AES COMMUNICATIONS STUDY

PHASE II: ALTERNATIVE SYSTEM CONFIGURATIONS

PHASE II REPORT

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1.0 INTRODUCTION

This report presents the results of the Alternative System Configuration Phase (Phase II) of a contract to study and recommend on a future communication system for the Canadian Atmospheric Environment Service. Phase II follows Phase I, the Information Collection Phase, and was intended primarily to develop alternative conceptual system configurations to meet the communications requirements determined in Phase I, to provide cost estimates for these configurations, to develop implementation plans relevant to a phased introduction of each alternative, to assess their impact on AES operations, and to recommend a preferred solution.

In actuality, Phase II has included the formalization of communications requirements, current, immediately required, and future; as well as the definition, costing and assessment of a number of alternative communication networks.

The traffic requirements and original communication system candidates were described in the Phase II Interim Report, issued on November 20, 1980. The future communication systems considered at that time were:

a) an upgrade of the present teletype network with its centralized message switch;

b) a variety of digital communication systems based on the use of the public packet switching networks as a backbone to interconnect major and intermediate processors, with regional networks connecting users and collectors to the backbone for data transmission; coupled with the existing facsimile networks; and

c) a range of alternatives in which single-carrier-per channel satellite transmissions are used to replace some or all of the land-line links.

Subsequently, only four of these alternatives have been developed in more depth, and are described in detail in this report.

These alternatives represent extreme possibilities: any practicable future system would undoubtedly contain a reasonable mix of the best features of each.

Chapter 2 of this report contains descriptions of four alternative systems. Each of these systems is designed to meet the current requirements and what have been described as the "immediate new services", i.e. traffic that AES would carry now if the network allowed it. For purposes of the study, it has been assumed that service is provided for:

a) major processors at CMC and Downsview;
b) intermediate processors (13);
c) user processors (72); and
d) users (148)
e) collectors (155)

The actual numbers used depend in a small way on the network architectures.

The upgrade option, an extrapolation of the current system; is described in Section 2.1. It is based in part on current plans and possible future developments anticipated by CNCP Telecommunications, the present carrier; and involves improvements to the present message switch and transmission facilities. It also considers a move to digital facsimile transmission from the present analog mode.

A terrestrial all-digital communication network in which message traffic, charts and satellite imagery are carried on a common, regionalized packet switched network is described in Section 2.2. High-speed regional networks are interconnected through a backbone network. Traffic, being in digital form, is integrated in the regions. This system has distributed switching, which could be centrally controlled.

Section 2.3 contains the description of an all-satellite network, in which every site is connected by satellite to a centralized switching centre, although any suitably equipped site could act as a distribution point.

A combination terrestrial/satellite system is outlined in Section 2.4. This system makes use of the fact that much of the same AES information is required by more than one user, by utilizing satellite broadcast of common message data, weather charts and satellite imagery, while maintaining an optimized digital communications network for collection and interactive traffic.

The costs of each of the systems are summarized in Section 2.5 in terms of circuit equipment, terminal interfaces, switching equipment, software development, installation, maintenance and ongoing circuit costs.

The very important costs associated with system design, specifications, writing, site preparation, installation, acceptance testing, and other aspects of implementation are discussed in Chapter 2 and elsewhere in the report.

For the purposes of the study, terminal equipment such as Visual Display Units (VDU), printers, fax recorders and so on are considered to be common to all alternatives. Terminal equipment is discussed in Chapter 3.

Network operation, assuming an AES-owned system, is discussed in Chapter 4.

The important characteristics that the future communication system must have, in addition to economical cost, such as flexibility and reliability are described below. In the face of uncertainty regarding funding, technological advances, organizational development and future requirements these criteria can assume an importance equal to that of cost. Each of the alternative systems is assessed in terms of the criteria and the results presented in Chapter 5.

An analysis of the systems, their strengths and weaknesses vis-a-vis AES requirements and potential application as part of future AES communications are presented in Chapter 6.

Recommendations for a future system are presented in Chapter 7.

1.1 ASSESSMENT CRITERIA

1.1.1 Introduction

The all-satellite, integrated terrestrial, one-way satellite and upgrade options are analyzed in terms of a common set of attributes and properties (collectively called "criteria") so their characteristics may be compared.

Some of the criteria are quantitative while others are qualitative. The accuracy of the quantitative data varies depending on the degree of certainty about requirements; the difficulty of system design, hardware and software specification and development; system maintenance and staffing; information storage and processing scenarios; aspects of operational procedures affecting communication requirements; advances, particularly digital, in facsimile and image coding and technology; and the phase-in scenario adopted for implementation of a new system.

The fundamental criterion is the ability of the proposed system to satisfy the current and immediately required new communication requirements. This ability is demonstrated as part of the description of each system, wherein just how each system does provide the capacity is shown. Once a specific communication system is proposed, even though designed to meet specific requirements, it will have a capacity to handle traffic other than that it was designed for. This excess capacity can be used in a variety of ways as discussed in the "Flexibility" section.

Provided that a system can satisfy the communication requirements, the next most important criterion is whether or not it could be implemented within budgeted cost and estimated schedule. In other words, important criteria besides the dollar cost are the reliability of the cost estimates, uncertainty about developmentability, technical feasibility and availability of the hardware and software, reliability of time and manpower estimates, deliverability and implementability.

1.1.2 Criteria

The criteria chosen to characterize the systems are:

a. cost for current and immediate new requirements, except for interactive computer access and distribution of radar imagery;

b. flexibility;

c. implementation;

d. risk;

e. service of Canadian interests;

f. reliability;

g. security;

h. constraints; and

i. acceptability.

In detail, the criteria against which the systems will be compared are:

1.1.2.1 Cost

The cost of systems to provide current requirements and all new immediately required traffic has been estimated. The components of the cost are capital equipment and nonrecurring costs, and recurring operational and maintenance costs.

The capital cost components are:

1. Hardware - computer switching equipment;
   - data terminal interface equipment; and
   - circuit interface equipment.

2. Software - purchase of vendor supplied software packages.

3. Note that the costs of taking a system through the stages of detailed specification, system design, project management, procurement, delivery, installation and turnover are not included in these costs.

Recurring costs are:

1. Circuit costs.

2. Maintenance, calculated as one percent per month on capital costs.

3. Staffing for network software maintenance, routing, service alterations and for manning of the network control centre, including network maintenance management.

1.1.2.2 Flexibility

Flexibility is defined in terms of:

1. Potential to accomodate growth in existing traffic or to add stations of a character similar to those now defined.

2. The ease of accommodating changes in traffic routing and scheduling in the network control software.

3. The ability to accommodate new and presently unknown future services.

4. The provision for non-AES user access.

5. The ability of the system to accommodate new operational procedures.

6. The ability of the system to incorporate new technologies.

7. The response of the system during abnormal weather conditions, major power blackouts, and other disruptions.

1.1.2.3 Implementation

Implementation, here, is concerned with the way in which the systems could be introduced into service. The relevant aspects of implementation:

1. Phase-in, or the ease of transition from the current system to a new system.

2. Training requirements, both for users of the system and operators of the network.

1.1.2.4 Risk

One of the criterian which any new system must be assessed against is the risk involved in starting an implementation of it. This risk has been assessed in terms of:

1. Potential investment loss, that is the amount of money and time which must be invested before the new system operates to any degree whatsoever, and which would be lost if, for any reason, implementation were to be terminated prematurely.

2. The probability of actually meeting communication needs within budgeted costs and estimated times, after the system has been clearly defined.

3. The confidence in the technical feasibility of the proposed system.

4. The effect on the system of errors in traffic estimates.

1.1.2.5 The Serving of Canadian Interests

The proposed systems are assessed in terms of their compatibility with trends in communications technology, government policy, and Canadian industrial concerns; specifically in terms of:

1. The possibility and cost impact of utilizing shared communication services and facilities with other government agencies and departments.

2. The potential for "contracting out" parts or all of the system, for design, implementation and operation.

3. The amount of Canadian content in the system.

4. Compatibility with industrial and/or government policies.

5. Export potentials generated by the procurement of such a system in Canada.

1.1.2.6 Reliability

The reliability of the systems is of major concern. It is assessed in terms of:

1. The reliability of individual components and links.

2. The vulnerability of the network to critical failures.

3. The maintainability of the system.

1.1.2.7 Security

International agreements bind Canada to confine weather information within national boundaries in times of emergency. The current interpretation of this commitment is that weather information carried on land lines (and their micro- wave components) within national boundaries are considered to be within national control and therefore to meet the spirit of this commitment.

1.1.2.8 Constraints

The systems are assessed in terms of:

1. Regulatory constraints.

2. Tariffs.

3. Interconnectability, with the National Weather Service, DND, and so on.

1.1.2.9 Acceptability

The new system should be user friendly, its use compatible with familiar procedures. The system should be functional and perceived by its users as a positive enhancement of their capabilities. The acceptability is assessed in terms of:

1. Its acceptability to AES operational, development and managerial personnel.

2. Requirements for retraining and re-education. This includes not only the amount of retraining that is necessary but also the need for re- orientation of the attitudes of a large proportion of users.

3. The perception of the new system as a threat or as an enhancement to the work function of individuals and groups.

5. Compatibility of the system with capabilities of AES personnel.

6. Compatibility with long-range AES information processing plans, increasing government decentralization, the regionalization of AES, and its role vis-à-vis other federal and provincial government departments and agencies.

7. Compatibility with trends in communications, computers and terminals.

1.2 REQUIREMENTS

A number of interim documents were prepared after the completion of Phase I of this study. These documents specified the service and traffic requirements for the conceptual designs described in Chapter 2 of this report. They contained the following:

- generalized definition of an AES nodal hierarchy and of AES traffic types;
- summary of negative aspects of today's AES networks;
- summary of service specifications for today;
- summary of AES-priorized immediate new services;
- summary of AES-priorized estimates of long term new services;
- summary of generalized traffic for today's services and immediate new services.

The relevant documentation has been integrated into Appendix A.

Although these service requirements and the resulting traffic figures were used for the generation of the conceptual system designs described in Chapter 2 of this report, the degree of confidence that can be placed on the estimates of immediate new services and future requirements is not high. Many uncertainties face AES management and planning and the resulting uncertainty in future requirements for communications has been significant. This uncertainty is not ameliorated by the absence of an AES communications planning function.

2.0 SYSTEMS DESCRIPTIONS

This chapter contains descriptions of four potential future communication systems. The descriptions are preceded by an introductory discussion of networks in general for those readers who are unfamiliar with subject.

The alternative future systems: an upgrade of the present AES system, an integrated digital system, an all-satellite system, and a satellite broadcast/terrestrial point-to-point network combination are described in detail in this chapter. The reader who is not interested in the details of each option may wish to read the introductory portions of each section and proceed to the assessment of each contained in Chapters 5 and 6.

2.0.1 Introduction

2.0.1.1 General Comments on Networks

Communication networks may be characterized in a number of ways. The systems described in this chapter represent fairly extreme examples of different approaches, and illustrate the advantages and disadvantages of those approaches.

A network consists of terminals, lines and switches. Interconnections may be established on a permanent or temporary (per call) basis; the links established may be used exclusively by the parties connected, or may be shared by many users; the switching may be centralized or distributed; use may be made of shared, public facilities or dedicated, leased lines; and traffic of different types may be integrated and carried on the same network, or on separate networks.

Perhaps the most common network configuration is the Star Network, in which each terminal has a point-to-point connection to a central site. Because communication lines are expensive, attempts are made to optimize the way in which they are used. The most common configuration uses multidrop or multipoint lines, which are lines with two or more terminals connected to the one communication line. To control the flow of data in such a network, a set of line control procedures are necessary. Multidrop lines are particularly suitable for applications in which each terminal transmits intermittently and does not need to utilize the line constantly. They therefore make more efficient use of the lines in the network than if each terminal were connected to a central site by point-to-point lines.

In many applications, there may be terminals that only need to transmit data for a relatively short time per day. It would not be economical to install a private line for each terminal when the line is being used for such a small part of the time. In these cases use is made of various switched networks that are available. Switched networks enable establishment on demand of point-to-point connections between two terminals and to maintain a connection for as long as required.

There are three basic types of switched networks:

- circuit switched networks such as the telephone and the Telex/TWX networks;
- packet switching networks; and
- broadcast networks.

A telephone network consists of many telephone exchanges or switching offices linked together in a mixture of mesh and hierarchial networks. Subscribers' telephones are connected into a nearby telephone exchange by physical pairs of wires. The telephone exchanges themselves are large switching units that enable subscribers to set up point-to-point connections between telephones. Around local metropolitan areas telephone exchanges tend to be connected by cables consisting of hundreds of pairs of wire. Over longer distances coaxial cables or a combination of coaxial cable and microwave radio systems are used. In Canada, among other countries, satellite communications are used. The virtue of satellite communications is that the satellite can provide very wide coverage on the ground and within the field of view of the satellite it is theoretically possible to set up an earth station and immediately receive very high quality communications. New communications media such as optical fibre are emerging.

The communication channels that can be derived from the telephone network can be used for many purposes. The major user of the normal commercial telephone system is the user with a telephone. Some of the other uses for the telephone network, which usually carries voice conversations, are:

a) <u>Telex Network</u>

The telex network operates in a manner similar to the telephone network except that the terminals are teleprinter devices rather than telephone handsets.

b) <u>Telegram Networks</u>

Common carriers usually provide some form of telegram network which uses communication lines derived from the telephone network but instead of using the conventional telephone exchanges for switching, uses different switching equipment that is often computer-based.

c) Public Message Switching Systems

Many carriers provide an automatic switching service to their customers. These systems provide communication between terminals and a central computer to form a store and forward message switching system. The computer can store messages in its mass storage system and forward them to one or to many receivers. Input messages can be queued on the mass storage and output when the terminal is ready. Priorities can be built in so that urgent messages can take precedence over routine traffic. If a terminal is out of action the other terminals can still send messages to it which will be stored until the terminal is ready. If the same message is to be sent to multiple destinations, the calling terminal sends one copy of the message and the computer forwards it to the receiving stations. Because there is a computer in the system, the network allows communication between terminals that would otherwise be incompatible. Many other facilities can be provided such as a retrieval mechanism whereby specific messages can be recovered from the mass storage system. Also, computers can keep track of traffic statistics to provide data for the network manager so that plans for the future can be completed.

Lines may be leased from communication carriers and used for purposes other than telephone traffic. Leased lines normally by-pass the switching equipment and the telephone exchanges, which provides a better quality connection than if the switched network is used. Leased lines may be used for data transmission.

Data may be transmitted through the switched telephone network on either dial-up or dedicated, leased lines. In the latter case the lines are the same as those used in the telephone network except that they by-pass the switching equipment in the telephone exchanges. Dial-up lines can now be used for a range of data speeds up to 9600 bits per second. It is possible to obtain even higher speeds, such as 56,000 bits per second, with leased broadband circuits.

Common carriers are being increasingly pressured to provide improved data communications facilities. Users want higher transmission speeds, lower error rates, faster connect times and lower costs. An ideal situation from the user's point of view would be one whereby a terminal could be connected to a computer instantaneously and where the user pays only for the number of bits that are transmitted. If we could achieve virtually instantaneous connect times with a public switched data network, then even transaction-oriented terminals could establish a fresh connection for each transaction. The call would be held for the duration of that particular transaction and would then be cleared. Modern switching systems cannot achieve the ideal but they can set up calls very quickly.

Digital transmission systems have been developed that allow higher bit rates. By using a series of time division multiplexers it is relatively simple for a carrier to set up a digital transmission system that provides permanent point-to-point or multipoint facilities for its users. Owing to the heavy investment in transmission equipment digital networks do not extend beyond major trunk routes. Those users who have terminals and computers close to the digital network will be able to interface to the network using relatively inexpensive interface equipment rather than the modems used on the telephone network. Users who are a long way from the digital network use conventional lines and modems to get to the digital network.

Modern switching technology enables circuit switching to be incorporated into a Time Division Multiplex (TDM) transmission network. It becomes possible to use a switched service for a transaction-oriented system where a new connection is made for each transaction.

Apart from the activities involved in setting up and disconnecting a call, a digital network is transparent to the user. This means that, although delayed in time, the information that comes out is the same as the information that goes in. The terminal equipment at each end of a connection must therefore be compatible in order to use the network. This is the same state of affairs that exists with the telephone network. Being transparent to data, the network is also transparent to user protocols. To exchange information between different systems, both systems must be compatible from the point of view of speed, code, format, error control method and overall protocol.

In 1968, a study program was established by the International Telegraph and Telephone Consultative Committee (CCITT) to set the basis for international standardization, leading to the implementation of public data networks. In 1972, the first series of recommendations were approved. The main thrust of the work, up until 1976, was directed towards circuit switching. In 1976, however, a major diversion in direction started to take place with the sudden appearance of the X.25 Virtual Call Packet Switched Service. As a result, the emphasis on circuit switching in Public Data Networks (PDN) has been subsequently overshadowed by the fascination for packet switching technology. Circuit switching has not passed into oblivion but is being actively pursued by the Nordic countries, Japan, The Federal Republic of Germany, Italy, Hungary and Canada. A current open question is whether or not an efficient, fast circuit switched operation will prove more effective than the popularized packet switched service of X.25.

Data communication networks are currently provided by common carriers and by the computer manufacturers. Common carrier networks are of the leased, dial, fast circuit switched and packet switched types which provide digital transmission service between end users. The network designs of computer manufacturers provide the ability for sharing processor resources among locations and providing improved system availability through remote back-up.

Today there is a way of looking at networks in terms of layered architectures that are used by all of the experts. Today's layered architectures are rule books upon which the implementations are based. They consist of a collection of protocols which are the rules by which physically separated entities interact. In this context, a number of private network implementations have evolved and the common carriers have agreed upon a number of closely related standards.

Typical of the commercially provided computer networks are the Systems Network Architecture (SNA) offered by IBM, and DECNET offered by Digital Equipment Corporation. SNA is a hybrid, peer hierarchical structure in which any terminal can gain an access path to any of the applications in any of the host computers. It is, in effect, a mesh of trees connected by physical paths between communication controllers. DECNET, based on the Digital Network Architecture (DNA), is a peer computer network with machines connected together in a mesh or hierarchy. Both of these networks are based on a number of protocol layers which provide a physical link between the nodes, provide path control, transmission control, data flow control, presentation services to the end users.

In the computer networks such as SNA and DECNET, the physical transmission level function between nodes in the network is, of course, provided by the common carriers. Carriers have been investigating whether there is any technical reason why other functions of networking, at a higher level than the transmission level, might not also be provided by them.

At the transmission level, an urgent need of the data processing community to have dial-up service with much faster connect times and much shorter minimum billing increments than is provided in the ordinary voice grade dial-up service is being met by a protocol called X.21 which can be used for dialing and disconnecting at data processing bit-stream speeds, thus serving as the basis of fast circuit switching common carrier networks.

Packet switching has been inspired by the idea of sharing communication channel capacity across a number of users by implementing the same time-slicing philosophy that had earlier proved so successful in sharing the execution power of a single processor across many user processes. Every user node that connects to a packet switched common carrier makes a contact with the carrier by following standard protocols to hand him bit streams already segmented into packets, with each packet supplemented with a header saying to which other user node he wishes the packet delivered. Widespread interest in packet switching on the part of the carriers has led them to standardize this contract in the form of the CCITT Recommendation X.25. This contract includes an agreement on the electrical interface, the data link control, how the remote user is to be addressed, packet size, how the flow of packets toward and out of the carrier's network is to be regulated, and how certain error recovery actions are to be effected. It also includes some network control functions such as protocols for establishing and disestablishing the access path. Thus the X.25 standard descibes the way in which user nodes agree to exchange packets with the carrier network. Information may be exchanged through a packet switched network over a full duplex path, termed a virtual circuit, or as a datagram in which the duration of the contract is essentially only one packet long.

Fast circuit switching and packet switching both offer the user the economies of paying for the transmission service only to the extent that it is used. Fast circuit switching has the particular advantage over packet switching, that once the transmission path has been set up, it is totally transparent. That is, except for uncontrollable random errors, the bit stream out is the same as the bit stream in for a period of time whose duration is up to the user. Packet switching, although highly non--transparent since the user is required to adhere to what the contract says about packet length, rate of flow, header structure and so on, does allow the carrier to offer the user more of the access path function than does fast circuit switching and it allows him many freedoms in buffering, delayed delivery and so on. The carriers will provide user interfaces that perform the packetizing function and call set-ups for unsophisticated users, so that they are unaware that they are using a packet network.

Even though networks have been growing more complicated, they are becoming easier to dissect and understand as systematic formalization and layering become more pervasive in the implementations. One reason for the persistence of complexity is that, until now, the architects have carried a heavier burden than is commonly realized of maintaining compatibility with individual software and hardware product offerings that preceded the evolution of systematic, clearly layered sets of network protocols. These earlier offerings are gradually disappearing and current releases are adhering more and more to the strict terms of the architecture. The layering and modularization of hardware and software means that new ideas can be more easily incorporated without producing system-wide disruptions.

It is clear that evolution of Public Data Networks is towards single integrated common carrier offerings which can provide a variety of services which match the users' capabilities and traffic characteristics. These trends are evident in the rapid evolution of Public Data Networks offered by Canadian common carriers.

The TransCanada Telephone System (TCTS) was the first common carrier in the world to introduce a nationwide digital data communication system that was available on a commercial basis. This system, called Dataroute, was introduced in 1973. Dataroute consisted of a 56 kilobits per second communications path linking Vancouver, B.C. to Saint John, New Brunswick and Canada's nine largest cities. Users in the Dataroute serving areas were connected to the trunk by digital local loops, those farther away accessed the system through existing dial-up or analog private line facilities. Each user was connected to the local loop through a black box interface device. It permitted connection of compatible terminals operating at 110 to 19.2K bits per second. Dataroute was created to meet the specialized requirements of data and computer communications users; providing direct digital transmission whereas elsewhere transmission of digital information had to utilize networks originally designed for voice characteristics. Dataroute provided full duplex, private line, serial, digital data transmission between designated serving areas and a broad range of synchronous and asynchronous speeds. It provided an end-to-end service from one business machine interface to another. It was primarily a private line service that could accommodate dial access at the remote end of a two point channel. It provided point-to-point private line, multi-point and multi-drop private line, and dial access facilities. Dataroute was introduced to take advantage of three major advantages of data transmission. First, the relative ease in overcoming noise and distortion resulting in transmission at least ten times as accurate as comparable transmission on private anlog lines; second, exploitation of inherent efficiencies enabling introduction of new data services at more economical prices than was possible with analog technology; and third, the elimination of complex and costly modems to convert digital signals to analog and vice-versa thereby eliminating two potential error sources. Dataroute remains the basic backbone of new network services and continues to provide low cost, high accuracy performance for those applications which continue to operate in a private line environment. It, in common with most private line systems, suffers from low facility utilization.

