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on the

CHAD BASIN TELECOMMUNICATIONS STUDY

for the

DEPARTMENT OF STATE

AGENCY FOR

INTERNATIONAL DEVELOPMENT

JUNE 1970

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I. INTRODUCTION

The present Supplementary Report on the Chad Basin Telecommunications Study is sponsored by the United States Agency for International Development, Department of State, at the request of the Chad Basin Commission. The earlier study, under similar auspices, was completed in September 1969 and a Final Report was submitted at that time.

This Supplementary Report is submitted in accordance with the requirements of Task Order No. 2 of the Basic Ordering Agreement Contract AID/csd - 2243 between the Agency for International Development and MORCOM Systems, Inc.

The initial study lead to the conclusion that a troposcatter radio link between Fort Lamy and Maiduguri was the most suitable system in terms of technical and economic feasibility. The present study is concerned with an investigation of the feasibility of a microwave system connecting Fort Foureau in Cameroon with Maiduguri and utilizing the previously proposed Fort Lamy - Fort Foureau cable for access to Chad. This investigation also considered the effect of traffic which might be transmitted between Cameroon and Nigeria and thus enhance the feasibility of the microwave system. In addition to a revised traffic

analysis and a determination of technical requirements, the present investigation has provided new microwave investment cost estimates, new revenue estimates, and amended internal rate-of-return calculations and benefit cost ratios.

Although the scope of work only required consideration of a cable link between Fort Foureau and Fort Lamy, an evaluation was also made of a microwave link for this connection.

In addition, revised troposcatter investment cost estimates were prepared. An amended internal rate-of-return calculation and benefit cost ratios were also developed for a combined tropo system and cable link.

II. CONCLUSIONS AND RECOMMENDATIONS

The following Section summarizes the principal conclusions of each part of the study and recommendations are presented concerning the proposed system alternatives.

1. Traffic Estimates: -- In addition to the estimates of the original study for traffic between Chad - Nigeria and Chad - Cameroon, the present study found that a significant amount of traffic between Cameroon and Nigeria could be expected to transit the proposed microwave system.

Estimates of Cameroon - Nigeria traffic that would transit the proposed microwave system were developed for the period from 1972 through 1980. The estimates of this telephone traffic show an increase from 1,300 calls in 1972 to 12,300 calls in 1980. The telegraph portion of this traffic shows an increase from 1,200 messages in 1972 to 3,100 messages in 1980. The telex calls show an increase from 200 calls in 1972 to 3,000 calls in 1980.

The towns along the proposed microwave route are not expected to generate any significant amount of traffic during the period under consideration. It was also concluded that the amount of intercontinental traffic stimulated by the proposed system would not have any significant revenue effect, since Chad and Cameroon both have existing intercontinental

HF radio circuits which are capable of handling such traffic.

2. Channel Requirements: -- The 12 voice channel requirements of the original study will be adequate to handle the expanded traffic requirements of this study.

3. System Alternatives: -- Two microwave system alternatives were considered for the proposed route. The first would consist of five links between Fort Foureau and Maiduguri with a submarine cable link between Fort Foureau and Fort Lamy. The alternative microwave system would be the same, plus a sixth radio link between Fort Foureau and Fort Lamy. Both systems would connect with the Cameroon Microwave System at Fort Foureau. The third alternative considered consisted of a combined troposcatter and cable system, as discussed in the original report.

4. System Cost Estimates: -- The estimated construction cost of the five-link microwave system with the submarine cable link was $447,000. The alternative six-link microwave system would cost $499,000. The corresponding annual operating costs would be $38,600 and $44,000, respectively. The estimated cost of the troposcatter system with a cable link connecting Fort Lamy and Fort Foureau would be $433,000. The annual operating cost of the tropo-cable system would be $28,100.

5. System Revenues: -- System revenues under expanded traffic conditions include $42,307 of telephone revenues in 1972 increasing to $108,011 in 1980. Telegraph revenues were estimated to decrease from $27,639 in 1972 to $25,835 in 1980. Telex revenue estimates showed an increase from $2,869 in 1972 to $20,724 in 1980.

6. Financial and Economic Analysis: -- Detailed financial analyses were performed on the two microwave system alternatives. The results showed that an internal rate of return of 16.0% could be expected for the five-link microwave system with the submarine cable connection. An internal rate of return of 12.9% was calculated for the six-link microwave system alternative. In addition, an internal rate-of-return of 18.6% was calculated for the combined tropo and cable system.

7. System Implementation Plans and Training: -- The conclusions of the original study with regard to implementation plans and training for the microwave and cable links are considered to remain valid for this study. The same would be true for the troposcatter cable system combination.

8. System Recommendations: -- The choice between the two microwave alternatives considered in this supplementary study reduces to a question of the best means of linking Fort Foureau and Fort Lamy. The

armoured submarine cable has certain technical and operating advantages over a microwave link between these two locations. The cable link would have greater initial channel capacity, including two video pairs for program transmission, and would obviate the need for as much as 24 multiplex channel terminations. The cable link would also be simpler to maintain.

The cable link was also included as part of the amended troposcatter estimates.

The choice between the microwave and troposcatter systems reduces to a question of cost and the practical considerations involved in operation and maintenance.

III. TRAFFIC ANALYSIS

The original Chad Basin study contemplated that the link between Fort Lamy and Maiduguri would provide direct communication between those two cities primarily, and the estimates of traffic were restricted accordingly. In this supplementary study, all of the other possible sources of traffic were reviewed and considered.

1. Traffic Generated in the Towns Along the Microwave Route: -- These towns are small with no present telephone development. During the period to 1980, it is felt that any such development would have no appreciable effect on the overall estimates.

2. Intercontinental Traffic: -- This consists of traffic between Africa and other nations of the world. It is unlikely that the advent of the Fort Lamy - Maiduguri link would stimulate this class of traffic to an extent that would have any significant revenue effect. Both Cameroon and Chad have existing international HF radio circuits which handle voice, telex, and telegraph traffic to major European cities for interconnection with world telecommunication networks. These HF radio circuits have substantially greater capacity than is now being used and should be adequate to handle this type of traffic for a number of years.

3. International African Traffic: -- This consists of traffic between African nations. It appears that a significant contribution would be made

by the proposed microwave system in stimulating traffic between Chad, Cameroon, and Nigeria. At present there is very little of such traffic, except between Chad and Cameroon over the existing Fort Lamy - Douala HF link. Most of the traffic that exists between Chad - Nigeria and Cameroon - Nigeria is transited via Paris and London.

Traffic estimates were developed in the original MORCOM study for the route between Chad and Nigeria. These estimates are retained in the present supplementary study.

The Chad - Cameroon traffic will be primarily attributable to the Cameroon Microwave System now being built. Consequently, this traffic will have very little economic effect on the proposed project. However, nominal traffic figures for this route are included in the estimates of traffic carried between Fort Lamy and Fort Foureau.

The estimates of traffic between Cameroon and Nigeria which would be carried over the proposed system are based on data collected by the Africa Preinvestiment Survey team of the International Telecommunications Union (ITU). This survey was conducted in 1969, and included traffic estimates for 1970, 1975, and 1980. These estimates were for minutes of use per average business day of telephone and telex traffic between Cameroon - Nigeria and Nigeria - Cameroon. Only a part of this traffic could be expected to pass over the proposed microwave system. The

greater part would be routed between Lagos and Douala - Yaoundé over a proposed Cameroon - Nigeria microwave link connecting Calabar (Nigeria) and Buea (Cameroon). It is estimated that this link would have 12 voice channels in 1975 and 60 voice channels in 1980.

The proportion of Cameroon - Nigeria traffic which would be applicable to the Chad Basin microwave system was estimated by drawing a geographic line on the map of Nigeria. This line roughly divided the country into a northern and a southern sector. It was then assumed that traffic from cities north of the line would be routed via Maiduguri and Fort Foureau, while traffic from cities south of the line would be routed via the proposed Calabar - Buea coastal facilities.

The lines in service in the 36 cities north of the dividing line were 25 percent of the total for Nigeria so it is assumed in our estimates that 25 percent of traffic between these cities and cities in Cameroon would pass over the Maiduguri - Fort Foureau route. It was also assumed that the 25 percent figure was applicable to traffic originating in Cameroon. The microwave link from Yaoundé to Fort Foureau is not yet completed and there actually is no telephone development at present in cities along the route. However, from the magnitude of the ITU estimates, it appears that substantial development is anticipated in both Cameroon and Nigeria.

Telex estimates were handled in the same manner as telephone; 25 percent of the ITU estimates interpolated between 1970, 1975 and 1980 on a

straight line basis.

Telegraph traffic data were not collected in detail as were the data for telephone and telex. Only the amounts originating in each African country are shown. In developing our estimates of telegraph traffic, the number of words of Cameroon and Nigeria traffic was converted to messages and compared with total telephone messages in these two countries. For 1970 the ratio of telegraph to telephone messages is shown as 126 percent; in 1975, 45 percent; and in 1980, 17 percent. These percentages were applied to the estimates of Cameroon - Nigeria telephone traffic to obtain the number of telegraph messages, and 25 percent of that number was taken to represent the volume expected to pass over the Fort Foureau - Maiduguri route. The compilation of all traffic estimates is shown in Table 1.

