IDP managers in Dakar, Saint Louis, and Bakel use the teleconferencing capability of the project to hold regularly scheduled staff meetings on a weekly or biweekly basis. This use of telecommunications in effect bridges geographic distances and encourages a sense of involvement and participation at all project levels.

The system's feature of transmitting hard copy by facsimile among the sites will affect and support several aspects of IDP management. It will promote the efficient administration of funds disbursement at the local level (Bakel) in allowing necessary signatures from SAED-Saint Louis, for example, to be obtained with a short turnaround time. The system can also aid budgetary oversight at all levels. The facsimile system is expected to make a critical difference in program management, especially as regards interaction between the zone office in Bakel and the SAED

industrial division in Ross-Bethio, which has overall responsibility for equipment maintenance and spare parts. This system allows equipment or services to be ordered reliably and quickly while maintaining administrative oversight of the movement and availability of supplies and services.

The health care sector could use the system to support logistical or administrative tasks such as ordering supplies or pharmaceuticals for patient evaluation.

The telecommunication pilot project is also expected to make a critical difference in the finalization and implementation of the proposed OMVS/IDP Management Information System (MIS). The goal of the MIS is to collect information on project implementation and effects. The purpose of the system is to focus on improving project implementation and management so that individual project elements can be modified or rescheduled as necessary.

Project implementators, implementation team members, RDA headquarters, and field agents will feed the information into the system. This information will be filtered through the system and combined at various steps - for example, from the village level to the zone levels, the division headquarters in Bakel, SAED headquarters in Saint Louis, and then to Dakar.

The telephone system will assist the development and administration of the MIS in the following ways:

- The various data gathering forms that were or will be designed in support of MIS will need to be field tested. Feedback and discussions among the different levels of the project structure will help in refining the data collection instruments and formats.

- Information currently maintained at the village, business or supplier levels can be obtained easily by telephone.

- Observations of members of the project implementation team can be solicited and taken into account to refine data collection procedures - the team could offer suggestions as to what kind of information can be integrated on one form, where different forms are needed, and what type of information is best solicited verbally.

- Over time, the reporting requirements may change in the different phases of project implementation; the telephone feedback system will allow the administrators of MIS to be responsive to such changing needs and to validate procedures periodically.

The MIS will be useful only if careful and timely reporting is encouraged. Particularly in the initial project phases, the teleconferencing

system can be used to encourage staff to follow established procedures. Effective use of the telephone system for this purpose should involve discussions at different levels of project participation to make all concerned aware of the utility of the MIS. In this application, the facsimile system again will be of significant value in allowing for quick and reliable transmission of data, exchange of forms, and discussion of issues. The MIS will initially be operated manually, in which case facsimile transmission will be valuable. If the decision is made later to automate the system, the satellite transmission system will allow the transmission of these data.

#### 3.7.4.3. Project Implementation

Significant inputs and investment are being channeled into the region for project components such as road and perimeter construction. The telephone system can increase efficiency and reduce waste by providing logistics support for construction inputs ranging from routing cement barriers to scheduling bulldozers to digging perimeters of fish ponds. Ready access to advice or back-up support can help ease problems or delays expected to occur during this phase.

#### 3.7.4.4. Training

A critical component of the IDP is the training program. The massive inputs and changes engendered by the IDP will require new skills, knowledge, and responsibilities for the rural population and farmer groups, as well as for extension personnel, merchants, and artisants. Anticipated decentralization of the RDA's will also lead to new roles and tasks for farmers and field personnel.

The overall IDP training plan is described in another section specifying various target groups for training, training approach, and subject matter. Mobile Training Units (MTU's) play a significant role in training at the village level. These MTU's will be equipped with basic pedagogical materials and serve as the focal point for village contacts. The composition of the MTU will vary depending on the objective of the training sessions. An MTU team will make approximately four contacts per year with each project village. Extension agents or technical counselors will also have regular contact at the village level and will be partially responsible for scheduling the MTU's and planning team composition.

The operation and scheduling of the MTU will not be difficult to coordinate, as all team members will not be permanently located at the division level; some may come from other towns, possibly as far as the seat of the RDA or the national capitals.

The pilot project will test the effectiveness of the telephone system for scheduling, coordination, and logistics support. It will allow the

MTU manager from Bakel to contact Saint Louis or Dakar to advise or discuss pending requirements. Technical counselors at the VHF sites will be able to contact Bakel regarding requirements or modifications in the MTU schedule or team composition necessitated by local circumstances. They can also report mechanical problems of the MTU or its equipment from these sites so that spare parts, supplies, or additional teaching aids can be requested from the field, most likely from the OMVS pedagogical services in Saint Louis or from RDA pedagogical units.

Agricultural radio broadcasting could support the work of the MTU's by including announcements regarding the MTU's route. The MTU team could also relate feedback to radio programmers at the village level regarding acceptancy, interest, and value of the broadcasts.

Two VHF sites near Bakel and one location in Bakel will be connected into a basic audioconferencing network. This network can be used for continuing training sessions for special target groups. Target groups should include various individuals responsible for different aspects of perimeter management, such as pumps, bookkeeping, and scheduling of village activities as well as extension and credit agents. This in-service training by audioconferencing will be designed to supplement face-to-face meetings at the village level (by MTU team) or at the division level in Bakel or other cities.

For in-service training of IDP implementors in various categories such as agricultural extension, rural financing, and fish pond management, the audioconferencing system can be used on a biweekly or monthly basis between the VHF sites and Bakel, and, as required, between Saint Louis, N'diaye, Ross Bethio, or Dakar. These sessions will be designed to provide maximum opportunity for field-level personnel to assist in solving actual problems in the field and to exchange experiences. Feedback from these sessions will also help the designers of the training programs at OMVS or the RDA level to modify their training approach to suit field requirements.

Workers in the health care sector will have to deal with altered health conditions resulting from environmental changes wrought by dam construction. An audioconferencing system will offer local care providers the opportunity to receive advice and training on new interventions or approaches.

The role of the telephone system in the formal education sector has been limited to date to administrative and logistics support. A larger role may develop in the future with regards to staff meetings or in-service training. Some technical assistance should be made available in this area.

### 3.7.4.5 Monitoring

Careful monitoring of a series of indicators is an integral component of SRB development, particularly for OMVS activities. Such indicators include groundwater measures under the Groundwater Monitoring Project, IDP project implementation, status and changes of the social and economic conditions in the region under the IDP, ongoing OMVS activities, environmental changes and conditions (such as effects on fish stock or erosion under IDP), changes in health conditions because of dam construction (such as rising incidence of malaria or water-born diseases), and increased adoption of new agricultural techniques and practices as a result of the Agricultural Research Program.

Monitoring systems are being developed and implemented for each of these indicators. In the Bakel division, the telephone system will aid project planners in designing, implementing, revising and encouraging compliance with the monitoring system. For example, information gathered at the village level will be forwarded to Bakel, where it will be condensed and entered on appropriate forms. Village-level personnel can discuss problems with the forms or the process with the various managers responsible for monitoring in Saint Louis or Dakar, and appropriate modifications can be arranged. The telephone system will also encourage field-level staff to comply with the monitoring system, particularly if it is also used for feedback, appropriate explanation, and analysis in the field. Although many of the indicators monitored may not require immediate field action, the telephone system will help to assure that problems are detected early and corrective measures taken as soon as possible. The system will be particularly useful in signaling poor health conditions and encouraging immediate action to correct them.

The facsimile system is of particular use to monitoring efforts in that it allows for the reliable and timely transmission of numbers, designs, and text. If forms are designed appropriately, information can be transcribed easily for the appropriate analytical tools, including data processing. Information gleaned through the monitoring system will be directed largely to OMVS, presently located in Dakar; data related to the health component will go to the University of Dakar. Provisions will be made to provide RDA's and other interested parties access to the information as well. It may be desirable to hold twice-annual audioconferences in Bakel, Saint Louis, and Dakar, to discuss changes in indicators and to encourage interest in the monitoring system.

Later, the telephone system could also provide up-to-date information to the field on water levels, flood control, or flood warnings. This information will be critical once the dams are in operation.

### 3.7.4.6. Research/Extension Linkages

The establishment of effective links between agricultural research and activities of the extension arms of the RDA's will be of critical long-term importance to the SRB development. Another important factor is the coordination of the research activities and programs of the three national research centers. Although none of the sites of agricultural research centers will be affected by the first pilot project, the communications component will promote an active interface with these centers through different means. For example, the Fanaye research center is a reasonable distance (about two-hours) from Saint Louis. Researchers visiting SAED could arrange to discuss their ongoing activities, via audioconference, with agents or MTU staff in Bakel as well as to solicit their advice and suggestions. These researchers could be brought into staff conferences and training sessions via audioconferences as required. A future regional system should alsc link the three national research sites into a basic audioconferencing system, which would be of great value for coordination of research activities.

### 3.7.4.7. Private Sector Applications

A reliable telephone system could be a valuable asset in promoting private sector participation in the SRB development for input delivery, equipment repair, product processing, and marketing in accordance with OMVS/SAED objectives. (for further discussion, see Section 3.0, Volume III, Economic Analysis). Linkage with Matam and Kayes would be beneficial for this sector as commercial activities link Bakel to these two locations. Saint Louis also serves as a significant commercial market place for Bakel, however, and its importance will increase in this regard once the all-weather road is completed. In addition, many contacts with Dakar will be critical where the major suppliers are based. The basic pilot project, which constitutes the initial phase for long-term development, will help stimulate private sector activities in the following ways:

- providing information on production prices and general market conditions for perishable goods in major market centers;
- providing logistics support for establishing small-scale local processing capacity such as vegetable drying and rice hulling in the Bakel region;
- establishing commercial inventory control in the ordering and stocking of supplies, especially between major suppliers and rural artisans, or in the ordering of private commercial consumer goods by individuals or villages;
- lending support to financial transactions such as the collection of invoices/bills;

- managing the private transportation system (taxi-brousse, busses, trucks) and airline reservations;
- organizing village associations in zonal or regional groups;
- increasing access to banking information;
- arranging for contacts in personal or medical emergencies and with distant family members.

The potential savings or economic benefits accrued through testing these applications would be subject to an evaluation study.