To increase the utilization of existing trunks and switches, TCTS introduced a universal shared intelligent network for data communications called Datapac. Datapac is a national data network designed to accommodate many users, many uses and many types of equipment, and to undertake a number of communications functions. It is build around nodal switches, with digital Dataroute transmission facilities linking these switches. It can provide a range of services to match the varying characteristics such as response time and volume that define the many applications for data communications. It is a multi-application network with provision for handling query/response, time sharing, bulk transfer, data retrieval and data collection functions among others. Datapac is a packet switching network. Packet switching as used in the Datapac network makes possible a range of functions and benefits such as:

1. By using one common agreed standard for the format of the packets, it is easier for many types of terminals and computers built by many manufacturers to communicate with one another.

2. Packet switching nodes accept streams of packets from many sources and dynamically interleave them on digital high capacity internodal trunks. This means a more efficient use of transmission facilities and therefore reduced investment of lower costs.

3. The network nodes route individual packets of data through the network along the most appropriate path, using a system of alternate routing. In some cases, a series of packets from one terminal may be split up and sent along different routes, depending on volumes of traffic, trouble conditions and other factors. At the receiving node, they are reassembled in their correct sequence and delivered to the destination. This gives a higher degree of protection should one particular transmission route become congested or interrupted.

4. The packets are transmitted from node to node with overall error control. Accuracy is estimated to be in the region of one undetected packet error in 10^{12} packets transmitted through the network.

5. The switching nodes are programmable computers and can be instructed to undertake a variety of communications processing functions that are normally undertaken by the host computer or not available on other sytems.

6. Datapac can provide several kinds of network operations from fully switched to closed user group. A closed user group is a private system within the matrix of the shared network. It bars access to non-authorized terminals and allows terminals within one group to communicate only with accredited terminals in that same group.

7. Datapac allows a charging system based on the amount of information sent and not on connect time or bandwidth leased. Datapac tariffs are less distance sensitive than the networks of the past.

8. The intelligence of the network allows sophisticated diagnostic systems to be built-in to oversee and report on the operation of the network. In the Datapac network, a network control centre constantly monitors the performance of the network. In addition, critical elements in the network have backup facilities on standby ready to take over should there be any indication of deterioration of service. These are features that can be designed into a shared network but would be uneconomical to include in a private network.

To implement a packet switching network that is universally available and shared by many users, it is necessary to have a protocol that is common to the network users and the communications carrier. Such a standard protocol facilitates users at the diversity of terminals in terms of both manufacturer and function to access the network and to communicate with one another. Datapac uses the Standard Network Access Protocol (SNAP), known internationally as X.25. The adoption of this standard facilitates the interworking of intelligent networks in many countries.

Data transfer through the Datapac network using SNAP is accomplished through the use of virtual circuits. These are logical associations between sending and receiving stations, using the information carried in the packet header and the intelligence built into the network. Two types of virtual circuits are available: switched virtual circuits and permanent virtual circuits. A switched virtual circuit is a temporary, network-recognized, logical association between two terminals. A virtual circuit is established between the terminals at the beginning of a call and cleared at the end of it. The use of permanent virtual circuits eliminates the need for call set-up as the terminals are always in the data mode. A permanent virtual circuit is a constant logical connection between two terminals.

Datapac's potential is towards the creation of broad, new communities of interest as application oriented services are developed. Its effectiveness depends largely on the number of users tied into the network. The accuracy, reliability, economy and flexibility of universal shared networks depends on a large number of users with a large number of applications.

Canada's other major common carrier, CNCP Telecommunications, also offers digital data communication trunks and networks. The CNCP nationwide, publicly accessible, computer-controlled data communications network is called Infoswitch. The Infoswitch network is different from the Datapac network in that it provides digital circuit switching as one of its basic services, as well as packet switching. The digital switching service is called Infoexchange and it provides a direct, physical digital link for the duration of a call. The packet switching service has two different modes of operation. The first, called the Infogram service, allows the user to form his own packets. The second, called the Infocall service, performs the packetizing and depacketizing of the data for the user.

The Infoexchange digital circuit switching service provides fast call set-up time (less than one second) and optional features such as hot line, abbreviated addressing, and a number of other digital telephone-like options.

The Infocall packet switching technology service appears much like the circuit switched Infoexchange service to the user. It also has a number of the optional features. Infocall users may interconnect with international networks in England, Australia, France, Italy, Switzerland, Germany, the Netherlands, and within three years Belgium, Denmark, Ireland and Norway. Infocall access also has an interconnection with the U.S. Tymnet computer service.

The Infogram service utilizes end-to-end packet technology. It has a network access protocol that will essentially be that of X.25 in the near future.

CNCP provides a number of interfaces to the Infoswitch network such as terminal-to-host computer concentrators and Infopoll service to polled multi-drop lines.

The Infoswitch network offers the following benefits to its users: The end user can choose the service which best suits his needs and benefit from the respective tariffs. For batch type transmission, the subscriber may use the circuit switched Infoexchange service and pay for connect time, while for a query/response application, the user may choose the Infocall service and pay primarily for the volume of data transmission. In addition, the subscriber will be able to use either the Infoexchange or Infocall service on a selective call-by-call basis. The network is characterized by a choice of tariffs, nationwide acessibility, a variety of speeds, codes and link protocols, a wide range of optional service features, fast call set-up, low delay in the network, high network availability and reliability.

A combination of circuit switching and packet switching means that this network can serve users with a wide variety of communication requirements.

A third category of network is the broadcast network in which all users can send to all others and all users receive all of the information. The Xerox-Digital-Intel "Ethernet" Office Communication System is of this type. Users must have the intelligence to select only the information they require, and to be able to identify when they are permitted to transmit. The DOC SLIM TDMA satellite data transmission scheme is a broadcast network, as are many mobile radio systems.

2.0.1.2 Current AES Networks

Currently, AES operates three distinct, separate networks. Data collection and message distribution is carried on dedicated, leased, multidrop, low-speed teletype circuits with a centralized store-and-forward message switch. Charts are broadcast as analog signals on leased, highly-conditioned voice grade telephone lines. Likewise, satellite photo and radar imagery is distributed on dedicated telephone line circuits. All other traffic is carried on the "Off-Network", which consists of a collection of radio, satellite and other circuits.

Thus, the system is fixed, centrally controlled, uses leased lines, and has separate facilities for traffic of different characteristics. Access to the central message switch is available across the country, even though it is physically located in Toronto. Additions to the system and changes in routing are very difficult and slow because of the difficulty in programming the antiquated switch.

The message system consequently is inflexible, but does allow any user who connects to the central switch to have access to any of the data stored there. Likewise any user who requires charts or photo images may obtain a drop on the fax lines.

2.0.1.3 Upgrade Option

The upgrade option is based on a mix of a new central message switch, and increased use of regional computers for regional networking via a public packet network. It also envisages a separate facsimile network addition to connect the major AES centres and establishes the facility for computer to computer communications via a public packet network. The basic thrust is to introduce the use of public packet networks for AES communications where it is beneficial to do so. This would allow more point-to-point interactive traffic, message flexibility and speed, at fairly high circuit costs.

2.0.1.4 Integrated Terrestrial System

The all-digital terrestrial packet-switched system uses a public packet network to interconnect a number of regional packet switching nodes that in turn would drive regional multidrop lines to the UP's. Users and Collectors would be serviced by multidrop lines from the UP's. Chart information would be digitized and fully integrated. Photo imagery would be transmitted on a separate network to the regional nodes where it would be integrated with the traffic on the regional networks.

This system is a hierarchy of distributed switching, which could be centrally controlled, that would allow complete flexibility in point-to-point routing of all traffic.

2.0.1.5 The All-Satellite Option

The satellite system is a star-connected circuit network with most traffic being broadcast continuously. Separate message channels are provided directly to each site as well. The satellite system has a central message switch, but can be used to maintain local data bases in an up-to-date status. Messages and facsimile traffic are transmitted on separate satellite channels, i.e. on separate networks.

2.0.1.6 The One-Way Satellite Broadcast

A system which utilizes satellite broadcast of the point-to-multipoint traffic in conjunction with terrestrial networks has also been described. It has a central message switch connected by public packet networks to the Processors, Collectors, Users and the satellite broadcast terminals. It provides point-to-point connectivity and widespread, flexible distribution.

2.1 UPGRADE OPTION

2.1.1 Introduction

In the System Selection Phase Interim Report of November 20, 1980, the Upgrade Candidate System was retained for further investigation and costing during the trade-off phase of this study. The reasons for including this candidate are as follows:

1. short term solutions may be required to carry AES over until a new system is available;

2. to provide possible components of an overall phase-in plan to a new system;

3. to provide a reference scenario where shorter term rather than longer term planning has been applied;

4. to provide a viable alternative approach to improving AES communications.

In the Interim Report, the main components of an Upgrade were presented as follows:

1. Upgraded message network;

2. DIFAX network;

3. Present photofax network expanded;

4. Interactive requirements met through development of the use of the public packet network;

5. Batch cpu-cpu to be carried on public packet network.

These components have been essentially maintained in the further development of the Upgrade Option. It must be understood that no claim is made that this option has been optimized or analyzed exhaustively. For the purposes of a trade-off analysis, it was considered to be sufficient to present a reasonable upgrade scenario to be costed. To this end, a number of trade-offs were analyzed and will be described below. A selection for costing and analysis is then presented.

2.1.2 Upgrades Investigated

2.1.2.1 Message Traffic

2.1.2.1.1 Requirements

The traffic requirements to be met for the baseline and immediate new services are described elsewhere (Appendix A). These can be summarized to consist of roughly a doubling of volume involving all levels of the network. Performance and adaptiveness problems as outlined in Appendix A.

2.1.2.1.2 Potential Upgrades for Message Traffic

Two scenarios were investigated: one based on the presence of local storage at UP's; another based on remote access by the UP's to their nearest regional weather centre's computer. The reason for looking at both of these is to measure the cost implications of both. Tables I and II highlight costs for both scenarios.

CHANGE: COSTS EXCLUDE TERMINAL EQPT AND PRINTERS	ONE TIME DEVELOP (K$)	CAPITAL (K$)	CHANGE IN ONGOING MONTHLY (K$)
- Replace switching computer and re-program	300		
- Provide each of the IP's with their own two-way 2400 b/s line to the switching computer			33
- Eliminate overhead circuits to IP's			-7
- Eliminate IP's collection and distribution drops			-3
- Increase speeds of distribution circuits to 300 b/s			14
- Purchase storage at UP's @12K		864	
- S/W for Terminals	100		
- Double capacity CMC to switch			5
TOTAL	400	864	51

TABLE I Message Upgrade (Remote Storage)

- Replace switching computer and re-program	300		
- Provide each IP with their own two-way 2400 b/s line to the switching computer			33
- Eliminate current overhead circuits to IP's			-7
- Eliminate distribution circuits			-15
- Eliminate collection circuitry to UP's			0
- UP's access to nearest IP via DATAPAC; 1200 b/s HD; no new cpu's, just extra memory, MUX's, and controllers		177	46
- Double capacity CMC to switch			5
TOTAL	300	177	62

TABLE II Message Upgrade (Remote Access to IP Storage)

An analysis was done on the cost-effectiveness of using public packet facilities as apposed to dedicated lines to serve all of the UP's in the AES and DND for the remote access costing described in Table II. Of the 72 sites, 45 locations (or about 60%) are on the public packet network used for costing purposes. Based on an assumed volume of 70 kilopackets per month per site, the public packet network was found to be more cost effective on average. (Actual traffic volume between the Regina UP and the Winnipeg IP for January, 1981 was 42 kpackets).

For the costing provided in Table II, all UP's which are not on the packet network were costed as having access by leased line to the nearest packet network access point.

It became clear that further analysis and optimization would result in the more remote location being served by low speed (multidrop) dedicated lines and on-site storage. An omptimized mix of facilities should lower overall costs sufficiently to warrant the added complexity.

2.1.2.1.3 Selection for Upgrade Candidate

The upgrade outlined in Table II was included in the trade-off for the following reasons:

- decrease dependence on central switch;
- introduce possibility of competitive carrier offerings;
- introduce redundancy through packet network, provide access to packet network;
- regional communications improved;

- provide more flexible base for planning;
- operating costs not significantly greater;
- provides very flexible access to data for UP's.

It should be noted that these scenarios are both predicated on the continued use of a central message switching computer. The replacement of this computer with a higher capacity and more flexible machine is an essential requirement. The assumptions used for the costing in Table I and II are that recurring port, access and other computer charges will remain unchanged and that there will be a one-time software development cost for custom enhancements specifically required by the AES system.

2.1.2.1.4 Revised costs based on CNCP Proposal

On February 11, 1981, CNCP made a tentative proposal to AES for the replacement of the Collins 8500 switching computer with a dedicated system based on the DEC VAX11/750. Suggested costs associated with this system were as follows:

Hardware and HW/SW support (60 MO.)	34K/MO
or (120 MO.)	30K/MO
One time software costs (over 25 MO.)	8K/MO
or (over 36 MO.)	6K/MO
ACU for each line attached to system	90/MO each
Tariffed peripherals (3 VDU's and printers)	751/MO

Current extended area tariffs would no longer apply and circuitry must be costed right to the computer.

This proposed system would provide:

Speeds up to 9600 b/s
Up to 64 asynchronous and 8 synchronous ports
X.25, BSC, HDLC, SDLC compatibility
Access to Telex, Infotex, Infoswitch
2128 MB Disk Drives
Networking options using DECNET
and other features.

A revised cost estimate was prepared for the selected Upgrade candidate described in Section 2.1.2.1.3, based on these tentative proposals, since the assumptions used previously to determine costs were not appropriate. This revised costing is shown in Table III below.

It should be noted that the CNCP proposal when applied to the current teletype network results in about a $4K/month increase in ongoing costs. It is also noted that AES would have to develop a policy for costing to users. Under the new proposal, a user located far from Toronto would pay more for line charges than one located near Toronto. In addition, a policy would have to be developed for partial cost recovery of the computer rental costs.

Finally, since a significant portion of the new costs would be fixed, future off-loading of the proposed new switching computer would not result in as large a reduction in costs as under the present arrangement.

CHANGE: COSTS EXCLUDE TERMINAL EQPT AND PRINTERS	ONE TIME DEVELOP (K$)	CAPITAL (K$)	CHANGE IN ONGOING MONTHLY (K$)
- Remove distribution circuits, overhead circuits, 2 CMC lines, all port, access, polling charges and computer (C8500) charge			-54
- Add new CPU costs (120 MO.'s) and ACU's for 35 AES circuits			33
- One time programming of new system	300		
- Add new 2400 b/s links to IP's and CMC, and costs of hauling low speed lines to Toronto using Infodat			21
- UP's access to nearest IP via DATAPAC; 1200 L/S HD; no new CPU's, just extra memory, MUX's, and controllers		177	46
TOTAL	300	177	46

TABLE III

Revised Table II Based on CNCP Proposal

2.1.2.2 Facsimile (Chart) Traffic

2.1.2.2.1 Requirements

The requirement for chart traffic can be summarized as follows:

- roughly a doubling of traffic between CMC and the IP's decreasing in a number of years as digital and gridpoint information replaces charts;
- selective distribution required for roughly 30% of CMC to IP charts;
- little change (10-20% increase) in regional charts.

2.1.2.2.2 Potential Upgrades for Chart Traffic

A number of possible proposals were investigated including digital fax as suggested in the interim report. These proposals are as follows:

(a) Digital Fax Network

An upgrade to digital facsimile provides an overall three-fold increase in throughput at between three to four times the system cost of today for leased equipment, or an 18% reduction in operating costs for purchased equipment. Non-recurring costs are about $150K for the leased system and about $3.5M for a purchased system. High quality and fast chart transmission along with selectivity at the receiving end are the chief advantages.

(b) Add Multidrop Trunk Between IP's and CMC

Since the principal requirement for an increase in chart traffic is between CMC and the IP's, increasing the capacity between these centrers is probably sufficient. This need can be met by the addition of a separate single multidrop circuit across Canada connecting these centres. Operation would be scheduled broadcast with CMC being the prime originator. IP's could also broadcast any special purpose charts for the use of CMC or the other IP's (e.g. oceonographic or ice charts). Circuit costs would be roughly $10K per month. Analogue or digital equipment could be used depending on whether the three-fold cost difference is justified by the requirements for doubling of traffic and higher quality (see Chapter 3 for Terminal Equipment costs).

(c) Re-configuration of Current Network

Requirements could in part be met by a star network centred at CMC. The increased cost for circuitry is estimated to be $20K per month. CMC must then be able to transmit different products on up to 6 separate lines. To introduce this capability at CMC has been costed at roughly $400K for hardware and $200K for software. Inter-regional transmissions are not facilitated in this way.

(d) Selection for Upgrade Candidate

The addition of an analog multidrop fax trunk connecting CMC and IP's and with all sites capable of transmitting is selected for the following reasons:

- meets apparent traffic requirements;
- lowest cost and disruption;

- allows inter-regional transmission;
- can be easily removed in future when predicted traffic decrease occurs.

Costs for this option excluding terminals is roughly $10K per month for circuitry and $50K capital for interface equipment at CMC.

2.1.2.3 Facsimile (Photo) Traffic

2.1.2.3.1 Requirements

Expand number of stations to include all of UP's.

2.1.2.3.2 Photo Traffic Upgrade

It is proposed that the network be expanded to that of the current 1801 chart facsimile circuitry. Circuitry cost increased would be about $37K per month.

2.1.2.4 Batch Traffic

2.1.2.4.1 Requirements

- to carry a 33 fold increase of gridpoint data from CMC to the IP's;
- to carry a variable amount of climate archive data between HQ and IP's;
- to allow other cpu-cpu interaction.

2.1.2.4.2 Batch Traffic Upgrade

It is proposed that the computer at CMC and HQ be interfaced to a public packet network and that extra ports be provided at IP's for computer to computer communication. Costing is as follows:

	Development (K$)	Capital (K$)	Monthly Recurring (K$)
- packet interface and controller at CMC for 3 X 9600 ports to net (6 X 4800 virtual ports)	100	100	1
- packet interface and controller at HQ for 1 X 9600 port to net (2 X 4800 virtual ports)	50	50	.5
- extra capacity at IP's; (assume already interfaced to network to service UP's)		50	.5
- access to net			3
- network use (based on gridpoint data only)			1
TOTAL	150	200	6

Table IV

To develop higher layers of software for communications between computers will require in house PY's.

2.1.3 Upgrade Costs

Total costs for an upgraded system are calculated as follows:

(Based on CN-CP Proposal)

2.1.3.1 Current Costs (Excluding Terminals and Radar) (79-80)

Teletype Network	$ 119 k/mon
Paperfax	50
Photofax	11
Misc.	15
	195 k/mon (55% of total cost with terminals)

2.1.3.2 Upgrade Option

	Devel.	Cap.	Change in O/M
Teletype and interactive access	300	177	46/MO
Analogue fax trunk		50	10
Photofax expansion			37
Batch	150	200	6
Total (excluding terminals)	450	427	99 increase

2.1.3.3 Additional Equipment

It is assumed that an additional computer at each of six regional IP's would be required for the following reasons:

- backup and redundancy;
- servicing of local networks;
- increased total traffic.

The cost for these is estimated to be $150K each with a $200K software development cost.

2.1.3.4 AES Person-Year Increases for Operation

- Network "Control" and monitoring in regions

@ 1 per site	6

- Software maintenance and change

@ .25 PY per site	1.5
1 analyst & coordinator	1
.25 at CMC & HQ	.5

- Administration increase

.25 PY per region and .5 at HQ	2
	11

2.1.3.5 Total System Cost (Excluding Terminals)

Non recurring:

Sofware and development	650K
Capital - computers at IP's	900K
- interfaces, controllers, multiplexers	427K
	1977K

Recurring:	
Current	2340K/yr
Estimated increase	1188K/yr
Computer maintenance	108K/yr
	3636K/yr

This is a 64% increase in operating costs excluding terminals.

PY (AES) for operation	11PY

2.1.4 Performance

2.1.4.1 System Loading

The traffic handling capability of the Upgrade proposal is presented in Table V. Utilization factors (as defined by the ratio of the offered load to the line or channel capacity) have been calculated for the main communication channels serving major classes of modes in the Upgrade proposal. Two sets of figures are presented; baseline traffic as summarized in Appendix A, and incremental traffic resulting from immediate new services as summarized in the addendum section 3.3 of Appendix A. Offered load was calculated using traffic estimates provided in Appendix A. For peak loads, peak traffic figures were summed over all traffic types relevant to the circuit in question. Peak rates were assumed to ocurr over a 10 minute period for observations and 30 minute period for all other message traffic. Average rates were assumed to occur over an hour. For batch traffic, a 30 minute peak period was assumed and a 12 hour average period was used.

It can be seen in number 4 of Table V, 110 b/s multidrop lines serving Users and Collectors, a refinement of the design is required to meet requirements (it is noted that the baseline traffic figures represent roughly a doubling of today's traffic). This could involve more lines or scheduling of traffic peaks. In Table V, all peaks are assumed to co-incide.

2.1.4.2 Comments on Present Problems and Future Traffic

A qualitative assessment was done to measure the ability of the proposed Upgrade Option to solve current operating problems (these were outlined in Appendix A. This assessment is described below.

