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TELECOMMUNICATIONS SURVEY FOR THE AGROMET-HYDROMET PROJECT IN THE SAHEL

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Telecommunications Survey

for the Agromet-Hydromet Project

in the Sahel

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I. BACKGROUND

A. Objective of the Study

The objective of the agrometeorological project is to establish a series of agrometeorological and hydrometeorological stations throughout the seven countries of the Sahel, to collect data from these stations, forwarding it to a regional centre currently being constructed in Niamey, to prepare forecasts and advisories for use by the farmers and herders of the region, and to disseminate these products to the ultimate users throughout the region. For technical and administrative reasons it is assumed necessary to collect data within a country first at the national capital and to forward this data in a second step to the regional centre in Niamey. Data verifications and possibly a small amount of processing will take place in the national capitals prior to forwarding the data to Niamey.

To be effective the data must be acquired, collected and processed in near real-time. To accomplish this objective, a telecommunications network is required to transmit both the raw data to Niamey and to retransmit the forecast products to the field. Within the framework of the entire project, this study is concerned solely with the telecommunications aspects of the system. In particular, this study is concerned with determining the telecommunications system necessary to accomplish the following objectives:

(1) Collect the data for each country at the national capital concerned,

(2) Relay the national data collection to the regional centre in Niamey,

(3) Distribute the forecast products generated in Niamey back to the national capitals, and

(4) Disseminate the forecast products received in the national capitals to appropriate government officials and the ultimate users.

B. Previous Studies

Following the severe drought years in the early 1970's the leaders of the Sahelian countries organised themselves into a regional organisation called CILSS (Comité permanent Inter-état pour la Lutte contre la Secheresse au Sahel). In their first meeting of Chiefs of State and Ministers in September 1973, CILSS resolved to undertake projects to strengthen their agrometeorological and hydrological services on both the national and regional levels. Prompted by these resolutions WMO undertook a study by E. G. Davy, a WMO consultant, to inventory the existing institutional and technical meteorological resources in the Sahel and to enumerate the needs for improvements by external assistance.

In 1974 the United Nations Development Programme (UNDP) agreed to finance a multi-disciplinary mission under the direction of Prof. E. Bernard, a noted Belgian agrometeorologist. Following that mission, UNDP agreed to provide $4.2 million to finance certain portions of the first two years of the programme. In 1975, the National Oceanic and Atmospheric Administration (NOAA), acting as an agent for the Agency for International Development (AID), organized a multi-disciplinary mission to examine the situation in the Sahel, to analyze the requirements necessary to strengthen the agrometeorological and hydrological services in the Sahel, and to suggest U. S. contributions to the programme that might be uniquely suited to the advanced technologies of the U.S. Following that mission, AID indicated an interest in contributing, among other items, the

telecommunications equipment the project required. To determine those requirements AID commissioned the present study in the late spring of 1976.

C. Geography and Economy of the Sahel

The geography and economy of the Sahel have had an influence on the present state of the meteorological and telecommunications systems of the region. A review of the salient facts can provide insight into the development problems to be encountered.

1. Topography

For the most part, the topography of the entire Sahelian zone consists of a featureless plain or plateau. Considering that it is over 4000 kilometres from Dakar to the eastern border of Chad, this is a vast plain indeed. There are only a few substantial features to relieve the monotonous terrain. The first is a series of low lying hills in southwestern Mali which give rise to higher mountains beyond in Guinea. The highest of these within the borders of Mali is approximately 600 metres in height. The second feature of note is the Aïr or Azbine in north central Niger. This area is a series of small massifs interspersed with small groups of mountains, the highest of which is approximately 1900 metres. The main part of the massif lies north of the city of Agadez. The third feature, and by far the most impressive, is the Tibesti Massif in northern Chad. This large geographic feature contains some of the most spectacular mountain ranges and rugged terrain in the entire zone. The Tibesti Massif, however, lies so far north in Chad, in the Sahara, that it lies outside the region of interest for this study.

Thus, in general, line-of-sight communications are not inhibited by inhospitable terrain.

2. River Systems

The Sahel is dominated by three river systems, the Senegal, the Niger, and the rivers flowing into Lake Chad. The Senegal rises in northern Guinea, flows northward through the extreme western corner of Mali and, turning westward, flows to the sea at St. Louis. This river, through its lower course, forms the boundary between Senegal and Mauritania.

The largest river of West Africa, the Niger, also finds its head waters along the Mali-Guinea border and flows northeastward through southern Mali to a large inner delta lying between San and Tombouctou. From this delta, the river turns eastward, then southeastward, flowing through the southwestern corner of Niger, and finally through Nigeria to the Gulf of Guinea.

Lake Chad lies at the intersection of the boundaries of Niger, Chad, Nigeria and Cameroon. Its largest tributary is the Chari which flows northward through the southwestern portion of Chad until reaching Lake Chad just north of the capital city of N'Djamena. Although not saline, Lake Chad has no known outflowing rivers.

Finally, one other river system is of interest, that of the Gambia. The Gambia River begins in northern Guinea, flows northwestward through southern Senegal, and then through the length of the country of The Gambia. As might be expected, most of the hydrological stations in the Sahel deal with these principal river systems and their tributaries.

3. Economy

During the colonial period, Senegal, Mauritania, Mali, Upper Volta, and Niger were all part of French West Africa. Consequently, their economies are relatively closely interlinked, and trade flows east-westward through them with less difficulty than in other directions. Chad, on the other hand, was part of French Equatorial Africa during the colonial period, and as a result, its economic ties lie mostly to the south through the Central African Republic and the Cameroon. As will be shown later, this partially explains the weakness of the telecommunications links between Chad and the rest of the Sahel.

II. CURRENT SITUATION

A. The ASECNA Observing and Telecommunications Network

The only effective meteorological observing and telecommunications network in the region is operated by a regional organisation called ASECNA (Agence pour la Securité de la Navigation Aérienne en Afrique et à Madagascar). This organisation provides air traffic control and aviation meteorological services to air carriers and general aviation throughout the francophone countries of the Sahel, i.e. throughout all countries except The Gambia. The meteorological observing network in each country is linked by high frequency single side band (SSB) voice radio to the capital cities for relay of the collected data and for transmission of forecast products. Considering the environment in which the system operates and the limitations it operates under, the efficiency is remarkably good.

1. The ASECNA Synoptic Station Network

At the present time ASECNA operates a network of 72 synoptic observing stations. Table 1 on the following page contains a list of these stations together with the method of transmission for each. Almost all possess high frequency SSB transceivers. In Senegal, Diourbel, Kolda and Podor are exceptions having only AM radio transceivers. In Mali, Kita, and Bougouni have no radio telecommunications and use the mails. In Chad, budgetary restrictions have resulted in closing several stations to the present level of 12. Further reductions are contemplated.

TABLE 1. ASECNA SYNOPTIC STATIONS

With Mode Of Transmission

SENEGAL	(13 stations)
DAKAR	SSB
Diourbel	AM
Kaolack	SSB
Kédougou	SSB, AM
Kolda	AM
Linguère	SSB
Matam	SSB
Podor	AM
Saint-Louis	SSB
Tambacounda	SSB
Ziguinchor	SSB
Simenti	By letter
Cap Skirring	By letter

MAURITANIA	(12 stations)
NOUAKCHOTT	SSB
Bir Moghrein	SSB
F'Derik	SSB
Nouadhibou	SSB
Atar	SSB
Akjoujt	SSB
Tidjikja	SSB
Boutilimit	SSB
Rosso	SSB
Néma	SSB
Kiffa	SSB
Aïoun el Atrouss	SSB

MALI	(17 stations)
BAMAKO	SSB
Tessalit	SSB
Kidal	SSB
Tombouctou	SSB
Gao	SSB
Nioro du Sahel	SSB
Ménaka	SSB
Kayes	SSB
Mopti	SSB
Kita	By letter
Ségou	SSB
San	SSB
Kenieba	SSB
Koutiala	SSB
Boubouni	By letter
Sikasso	SSB
Hornbori	SSB

UPPER VOLTA	(7 stations)
OUAGADOUGOU	SSB
Dori	SSB
Ouahigouya	SSB
Fada N'Gourma	SSB
Bobo-Dioulasso	SSB
Boromo	SSB
Gaoua	SSB

NIGER	(11 stations)
NIAMEY	SSB
Bilma	SSB
Agades	SSB
Tillabéry	SSB
Tahoua	SSB
N'Guigmi	SSB
Maradi	SSB
Birni-N'Konni	SSB
Zinder	SSB
Maine-Soroa	SSB
Gaya	SSB

CHAD	(12 stations)
N'DJAMENA	SSB
Bol-Berim	SSB
Bousso	SSB
Moundou	SSB
Bokoro	SSB
Pala	SSB
Sarh	SSB
Ati	SSB
Faya-Largeau	SSB
Am-Timan	SSB
Abeché	SSB
Mongo	SSB

2. The ASECNA National Collection SSB Radio Network

In each of the six countries the synoptic data from the outlying stations is collected in the national capital via high frequency single side band transceivers. These transceivers are ususally Thompson (a French manufacturer) 30 watt models equipped with four frequencies. Two of the frequencies are selected for best day-time reception and the other two for best night-time propagation. The transmitter in the national capital is most often a 300 watt unit, frequently the same Thompson 30 watt model equipped with a 10-to-1 linear amplifier. The central station usually employs a large multi-element omni-directional antenna. The outlying transmitters often use simple dipole antennas having good omni-directional properties. Occasionally, a directional rhombic antenna is used.

Electrical power sources are a constant problem throughout the Sahel. Most of the larger synoptic stations are located at airports. In the larger cities central electricity is available, and the airport operates emergency generators for the whole facility. In the smaller airports, the airport will operate the primary generators as well as the emergency units. In the smaller stations not associated with airports, the station will operate diesel generators, both primary and back-up, for the station itself. In almost all cases the generators are Bernhard models (French manufacturer) equipped with over-sized oil impregnated air filters against the sand and dust. The sizes of these generators vary considerably.

Usually all transceivers in a country operate on common frequencies in a single net. The central station polls each outlying station in turn for its observation every three hours. It requires approximately 30 to 40 minutes to poll all stations in the national net for the synoptic observation data. As in any case when extensive coded numeric data is transmitted by voice, success depends upon careful training, good radio discipline, organised logging procedures and patience. Both the outlying station and the central station keep full logs. Operators of outlying stations are trained to record and relay data not received directly at the central post from other outlying stations.