### 3.7.4.8. Application within the IDP Zone

In addition to the satellite link between Saint Louis and Bakel, we propose a single channel terrestrial VHF connection to link two smaller but administratively important communities to Bakel. This system would provide the following services:

- Summon speedy and timely support from the village to the Bakel maintenance depot, technical specialists, credit agents, and private sector commercial enterprises dealing with pest control or crop transport. It was reported, for example, that a delay in pump maintenance (while under warranty) caused significant losses in rice production as the perimeter proceeded to dry out.
- Supervise management of perimeter or zone activities, including checking up progress of cooperatives, state of pump maintenance and repair, need for fertilizers, requirements for harvesting, and commercialization. Today, heads of perimeters or zone headquarters must travel to Bakel an average of two to three times per week to attend to administrative business.
- Conduct regular meetings between the key supervisor/manager and field staff/experts, and between technical counselors and village leaders, pumpists, or treasurers..
- Improve the organization of MTU work in perimeter construction or other perimeter activities, such as visits of credit agents, irrigation specialists; and of health or groundwater monitoring teams.

### 3.7.5. Technical Analysis

#### 3.7.5.1 Existing Telecommunication Systems in the SRB

In 1978, a microwave telecommunication link was financed jointly by the World Bank and the Caisse Centrale in the Fleuve region of Senegal. This link, part of the communication network of OPT, theoretically joins the communities of Thies, Saint Louis, Richard Toll, Podor, Matam, and Bakel, as well as a number of smaller communities en route. The ultimate capacity of the system from Thies to Richard Toll is 600 circuits, compared to an alleged 300 circuits from Richard Toll to Bakel. The Richard Toll - Bakel section of the route is presently equipped for a capacity of only 120 circuits, however. Bakel is equipped with a small manual switchboard.

In theory, this backbone system should provide for the major part of the telecommunication needs along the Senegal River on the Senegal side for the foreseeable future. In practice, however, the route has major deficiencies, including the following:

- Telephone service to Bakel via the route has been cut off since July 1981 because of fuel delivery and power supply problems.
- The microwave system's channel, designed to mitigate fading problems, is presently inoperative due to power supply problems.
- The Saint Louis automatic switchboard responds with frequent busy signals to attempted calls. OPT personnel indicate that it has exceeded its traffic handling capacity and should be extended.
- Calls from Podor and possibly from Matam are subject to periods of transmission cut-off, lasting several seconds because of dirty switch contacts according to OPT personnel.
- The system is subject to outages as a result of microwave repeater stations running out of gaseous fuel (propane or butane) used to generate electricity.
- Fading problems exist between Dakar and Saint Louis: OPT feels these could be eliminated by implementing space diversity on certain sections.

This system is clearly unreliable and incapable of satisfying present telecommunication needs in the Fleuve region, much less responding to future needs. As a result, parallel communication networks based on single sideband radios have proliftered among organizations in need of telecommunications but unable to rely on the OPT system. Such agencies include: SAED, ASECNA, Ministry of the Interior, Eaux et Forets, Meteo Nationale, Agriculture et Elevage.

A primary reason for the failure of the OPT system appears to be OPT's inability to maintain it properly. Since the original installation did not include a service contract, OPT was presented with a complex system for which it was ill-prepared in terms of on-the-job training, necessary vehicles for maintenance purposes, and ability to supply spare parts for failed components.

The original supplier of the system, Telecommunication Radio-Electrique et Telephonique (TRT) of France, has proposed a service contract to OPT to ensure the rehabilitation and proper operation of the system. The supplier's personnel would supply on-the-job training to a corresponding group of OPT personnel to be assigned to the task. The cost of such a service contract would be approximately $ 2,700,000 U.S. per year.

The OPT has neither accepted nor rejected the offer. We feel that the idea of a service contract for the rehabilitation of the system merits consideration by donors as the most logical long-term step in developing the telecommunication infrastructure on the Senegalese side of the Senegal River Basin. Since this course of action would probably take several years to negociate and implement, however, the problems with the OPT network could be a serious inhibiting factor in the short term for the OMVS activities in the Fleuve region.

It should also be noted that at present no reliable telecommunication network exists in the river basin in either Mali or Mauritania.

In view of these considerations, we propose a telecommunication network based on satellite technology, which would serve the following double purpose:

1) to provide for the short-term OMVS telecommunication requirements on the Senegalese side of the Fleuve region until such time as the existing OPT microwave system is upgraded between Dakar and Bakel (sometime after FY 1984);

2) to provide experience in the use of thin-route satellite technology in rural areas, with an eye to satisfying future telecommunication needs of the SRB areas in Mali and Mauritania, as well as telecommunication needs in other regions of the countries or the continent.

### 3.7.5.2 Technical Alternatives to the Proposed Plan

#### A. Rehabilitation of the Existing Microwave System

Rehabilitation of the existing microwave system would appear to be the most logical in the long term. Because of present

restrictions in the OPT, however, it is doubtful as to whether this course of action could be implemented rapidly enough to meet OMVS requirements. Rehabilitating the existing microwave system should thus be considered as a complementary and concurrent portion of an overall plan relying primarily on satellite technology on the Senegalese side of the Fleuve region.

The original supplier of the equipment has estimated a cost of $ 2,700,000 U.S. per year for rehabilitation of the microwave system.

## B. Single Sideband HF Radio Techniques

Single Sideband (SSB) HF radio is a technique that can be very useful for providing basic communications, but only in certain situations. Although it is relatively inexpensive (on the order of $ 10,000 to $ 15,000 for the equipment for one installation), HF is limited in terms of its communications capacities in comparison with regular telephone service. For instance,

- SSB HF radio receivers are inherently low-fidelity devices as a restricted voice frequency bandwidth is built into them to conserve the HF radio frequency spectrum.
- The inherent low-fidelity qualify of HF radio is further degraded by noise and interference levels far greater than allowed on regular telephone channels.
- An extremely variable transmission parameter, the ionosphere, at times causes complete fading of the signal for periods varying from seconds to hours. At best, this fading, coupled with the poor fidelity and noise, results in frequent repeats. At worst, it completely prevents communications for hours at a time.
- Facsimile, data (expect very low rate), and effective audioconferencing are not possible via HF.

In summary, HF radio techniques are not generally considered suitable for public use by untrained personnel except in cases where other techniques are not feasible.

## C. Recommendation

On the basis of the above analysis, we feel that a satellite pilot project would have the most significant long-term benefits to the region. We do urge OMVS, AID, and other donors to enter into an agreement with OPT Senegal under which OPT would rehabilitate the existing microwave system in Senegal, however.

### 3.7.5.3. Pilot Project Concept

The pilot project design is based on an analysis of requirements of the three project initiatives proposed by USAID, described earlier. While a pilot project fulfulling requirements for functional linkages between all key sites and activities under OMVS in the three member states would be ideal, it is too complex and costly to institute as a first phase. As noted elsewhere, (See Appendix, Figure 1), such a system might require a minimum of 20 sites. In addition, certain rules, regulations, and tariffs govern the domestic and cross-border use of the INTELSAT satellite system, which at present is the only space system available for the region, as well as those governing terrestrial cross-border communication between the three OMVS nations. The proposed policy study should aim to obtain multidonor commitment to overcoming these obstacles in the implementation and operation of such a system.

As a first step in the long-term process, we propose a pilot project in Senegal alone. This project would serve the information needs of the policy study and provide the basis for justifying costs and benefits of a future system expansion.

### 3.7.5.4. Pilot Project Technical System

#### A. Introduction

We propose that a two-circuit satellite link be established between Saint Louis and Bakel. The proposed system should be as independent as possible of the present OPT network so as not to be subject to that network's problems. The basic configuration would be built around the use of two thin-route satellite earth stations working on an INTELSAT satellite. At Saint Louis, the circuits would be interfaced with a PABX with a VHF link to Ross Bethio and a leased line on the existing microwave line to Dakar. Bakel would also have a PABX and VHF links to two major field posts.

A private network having telephone, facsimile, and audioconferencing capabilities would interconnect the following locations:

- Saint Louis
- Ross Bethio
- Bakel
- two field locations near Bakel
- Dakar (through leased lines)

(Dakar could be connected by standard long-distance telephone connections or have a dedicated microwave line. This decision would be

made during the detailed system engineering phase based on an assessment of the call handling ability of the Saint Louis switch and the availability of microwave lease circuits.)

## B. Equipment Summary

### 1) Network Configuration

The earth stations would provide two long-distance channels interconnecting the Saint Louis and Bakel PABX's. The PABX's would be designed to interface with the local exchanges in both Saint Louis and Bakel, allowing outside calls to enter or leave the network. The system would provide each end point with telephones, facsimile, and audioconferencing capability. At present, relative locations in Bakel and Saint Louis of the earth stations with attendant PABX, local OPT switchboard, and audioconferencing roon have not been determined. If they cannot be situated together, it will be necessary to install circuits between them to provide the required connections. We propose that SERST arrange for OPT to provide these circuits. Once the locations of the indicated components are established, however, a study will be made to determine the practical alternatives (such as radio) for these local connections and to choose the wisest approach.

### 2) Earth Station Design

The earth station system would be designed to use digital carriers with a capacity of two voice channels. As it is now proposed, the basic earth station would be equipped with solid-state transmitters and integrated circuitry designed specifically for low prime power and minimum maintenance. A 6.1 meter antenna would conform to the minimum presently allowed in the INTELSAT system. The parameters of the antenna and transmitter would qualify for use on INTELSAT V satellites. Ongoing discussions with INTELSAT may lead to the reduction of antenna size to 5 - 5.5 meters and modifications in the specifications, which could result in a significant savings in hardware. Because it is less expensive and easier to install, however, a smaller terminal could potentially expand the network in the future. Design of the earth terminal would begin prior to the actual start of the Senegal project as part of the ongoing system engineering effort of the Rural Satellite Project (RSP). RSP personnel have been working continually with ITS, NASA, and INTELSAT, regarding small terminal technology, and a model earth station suitable for the Senegal application is expected to be developed prior to project approval.

### 3) Equipment to be Delivered

The hardware would consist of:

PABX's in Saint Louis and Bakel;

- an earth station link via INTELSAT connecting the Saint Louis PABX to the Bakel PABX;
- a VHF link between Ross Bethio and the Saint Louis PABX;
- VHF links between the Bakel PABX and the two major field posts near Bakel;
- facsimile and audioconferencing equipment at Saint Louis, Bakel, and Dakar, interfaced into the PABX's;
- interface at the earth stations for the OPT network and the radio relay.