UPGRADE OPTION UTILIZATION FACTORS CIRCUIT DESCRIPTION	BASELINE TRAFFIC PK	1 HOUR AVG	INCREMENTAL TRAFFIC ADDED PK	AVG
1. 2400 b/s HD CMC-CN switch	83%	37%	113%	45%
2. 2400 b/s HD IP-CN switch	62%	14%	85%	18%
3. 1200 HD UP-IP (packet)	16%	5%	22%	7%
4. 110 HD multipdrop lines to Collectors/Users (15 lines 15/line) from switch	370%	95%	494%	121%
5. Batch 4800 b/s (packet) CMC-IP	2%	12 hour 0.1%	68%	12 hour 5%
6. Paperfax as today	90%	90%	90%	90%
Paperfax additional to IP's			90%	90%
7. Photofax as today	50%	50%	50%	50%

(Effective throughput for packet net is assumed to be ½ of the available bit rate)

TABLE V Line Loading For Upgrading Option

Present Problems	Solution Offered
2.1.4.2.1 Teletype Network (Performance)	
Low Speed	- Yes
Lack of Selectivity	- Yes for UP's - INFOMODE 200R or the equivalent terminals provide selectivity - No station addressing on low speed lines unless software in switch upgraded
Inadequate Request/Reply	- Yes for UP's - Manual handling results in delays - Replenishment of IP's data base could be handled on batch network - Software required at switch to improve R/R turnaround - Larger storage capacity increases available data
Inadequate Priority Handling	- Input problem ameliorated (frequent polling) - Output priority problems require better on line control over priority of messages. Time dependent priority levels required. Must be added to software in switch
Inadequate Quality Control	- Some improvement due to better control at data input level - Transmission errors not reduced unless better error correcting protocols used on lines by switch. Requires change in software or firmware in new switch.
Half Duplex Operation	- Could be changed to FD with new central switch and increased costs.
Lack of Hierarchy	- Yes
Polled Multidrop Circuits	- Still most economical. Dynamic control over polling could be improved by use of new switch.

Present Problems	Solution Offered
Reliability or Redundancy	- Partial. Duties partially shared by regional systems. More graceful network failure if central switch fails. - Use of packet network provides UP access to other IP's if host IP down.
Insufficient Control over Switch	- New software to improve control could be built into central switch.

2.1.4.2.2 Teletype Network (Adaptiveness)

Low Speed	- Yes
Lack of high speed ports	- Yes
Inflexible Interfaces	- Yes through use of up-to-date central switch except possible interconnect problems to competitive offerings if switch leased from carrier.
Inadequate system monitoring	- Yes depending on new central switch software.

2.1.4.2.3 Facsimile (chart) (Performance)	- Yes, although not totally flexible. Needs of IP's can be met separately.
Broadcast Mode	- No change.
Analogue	- No change.
Poor Request/Reply	- Partial due to dual network

2.1.4.2.4 Facsimile (chart) (Adaptiveness)

National/Regional Structure	- Yes
Broadcast mode	- Unchanged. System wide implications as a result of single change.

Ice Central's special communication requirements remain separate and are not costed. New inter IP analogue fax trunk could help somewhat.

2.1.4.4 Long Term New Services

(a) Graphics Distribution

The changes in graphics processing foreseen by AES will only be facilitated somewhat by the Upgrade Option due to the introduction of viable computer to computer communications between the CMC and regional centres. That is, it will be possible to more easily transfer data between groups of workers developing new graphics systems and products. Much, however, remains to be done. All operational graphics would still be transmitted via analog networks and A-to-D conversion would have to be carried out where users want to further manipulate graphics using digital means. Users would not be able to get access to graphic material except by acquiring a drop on one of the networks. This may buy much more than is required. Further development of digital graphics would probably be carried out on a piecemeal basis.

(b) Marine Transportation Support

This requirement is not met by the proposed Upgrade Option. It would consist of separate facilities whose costs and planning would be a shared undertaking between Transport, Environment, and the private sector. The introduction of a new centre would add new communications costs but would not alter the networks significantly. Separate communications facilities (i.e., more expensive) might have to be used to meet specific Arctic requirements.

The substitution of new ways to serve the marine community once HF facilities are no longer avialable is not addressed. It must be regarded as a separate problem under the Upgrade Option.

(c) Dissemination of Data to Users

Users will be served by Regional or National Computer Systems. One aspect of this approach is the fact that UP's will not be able to directly interact with communication facilities in their city (except for Weather Radio).

Graphic data will require a user to acquire special purpose equipment to drop on fax lines.

	Present Problems	Solution Offered
2.1.4.2.5	Facsimile (Photo) (Performance)	
	Broadcast	- No change
	Analogue	- No change
	Poor Request/Reply	- No change
2.1.4.2.6	Off-Network (Performance)	
	Reliance on Radio for AN data	- No change unless multidrop lines extended at extra cost, or satellite used for remote sites. Not costed.
	Reliance on dial up	- No change
	Radio for facsimile	- No change
2.1.4.2.7	Off-Network (Adaptiveness)	
	Special purpose facilities	- Physical interconnection less difficult due to new packet Network access available to IP's hardware.

2.1.4.3 Immediate New Services

The following Immediate New Services as summarized in Appendix A are not fully covered or supported by the Upgrade Option proposed for the Tradeoff Phase.

Radar communication is not costed. It is expected that, once a clear statement of requirements is agreed to, a separate network of dedicated and dial-up lines will need to be costed.

Excess regional computer capacity to regionally collect additional real time data from special networks and distribute it has been included. Specific options have not been looked at nor have the associated communications costs.

Electronic delivery of graphical information to CATV industry is not available except by IP production and delivery. This has not been costed (e.g., graphics on cable TV in Calgary).

Demand access to IP's data base by outside user is easy and flexible due to use of packet network. Access to Climate Archive is by separate packet net (not costed) or by new software in IP's to use AES computer-computer link to HQ.

2.1.4.5 Other Upgrade Scenarios

A number of other options could be investigated for consideration, among them the following:

- A new, in-house, central switching computer could be built.

- User Processors that meet certain criteria such as population served, distance from the nearest IP, diversity and requirements of user community, could be provided with on site storage and intelligence to serve the local needs.

- Integration of photo and chart facsimile to the User Processor level to reduce network duplication and expensive terminal equipment.

- Satisfying the message traffic needs of the user community by the use of a dedicated broadcast facility, either landline or satellite.

2.1.4.6 Future Development of Networks

Regional computers could gradually take over data collection and distribution, eventually removing the central message switching computer. Gradual reduction of circuitry and load on the central switching computer would not be economical under the CN-CP proposal.

The computer-computer network could begin to carry digital graphics leading eventually to a totally digital system.

2.1.5 Implementation

In order to implement the described Upgrade Option, a considerable number of parallel activities must be carried out in-house. Table VI outlines the major activities over a possible five year implementation plan and the AES PY requirements are highlighted. The opportunity for contracting out the activities listed is not large except for the central message switch upgrade which is based on a CNCP proposal.

During the first year of planning, a precise phase in plan will be developed. The major problem in terms of phasing in will be the installation of new computer systems in parallel with conversion of U.P.'s from being served by the switch to being served by the Regional computers.

DND implementation manpower has not been indicated however, it would seem that the requirement could be limited to 2 PY's per year for planning and administration.

	81	AES	82		83		84		85	
	Task	PY	Task	PY	Task	PY	Task	PY	Task	PY
1.	Immediate Line Speed up grade (selective). Minor Re-configuration Acquire ASR35 replacem.	½	Continue	½						
2.	Plan "UP" Subset for Ip access. Packet I/F, new termls. Stepwise Introduction Plan	1	Acquire H/W, Trmls, packet service for first step (1 region) Change over	2	2 Regions	2	2 more	2	rest	2
3.	Plan for new cpu's at IP's. System configur. Software specs. Packet I/F	2	Acquire 2 cpu's 1 for S/W Devel. Write s/W Implement In one region	2	2 Regions	2	2 more	2	rest	2
4.	Plan and implement packet access for CMC, Hq.	½	Finish implement	½						
5.	Plan for S/W packages for batch exchange	1	Write S/W, Do tests	1	Continue	½	Continue	½		½
6.	Specs for new CN switch softw. Plan.	1	Guidance to CN Plan change-over	1	Begin change-over New lines etc	1	Complete change-over	1		
7.	Plan new FAX line, Plan acquisition of chart recorders, CMC I/F SOFTW/HW.	½	Implement new FAX line, begin transmissions	½						
8.	Plan selective expansion of photofax net. Plan to acquire new termls.	½	Begin expansion. purchase trmls	½	Continue	½	Continue	½	Continue	½
9.	Readac related planning	½	Continue	½	Implement	1	Implement	½	Implement	½
10.	Investigate DCP, RADAR, etc.	½	Plan	½	Acquire	1	Acquire	1	Acquire	1
11.	Manage and co-ord., develop new user policies, interfaces.	2		2		2		2		1
	TOTAL EACH YEAR	10		11		9		9½		7½

TABLE VI. Proposed Five Year Implementation Plan

It can be seen that a core team of four to five HQ people supported by about an equal number in the field would be required to ensure a co-ordinated and well planned approach. The establishment of such a core team responsible for co-ordinated AES communications planning is recommended.

2.2 INTEGRATED TERRESTRIAL OPTION

2.2.1 Introduction

2.2.1.1 System Definition and Rationale

The Integrated Terrestrial System Candidate is a distributed system where the traffic is integrated and the communication is broken down into intra-regional and inter-regional. The rationale behind this candidate is to utilize a consolidated communication system very efficiently, thus reducing the amount of circuitry and hence reduces the monthly expenses.[1] Figure 2.2.1.1-1 shows the system structure.

The system consists of:

Network	Traffic
1. Satellite Photo Imagery Network (as present)	Inter-region satellite photo image distribution.
2. Public Packet Network	Inter-region distribution of all traffic except photo images.
3. Regional Network (Heirarchy of multi-drop and point-point lines)	Intra-region collection and distribution of all traffic including photo images.

The proposed system is a distributed system. (However, the routing and scheduling of the message traffic could easily be centralized if preferred.) The intent is to provide a complete communications system for carrying all present and future communications related traffic.[2]

2.2.1.2 Services and Traffic Specification

The Service requirements and traffic specifications are documented in Appendix A. All of the baseline services plus the immediate services defined are requirements of the proposed system. The quantitative interpretation of these services is also documented in Appendix A.

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1 Regional circuitry rental and terminal equipment rental are the main recurring costs of the present system. This chapter will deal mainly with the communication related hardware. Terminal equipment is discussed in Chapter 3.

2 The Off-Network is as present or upgraded to satellite collection and distribution. (Off-Network is communications to remote areas where terrestrial private links are not available or not economical; presently radio, TTY, TWS, satellite, etc., are used).

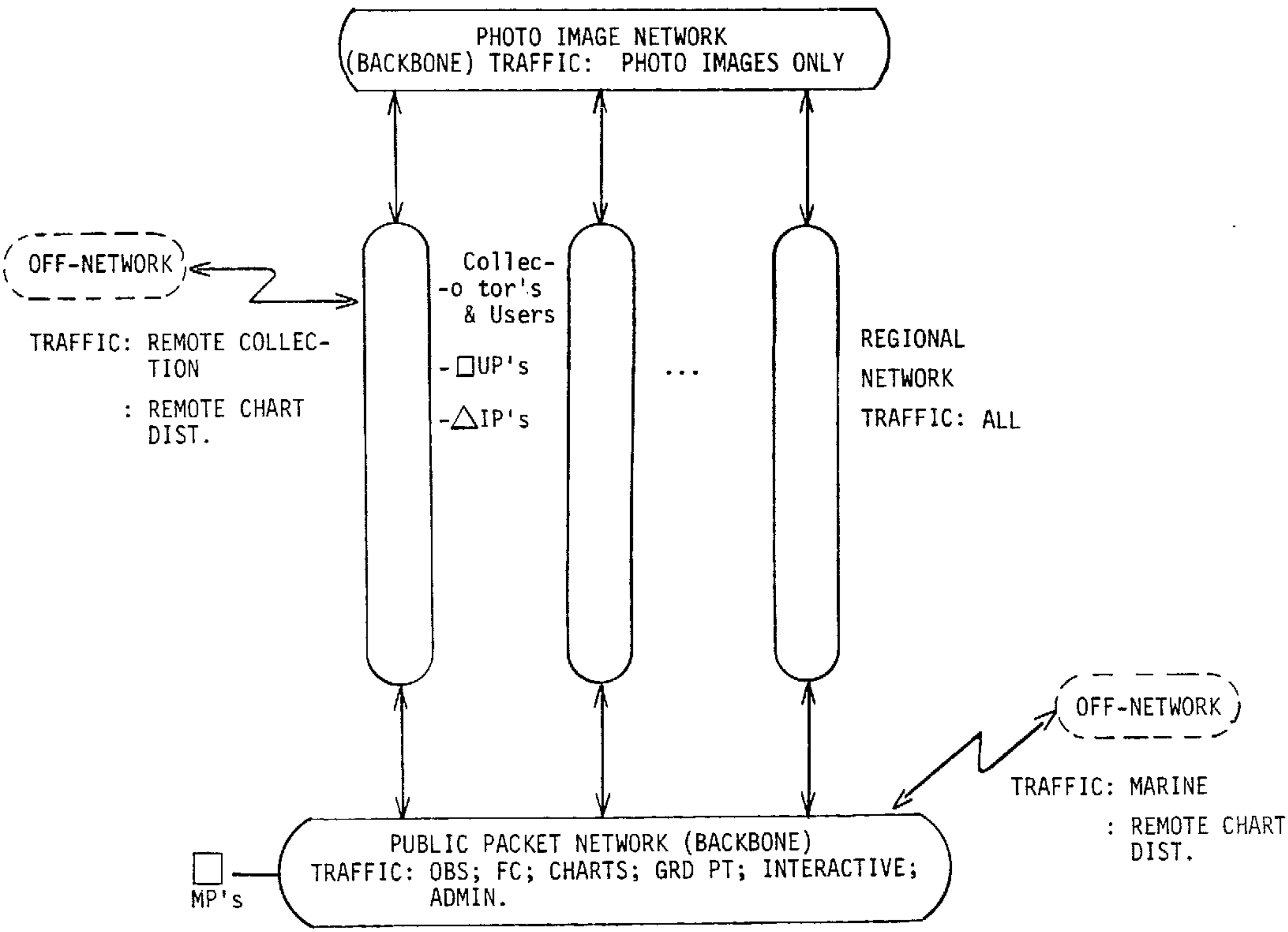

Figure 2.2.1.2-1 Integrated Terrestrial System

2.2.2 System Description

Figure 2.2.1.2-1 shows a conceptual diagram of the proposed system. The Users, Collectors, User Processors and Intermediate Processors are interfaced to a regional network. The Major Processors are interfaced to the Public Packet Network directly. All communications between regions occur through the packet network and all intra-region communications occur over the regional network. This section will describe each of the networks that make up the system. Subsequently, the hardware and software of the system is described.

2.2.2.1 Photo Image Network

The Photo Image Network consists of the main broadcast circuits as they exist today. All regional circuits would be eliminated. Figure 2.2.2.2-1 shows the circuits included. Regional distribution would be carried over the Regional Network.

As at present, photo images would be carried as analog transmissions over the photo network. In the future, if required, this network could be converted to digital to improve quality.

The Photo Image Network interfaces the regional networks, SDL and CMC. At the regional networks, the photo fax circuits interface to a Distribution Interface (DIF). At SDL and CMC the photo fax circuits interface as in the present network.

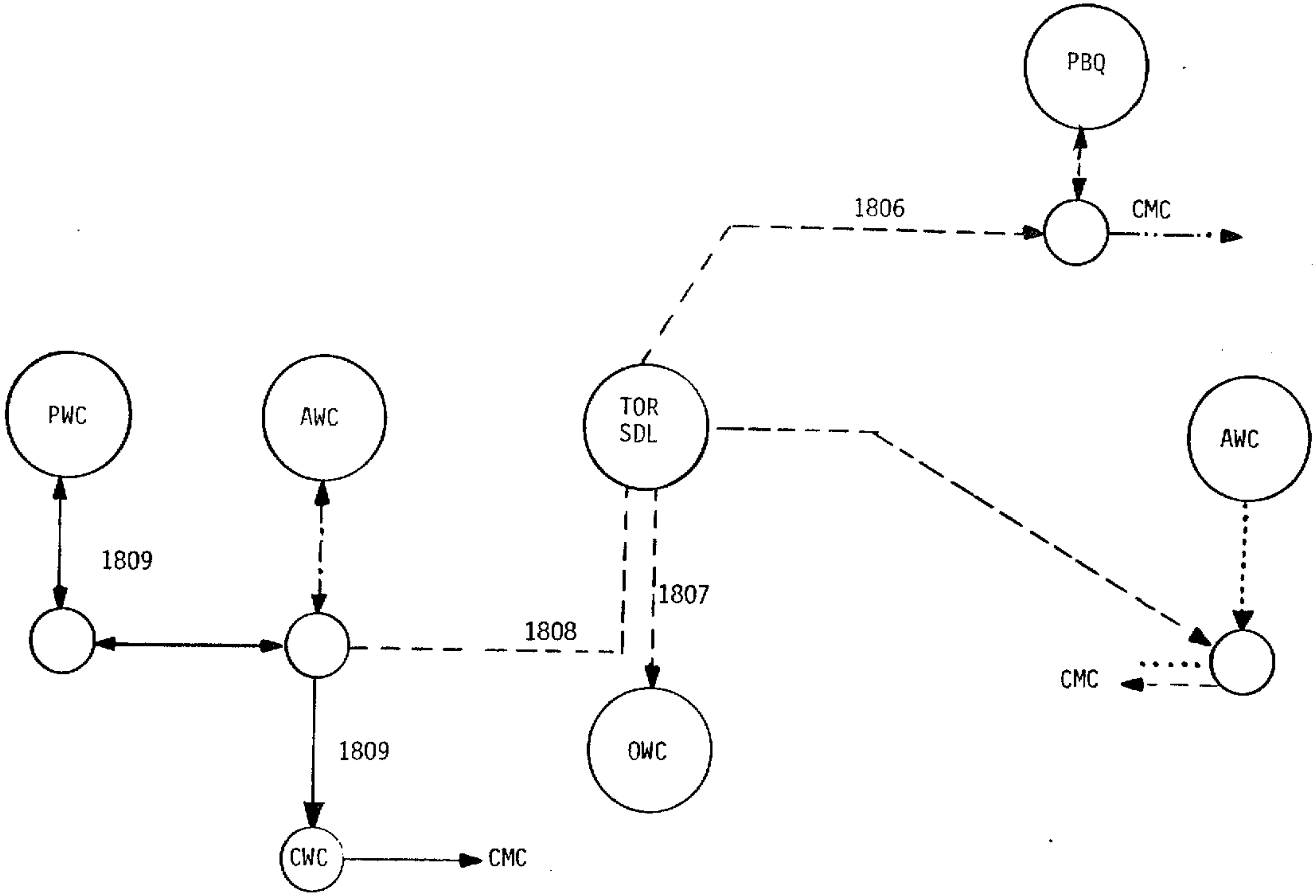

Figure 2.2.2.1-1 Photo-Network

2.2.2.2 Public Packet Network

The Public Packet Network interconnects the Regional Networks, AES HQ and CMC. The network could be either the TCTS Data Pac Service (DPS) or the CNCP Infogram Service (IGS). The interconnection of traffic is handled by Distribution Interfaces (DIF) through the Public Packet Network using the standard CCITT X 25 protocol or some subset of it, such as SNAP used by TCTS DPS. Details of the DIF hardware (H/W) and software (S/W) are discussed separately in Sections 2.2.2.4 and 2.2.2.5.

A single 9600 b/s access port is required to interconnect the regions and AES HQ. The CMC site requires three 9600 b/s ports, to meet the estimated Baseline and Immediate Services peak traffic.

Figure 2.2.2.2-1 shows the Public Packet Network and how it is interfaced. Note no modems are required as the access loops are digital. Packet size is 256 Bytes. The DIF H/W and S/W are compatible throughout the network. The configuration of the DIF at CMC and AES H/W is now described.

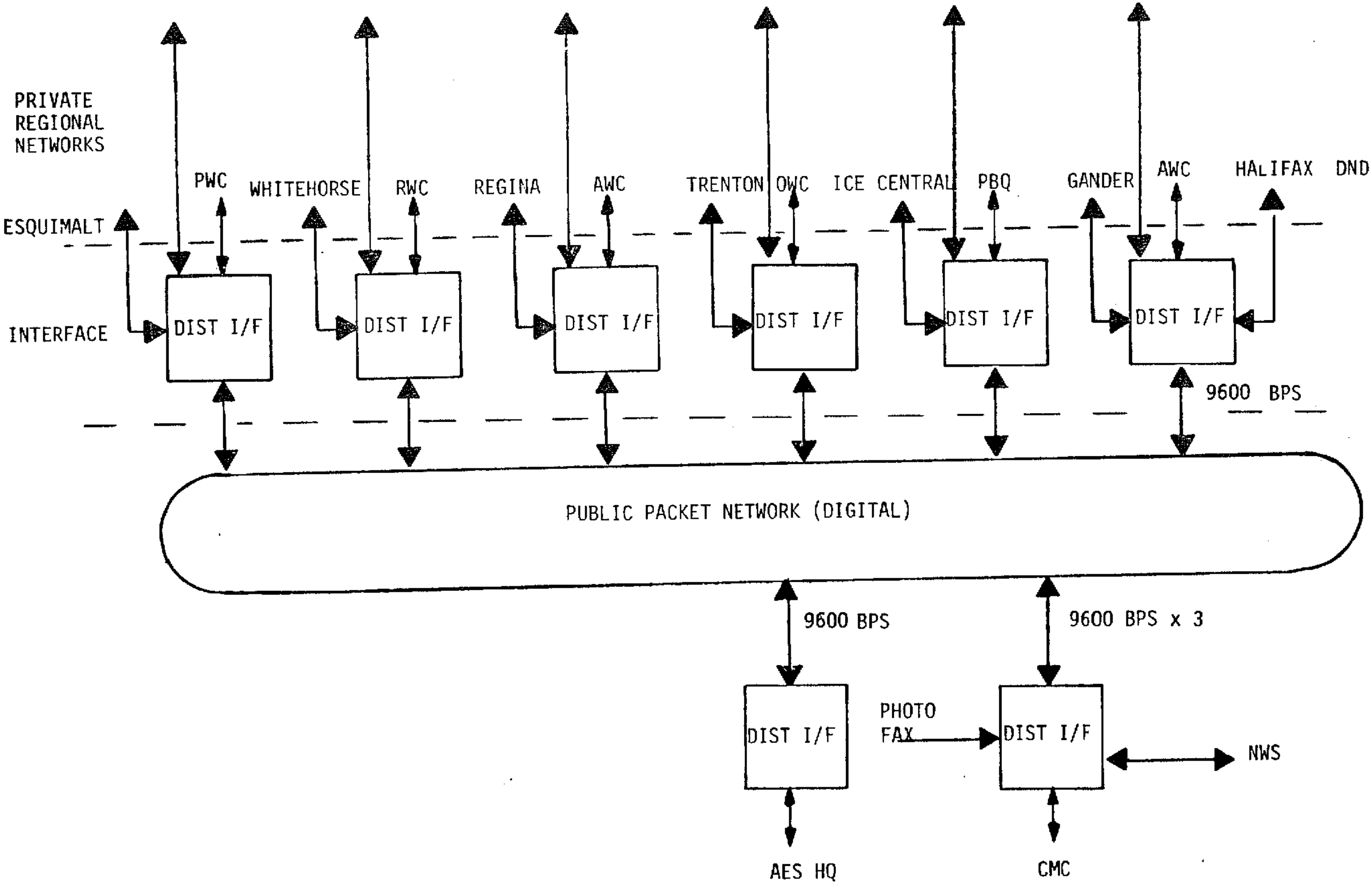

Figure 2.2.2.2-1 Public Packet Network Interfaces

2.2.2.2.1 CMC Access

Figure 2.2.2.2.1-1 shows an arrangement proposed for interfacing CMC terminal equipment, CMC CPU processing power, CMC message traffic and private user drops to users through the Public Packet Network. A list of the DIF ports is provided below.