3. The ASECNA Regional Radio Teletypewriter Network

Once the synoptic observations are collected in the national capital, they are keypunched onto paper tape and entered into the regional teletypewriter network for distribution to other capital cities in the region. Figure 1 on the following page displays this regional meteorological teletypewriter network. Certain characteristics of this network should be noted. First, Dakar, Niamey, and Brazzaville are equipped with automated switching centres. An automated switching centre is a telecommunications oriented general purpose digital computer which is connected directly to all incoming and outgoing teletypewriter circuits. Messages received at the centre are automatically fed into the computer where the software determines the addressees for the message from a fixed format block at the beginning of the message, and queues it for retransmission.

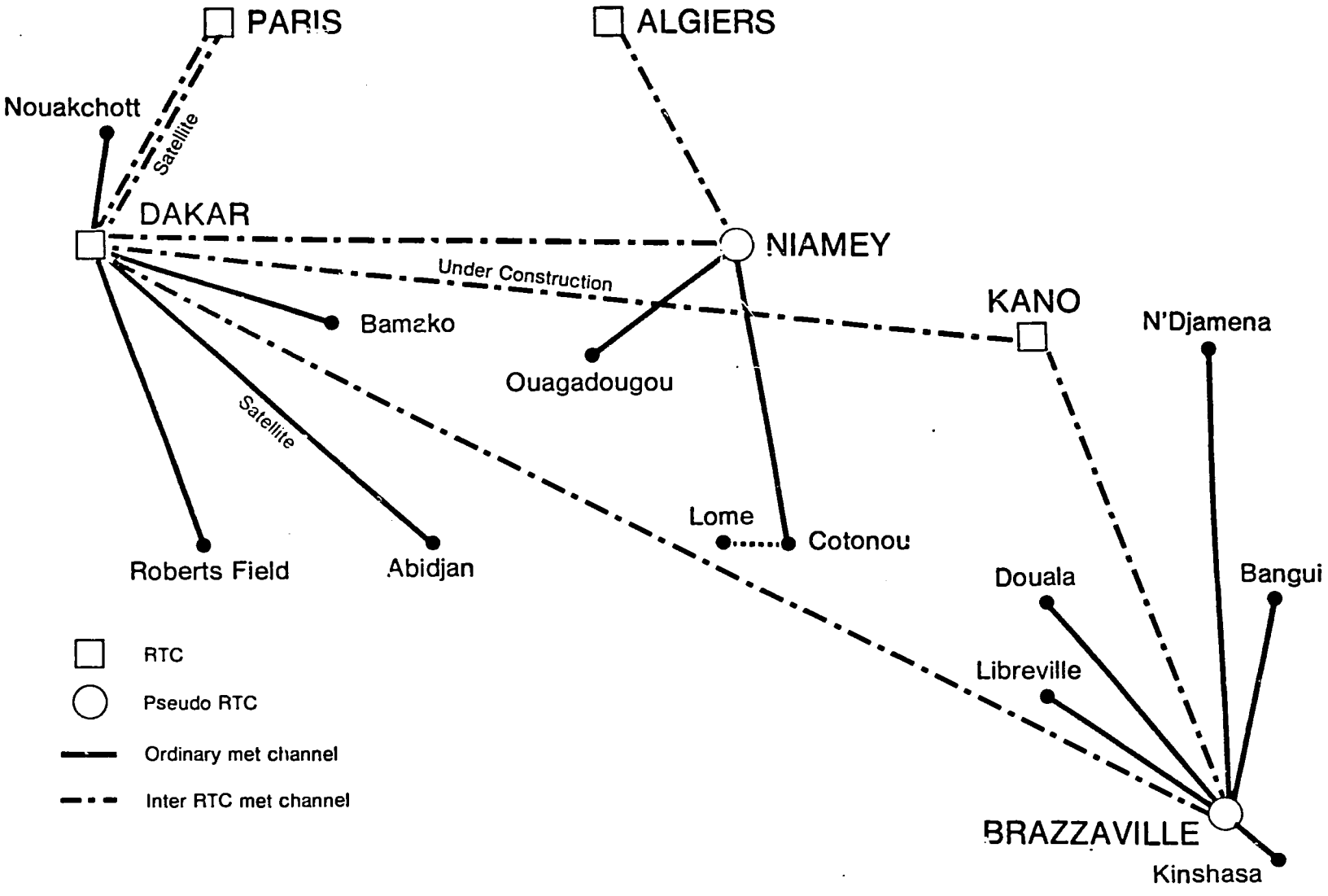

Figure 1. ASECNA Radio Teletypewriter Network

Thus, messages from Ouagadougou to Niamey pass directly to the centre at Niamey, while messages from Dakar, Nouakchott, or Bamako to Niamey pass through both the automated centres at Dakar and Niamey. Communications from N'Djamena to Niamey are more circuitous. The message passes from N'Djamena to the automated centre at Brazzaville, thence to the centre at Dakar and from there to Niamey. The Brazzaville-Dakar link is the weakest radio teletypewriter link in the entire routing with an availability of 85%.

A secondary point-to-point radio teletypewriter circuit does exist between N'Djamena and Niamey. This circuit is manual in nature and not connected to the automated telecommunications equipment in Niamey. It is used principally as back-up to the more circuitous routing which the automated system requires and handles any overload in the primary network. Further, it is used both for air traffic control and meteorological purposes.

A second regional radio teletypewriter network operated by ASECNA handles air traffic control communications including flight plans, air traffic control handoffs, clearances, and NOTAMS. Although logically the meteorological network can be thought of as separated from the air traffic control network, physically and operationally the two are completely integrated for maximum efficiency.

The Dakar-Paris and Dakar-Abdijan links are accomplished by satellite relay with highly satisfactory and reliable results. All other links are accomplished using high power high frequency radio communications with the usual redundancy coding and error detection and correction protocols. These links

operate with satisfactory quality but with only mediocre to moderate reliability. As in the case of the voice HF radio, transmission at night and especially during the pre-dawn hours is particularly unreliable.

4. The Gambian Situation

The Gambia is an anglophone country, and consequently, ASECNA does not operate there. The country has only one commercial airport, Yundum Airport, which is operated under contract to a British firm, A. I. L. In spite of the small size of the country, The Gambia operates five synoptic stations as follows:

Station	Communications
Banjul/Yundum	Radio
Banjul/Half Die	Telephone
Georgetown	Post Office/Telegraph
Basse	Post Office/Telegraph
Jenoi	Post Office/Telegraph

Only the station at Yundum makes observations round-the-clock, and only it is equipped with radio communications to other points in the region.

Even for the Banjul/Yundum station communications with Dakar is difficult, arduous, and often impossible. For air traffic control and meteorological purposes Banjul communicates by CW (morse code) radio to Freetown, from there to Roberts Field, Monrovia by voice radio and from there via ASECNA's HF radio teletypewriter circuit to Dakar. Occasionally, the air-to-ground voice radio channels are informally used to communicate directly between Dakar and Banjul.

At the present time a microwave link exists between Kaolack and Dakar, operated by the Senegalese Post Office. A similar microwave link is being installed between Banjul and Kaolack through assistance of UNDP and the International Telecommunications Union (ITU). This should considerably improve communications between Banjul and Dakar.

B. The Hydrological Network

Most of the hydrological stations in the Sahel have been installed under a contract with ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer). In several of the countries the installation of the observing stations has proceeded quite far. In others it has barely begun. Hence, the status of the network varies considerably from country to country. None of the hydrological stations installed by ORSTOM are equipped with telecommunications at this time.

1. Mauritania

In Mauritania a programme by WMO to install a network of hydrological stations has not yet begun. A small number of voluntary hydrological stations mostly in the south of the country along the Senegal River and its tributaries is all that currently exists.

2. Senegal

An ORSTOM project team has installed or is in the process of installing a network of 45 stations, river gauges, and recording river gauges, throughout the

southern portion of the country and along the Senegal River and its tributaries to the north. Table 2 on the following page lists those stations programmed for this network. These stations cover the Casamance, Gambia and Senegal River basins.

3. Mali

Mali has had a series of hydrological stations equipped with telecommunications, since the period of Mali/Guinea Flood Forecasting Project instituted by WMO in 1971. Although some of these stations have been decommissioned, a number remain operational. In addition, ORSTOM has currently a project team in Mali in the processs of installing approximately 30 additional river gauges and recording river gauges. Most of these stations are located in the south and southwestern parts of the country. Most of the stations are located in the upper Niger River basin. Some are located in the extreme western part of the country in the upper Senegal River Basin.

4. Upper Volta

Upper Volta already has an extensive collection of hydrological stations unequipped with telecommunications in its national network. ORSTOM is in the process of augmenting their number, improving the siting of others, and renovating the equipment for still others. At the end of 1975, the network numbered 51 stations as shown in Table 3 on page 16.

TABLE 2. HYDROLOGICAL STATIONS IN SENEGAL

Station	Equipment
Bakel	River Gauge
Matam	River Gauge
Kaédi	River Gauge
Saldé	River Gauge
Ngoui	River Gauge
Podor	River Gauge
Guédé	River Gauge
Dagana	River Gauge
Richard-Toll/Senegal	River Gauge
Rosso	River Gauge
Saint Louis	Recording River Gauge
Gourbassi	River Gauge
Richard-Toll/Guiers	River Gauge
Lac de Guiers	Recording River Gauge
Kédougou	Recording River Gauge
Mako	River Gauge
Simenti	River Gauge
Wassadou Amont	River Gauge
Wassadou Aval	Recording River Gauge
Fass	River Gauge
Gouloumbo	Recording River Gauge
Guenoto	River Gauge
Niokola Koba	River Gauge
Pont du Nieriko	River Gauge
Niaoula Tanou	River Gauge
Sintiou Maleme	River Gauge
Maka	River Gauge
Koussanar	River Gauge
Pont du Tiokoye	Recording River Gauge
Pont du Diarha	Recording River Gauge
Parc	Recording River Gauge
Missira Gonasse	River Gauge
Santhia Coundara	River Gauge
Fafakourou	Recording River Gauge
Kolda-Main	Recording River Gauge
Ziguinchor	Recording River Gauge
Dabo	Recording River Gauge
Koumbakara	Recording River Gauge
[illegible]a-Trib	Recording River Gauge
Koun-Kané-1	River Gauge
Koun-Kané-2	River Gauge
Sindia	Recording River Gauge
Diourbel	Recording River Gauge
Birkelane	Recording River Gauge