TABLE 1

ESTIMATES OF PROJECTED TRAFFIC GENERATED BY THE FORT LAMY - MAIDUGURI SYSTEM

(Incoming and Outgoing)

	Telephone			Telegraph			Telex		
Year	Chad-Cameroon & Nigeria	Cameroon Nigeria	Total	Chad-Cameroon & Nigeria	Cameroon Nigeria	Total	Chad-Cameroon & Nigeria	Cameroon Nigeria	Total
1972	28,500	1,300	29,800	48,700	1,200	49,900	1,700	200	1,900
1973	31,300	2,000	33,300	47,800	1,600	49,400	2,000	500	2,500
1974	34,200	2,700	36,900	46,200	1,900	47,100	2,400	800	3,200
1975	37,000	3,300	40,300	44,500	2,300	46,800	2,800	1,000	3,800
1976	39.700	5,100	44,800	41,600	2,400	44,000	3,500	1,400	4,900
1977	42,700	6,900	49,600	39,300	2,600	41,900	4,200	1,800	6,000
1978	45,500	8,700	54,200	38,000	2,800	40,800	5,200	2,200	7,400
1979	48,300	10,500	58,800	35,900	3,000	38,900	6,400	2,600	9,000
1980	51,200	12,300	63,500	33,800	3,100	36,900	7,800	3,000	10,800

NOTE: Telephone and telex messages are at the average length of 4.5 minutes as in the initial report.

Telegrams are 15 word messages.

IV. DETERMINATION OF CHANNEL REQUIREMENTS

Channel requirements were computed on essentially the same basis as in the initial study and checked by recourse to the methods recommended for Africa in the ITU study. The original estimates showed a need for slightly more than 9 voice channels, including telex and telegraph requirements. Two channels were added as spares. The additional traffic estimates of this supplementary study raise the channel requirements to 10 voice channels. Allowing two spare voice channels, the original estimate of 12 voice channels is more than adequate to meet the new total of projected traffic requirements.

V. MICROWAVE SYSTEM TECHNICAL REQUIREMENTS

The technical design of the telecommunication system between Fort Lamy and Maiduguri must be adequate to accommodate present and future telephone and message traffic from all tributary sources. The design of modern microwave and multiplex equipment is such that the capacity of the system can be readily increased as the demand for additional services justifies the cost. If the initial equipment configuration is properly selected, future traffic needs can be accommodated without sacrificing the original investment.

Two versions of a microwave telecommunication system between Fort Lamy and Maiduguri will be considered in this report. They differ only in the nature of the connection between Fort Lamy and Fort Foureau. The basic system would consist of a five-link microwave system between Maiduguri and Fort Foureau, with a submarine cable link between Fort Foureau and Fort Lamy. The alternative system would consist of the same five-link microwave system between Maiduguri and Fort Foureau plus a sixth microwave link connecting Fort Foureau and Fort Lamy.

The proposed system would interconnect with the national telecommunication networks of Chad, Cameroon, and Nigeria as shown in

Figure 1.

The microwave system would utilize narrow-band solid state equipment operating in the 2000 MHz band on a non-diversity, non-redundant basis. Diversity or equipment redundancy could be added later. Each station would consist of a single radio transmitter and receiver combination and the necessary voice multiplex and voice-frequency telegraph (VFTG) terminations. The necessary remote monitoring, signalling and order wire equipment would also be provided. The station complement of equipment would include batteries and battery charging equipment, spare equipment racks, antennas and tower, spare parts, and test equipment. The spare equipment racks would be provided to accommodate additional radio equipment if diversity and hot-running standby operation should eventually be desired. The proposed radio equipment would have an ultimate capacity of at least 72 voice channels. The unattended repeater stations would utilize essentially the same radio equipment as the terminals on a baseband back-to-back basis. No multiplex equipment would be provided at the repeater stations, although an order wire or service channel at each station would provide a voice channel for the use of maintenance personnel and any emergency communications. A primary power source would also be provided at each of the repeater stations, as well as alarm equipment which could be monitored at

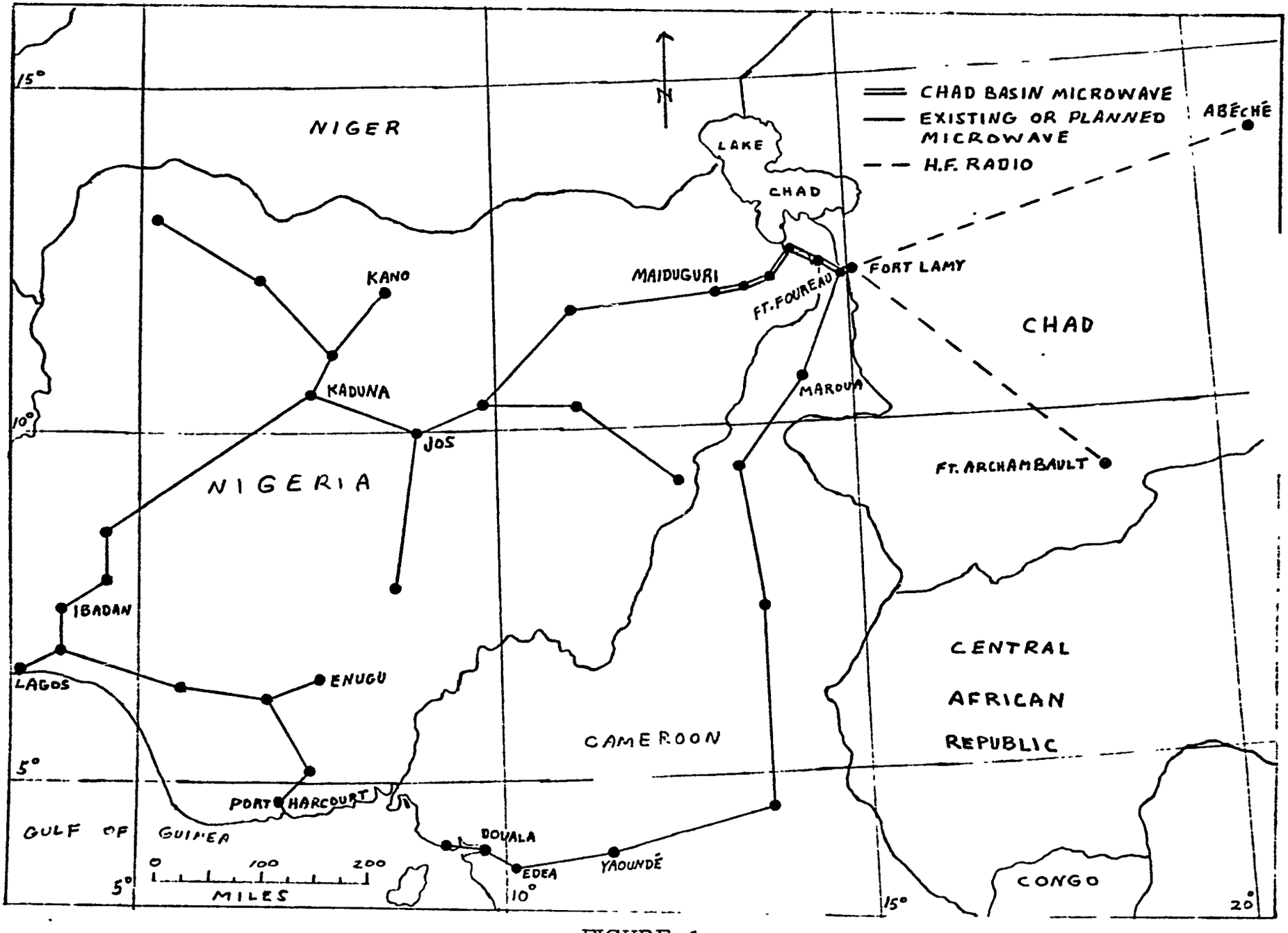

FIGURE 1

PROPOSED CHAD BASIN TELECOMMUNICATIONS SYSTEM WITH INTERCONNECTING ROUTES

the terminal stations.

1. Microwave System with Cable Link: -- A functional block diagram is presented in Figure 2 of the basic microwave system configuration with a cable link. It includes five radio links, two of which are entirely in Nigeria, two are entirely in Cameroon, and one crosses the international boundary between Cameroon and Nigeria. The cable link under the Chari River crosses the international boundary between Cameroon and Chad. The five microwave links average about 30 miles in length. The submarine cable which crosses the Chari River would be less than 2,000 feet long, but additional land cable would connect the shore ends of the submarine cable to the microwave or PTT terminals.

Baseband microwave repeaters are proposed at all of the relay stations. This will make possible an order wire or service channel at each station. Access to the baseband at all stations will also permit the handling of local traffic as it develops in the future.

The proposed microwave radio equipment will be able to accommodate at least 72 voice channels. This capability will provide for the addition of short-haul channels between towns and villages along the route as the need develops.