	Ports	Descriptor
1.	Public Network	3-9600 b/s full duplex RS232
2.	NWS	2400 b/s full duplex synchronous 4 wire
3.	DIFAX Input	4800 b/s simplex (input) synchronous 2 wire
4.	Analog NWS Input	4800 b/s simplex (input) synchronous 2 wire
5.	CMC Front End	9600 b/s full duplex X25, Serial or Parallel
6.	Disk	4 MB/sec Bus
7.	Private Ports	15-20 100 b/s simplex (output) asynchronous 2 wire
8.	CMC CPU Chart Output Bus I/F	

Estimated peak loading on the DIF I/O bus is about 30 transactions per second. The unit is capable of about 100 transactions per second. This yields a 33% utilization during peak use.

The chart encoders are Alden AFDIGS[1] which yield about 7.5 maximum and 5.0 typical compression ratios for weather charts. All NWS, CMC CPU or manual charts, are raster compressed before transmission.

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[1] U.S. Air Force Digital Facsimile Circuit

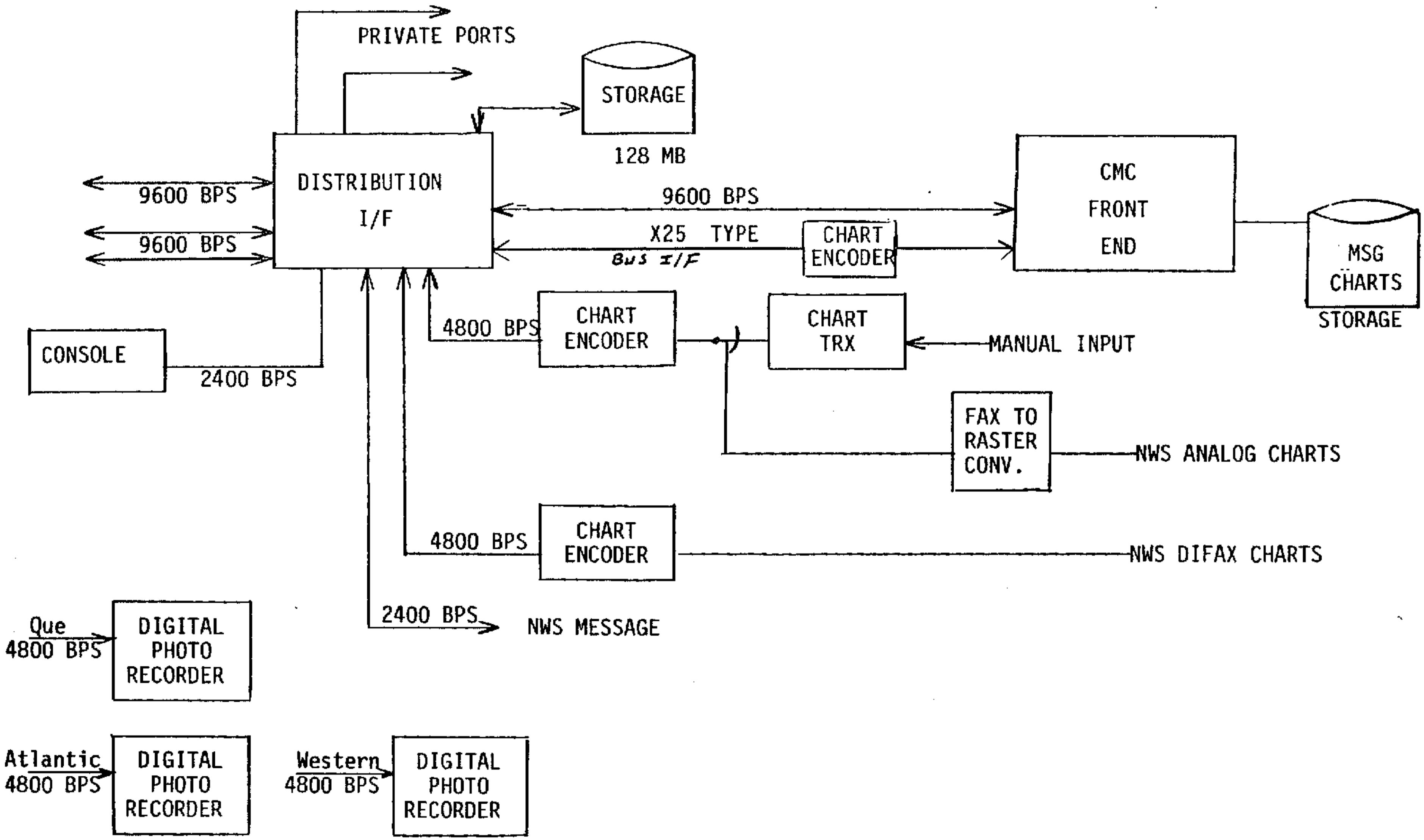


Figure 2.2.2.2-1 CMC Access

2.2.2.2.2 AES HQ Access

Figure 2.2.2.2.2-1 shows an arrangement for interfacing AES HQ CPU's and terminal equipment to users through the public packet network. A list of the DIF ports is provided below:

	Ports	Descriptor
1.	Public Packet Network	1-9600 b/s full duplex RS232
2.	Climate CPU	9600 b/s full duplex X25, serial or parallel
3.	Training CPU	2400 b/s full duplex X25, serial or parallel
4.	MSRB CPU	2400 b/s full duplex X25, serial or parallel
5.	CODECON CPU	600 b/s full duplex asynchronous 4 wire
6.	Chart Input	4800 b/s simplex synchronous 2 wire
7.	NCC	2400 b/s full duplex X25, serial or parallel

The chart decoder is the Alden AFDIGS type with the addition of an analog fax output for reception using the conventional fax recorders.

The Network Control Centre (NCC) consists of a PDP-11/34 mini-computer and standard peripherals as shown. No specific specifications for the equipment have been determined at this time.

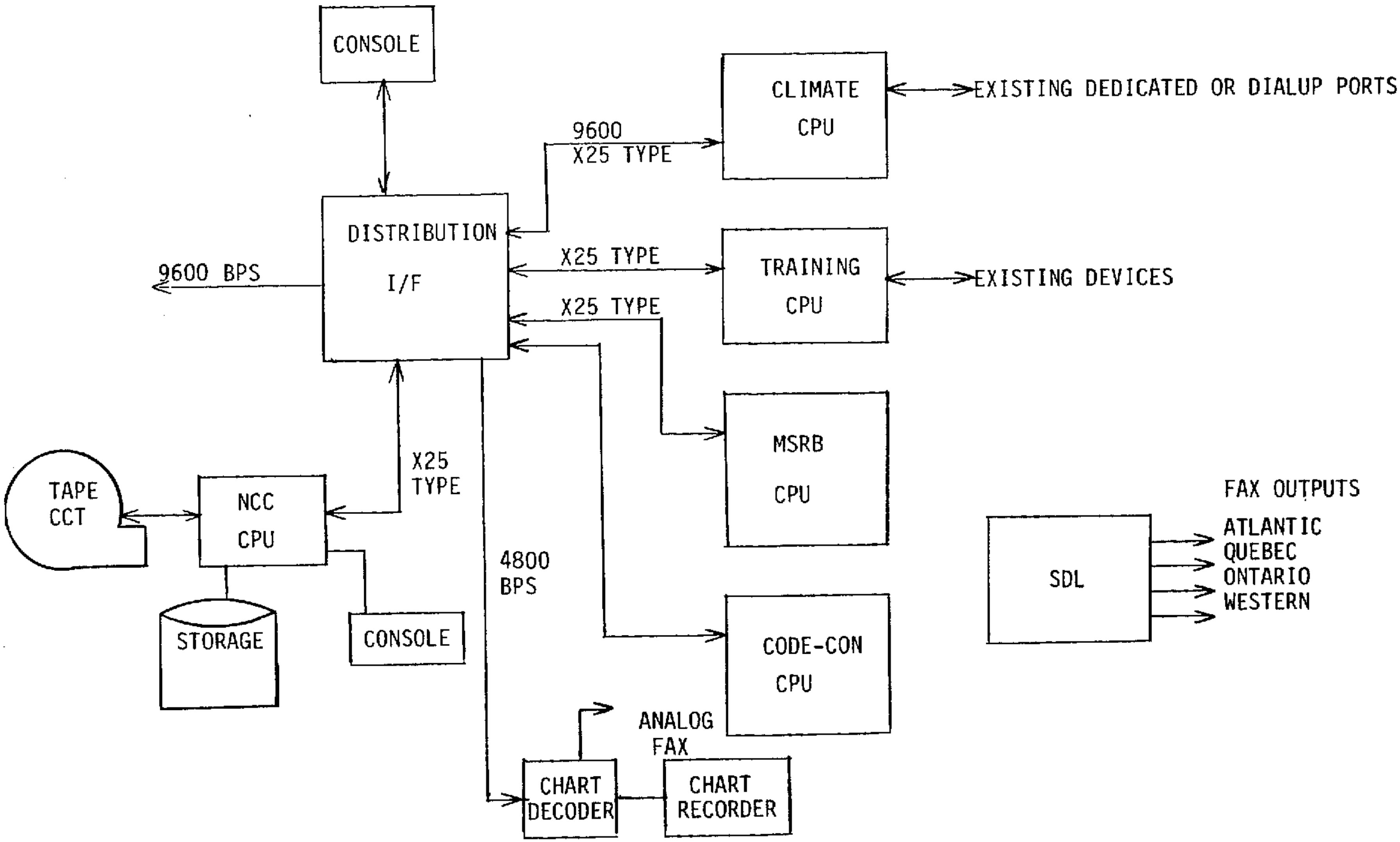


Figure 2.2.2.2.2-1 AES HQ Access

2.2.2.3 Regional Network

The Regional Network interconnects all collectors, users, user processors and intermediate processor sites to each other and to the Public Packet Network. This is accomplished by the DIF as at CMC or AES HQ. Figure 2.2.2.3-1 shows the configuration of the Regional Network. The Regional Network is made up of a number of different channel types that are compatible with the office's hierarchy.

Circuits	Offices Served
Serial or Parallel RS232	Local IPs
Dedicated point-to-point	Remote IPs
Multidrop private voice grade	UPs
Multidrop private teletype	Collectors and Users

The Regional Network hardware includes one distribution interface (DIF), a data terminal equipment interface (DTE) at each UP, plus chart decoders and encoders where charts are received and transmitted.

Distribution Interface (DIF)

The Regional Network is interfaced to the public packet network through the DIF. The Regional Network DIF is identical to that proposed for CMC or AES HQ. It is an existing MDA product that uses parallel processor technology and is modular in expansion. Up to 16 processors are possible; five are required.

	Ports	Description
1.	Public Packet Network	9600 b/s full duplex RS232
2.	Multidrop Voice Grade	2-9600 b/s full duplex synchronous 4 Wire (max. 10-15 drops) (typically 5-10 required)
3.	Remote IP	2-9600 b/s full duplex asynchronous 4 Wire
4.	Local IP HP CPU I/F	X25 type - serial
5.	Local IP chart recorder	4800 b/s asynchronous simplex
6.	Local IP chart tmtr	4800 b/s synchronous simplex
7.	Local Photo fax input	4800 b/s synchronous simplex
8.	Disk	4 MBytes/s Bus.
9.	CRT	1200/2400 b/s RS232

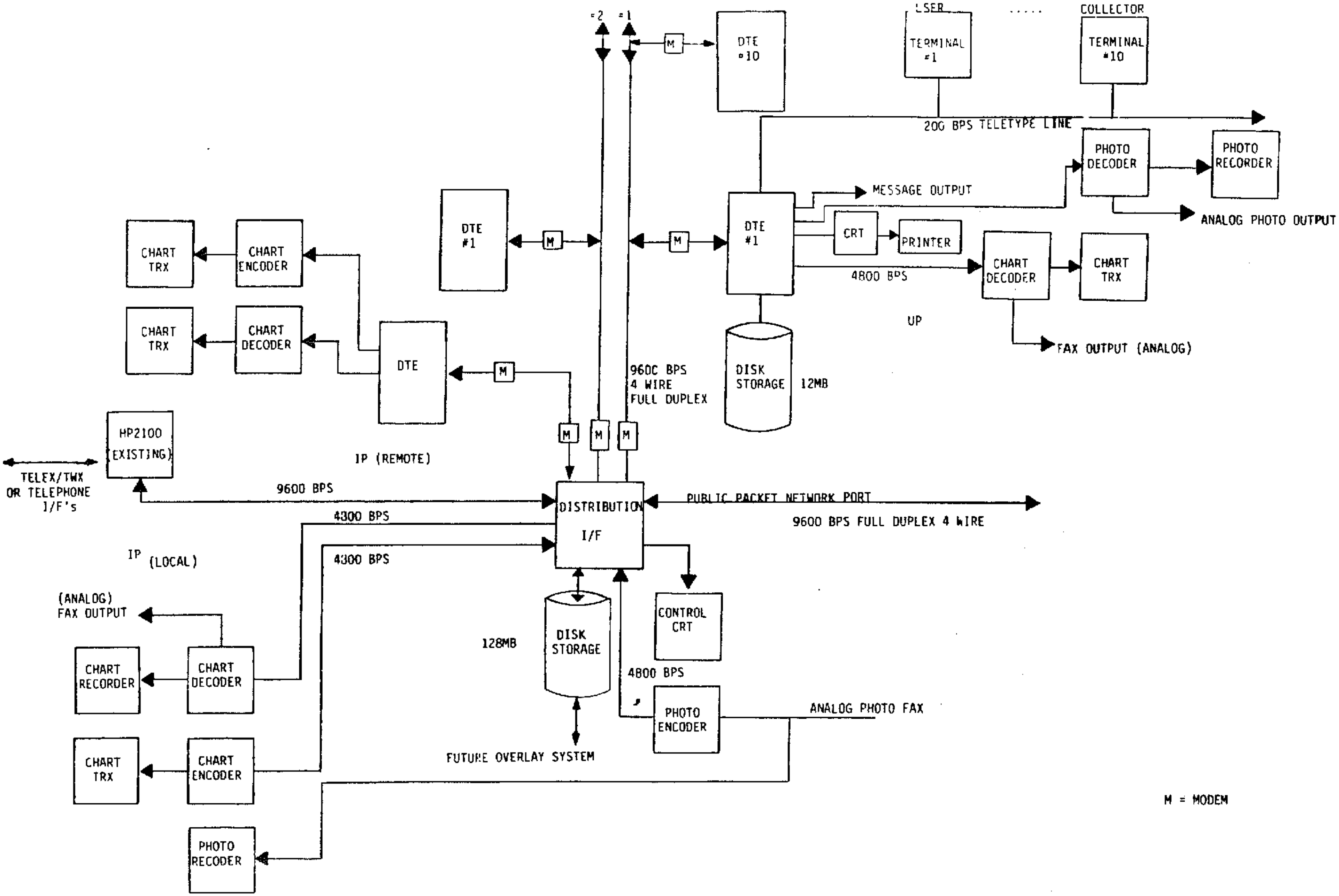


Figure 2.2.2.3-1 Regional Network

Data Terminal Interface Equipment (DTE)

The DTE interfaces a UP and a number (maximum of 10) of users and collectors to the multidrop voice grade line. The ports on a DTE are:

	Ports	Description
1.	Multidrop Voice Grade	9600 b/s synchronous 4 Wire full duplex
2.	Multidrop Teletype	200 b/s asynchronous 4 Wire full duplex
3.	Photo Decoder	4800 b/s synchronous 2 Wire simplex
4.	Chart Decoder	4800 b/s synchronous 2 Wire simplex
5.	CRT	1200 b/s RS232
6.	Message output	1200 b/s asynchronous 2 Wire simplex

The DTE is a custom microprocessor disk-based system. The disk is a Winchester type. A maximum requirement of 12 MBytes of storage is estimated. The architecture of the DTE system is developed and requires addition of a disk interface. At remote IP's, the DTE permits input from a chart decoder as does the DIF at a local IP. The DTE includes a polling controller to operate the teletype line.

Photo Image Encoder/Decoder

The Photo Image Encoder/Decoder H/W is assumed to yield a 5 to 1 compression on satellite weather images with neglible distortion. This is based on an experimental system.

Chart Decoder/Encoder

This is an Alden AFDIGS product which yields about a 7.5 maximum, and a 5.0 typical compression ratio on weather charts.

2.2.2.4 Hardware Summary

A summary of the H/W is provided below:

H/W	STATUS	ORIGIN
DIF	MDA product	Canada
DTE	MDA (modified) product	Canada
Chart Decoder/Encoder	Alden (modified) product	USA
Photo Decoder/Encoder	IAF developed product	Israel
Fax Converter A/D	Muirhead developed product	Canada
Modems 4800/9600 b/s (No conditioning required)	Vendor product (IBM)	USA
NCC CPU	DEC PDP-11/34	USA

2.2.2.5 Software

It is proposed to layer the system software to provide a flexible growth oriented system. The principal advantage of layered S/W is that changes at any one layer do not ripple through the system. It is proposed to use X25 with ECMA. The session, presentation and application layers would be custom.

The DIF acts as a private node with respect to the regional network and as a public node to the public packet network. The DIF and DTE operating system S/W is ATS, (Asynchronous Task Supervisor), an efficient and proven reliable package developed by MDA.

2.2.3 Operation

There are two principal types of traffic:

Broadcast Traffic (Message, Charts, Imagery, etc.) - The broadcast traffic is made up of intra and inter region disribution. The intra-region distribution is traffic originating within a regional and distributed within that region. The inter-region distribution is traffic originating within a region and distributed to other regions or originating at an MP and distributed to other regions. The DIF's act as a distributed message switch controlling intra- and inter-region distribution of broadcast traffic.

Traffic input to a DIF from within a region or an MP is first directed to the local DIF on an end-to-end basis. (Collectors and users traffic is concentrated first at a DTE and then forwarded to the DIF). The DIF looks up table (LUT) identifies intra- and inter-region destinations. Intra-region destinations are identified by the regional circuit leaving the DIF. Inter-regional destinations are identified by permanent virtual channels to other regions on MP's.

Traffic input to a DIF from other DIF's (inter-region distributed) is treated exactly as intra-region traffic. Between DIF's traffic is end-to-end and routed on a per call basis over permanent virtual circuits.

Traffic output from a DIF to the region is distributed to IP's on a point-to-point basis. Traffic to UP's, Collectors and Users is distributed by the multi-drop voice grade circuits on a broadcast basis. UP DTE's select that traffic required and that traffic to be forwarded on to Collectors and Users. For each piece of traffic, a look-up table is consulted, which designates for each piece of traffic to which regions it is to be distributed and to which circuits within a region. The DIF is acting as a message switch as well as a communications node.

Point-to-Point (Grid point, Soundings, Interactive) - point-to-point traffic is routed from end-to-end on a call-to-call basis. The DIF acts as packet node.

2.2.3.1 CMC Operation

The CMC CPU link to the DIF carries the following multiplexed traffic:

- Interactive,
- Observation,
- Forecast,
- Grid point data.

The charts are communicated via a separate bus I/F.

The CMC CPU still controls the release of its products, however this could be included in the DIF.

2.2.3.2 AES HQ Operation

In a manner similar to CMC operation, the DIF provides access for all AES HQ CPU's to the public packet network.

2.2.3.3 IP Operation

The regional Hewlett-Packard computers (HPs) are relieved from communications responsibility. It is proposed that the HPs still control release of products. All terminals interfaced to the HPs would have interactive access to all AES resources. IP charts can be sent simultaneous as CMC charts. It is assumed that IP charts are also compressed raster charts. The distribution of these charts are inter- or intra-region. The total traffic input to a regional network is the sum of the requirements of that region.

2.2.3.4 UP Operation

The DTE operates as a distribution interface unit with respect to the teletype drop traffic. Only a subset of the UP traffic is passed onto the collectors and users. This subset is determined by a look-up table at the DTE. Only charts preselected by the UP operator are recorded. The traffic on the voice grade lines is determined by the total requirements of all stations on the line including the teletype stations. Similarly, the traffic on a teletype line is the sum of all the users on the line.

The DTE disk provides a soft copy of all current data for the UP operations. A hard copy is obtained only when required. If additional data is required, it is obtained from the regional IP. Optionally, the DIF could service these requests.

2.2.3.5 User and Collector Operation

Basically, as at present. However, requests for additional data are permitted.

2.2.3.6 Routing and Scheduling

All releasing of data or charts is controlled by the source CPU or terminal operator. However, this function could be included into the DTE and the DIF. The routing of all broadcast traffic is controlled by the DIFs and DTEs, via Look-up Tables (LUTs). A change in routing is performed by changing the LUTs from the NCC.