TABLE 3. HYDROLOGICAL STATIONS IN UPPER VOLTA

Station	River	Equipment
Folonzo	Comoé	River Gauge
Diarabakoko	Comoé	Recording River Gauge
Karfiguela	Comoé	Recording River Gauge
Yendere	Leraba	River Gauge
Douna	Leraba	Recording River Gauge
Tin Akof	Beli	River Gauge
Koriziena	Gorouol	Recording River Gauge
Yakouta	Goudebo	Recording River Gauge
Bossegal	Sirba	Recording River Gauge
Bilanga	Sirba	Recording River Gauge
Liptougou	Faga	Recording River Gauge
Manni	Manni	Recording River Gauge
Niaogho	White Volta	River Gauge
Wayen	White Volta	Recording River Gauge
Yilou	White Volta	Recording River Gauge
Bittou	Nouhao	Recording River Gauge
Tagou	Kompienga	Recording River Gauge
Arly	Doudodo	Recording River Gauge
Nobéré	Red Volta	Recording River Gauge
Sakeinee	Red Volta	Recording River Gauge
Nebou	Sissili	Recording River Gauge
Dapola	Black Volta	Recording River Gauge
Ouessa	Black Volta	Recording River Gauge
Boromo	Black Volta	Recording River Gauge
Manumenso	Black Volta	River Gauge
Confluent	Black Volta	River Gauge
N'Wokuy	Black Volta	Recording River Gauge
Samandeni	Black Volta	Recording River Gauge
Banzo	Black Volta	Recording River Gauge
Batié	Bambassou	Recording River Gauge
Diébougou	Bougouriba	Recording River Gauge
Dan	Bougouriba	Recording River Gauge
Ninion	Vransso	Recording River Gauge
Leri	Sourou	River Gauge
Gouran	Sourou	River Gauge
Bourasso	Voun Hou	Recording River Gauge
Nasso	Kou	Recording River Gauge
Bagré	White Volta	Recording River Gauge
Yakala	White Volta	Recording River Gauge
Noumbiel	Black Volta	Recording River Gauge
Upper Reaches	Comoe	River Gauge
Bissiga	White Volta	Recording River Gauge
Gonse	Massili	Recording River Gauge
Dakaye	Red Volta	Recording River Gauge
Tenado	Black Volta	River Gauge
Niompourou	Black Volta	Recording River Gauge
Guena	Black Volta	Recording River Gauge
Pa	Grand Bale	River Gauge
Digouera	Plandi	Recording River Gauge
Kongoussi	Lake Bam	?

5. Niger

A similar situation exists in Niger. To the network of existing stations, ORSTOM is adding a number of new stations and upgrading certain of the existing stations. This is being done under a contract associated with the present project. At the end of 1975, a network of 27 hydrological stations exists, which are listed in Table 4 on the following page.

6. Chad

Chad also has been served by an ORSTOM team operating under contract to install and maintain a network of stations. At the end of 1975 Chad had a network of approximately 54 hydrological stations, most of them simple river gauges but a few possessing automatic recorders. Table 5 on page 19 contains a list of these stations.

7. The Gambia

Hydrological assistance to The Gambia is being provided directly through WMO rather than by means of a sub-contract with ORSTOM. Unfortunately, the WMO expert has not been in place as long as many of the ORSTOM teams in the other countries. Consequently, the development of the hydrological network is not as far advanced as in some of the other countries. The ultimate network will consist of 16 stations. Table 6 on page 20 depicts that planned network.

TABLE 4. HYDROLOGICAL STATIONS IN NIGER

Station	River	Equipment
Dolbel	Gorouol	River Gauge
Alcongui	Gorouol	River Gauge
Tillabéry	Niger	River Gauge
Téra	Dargol	River Gauge
Kakassi	Dargol	River Gauge
Garbé-Kourou	Sirba	Recording River Gauge
Niamey	Niger	River Gauge
Say	Niger	River Gauge
Diongoré	Goroubi	Recording River Gauge
Tamou	Diamangou	Recording River Gauge
Station W	Tapoa	Recording River Gauge
Barou	Mékrou	Recording River Gauge
Malanville	Niger	River Gauge
Birni N'Konni	Maggia	River Gauge
Tiérassa	Maggia	Recording River Gauge
Tsernaoua	Maggia	Recording River Gauge
Badiguichéri	Kori de Badiguichéri	Recording River Gauge
Baga	Zourourou	Recording River Gauge
Keita	Zourourou	Recording River Gauge
Guidan Roumji	Goulbi de Maradi	River Gauge
Madarounfa-pont	Goulbi de Maradi	Recording River Gauge
Nielloua	Goulbi deMaradi	Recording River Gauge
Bargaya	Goulbi de Gabi	Recording River Gauge
Koutchika	Korama	Recording River Gauge
Bagara	Komadougou Yobe	River Gauge
Gueskérou	Komadougou Yobe	River Gauge
N'Guigmi	Lake Chad	Recording River Gauge

TABLE 5. HYDROLOGICAL STATIONS IN CHAD

Station	River
Am Timan	Bahr Azoum
Baltimba	Bahr Ko
Boum Kebir	Lake Iro
Bousso	Chari
Chagoua Bridge	Chari
Djimtilo	Chari
Golongosso (R.C.A.)	Aouk
Koukou Angarana	Bahr Azoum
Kyabé	Bahr Keita
Mailao	Chari
Manda	Bahr Sara
Markounda (R.C.A.)	Nana Barya
Massénya	Bahr Erguig
Moissala	Bahr Sara
Naraganba	Petit Mandoul
N'Djamena T.P.	Chari
Sarh	Chari
Tarangara	Bahr Salamat
Argao	Nya
Baibokoum	Logone
Bebouladje (R.C.A.)	Pendé
Bologo	Tandjile
Bongor	Logone
Doba Cotontchad	Pendé
Eré	Logone
Goré	Pende
Katoa	Logone
Koumi	Logone
Lai	Logone
Logone Birni (Cam.)	Logone
Logone Gana	Logone
M'Bere (R.C.A.)	M'Bere
Moundou (Bridge)	Logone
Ouli Bangala	Lim
Tchoa	Tandjile
Deressia (Marou)	Ba Illi
Moulkou	Ba Illi (North)
Bol Dune	Lake Chad
Bol Berim	Lake Chad
Fotokol (Cameroon)	El Beid
Tildé (Cameroon)	El Beid
Am Dam	Batha
Am Guéréda	Batha
Ati	Batha
Delep	Melmelé
Oum Hadjer	Batha
Yao	Lake Fitri
Fianga	Lake Fianga
Gounou Gaya	Kabia
Léré	Lake Léré
M'Bourao	Mayo Kebbi
Patalao	Kabia
Pont Carol	Kabia
Tikem	Lake Tikem

TABLE 6. PLANNED HYDROLOGICAL NETWORKS IN THE GAMBIA

Station	River	Equipment
Banjul	Gambia	Recording River Gauge
Kemoto	Gambia	Recording River Gauge
Brument Bridge	Bintang	Recording River Gauge
Baligmo	Gambia	Recording River Gauge
Kaur	Gambia	Recording River Gauge
Pakaliba	Sofaniama	Recording River Gauge
Carrol's Wharf	Gambia	River Gauge
Kuntaur	Gambia	Recording River Gauge
Georgetown	Gambia	Recording River Gauge
Bansang	Gambia	River Gauge
Demba Wanda	Sandougou	River Gauge
Diabugu	Gambia	Recording River Gauge
Basse	Gambia	Recording River Gauge
Chambois Bridge	Prufu	River Gauge
Sudowol Bridge	Sima	River Gauge
Fatoto	Gambia	River Gauge

The Gambia's hydrological situation is unusual in one respect. Most of the upper reaches of the Gambian basin lie in Senegal. Thus, The Gambia is highly dependent upon Senegalese hydrological data on the upper Gambia to achieve reasonable forecasting capability on the river in its own territory.

C. Electrical Power Sources

In general, every locality which has commercial electricity available uses the European standard, i.e. 220 volts, 50 hertz. Table 7 on the following page presents a list of the major cities of each of the seven countries which have commercial electricity to these specifications. However, this table does not present the full picture. First, the variability of the power sources is incredible by American or European standards. The voltage levels in some places have been known to vary from 150 volts to 280 volts. Frequency has been known to vary from 40 to 58 hertz. Much electronic equipment will not operate under such variations. Most motor driven mechanical equipment will have its service lifetime dramatically reduced under such circumstances. This assertion is borne out by actual observations in the Sahel.

Additionally, there are cities which are nominally supposed to have commercial electricity, but the electricity is available only a portion of the day. This occurs even in the larger cities where electrification has outstripped the ability of the power stations to supply the electricity. The solution is novel: A portion of the city is blacked out, and the blacked out portion is rotated from sector to sector throughout the day. Thus, often smaller cities are better supplied with

TABLE 7. CITIES WITH COMMERCIAL ELECTRICITY IN THE SAHEL

(220 volts, 50 hertz)

MAURITANIA

Nouakchott
Rosso
Kaedi
Atar
F'Derik

SENEGAL

Dakar
Saint Louis
Tambacounda
Linguère
Ziguinchor

THE GAMBIA

Banjul
Georgetown

MALI

Bamako
Kayes
Sikasso
Ségou
Mopti
Gao

UPPER VOLTA

Ouagadougou
Bobo-Dioulasso
Koudougou
Ouahigouya
Fada-N'Gourma

NIGER

Niamey
Agadez
Tahoua
Maradi
Zinder

CHAD

N'Djamena
Sarh
Several others

electricity than larger ones. In some of the smaller cities without electricity, a factory, airport, commercial enterprise or other installation will possess electrical generating equipment and supply electricity not only for their industrial purposes, but also to the residences of their employees or other users in the neighbourhood. Thus, one finds a wide variety of generating equipment all the way from large municipal dynamos down to medium size diesel generators down to small portable generators. Almost without exception all of this generating equipment burns some form of petroleum based fuel.

D. The National Post, Telephone and Telegraph Networks

All seven of the CILSS countries follow the European model for the organisation of their national post office, telephone and telegraph networks, i.e. they are all nationalized enterprises under a centralized administration. Most often they are called OPT (Office de la Poste et Télécommunications). Discussions were held in each country concerning the current state of the telegraphic and telephonic networks. Although detailed data was obtained on the extent and efficacy of each, it is not reproduced here due to its voluminous nature and general inapplicability. It suffices to present the general conclusions.