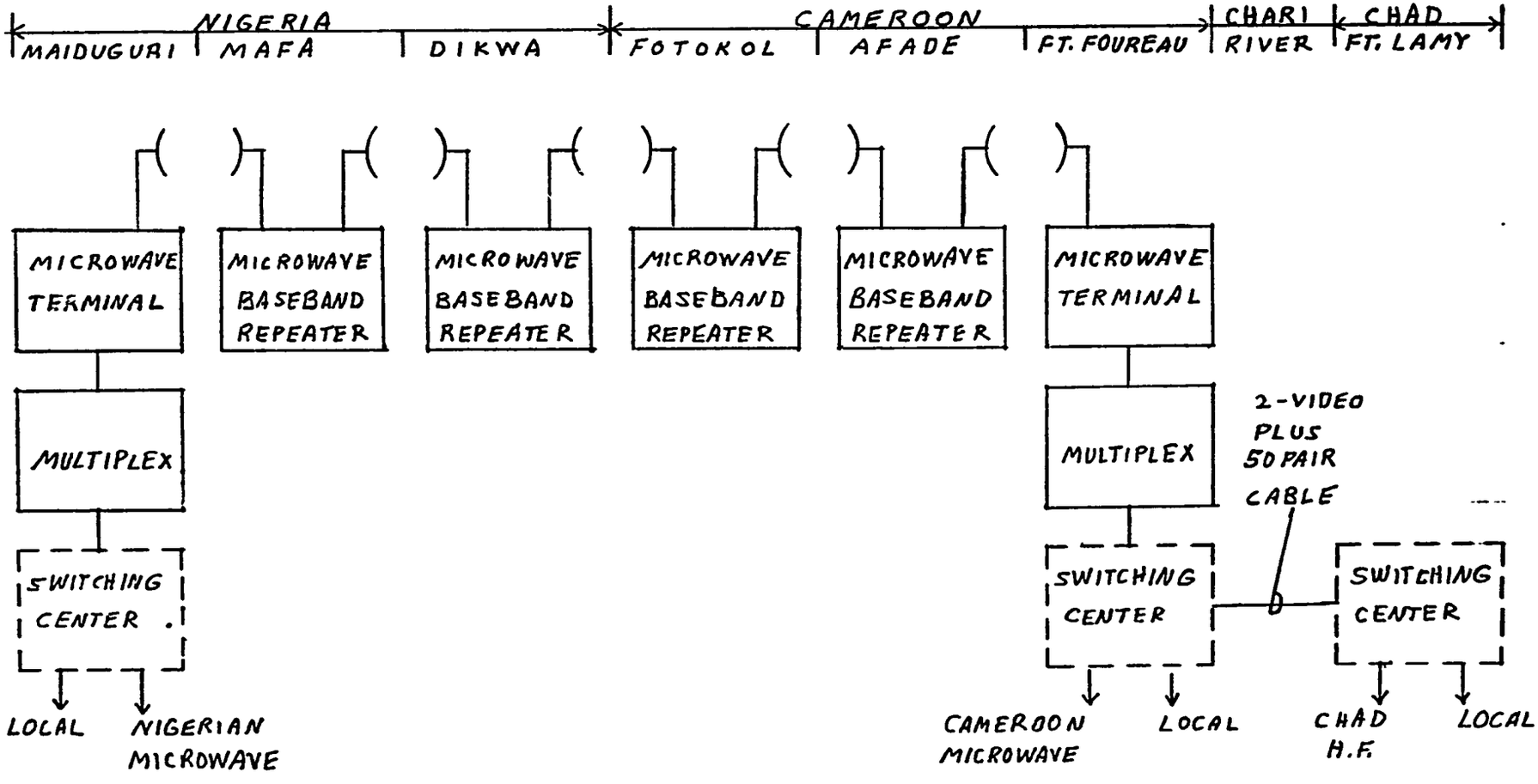

FIGURE 2

BLOCK DIAGRAM OF PROPOSED MICROWAVE SYSTEM

The cable across the Chari River from Fort Foureau to Fort Lamy would be armoured and pressurized. It would contain 50 pairs of No. 22 gage telephone wire and two video pairs. The video pairs would provide transmission capability for television channels that might be made available in the future by means of the Cameroon microwave system. Figure 3 shows the physical features of a typical armoured cable section. The cable should preferably be buried in an underwater trench which can be dug either by a clam-shell scoop or a high pressure water jet. The river current or change in water depth should not present any problems provided the cable is suitably buried in an underwater trench or weighted with ballast on the river bottom. However, the armoured cable should be solidly anchored in concrete bulkheads at each shore end and above the high water level. The cable should be trenched into the water from the bulkheads and the trenching should be protected with riprap or other material on the river bank. Some or all of the available cable pairs, as desired, would then be extended from the shore terminations to the appropriate PTT office or microwave station by conventional overhead or buried cable pairs.

2. Microwave System with Additional Radio Link: -- A functional block diagram of an alternate plan for connecting Maiduguri and

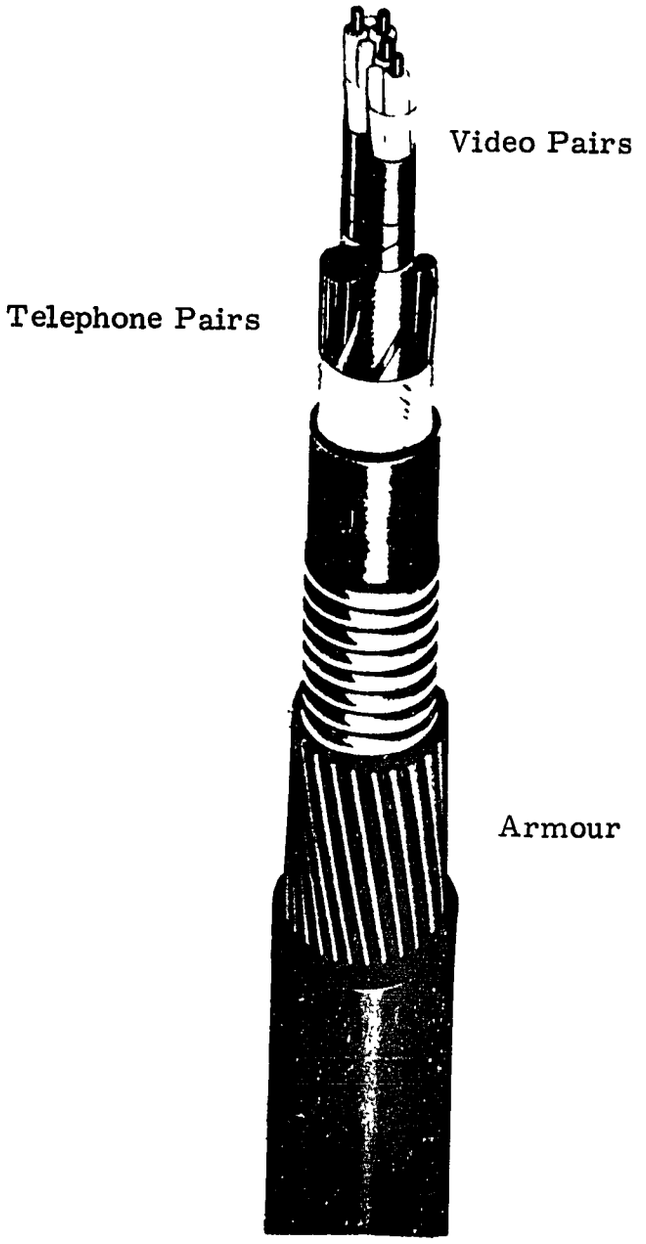

FIGURE 3

TYPICAL ARMOURED CABLE SECTION

Fort Lamy is shown in Figure 4. This system includes the five microwave links proposed in the basic plan already discussed, plus a sixth link in lieu of the cable link between Fort Foureau and Fort Lamy.

3. Microwave System Reliability: -- As indicated in the original MORCOM report on the Chad Basin Telecommunications Study, a single non-diversity, non-redundant radio channel system is considered for reasons of economy. This sacrifice of a certain amount of system reliability is assumed on the grounds that service would be provided over a route where there is now no service at all. However, each station configuration would be planned so that standby or diversity receivers and transmitters could be easily installed as future system requirements dictate.

In the preparation of a detailed engineering analysis of the proposed system, however, full consideration should be given to the system performance to be obtained with and without diversity. Such a consideration will include the particular path propagation conditions, equipment reliability and system maintenance. Standard methods and formulas for treating each of these factors in quantitative terms should be utilized. With respect to path propagation, it will be important to investigate the effects of dust storms (Hamadan), and of

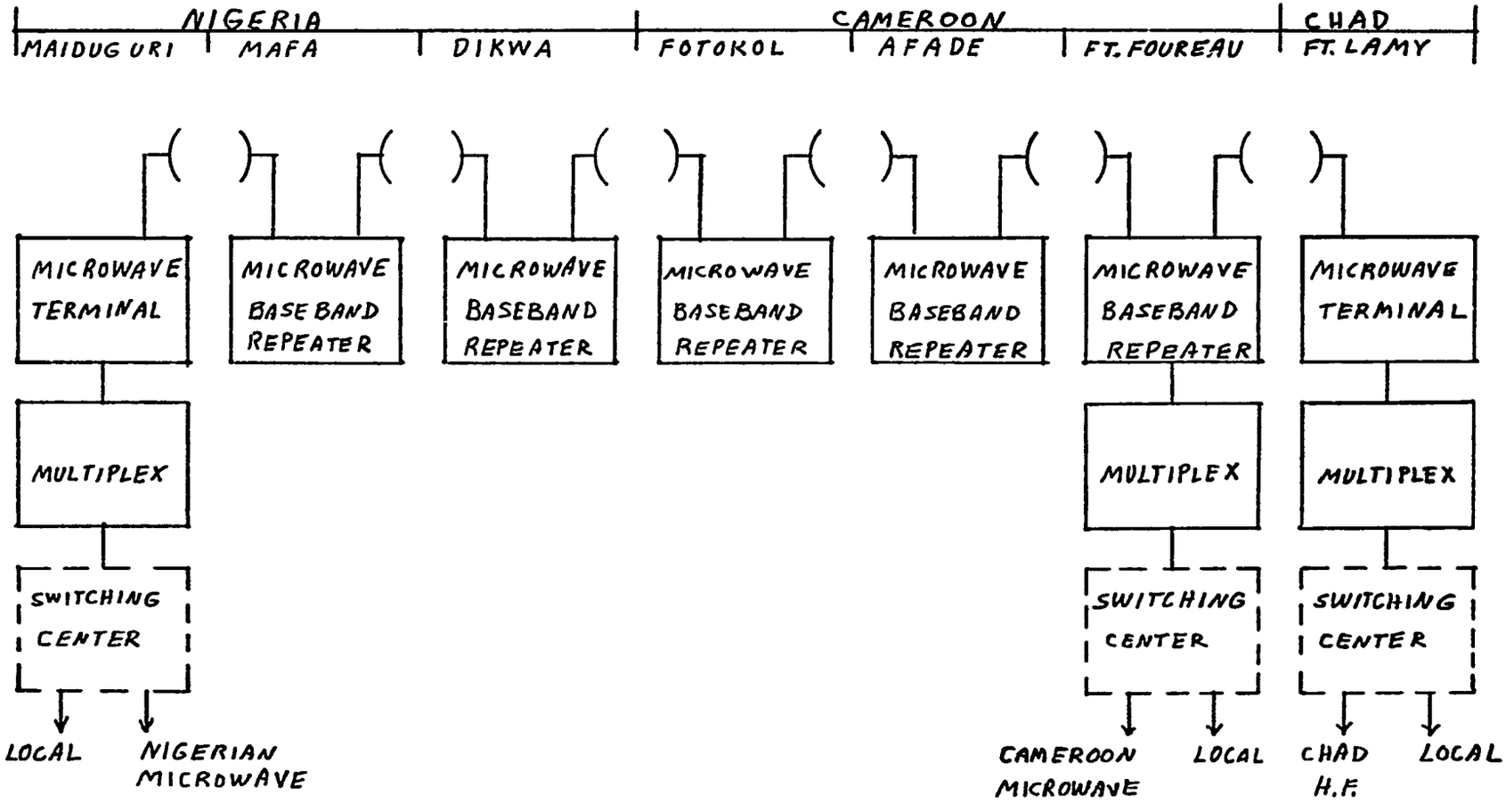

FIGURE 4

BLOCK DIAGRAM OF ALTERNATE MICROWAVE SYSTEM

inversions of atmospheric conditions which produce visible mirages. Both of these factors can affect microwave radio propagation.