2.2.3.7 Network Control Center (NCC)

At the DIFs and DTEs monitoring data and traffic statistics are collected and forwarded to the NCC for monitoring and analysis. LUTs and operational S/W are down loadable from the NCC to the DIFs and DTEs. To change the broadcast routing of a message may involve changing one, two or three LUTs depending on the hierarchy of the station involved.

2.2.4 Performance Analysis

2.2.4.1 Traffic Loading

Channel Loading Calculations

Traffic Components	Source (From User or Collector)	Sink (To User or Collector)
TELETYPE CHANNEL (Maximum 10 drops)		
1. Observation data Baseline Services Peak Load = (5 min)	13.6 K Chars/region x 10 sites max. ÷ 51 sites/region = 2.7 K chars	95K chars total x .15 per site = 14 K chars
Average Load = (1 hr)	11.0 K x 10 ÷ 51 = 2.1 chars	77 K x .15 = 11.5K chars
Baseline & Immediate Services	PK = 2.7 + 45% = 3.9 K AV = 2.1 + 45% = 3 K	PK = 14 + 45% = 20 K AV = 11.5 + 45% = 16.7 K
2. Forecast Data Baseline Services	PK = 0	86.4 K total x .25 per reg. x .5 per VF circuit (11 K) + 80 K x .35 ÷ 8 (3.5 K) = 14.5 K
	AV = 0	96 K x 25 x .5 (12K) + 300 x .35 ÷ 8 (13K) = 25 K
Baseline & Immediate Services	PK = 0 AV = 0	14.5K + 10% = 16 K 25 K + 10% = 28 K

Traffic Components	Source (From DTE)	Sink (To DTE)
VOICE GRADE LINE (Maximum 10 Drops)		
1. Observation Data Baseline Services	PK = 13.6 K per region x 10/12 x = 11 K AV = 11 K x 10 ÷ 12 = 9 K	95 K total x .5 = 48 K 77 K x .5 = 39 K
Baseline & Immediate Services	PK = 11 K + 45% = 16 K AV = 9 K + 45% = 13 K	PK = 70 K Av = 56 K
2. Forecast Data Baseline Services	PK = 0 AV = 0	PK = 86.4 total x .5 per region x .5 per circuit (21 K) + 25 K x .5 (12.5 K) + 80 K x .35 x 0.51 (14 K) = 47.5 K AV = 96 K x .5 x .5 (24) + 30 x .5(15 K) + 300 K x .35 x .5 (52.5) = 92 K
Baseline & Immediate Services	PK = 0 AV = 0	PK = 47.5 K + 10% = 51 K AV = 92 K + 102 = 101 K
3. Charts Baseline Services	PK = National + Regional = 5 + 1 charts = (11MB + 11MB x 1/5) ÷ 8 ÷ 5 = 330 KBytes (≅1500 BPS) AV = National + Regional = (384 MB + 384 MB x 363/2194) ÷ 8 ÷ 5 ÷ 24 = 466 KBytes (≅1050 BPS)	0 0
Baseline & Immediate	PK = 330 KBytes AV = 466 Bytes + 15% = 536 KBytes	0 0

Traffic Components	Source (From DTE)	Sink (To DTE)
4. Satellite Imagery Baseline	0	PK 10" x 10" x 100 x 100 8 125 KBytes AV 95 per day 24 (4) x 125 KBytes 500 KBytes *
Baseline & Immediate	0	
	0 0	PK 125 KBytes AV 500 KBytes
* at 5:1 compression		

Traffic Components	Source (From Region)	Sink (To Region)
<u>PACKET NETWORK REGION-LINK</u>		
1. Observation Data Baseline Services	PK = 13.6 K x 5 regions x .8 + 13.6 x 2 = 82 K char AV = 11 K x 5 x .8 + 11 x 2 = 66 K	95 K total x .8 = 76 K 77 K x .8 = 62 K
Baseline & Immediate Services	PK = 82 K + 45% = 119 K AV = 66 K + 45% = 96 K	76 K + 45% = 110 K 62 K + 45% = 90 K
2. Forecast Data Baseline Services	PK = 7.2 K x 5 regions x .5 + 7.2 K (NWS & CMC) - 25 K AV = 8 K x 5 x .5 K 8 K = 28 K	(86 K x .5 = 43 K + (25 K x .5 - 12.5 K) + (80 K x .35 = 28) = 84 K (96 K x .5 = 48 K) + (30 K x .5 = 15 K) + (200 K x .35 = 105) = 168 K
Baseline & Immediate Services	PK = 25 K + 10% = 27 K AV = 28 K + 10% = 31 K	84 K + 10% = 93 K 168 K + 10% = 185 K
3. Grid Point Data Baseline	PK = 0 AV = 0	32.5 K x .35 = 11 K 55 K ÷ 12 x .35 = 2 K
Baseline & Immediate Services	PK = 0 AV = 0	11 K x 20 (CMC) + 11 K + 10% (AES) = 232 K 2 K x 20 + 2 + 10% = 40 K

Traffic Components	Source (From Region)	Sink (To Region)
4. Charts ** Baseline	PK = 1 Regional chart = 1.9 MB ÷ 8 ÷ 5 = 48 KBytes (≅1300 BPS AV = 10 per day = 48 KBytes x 10 ÷ 24 = 20 KBytes (≅ 50 BPS)	PK = 5 National charts = 11 MB ÷ 5 ÷ 8 = 275 KBytes (≅1250 BPS) AV = 384 MB ÷ 24 ÷ 8 ÷ 5 = 400 KBytes (≅ 900 BPS)
Baseline & Immediate Services	PK = 1 Regional chart = 1.9 MB ÷ 8 ÷ 5 = 48 KBytes (≅1300 BPS) AV = 384 MB ÷ 24 ÷ 8 ÷ 5 = 48 KBytes x 10 ÷ 24 = 20 KBytes (≅ 50 BPS) (AV = 10 charts per day)	= 275 KBytes + 62% = 450 KBytes (≅ 2000 BPS) 400 KBytes + 62% = 648 KBytes (≅1444BPS)
5. Sounding Data Baseline Services	PK = 0 AV 0	0 0
Baseline & Immediate Services	PK = 40 K AV = 40 K (every 1½ hr) x 2/3 = 26 K total	40 K 26 K ÷ 3 (IPS per source) = 9 K per IP
** assumes 5:1 compression		
PACKET NETWORK CMC LINK	(From CMC)	(To CMC)
1. Observation Data Baseline Services	PK = 0 AV = 0	95 K total 77 K total
Baseline & Immediate Services	PK = 0 AV = 0	95 K + 45% = 138 K 77 K + 45% = 116 K
2. Forecast Data Baseline Services	PK = (25 K x 6 x .5 = 75 K) + (80 K x 6 x .35 = 168 K) = 243 K AV = (30 K x 6 x .5 = 90 K) + (300 K x 6 x .35 = 630 K) = 720	86.4 K (IP) x .5 = 43 K 96 K (IP) x .5 = 48 K
* Assumes raster transmission		

Traffic Components	Source (From CMC)	Sink (To CMC)
Baseline & Immediate Services	PK = 243 K + 10% = 267 K AV = 720 K + 10% = 792 K	43 K + 10% = 47 K 48 K + 10% = 53 K
3. Grid point Data Baseline Services	PK = 32.5 K x 6 x .35 = 68 K AV = 55 K (per 12 hr) ÷ 12 x 6 x .35 = 9.6 K	0 0
Baseline & Immediate Services	PK = 68 K x 20 = 1360 K AV = 9.6 K x 20 = 192 K	0 0
4. Chart Data Baseline Services	PK = (11 M Bit ÷ 5 ÷ 8 = 275 KBytes) x 6 + 275 K x .62 (AES) = 1820 KBytes (≅8100 BPS) AV = (384 M Bits ÷ 24 ÷ 8 ÷ 5 = 400 KBytes) x 6 + 400 x .62 = 2648 KBytes (≅5900 BPS)	0 0
Baseline & Immediate Services	PK = 1820 KBytes + 62% = 2949 KBytes (≅ 13100 BPS) AV = 2648 KBytes + 62% = 4289 KBytes (≅ 9550 BPS)	0 0
PACKET NETWORK AES LINK	(From AES HQ)	(To AES HQ)
1. Observation Data Baseline Services	PK = 0 AV = 0	95 K 77 K
Baseline & Immediate Services	PK = 0 AV = 0	95 K + 45% = 138 K 77 K + 45% = 116 K

Traffic Components	Source (From AES HQ)	Sink (To AES HQ)
2. Forecast Data Baseline Services	PK = 0 AV = 0	84 K (as IP) 168 K (as IP)
Baseline & Immediate Services	PK = 0 AV = 0	93 K 185 K
3. Grid Point Data Baseline Services	PK = 0 AV = 0	11 K 2 K
Baseline & Immediate Services	PK = 1 K AV = 1 K	11 K x 20 = 220 K 2 K x 20 = 40 K
4. Sounding Baseline Services	N/A	N/A
Baseline & Immediate Services	PK = 0 AV = 0	40 K as per IP 9 K as per IP
5. Charts Baseline Services	PK = 0 AV = 0	PK = 275 KBytes x .62 = 171 KBytes (≅ 760 BPS) AV = 400 KBytes x .62 = 248 KBytes (≅ 551 BPS)
Baseline & Immediate Services	PK = 0 AV = 0	PK = 171 KBytes + 100% = = 341 KBytes (1520 BPS) AV = 248 KBytes + 100% = 496 KBytes (1102 BPS)

2.2.4.2 Utilization

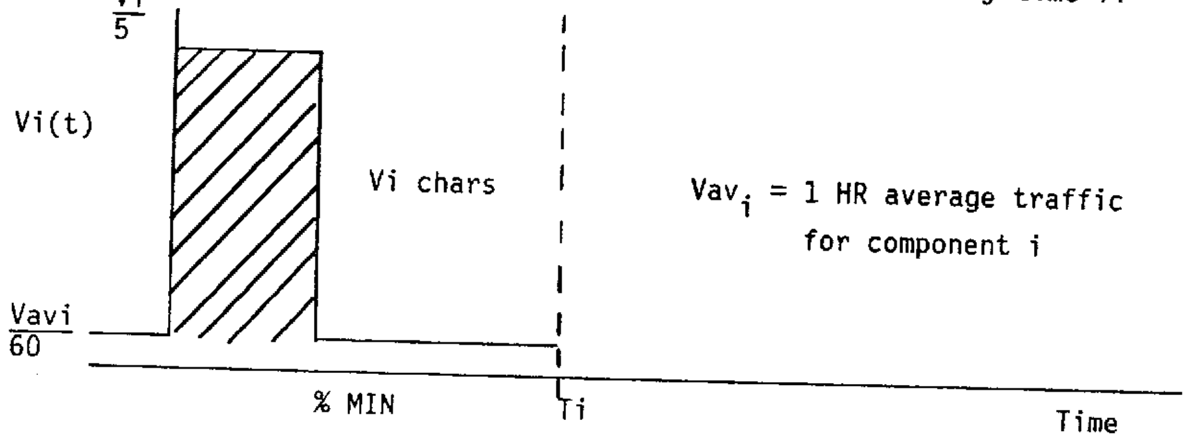
Channel Utilization

The peak period channel utilization U_{PK} is approximated by:

$$U_{PK} \cong \frac{Vi}{Ti} + \frac{Vj}{Tj} + \frac{Vk}{Tk} \cdots$$

Valid for $Vi/5 \gg Vav/60 \times (Ti - 5)$

where Vi = 5min PK traffic for component i with delivery time Ti



The average channel utilization is given by:

$$Vav = \frac{Vavi}{1\ HR} + \frac{Vavj}{1\ HR} + \frac{Vavk}{1\ HR} \cdots$$

Table 4.2-1 below defines the components, delivery time, loading, channel utilization and utilization efficiency of each channel, for the Baseline services and for the Baseline plus Immediate services.

Vi Traffic Component	Delivery Time Ti (min)	Capa-city	BASELINE Teletype Line 200 BPS LOAD AV / PK	BPS AV / PK	VF Line 9600 BPS LOAD AV / PK	BPS AV / PK	Reg. Link 9600 BPS LOAD AV / PK	BPS AV / PK	CMC Link 9600 BPS x 3 LOAD AV / PK	BPS AV / PK	AES Link 9600 BPS LOAD AV / PK	BPS AV / PK
1-Observation	10	Source	2.1/2.7	5/ 36	9/ 11	120/147	66/ 82	146/1100	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	11.5/ 14	26/186	39/ 48	87/640	62/ 76	138/1013	77/ 95	171/1266	77/ 95	171/1266
2-Forecast	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	28/ 23	62/111	720/243	1600/2413	0/ 0	0/ 0
		Sink	25/14.5	55/ 65	92/148	204/213	168/ 84	373/373	48/ 43	106/146	168/ 84	373/373
3-Grid Point	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	9.6/ 68	22/302	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	0/ 0	0/ 0	2/ 11	4/ 49	0/ 0	0/ 0	1/ 1	2/ 4
4-Sounding	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
5-Charts	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	20/ 48	50/1300	2648/1820	5900/8100	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	466/330	1035/1466	400/275	900/1250	0/ 0	0/ 0	248/171	551/760
6-Imagery	10	Source	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	500/123	1111/1666	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
TOTAL Load		Source	2.1/2.9	- -	9/ 11	- -	115/156	- -	3469/2131	- -	0/ 0	0/ 0
		Sink	37/ 28	- -	1097/649	- -	635/438	- -	125/138	- -	494/351	0/ 0
TOTAL BPS		Source	- -	5/ 36	- -	120/147	- -	260/2511	- -	9855/11008	- -	0/ 0
		Sink	- -	81/251	- -	2437/3985	- -	1417/2649	- -	277/1412	- -	1097/2403
Utilization %		Source	- -	8.5/ 18	- -	2.5/ 3	- -	3/ 26	- -	34/ 38	- -	0/ 0
		Sink	- -	40/126	- -	25/ 42	- -	15/ 28	- -	1/ 5	- -	11/ 25

Vi Traffic Component	Delivery Time Ti (min)	Capa-city	BASELINE & IMMEDIATE Teletype Line 200 BPS LOAD AV / PK	BPS AV / PK	VF Line 9600 BPS LOAD AV / PK	BPS AV / PK	Reg. Link 9600 BPS LOAD AV / PK	BPS AV / PK	CMC Link 9600 BPS X3 LOAD AV / PK	BPS AV / PK	AES Link 9600 BPS LOAD AV / PK	BPS AV / PK
1-Observation	10	Source	3/3.9	6/ 52	13/ 16	28/215	96/119	213/1585	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	16.7/ 20	37/266	56/ 70	124/933	90/110	200/1466	116/138	257/1840	116/138	257/1840
2-Forecast	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	31/ 27	69/120	792/267	1760/1186	0/ 0	0/ 0
		Sink	28/ 16	62/ 71	101/ 51	224/226	93/185	206/822	53/ 47	117/209	185/ 93	411/413
3-Grid Point	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	192/1360	426/6044	2/ 11	4/ 48
		Sink	0/ 0	0/ 0	0/ 0	0/ 0	40/232	89/1030	0/ 0	0/ 0	40/220	88/977
4-Sounding	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	26/ 40	58/177	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	0/ 0	0/ 0	9/ 40	20/177	0/ 0	0/ 0	9/ 40	20/177
5-Charts	30	Source	0/ 0	0/ 0	0/ 0	0/ 0	20/ 48	50/1280	4289/2949	9550/13100	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	536/330	1191/1466	648/450	1440/2000	0/ 0	0/ 0	496/341	1102/1520
6-Imagery	10	Source	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
		Sink	0/ 0	0/ 0	500/125	1111/1666	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
TOTAL Load		Source	3/3.9	- -	13/ 16	- -	273/234	- -	5273/4566	- -	2/ 11	- -
		Sink	44.7/36	- -	1206/576	- -	880/1242	- -	169/185	- -	836/310	- -
TOTAL BPS		Source	- -	6/ 52	- -	28/215	- -	1270/4419	- -	11675/20330	- -	4/ 48
		Sink	- -	99/337	- -	2649/4291	- -	1955/5500	- -	374/2050	- -	1877/4927
Utilization %		Source	- -	3/ 26	- -	.5/ 5	- -	14/ 46	- -	40/ 70	- -	.1/ 1
		Sink	- -	50/169	- -	28/ 45	- -	20/ 57	- -	2/ 11	- -	20/ 51

LOAD - K chars or K bytes
BPS - Bib Per Sec Averaged
Source & Sink Reference; see load calculations

Table 2.2.4.2-1 Channel Utilization

2.2.4.3 <u>Quality/Reliability</u>

The Public Packet network is rated at bit error probability of 1 in 10^{12}, which is excellent. The bit error probability of the regional network voice grade lines on a broadcast operation would be 1 in 10^{6} without Forward Error Correction (FEC). (The inclusion of FEC is not proposed)[1]. This is at least two orders of magnitude better than present. The bit error performance of the regional network teletype lines on a broadcast operation would be as present. For point-to-point operation, as for collection, or interactive, FEC would be included.

The Distribution Interface (DIF) hardware is modular in that the number of parallel processors is optional. Thus with the inclusion of a spare processor, the unit would have some inherent redundancy capabilities. A downtime of minutes would result.

The DTE and the DIF are expected to yield greater than a 95% availability. A spare DTE for each region is recommended.

2.2.5 <u>COSTING</u>

(excludes any markup, discounts or taxes)
(all man days are calculated at $500 per day; i.e., Senior Engineer)

2.2.5.1 <u>Capital Outlay</u>

2.2.5.1.1 <u>Distribution I/F</u>

		H/W	S/W
H/W - Materials	$ C		
- Basic Memory	25 K		
- Storage Controller	15 K		
- Console	3 K		
	43 K x 8	350 K	
New Development			
- Sync Ports	30 MAN DAYS (MD)	15 K	
- Contingency Overall (Private Distribution)	100 MD	50 K	
S/W - Development			

---

[1] The inclusion of FEC is optional. The increase in loading due to FEC is dependent on the performance required. A 20% increase in redundancy is justifiable but likely only necessary for the message traffic.

- Basic	500 MD	250 K
- Private Dist (CMC)	60 MD	30 K
- Contingency Overall	130 MD	65 K

2.2.5.1.2 DTE

H/W - Materials

- Basic Memory	10 K	
- Storage Disk Controller	8 K	
	18 K x (72 + 6) = 1405 K	

Development

- MODS Disk I/F	150 MD	75 K
- Contingency	50 MD	25 K

S/W Development

- Basic	275 MD	140 K
- Contingency	100 MD	50 K

2.2.5.1.3 Chart Encoders/Decoders

- Encoders	25 K x (6 + 2) =	200 K
- Decoders	8 K x (72 + 13 + 1) =	680 K

US Exchange is cancelled by volume discount.

2.2.5.1.4 Photo Encoders/Decoders

		H/W	S/W
- Encoders	12 K x 6 =	75 K	
- Decoders	6 K x (72 + 6) =	470 K	

2.2.5.1.5 Network Control Centre (NCC)

H/W	175 K	
S/W 600 MD		300 K

2.2.5.1.6 Modems 5 K x (72 + 6) = 350 K

9600/4800 BPS

2.2.5.1.7 AES CPU I/Fs (Minimal S/W)1

HP2100 I/F	H/W (serial I/F) 5K x 15	75 K	
	S/W 100 MD		50 K
CMC I/F	S/W 150 MD		75 K
Climate I/F	S/W 150 MD		75 K
			200 K1

A great deal of S/W overlap is anticipated.

2.2.5.2 Operation

2.2.5.2.1 Circuitry

	VF intercity circuits (includes maint.)	500 K/Yr
	Teletype circuits (includes maint.)	600 K/Yr
	Photo FAX circuits (backbone)	100 K/Yr

2.2.5.2.2 Packet Network Usage 100 K/Yr

2.2.5.2.3 Packet Network Access 9600 BPS 350/mth x 9 40 K/Yr

A great deal of S/W overlap is anticipated.

2.2.5.2.4 Packet Network Hot Lines 5 K/Yr

2.2.5.3 Maintenance

Hardware	1% per month on H/W	400 K/Yr
System maintenance		in NCC manpower

2.2.5.4 Implementation

Description of events (5YR plan)

Phase I - YR # 1 SPECIFICATION AND TEST

1. System Specification
2. H/W Specification and System Design

3. Implement Prototype Test Facilities for:
   - Packet I/F to CMC
   - Packet I/F to AES HQ
   - Packet I/F to an IP
   - DTE I/F to a UP
4. Monitor Test Facilities and Revise Specs.

Phase II YR # 2, 3 Reduce Switch Load; Remove National Paper Fax Network

1. Install Packet I/F's to all IP's
2. Install Regional Network for one regional
3. Operate DIF at CMC as central switch
4. Add NCC for configuration.

Phase III YR # 3, 4 — Reduce collection system; Expand Regional network

1. Install two more regions
2. Remove present TTY and fax circuits of regions with new service

Phase IV YR # 4, 5 — Complete expansion

1. Install final three regions
2. Remove TTY and fax circuits
3. Convert to distributed switch operation
4. Remove CNCP switch.

System Specification

Man day requirements - for Phase I item 1.

3 AES persons for 90 MD
1 consultant for 90 MD

- for Phase I item 4

3 AES persons for 30 MD
1 consultant for 30 MD

Hardware and System Design Spec

Manpower requirements:

1 - Senior Engineer	90 MD	(system)
2 - Int. Engineers	90 MD	Function H/W and S/W
2 - AES persons	90 MD	

System Checkout and ATP

On completion of each phase the system will be checked out and an ATP run to show system operates within specifications.

PH I	Item 4	-	2 engineers	30 MD
		-	2 AES persons	30 MD
PH II		-	3 engineers	30 MD
		-	3 AES persons	30 MD
PH III		-	3 engineers	30 MD
		-	3 AES persons	30 MD
PH IV		-	3 engineers	30 MD
		-	3 AES persons	30 MD

2.2.5.5 Staffing and Operations

The scenario proposed is the NCC staff do all system S/W support and fault location. Once a fault is located one of the following groups are contacted:

- Modem supplier;
- Telco; or
- H/W manufacturer.

On site NCC staffing would be as follows:

Team Persons

	Full shift (8 am - 4 pm)	Partial Shift (4 pm - 8 am)
Manager	2	0
System Diagnostics and Support	4	3
Implementation	2	0
Planning	3	0
Dispatch	2	1
S/W Development	3	0
	16	4

The above persons are total, not additional to present staff.