In each of the seven countries, the OPT telephone and telegraph network was judged to be incapable of providing the necessary service required to transmit the data from the observation stations to the national headquarters. First, the OPT networks serve only the larger cities with links to the national capitals. In almost all of those cases the city is served with an ASECNA synoptic station using single side band radio communications. Thus, most of the additional agrometeorological and hydrological stations would be located in smaller

villages or in the country which would not be served by OPT communications. In those few places which would be so served, the service is so minimal and the amount of traffic so large that unacceptable delays would be the rule almost all of the time. For example, in the small country of The Gambia the WMO expert experienced delays of up to 45 hours in using the OPT telegraph network. Several times his message failed to arrive at all.

Regionally, the OPT telephonic and telegraphic networks are hardly linked together at all. Thus, it is inconceivable to imagine the OPT networks as a viable possibility for communications between the national capitals and the regional centre in Niamey.

In some cases the national meteorological centre to be established may not be co-located with the ASECNA national communications centre. In these cases it will be necessary to establish a communications link between the two centres. In all cases but one the OPT telephonic/telegraphic network in the capital city has been judged adequate to provide this service. This topic is discussed in greater detail in the following section.

E. Collateral Projects

There are five other projects or organisations in the Sahel which have potential impact upon the telecommunications aspects of the present agrometeorological project. They are: (1) the Senegal River Commission, (2) the Niger River Commission, (3) the Lake Chad Basin Commission, (4) the UNDP/WMO Mali/Guinea Flood Forecasting Project, and (5) the WHO Project for the Fight against Onchoceriasis.

1. Senegal River Commission

The Senegal River Commission plans a radio network connecting various hydrological stations along the Senegal River and its tributaries. Unfortunately, this project is in the earliest planning stage and has not yet secured significant financing for any phase of its efforts. Consequently, planning of the telecommunications of the present project should proceed irrespective of the proposals of the Senegal River Commission.

2. Lake Chad Basin Commission

Similarly, the Lake Chad Basin Commission plans a system of hydrological stations interconnected by a radio network. As in the case of the Senegal River Commission, significant financing has not been secured, and planning for the current project should proceed irrespective of the proposals made by the Commission.

3. Niger River Commission

The Niger River Commission has developed similar proposals for the installation of a collection of hydrological stations in the lower Niger basin interconnected with a radio network. Unlike the other two commissions, however, significant internal interest has been generated, and prospects for external financing look plausible. Schedules for the installation of the telecommunications network are not as far advanced as those of the current program. Consequently, design of the present telecommunications network should proceed without waiting for plans of the Niger River Commission, to materialize.

However, continuing coordination is desirable for two reasons. First, when the telecommunications network of the Niger River Commission is designed, compatibility with the presently proposed network is desirable through the use of common radio set types, compatible frequencies, and common generating equipment. Second, when the network of hydrological stations for the Commission becomes operational, the development of a forecasting model will require computer processing capability. Niamey is the logical location for this effort, and most probably a shared facility with the current agromet project will be sought. Provisions for such an eventuality should be made at this time.

4. Mali/Guinea Flood Forecasting Project

In 1971, UNDP in conjunction with WMO entered into agreements with the governments of Mali and Guinea to install a flood forecasting system in the Upper Niger River basin. The project envisaged 18 hydrological stations in Guinea equipped with SSB transceivers and 19 such stations in Mali. Table 8 on the following page enunerates the 19 stations in Mali. As shown, two of these stations were not equipped with radio transceivers. These stations were operated under UNDP/WMO supervision through the planned termination of the project in 1974. Since that time, however, the status of the network has steadily declined, until at the present time only a fraction of the original network remains operational. In particular, the stations that remain operational are:

Bamako	Cinzana
Kangaré	Bougouni
Kouoro	Guélélinkoro

TABLE 8. HYDROLOGICAL STATIONS IN THE MALI/GUINEA PROJECT

Station	Type SSB	Installation Date	Purpose of the Project
Bamako	50W T.H.	1971	Exchange hydromet data and messages with Conakry and Kankan
Bamako	100 W CMC	Apr. 30, 1974	Centralization of satellite station data from Mali
Bankankoro	10W CMC	Apr. 27, 1974	Banankoro hydro data
Koulikoro*	50W T.H.	1972	Koulikoro hydro data
Siguiri*+	50W T.H.	1972	Siguiri hydro data
Ke-Macina*	50W T.H.	1972	Ke-Macina hydro data
Mopti*	50W T.H.	1973	Mopti hydro data
Guélélinkoro	10W CMC	Apr. 5, 1974	Guélélinkoro hydro data
Sélingué (Kangaré)	10W CMC	March 5, 1974	Sélingué hydro data
Yanfolila	20W CMC	July 7, 1974	Yanfolila hydro data
Bougouni	20W CMC	Oct. 5, 1974	Bougouni hydromet data
Dioila	10W CMC	Sept. 5, 1974	Dioila hydromet data
Douna (Cinzana)	20W CMC	Sept. 5, 1974	Douna hydro data
San	10W CMC	March 10, 1974	San hydromet data
Tyinkongo	10W CMC	Not installed	Tyinkongo hydro data (future forecasting system)
Kankela	10W CMC	Not installed	Kankela hydro data (future forecasting system)
Pankourou (Niena)	10W CMC	Jan. 10, 1974	Pankourou hydro data
Tyo (Beleco)	10W CMC	1975	Tyo and Markala hydro data
Kourou	10W CMC	Feb. 10, 1974	Kourou hydro data

* Installed by the Malian Navigation Company linked to the project network by special frequencies

+This station, although listed in Mali, is believed to be in Guinea.

TH = Thompson-Hinston
CMC = Canadian Marconi Corporation

To the extent that these stations are useful in the proposed network, they should be retained. To the extent that the non-operational stations could be useful to the proposed hydrological network, they should be rehabilitated by equipment repair or replacement. Telecommunications equipment from the other stations should be retrieved and cannibalized for replacement purposes and for spare parts. It is recognized that the equipment used on this project is of Canadian and French manufacture and hence likely to be incompatible (from the view of spare parts) with that selected for the rest of the network. Nevertheless, such gratuitous equipment will serve a useful interim purpose.

5. WHO Project for the Fight Against Onchoceriasis

Finally, the WHO Project for the Fight against Onchoceriasis has installed a single side band radio transceiver network in portions of the Ivory Coast, Ghana, Togo, Benin, Niger, and Upper Volta. Of the 19 stations in this network, four lie within the boundaries of Upper Volta and Niger. They are:

Ouagadougou	Leo
Bobo-Dioulasso	Niamey

Each of the transceivers in the network are 100 watt Canadian Marconi SSB units, powered by storage batteries which are recharged by portable Honda petrol powered generators. Each generator unit weighs approximately 15 kilograms. The transmitter power of 100 watts has proved very satisfactory in increasing reliability of communications. The central transmitter normally operates at 300 watts, but has a linear amplifier attached which is capable of boosting output to more than 1000 watts.

The three stations of Ouagadougou, Bobo-Dioulasso and Niamey all duplicate present synoptic stations operated by ASECNA and are of no value to the project. Leo is currently listed as a climatological post of secondary importance. Hence, the WMO transceiver at Leo could be used to transmit agrometeorological data if it were equipped with the appropriate frequencies. This possibility should be explored.

III. PROPOSED AGROMETEOROLOGICAL/HYDROLOGICAL TELECOMMUNICATIONS NETWORK

A. Introduction

The central assumption behind the entire agrometeorological project is that the data from the observation stations in each country will be collected at a central headquarters in the national capital, and that after error detection and correction the data will be forwarded to the regional centre in Niamey. No attempt has been made to disturb this assumption, and no alternatives have been considered.

B. National Observation and Data Collection Networks

In the cases of Senegal, Mali and Upper Volta national meteorological services are currently in existence, and the WMO expert has been in place for sufficient time to develop a plan for the establishment of a system of agrometeorological and hydrological stations equipped with telecommunications. In these cases the desires of the chief of the meteorological service and the advice of the WMO expert has been used to prepare a suitable network of stations. In the case of The Gambia a similar plan has been prepared, even though some of the organisational infrastructure has not yet been established. In the cases of Mauritania, Niger, and Chad, the governments have elected to use the meteorological services of ASECNA, and the WMO expert has not yet been in place for sufficient time to prepare a plan of stations. In these cases current thinking from all sources, including the chief of the meteorological division of

ASECNA, the ORSTOM team chief, and the WMO expert has been used in an attempt to develop a tentative list of stations. All cases were reviewed with the Programme Coordinator in Niamey.

Table 9 on the following page summarizes the tentative list of stations to be equipped with telecommunications under the present project. In addition, those existing synoptic stations which will acquire additional observational responsibilities have also been included. Those existing stations, either synoptic or hydrological, which will change neither their observational responsibilities nor their telecommunications capabilities have not been included.

Again it should be stressed that this list should not be considered binding. Additions, deletions or substitutions can be made anywhere in the list in reasonable numbers without disturbing the conceptual structure. Inasmuch as the data will be collected national via HF voice radio, neither the actual locations of the stations nor their exact number are critical in the layout of the national data collection network.

HF voice radio has been selected as the most cost-effective solution to the overall national communications problem for several reasons. HF voice radio is considerably less expensive than HF radio teletypewriters and nearly as effective for the small amount of data to be transmitted. Distances are too great for VHF radio without repeaters which are unacceptably expensive. Finally, the OPT telephone and telegraph circuits do not exist in sufficient quantity to be considered feasible at all. With current technology no other alternatives exist.