The reliability of a communications system depends critically upon the system design. Both the electronic and the power supply equipment are subject to occasional failures, and radio paths are affected by propagation conditions. Good engineering requires that all sources of system failure be assessed for probable failure rates, and that the total time lost be considered against the cost of protection against failure for each system element.

In a tandem link microwave radio circuit, the chances of system outage are multiplied as the number of links increases. If the stations are unattended, as is usually the case for modern microwave routes, an outage continues until the maintenance crew arrives at the faulty station, and locates and corrects the trouble. This may take hours, or even days.

On multi-link microwave routes, protection against such long outages, due to equipment failure, can be provided by installing stand-by microwave equipment, and auxiliary power supplies. If a failure occurs in the operating equipment, a pilot signal is lost, and this triggers an automatic transfer to the stand-by equipment. An alarm signal is also sent in each direction along the route, to identify the location and

type of trouble. Battery power supplies are usually good for periods of 8 to 24 hours, in such emergencies. This method virtually eliminates the possibility of long-term system failures. However, the advantages of a standby system are lost unless the basic system equipment is repaired and restored to service promptly after an outage occurs.

A single troposcatter link avoids the disadvantage of the multiple probability of failure inherent in multi-hop microwave routes. Troposcatter links also must use some standby equipment, operating in the form of dual or quadruple diversity, to overcome the rapid fading inherent in the troposcatter propagation paths. Hence, a troposcatter link, even if only a dual space diversity link (one transmitter with two receivers and two antennas) -- will have some measure of protection against equipment failure.

Propagation fades will sometimes occur in microwave links. This is due to changing meteorological conditions over the radio path. Energy arrives at the receiving antenna over two or more slightly different paths, resulting in alternate enhancement and degradation of the received signal. An effective remedy for this problem is the use of frequency diversity -- that is, two transmitters operating on different frequencies, and transmitting the same messages to two separate receivers, the outputs of which are automatically combined. Deep fades

rarely occur on both frequencies simultaneously.

From the point of view of reliability, the troposcatter system discussed in the original study does provide for a measure of standby protection. However, this protection is on the receiver side only. No standby protection is provided for a transmitter failure. The microwave systems discussed in this report do not provide for standby protection on either the transmitter or receiver side.

4. Voice Channel Multiplex Requirements: -- The functional Block Diagram of Figure 2 which describes the layout of the basic microwave system with a cable link, shows that multiplex equipment is required only at Maiduguri and Fort Foureau. At these locations, the voice channels connect via switching centers to the national telecommunication systems already in operation or under construction.

The revised traffic analysis of Section III shows that the 12 channels of multiplex proposed in the original report should still be adequate to meet the expanded traffic requirements considered in this study.

Figures 5 & 6 show the baseband equipment at the microwave terminal stations. The baseband terminal consists of amplifiers, pads, test and monitoring points, as well as other components required at the interface of the microwave and multiplex equipment. The signalling and line conditioning equipment includes the voice channel