COST SUMMARY

NON RECURRING $ C			RECURRING $ C		
H/W	S/W	INSTALL.	ADDITIONAL OPR. MAN	OPR. COSTS	MAINT. (H/W)
4000 K	1050 K	100 K & Expenses	400 K/YR	1350 K/YR	400 K/YR

2.2.5.6 Site Preparation

User & Collector Sites	(155 148)	NEGLIBLE
UP sites	(72 6)	
IP sites	(6)	
MP sites	(2)	

2.2.5.7 Site Installation (One Year Program)

User and Collector sites	- Telco	(155 148) x 30 $	15 K
	- Terminals (by AES)	NA	
UPs	- Telco	(72 6) x 30 $	3 K
	- DTE	(72 6) x 1 MD	40 K
IPs	- Telco	8 x 100 $	1 K
	- Distribution I/F	6 x 3 MD	10 K
	- Distribution I/F	2 x 10 MD	10 K
		Subtotal	80 K
Travel Expenses	Living Expenses		EXTRA
	Airfares		EXTRA

2.2.6 Benefits

1. Integrated Communication System -

The proposed system is designed to handle all AES traffic.[1] It is a total communication system. The proposed system will provide communications for the broadcast traffic plus, data base access plus remote processing access. The costed system includes the interconnection of all AES, DND, and MOT computer resources! The system is most suited to other government agencies to provide cost sharing.

2. Growth -

The proposed system easily handles the baseline plus immediate traffic[2] requirements with about a 100% expandability, at no cost. Beyond this, the regional multi-drop voice grade circuits would require reconfiguration[3] to increase the effeciency of use.

---

1. In remote areas where terrestrial circuits are not available satellite is proposed.

2. The provided traffic estimates are worse case and ball parked on the high side!

3. Four wire duplex regional circuits could be converted to a simplex broadcast service plus a half-duplex point-point service. This arrangement permits more efficient use of the total channel.

3. Security -

The access and reception of data is controllable.

Alternately, Data Route and Info Data 19.2 KBPS services are becoming more widely available at UP sites at a reasonable cost.

4. Risk -

The terrestrial system incorporates a low risk development approach by the use of a Universal distribution I/F and the DTE H/W unit plus reusable layered S/W.

The addition of a one-way satellite system for distribution of broadcast products is compatible and complementary to this system.

5. Economy of Phase-In -

Due to the modularity of H/W and S/W, the DTE and DIF can be upgraded while installed in a stepwise fashion.

6. Flexibility -

The basic system proposed is compatible to a hybrid system where all broadcast traffic is routed via CMC through a one-way satellite broadcast system. The terrestrial system strengths are in point-point communications, which is to become a major component of AES user traffic!

2.2.7 Comments on Present Problems and Future Traffic

Present Problems - Message

(i) Performance

- Speed: For estimated traffic the proposed system is 50% loaded during peak periods, hence speed is not slow.

- Selectivity and Request/Reply: All sites will have a selected amount of data available to it. This selection function is operated from the NCC. Additional data is obtained effeciently and quickly by a request command.

- Priority Handling: System will not need priority handling at the message level.

- Quality Control: For links the system will monitor quality and maintenance will be envoked when quality falls below an

	acceptable standard.
	For operator input, the system permits a distributed quality control method at the regional weather centres.
- Half Duplex operation:	All links are full duplex.
- Hierarchy:	There is a hierarchy of links to suit the hierarchy of users.
- Polled Multipdrop Circuits:	This approach is acceptable to minimize complexity.
- Reliability or Redundancy:	System is distributed so no critical nodes exist. DIF's are modular with internal redundancy provided. DIF's and DTE are highly reliable.
- Control over switch:	AES would have control.

(ii) Adaptiveness

- Inflexible Interfaces:	DIF's and DTE,s are modular and micro processor based.
- Speed	System regional speed is 9600 b/s with growth to 19.2 Kb/s.
- Low Speed Ports:	Distributed system; has high speed ports.
- System Monitoring:	NCC would be adequate.

<u>Present Problems - Charts</u>

(i) Performance

- Broadcast mode:	Multi sources are permitted to transmit to all or any number of sinks.
- Analog:	No digital; but analog is available
- Poor request/reply:	Request for additional or retransmissions is expedient.

(ii) Adaptiveness

- National/Regional Structure:	Simultaneous transmission of regional and national charts are permitted.
- Broadcast mode:	See performance.

Present Problems - Photos

(i) Performance

- Broadcast Limited:	As present.
- Analog	As present, but could be modified to digital, for inter-region. Intra-region is digital.
- Request/Reply:	Retransmission is permitted by request message.

Present Problems - Off-Network

(i) Performance

- Reliance on radio:	Propose upgrade to two way DCP at 1 KBPS.
- Reliance on dial up:	As present.
- Radio fax:	As present; or Marisat DCP or HF digital.

(ii) Adaptiveness

- Special purpose facilities:	The DIF's and DTE's are suited to handle added functions.

Future Traffic

(i) Graphics

The proposed system is compatible to AES anticipated changes in graphics processing. A change over to the use of grid point data instead of charts is most advantageous. The introduction of graphics overlay products and the distribution of radar images are within the capabilities of this candidate.

(ii) Marine Transportation Support

This is a special area not included in the terrestrial system capabilities. It is proposed that future services such as:

- MOBSAT;
- MARISAT; and
- DIGITAL HF

would be most suited and could be readily interfaced to the proposed candidate.

(iii) Dissemination to Users:

All AES, DND and MDT users will be interconnected, hence ensuring data dissemination will not be limited.

2.3 SATELLITE OPTION

2.3.2 System Operation

2.3.2.1 General Outline

The operation of a possible satellite communications system for the A.E.S. as outlined in this report is designed to take maximum advantage of the essentially "Hub" nature of their requirements, where raw data from all over Canada is processed centrally and then re-distributed in an integrated format.

In order to do this, a large number of low capacity channels have been allocated across the country to data gathering, that is, collecting all the SA's, SM's, etc. This raw data is relayed by the satellite to C.M.C. where it is collated and re-transmitted on a single higher capacity channel for general Canadian distribution, along with other data such as that from N.W.S.

The information is then processed at various centres and the weather charts, forecasts, warnings and other processed information are broadcast to the users of this data via the satellite.

Thus, while many channels are used to gather data allowing for simplicity in both the small station message equipment (ASR 35's for example) and the transmission equipment, the formatted and processed information is broadcast on only a few higher capacity channels to minimize the number of receivers needed at the usually more sophisticated offices that require this information. All this information is thus available everywhere, yielding great flexibility in the layout and organization of future re-organization of the A.E.S. system.

2.3.2.1.1 A.E.S. Office Classification

A hierarchial set of 'nodes' or 'offices' has been defined to describe the existing A.E.S. offices with the specific intention of avoiding the use of A.E.S. terminology (WO4 etc.) which can give rise to some mis-interpretation and occasionally controversy. The classification is given in Appendix A.

For the purposes of the all satellite option the nodes are numerically as follows:

STATION TYPE		NO.
M.P.	Downsview & C.M.C.	2
I.P.'s	Regional Centres C.F.F.C.'s Gander/Whitehouse Ice Central	13
UP's		72
Users		148
Collectors		155

55 collectors are currently "Off Network"

2.3.2.1.2 Earth Station Classification

For the purposes of this report, there are four classes of Earth Stations needed to meet the system requirements for this network. The separate classes are basically defined by the data handling capacity of the station. This determines the number of carriers received and transmitted and this in turn determines the transmitter (HPA) power level required at that Earth Station. As the traffic through any A.E.S. station is indirectly related to the station classification itself, a relationship is seen between the class of Earth Station and the station classification. Thus, the ground stations required are:

CMC & Downsview (M.P.'s)	require a	Class I
IP's	require a	Class II
U.P.'s	require a	Class III
Users & Collectors	require a	Class IV

Further details of the Earth Stations can be found in Section 2.3.3 "Earth Station Equipment".

SATELLITE EARTH STATIONS

STATION TYPE	APPROX. NUMBER OF STATIONS	SERVICE					
		DATA		CHARTS		IMAGERY	
		TX	RX	TX	RX	TX	RX
CMC	2	X	X	X	X		X
I.P.	13	X	X	X	X	X	X
U.P.'s	72	X	X		X		X
Users	148	X	X				
Collectors	155	X	X				

2.3.2.1.3 Available Satellites and Communication Frequencies

Currently there are two Canadian owned satellites under development and construction which could be considered as possible future carriers of the AES traffic, these being ANIK C and ANIK D.

ANIK C is an advanced satellite using the "new" frequency bands at 12 and 14 GHz which offer a number of potential advantages over the usual 4/6 GHz band. ANIK D uses the conventional 4/6 GHz band using 24 500 MHz transponders with orthogonal polarization.

ANIK C

ANIK C is a spin stabilized satellite operating in the 12/14 GHz band. It will have 16 channels, each operating with a bandwidth of 54 MHz, with a design lifetime of 10 years and a minimum mission life of 8 years. It will have 4 spot beam antennas which will provide coverage for the southern half of Canada, including all the major urban centres. The northern limit of reception and transmission runs just south of the 60th parallel and the southern share of Hudson Bay. The southern limits of reception is just south of the Canadian/U.S.A. border and the Great Lakes.

Figure 2.3.2.1.3-1 shows the transmit pattern of ANIK C. The "Spot Beam" nature of the Anik C earth coverage limits the usefulness of the satellite to AES's communication system in two ways:

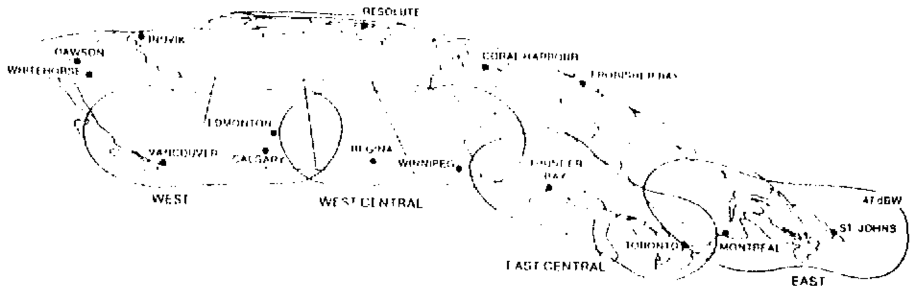
1. the coverage area does not extend far enough north to include all the the user's facilities; and

2. the fact that spot beams are used in the southern urban belt means that a "broadcast" mode of communication would involve the transmission of the same data on four separate carriers.

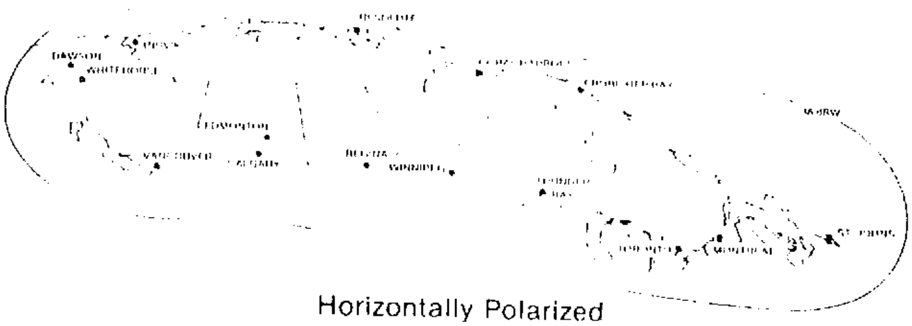
The 12/14 GHz band carries both penalties and advantages. One area of concern in the past have been the increased attention of these frequencies during times of heavy precipi- tation and the use of higher frequency technology. ANIK B (launched December 78) carried experimental transponders to in- vestigate these concerns and the difficulties have now been satisfactorily resolved.

On the other hand, there are two definite advantages of the use of these frequencies, and these are, firstly, that normal terrestrial microwave links do not operate at these frequencies and consequently there is little or no interference to the satellite signals in major urban areas, and secondly, the higher frequencies result in smaller anntennas being required to meet similar performance criteria to the lower frequency bands, leading to a cost saving in hardware and installation costs. It is also easier to make portable equipment using these frequencies as the equipment becomes both smaller and lighter.

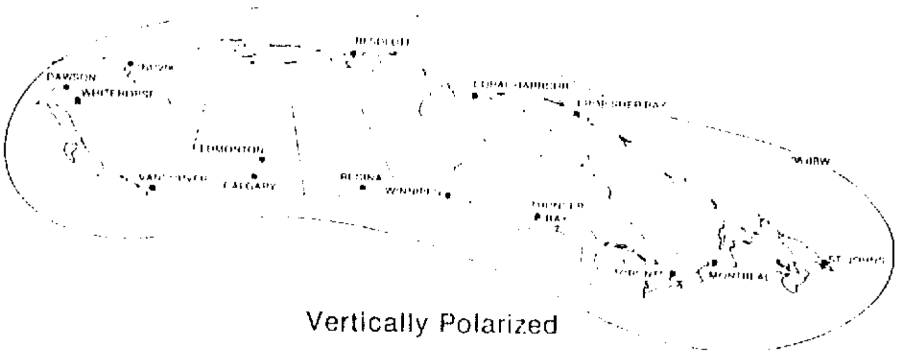
Anik C 12 GHz Transmit Pattern (EIRP) (Typical)



Anik D 4 GHz Transmit Patterns (EIRP) (Typical)



Horizontally Polarized



Vertically Polarized

Figure 2.3.2.1.3 - 1   Satellite Footprints

ANIK D

ANIK D is a spin stabilized satellite operating in the 4/6 GHz band with 24 transponders of 36MHz bandwidth each. Orthogonal polarization techniques will be used to allow frequency "re-use" making possible the operation of two transponders in the same frequency band. It has a design life- time of 10 years with a minimum mission life of 8 years. Its projected launch date will be 1982 by means of the NASA Space Transportation System (Shuttle).
As with the 12/14 GHz frequencies, the 4/6 GHz frequencies used by ANIK D have both positive and negative aspects to their use.

One difficulty of working in this band is that it utilizes the same frequencies as terrestrial common carriers links which are found in some concentration in all larger urban centres. This means that frequency coordination studies will have to be performed as a part of each earth station site selection in order to ensure an acceptable level of mutual interference between the earth station and terrestrial communication system. The characteristics of the AES satellite system proposed tend to indicate that instances of unacceptable interference will be infrequent.

The characteristics may be summarized as follows:

1. Low Earth Station Transmit Power

The earth station transmit power is only of the order of 1 watt per SCPC "regular" carrier (or 1/10 watt per mini-carrier). By earth station standards, this represents a low power level. (For example TV transmission typically requires 1500 Watts). For this reason interference from the earth station into a terrestrial microwave system is unlikely to be a problem in a significant number of cases.

2. Earth Station Receives Narrow Bandwidth

SCPC systems are inherently narrow band. In the AES system, the receiver bandwidth is 38 kHz for the "regular" carrier receivers and 8 kHz for the "mini" carriers. (This compares with bandwidth of TV receivers in the order of 36MHz). This narrow band characteristic contributes to the "ruggedness" of SCPC (i.e., its low sensitivity to interference to other sources) and lowers the likelihood of interference with the SCPC system from terrestrial microwave systems.

3. Flexibility of Frequency Plan

As detailed in Appendix B, a satellite transponder allocated for SCPC has a large number of frequency "slots" (typically 800) which are in turn allocated to particular routes. SCPC channel units are equipped with synthesized transmitters and receivers so that frequencies may be readily reset (by thumbwheel switches for example). The frequency agility (or flexibility) of the system frequencies makes it a comparatively simple matter to change the operating frequency of a particular channel in the event of interference with terrestrial microwave systems.

In cases where technical difficulties do arise due to interference, it may be necessary to locate the earth station away from the user facility in order to reduce the interference to an acceptable level. In these cases a "backhaul" (i.e., a terrestrial communications link) between the earth station and the user facility would be necessary.

On balance, Anik D is seen as a more suitable medium than Anik C for the AES communication system and has been used in the satellite system model described in this report. Figure 2.3.2.1.3-1 shows the transmit pattern of Anik D.

2.3.2.1.4 Transmission Channels

The system proposed uses SCPC (Single Channel per Carrier) techniques. SCPC is described in Appendix B at the end of this report.

The system is one in which a single satellite transponder of 36 MHz bandwidth can be divided typically into 800 channels of 45 kHz, each capable of supporting a data transmission rate of 9.6 kbps. At the expense of increased earth station transmit power it is possible to "upgrade" the system to provide the capability of 56 kbps per 45 kHz frequency "slot" (see Appendix I).

The system employs, in addition to the 9.6 kbps carriers, "mini-carriers" (using 10dB less power) with the capability of 300 bps (see Appendix B).

Anik D, which is scheduled for launch in 1982, will have a total of 24 transponders. The SCPC carriers proposed for the AES communication system of the foreseeable future represent a small fraction of the capacity of one of those transponders. Details of the allocation of the data for these AES. channels are given in the next section, 2.3.2.1.5.

The channel allocation itself is shown in Table 2.3.2.1.4-1 where the information, divided by:

- message;
- batch & interactive;
- imagery;
- charts;

is related to the various station classification as outlined above.

As may be seen from Table 2.3.2.1.4-1, light "regular" carrier frequency slots (45kHz) have been allocated for "mini-carrier" operation. These 40 mini-carriers form 40 half-duplex circuits between CMC and all other stations. The circuits are shared for Users and Collectors with low data rate requirements, one circuit is allocated to a number of stations and time shared. Stations with greater data rate requirements (IPs for example) have a dedicated mini-carrier circuit. The half-duplex nature of the mini carrier circuits is described in Appendix I which also describes the way in which they can be used to emulate AES's present communication procedures.

Table 2.3.2.1.4-1 shows that Satellite Channel Number 1 is used for message transmission from CMC to all stations except those with data receive requirements low enough to be satisfied with a half-duplex mini channel circuit.

As an example of the signal flow through the message communication system, we will consider the relay of data from a Collector to its Regional Centre (an IP).

The half-duplex circuit from the Collector to CMC is shared with a number of other Collectors and Users. The Collector being considered will transmit its data (at up to 300 b/s) only when polled by CMC, so that the sequence of events is:

1. CMC polls collector (on half-duplex circuit);

2. Collector transmits its data (on same circuit);

3. CMC receives data (on same circuit);

4. CMC multiplexes data onto its 9.6kb/s broadcast data stream;

5. CMC transmits its 9.6kb/s data (on Channel #1) Note: This is a continuous process; and

6. Regional Centre (parent of the Collector being considered), receiving the 9.6kb/s carrier, extracts data destined for that Regional Centre, including the data from the Collector.

SCPC Channel Allocation				
Channel Number	Number of mini Channels	Traffic	Originating Station(s)	Receive Stations
1	N/A	Message	CMC	All stations except low capacity stations which use mini carrier receivers.
2, 27	N/A	Interactive and Batch	MPs, IPs (TDM)	MPs, IPs
3 thru 6	N/A	Imagery	MPs, IPs (Time shared)	MPs, IPs
7	N/A	Charts	CMC	MPs, IPs some UPs
8 thru 18	N/A	Charts	IPs	UPs
19 thru 26	5 ea.	Message	CMC, UPs Users, Collectors	CMC, UPs, Users

Table 2.3.2.1.4-1

2.3.2.1.5 Lines of Direct Communication

Figures 2.3.2.1.5-2 through 6 illustrate the lines of direct or principal communication for AES data using the satellite system.

Although the charts designate C.M.C. as being the main switching centre, this role could be either duplicated or transferred to any other station desired to better meet the A.E.S. requirements.

All Canadian data is collected at C.M.C. directly from all the collection points. This data is then collated, and re-broadcast to all stations receiving the high-capacity message broadcast circuit, (Channel 1 in Table 2.3.2.1.4-1). These stations will program their receivers to accept only that data that is required and reject the rest. For users requiring very small amounts of data and requiring cheap terminal equipment, messages can be formatted by the message switch and passed on via a low speed channel as at present.

Every centre that produces charts broadcasts these directly to all who need them. However, in order to reduce the number of receivers modems per station, it is proposed that the I.P.'s receive all the C.M.C. and relayed N.W.S. traffic and then re-broadcast as required a mix of these and their own charts on one channel to their region of interest. Two channels will be time shared by all the regions in the initial scheme.

Imagery

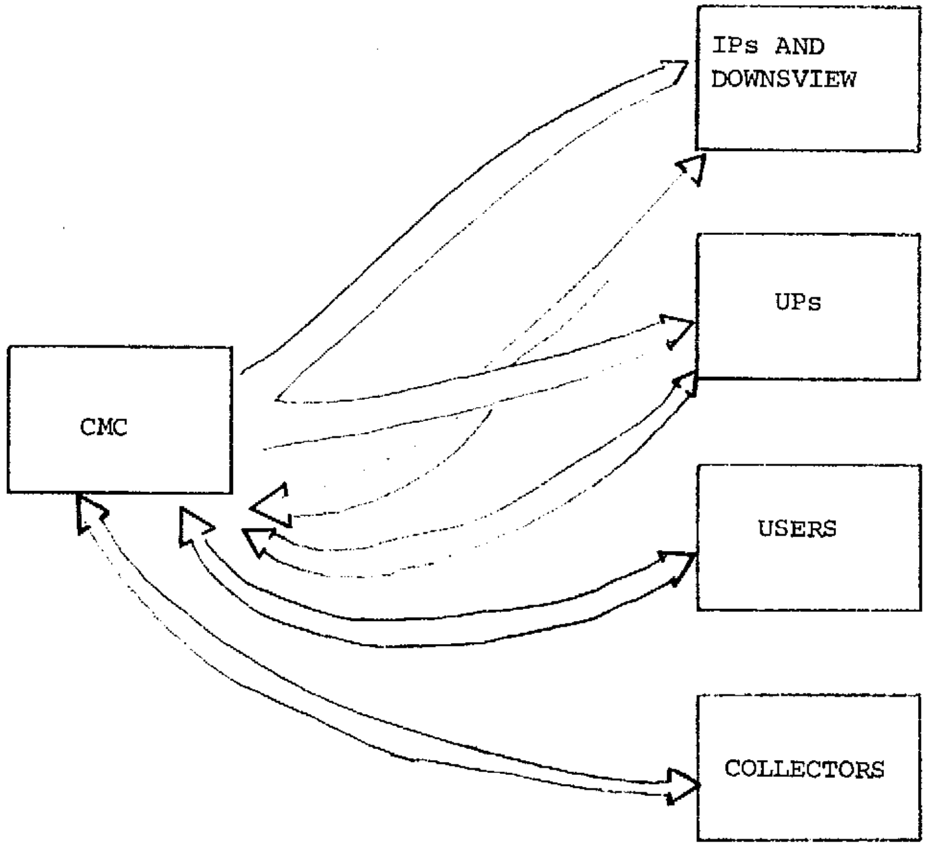
Processed satellite photgraphs are transmitted by the station which processes them. There are 4 SCPC channels available for this. For these purposes there will be a trade-off decision as to whether each station should have its own transmitter and hence require all receiving stations to have 3 or 4 receivers, or whether to time share transmission channels. An input from A.E.S. would be required on this point. Time sharing of transmission channels is recommended and assumed.