4) Prime Power Sources

Since prime power is a major consideration in most locations, the Bakel earth station would be equipped with a photovoltaic power source and the VHF links, except those in Saint Louis, would be solar powered. The Saint Louis equipment would be designed to use commercial power. Because there is generally a direct correlation between the amount of prime power required and the maintenance involved for electronics equipment, earth stations would be designed for the minimum prime drain and measures would be taken to eliminate the need for air conditioning of the equipment.

The photovoltaic (PV) power system for the Bakel earth station will employ PV modules capable of operating under severe environmental conditions. The system will also include low maintenance storage batteries, specially designed for photovoltaic applications. Assuming the earth station requires an AC power supply, an inverter will be provided to change the DC output of the PV system to AC. An engine generator will also be integrated into the unit to augment the storage capacity and/or serve as a backup unit. The complete system will be designed, fabricated, and tested in the U.S. prior to shipment to Senegal. Adequate training programs will be offered, along with operation and maintenance and troubleshooting and repair manuals. At least one year of technical monitoring by a U.S. contractor will be provided.

C. Telephone/Radio Interface

The earth station system would be designed for a capacity of two voice channels between Saint Louis and Bakel. These two channels would be interfaced into the exchange at each end to permit complete versatility of use. The PABX would be capable of interfacing either directly into the local loop signaling or providing standard E/M interfaces for distance dialing using MFC-R2 signaling. Either 2-wire or 4-wire connections would be possible. These lines could therefore be used by OMVS or split - one to OMVS and one to OPT in any arrangement, such as time of day. Should there be a need for relaying audio broadcast material, the

earth station facilities could be used in a standard telephone channel band width for such a relay. No additional radio relay equipment will be supplied. Provision would be made to allow connection at the earth stations by the radio authority, and a switching arrangement would be built into the PABX to permit switchover from telephone to radio relay. The radio relay would be "voice-quality only" for use in either AM or FM distribution. Standard facsimile and audioconferencing equipment would be supplied for interface with PABX's. The network would thus be fully capable of interfacing into the following :

- the OMVS private network;
- the local telephone networks in Saint Louis and Bakel;
- the long-distance network in Saint Louis; and
- the radio-relay network from Saint Louis to Bakel.

Because the system provides only two lines, a time-sharing arrangement must be developed based on the requirements. Channels can later be expanded if the need arises.

D. Civil Works

AID would provide the electronic equipment network design and system hardware, along with supervision for installation, testing, and the first three months of operation and maintenance. Civil works specifications would be provided as part of the electronic equipment delivery. AID would also furnish assistance in site selection. The civil works for the earth terminal would be comparatively minimal, given the small size of the terminal itself. One major criteria in procuring the equipment would be simplicity of installation, including pad. Usually, the installation pad for such terminals is either a very small concrete pad or three small pillars. The VHF towers would be kept at the minimum requirements for adequate performance.

### 3.7.5.5 Maintenance Concept

Public telephone operation is provided around the clock almost universally. Accordingly, all equipment should be designed for continuous operation. The life of modern radio equipment is significantly extended and its reliability significantly increased if the equipment is continuously energized. Turning the power on and off in modern electronic equipment is undesirable. The plan, therefore, would provide for battery back up to the photovoltaic sources.

It is neither necessary nor desirable for the station to be staffed 24 hours a day. The maintenance plan would require a system manager to be stationed in Saint Louis and a site engineer in Bakel. These person-

nel would be assigned to oversee the maintenance of the earth stations and other electronic equipment, assisted by technicians from a maintenance pool. The stations do not require full-time personnel and could be left unattended exception for security personnel. The system manager task could be a part-time duty of a division maintenance chief. The technical subcontractor, Teleconsult (TLC) will assist in setting up the maintenance structure, which would include regular preventative maintenance tasks as well as those to be performed periodically. Full documentation and training for these tasks would be delivered. Technicians would be expected to maintain all the equipment delivered for the network and to service the earth station, VHF radio, and terminal equipment as required.

Since maintenance may be a major problem, we suggest an intensive training program with backup support for two years, divided into the following segments:

- six weeks of training in the U.S. for two engineers;
- on-the-job installation and test;
- three months of in-country training and maintenance supervision for engineers and technicians after start-up;
- contingency fund (administered by contractor for spare parts and travel/telephone in case of emergency);
- on-call service for 21 months.

We propose that two engineers receive six weeks of training at the earth station vendor's manufacturing plant prior to shipment of the earth station equipment. This training would focus on characteristics of the equipment, its operation, and maintenance.

The engineers selected for this training should have previous experience in the operation and maintenance of microwave systems. Experience in organizing and instructing training programs would also be desirable to permit these engineers to aid in training technicians in-country.

Upon their return to Senegal, the engineers would receive on-the-job training during installation and testing and then be assigned to maintain the earth stations. The engineer would be provided with technical and maintenance manuals on the earth station, VHF, and terminal equipment by vendors. Direct supervision of operations and maintenance would be provided by Teleconsult for the first three months of operation. Support would be provided by TLC on an on-call basis for the next 21 months of operations.

### 3.7.6. Management Plan

The pilot project would fall under the authority of SERST in Senegal, which would establish a project office in Dakar with a technical director working full-time on the project during the implementation phase and part-time during the operational phase. In addition, a full-time field director would be required in Saint Louis to work with SAED and OMVS.* These two GOS personnel would be assisted by the contractor's field director, who would be based in Saint Louis and travel frequently to Dakar and Bakel. The contractor field director, scheduled to work in Senegal for about 18 months beginning 6 months prior to the onset of project operation, would carry out the tasks defined as the field-level responsibilities of the contractor under the institutional arrangements section.

These three individuals would have primary responsibility for planning, implementing, and operating the pilot project. They would coordinate and monitor all phases of project development with regard to both applications and engineering. The field director would be responsible for the technical subcontractor, who would provide engineering assistance on a day-to-day basis, working with SERST's technical director.

For each of the participating sites, SERST or SAED would assign one person to serve as the community coordinator for the duration of the pilot project. The contractor would attempt to attain the support of Peace Corps, other volunteers, or local hire personnel to coordinate activities in Bakel and in Dakar. Clerical and operational assistance would be provided in Saint Louis for the field office.

Project personnel would work with the different system users to encourage novel and innovative uses of the system. They would assist in the analysis of tasks and functions of the user agencies and suggest ways of improving efficiency through telecommunications. For example, with regard to in-service training and supervision of agriculture extension agents, different formats of audioconferences would be tested to determine which are most effective for the local environment.

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* If a radio broadcast component is included in the IDP, some tasks, functions, and technical assistance for the telecommunication and radio broadcast components are very similar and could be combined, making more efficient use of staff resources.

Coordinating committees would be established at each project site. In Dakar there would be two such committees: a technical coordination committee, chaired by SERST and serving as the main vehicle for SERST to coordinate inputs and resources of the participating technical agencies such as OPT, Telesenegal, and ORTS; and a policy committee, also chaired by SERST but composed of the key agencies using the system (i.e., SAED, OMVS, AID, BNDS, University of Dakar, Water and Forest Services, and Meteo Senegal). Policy committee tasks would include reviewing the application program, schedules, and the use of the common facilities and specifying new directions for the application program as required.

In Saint Louis, one coordination committee, under the chair of the local GOS project director, would be composed of technical and user agencies and include a representative from Ross Bethio. The tasks of the committee would include detailed planning of the applications, scheduling, and providing substantial personnel support.

In Bakel and at the VHF sites, user committees of community leaders and local officials, including SAED an the Health Ministry, would identify local project needs and maintain, stimulate, and coordinate local use of the system. The local field representative would assist the local committees.

One role of all the committees would be to monitor local activities and provide feedback to the field director.

For a preliminary management plan see Appendix, Figure 3.

The following sections provide more detail on the roles and responsibilities of the key personnel in the project.

3.7.6.1. Staffing Pattern

A. Technical Director, to be assigned by SERST, Dakar, will have the following responsibilities:

- supervise or execute all responsibilities of SERST, including managing couterpart-resources, such as OPT, Telesenegal, and ORTS contributions;
- facilitate work of AED's technical sub-contractor, Teleconsult;
- assist in developing specifications and procurement;
- facilitate clearances and other activities under SERST responsibility in this project;
- organize and manage the technical coordi-

nation and the policy committees in Dakar, coordinate inputs from Dakar-level user agencies.

B. Field Director, to be contracted by AID, will do the following:

- manage day-to-day field activities of the project;
- organize working groups of users;
- assist users in service identification and application planning;
- promote use of communication services by development projects and general public;
- serve as liaison with site communities and organize community committees;
- coordinate operations, performance, and maintenance with local technical staff;
- train working group members of users in system use, applications planning, and evaluation;
- train community members in the use of system;
- coordinate training of site coordinators;
- assume responsibility for formative evaluation feedback;
- negotiate schedule and implement system use with users, ministries, and sites;
- set up and administer audioconferences.

C. Contractor Field Director

- assist 1) and 2) above in all tasks;
- coordinate, supervise, and implement all responsibilities charged to the project including commodities, technical assistance, training, and engineering assistance, and facilitate the activities of the evaluation subcontractor;
- submit monthly progress and financial reports to USAID/RBDO.

D. Community Coordinator, Bakel and Dakar

- stimulate, initiate, and coordinate community participation by setting up and promoting community committees;
- set up meeting rooms and remind participants of schedules and activities;

forward requests from communities to field director in Saint Louis or Dakar;
- maintain basic logs and other evaluation instruments.

3.7.6.2. Advisory and Working Groups Committees

A. Technical Coordination Committee/Committees

SERST, OPT, Telesenegal, ORTS

- represent interests of individual organizations in the project;
- coordinate and monitor technical contributions to the project, as being provided by each agency;
- advise on technical system design, implementation plan, and provide resources for O&M.

B. Policy Committee, Dakar

This committee should include a representative from each participating organization and key individuals with long-term interest in the project, including OMVS, SAED, BNDS, Eaux et Forets, Meteo Senegal, and USAID. The committee should carry out the following tasks:

- represent individual agencies' interests in project planning;
- follow up requests from the field for specific assistance or resources;
- suggest field application and provide support and resources from Dakar;
- coordinate and identify appropriate available software;
- assist RBDO and evaluation contractor in rural telecommunication studies.