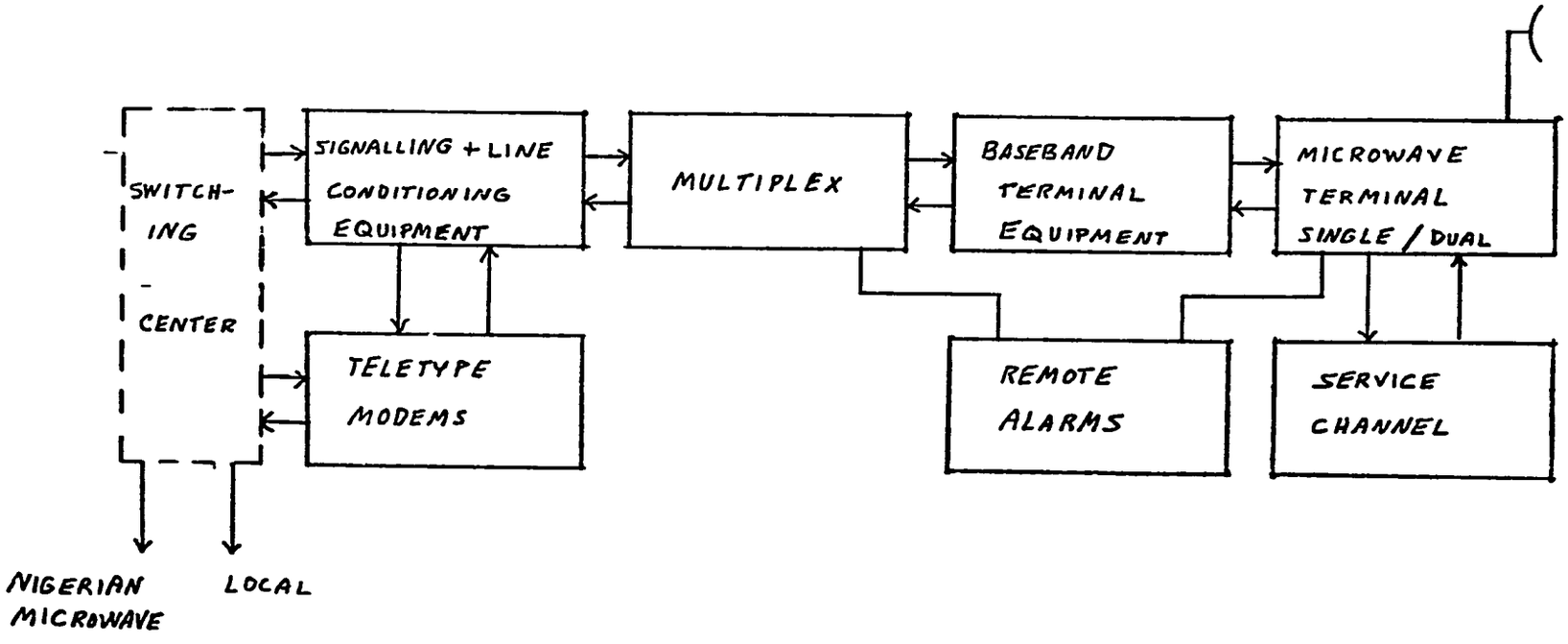

FIGURE 5

BLOCK DIAGRAM OF MAIDUGURI MICROWAVE TERMINAL EQUIPMENT

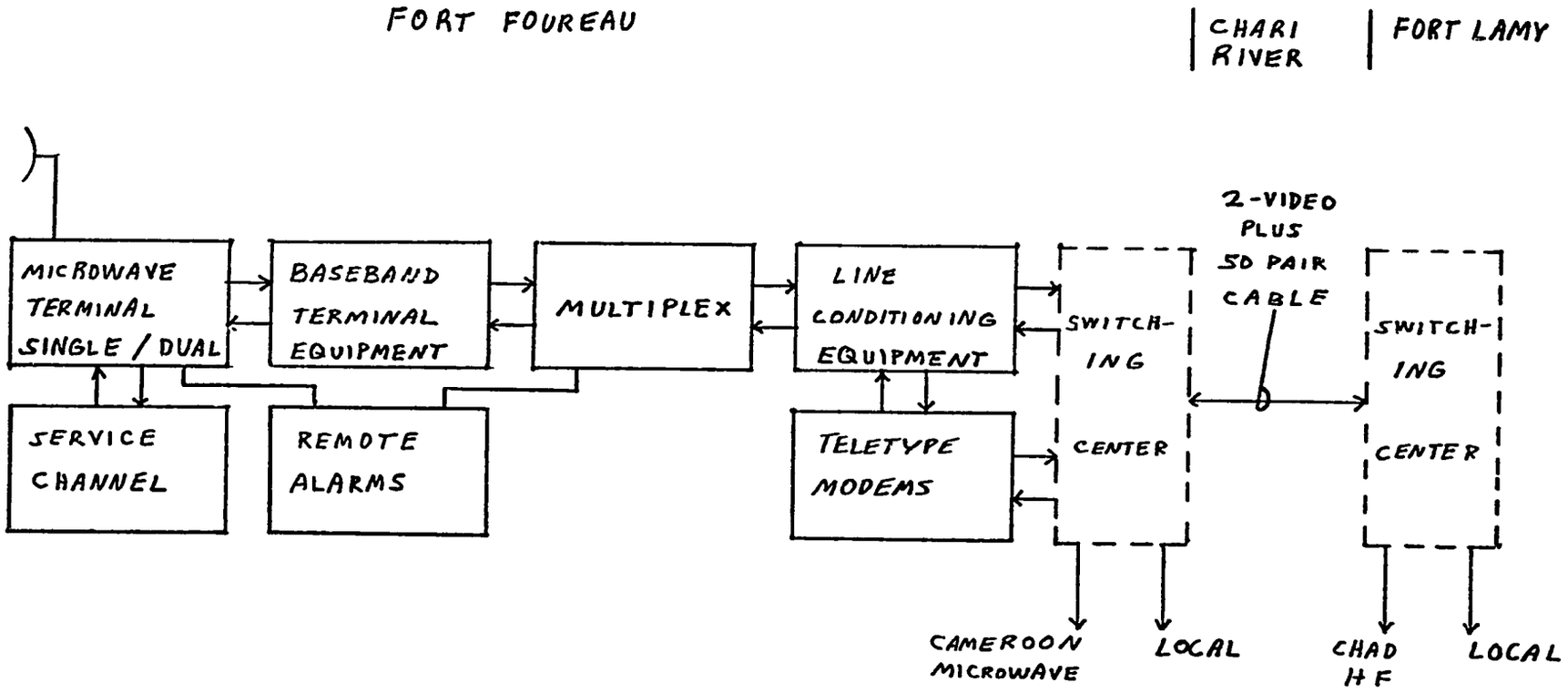

FIGURE 6

BLOCK DIAGRAM OF FO' RT FOUREAU MICROWAVE TERMINAL EQUIPMENT

amplifiers, pads, test jacks, signalling equipment, and 2 wire/4 wire hybrids which are required to process the voice channels for proper interconnection with the adjoining systems of each country. The teletype modems provide the direct current to voice-frequency transformation necessary to couple teletype and telex equipment into the audio frequency voice channels. A single voice channel will accommodate up to 16 teletype circuits operating at speeds of 100 words per minute.

No multiplex equipment is required at Fort Lamy for the Basic Microwave System using a cable link. The 50-pair cable carries the voice and other traffic directly between the switching centers located at Fort Foureau and Fort Lamy. This system plan requires less multiplex and microwave equipment, and provides simpler switching flexibility than the microwave system plan with an additional radio link. The cable also provides for local traffic between Fort Lamy and Fort Foureau without the need for multiplex equipment. The two video pairs included in the 50-pair cable also provide a television channel capability that would not be available with the narrow-band microwave equipment under consideration.

The multiplex requirements at Fort Foureau, for the microwave system plan with an additional radio link, are shown in the functional block diagram of Figure 7. In this plan, the multiplex requirements

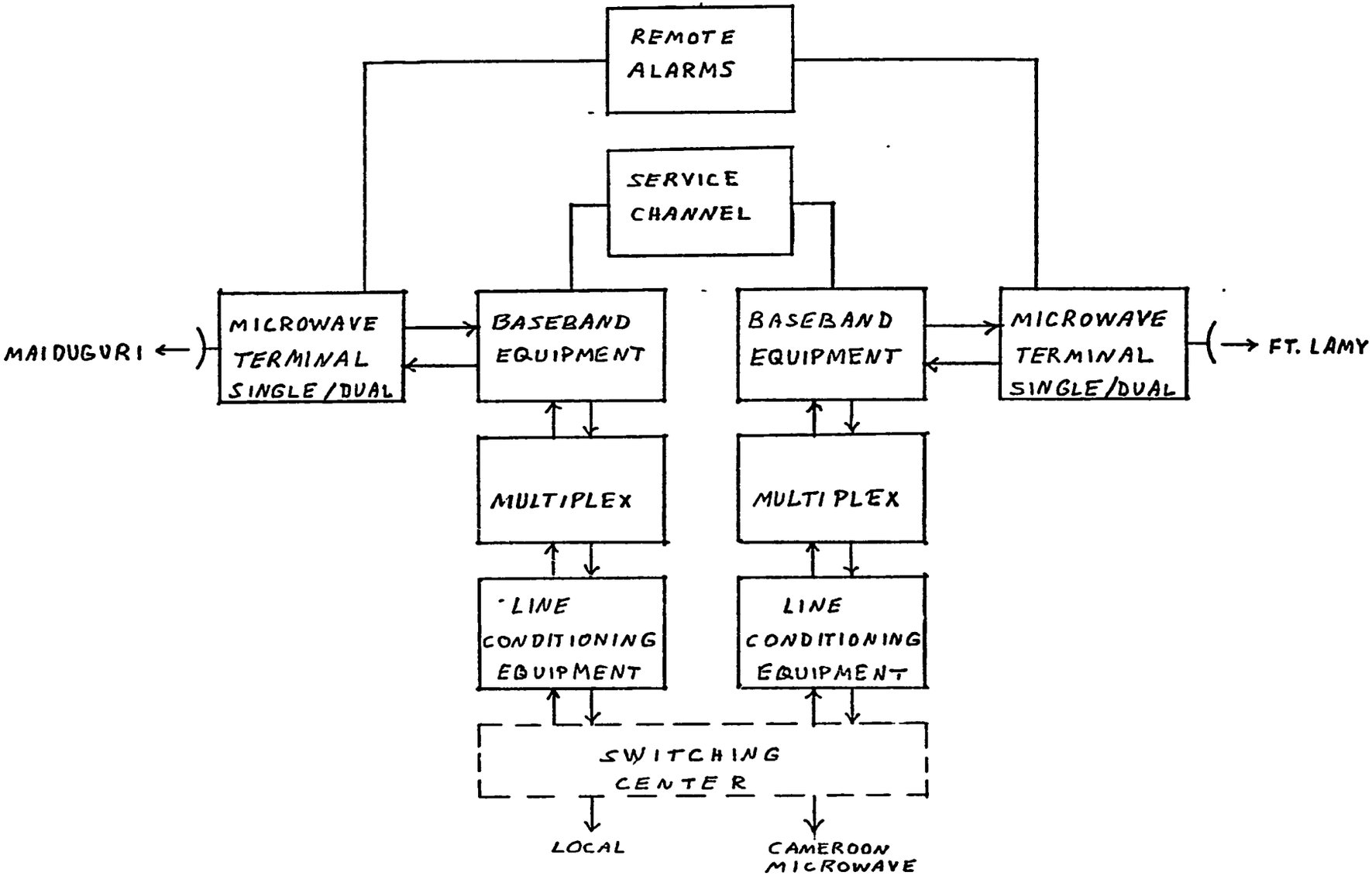

FIGURE 7

BLOCK DIAGRAM OF FORT FOUREAU EQUIPMENT - ALTERNATE PLAN

at this station are double that required by the basic microwave system with a cable link, assuming that all channels are brought down to audio level. It should also be noted that a full complement of multiplex equipment would be required at Fort Lamy if the radio link is used instead of a cable link.

5. Repeater Station Requirements: -- A functional block diagram of the repeater stations proposed for the microwave route is shown in Figure 8. The stations would be located at Mafa and Dikwa in Nigeria, and at Fotokol and Afade in Cameroon. These unattended stations are provided with a remote alarm system which monitors equipment status and reports failures back to the two terminal stations. A service channel telephone would be provided at each repeater to provide a party-line connection with all stations. The remote alarm system and the service channel will function independently of any multiplex equipment.

As local traffic develops along the microwave route, multiplex equipment can be provided at any repeater station, and connected to the microwave baseband as shown in Figure 7 for Fort Foureau.

Since the repeater stations would be unattended, high reliability and low maintenance requirements are important. The electronic equipment should be solid state design as far as possible. Power for operation of the equipment will be provided by batteries, and power for

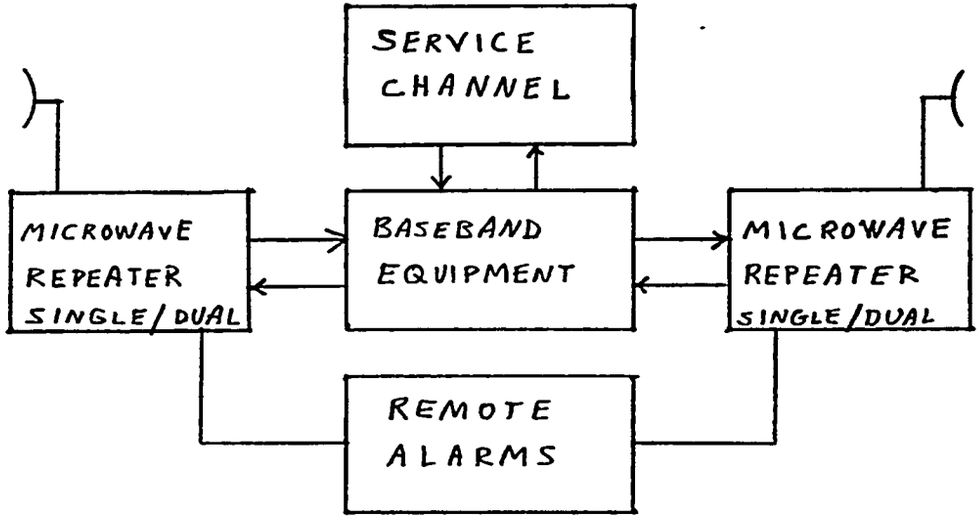

FIGURE 8

BLOCK DIAGRAM OF MICROWAVE REPEATER STATION

battery charging will be obtained by means of a gas-fueled thermoelectric generator. This type of equipment is available for microwave repeater station use, and is designed for mounting in a shelter, or on a pole. The total power consumption of a typical repeater station of the type described above is about 100 watts.

6. Interface Requirements With Other Microwave Systems: - - The proposed microwave system will provide voice channel terminations at Maiduguri, and Fort Foureau. These voice channels will be connected, through local switching centers, with the local telephone systems and the national microwave systems of Nigeria and Cameroon. At Fort Lamy, connections will be made to the local telephone system and to the domestic and international HF radio circuits which terminate there. All of these connections should be made at audio frequencies using single voice channels, in order to provide maximum flexibility. The recommendations of the CCIR and CCITT would be observed in making international voice channel connections. Available information on the Cameroon and Nigerian microwave systems indicate that their interface specifications are consistent with these CCIR and CCITT recommendations.