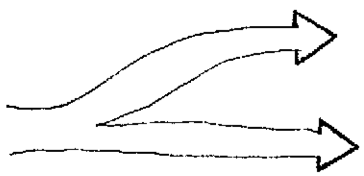
Interactive and Batch

For A.E.S. purposes, Batch is assumed to mean the transfer of Grid Point Data from C.M.C. to a regional centre (or I.P.). This is a one way straight data transfer as shown in the diagram. "Interactive" is remote data access and is transmitted along the "Message" paths as shown.

Figure 2.3.2.1.4-2 - Message Communication

LINES OF DIRECT COMMUNICATION





SINGLE ONE-WAY
9.6 kb/s MESSAGE CARRIER

MULTIPLE (40 TOTAL) 300 b/s HALF
DUPLEX MESSAGE CARRIERS
("MINI-CARRIERS")

IP INTERMEDIATE PROCESSOR
UP USER PROCESSOR

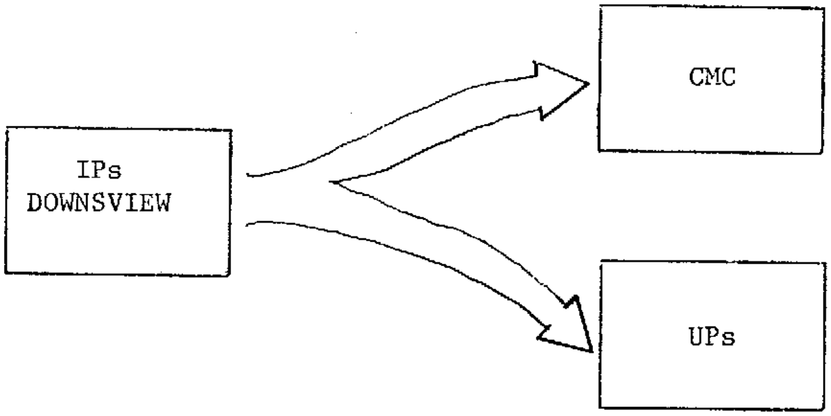


Figure 2.3.2.1.4-3 IMAGERY COMMUNICATION

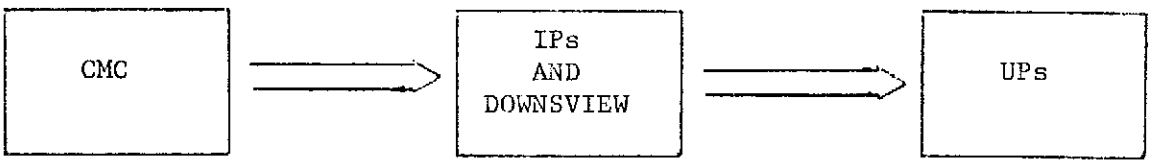


Figure 2.3.2.1.4-4 CHARTS COMMUNICATION

LINES OF DIRECT COMMUNICATION

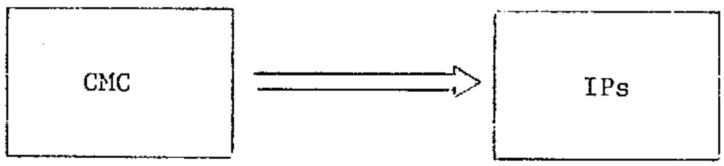


Figure 2.3.2.1.4-5 BATCH COMMUNICATION

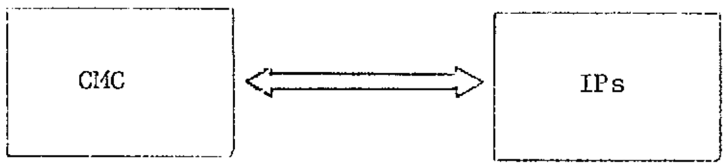


Figure 2.3.2.1.4-6 INTERACTIVE COMMUNICATION

2.3.2.1.6 Circuit & Office Throughput Analysis

All traffic used for these calculations is taken from Appendix A.

Table 2.3.2.1.5-1 (1-4) - Throughput Volumes for Each Type of Node

These tables list the received and transmitted traffic for each class of node. They give the following information - referring to individual stations of that type.

CHANNEL	The satellite channel (see Table 2.3.2.1.4-1) on which the information is carried.
L	The average length of a message, in bytes, or characters.
5 min. pk. VOL. kch	The peak 5 minute volume of data expected to be transmitted as received at/from the node, measured in kilobytes/characters.
1 hr. av. vol. kch	The normal average traffic measured over any one hour, in kilobytes/characters.
Delivery	This is the time allowed for delivery of a message after its issue, and is with respect to transmission only.
Peak	Where given, this is the normal time that a Time scheduled message will be formatted for transmission and relates to scheduled traffic only.

Charts & Imagery: These are not described in the above terms, and the data is self-explanatory.

Table 2.3.2.1.5-2 - Station Transmission Requirements

These tables list total traffic parameters collectively for the A.E.S. station types. The columns are as follows:

No.	The number of stations allocated to that particular class for the purposes of this study. (See Section 2.3.2.1.1, Downsview included as an I.P. for these tables).
pk. vol. kchs/5 min.	This is the peak 5 minute volume of traffic transmitted from any group of stations. Note that this refers to the peak loading and is not a summation of the 5 minute volumes

unless they coincide in transmission times.

Bit Rate	This is the allocated channel bit rate - see Section 2.3.2.1.4.
No. of Chans.	This gives the total number of channels made available to the group of stations e.g. 11 channels at 110 b/s service all the 155 Collectors giving approximately 14 stations per channel.
Chan. pk. utilization	This is the channel 'loading factor' while it is carrying the 5 minute peak transmission.
kCHs/hr.av.	This is the average traffic load generated by the complete group of stations over any one hour.

In the case of the I.P.'s and the U.P.'s the term "mini" refers to a 110 or 300 b/s channel and "full" refers to a 9.6 kb/s SCPC channel.

Only Satellite Channel traffic is given.

Table 2.3.2.1.5-3 - Transmit Channel Allocation

These tables give the traffic details for each of the satellite SCPC channels. The channels themselves are as allocated in Section 2.3.2.1.4.

The following statistics are given:

Traffic	Type of A.E.S. traffic to be carried on the channel.
5 min. pk. kCH.	The channel 5 minute peak loading in kilo characters. In the case of the full SCPC channels divided up into 5 mini channels, the loading of each mini channel is also given.
1 hr. AV (kCH)	As above, but for one hour average loading.
Bit Rate	Channel bit rates used.
Average Utilization	Average utilization of channel as a percentage of maximum capacity.
pk Utilization	Peak channel utilization as a percentage of maximum channel capacity.

Note: For the calculation of the statistics used in these tables one character was taken to be 11 bits of information. In reality the final number will vary slightly from this dependant on the code used and on the type of forward error correction used for the transmission. This is likely to be a 3/4 code. (See Section 2.3.2.4.4).

Channel Capacities

Mini Channels - Most of these channels were originally intended to operate at 110 b/s. However, revised traffic estimates (see "System Selection Phase Report) shows a requirement to operate these channels at 300 b/s. This is easily accomodated.

The current figures also assume that all SA's and SM's etc. must be collected within 5 minutes of the hour. A relaxation of this number to 10 minutes in conjunction with the 300 b/s option give an immediate effective capacity increase of 4 times. (Note that this is related to the peak traffic loading. The average loading is so low that no consideration of increases need be made at this time).

SCPC Channels using full Bandwidth - In order to reduce the transmitters power requirements, and thus keep costs of station hardware to a minimum, these channels are intended to be operated at 9.6 kb/s. However, should future traffic patterns demand, they may be increased to a maximum of 56 kb/s (see Appendix B, 2.3-1), giving a 5 fold traffic capacity increase. Due to a low overall channel utilization at 9.6 kb/s, it is not anticipated that this will become necessary in the foreseeable future. If it did, some further changes would become necessary involving the Switch Software and some of the Station hardware in receivers. This could be foreseen and planned for well in advance of the requirement, but the potential is there from the start, built into the system.

Table 2.3.2.1.5-4 - Channel Utilization Costed System

This table gives the average channel utilization for both transmission and reception of required data on the proposed Satellite circuits. In particular; Interactive and Batch is a new service for which two channels of 56 kb/s capacity may be allocated to the traffic. Initially the channels will be run at 9.6 b/s. No detailed analysis has been done as the available capacity far exceeds the expected traffic levels.

Satellite Imagery was adjusted to give 10% capacity over the maximum number of photos expected in the immediate requirements. More channels can be added if and when neccessary to cover future expansion. Numbers reflect analogue transmission, equivilant to about 13kb/s, uncompressed data. Average utilization gives channel utilization where given traffic is applied to an hourly cycle. (As this is not always the case, for example with forecast traffic, the figures represent a "worst case").

The Peak Period figure is derived by assuming, theoretic- ally, that all traffic is available for transmission at the beginning of any hourly period and is then transmitted at the full channel capacity. The period of time it would thus take to transmit all the hourly traffic is given. This, subtracted from 60, therefore gives the spare time available on the channel in any hour at the given transfer rate of information (Bit rate).

Throughput Volumes
Per Site

MAJOR PROCESSOR (C.M.C.)

Information	Channel	L	5 min. pk. Vol. kch.	1 hr. av. Vol. kch.	Delivery	Peak Time
Transmit						
Fcst	1 &/or 2	1400	25.0	30.0	30	
Batch	2	1800	32.5	55.0		
Admin						
Interactive		Undefined				
Charts	7	17"	peak 270 ins./hour = 13 kb/s			Compressor 2.6 kb/s
			average 180 ins./hour = 8.75 kb/s			1.75 kb/s
Received						
Observations	minis.	88	56.7	70.0		H + 05
Fcsts (I.P.'s)	mini or 2	385	77.8	86.4		
N.W.S.	Terrestial	500	64.0	240.0		
Charts						
Imagery	3 ... 6	From Edmonton	23/day			
		Halifax	3/day			
		S.D.L.	94/day			

Table 2.3.2.1.5-1 (1)

Throughput Volumes
Per Site

INTERMEDIATE PROCESSORS

Information	Channel	L	5 min. pk. Vol. kch.	1 hr. Av. Vol. Kch.	Delivery	Peak Time
Transmit						
Fcst (Reg.)	Mini or 2	385	7.2	8.0		
Admin.	Mini or 2					
Interactive	2		7.0	12.6 per user site		
Charts	Current Max. 208 minutes = 520 inches					
	Data Equivilent		3.28 MBytes/hr.		uncompressed	
	Channel 8/9		656.3 kBytes/hr.			
Imagery						
Receive						
Observations	1 or 2	88	45.3	56.0		4 + 15
Fcst (Reg.)	1 or 2	385	43.2	48.0		
Fcst (C.M.C)	1 or 2	1400	12.5	15.0		
N.W.S.	1 or 2	500	40.0	150.0		
Interactive	2		S(0.1)*	S(0.6)*		
Batch	2	1800	32.5	4.6		
Charts	8 thru 18					
Imagery						

*S = No. of interactive sites:

Table 2.3.2.1.5-1 (2)

Throughput Volumes Per Site

USER PROCESSORS

Information	Channel	L	5 min. pk. Vol. kch	1 hr. Av. kch	Delivery (mini)	Peak Time
Transmit						
Obs.	(mini)	88	0.1	0.071	5	H + 05
Interactive	mini		0.1	0.6		
Admin.						
Receive						
Observat.	1	88	29	35		H + 15
Fcst. (Reg.)	1	385	43.2	48		
Fcst. (Nat.)	1	1400	11.5	15		
N.W.S.	1	500	48	180		
Interactive	2	?	7.0	12.6		
Charts	8 thru 18					
Radar						

Table 2.3.2.1.5-1 (3)

THROUGHPUT VOLUMES FOR EACH TYPE OF NODE

Collectors	(Each)	L	Vol.(Max.) (Ch.)	Time	Del.
One Channel (	Px	88	100	10 minutes	–
(mini) (	Tx	88	100	10 minutes	H + 5 mins.

Users

	Channel	L	5 min. pk.vol.(kch)	1 hr. kch av. vol.	Delivery	Time
Transmit						
Observations	(mini)	88	0.1	0.071 ~	5 mins.	H + 05
				=	5 mins.	Specials
Receive						
Observations	1	88	8.5*	10.5		H + 15
Fcst.	1	385	21.6	24.0 (?)		
N.W.S.	1	500	48.0	180 (?)		

Table 2.3.2.1.5-1 (4)

*15% of Max. National Traffic (per site)

TRANSMISSION REQUIREMENTS (MESSAGE)

	STATION TYPE	NO.	Pk. Vol. kCH/5 min.	bit rate	Chan Pk Utilization (over 5 mins.)	No. CHANS.	kCH./Hour average (total)
	COLLECTOR	155	15.5	110	50%	11(m)	24.8
	USERS *	118	11.8	110	50%	8(m)	22.4
	U.P.'S *	102	10.2	110	50%	7(m)	19.0
	I.P.'S (mini)	14	100.8	300 b/s		14(m)	112
Interactive	full	14		9.6 kb/s		1	
General	MP (C.M.C.) full	1	25	9.6 kb/s	9.6%	1	30
Interactive	full	1				1	
	N.W.S. (for relay)	1	80	9.6 kb/s		1	300

m = mini channel (5 to one SCPC Channel)

∴ Total SCPC channels for (minis) = 8 at 5 minis/SCPC Channel

* NEW STATION ALLOCATION GIVES UP'S = 72, USERS = 148.

Table 2.3.2.1.5-2

TRANSMIT CHANNEL ALLOCATION

C.M.C. acts as Communications "hub", volumes and channels are defined in chart ( ) for all other offices.

	CHANNEL NO.	TRAFFIC	5 min. pk kCH	1 hr. aver. kCH	Bit Rate	Average Utilization %	Peak Utilization %
	1	General Msg.	100.8	492.2	9.6 K	15.8%	38.5%
	2	Interactive & Batch					
Imagery	3 4 5 6	Satellite Imagery from I.P.s	Channel Allocation and Loading to be Assigned. SEE TABLE 2.3.2.1.5-4				
Charts	7 8 thru 18	C.M.C. charts Regional Charts Regional Charts	Distribution data not yet available. SEE TABLE 2.3.2.1.5-4				
Mini Channels	19 20 21	I.P. Comms.	100.8 Total 7.2 each	11.2 Total 8.0 each	300	8.2%	88%
	22 23 24	U.P. Comms. User Comms.	10.2 Total 1.5 each 11.8 Total 1.5 each	19.0 Total 2.7 each 22.4 Total 2.8 each	110 110	7.5% 7.8%	50% 50%
	25 26	Collector Comms.	15.5 Total 1.4 each	24.8 Total 2.3 each	110	6.4%	50%

NOTE: FOR UP'S, USERS & COLLECTORS, TRANSMISSION REQUIREMENTS ONLY ARE GIVEN IN THIS TABLE
TABLE 2.3.2.1.5-4 INCLUDES MESSAGE DISTRIBUTION TO THESE SITES

Table 2.3.2.1.5-3

CHANNEL UTILIZATION — COSTED SYSTEM

CHANNEL NO.	TRAFFIC TYPE/ SOURCE	1 hr. Av. kch	TRANSMISSION BIT RATE	AVERAGE UTILIZATION	PEAK PERIOD
1	General Message	492	9.6 kb/s	16.2%	9½ mins.
2/27	Interactive & Batch		9.6 kb/s full duplex		
33 : 6	Satellite Imagery	Max. No. of Photos Summer	10 mins./photo	Max. 90% Av. 78%	54 mins. 47 mins.
7	CHARTS CMC	15 hrs. 11 total Tx	For analogue, as at present	63% per day	Equiv. per hour 37 mins 58 secs
8 thru 18	CHARTS Regions	17 hrs. 21 total Tx	24½ secs./inch	36% per day	21 mins.36 sesc
19 *	UP's Tx obs/	600 ch./hr./station	300 b/s	(1) 44% (2) 4.7%	(1) 26 mins. 40 (2) 2 mins. 49
*	Collectors } obs	Tx 5.6		~ 1.7%	~ 1 min.
26 *	Users } fcst NWS	Rx 47.6	300 b/s	44%	26 mins. 10

*NOTES UP's.
(1) All UP's (72) on one circuit - transmit only
(2) At 9.4 stations/circuit - transmit only. (as Collectors & users)
(3) 9.4 stations per circuit for collectors & users.
(4) Up to 5 channels are available (from UP's) as spacer to be used where required (or one full SCPC channel).

Charts

All CMC charts are transmitted Channel 7 using the existing analogue transmission format. As this channel's use is exclusively for C.M.C., there will be sufficient capacity to handle the required 10%-15% increase required (see also Section 2.3.2.1.6).

Imagery

C.M.C. will have the communications capacity to receive all the Imagery channels, that is, each of the national channels (4) will have a receiver/demodulator unit.

2.3.2.2 Network Operation

This section outlines the operation of the network from the various classes of station. It will relate to the transfer of messages only. Equipment, data base requirements and intelligence are described elsewhere.

2.3.2.2.1 Collectors and D.C.P.'s

As these include both manned and unmanned (autostation) stations a variety of command, control and administrative messages may be received. These may be either machine generated or directly sent messages. ("person generated")

These stations will format their data according to schedule (as at present) and enter it into the send equipment (ASR35, Infomode 200, etc.) from where it will be polled by the central switch.

2.3.2.2.2 Users

These offices require greater amounts of received data to that of the collectors, principally concerning local weather data and forecasts.

Transmission of Data

This will take place in the same way as for all the collectors. Data will be transmitted on request (polling) and should be transmitted in a 'non-destructive' readout. That is, the data should be retained in the sender (or re-entered) so that it may be repeated if Quality Control determines an irregularity in the received message.

Reception Requirements

The Satellite System proposed is capable of providing three alternative ways of satisfying Users' data requirements. The method (a) below satisfies the requirements of Users with low data rate requirements. Methods (b) and (c) may be used for Users with data rate requirements exceeding 300b/s.

(a) Receive on 300 b/s Circuits

This would allow the Users to continue to operate as at present, with no perceived changes in the system, with the exception of a reduction of unwanted traffic. Messages of the required data would be formatted at the central switching facility relay, as at present.

(b) Receive on 9.6 kb/s Channel Dumb Terminal

All data transmitted on the high capacity channel would be received on a dumb terminal and required items manually selected for hard copy printout. This would require some careful organization on behalf of the A.E.S. For example: All messages received between H 06 and H 07 will be printed out at stations A-D. Hence the correct messages must be arranged to be carried at these times. Special formatting requests to the switch would be required.

(c) Receive on 9.6 kb/s Channel - Smart Terminals

All data transmitted on the high capacity channel will be received selectively by an intelligent terminal, the required data being recognized by header information. No special formatting will be required and each station can operate more or less independantly of the network. This method is recommended.

2.3.2.2.3 User Processors

Transmission Requirements

User Processors transmit messages and data only. These will be transmitted in the same way as for the Collectors and Users. Low capacity 300 b/s circuits will be used to carry this data, and this will be interfaced directly with the central switch (CMC). However, as some of these stations may require a fast turnaround message request/reply serice ("interactive") so that the polling rate for these channels will be higher than for the Collectors and Users.

Receiver Requirements

These stations require reception of both message and charts in all the offices.

Charts

It will be possible to receive charts from two sources, that is from CMC directly and from Intermediate Processors.

(a) C.M.C.

All CMC and NWS charts will be broadcast across Canada on Channel 7 and any office that desires to may operate a receiver for this frequency. The chart recorder may be interconnected directly to the modem output and there will be no perceived changes in the operation from the point of view of the station.

(b) IP's

For the proposed 'modus operandum', the IP's will receive all the CMC and NWS charts transmitted. They will then select a sub-set of these for relay to their own region and add these to locally produced charts thus the UP may operate on one channel only, receiving a sub-set of the whole, organized for his purposes by arrangement with the IP.

The UP's could alternatively operate two chart recorders and receive all CMC and IP traffic.

Message Reception

All U.P.'s will meet their data requirements by accessing the high capacity (9.6 k/s) channel 1.

Intelligent terminals will be used to select the messages required and to dump unwanted information. (This information will still be available on request from the system data base).

For request/reply, ("interactive"), data access there can be three, interrelated, modes of operation.

(a) Local Data Base

As all raw data and processed information is transmitted on the general message channel, No. 1, virtually all possible required information passes through each User Processor during the course of the day. Including the NWS traffic, this is of the order of 12 Mbytes/day. Excluding the NWS traffic, about 5 kbytes, which is an average traffic density of less than 200 Kbytes per hour.

Thus various levels of local data base may be designed, each 'increased' level reducing the request/reply requirements of the communications system.

A "best-mix" of these should be designed at a later stage in the programme. The communications system is not dependent on the choice of sub-system and, in fact, changes can, and will be expected, to be made over the next decade along with changing A.E.S. requirements.

(b) System Data Base Access via 300 b/s Channels

The low speed 300 b/s circuits may be used for both request and reply.

With no local data base, this may result in unacceptably long delays. With a limited local data base, the traffic can be reduced to a level consistent with acceptable turnaround times.

(c) System Data Base Access via 300/9600 b/s Channels

This is the costed system of operation. The request would be sent out on the low capacity line, and the reply received via the 9.6 kb/s general message channel.

(d) Best Mix

A best mix of the above might optimize the system.