C. Coordinating Committee: Saint Louis

This committee should include one local representative from each participating organization to be responsible for the institution's utilization program. The committe would:

- identify, define, and implement utilization program of individual agencies;

- serve as liaison with the agency's staff at community level;
- identify resources/expertise required from Dakar.

D. Community Coordinating Group, Bakel, VHF sites

This group would include a coordinator, village leaders, representatives of farming associations, teachers, health aides, local government, and an RSP systems operator. It would:

- identify community needs/interests;
- coordinate local activities and schedules for sessions;
- provide feedback to Saint Louis concerning programs and community interest;
- keep logs and maintain responsibility for ongoing data collection.

3.7.7. Project Resources

Resources for the pilot project will be provided by USAID Dakar, AID/Washington, and the Government of Senegal. USAID will provide the following:

3.7.7.1. Institutional Contract

USAID (Dakar and Washington/Science and Technology) will carry out its project responsibilities through contracts with qualified organizations. Through these contracts, the resources would be made available to plan and execute all AID inputs.

It is proposed that RBDO commit its funding for the telecommunication component of the program through AID/Washington to the Rural Satellite Program (RSP) which is being administered by the Academy for Educational Development (AED) as prime contractor with Teleconsult, Inc. (TLC) as engineering subcontractor. If this arrangement becomes a reality, Science and Technology/Education will provide partial funding and assist in project management. It will also fund the Abt Associates evaluation activity.

In addition, under a separate interagency agreement with NASA, AID/Science and Technology/Education has sponsored the development of appropriate photovoltaic power sources for small satellite earth stations. A unit developed and purchased under this agreement will be supplied to power the earth station in Bakel. In addition, the supplier and NASA will devise and implement appropriate training as well as evaluation plans. It is also possible that one of the earth stations to be provided for the

pilot project will be supplied through another interagency agreement between AID/Science and Technology and the Institute for Telecommunication Sciences (ITS), an Institute of the Department of Commerce. Under this agreement, ITS has studied and developed specifications for low-cost twin route earth stations.

One advantage of this arrangement is that the RBDO can draw on the already existing staff, resources, and institutional capabilities of these contractors. In addition, under the RSP, budgetary and staff support will be provided through the AID/Washington-funded RSP contract. Abt Associates, the contractor responsible for the RSP evaluation, would administer the necessary evaluation tasks. For the planning, implementation, and evaluation of the rural satellite pilot project, AED and Abt would work with SERST. For the policy study, AED would work with OMVS.

3.7.7.2. Technical Assistance

A major goal of the Rural Satellite Project in the OMVS region is to assist the host countries in developing a range of skills in interactive telecommunications to extend the quality and reach of rural development programs. Achieving this goal requires close collaboration between communication specialists and the specific user agencies participating in the satellite project. The provision of technical assistance by communication specialists will be essential, both for helping the agencies identify the activities that can best benefit from the use of telecommunications, and for organizing the agency so that the telecommunication system can be used effectively.

Introducting telecommunications into an agency will not necessarily improve agency functions. Improperly introduced, communications can impede agency activities by overburdening personnel or by promoting the inefficient development of management structures. Technical assistance is provided under the program to help agencies organize their activities to function more effectively. In addition to a full-time technical assistant serving for over 20 months, the Senegal Rural Satellite Project would provide up to seven person-months of technical assistance. While specific types and amounts of technical assistance in different categories cannot be identified until after the completion of the project agreement, general categories of assistance can be classified as follows:

A. Management and Administrative Support

Technical assistance in this area is critical to the success of the project and would draw on experts and practitioners in interactive and management communication.

A wide body of knowledge and experience has been developed in the U.S. over the past 10 years as telecommunications have become increasingly

recognized as a tool for the management of decentralized and multi-locations programs. The project should draw on and adapt to local conditions operational experience in the application of telecommunications to managing and controlling agricultural projects; administering an MIS; and supporting agricultural extension agents in the field with new information, extension techniques, technologies, procedures, up-to-date price and weather information, and in-service training.

### B. Health Care

The system's major health applications will be instrumental in monitoring health conditions and in arranging logistical support for health survey teams and medical supplies. It might be desirable for groups with relevant experience, such as the Hawaii-based Medex program operating a two-way medical consultation and training system in Guyana, to advise health care providers on the use of communications to improve rural health care.

### C. Community Development and Organization

Experience with similar rural telecommunication projects has indicated that the most effective use of communication facilities requires a certain level of community organization. We propose that one local community coordinator serve in each site to initiate and sustain community participation in the project. Carefully planned exchanges and discussions between farmer organizations, cooperatives, and officials in Bakel, Saint Louis, or even Dakar could help encourage farmer participation in the development process, which is a primary IDP objective. The coordinator would need technical assistance from individuals who have worked with community development aspects of other communication projects, particularly in Canada, Appalachia, and Alaska, as well as in other developing countries such as the Philippines.

### D. Engineering and Hardware Support

The contractor will be responsible for system engineering and the development of technical specifications, procurement, and installation supervision. It also will assist the Senegalese counterpart in site selection and furnish specifications for the foundations, equipment and facilities parameters, training and initial system supervision, and interface requirements for interconnecting the new equipment with the existing telecommunication system.

Hardware provided under AID funds will include two satellite earth stations, two PAB's, three VHF links (solar powered), peripheral equipment such as facsimile machines, and teleconferencing equipment. USAID will handle system procurement, insurance, and freight costs to Senegal. The total cost for hardware is budgeted for $780 thousand.

Space-segment costs, budgeted in the order of $100,000 are based on the assumption that INTELSAT will either consider the project as an experiment or develop a cost structure on an "as-used" basis for rural development. This policy is not in effect at present. With no concession from INTELSAT, the annual cost would be based on lease of one-quarter transponder at a cost of $200,000 per year. The first step for project planners should thus be to apply for status for the project as an experiment. Approval is likely, as (1) Bakel will be fully solar powered, and (2) a totally digital small terminal will be designed to handle peripheral equipment not presently used in standard networks. At this time it is not clear whether the Saint Louis - Dakar link will be a full-time leased channel or if the nework will be accessed on an as-required basis.

Should an additional earth station be required for other sites, the incremental cost for hardware would be approximately $275,000, including all telephones and audioconferencing equipment as in Saint-Louis and Bakel.

If AM radio distribution facilities are required at a location such as Bakel, the estimated cost for a 150-foot tower and 10 KW transmission would be $200 for the hardware and installation. Connections from the earth station to the transmitter are not included in the price.

The maintenance contingency budgeted at $25 thousand will include a provision for handling emergency situations without the aid of a resident expatriate engineer, thus removing a large cost from the program. It is hoped that most problems can be handled through telephone conversations between the U.S. supplier and project personnel in Senegal.

In addition, through an agreement with NASA, AID will provide a photovoltaic power unit to supply the energy for the earth station in Bakel.

#### 3.7.7.3. Training

The training goals of the Senegal Rural Satellite Project are designed to satisfy three criteria:

a) To train project staff and community members at different levels to meet the operational needs of the pilot project. Specific training plans would be designed based on the proposed job descriptions of key project personnel, including the Senegalese project director and the key individuals of SAED and OMVS. Training site would depend on the level of skills and/or expertise required. During the pilot phase, individuals from Mauritania and Mali also could be trained to perform similar tasks in their own countries.

b) To train key individuals to provide project support and follow-up for Senegal and the region. Staff members of a local university or training institution would be trained in interactive telecommunication planning, application, technique, and research. Ultimately, they would conduct in-country training sessions for project staff, participating ministries, and communities, and would encourage the development and growth of interactive telecommunication applications in other development projects and areas of Senegal.

c) To train engineers in the operation and maintenance of the earth station equipment. Two engineers would receive training on project equipment and would subsequently conduct training sessions for other engineers and technicians. As part of its responsibilities, TLC would also administer extensive on-the-job training for operations and maintenance of the equipment.

The proposed level of effort for short-term training is up to six person-months of U.S.-based training and two in-country training seminars. In addition, the contractor's field coordinator and short-term consultants will conduct on-the-job training as required.

Aside from short-term, project-specific training, long-term training would be required for at least one individual over a two-year period. This person, most likely working within the OMVS, would be responsible for the development and promotion of an OMVS-wide telecommunication system and applications plan. Training should be designed to provide the individual with the skills to integrate a knowledge of basic telecommunication system design with an understanding of communication needs assessment. The task of the individual(s) would be to promote and carry out the recommendations formulated in the policy study.

### 3.7.7.4. Administrative and Logistical Support

AID will pay for travel, per diem, and office equipment of its expatriate staff. It will finance the international travel of host country personnel, including trainees. In addition, AID will finance the training of host country technical staff as well as key application personnel. Two seminars will be financed, as well as a final project video tape.

The Government of Senegal, through SERST and SAED, will provide several resources. SERST has nominated a technical director to head the overall project development and implementation. This person will be assisted by a technical coordination committee, composed of representatives of the Post Office and Telecommunication, Telesenegal, and possibly the Office of Radio and Television, as well as SAED. Counterpart resources will be made available through agreements between SERST and those agencies to cover personnel and supply costs to support

system design and development, site selection, and surveys, including the photovoltaic system, civil works, installation, and local transportation. In addition, the GOS will provide sites for the earth station and VHF equipment as well as appropriate facilities for the peripheral equipment. The operational support contribution of the GOS will include technical and operator support at the project sites, first-level operating and maintenance engineering backstopping support, and field counterparts as required. GOS is also responsible for all relations and negotiations regarding space segment capacity and will contine to pay all salaries of staff sent for overseas training.

USAID and OMVS will supply resources for the policy study. USAID will make available up to nine person-months of professional assistance, including the services of an engineer and an economist. Through agreements with appropriate institutions in the three member countries and the organization's own staff time, OMVS will make counterpart personnel resources avaialble to carry out the study.