TABLE 9. STATIONS TO BE EQUIPPED WITH TELECOMMUNICATIONS

Tentative List

Station	Services		Communications	
	Existing	Proposed	Existing	Proposed
MAURITANIA				
Aleg		A		SSB
Boghé		A,H		SSB
Foun-Gléita (Mbout)		A,H		SSB
Kaedi		A		SSB
Kankossa		A		SSB
Keur Massène		A,H		SSB
Maghama		A,H		SSB
Selibaby		A		SSB
SENEGAL				
Kédougou	S	H	SSB,A3	
Kolda	S	H	A3	
Ziguinchor	S	H	SSB	
Simenti	S	H		SSB
Bakel		H		SSB
Bambey		A		SSB
Guédé		H		SSB
Louga		A		SSB
Nioro du Rip		A		SSB
THE GAMBIA				
Banjul	H			Telephone
Georgetown/Sapou	S	A,H		SSB
Jenoi	S			SSB
Basse	S			SSB
Gouloumbo (Senegal)		H		SSB
Wassadou Amont (Senegal)		H		SSB
MALI				
Gao	S	H	SSB	
Tombouctou	S	H	SSB	
Goundam		H	SSB	
Mopti	S	H	SSB	
Kayes	S	H	SSB	
Samé		A		SSB
Kita	S			SSB
Sotuba		A		Telephone
Nara		A		SSB
Bougouni	S			SSB
Faraka		A		SSB
Niono		A		SSB
Dogo		A		SSB
Ansongo		A,H		SSB

TABLE 9. (continued)

Station	Services		Communications	
	Existing	Proposed	Existing	Proposed
UPPER VOLTA				
Boromo	S	H	SSB	
Mogtedo		A		SSB
Saria		A		SSB
Farako-Ba		A		SSB
Beregadougou		A		SSB
Niangoloko		A		SSB
Diebougou		A,H		SSB
Bissiga		H		SSB
Niompourou		H		SSB
NIGER				
Birni N'Konni	S	H	SSB	
N'Guigmi	S	H	SSB	
Niamey	S	H	Tele-phone	
Tillabéry	S	H	SSB	
Arlit		S,A		SSB
Filingué		A		SSB
Dogondoutchi		A		SSB
Dosso		A		SSB
Tapoa		A		SSB
Dolbel		H		SSB
Nielloua		H		SSB
CHAD				
Am Timan	S	H	SSB	
Bousso	S	H	SSB	
N'Djamena	S	H	Tele-phone	
Sarh	S	H	SSB	
Moundou	S	H	SSB	
Ati	S	H	SSB	
Koro-Toro		S,A		SSB
Goz-Beida	S	A		SSB
Bardai		S,A		SSB
Bongor		S,A,H		SSB
Lai		S,H		SSB
Mao		S,A		SSB
Baibokoum		H		SSB

S = Synoptic
A = Agromet
H = Hydromet

ASECNA experience indicates that a single family of operational frequencies can be used to collect synoptic data from as many as 15 observation stations. Since most of the ASECNA national networks contain approximately one dozen stations, additional stations equipped under this project should not be integrated into the ASECNA network. Separate independent frequencies should be allocated, and separate headquarters transceivers stations should be equipped. Logically, the central transceiver located at the national meteorological headquarters. Thus, as many as 15 stations could be included into this additional data collection network. The proposed average is seven.

The location and organisation of the national agrometeorological centre in each country determines to a great degree the telecommunications requirements in the capital city. First, to the extent that the national agrometeorological centre is not co-located with the ASECNA communications centre, communications between them will be required. Second, the national agrometeorological centre and possibly the ASECNA communications centre will be collecting hydrological data. In most of the countries where a national meteorological service currently exists, a national hydrological service also exists, but in a different location and different ministry from either of the above. This situation may pose administrative problems.

1. Mauritania

The geography of Mauritania is such that most of the agricultural activity lies in the extreme south of the country near the Senegal River. Further, most of the hydrological stations will be concerned with the Senegal River as well. The eight stations proposed lie in that area and have been selected to provide maximum

coverage of functions. Four of the proposed stations will make hydrological as well as agrometeorological observations. It is recognised that in these cases the location of the hydrological equipment may be some distance from the agrometeorological equipment. In these cases field telephone communications or ground transportation is assumed. The question of a need for a relay from the agricultural area to Nouakchott has been raised. At the present time this is not thought to be necessary.

For the present, Mauritania has elected to utilize the meteorological services of ASECNA. Further, the WMO expert has been in place only a short time. Consequently, proposals for the location of the national agrometeorological centre have not yet been finalized. However, the most logical and advantageous location is in the central building at the Nouakchott Airport. ASECNA has centralized its operations in this building, and sufficient adjacent space is believed to be available. Because communications between the two centres could then be accomplished in person, no other telecommunications equipment is required other than the central HF SSB voice transceiver required to communicate with the outlying stations.

2. Senegal

In Senegal three existing synoptic stations currently equipped with telecommunications coincide with hydrological stations. Hydrological observations will be incorporated into the regime of the stations with ASECNA's concurrence. A fourth synoptic station which currently lacks telecommunications also coincides with an important hydrological post. In this case the hydrological observations will be included in the stations responsibilities and the entire installation equipped with telecommunications and integrated into the current project

network. Two additional hydrological stations on the Senegal River which have already been installed by ORSTOM will be equipped with telecommunications. Finally, three agrometeorological stations will be inaugurated and equipped with telecommunications.

The Senegalese national meteorological service is currently located in the GATE building adjacent to the Dakar-Yoff airport. This building was constructed with WMO assistance in a previous project, now concluded. The ASECNA operations centre is located in the main airport building a scant 50 metres away. The national agrometeorological centre can and should be located in the GATE building. In this case communications with the ASECNA centre can be accomplished in person or by means of local telephone or teletypewriter lines leased from local authorities. The central HF SSB voice transceiver is the only project equipment required.

3. The Gambia

The Gambia currently operates four synoptic stations but only one is equipped with telecommunications, Yundum Airport. The other three will be equipped with telecommunications under the current project. An agrometeorological station at Sapou will report its observations to the synoptic station at Georgetown which is close enough for ground transportation or field telephone communications, and the hydrological station will be incorporated in to the station complex as well. Present plans by the Gambians indicate that the Georgetown synoptic station may be moved in the future to Sapou, thereby further simplifying the arrangements. The hydrological station in Banjul will communicate its observations to headquarters by telephone which is adequate in the capital area.

Much of the hydrological forecasting for The Gambia depends upon data on the upper Gambia River basin in Senegal. Hence, two Senegalese hydrological stations set up by ORSTOM will be equipped with telecommunications. It is currently planned that these stations will report to the Gambian agrometeorological centre. If such an arrangement causes administrative or political problems, then alternatively these last two stations could report to the Senegalese meteorological centre, who in turn would ensure relay of the data to the Gambians by means of the regional teletypewriter network.

Due to the absence of an organisation equivalent to ASECNA, the Gambian regional telecommunications situation is a bit more complicated. The largest amount of regional telecommunications available, as meagre as it is, is located at the Yundum airport, 10 kilometres from Banjul. The national agrometeorological centre could most conveniently be located here. This is reinforced by Gambian plans to construct a new terminal building, which would release additional space for use by the centre. In this case, the centre would need be equipped only with the usual central HF SSB unit. The Yundum synoptic observation would be taken on the spot, and the Banjul hydrological observation could be relayed to the airport by telephone, which has been judged sufficiently reliable.

Alternatively, it should be recognised that the office of the national hydrological service is located in the city of Banjul itself. Thus, the national agrometeorological centre could feasibly be located in adjacent quarters. In this case the national data collection could occur at that point and be relayed to Yundum Airport via teletypewriter circuits obtained from local authorities. In this case two additional teleprinters would be required. Of the two alternatives, the former is moderately preferably from a telecommunications viewpoint.

4. Mali

The Chief of the Meteorological Service in Mali in coordination with the WMO expert has already prepared plans for a national meteorological network. These plans specify that observational data will first be collected in the capitals of the six principal subdivisions of the country and then be forwarded to the national capital. This plan has two principal disadvantages. First, its structure will require additional staff which probably cannot be made available in the near future due to lack of training and financial resources. Second, this structure implies that the data must be relayed twice, once to the national capital and a second time to the Niamey centre. Whenever voice radio is employed to transmit data, this procedure should be avoided whenever possible. However, the commonality of equipment implies that the network may be later operated in the sub-divided fashion should it prove preferable. A re-allocation of frequencies is all that is required.

Four of the current ASECNA synoptic stations equipped with telecommunications coincide with hydrological stations. The hydrological observations will be included in the regime of these stations and reported to the ASECNA national communications centre at the appropriate times. Two other ASECNA synoptic stations not equipped presently with telecommunications will be so equipped under the present project and integrated into the ASECNA network. Of the 13 agrometeorological stations requested by the Malian Meteorological Service seven will be commissioned and equipped with telecommunications. Six of these will utilize the standard HF SSB radio units, and the seventh, Sotuba which lies near the capital, will depend upon telephone. One of these seven stations, Ansongo, will also make hydrological observations.

With respect to the location of a national centre, the Malian situation is rather difficult. The Malian national meteorological service is currently allocated space in the administration buildings of the old airport located approximately five kilometres to the northeast of the centre of Bamako. This space was previously occupied by the ASECNA communications centre prior to its relocation to the new airport. Much of the electrical wiring for the communications centre still remains although its state of repair is unknown. The new airport is located on the other side of the Niger River from the city and approximately 20 kilometres away to the east-southeast. Further, the national hydrological service is located in the city centre at a third location. Given the space already allocated to the national meteorological service and the unavailability of space at the new airport, there appears to be little hope of changing this circumstance.

As a result substantial communications equipment will be required. In addition to the usual central HF SSB radio transceiver unit, a method of communications to and from the new airport must be found. The telephone system has been judged to be inadequate. The river has served as a barrier to telephone service to the other side up to the present time. Present airport communications is accomplished by a microwave system that is fully utilized. Thus, a microwave or VHF radio link between the national agrometeorological centre and the ASECNA centre at the new airport appear to be the only feasible methods. This link should be designed principally for teletypewriter traffic and include at least two teleprinters as a minimum.

5. Upper Volta

In Upper Volta the current synoptic station at Boromo will assume hydrological

observation responsibilities as well. In addition, six agrometeorological stations will be established and equipped with telecommunications. One of these, Diebougou, coincides with a hydrological station already established by ORSTOM, and consequently this data will also be collected. Two additional ORSTOM hydrological stations, Bissiga and Niompourou, will be equipped with telecommunications under the present project.

The present quarters of the national meteorological service are in government administration buildings near the centre of Ouagadougou. The proposed location of the agrometeorological centre is in buildings to be constructed adjacent to university and training facilities also near the city centre. The airport, in which the ASECNA centre is located, is a mere five kilometres away, and communications between the two will pose no problem whatsoever. The telephone system has been judged to be adequate, and a leased teletypewriter circuit with two teleprinters will more than suffice. The usual HF SSB radio transceiver completes the equipment requirements.