The interface recommendations for voice channel interconnections are listed as follows:

Voice Frequency Test Tone Levels

	2 Wire Circuits	4 Wire Circuits
Transmit	0 dBm	-16 dBm
Receive (adjustable)	- 2 dBm	+ 7 dBm

Line Impedance (Transmit and Receive)

2 Wire Circuits	4 Wire Circuits
600 or 900 ohms balanced	600 ohms balanced

Channel Frequency Response
300 to 3400 Hz

Channel Frequency Stability
± 1 Hz (using synchronized pilots)

Test Tone Level Stability
± 1 dB per link

Signalling Tone Level
- 20 dBm0

Several signalling options would be available with the line conditioning equipment at each multiplex terminal. The exact interface requirements would depend upon the signalling methods to be chosen. These must be engineered individually.

VI. REVISED INVESTMENT AND OPERATING COSTS

A breakdown of investment and operating costs is presented in this section covering the proposed microwave system between Maiduguri and Fort Foureau, plus the connecting cable link between Fort Lamy and Fort Foureau. A similar cost breakdown is presented for a microwave system which includes an extra link to connect Fort Lamy and Fourt Foureau in place of a cable.

1. Microwave System With Cable Link: -- The proposed microwave system would utilize solid state equipment operating in the 2000-MHz band on a non-diversity and non-hot-running standby basis. The cable link would consist of a 50-pair telephone cable plus two video-pairs, with steel armour for the river-crossing section. The total capital investment for the combined system would amount to $446, 556. The details of this cost estimate are shown in Table 2. The estimate of annual operating costs for the combined system amounts to $38, 600. The details of the operating cost estimate appear in Table 3.

A detailed financial analysis of a telecommunication system connecting Fort Lamy and Maiduguri, and providing an interconnection between Chad - Cameroon, and Cameroon - Nigeria, based on the combined microwave - cable system, is presented in Section VIII.

TABLE 2

MICROWAVE SYSTEM WITH CABLE LINK

INVESTMENT COSTS
(In U. S. Dollars)

Fort Lamy - Maiduguri

Items	Foreign Currency	Local Currency	Total
Radio Terminal Equipment	$ 10,380	$	$ 10,380
Repeaters (4)	41,520		41,520
Voice Freq. Multiplex	24,360		24,360
Order Wire	3,400		3,400
Fault Alarms	8,200		8,200
Antennas & Tower Mounts	9,000		9,000
Wave Guide	7,000		7,000
Towers	48,000		48,000
Batteries & Chargers	21,000		21,000
Cable with 50 - pair #22 gage wire plus two video pairs (11,000 feet unarmoured)	7,700		7,700
Cable with 50 - pair #22 gage wire plus two video pairs (2000 feet armoured)	6,000		6,000
Cable Pressurizing Equipment	600		600
Cable Terminating Equipment	1,200		1,200
Installation, Test & Training	83,600	53,096	136,696
Power Supplies	30,000		30,000
Test Equip. & Spares	15,000		15,000
Buildings		20,000	20,000
Packing & Shipping	21,500		21,500
Engineering	35,000		35,000
TOTAL	$ 373,460	$ 73,096	$ 446,556

TABLE 3

MICROWAVE SYSTEM WITH CABLE LINK

ANNUAL OPERATING COSTS
(In U.S. Dollars)

Fort Lamy - Maiduguri

Item	Foreign Currency	Local Currency	Total
Electronic Spares	$ 8,000	$	$ 8,000
Salaries	-	16,600	16,600
Power	-	3,000	3,000
Building & Maintenance	-	2,000	2,000
Vehicle Operation & Maintenance	-	1,500	1,500
Training	-	4,000	4,000
Traffic Expenses	-	3,500	3,500
TOTAL	$ 8,000	$ 30,600	$38,600

2. Microwave System With Additional Radio Link: -- The alternative to the microwave system with a cable link, would be to provide an additional radio link in place of the cable crossing the Chari River. Cost estimates for this alternative system indicate that a capital investment of $498,866 is required. The details of this estimate are shown in Table 4. The estimate of annual operating costs for this alternate microwave system is $44,000. The details of this estimate are shown in Table 5.

A detailed financial analysis of this microwave system alternative is also included in Section VIII of this report.

3. Troposcatter System With Cable Link: -- The revised cost estimate for the tropo-cable link combination shows that a capital investment for this alternative would amount to $433,000. The details of this estimate are shown in Table 6. The estimate of annual operating costs for this system is $28,100. The details of the estimate are given in Table 7.

A detailed financial analysis of the troposcatter-cable system alternative is included in Section VIII of this report.

TABLE 4

MICROWAVE SYSTEM WITH ADDITIONAL RADIO LINK

INVESTMENT COSTS
(In U.S. Dollars)

Fort Lamy - Maiduguri

Items	Foreign Currency	Local Currency	Total
Radio Terminal Equipment	$ 15,570	$	$ 15,570
Baseband Repeaters (5)	46,710		46,710
Voice Freq. Multiplex	48,720		48,720
Order Wire	4,000		4,000
Fault Alarms	9,000		9,000
Antennas & Tower Mounts	10,800		10,800
Wave Guide	8,400		8,400
Towers	48,000		48,000
Batteries & Chargers	25,500		25,500
Interface Equipment including racks, jack panels, and wiring	7,000		7,000
Total	$223,700	$	$223,700
Installation, Test & Training	95,550	55,616	151,166
Power Supplies	30,000	-	30,000
Test Equipment & Spares	16,500	-	16,500
Buildings	-	22,000	22,000
Packing & Shipping	17,500	-	17,500
Engineering	38,000	-	38,000
Total	$197,550	$ 77,616	$275,166
GRAND TOTAL	$421,250	$ 77,616	$498,866

TABLE 5

MICROWAVE SYSTEM WITH ADDITIONAL RADIO LINK

ANNUAL OPERATING COSTS
(In U.S. Dollars)

Fort Lamy - Maiduguri

Items	Foreign Currency	Local Currency	Total
Electronic Spares	$ 9,500	$ -	$ 9,500
Salaries	-	18,500	18,500
Power	-	3,500	3,500
Building & Maintenance	-	2,500	2,500
Vehicle Operation & Maintenance	-	1,500	1,500
Training	-	5,000	5,000
Traffic Expenses	-	3,500	3,500
Total	$ 9,500	$ 34,500	$44,000

TABLE 6

TROPOSCATTER SYSTEM WITH CABLE LINK

INVESTMENT COSTS
(In U.S. Dollars)

Fort Lamy - Maiduguri

Item	Foreign Currency	Local Currency	Total
Tropo Radio Terminal (2)	$ 61,400		$ 61,400
Voice Freq. Multiplex	24,360		24,360
Order Wire	1,100		1,100
Fault Alarm	1,760		1,760
Parabolic Antennas (4) (30 ft. dia.) with Tower Mounts	78,160		78,160
Wave Guide	5,500		5,500
Cable with 50-pair 22-gage wire plus two videopairs (11,000 ft. unarmoured)	7,700		7,700
Cable with 50-pair 22-gage wire plus two videopairs (2000 ft. armoured)	6,000		6,000
Cable Pressurizing Equipment	600		600
Cable Terminating Equip.	1,200		1,200
Installation, Test & Training	66,300	49,320	115,620
Power Supplies	33,000		33,000
Test Equip. & Spares	15,000		15,000
Building, floor space		20,000	20,000
Packing & Shipping	26,500		26,500
Engineering	35,000		35,000
Total	$ 363,580	$ 69,320	$432,900

TABLE 7

TROPOSCATTER SYSTEM WITH CABLE LINK

ANNUAL OPERATING COSTS
(In U. S. Dollars)

Fort Lamy - Maiduguri

Item	Foreign Currency	Local Currency	Total
Electronic Spares	$ 8,000	$	$ 8,000
Salaries		8,000	8,000
Power		3,000	3,000
Building & Maintenance		1,600	1,600
Vehicle Operation & Maintenance		- -	- -
Training		4,000	4,000
Traffic Expenses		3,500	3,500
Total	$ 8,000	$ 20,100	$ 28,100

VII. DEVELOPMENT OF REVENUES

There are two ways to view the revenues resulting from the introduction of service by the proposed new facility between Fort Lamy and Maiduguri. The first is the economic concept in which estimates of all of the revenues (traffic volumes times rates) from traffic passing over the proposed microwave system are compared with estimates of revenues based on the volumes of traffic transmitted over existing facilities. This increment over present operation is the economic benefit. This is the concept used in determining the internal rate of return.

The second is the accounting concept, in which the new system is considered as an entity entitled only to the portion of revenue which it earns; for example, on a message originating in Kano, Nigeria, passing over the link to Garoua, Cameroon, only a portion of the revenue, presumably based on length of haul, would accrue to the proposed system. This is the concept used in the financial income statement and balance sheet of Section VIII.

The rates and revenue estimates developed in the original study for traffic between Chad and Nigeria are retained in this supplementary report. Similarly, the estimated revenues for the Chad - Cameroon traffic, which were presented in the original study, are also retained. The additional revenues developed in this study are due entirely to traffic between Cameroon and Nigeria which would flow over the proposed microwave

system.