### 3.7.8. Implementation Schedule

The proposed pilot project schedule is based on a preliminary assessment of project technical assistance and program planning needs as well as an assessment of administration needs for implementation. Following approval of the overall IDP project and detailed negotiation in April 1983, the definition and procurement of the hardware system, estimated to take a minimum of 13 months, will set the pace for the project schedule. Every effort will be made to expedite the system design and procurement processes so as to provide a reliable telephone link between Saint Louis and Bakel as early possible to aid managers and implementators of existing projects, notably the USAID/SAED-sponsored Irrigated Perimeters Project in Bakel. The prompt installation of the telephone system will be essential to the implementation of administrative and MIS support as well as the training component, as explained in the section on systems applications. Beginning the procurement process following the obligation of funds but prior to formal country agreements could save up to three months. For details of the proposed project implementation plan, see Appendix, Figures 4 and 5; Figure 4 details the hardware plan.

During the 13-month period of installation, project staff would be recruited and trained, offices would be established (about six months prior to system operation), and a detailed operations schecule would be developed. Local, regional, and national coordinating committees would be organized, and information and training would be offered to project staff and potential system users in the use of communication services. As an essential element of project evaluation, baseline data could be gathered during this period on the detailed functioning of existing OMVS, SAED, USAID project management, established communication patterns, costs and practices, transportation, and demographic statistics on project sites and possible control communities.

During the second and third years of the pilot project, the communication system would be fully operative. The system would be used primarily for two-way voice communication--both person-to-person and teleconferencing--and facsimile transmission among OMVS, SAED, and USAID managers, supervisors, project field personnel, and affected publics in the pilot area. The contractor will transfer its field activities to the local counterparts after 20 months. O&M support and specific appplications support tasks will be continued, as required, until September 1985.

The contractor will provide regular progress reports to OMVS and RBDO. In addition, it will hold a number of seminars over the life of the project to acquaint interested parties in OMVS states with the technology, operations, and benefits of the pilot project.

The summative evaluation, to be conducted by the sub-contractor, will provide an overview of the project's social benefits, costs, and effectiveness in meeting managerial, technical, and social goals. The contractor would summarize overall project findings and present an evaluation in a final report.

### 3.7.9. Evaluation

#### 3.7.9.1. Introduction

Supplementing the usual program evaluation characteristic of AID projects will be an ongoing evaluation of the telecommunication capacity to determine the potential for future expansion, This evaluation will be funded through the AID/Washington contract of the agency-wide Rural Satellite Program.

The contractor selected to implement the project will attempt to develop a working relationship with a Senegalese institution to which it can turn for assistance in conducting the evaluation and developing in-country capabilities.

A U.S. evaluation specialist will make a series of trips to Senegal to establish methodology, provide training, and guide data collection. The contractor responsible for the RSP will be responsible for the logistics of the evaluation.

#### 3.7.9.2. Evaluation Methodologies

The evaluation will include periodic sample surveys, intensive observations of key institutions in the project area, and economic analyses. These methods are designed to address several issues, ranging from efficiency of the interactions to institutional impact to cost-

benefit analyses. The following description of evaluation topics should be refined to ensure that USAID and Government of Senegal evaluation needs are fully met.

3.7.9.3. Evaluation of Institutional Impact

The evaluation will look at key institutional users of the new telecommunications systems to ascertain impact, particularly in management effectiveness. This process will involve a four-step analysis to determine the following:

1) use made of the new capacity (e.g., frequency of calls or audioconferences, by whom, to whom, administrative vs. programmatic vs. personal uses);

2) changes in institutional operations resulting from the use of the communications (e.g. less travel, more direct contacts between managers and functionarès, modified administrative monitoring systems, new supply control procedures, more time spent in training activities made possible by telecommunications);

3) resultant changes (pro or con) in the efficiency of these institutions and in their impact on clients (e.g. major changes in number of clients reached, speed of dealing with problems, outreach to different subpopulations, reduced administrative errors, improved staff capabilities, improved morale from reduced isolation);

4) problems and attitutes of users.

Evaluators should be alert to factors often not systematically studied or qualified, but which are fundamental to the operation of an institution. In Alaska native health centers, for example, reliable communications via satellite not only improved the services of community health providers, but also produced a profound improvement in the morale of the community health providers; the improvement resulted from diminishing their sense of isolation and frustration when they needed professional advice. In terms of the long-run viability of the primary health care system, this was the single most important achievement, and the kind of effect to which the evaluation will attempt to be sensitive.

3.7.9.4. Evaluation of Technical Performance

A procedure will be established to determine the reliability and quality of system performance. In addition, analyses will determine major sources of technical difficulty. NASA will manage its assessment of the photovoltaic system in conjunction with the contractor.

3.7.9.5. Record of Costs

A record of all project costs will be developed, both for external assistance and local costs. In addition, estimates will be obtained of reductions (or increases) in other costs related to the system, such as potential reductions in terminal cost.

3.7.9.6. Assessment of Benefits

This kind of intervention can promote many different types of benefits. If local institutions run more effectively, they may reach more clients and increase their productivity. Communications may well reduce market inefficiencies such as spoilage of agricultural produce. Reliable public telephone services should spur economic development through the growth of private enterprise.

It will be difficult, however, to evaluate these benefits with some common measure and to distinguish the impacts of telecommunications from those of other project inputs. A cost/benefit approximation may be attempted. A series of cost-effectiveness analyses in relation to various user agencies, however, will provide a more credible analytic base for future decisions.

3.7.9.7. Case Study

The contractor will produce a describe case study integrating the findings of the evaluation and providing an easily accessible basis for further planning.

3.7.9.8. Coordination of Studies in the Countries

AID/Washington will be evaluating other satellite uses at the same time, some of which may be related to this project- for example, work by the Latin American Bureau, with some S&T bureau involvement in rural Peru. Thus some overlap of evaluation methods and findings will be possible.

3.7.9.9. AID Program Evaluation

The intensive evaluation will provide an unusually rich basis for undertaking periodic AID evaluations of project progess. The AID evaluation program will follow this schedule:

1) Pre-Operational Evaluation

After completion of hardware installation, 12 months after AID/Washington approval.

2) Mid-Project Assessment

24 months after AID/Washington approval.

3) Final Assessment

Approximately 36 months after AID/Washington approval.

The contractor will be responsible for providing records of specifications, schedules, and expenditures.

The S&T office responsible for the Rural Satellite Program, Science and Technology/Education/Washington, will join the Mission for these periodic evaluations.

3.7.10. Economic Analysis

Telecommunications acts as a facilitating factor in development by increasing the efficiency and frequency of development service deliveries, extending development services, and increasing the performance and breadth of the private sector. Communications can augment development only in the presence of other economic factors, such as integrated rural development programs or development of natural resources in a region. Communications can greatly enhance the development agencies' results in development activities by improving their administration; access to information; training opportunities; and access to markets, suppliers, and outside expertise. While these benefits may be indirect in terms of the overall quantifiable benefits to economic growth, they fill important short-term needs.

For example, using communications in agricultural development activities may improve the coordination of extension activities and the levels of information available to extension agents, thus enhancing farmers' knowledge of improved cropping and marketing techniques. Whether these benefits lead to increases in farm income, however, depends on access to markets, land-holding patterns, availability of credit and many other variables.

The benefits of telecommunications can be categorized as either "deliberate" or "spontaneous". Deliberate benefits are those derived from improvements in the delivery of particular development services that are part of public sector programs, such as primary health delivery. Spontaneous benefits are unplanned activities, such as changes in private-sector activity, which are highly dependent on local conditions.

Studies in Alaska and elswhere have indicated that introducing telephone services to economically vibrant areas can greatly enhance economic activity. For example, fish canneries located in the Alaska Peninsula have benefited from regular contact with their markets in Seattle, who have helped them determine how to pack fish and when to ship. This is an example of a spontaneous benefit.

In economically stagnant areas, however, such as subsistence fishing villages, the introduction of the telephone has a relatively small effect on the level of economic activity. Nevertheless it provides valuable social and economic benefits to those villages by transmitting information that can improve the quality of health care provided by village health aides or aid agricultural extension agents in development activities.

The proposed OMVS Rural Satellite Project is designed to support the goals and strategies of major development agencies, as well as the private sector. The overall benefits of introducing telephone and ancillary services are expected to outweigh the anticipated long-term costs of the project.

#### 3.7.10.1. Expected Benefits to the Senegal River Basin Region

Benefits to be derived from this project include the following:

- Improved management of development agency field activities as a result of expediting the exchange of management information necessary for executing activities such as the OMVS/IDP Management Information System and allowing for regular meetings between managers and field staffs.

- Improved supervision of field staffs.

- Improved surveillance and monitoring of local environments and activities on matters that may require outside intervention, such as health care, agricultural research, fertilizer requirements, and groundwater levels.

- Ability to expand and augment the training of field workers and rural populations.

- Improved management of private agencies, including banks and credit agencies.

- Greater productivity for local farmers through increased logistical support, access to banking information, inventory control, access to new markets, and access to prices and market conditions, particularly for perishable goods.

- Greater conservation of energy and resources by allowing for telephone communications instead of the many meetings now required to effect simple exchanges of information.

- Improved management of the private transportation system and access to airplane reservation systems.

- Greater ease and faster turnaround time in ordering supplies such as pumps, parts, fertilizers, and seeds from the government and commercial agencies.

- Greater ease in maintaining personal contacts with family members who work in cities, particularly in emergency situations.

Bakel will become increasingly economically vibrant as irrigation pumps in the perimeter improve agricultural conditions and stimulate migration to the river basin area. The use and importance of telecommunications is expected to increase both for Bakel and the overall Senegal River Basin during this period.

A key challenge for the SAED program will be to resolve problems related to the supply of inputs to perimeters. The volume of inputs will have to expand, particularly in terms of diesel fuel and gasoline to power more irrigation pumps as well as agricultural supplies such as fertilizer, insecticides, and seeds. Telecommunications can aid in scheduling deliveries to minimize inventory costs, and in facilitating emergency requests for spare parts and/or maintenance. This service could greatly reduce equipment down-time and thus cut losses. For example, a pump under warranty on a major perimeter broke down during a critical season and could not be fixed locally. By the time a service contractor was able to travel to the site to repair the damage, the crop had been lost.

It should be noted that the Bakel project zone is SAED's only intervention zone with an administrative base outside of the Fleuve region. Thus local SAED agents cannot rely on their superiors in Saint Louis to

work out problems or collaborate with technical officials from other services based in Bakel, who report to the regional capital of Tambacounda. Telecommunications could substantially improve the managerial relation between SAED and its agents and other services and consequently improve agent productivity.