6. Niger

Four of the current ASECNA synoptic stations coincide with hydrological stations established by ORSTOM. Hence, hydrological observations will be included in the regime for these stations, the data being reported to the ASECNA national communications centre in Niamey. The assumption here is that the hydrological equipment is sufficiently close to the ASECNA station to permit ground transportation or field telephone communications between them. An additional synoptic and agrometeorological station, at Arlit, will be established and equipped with telecommunications. Four additional agrometeorological stations will be established and equipped with telecommunications. Finally, two existing ORSTOM hydrological stations will be similarly equipped.

For the present Niger has elected to utilize the services of ASECNA. ASECNA's regional communications centre is located in the administration buildings at the airport, approximately 10 kilometres to the northeast of the centre of Niamey. The agrometeorological staff is currently located in temporary quarters near the city centre. The permanent national agrometeorological centre could most conveniently be located in the new regional centre building. The only other convenient location is adjacent to ASECNA in the airport administration buildings--a dim possibility.

Thus, it will be necessary to provide communications between the new regional centre and the ASECNA communications centre. The telephone system has been judged adequate for handling the traffic, but due to the amount of traffic, a private microwave link would have the advantage of permitting multiple voice conversations, transmission and reception of teletypewriter traffic, and receipt of facsimile information, all simultaneously. The ususal HF SSB transceiver is also required.

7. Chad

In Chad the situation is more complicated. As mentioned earlier, difficulties in obtaining new telecommunications equipment for ASECNA has caused the Chadian network to be reduced to its current level of 12 stations. Further, nine of these stations currently use telecommunications equipment manufactured in 1964. Thus, if new equipment is not forthcoming in the near future, some of these nine stations will be cannibalized and the network reduced to eight stations. The above notwithstanding, however, this mission believes that the best opportunity for financing replacement equipment of the ASECNA synoptic

network lies in sources other than the present project. Such a statement, however, should not be interpreted in a manner that would tend to reduce the urgency of the need for such replacement equipment.

Six of the current synoptic stations coincide with hydrological stations established by ORSTOM. Hydrological observations will be included in the regime for these synoptic stations as in the foregoing cases. Once again the assumption is that the two sets of equipment are in sufficiently close proximity to permit the joint communication of data. One synoptic station, Goz-Beida, which currently does not possess telecommunications capability coincides with a proposed agrometeorological station. The complex will be telecommunications equipped. Five additional synoptic stations will be established and equipped with telecommunications. Of these, four coincide with proposed agrometeorological station and two with existing ORSTOM hydrological stations. All will be telecommunications equipped. Further, two of these proposed stations Bardai and Koro-Toro, satisfy deficiencies in the Chadian network as requested by WMO. Finally, one additional existing ORSTOM hydrological station, Baibokoum, will be telecommunications equipped.

Chad also has elected to use the meteorological services of ASECNA for the present time. However, the government has proposed a site for future construction of a headquarters approximately 40 kilometres from the centre of N'Djamena. This site lacks basic improvements such as water, electricity, telephone and sewer services. Thus, the proposed site presents serious problems. Suitable temporary space could probably be made available in the administration buildings at the airport adjacent to the ASECNA communications centre. More permanent quarters would probably require construction of a small building on the airport itself. Sufficient land adjacent to the present administration buildings makes this a feasible proposal. Although the government has plans for

relocating the present airport to an area more distant from the city, a realistic estimate of the resources required implies that such a project will not be accomplished within a decade. Thus, the present airport is the logical solution for the near and intermediate term.

Due to this co-location the only equipment requirement of the national agrometeorological centre is the usual HF SSB radio transceiver unit. If and when the national meteorological service acquires a separate building, the requirement for a teletypewriter link between it and the ASECNA centre can be re-examined.

C. Regional Communications

Once the data has been collected at the national agrometeorological centres, it is still necessary to forward this data to the regional centre in Niamey. As mentioned earlier this will be accomplished by using the ASECNA regional radio teletypewriter network. The previous section of this chapter demonstrated feasible methods by which the data might be transferred from the national agrometeorological centre to the corresponding ASECNA communications centre. In the cases of Mauritania, Senegal, and Chad the facilities will be co-located. In the cases of Mali, Upper Volta and Niger local teletypewriter circuits will be used. Only the first of these will not be able to use the local telephone system. The Gambia of course, is a special case.

In general, the additional traffic can be handled by the ASECNA network with no hardware change. Sufficient capacity exists in the circuits to accomodate the agrometeorological and hydrological messages which are presumed to occur two or three times per day. However, software changes will be required in the

automated switching computers at Dakar, Niamey, and possibly Brazzaville to accomodate the new addressees which the regional and national agrometeorological centres represent. Provision for these software changes should be made in the overall project budget. Presumably they can best be made by ASECNA personnel on-site.

Two general deficiencies in this network must be resolved before it will operate satisfactorily for the present project. First, a link between Dakar and Banjul must be established. The present mode of operation as described in Chapter II is unsatisfactory. Second, the present link between N'Djamena and Niamey is marginal when considering the increased traffic load. A means of strengthening this link should be sought.

1. The Dakar-Banjul Link

A direct link between Banjul and Dakar is absolutely necessary. The best solution would be a VHF radio teletypewriter circuit between Yundum Airport and the ASECNA communications centre at Dakar. The distance between the two is approximately 125 kilometres, hence a high powered, say 1000 watts, VHF transmitter coupled with a multiple element Yagi antenna would suffice.

A satellite link would be ideal but has been rejected as not cost-effective until substantially more traffic between those points can be found. An HF radio teletypewriter link would be satisfactory but would probably have lower reliability at no reduction in total cost. As mentioned in Chapter II, a microwave link between Banjul and Kaolack is currently under development. If sufficient project funds are not available for a dedicated VHF link, more detailed explorations of using this alternate means of communications should be pursued.

2. The N'Djamena-Niamey Link

Initially, the project may use the link as it currently exists, i.e. via Brazzaville to Dakar then via Dakar to Niamey. However, reasonably early in the project plan increased reliability in the N'Djamena-Niamey link should be sought. To accomplish this, two alternatives are available. First, to improve the quality of the Brazzaville to Dakar portion of the automated network. Currently, HF radio is used as the mode of transmission. A satellite link would improve the availability of that circuit from its present 85% to near 100%. This solution has the advantage that it improves one of the main regional circuits in Region I of the Global Telecommunications System of WMO. However, this solution has the disadvantages that it is more costly and seeks to achieve objectives that could be considered outside the mandate of the present project.

Alternatively, one may choose to improve the quality of the manual HF radio teletypewriter circuit that currently exists between these two points. The dual channel transceivers and associated antennae are already in place and operational. Only a TOR converter and associated teleprinter and keyboard at each end is required to make the second channel operational. This solution is considerably less expensive. Further, it has the advantage that it adds redundancy to the over-all regional communications which could not be achieved by any improvement made to the Brazzaville-Dakar link. This second solution is recommended.

D. Miscellaneous Equipment Considerations

There are a number of items of secondary nature which deserve comment at this point. First, the Regional Centre, which will consist of three separate buildings

must be equipped with intra-centre communications. At the present time the telephone system is thought to be adequate to provide the required service. However, if this is not the case, the project itself must be prepared to provide this telephonic equipment and service.

Second, the Regional Centre must be equipped with at least one and preferably two facsimile recorders to obtain the graphic information that originates in Paris and Dakar. These facsimile recorders may obtain input either from independent radio receivers located at the centre or via microwave relay from the ASECNA centre at the Niamey airport. In the former case an HF receiver would be required for reception of Dakar and satellite receiver for reception of transmissions from Paris. In the latter case two additional channels on the microwave link would be required.

Third, many of the tranceiver sites will be adjacent to petrol powered generators, teleprinters, or other noisy equipment. Hence, noise-cancelling microphones are desirable for all such locations. For purposes of standardization noise-cancelling microphones throughout should be considered.

Fourth, the Banjul/Yundum centre is currently without any sort of graphic data. All other national agrometeorological centres can obtain facsimile and/or APT products from their associated ASECNA facility. A facsimile receiver and recorder and an APT receiver and recorder for Banjul/Yundum should be considered.

E. Dissemination

To be effective the processed information developed by the project must be

disseminated to appropriate government officals and to the ultimate users -- the herdsmen and farmers in the region. The forecast products and advisory bulletins developed in Niamey should be distributed over the same regional radio teletypewriter network that was used to collect the raw data. This network will ensure that the forecast products are distributed to the seven national capitals. One can safely assume that, with proper administrative procedures, dissemination of the product information to appropriate officials will occur within each of the seven capital cities.

Dissemination to the ultimate users in the outlying areas, however, is another matter. The proposal that the national radio broadcasting networks can be used effectively for this purpose is a sound one. Table 10 on the following page presents the status of each of the national radio broadcasting networks and the number of radio receivers in each country. It is estimated that the radio broadcasting facilities in the region are capable of reaching 65-70% of the indigenous population. Most of the radio receivers are of the battery operated, transistorized variety. While this type of receiver is independent of external electrical sources, it is highly dependent upon a source of dry cell batteries. Such sources in the Sahel can be described as widely dispersed, quantitatively inadequate, and subject to frequent supply shortages. This mission discovered that two out of the four radios in one village were inoperable due to lack of batteries, that the nearest sources of supply was 60 kilometres away, and that they had been unavailable there for two months. To ensure adequate reception coverage, the national governments should encourage the expanded flow and distribution of small transistorized radios and batteries as the dissemination effort gets under way. Such encouragement could be incorporated into other communications and mass media development programmes.

TABLE 10. RADIO BROADCASTING FACILITIES IN THE SAHEL

Country	Network	Languages and Transmitters	Radio Sets
Senegal	Radiodiffusion du Sénégal	French, four vernacular languages	275,000
Gambia	Radio Gambia	English, Wollof, Mandinka	60,000
Mali	Radio Mali	French, English, Bambara, Peulh, Sarakolé, Sonrai Moorish, Wollof	75,000
Mauritania	Radiodiffusion Nationale de Mauritanie	French, Arabic, Wollof, Toulcouleur, Sarakolé (four transmitters, two of 100 kw.)	75,000
Upper Volta	La Voix du Renouveau (Upper Volta)	French, 13 vernacular languages (one transmitter in Ouagadougou, one in Bobo-Dioulasso)	88,000
Niger	"La Voix du Sahel", Office de Radiodiffusion-Télévision du Niger	French, Hausa, Zerma, Tamachek, Kanuri, English (twice per week), Arabic	100,000
Chad	Radiodiffusion National Tchadienne	French, Arabic, seven vernacular languages; Transmitters: 100 kw. short wave, 20 kw. medium wave	70,000

Various national networks already broadcast programmes at certain fixed times which are aimed at different segments of the rural population. The regularity of these programmes is one of the large keys to success. These programmes become known throughout the country, and as a result, acquire a regular audience. Agrometeorological material, in a vernacular easily understood by herdsmen and farmers, could be included in these programmes. Additional, specialized programmes for this purpose could easily be developed.