1. Telephone Revenues: -- Revenues are estimated by the application of existing or adjusted rates to the estimates of traffic volumes. The incremental revenues resulting from a new facility compared to existing facilities, in relation to rates and volumes, may be calculated from the formula:

$$I = R_2 (T_1 + X) - R_1 T_1$$

where:

I = Increase in revenues

R_1 = Present rate

R_2 = Proposed rate

T_1 = Present traffic volume

X = Expected increase in traffic

For example, incremental revenue for projected traffic between Nigeria and Cameroon for 1975 over the proposed new microwave system is as follows:

R_1 = \$ 8.82 (existing rate)

R_2 = \$2.80 (proposed new rate)

T_1 = 800 messages

X = 4,200 messages.

$$I = 2.80(800 + 4,200) - 8.82 \ (800)$$

$$= 14,000 - 7,056$$

$$= \$ 6,944$$

The revenues estimates for traffic between Fort Lamy and Maiduguri in the original study were not changed. Since there are no present facilities between these two cities, all of the estimated revenues may be considered incremental and due solely to the availability of the proposed new system. However, traffic over the route between Cameroon and Nigeria would be subject to incremental treatment. Although small in volume, there is actually some such traffic, via other countries but principally France and Great Britain. The following tabulations illustrate the method of estimating the telephone revenue:

Via Proposed System	1970	1975	1980
(a) Messages (3 min.) Cameroon - Nigeria	1,600	20,000	74,000
(b) 25 % - Passing over Microwave System	400	5,000	18,500
(c) Revenue at $2.80 (twice 1.40 for Fort Lamy - Maiduguri)	1,120	14,000	51,800
Via Existing Facilities			
Messages -- Cameroon-Nigeria			
(d) Assume 15% growth per year	1,600	3,200	6,500
(e) 25% - Attributable to proposed system	400	800	1,625
(f) Revenue at 27 gold francs or $8.82	3,528	7,056	14,333
Increment	- 2,408	6,944	29,907

On a straight line basis the estimated revenues by years to 1980 are:

1972	1,332
1973	3,203
1974	5,073
1975	6,944
1976	11,537
1977	16,130
1978	20,723
1979	25,316
1980	29,907

The relatively large estimated increases in traffic volumes projected by the ITU team lead to the conclusion that they had anticipated decreases in rates as the various African expansion projects were realized. Consequently, this was taken into account in applying the formula to determine incremental revenues. A definite effort was made to select rates that were reasonable in comparison with other rates for similar services. For example, it appears reasonable that having selected the rate of $1.40 for a three minute call between Fort Lamy and Maiduguri that calls between points in northern Cameroon and northern Nigeria would be twice that amount -- $2.80. This selection produced incremental revenues that would provide an adequate interim rate of return to support the undertaking but at the same time would appear to be sufficiently reasonable to attract the traffic volumes forecast by the ITU.

In considering the selection of appropriate rates, use was made of the conventional rule that, all other things being equal, a given percentage decrease in rates results in only about half of that percentage decrease in revenues.

2. Telex Revenues: -- Telex revenues were handled in substantially the same manner as telephone. It was assumed that without the improved facility of the Fort Lamy - Maiduguri link these revenues would increase at 15 percent per year, the same as for telephone. This percentage appears to be in line with expectations published in the 1967 Addis Ababa General Plan for the Development of the International Network in Africa. Traffic volumes in 1970 were estimated at 1,400 three-minute calls increasing to 6,000 and 18,000 in 1975 and 1980, respectively. Applying 25 percent to these figures gives the volumes expected over the proposed microwave system. A 15 percent increase per year of traffic over existing facilities, after the 25 percent adjustment, resulted in a figure of 2,800 calls in 1975 and 5,700 calls in 1980. The difference in the number of calls for the corresponding years represents the increment of traffic resulting from the availability of the new system. The present rate is generally 27 gold francs or $8.82 (a gold franc is valued at $.3267) and the proposed rate is the same as for a three-minute telephone call. When these rates were applied to the estimated volumes, the incremental revenue was $7,800 in 1975 and $21,000 in 1980. Intervening years were interpolated on a straight line basis as for telephone.

3. Telegraph Revenues: -- As previously mentioned, no telegraph data comparable to those for telephone and telex were provided by the ITU Survey Report. In order to derive an estimate for telegraph, recourse was had to the relationship between telephone and telegraph volumes. The number of 15-word messages originating in Cameroon and Nigeria was compared with the number of three-minute telephone messages originating in these two countries. The following tabulation shows the development of the revenues.

		1970	1975	1980
(a)	Percent telegraph to telephone traffic	126%	45%	17%
(b)	Telephone messages; Cameroon - Nigeria	1,600	20,000	74,000
(c)	Applicable to northern area 25%, b X 25%	400	5,000	18,500
(d)	Estimated telegraph messages, a X b X 25%	500	2,250	3,145
(e)	Present outlook - no increase	500	500	500
(f)	Revenue based on present volume, $3.90 X e	1,950	1,950	1,950
(g)	Revenue based on expected volume and new rate, $1.42 X d	710	3,195	4,466
(h)	Incremental Revenue	-1,240	1,245	2,516

The assumption is that without the new link, telegraph traffic between Nigeria and Cameroon would remain at the present level. The present rate of $3.90 for a 15-word message is based on the rate of .80 gold francs ($0.26) per word. The proposed rate is $1.42, approximately twice the rate for an interurban telegraph message in Chad. The ITU study points out that "telegraph rates are very complex and cannot be analysed in this study," so that there appears to be no better basis for estimation. The revenues for intervening years were interpolated on a straight-line basis.

VIII. FINANCIAL ANALYSIS AND ECONOMIC FEASIBILITY

This section of the report includes the conventional proforma accounting statements and time profile analyses. The former are simplified by the absence of debt, since it is proposed to finance the project by a direct grant from USAID. This also eliminates the need for a schedule of financing.

1. Financing Analysis: -- The sources and application of funds are shown in Table 8 for the three systems -- five links with a cable under the Chari River; six microwave links; and troposcatter with a cable. Other financial statements are in Tables 9, 10, and 11. Revenue projections are the same for the two systems but investment and operating expenses are somewhat higher for the six-link plan and lower for the troposcatter. No attempt has been made to indicate the disposition of the accumulated cash flow other than to recommend a depreciation fund. (See 3.1)

2. Benefit-Cost Analysis: -- The nature of this type of analysis and the development of internal rates of return are discussed in the original MORCOM Study. The same procedures have been followed in this study. As shown in Tables 12, 13, and 14, the internal rate of return for the five-link system is 16.0 percent; the six-link system is 12.9 percent; and the troposcatter system is 18.6 percent. Table 15 shows benefit-cost ratios over an interest rate range of three percent on either side of the computed internal rate of return.

TABLE 8 (Sheet 1)

SOURCES AND APPLICATION OF FUNDS
(January 1, 1971 to December 31, 1980)

FIVE LINKS WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

Sources of Funds

Net Operating Income	501,034
Cash Generated by Depreciation	254,790
Grant from AID	447,000
	1,202,824

Application of Funds

Construction of Communications Link		
Local Currency	73,000	
Foreign Currency	374,000	
		447,000
Cash Balance (Working Capital)		755,824
		1,202,824

SIX LINKS INCLUDING A LINK CONNECTING FORT LAMY AND FORT FOUREAU

Sources of Funds

Net Operating Income	424,142
Cash Generated by Depreciation	284,427
Grant from AID	499,000
	1,207,569

Application of Funds

Construction of Communications Link		
Local Currency	78,000	
Foreign Currency	421,000	
		499,000
Cash Balance (Working Capital)		708,569
		1,207,569

TABLE 8 (Sheet 2)

SOURCES AND APPLICATION OF FUNDS
(January 1, 1971 to December 31, 1980)

TROPOSCATTER SYSTEM WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

Sources of Funds		
Net Operating Income		600,892
Cash Generated by Depreciation		246,807
Grant from AID		433,000
		1,280,699
Application of Funds		
Local Currency	69,000	
Foreign Currency	364,000	
		433,000
Cash Balance (Working Capital)		847,699
		1,280,699

TABLE 9 (Sheet 1)

FIVE LINKS WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

PROFORMA INCOME STATEMENT AND BALANCE SHEET

INCOME STATEMENT	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Revenues										
Telephone	-	42,307	61,883	68,133	74,381	81,315	87,833	94,559	101,286	108,011
Telegraph	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex	-	2,869	4,530	5,589	6,898	8,675	10,803	13,443	16,700	20,724
Total Revenues	-	72,815	102,489	108,703	115,075	122,387	129,290	136,956	145,414	154,570
Operating Expenses										
Operation & Maintenance	-	27,975	37,400	37,600	37,700	37,900	38,100	38,200	38,400	38,600
Depreciation	-	28,310	28,310	28,310	28,310	28,310	28,310	28,310	28,310	28,310
Total Operating Expenses	-	56,285	65,710	65,910	66,010	66,210	66,410	66,510	66,710	66,910
Net Operating Income	-	16,530	36,770	42,793	49,065	56,177	62,880	70,446	78,704	87,660
Cash Flow	-	44,840	65,089	71,103	77,375	84,487	91,190	98,756	107,014	115,970

TABLE 9 (Sheet 2)

FIVE LINKS WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

PROFORMA INCOME STATEMENT AND BALANCE SHEET

BALANCE SHEET	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Assets										
Plant Investment	447,000	447,000	447,000	447,000	447,000	447,000	447,000	447,000	447,000	447,000
Less: Depreciation Reserve	-	28,310	56,620	84,930	113,240	141,550	169,860	198,170	226,480	254,790
Net Plant Investment	447,000	418,690	390,380	362,070	333,760	305,450	277,140	248,830	220,520	192,210
Cash & Other Current Assets	-	44,840	109,929	181,032	258,407	342,894	434,034	532,840	639,854	755,824
Total Assets	447,000	373,850	500,309	543,102	592,167	648,344	711,174	781,670	860,374	948,034
Liabilities and Equity	447,000	373,850	500,309	543,102	592,167	648,344	711,174	781,670	860,374	948,034

TABLE 10 (Sheet 1)