The RDA agents in zone headquarters or perimeter sites reportedly visit the department administration a minimum of twice a week to obtain approvals, discuss directives, and coordinate the delivery of supplies. Such travel promotes not only expensive transportation costs, but inefficient use of managerial time.

Unrealiable present telephone and mail services also force regional administrators to send vehicles, staff, and messengers to Saint Louis or Dakar to relay urgent information at significant cost.

One goal of the IDP is to increase the private sector's involvement in supplying inputs and services to the Fleuve region. Telecommunications will have a favorable impact on many private sector activities, including inventory control, marketing, purchasing, delivery schedules, and planning. Trucks sometimes arrive to deliver cargo, only to find that unloading capacity has been exceeded at the warehouse. The costly and unnecessary return trips that result could be averted through reliable communications.

The greatest impact of the telecommunication system would be felt in private sector activities involving the production and marketing of livestock in the region. Livestock raised in Bakel moves west to its terminal market in Dakar. Telecommunications could catalyze the livestock trade by improving contact with the market in Dakar, allowing traders to discover previously unrealized opportunities in additional terminal markets, and providing traders with better information to select appropriate markets.

The telecommunication system could also assist in the creation and maintenance of markets for vegetables, which could become an important output of Bakel agriculture. Improved information about market opportunities in combination with the introduction of effective mechanisms for preserving vegetables could make vegetables an important source of farm income.

Reports from the field indicate that late deliveries of supplies--such as bags for the commercialization of rice--disrupt the marketing process. The absence of timely information about rice prices in the villages leads to uncertainties among the farmer organizations in allocating very limited resources for investment. The telecommunication system could be particularly useful in providing logistical support and coordinating shipments with the opening of the new road between Bakel and Saint Louis in late 1982.

Residents of the Bakel region typically are quite mobile, traveling throughout Senegal and to France to pursue trade and employment opportunities. The telephone system could be of direct benefit to dispersed families, both for personal and business communications.

The introduction of telecommunication services, including telephone, facsimile, and audioconferencing, will establish a rapid connection with centers of administration and sources of information. The facsimile service will allow reports to be sent back and forth to Bakel easily and will speed the delivery of documents for allocating funds, ordering goods and services, or obtaining approval signatures. Increased access to managerial and information centers increases both the quality and quantity of control and information in the field. Economic effects will be measurable in terms of managerial output, transportation costs, allocation of manpower among tasks, productive efficiency of particular activities, production levels, and sales levels. Introducting telecommunications will be valuable to Bakel in overcoming information and logistical bottlenecks that hinder the operation of development and commercial activities.

One of the outputs of the pilot project will be a rigorous, quantitative assessment of the expected benefits, as discussed in the following section.

### 3.7.10.2. Cost-Effectiveness and Cost Benefit Considerations

It is important to consider the cost-effectiveness of the proposed system as compared to other means of solving the same set of problems. As this proposal concerns a pilot project, it necessitates a longer range analysis of cost-effectiveness and cost/benefit ratios than a fully operational project. The project's aim is to assess long-range communication requirements of the Senegal River Basin; its results will provide important data for planning the cost and scope of a larger regional project.

Satellite telecommunication systems can be highly cost-effective for rural communications compared to other transmission technologies, as they use small, inexpensive earth stations that do not require costly microwave repeaters in remote locations with the attendent maintenance and operation difficulties. Other advantages of satellite systems include the following: failures are isolated to single earth stations; the system requires little maintenance; it can operate on very small power supplies; it can be adapted inexpensively to receive a range of different media running from telephone to radio to television; and most importantly, it can be installed in locations of most extreme need without having to follow the hierarchical structure required by terrestrial systems. For dispersed rural communities, the satellite system's ability to establish

rapidly multipoint transmission and reception points can be an important boost to development.

A cost-effectiveness analysis of the system based on current costs would be deceptive in light of the project's initial scale and available technology. As Senegal is now served only by INTELSAT and has no access to high-powered satellite beams, it must use relatively expensive earth stations for the initially low level of traffic anticipated for the system,* which will increase the unit cost per call or other measurement of output.

INTELSAT service is also more expensive than other satellite systems. The recurrent cost for the initial phase could amount to $200,000 per year. The initial cost would be high for the number of earth stations used in the pilot project because of INTELSAT's minimum leasing requirements (i.e., 1/4 transponder, which is enough to handle approximately seven earth stations). While it is likely that INTELSAT will offer options to reduce space capacity cost to about $50,000 per year for the two earth stations or make free satellite capacity for a year, this amount is still greater than the cost of a comparable capacity on a domestic class satellite.

The key point is that the cost of using satellites for the kind of communications discussed in this proposal should decrease dramatically in Senegal over the remainder of the decade. Progress achieved in initiatives launched by several European governments and the International Telecommunications Union indicates that a domestic class satellite could be available to Africa within the next five years. As a result, the costs of both the ground and space segments will decrease, while still allowing continued operation of pilot project earth stations with minimal modifications. In addition, the real costs of thin-route earth stations are expected to decrease substantially over the next few years as technologies change and production lines for earth stations are established. Finally, an expanded telecommunication system incorporating multiple villages receiving service through a combination of earth stations and radio links can be expected to increase while other cost

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* There is a tradeoff in satellite communications between the directional power of the transmitted signal from the satellite and the size of the earth station. A high powered directional signal from the satellite permits small, relatively inexpensive, earth stations, while a lower powered signal requires larger, more expensive earth stations. Satellites of the "domestic" class, such as those serving the U.S., have greater signal strength, as the signal is focused over a relatively small area. INTELSAT satellites provide a much lower directional signal strength as their signals are transmitted over a much broader area.

factors remain unchanged. The proposed pilot project, however, with its accompanying evaluation, will yield critical economic benefit information upon which future investment decision can be made.

It is important to note here that multiple-use telecommunication systems like the one proposed will generally be more cost-effective than other alternatives. In this case, cost-effectiveness of a larger regional satellite system using the more efficient earth station technologies and satellites available later in the decade should be viewed prospectively.*

Determining relationship between costs and benefits is far more difficult because of the relatively short period covered by the project and the complexities of quantifying the indirect benefits derived, particularly long-term indirect benefits. Because it generally takes two or three years before telecommunication demand in new service areas stabilizes enough to measure cost-effectiveness, evaluating the project's immediate benefits may be difficult.

Organizations like the World Bank and the ITU have faced problems for a number of years in measuring the social benefits of telecommunication projects. The indirect effects of development are difficult to ascribe, in a rigorous quantitative manner, to the telecommunication investment. For example, evidence shows that telecommunication investments can lead to improvements in the quality of community health. Yet it is difficult to ascribe improvements in the health of individual patients to the telecommunication system in light of the number of intervening variables, including the patient's condition, the skill of the medical professional, and the availability of medicines; moreover, public gains from improved individual health under a telecommunications sytems, in terms of higher community income and improved quality of life, are even more difficult to measure.

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* This statement is not meant to imply that the proposed system is overly expensive. The proposed system will be competitive with other rural telecommunication systems because it is designed to minimize system operation and maintenance costs through the use of modular, photovoltaic-powered earth stations. Thus, the stations would have no recurring fuel expenses and would be designed for unmanned operations. Infrastructure requirements for the stations will be minimal because, once installed, neither the station nor the power source will require access for trucks or heavy equipment. The equipment will not require high grade roads for installation.

A study of the benefits of telecommunications in small business enterprises in Kenya* showed, through the use of microanalytic techniques,** that the firms studied could obtain net benefits***, ranging from 1.3% to 9.2% of total revenues if they had access to improved telecommunication services. The most significant benefits accrued to business expansion activities, although telecommunication costs were also substantial. Businesses reported that better telephone service would give them increased access to markets. The higher levels of information would allow better use of available productive capacity by diminishing machine down-time, improving the allocation of managerial time, and increasing the regularity of sales, among other effects. Similar findings have emerged from studies by Pool and Stevens now being completed in Egypt. The pilot project is expected to accrue like benefits for quasi-statal organizations such as SAED.

Other studies drawing upon macroeconomic and demographic data (including GNP) have indicated causal links between new telephone investment and economic growth. Studies by H. Hudson and D. Goldschmidt, et. al., have shown that introducing telecommunications to rural areas has had a substantial effect on the quality of health care, the operation of educational institutions, the operations of government agencies, the ability of local groups to organize their activities (such as applying for government services), and the ability of commercial enterprises to respond to changes in relevant market demand. These studies, while largely anecdotal because of the enormous cost of gathering statistical data on development benefits, clearly indicated that economic and social benefits derived from telecommunication investment are substantial.

Given the long-term and regional goals of the project, rigorous attempts will be made to indicate the prospective cost effectiveness of the project system as well as its qualitative and quantitative benefits. The prospective cost-effectiveness study will compare the prospective costs of the larger system with those of feasible alternatives, given various measurements of output.

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* Communications Studies Planners International, New York, January 1982.

** Those exceeding costs by factors ranging from 10-300.

*** The benefits were measured for the following categories of productive activity: business expansion, sales price effects, purchase price effects, stock levels, vehicle use, production stoppages, distribution costs, labor time, and managerial time. In estimating the corresponding costs of improved service, it was assumed that time rental and call charges collected by the Kenya Posts and Telecommunications Corporation are approximately equal to the annual costs of providing lines and switching/trunk capacity respectively.

The measurement of qualitative and quantitative benefits necessarily will be derived from the project evaluation. This evaluation will employ a number of longitudinal field measurements, paralleling those used in the farm surveys proposed by SAED, which will indicate positive benefits and negative effects in the following areas:

- administration and management of government agencies;
- provision of public services to Bakel;
- scope of public services in Bakel;
- efficiency of private sector operations;
- changes in private sector productivity and levels of production;
- changes in indicators of public well-being (e.g., health, income) which may be tied to the project;

The evaluation will study these benefits from the proint of view of perimeters, as these are the focus of the SAED activities in Bakel. It will measure benefits in terms of livestock production and sales and delivery of public services.

A detailed baseline analysis should be completed prior to the initiation of communication activities, indicating the economic changes anticipated from other development activities in the area to allow for data disaggregation. There will be methodological limits on the degree of successful disaggregation of telecommunication inputs from others; nevertheless, the analysis should be pushed to its practical limits. This analysis will, in turn, provide the data to assist project staff in making decisions concerning the desired levels and types of long-term satellite and other telecommunication investments that could promote development in the Senegal River Basin.