Additional dissemination techniques should be considered as possible back-up to supplement mass radio broadcasting. In particular, consideration should be given to establishing roving government agents, patterned after the U.S. Department of Agriculture's county agent programme. Such roving agents would visit farming and herding villages, informing them of the radio programmes and instructing them how to take advantage of the information. These agents might be drawn from the observer cadre used to staff the various agrometeorological observation stations. Such personnel would already be trained in agrometeorology, and in many cases might be associated with experimental farms or agricultural stations. In this case such agents might have already developed a special rapport with the surrounding farming communities which would be exploited. Further, the staffing and training costs would be minimized, and the agents' access to the telecommunications network would place the most current information at their disposal. Admittedly, the transportation and fuel costs of such a programme would be quite high.

IV. SUPPORT CONSIDERATIONS

A. Introduction

For the proposed project to be successful, it is necessary to review every aspect of the social and economic infrastructure into which the telecommunications equipment will be placed to determine weaknesses that require support. There are three areas which Sahelian countries almost totally lack: reliable electrical power, maintenance facilities for medium or high technology material, and adequate training.

B. Electrical Power Sources

As described in Chapter II only a handful of cities in each country have a commercial source of electricity available. In all of these locations a synoptic station is already in place. Hence, regardless of the changes made to the tentative list of agrometeorological and hydrological stations, a source of electricity will be required. Three alternatives were considered. First, each radio transceiver in an outstation might be provided rechargable batteries and a manual charger. This alternative has the advantage that it is highly durable and reliable at minimum cost. However, the technique effectively limits the power output of the transmitter. At 5 to 10 watts output, the system is ideal. At 30 watts output, the technique is strained. At 100 watts, manual charging becomes time consuming whenever transmissions are moderately voluminous. It was thought that 100 watts transmitter power was a sufficient asset that it should be retained, and the alternative was judged second best.

Second, each outstation would be provided with a diesel generator sufficient to operate all radio equipment upon demand. This solution requires a large expenditure for the sole purpose of avoiding storage batteries. Further, the technique requires heavy maintenance. Consequently, this alternative was rejected.

Finally, use of a small petrol or diesel powered generator to recharge storage batteries was considered. This alternative has the advantage of a small capital investment and only moderate maintenance. The disadvantage is that storage batteries are required which have a service life in the Sahel of two years maximum. Nevertheless, this combination was felt to be the best trade-off among the alternatives.

From the tentative list of stations it can be seen that 49 chargers and twice that number of storage batteries are required. The central stations in the national capitals can operate on the commercial power that is available provided that voltage stabilizers are used. In the cases where the national agrometeorological centres are to be co-located with the ASECNA telecommunications centres, the power to be provided at these installations can be assumed to be quite acceptable.

C. Maintenance Considerations

The necessity of continuing maintenance to the success of this project cannot be overstressed. The maintenance capabilities of the Sahelian countries are woefully inadequate. There is an inadequate financial reserve to provide for the

maintenance of almost everything. There is an inadequate supply of spare parts. There is inadequate transportation necessary for efficient maintenance. There is an inadequate number of trained personnel. There is a certain fatalism in the people to accept the premature failure of a mechanical device and not to attempt its restoration. Almost total external maintenance support for the donated telecommunications equipment for a minimum of five years must be programmed. Additional partial maintenance support for five more years must also be planned.

1. Field Maintenance

Duplication of equipment at each field location would provide the highest reliability possible. However, this solution is not cost-effective for several reasons. To ensure absolute redundancy not only the transceivers but also the antennae, battery chargers, and possibly the batteries would have to be duplicated. Otherwise the failure of unduplicated equipment could expose the station to total failure. Such equipment could better be used to outfit a second station. Even if one station were off the air for a while, data from both stations would eventually be available for climatological purposes. Consequently, available resources should be used to equip as many stations as possible without redundancy.

In the field without proper test equipment there is little a radio operator can do to repair his transceiver beyond replacing an occasional fuse. Therefore, maintenance to this item will be limited to dusting the unit to keep it clean and replacing fuses. Each outstation will be supplied with spare fuses and an appropriate cleaner. Inoperable units will be exchanged for operable ones by repair technicians sent from the national capital.

With respect to antennae, which are expected to be simple dipoles strung from poles or trees, more field maintenance is possible. To repair the antenna after it is broken by severe weather or other causes, the station operator should be supplied with antenna wire, lead-in wire and sufficient hand tools to make on-site repairs.

Batteries require little maintenance beyond keeping them filled with water and occasionally checking them with a hydrometer. This, the operator should be expected to do. Since ground water is so mineral laden and rain water so rare, distilled water is probably advisable.

The small portable petrol powered generators require continual but simple maintenance. Filters should be periodically changed, oil changed, and points and plugs replaced.

2. National Centre Maintenance

As mentioned above, repair of radio transceivers requires substantial test equipment. Initially in the programme all transceivers will be sent to Niamey for repair. The radio technician at the national capital should occupy himself only with retreiving the inoperable unit from the outstation and sending it by air to Niamey. For accomplishing this the technician should be equipped with a Land-Rover and two-way radio communications. A radio of the same type as provided the other outstations should satisfy the two-way communications requirements. Spare parts, consumables, manuals, and tools for the maintenance of the Land-Rover should also be provided.

As the network grows, however, it will become increasingly desirable to perform such repairs in the national capital. At that point a radio repair shop should be established, equipped with at least the following:

Signal generator
VTVM
Oscilloscope
Wave form generator
Supply of spare parts
Manuals (in French)
Hand tools

As in the case of the transceivers at the central location, this test equipment will require stabilized commercial electricity. Naturally, the central site should also be equipped with sufficient spare transceivers to permit the exchange in the field.

With respect to maintenance of the generators, the national centre should be expected to perform all minor and major maintenance including complete overhaul. Thus, each centre should be equipped with a full set of manual tools and appropriate maintenance manuals (in French) to facilitate this. Most maintenance of items such as this is accomplished by part exchange and few items need be fabricated on-site.

3. Regional Centre Maintenance

As mentioned above initially the Regional Centre will be expected to perform all electronic maintenance. Thus, the above test equipment requirements also hold for Niamey as well. However, Niamey is also expected to become a training facility for electronic technicians. Consequently, the above test equipment should be duplicated for training purposes.

All maintenance of the more specialized equipment, in particular the limited number of microwave links to be established and the associated teleprinter equipment, should be accomplished by the regional centre at Niamey. This will require additional test equipment recommended by the manufacturer and additional spare replacement items for exchange.

With respect to maintenance of the generators, the Regional Centre should be expected to perform only that maintenance which cannot be performed at the national capitals, namely procedures involving welding, brazing, machining or the equivalent.

D. Training Considerations

At the present time insufficient trained electronic and mechanical repair technicians exist in all of the countries of the Sahel. In fact, in many of them it may be difficult to find an adequate number of qualified candidates. The project should, therefore, be prepared to train all of the required technicians and if necessary to provide such remedial education as may be required.

1. Electronic Technicians

Currently, ASECNA operates a school, "Ecole Africaine de la Météorologie et de l'Aviation Civile" (EAMAC), in Niamey. This school is the ideal place for the training of the electronic technicians. However, it will be necessary to alter its current curriculum for two reasons. First, much of the equipment to be installed will be of U.S. manufacture and hence different from that currently

installed in the ASECNA system. Second, the curriculum of EAMAC tends to be theoretical in nature and not particularly adapted to the specific repair functions to be performed by the technicians. The American system of practical education of electronic technicals is superior in this regard. It can be taught to candidates who do not have a grounding in mathematics through the calculus or in basic electrostatics and electromagnetics. This technique is raised to its most sophisticated form in the American military schools where electronic technicians are trained in a wide variety of equipment in six months. A specialized curriculum in this direction should be prepared. In all probability an adequate curriculum requiring no more than 1 1/2 years can be developed. Ultimately, 10 such candidates should be trained.

2. Mechanical Technicians

A similar programme should be established for those technicians concerned with the generators, the Land-Rovers, and the other mechanical aspects of the national centres. Candidates should be trained at Niamey on the premises of the Regional Centre itself. A training programme not to exceed one year is thought to be sufficient.

E. Administrative Considerations

As mentioned in Chapter II the office of hydrology often resides in a different ministry than the office of meteorology. Because this project covers observations and forecasts of both types, it is necessary to ensure that there is proper coordination among all parties. A lack of coordination in this regard is already evident to some extent in the project. Therefore, an inter-ministerial co-ordinating committee in each country of the Sahel is thought to be the best

mechanism for re-establishing and ensuring this type of co-ordination. A recommendation to each of the governments involved is indicated.

V. EQUIPMENT, SCHEDULES, AND BUDGETS

A. Proposed Equipment List

Table 11 on the following page specifies a list of telecommunications equipment for the project. The list contains all equipment items and applicable spare parts. It does not however, specify the continuing need for external maintenance or maintenance assistance which, as previously stated, will be required for a 10-year period. Nor does it include the continuing supply of consumables which will be required. The latter are absolutely necessary but from a cost standpoint relatively minor.

The equipment list has been divided into three categories. The low priority items are not absolutely necessary for a satisfactory functioning of the telecommunications network. However, they are desirable items, in some cases highly desirable. These items include the equipping of Banjul with APT and facsimile reception capability, for example.

The high priority items are all required. However, the second group can be delayed until the remainder of the system has been installed and is operational. These items include spares for the outstation SSB transceivers, the national centre transceivers, and the petrol powered generators. Until the network is fully outfitted, items from the initial shipment can serve the purpose of spares. Finally, the shipment of the remainder of test equipment layouts can be delayed until sufficient candidate technicians have been trained, and the entire network has been outfitted.