SIX LINKS INCLUDING A LINK CONNECTING FORT LAMY AND FORT FOUREAU

PROFORMA INCOME STATEMENT AND BALANCE SHEET

INCOME STATEMENT	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Revenues										
Telephone	-	42,307	61,883	68,133	74,381	81,315	87,833	94,559	101,286	108,011
Telegraph	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex	-	2,869	4,530	5,589	6,898	8,675	10,803	13,443	16,700	20,724
Total Revenues	-	72,815	102,489	108,703	115,075	122,387	129,290	136,956	145,414	154,570
Operating Expenses										
Operation & Maintenance	-	32,030	42,800	43,000	43,100	43,300	43,500	43,600	43,800	44,000
Depreciation	-	31,603	31,603	31,603	31,603	31,603	31,603	31,603	31,603	31,603
Total Operating Expenses	-	63,633	74,403	74,603	74,703	74,903	75,103	75,203	75,403	75,603
Net Operating Income	-	9,182	28,086	34,100	40,372	47,484	54,187	61,753	70,011	78,967
Cash Flow	-	40,785	59,689	65,703	71,975	79,087	85,790	93,356	101,614	110,570

TABLE 10 (Sheet 2)

SIX LINKS INCLUDING A LINK CONNECTING FORT LAMY AND FORT FOUREAU

PROFORMA INCOME STATEMENT AND BALANCE SHEET

BALANCE SHEET (December 31)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Assets										
Plant Investment	499,000	499,000	499,000	499,000	499,000	499,000	499,000	499,000	499,000	499,000
Less: Depreciation Reserve	-	31,603	63,206	94,809	126,412	158,015	189,618	221,221	252,824	284,427
Net Plant Investment	499,000	467,397	435,794	404,191	372,588	340,985	309,382	277,779	246,176	214,573
Cash & Other Current Assets	-	40,785	100,474	166,177	238,152	317,239	403,029	496,385	597,999	708,569
Total Assets	499,000	508,272	536,268	570,368	610,740	658,274	712,411	774,164	844,175	923,142
Liabilities and Equity	499,000	508,272	536,268	570,368	610,740	658,274	712,411	774,164	844,175	923,142

TABLE 11 (Sheet 1)

TROPOSCATTER SYSTEM WITH CABLE

PROFORMA INCOME STATEMENT AND BALANCE SHEET

INCOME STATEMENT	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Revenues										
Telephone	-	42,307	61,883	68,133	74,381	81,315	87,833	94,559	101,286	108,011
Telegraph	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex	-	2,869	4,530	5,589	6,898	8,675	10,803	13,443	16,700	20,724
Total Revenues	-	72,815	102,489	108,703	115,075	122,387	129,290	136,956	145,414	154,570
Operating Expenses										
Operation & Maintenance	-	20,100	26,900	27,100	27,200	27,400	27,600	27,700	27,900	28,100
Depreciation	-	27,423	27,423	27,423	27,423	27,423	27,423	27,423	27,423	27,423
Total Operating Expenses	-	47,523	54,323	54,523	54,623	54,823	55,023	55,123	55,323	55,523
Net Operating Income	-	25,292	48,166	54,180	60,452	67,564	74,267	81,833	90,091	99,047
Cash Flow	-	52,715	75,589	81,603	87,875	94,987	101,690	109,256	117,514	126,470

TABLE 11 (Sheet 2)

TROPOSCATTER SYSTEM WITH CABLE

PROFORMA INCOME STATEMENT AND BALANCE SHEET

BALANCE SHEET	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Assets										
Plant Investment	433,000	433,000	433,000	433,000	433,000	433,000	433,000	433,000	433,000	433,000
Less: Depreciation Reserve	-	27,423	54,846	82,269	109,692	137,115	164,538	191,961	219,384	246,807
Net Plant Investment	433,000	405,577	378,154	350,731	323,308	295,885	268,462	241,039	213,616	186,193
Cash & Other Current Assets	-	52,715	128,304	209,907	297,782	392,769	494,459	603,715	721,229	847,699
Total Assets	433,000	458,292	506,458	560,638	621,090	688,654	762,921	844,754	934,845	1,033,892
Liabilities and Equity	433,000	458,292	506,458	560,638	621,090	688,654	762,921	844,754	934,845	1,033,892

TABLE 12

FIVE LINKS WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

TIME PROFILE AND BENEFIT COSTS
(In U. S. Dollars)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
BENEFIT STREAMS										
Telephone Revenues	-	43,406	64,525	72,180	80,110	90,833	101,140	111,656	122,172	132,684
Telegraph Revenues	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex Revenues	-	3,105	5,003	6,298	7,843	10,478	13,465	16,964	21,080	28,963
Residual Value of Property	-	-	-	-	-	-	-	-	-	192,210
TOTAL	-	74,150	105,604	113,459	121,749	133,708	145,259	157,574	170,680	376,692
COST STREAMS										
Capital Costs	447,000									
Operating Costs	-	27,975	37,400	37,600	37,700	37,900	38,100	38,200	38,400	38,600
NET BENEFIT	(447,000)	46,175	68,204	75,859	84,049	95,808	107,159	119,374	132,280	338,092

Internal Rate of Return 16.0%

TABLE 13

SIX LINKS INCLUDING A LINK CONNECTING FORT LAMY AND FORT FOUREAU

TIME PROFILE AND BENEFIT COSTS
(In U. S. Dollars)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
BENEFIT STREAMS										
Telephone Revenues	-	43,406	64,525	72,180	80,110	90,833	101,140	111,656	122,172	132,684
Telegraph Revenues	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex Revenues	-	3,105	5,003	6,298	7,843	10,478	13,465	16,964	21,080	25,963
Residual Value of Property	-	-	-	-	-	-	-	-	-	214,573
TOTAL	-	74,150	105,604	113,459	121,749	133,708	145,259	157,574	170,680	399,055
COST STREAMS										
Capital Costs	499,000									
Operating Costs	-	32,030	42,800	43,000	43,100	43,300	43,500	43,600	43,800	44,000
NET BENEFIT	(499,000)	42,120	62,804	70,459	78,649	90,408	101,759	113,974	126,880	355,055

Internal Rate of Return 12.9%

TABLE 14

TROPOSCATTER SYSTEM WITH CABLE CONNECTING FORT LAMY AND FORT FOUREAU

TIME PROFILE AND BENEFIT COSTS

(In U. S. Dollars)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Benefit Streams										
Telephone Revenues	-	43,406	64,525	72,180	80,110	90,833	101,140	111,656	122,172	132,684
Telegraph Revenues	-	27,639	36,076	34,981	33,796	32,397	30,654	28,954	27,428	25,835
Telex Revenues	-	3,105	5,003	6,298	7,843	10,478	13,465	16,964	21,080	25,963
Residual Value of Property	-	-	-	-	-	-	-	-	-	186,193
Total	-	74,150	105,604	113,459	121,749	133,708	145,259	157,574	170,680	370,675
Cost Streams										
Capital Costs	443,000	-	-	-	-	-	-	-	-	-
Operating Costs	-	20,100	26,900	27,100	27,200	27,400	27,600	27,700	27,900	28,100
Net Benefits	(443,000)	54,050	78,704	86,359	94,549	106,308	117,659	129,847	142,780	342,575

In ternal Rate of Return 18.6%

TABLE 15

BENEFIT - COST RATIOS

FIVE LINKS WITH CABLE CONNECTING FORT LAMY & FORT FOUREAU

Interest Rate	Benefit - Cost Ratio
13%	1.15
14	1.10
15	1.05
16	1.00
* 16.0	1.00
17	.95
18	.90
19	.86
20	.83

SIX LINKS
INCLUDING A LINK CONNECTING FORT LAMY & FORT FOUREAU

Interest Rate	Benefit - Cost Ratio
9%	1.22
10	1.16
11	1.10
12	1.05
* 12.9	1.00
13	.99
14	.94
15	.90
16	.86

TROPOSCATTER
WITH CABLE CONNECTING FORT LAMY & FORT FOUREAU

Interest Rate	Benefit - Cost Ratio
15%	1.18
16	1.13
17	1.08
18	1.03
* 18.6	1.00
19	.98
20	.95
21	.91
22	.87

* Corresponds to internal rate of return.

3. Financial and Revenue Considerations: -- This supplementary study has provoked the opinion that several financial and accounting matters should receive further consideration.

3.1 Depreciation Reserve Fund: -- Inasmuch as the proposed telecommunications system is not the property of any one of the participating nations, but is dedicated to the serving of all of them, a problem arises as to the provision for the restoration of the property at the expiration of its useful service life. It is recommended that the participating nations contribute, periodically, portions of their revenues to an investment fund designed to produce at the end of 15 years an amount sufficient to provide the same or equivalent telecommunications facilities as the original investment. Interest earned by the fund would reduce the amounts of the current contributions. Because of the unsettled questions of ownership, allocations, and responsibilities, it seemed inappropriate to attempt to show such a fund and its corresponding reserve in the balance sheet in this study.

3.2 Division of Revenues and Rates: -- The financing of the proposed system by a direct grant does not alter the need for studies to provide for the disposition of revenues derived from it nor for the allocation of operating expenses. It would appear expedient to study in depth the basis for these allocations as well as the methods of implementation to be employed. The rates used in the estimates in this study should be reviewed. Agreement should be reached on approved schedules which would provide an adequate return and at the same time encourage the use

of the service in the best interest of each nation's economic development. A general discussion of this matter is to be found in the MORCOM "Memorandum of Consideration for a Telecommunications Division of Revenues Plan." It should be realized that any plan designed to produce equitable results requires the collection and analysis of considerable accounting and statistical data as well as engineering studies.

3.3 Financial Arrangements Among the Several Nations: -- At some time before the completion of the project, representatives of the several nations should decide upon uniform methods of operation and accounting, as well as other procedures applicable to the whole system.