### 3.7.10.3. Calculating the Benefits of Telecommunications

To quantify the benefits that will accrue to an operational telecommunication system, the World Bank suggests a number of approaches designed to estimate potential demand in a developing country context. Assuming that the benefits of telecommunication service are roughly equivalent to the fees users would be willing to pay to use the system, measuring benefits should be a relatively straightforward process (provided that user demand and tariffs can be accurately measured). Telecommunication demand in developing countries is notoriously difficult to predict. Even after the infrastructure is installed, long waiting periods for connections (sometimes more than two years) and the usual unreliability of telecommunications in a poor country discourage potential users from applying for a service connection. Nevertheless, both apparent and suppressed demand for telecommunications can be estimated through a variety of measures, such as volume of use, system congestion, total revenues, and waiting lists for telephone connections. Shadow-pricing

techniques are also useful to determine the true value to users in the presence of market price distortions. For example, it might be useful to look at the prices subscriber applicants say they would be willing to pay for offices or houses with and without telephones in order to estimate the telephone, value to businesses and residential users.

An alternative strategy for quantifying the benefits of introducing telecommunications would be to analyze substitute costs by estimating the total costs of providing the same vital services as telecommunications through alternate means. For example, in the case of communicating vital messages from Bakel to Saint Louis, the cost of the current practice of sending a messenger between the two cities could be estimated; this fugure could then be multiplied by the number of trips that could be saved if reliable telecommunication service existed between the two points. The resulting figure, together with the costs associated with the other current alternatives that telecommunications would replace, would provide a general indication of the benefits of investing in telephone service. This estimate of expected benefits will probably be low, as many alternate costs will be either not apparent or impossible to estimate . The analysis of demand discussed above should be considered to arrive at a higher estimate. Some combination of the above methodologies should be employed to arrive at an overall cost/benefit ratio for the proposed project.

Terms of reference for the telecommunications policy study appear in section 3.8. of Volume III, "Project Planning and Feasibility Studies Analysis."

# APPENDIX I: FIGURES

## FIGURE 1 - ILLUSTRATION OF REQUIREMENTS OF A SENEGAL RIVER BASIN - WIDE TELECOMMUNICATION SYSTEM

### A. Requirements

1) Apparent key sites at the national levels which must relate to the national capital or to the seat of the RDA for implementation and policy direction:

   Senegal: Dakar, Saint Louis
   Diama, Ross-Bethio, N'diaye, Richard Toll, Fanaye, Dagana, Podor
   Nyanga, Guede, Matam, Aero Lao, Bakel, Kidira, others

   Mauritania: Nouakchott
   Boghe, Kaedi, Selibaby, Gouraye, others

   Mali: Bamako, Kayes
   Same, Manantali, others

2) Apparent key agriculture research sites which must relate to agriculture extension activities, to each other, and to other national/international centers:

   Fanaye, Kaedi, Same, others to Saint Louis, Nouakchott, Kayes Bamako, Dakar, others and among each other.

3) Private Sector communications, presently mostly geared to the capitals, will have increasing needs for cross-river communication, particularly for navigation and transportation. Later, such needs may develop for commerce and trade.

4) Other national agencies responsible for inputs to fisheries development, livestock development, credit, and banking, to name a few, have their own institutional structures, linkages, and sites which need to be connected.

5) OMVS (if based in Dakar or Saint Louis) will need to be linked to the capitals and RDA headquarters.

   In addition, various units need direct and immediate access to field-level information and data for a series of responsibilities including: groundwater monitoring, health condition and vector habitat monitoring, water level and irrigation control, flooding.

6) The various donor agencies, depending on their level of field project activities, will need reliable telephone services from their offices to the field.

Figure 1 (Cont.)

B. Tasks

1) Some of the locations sited are supposedly on reliable telecommunications networks (e.g., PANAFTEL), others are on rudimentary networks, and others have no service. A baseline of system availability, performance, and reliability needs to be established.

2) Many of the sites need to link to several other sites, thus traffic routing and volume needs to be established for the whole region.

3) Cost trade-offs and cost of technical penalties need to be assessed for the network as a whole to arrive at the most economically viable system. Increased technical flexibility brings with it increased costs. For example, for Kaedi to communicate directly with Fanaye, as well as to have a direct connection to Nouakchott may require a terrestrial link to Fanaye and a satellite link to Nouakchott; or it may require a second satellite link to Fanaye (depending on traffic volume); or the call may have to be routed via satellite via Nouakchott to Saint Louis to Podor (at a performance penalty). All options have different cost implications.

4) The modeling tasks can be achieved without major investment as the number of sites are finite and have relatively low traffic requirement levels.