TABLE 11. PROPOSED EQUIPMENT LIST

High Priority - Initial Shipment	Unit Price	Extension
49 HF SSB transceivers, 4 freqs., dipole antenna - Outstations	$ 3,000	$ 147,000
7 HF SSB transceivers, 10 freqs., umbrella radiator antenna, linear amplifier - NMC's	5,000	35,000
7 HF SSB transceivers, 10 freqs., mobile whip antenna - Mobile stations	3,000	21,000
98 Storage batteries, 60 ampere-hours, 14 volt - Outstations	50	4,900
49 Generators, 1/2 horsepower, 15 amperes output - Outstations	1,000	49,000
7 Voltage stabilizers, 220 volt, 50 hertz	500	3,500
7 Land-Rover vehicles, 4 wheel drive- National centres	10,000	70,000
2 VHF transceivers, linear amplifier, TOR converter, Yagi antenna with mast - Banjul	7,000	14,000
4 Microwave transceivers, TOR converter, parabolic dish antenna with mast	15,000	60,000
7 Teleprinters with keyboard	3,000	21,000
1 Test equipment layout (inc. items in Chapter IV) - Regional centre	20,000	20,000
2 Teleprinters, TOR converter	4,000	8,000
		$ 453,800
High Priority - Second Shipment		
8 HF SSB transceivers, 4 freqs., dipole antenna - Spares	3,000	24,000
2 HF SSB transceivers, 10 freqs., umbrella radiator antenna, linear amplifier	5,000	10,000
10 Generators, 1/2 horsepower, 15 ampere output - Spares	1,000	10,000
6 Test equipment layouts (inc. items in Chapter IV) - National centres	20,000	120,000
2 Facsimile recorders - Regional centre	10,000	20,000
		$ 184,000
Low Priority		
1 Facsimile recorder with HF receiver, antenna - Banjul	12,000	12,000
1 APT receiver, recorder, tracking synchronizer, antenna - Banjul	25,000	25,000
		$ 37,000
Grand Total		$ 674,800

In each case the price includes the equipment item itself, any additional material required, such as linear amplifiers or antennae and sufficient spare parts for its maintenance. Additionally, the price includes shipment to an African port, brokerage, freight forwarding charges and shipment inland. Because of the character of the project, customs has been assumed to be nil.

Although most all of the HF SSB transceivers in the region are currently of French manufacture, the addition of 50 to 60 new units to the area will warrant additional support. Consequently, purchase of U.S. origin equipment together with appropriate spares and spare parts should pose no adverse consequence. The same statement can be made about the generators. With the exception of the facsimile recorders and teleprinters, the remainder of the equipment is highly specialized and must be supported individually regardless of national origin. Thus, U. S. manufactured equipment poses no problem. Two of the teleprinters will be installed in Niamey. These might benefit from being Siemens 1000 or SAGEM models to coincide with the equipment already being supported at the ASECNA communications centre there. The third will be installed in Banjul and may be of U.S. origin without adverse consequence. Two of the facsimile recorders will be installed in the Niamey centre, and as in the case of the teleprinters, might benefit from being of like manufacture as those at ASECNA. The third will be installed in Banjul and may be of U.S. manufacture.

B. Installation Schedule

In each of the countries the national collection network may be implemented solely through the installation of HF SSB transceivers. However, in the cases of The Gambia, Mali, Upper Volta, and Niger, some link must be made from the

national agrometeorological centre to the ASECNA regional telecommunications system. Consequently, the installation of the national collection networks should proceed first in the countries of Mauritania, Senegal, and Chad while the installation of the VHF, microwave and telephone links are installed in the other countries. The assumption here is that two installation teams would be operating simultaneously. Upon completion of the installation of the national collection networks just mentioned, the remainder may be addressed. Of the four links between the national agrometeorological centre and the corresponding ASECNA communications centre, the one at Niamey is most critical because the entire system depends upon it. Thus, it should be addressed first.

The following schedule for the purchase and installation of the telecommunications equipment appears feasible at this time:

Nov. 1976	-	IFB for equipment purchases published
Dec. 1976	-	Bids for equipment received
Feb. 1977	-	Contract for equipment purchases signed
Apr. 1977	-	Equipment (first shipment) shipped
June 1977	-	Equipment (first shipment) arrives at African port
Aug. 1977	-	Equipment (first shipment) arrives at destinations
Sept. 1977	-	Installation of first group of SSB's begins, Installation of VHF, microwave and telephonic links begins
Oct. 1977	-	Equipment (second shipment) shipped
Dec. 1977	-	Equipment (second shipment) arrives at African port
Feb. 1978	-	Equipment (second shipment) arrives at destinations
Mar. 1978	-	Installation of first group of SSB's complete, Installation of VHF, microwave and telephonic links complete Installation of second group of SSB's begins
Aug. 1978	-	All installation complete

The installation of the HF SSB transceivers can be accomplished simultaneously with other aspects of station establishment including installation of meteorological equipment and facilities for human accomodation. Thus, the outstation

installation team is expected to operate in the region for approximately 11 months. The other, more specialized team will operate for approximately six months or less.

C. Financing Considerations

As the cost estimate for the above equipment list indicates, the total is expected to exceed the $500,000 allocated to telecommunications equipment by US-AID. Consequently, other sources of financing some of the equipment might be sought. Some equipment will principally benefit ASECNA. It is not inappropriate to visualize this equipment financed from other sources. In particular, the French US-AID equivalent, "le Fond d'Aid et de Cooperation" (FAC), has already made substantial contributions to projects involving ASECNA. Similarly, other financing might be sought for the APT receiver and the facsimile recorder destined for Banjul. Inasmuch as this equipment is considered of second priority, even if other sources are not found, initial project success is not endangered.

The high priority equipment is estimated at $644, 900. Inasmuch as all of the estimates for this equipment have been made on the generous side, it is conveivable that this equipment could be purchased for the allocated $500,000. If not, other donors should be sought. The teleprinters are few in number, and if supplied by a U.S. manufacturer, would require a modest amount of special support. Purchase of Siemens 1000 models by another donor would alleviate this problem and tend to standardize the equipment in the region. Land-Rovers are another example of equipment which will not be of U.S. origin, and hence as

easily supplied by another donor. In addition to the present donors, representatives of FAC (France) have already indicated an interest in contributing to the project. The above items are as accessible to FAC as to US-AID.

D. Interim Action Items by WMO Experts

A number of action items have to be accomplished before detailed specifications of the telecommunications equipment can be finalized. Some of these can be undertaken immediately by WMO experts on-site. These items should be undertaken as expeditiously as possible.

1. Frequency Selection

As mentioned earlier the outstations should be equipped with four frequencies, two for day-time communications and two for night-time. Frequencies in adjacent countries should be different to avoid interference. A frequency plan should be developed by the project staff using advice from the telecommunications department of ASECNA in each country as to which frequences have the least congestion. After the plan has been developed, applications should be made to each of the national governments involved for allocation of these frequencies.

Further, the HF SSB transceivers at the national agrometeorological centres should have the frequencies of the corresponding national synoptic network operated by ASECNA. ASECNA's concurrence in this should be sought, and then application made for these frequencies to be allocated to the central transceiver. Because of the added back-up capability, ASECNA's concurrence should not be difficult to obtain.

Finally, application for allocation of frequencies for the microwave and VHF links should be undertaken as expeditiously as possible. The VHF link between Banjul and Dakar is likely to be especially time consuming because of the international character of the circuit and the relative lack of co-ordination that exists between the two countries.

2. Initial Station Selection

As discussed at the beginning of this report, final selection of stations has not been made in all countries. Design of the agrometeorological and hydrological network in each country should be completed as expeditiously as possible. This will determine with greater precision the total number of transceivers required and the exact ranges. These factors could have a bearing on the technical specifications of the equipment as well as the over-all financing of the telecommunications aspects of the project.

3. OPT Line Lease Arrangements

In Ouagadougou the link between the national agrometeorological centre and the ASECNA centre is expected to be accomplished by telephone line. Hence, costs and schedules should be prepared as soon as possible to determine the parameters of this installation.

In Niamey this mission has elected to prefer a dedicated microwave link for this purpose over a series of telephone lines leased from the OPT. This election was made because of the volume of telegraphic, voice, and facsimile traffic

expected to flow over this link. Costs of a leased line are estimated at $2,000 per line per year with an equivalent one-time cost for installation. Use of this alternative should be pursued until it is finally determined to be infeasible or non cost-effective.

Needless to say, these analyses should be completed in time to influence the corresponding equipment purchase by US-AID.

APPENDIX

PERSONS CONTACTED OR INTERVIEWED DURING STUDY

GENEVA

Mr. R. H. Foote	-	Director, Technical Cooperation Department, WMO
Mr. D. H. Nijhoff	-	Chief, Division for Africa, Technical Cooperation Department, WMO
Mr. B. Lagarde	-	Officer, Division for Africa, Technical Cooperation Department, WMO
Mr. Haldeman	-	Officer, Division for Africa, Technical Cooperation Department, WMO
Dr. G. Weiss	-	Director, World Weather Watch, WMO
Mr. H. Bari	-	Chief, Operations and Facilities Division, World Weather Watch, WMO
Mr. Elamly	-	Regional Officer, Africa, World Weather Watch, WMO
Prof. J. Nemev	-	Director, Hydrology and Water Resources Department, WMO
Mr. Connaughton	-	Agrometeorological Officer, WMO
Mr. E. Davy	-	Consultant in Agrometeorology to WMO
Mr. G. Cartwright	-	Science Attaché, U.S. Diplomatic Division, Geneva
Mr. Shatard	-	Chief, Africa Division, Technical Cooperation Department, ITU

SENEGAL

Mr. R. Vasic	-	WMO Expert (agroclimatologist)
Mr. B. Borna	-	Resident Representative, UNDP
Mr. Newmann	-	Deputy Resident Representative, UNDP
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Mr. Sene	-	Chef-Ajoint de la Division de la Météorologie
Mr. Mandengué	-	Directeur-Général de la Meteorologie, ASECNA

Mr. Pittavino	-	Officer, ASECNA
Mr. Gardnier	-	Officer, ASECNA
Mr. Giraud	-	Officer, ASECNA
Mr. Lerique	-	Hydrologist, ORSTOM
Mr. Schnoover	-	Programme Officer, US-AID
Sec. Sall	-	Secrétaire-Général du Ministère des Travaux Publics, Urbanisme et du Transport
Sec. Sy	-	Secrétaire-Général du Ministère du Developpement Rural et de L'Hydraulique

MAURITANIA

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Mr. Crete	-	Telecommunications Chief, ASECNA
Mr. J. Hoorelbeck	-	Expert, ORSTOM
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THE GAMBIA

Mr. P. Hutchinsom	-	WMO Expert (agroclimatologist)
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NIGER

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