Figure 2 - BASIC EQUIPMENT CONFIGURATION

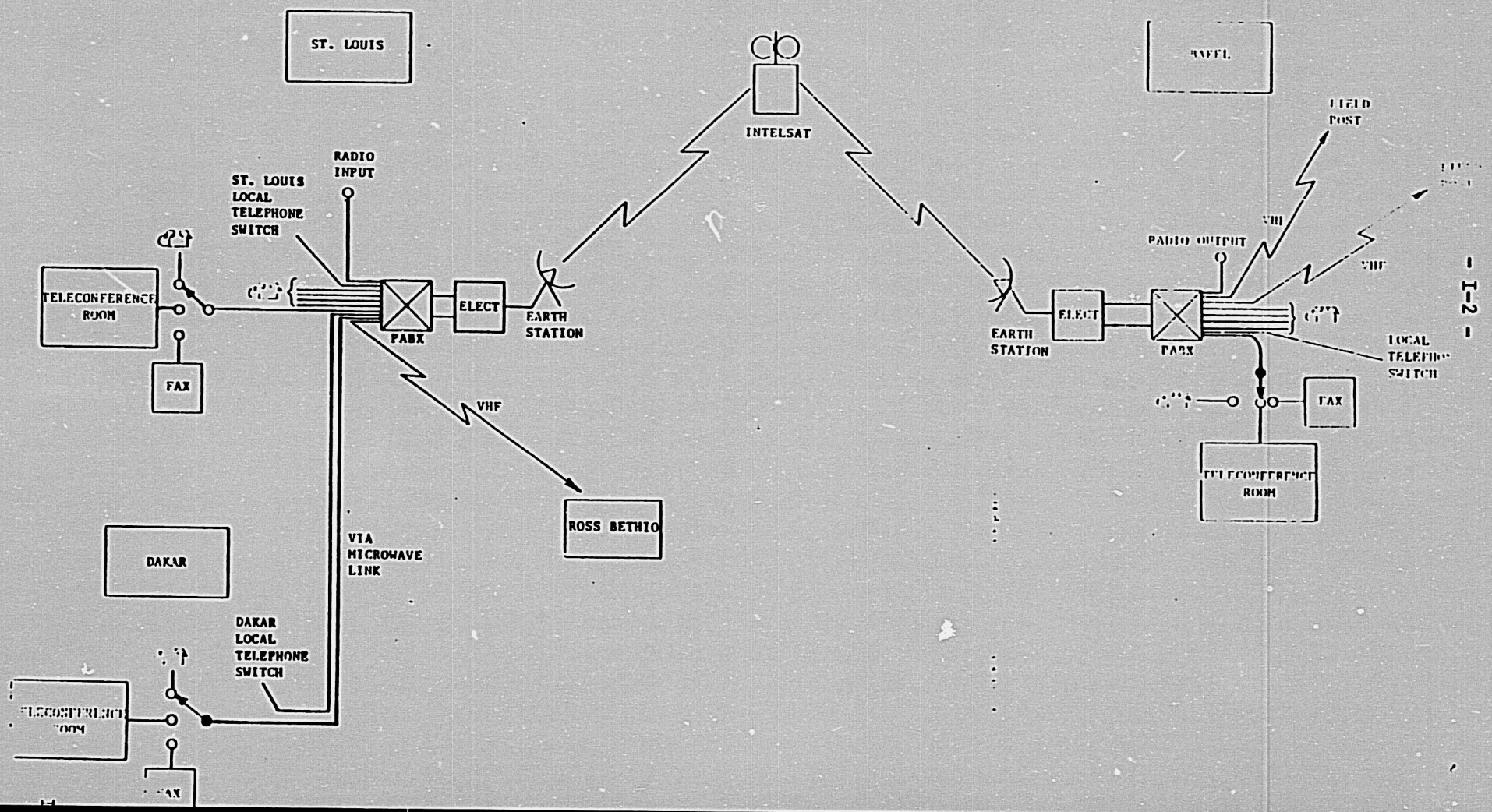


Figure 3 - CONFIGURATION OF MANAGEMENT RESPONSIBILITIES

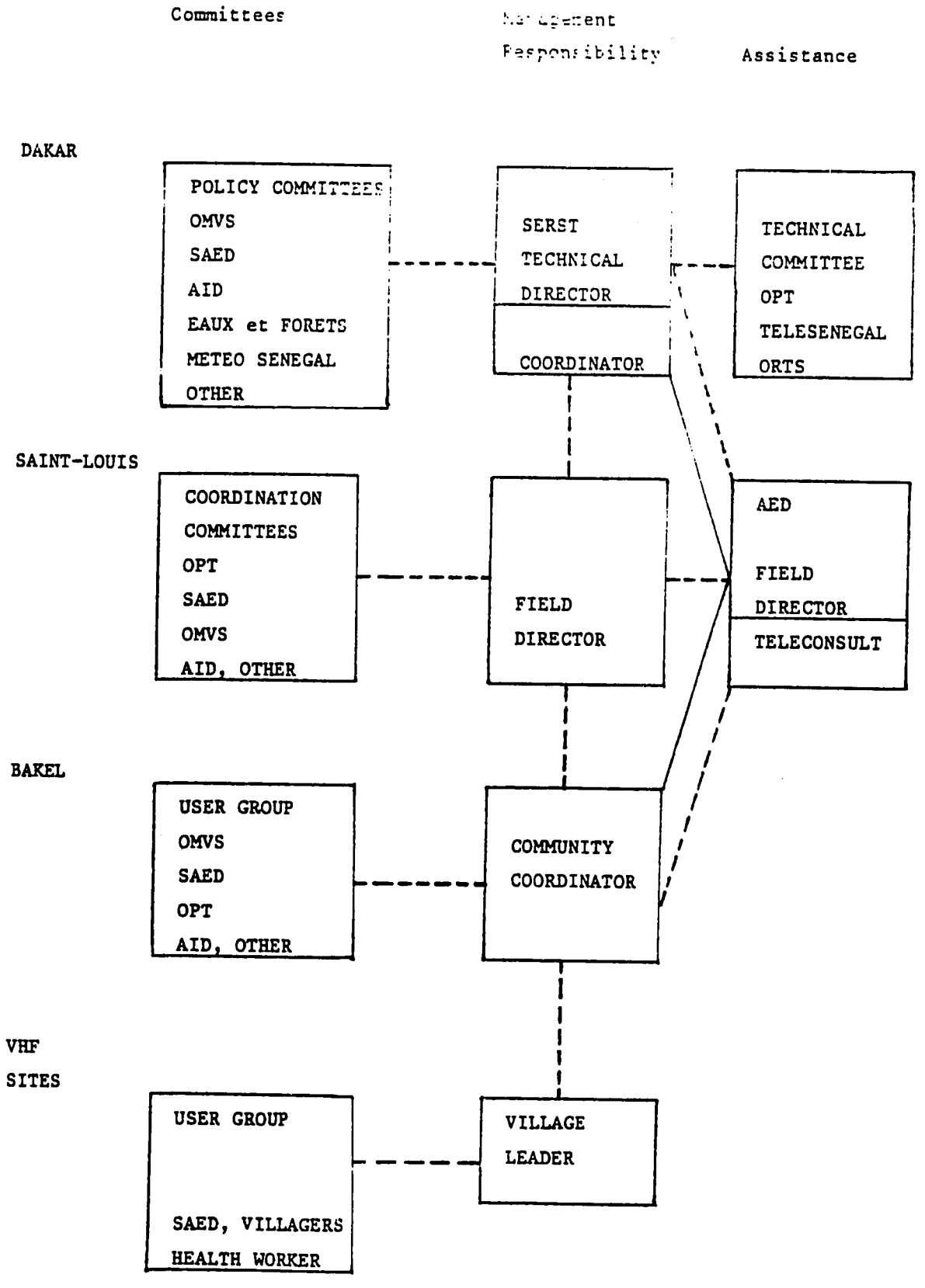


Figure 4 - SCHEDULE OF IMPLEMENTATION ACTIVITIES

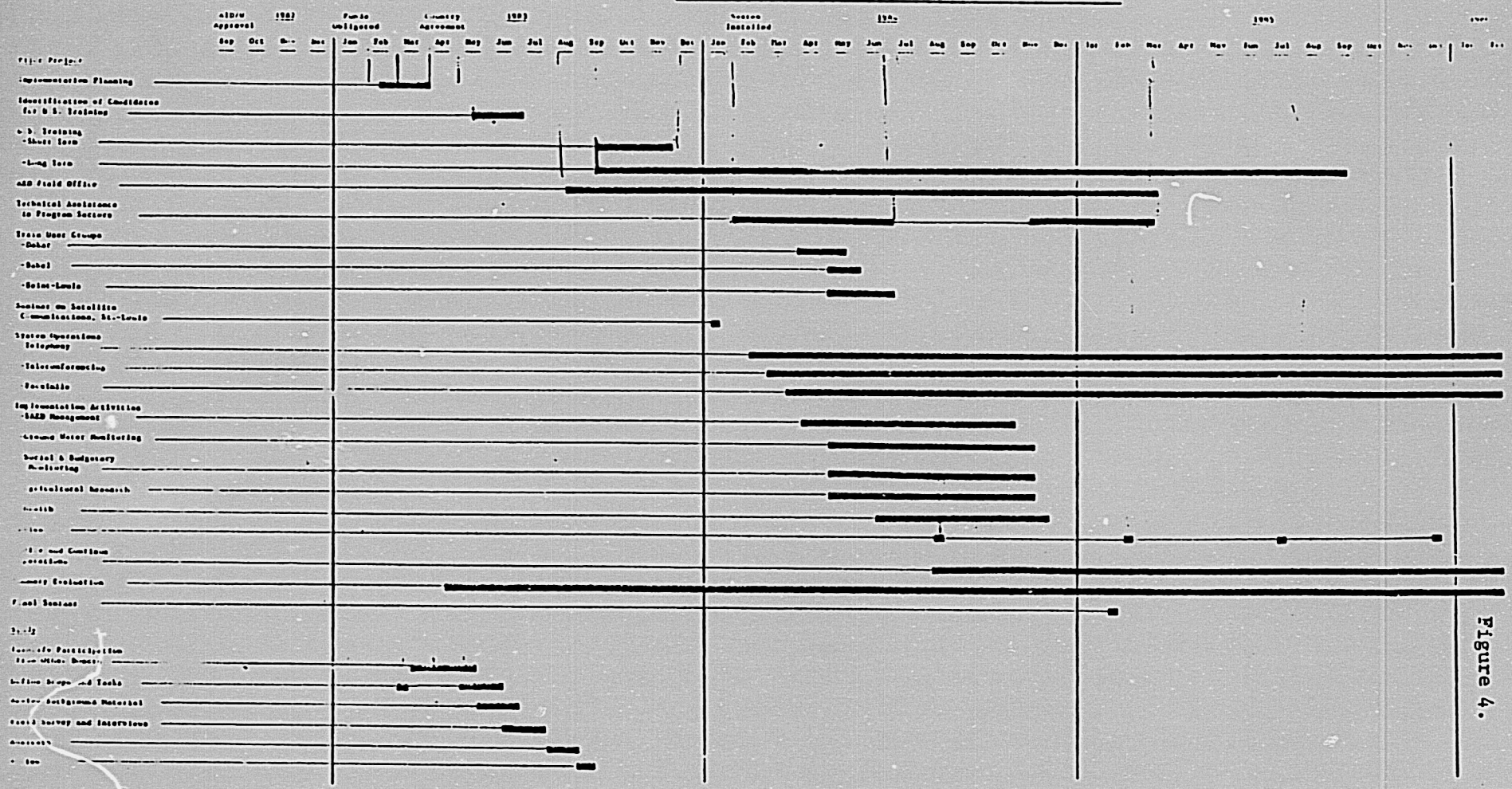
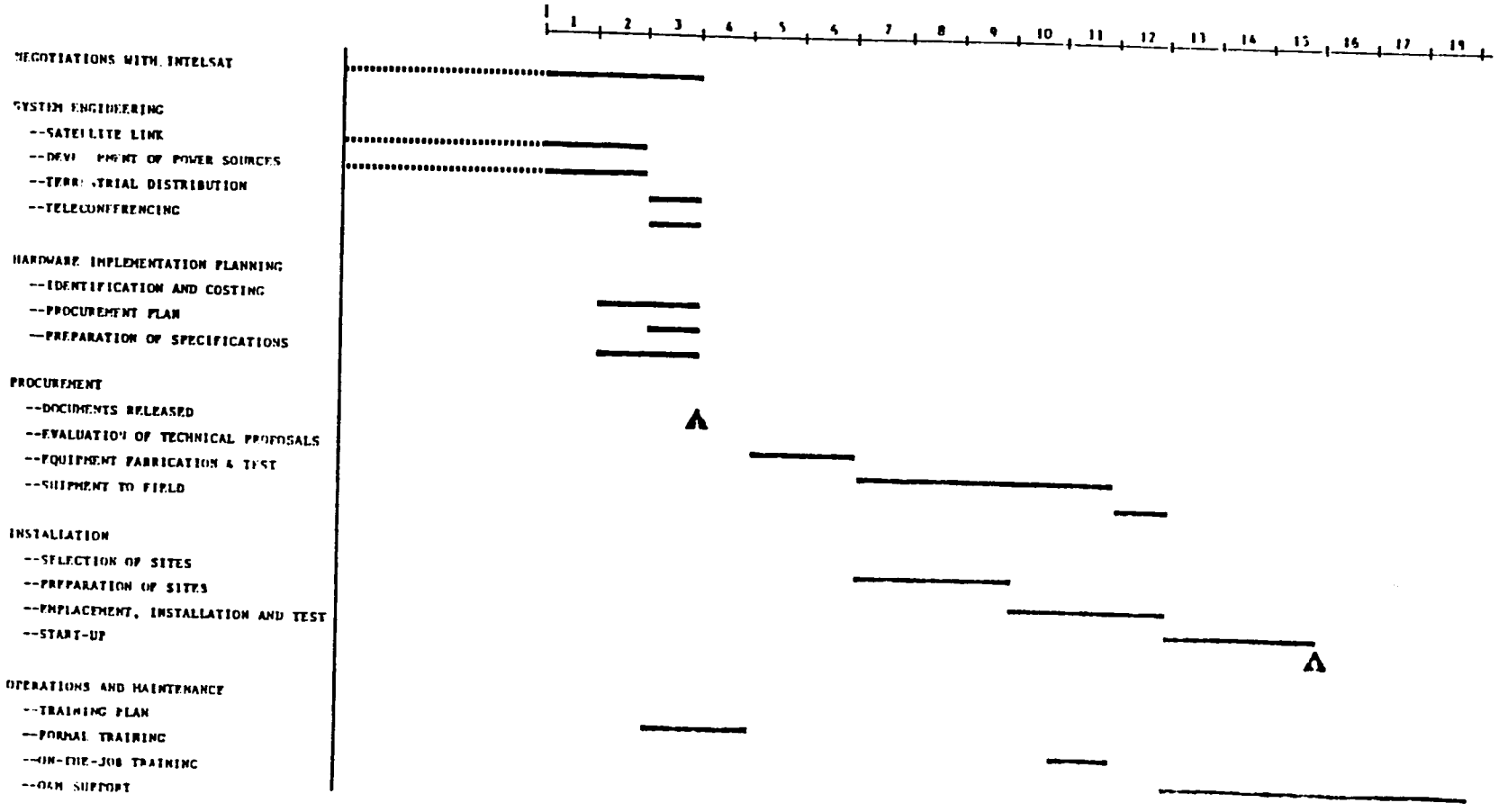



Figure 4.

Figure 5 - PROPOSED SCHEDULE FOR SENEGAL PROJECT HARDWARE



APPENDIX II

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