Other Requirements

Other possible 'immediate' but not implemented requirements for U.P.'s are discussed in Section 2.3.8. Existing Radar arrangements are expected to remain temporarily untouched. This is discussed in section 2.3.8.2.

The U.P.'s on an individual basis for special cases, may be incorporated into the 'Interactive Net' as discussed in the next section for Intermediate Processors.

2.3.2.2.4 Intermediate Processors

The Intermediate Processor is involved with all three types of transmission: Messages, Charts and Imagery.

Messages

Interchange of message information between IP's and the network may happen in one of two ways.

The first method described is the method costed for this stage of the study, and results in a relatively high degree of autonomy for the IP's.

The second will involve using a packet switching routine to allow all the IP and MP communication processors to be interconnected. Digital Equipment Corp. (DEC) produces a software package for such a system under the tradename DECnet. This network would generate a highly flexible integrated network for a minimal software outlay.

(a) Method I

All IP's will transmit their data and messages via CMC (or the Network Switch if located elsewhere) via 300 b/s channels, one per IP, where they are routed to their destination, and processed as required. Return information is carried via channel 1 or 2.

(b) Method II

All the IP's and MP's have their communication processors linked by means of a packet switched system controlled by a DECnet (or equivalent) software package. This operates in a duplex mode at 9.6 kb/s on channel 2. This channel may be upgraded if necessary to handle up to 56 kb/s (see Appendix B).

Charts

Intermediate Processors will receive charts on channel 7 transmitted by C.M.C. and will transmit regional charts on channels 8 through 18. There are two proposed means of operating this system for discussion. The first method has been costed.

(a) The IP's will gather all information disseminated from CMC and relay the relevant charts along with their own to the UP's. Preliminary figures show that this will operate satisfactorily, but a deeper analysis will be needed to allow detailed system design and appropriate schedules to be proposed.

(b) The IP's will transmit their own charts only on the allocated channels and the UP's will receive CMC charts on the separate channel.

These channels are sufficient to handle the existing traffic requirements of the A.E.S. as given in the traffic details without any increase of operating speed. If increased traffic densities are required in the future, or if it is required to minimize space segment costs, more efficient methods may be used to carry the data. These include:

(a) digitizing the data (which yields a 5:1 data compression) and transmitting the compressed data on a 9.6 kb/s data carrier;

(b) as (a) except using a 56 kb/s data carrier.

Satellite Imagery

Four SCPC channels will be allocated to carry the satellite imagery from the processing stations. The signals will be broadcast in analogue format as at present and the receiving stations will not perceive any change in the system from present operations i.e. the existing facsimile machines, or replacements, will be able to interface directly with the channel via an RS232 plug or equivalent. Some channel time sharing will be necessary. For example, Halifax does not need a channel for very long for an average of 3 photos a day. Time sharing details will be determined during the system design and allowance for this (time-sharing) has been made in the system costing.

Batch

Batch, as grid point data from C.M.C., will be received via channel 2 at 9.6kb/s. The tables in Section 2.3.2.1.5 give the channel loading for this.

2.3.2.2.5 Major Processors

There are two AES units that have been given the title of Major Processors. These are CMC and Downsview.

(a) CMC

For the purposes of this document and of this phase of the study, CMC will act as the Communications 'Hub' and switching centre for the proposed system. All equipment relating to this function will have built-in redundancy to avoid any catastrophic system failure between the modems and the antenna. (See Section 2.3.2.4).

From there, it should be regarded as a system trade-off decision as to whether there should be an on-site communications computer, operating in "hot" standby, or whether this should be handled remotely, for example at Downsview, to ensure the continuity of service. Costs of the Transmit/Receive equipment up to and including the modems are given, and these would be approximately mirrored in a duplicated system with space redundancy.

Message Traffic

Received Traffic.

C.M.C. acts as the central message receiving hub for all the 110/300 b/s circuits on the AES system, that is, channels 19 to 26, a total of 40 channels.

The Users, Collectors and User Processors operate on a 'polling' basis, as at present. When any circuit is free, i.e. no transmission is being received, the circuit will be polled according to a schedule of station priority, calling for the next input.

All the Intermediate Processors have a circuit apiece, and this can transmit directly. (Method I, Section 2.3.2.2.4). When using method II, where all the I.P.'s and MP's are linked using a DECnet type system, the IP 300 b/s circuits vanish as communications take place at higher (9.6 kb/s) speeds. This traffic would be handled on channel 2.

Transmitted Traffic

All the traffic is collated at the main switch and then transmitted on the high capacity general message channel, No. 1. It is intended that eventually everyone requiring any message (alpha-numeric) data on the AES circuits will have the capability to extract the messages they want from this circuit. Until this happens, messages may be "bulletinized" as at present for distribution to those 'Users' not accessing the general message channel.

Special formatted traffic such as Batch and Grid Point data will be transmitted on channel 2 according to schedule.

All special traffic destined for Collectors will be transmitted on the appropriate 'mini' channel.

(b) Downsview

There are two perceived possible operational modes for Downsview. The first is that it operates principally as an Intermediate Processor, with the exceptions as shown below, and the second is that it has the same transmission/reception capability as CMC in order to act as a 'back-up' station for times in which, avoidably or unavoidably, CMC is "off the air".

Although Downsview acts as an I.P. in many respects, it has supplementary functions that increase its communication requirements. The principal extra functions are as follows:

Archives

In order to aquire data for the archives a very much higher percentage of the daily traffic must be retained and processed, thus requiring greater memory allocation for the F.E.P., or alternatively, a separate memory store and processor for the archiving department which could have a direct tap onto the general message channel output from the receive modem - Channel 1.

Quality Control

In order to operate its Quality Control facility, Downsview needs rapid access to all hourly and synoptic data. This may be simply achieved in two ways:

- arranging the scheduled re-transmission of this data from CMC on channel 1 to meet the time constraints of the Q.C. department;

- having the capacity to receive the raw data as it is relayed from the satellite.

If Downsview has a full duplicate, (to CMC), communications capacity, then this second possibility will be automatically available.

Training Branch

This AES department has need of a variety of information in order to carry out its function. In the current communications arrangement, or any similar system, there is limited access to the required data. However, in the proposed satellite communications system all the network data including regional charts is broadcast, and hence available everywhere. In addition for an IP operating on the interactive channel 2, the whole system data base is available. Thus Training Branch could operate in any desired way. The requisite data storage and communications facilities can be made available.

2.3.2.3 Mobile Users

The use of a satellite to handle network communications allows the use of mobile stations using standard network equipment and procedures. Mobile stations can be divided into two groups, these being "Fully Mobile" and "Deployable".

2.3.2.3.1 Fully Mobile Stations

Any platform sufficiently stable to allow the operation of a stabilized antenna platform can operate as part of the proposed network as long as they are within the 'foot print' of the satellite. This includes shipping and aircraft.

2.3.2.3.2 Deployable Stations

The satellite based communications network allows standby, or and mobile, stations to be moved quickly into temporary positions in cases of emergency or for short term 'studies' of a particular area. These could be assembled in a matter of hours when needed. They have not been costed in this proposal. Examples of use and location:

- oil drilling rigs in Arctic and North Atlantic;
- special intensive weather/climate studies in an area;
- flood or other major event monitoring.

2.3.2.4 System Reliability

2.3.2.4.1 Redundancy

The Major Processors and the Intermediate Processors would have redundancy in the principal components for the Transmitter and Receiver - i.e. High Power Amplifier, Low Noise Amplifier, Upconverter and Downconverter in the RF Section. In the proposed system the individual channel equipment would not be redundant except where specially requested by AES.

Although it has not been costed, it is proposed that consideration be given to having a second Ground Station with the capability to take over the communication functions of C.M.C. should the requirement arrive, e.g. at Downsview.

User Processors, Users and Collectors would not have redundant equipment, unless specially requested.

2.3.2.4.2 Maintenance and Repair

The communications equipment would be modular in design allowing a quick change of modules in the event of failure. An alarm system would indicate channel failure as it occurs and in the case of a failure in the main transmission chain of an MP or an IP, the redundant equipment would automatically be switched into the circuit. Computer and switching equipment would normally be maintained by a service contact/agreement with the suppliers.

2.3.2.4.3 Storm & Disturbance Immunity

The communications equipment would be designed to be immune to signal interference due to storms and atmospheric disturbances. However, at predictable periods, twice a year, sun outage will occur. Depending on the latitude of the ground station these will be approximately as follows:

Approx. angle subtended by Sun at 5 cm. band	2.6 degrees
Half power B/W of 10ft Antenna at 5 cms	1.2 degrees
Total	3.8 degrees

As the Earth rotates through 1 degree in 4 minutes
Total (maximum) time of Sun Outage - 15 minutes

This represents a worst case outage. Outages occur twice a year, one in the spring and in the fall, and last for approximately 4-5 days for outages greater than one minute, and about 12-14 days in all.

2.3.2.4.4 Quality Control and Error Control

There are two aspects for consideration and these are the control of Transmission Errors and the A.E.S. control of the quality of data.

The control of transmission errors in the transmission path is aided by the use of 'Codec' equipment giving Forward Error Control capability. For this system the transmission path errors should not exceed 1 in 10 to the seventh or approximately one character error in a million.

As far as AES Quality Control of data is concerned, in the satellite system all data "passes through" the system communication hub (at CMC). This provides a convenient centre for the AES control of data (including errors of input).

2.3.3 Satellite Earth Stations

2.3.3.1 Earth Station Characteristics

Figure 2.3.3.3-1 shows a block diagram of the fully redundant earth stations which would be used at CMC and Downsview (Class I) or at IP sites (Class II).

The earth station comprises five major sub-systems:

- Antenna;
- High Power Amplifier (HPA);
- Low Noise Amplifier (LNA);
- Ground Communications Equipment (GCE) (consisting of the up-and down-converters);
- Single Channel per Carrier (SCPC) Equipment.

2.3.3.2 Antenna

The antenna is a parabolic dish similar to those used throughout Canada and the U.S. for TV Receive Only and Two-way message service. The antenna serves transmitter and receiver. The transmit and receive signals are orthogonally polarized and the feed system provides the necessary isolation. The beam width is of the order of 1.2 degrees. Since the ANIK satellite station - keeping is approximately 0.1 degrees, no automatic tracking is required.

Antenna Specifications

Diameter		10 feet	
Gain	Transmit (i.e. 6GHz)	44	db (approx)
	Receive (i.e. 4GHz)	40.5	db (approx)
Beamwidth			
@ 3 db point		1.2 degrees	
@10 db point		2.2 degrees	

2.3.3.3 High Power Amplifier (HPA)

The function of the HPA is to accept the output of the upconverter and amplify it to provide the necessary transmit power corresponding to the specified EIRP.

At Class I stations the HPA is a 400 Watt Travelling Wave Tube (TWT). At the IP's a 20 Watt TWT is used.

The TWT is a microwave amplifier with a wide bandwidth (500 MHz typically). The wide bandwidth makes it suitable for satellite communications where the satellite total bandwidth is 500 MHz.

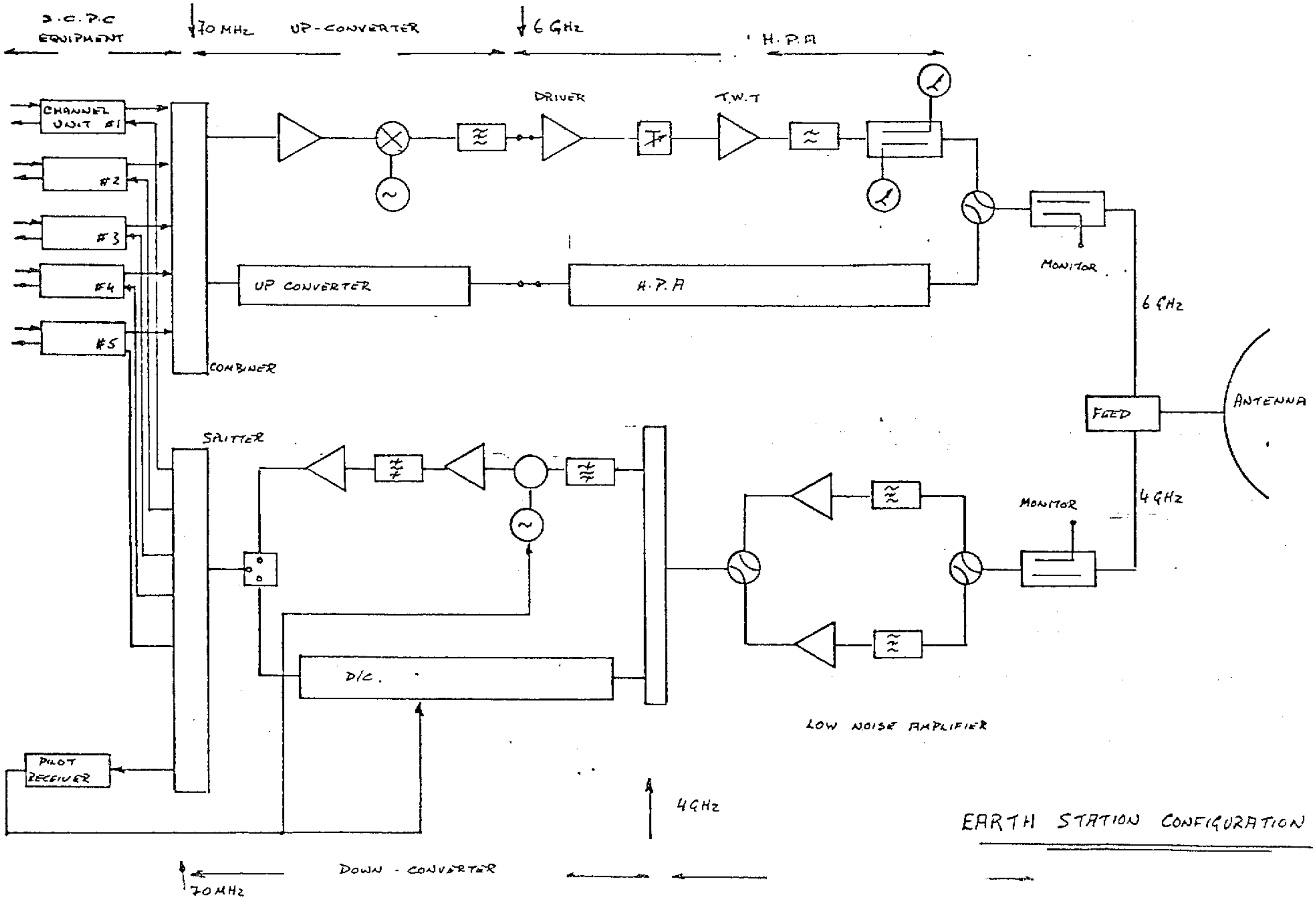


Figure 2.3.3.3-1

The HPA is complete with the necessary monitoring equipment and a low level solid-state driver amplifier.

HPA Specifications

Power:	
400 Watts	(Class I)
20 Watts	(Class II)
Frequency Range	5.925 to 6.42 GHz
Bandwidth	500 MHz
Gain	70 db, min.

2.3.3.4 Low Noise Amplifier (LNA)

Since satellite power is severely limited, the down link carrier level is very low. For this reason it is important that the receiver front end amplifier be as "quiet" as practicable in order not to corrupt the received carriers. The state-of-the-art for GaAsFET amplifiers is a noise temperature of 80 degrees Kelvin. Noise temperature lower than this requires parametric amplifiers which are much more expensive to buy and maintain than FETS. The LNA subsystem consists of a redundant pair of FET amplifiers with automatic switching in the event of failure.

LNA Specifications

Frequency Range	3.7 to 4.2 GHz
Bandwidth	500 MHz
Gain	60 db
Noise Temperature	80 Kelvin

2.3.3.5 Ground Communications Equipment (GCE)

The GCE comprises the equipment which forms a link between the SCPC subsystem and the HPA and LNA. The transmit output of the SCPC subsystem at 70MHz is mixed up to the 6GHz transmit band by the upconverter. The output filter in the upconverter is 40 MHz wide (enough for one satellite transponder). There are redundant upconverters, each feeding one of the redundant HPAs. For SCPC transmission where the carrier spacing is very close (for example 45 kHz for SCPC carriers or 45 kHz for 5 "mini-carriers") it is important to hold a very high frequency stability for the transmit carrier. The local oscillator stability is therefore required to be about 1 part in 10 to the ninth.

The downconverters accept the output of the LNA at 4GHz and convert it to 70MHz which is then fed to the SCPC equipment. The image reject-filter at the downconverter input is 40 MHz

The pilot receiver receives a pilot tone from the satellite, compares it with a locally generated reference signal and uses the resulting error signal to control the downconverter local oscillator frequency. In this way frequency error originating in the satellite and downconverter is eliminated.

GCE Specifications

Upconverter

Input Frequency	70 MHz
Bandwidth	50 to 90 MHz
Output Frequency	5.925 to 6.425 GHz
Instantaneous bandwidth	40 MHz
Input level	-30 dBm per carrier
Output level	-20 dBm per carrier
Frequency Stability	1 part in 10 to the ninth

Downconverter

Input Frequency	3.7 to 4.2 GHz
Instantaneous bandwidth	40 MHz
Output Frequency	70 MHz
Bandwidth	50 to 90 MHz
Input level	-60 dBm per carrier
Output level	-20 dBm per carrier

2.3.3.6 Single Channel Per Carrier (SCPC) Equipment

The function of the SCPC equipment is, on the transmit side, to accept the data input and produce an intermediate frequency (IF) carrier modulated by that data. On the receive side the SCPC receiver accepts a modulated carrier and demodulates it to provide the data output.

The subsystem consists of a number of channel units. The carrier output of these channel units is combined and fed to the upconverter. Similarly the output of the downconverter is split on a power basis before being fed to the SCPC channel units.

Several alternatives exist for the modulation techniques to be used. These fall with two broad categories:

(a) FM (analog)
(b) PSK or FSK (digital)

The advantages of analog FM technique are as follows:

- cost/cheaper than digital
- less complex than digital
- requires less RF power (i.e. more carriers can be accommodated per satellite transponder)

The disadvantages are:

- bit rate per carrier is less than with digital (9.6 kb/s versus 56 kb/s)
- requires external data modem.

On balance at this time the FM technique appears to be the best method for this system.

Further detail of SCPC, both analog FM and digital are given in Appendix B.

<u>SCPC Specifications</u>

Type	Analog FM
Carrier Spacing	45kHz (8 kHz for mini-carriers)
Bit rate	9.6 kb/s
Bit error rate	1 in 10 to the sixth
Carrier to Noise Density	-173.6 dBW/K for regular channels -183.6 dBW/K for mini carriers.

2.3.3.7 Proposed Earth Station Equipment & Costs

Satellite Earth Stations

STATION TYPE	APPROX. NUMBER OF STATIONS	SERVICE					
		DATA		CHARTS		IMAGERY	
		TX	RX	TX	RX	TX	RX
CMC, Downsview	2	X	X	X	X	X	X
IP's	13	X	X	X	X	X	X
UP's	72	X	X		X		X
Users	148	X	X				
Collector	155	X	X				

2.3.3.7.1 Satellite SCPC Parameters

The calculation parameters for the satellite system are give below, for:

- full SCPC channels;
- SCPC sub-channels with 5 mini-carriers per SCPC standard channel.

SCPC Carriers

(EIRP)
uplink 48 dBW

(C/T)
Total -173.6 dBW/K, or 55 dbHz (C/No)

"Mini-carriers"

(EIRP)
uplink 38 dBW

(C/T)
Total -183.6 dBW/K, or 45 dbHz (C/No)

The figures show that the C/No required to deliver a Bit Error Rate (BER) of 1 in 10 to the power 6 is achieved for the end-to-end link. The sources of noise include the up-path thermal, the downpath thermal, and satellite intermodulation. See Appendix B for the details of the SCPC performance for different value of C/NO.

2.3.3.7.2 Station Hardware/Costs

This section describes the principal hardware needed for the various "levels" of earth stations to meet the requirements. For the purposes of this presentation, CMC is deemed to be the switching, or control, centre of the network.

In reality, this could be placed wherever the AES required it. This would be a further design input. An estimated cost is assigned to each type of earth station, and it should be emphasized that this is only a "rough order of magnitude" estimate. A formal costing has not been attempted.

(a) CMC

Antenna diameter: 10 ft.
LNA Noise termperature: 80K
G/T: 19 dB/K

Equipment:

- Redundant 400 Watt TWT HPAs
- Redundant Upconverters
- Redundant Downconverters
- SCPC Equipment
  - SCPC Carrier transmitter qty 4
    SCPC Carrier receiver qty 5
    SCPC Mini-carrier Transceiver qty 40

    Facsimile Equipment
    Rectifier and Battery
    Cost: Approx. $0.5 million

(b) IP's and Downsview

Antenna diameter: 10 ft.
LNA Noise Temperature: 80K
G/T: 19 dB/K

Equipment:

- Redundant 20 Watt TWT HPAs
  (100 Watt TWT HPAs in stations transmitting imagery)
- Redundant Upconverters
- Redundant Downconverters

- IF Common Equipment
- SCPC Carrier transmitter qty 3
- SCPC Carrier receiver qty 5

Message equipment
Facsimile equipment
Rectifier and battery
Cost: Approx. $100K

(c) User Processors requiring two-way message and charts receive

Antenna diameter: 10 ft.
LNA Noise Temperature: 80K
G/T: 19dB/K

Equipment:

- Non-redundant 1 Watt FET HPA
- Non-redundant Upconverter
- Non-redundant Downconverter
- IF Common Equipment
- SCPC mini-carrier transceiver
- SCPC carrier receiver, qty 2

Message equipment
Facsimile equipment
Rectifier and battery
u Cost: Approx. $25K

(d) Users and Collectors

Antenna diameter: 10 ft.

Equipment:
- Non-redundant 1 Watt FET HPA
- Non-redundant Upconverter
- Non-redundant Downconverter
- SCPC mini-carrier transceiver
- Message Equipment
- Rectifier and battery
- Cost: Approx. $12K

2.3.3.8 System Costs - Space Segment

On the basis of the preceeding paragraphs the following section gives a rough order of magnitude cost analysis of the satellite system, referring to the transmission path and equipment only. These costs are broken down into:

- Total Capital Cost
- Satellite Useage Costs
- Maintenance Costs

The system considered is expected to be "hardware intensive" and thus will not accumulate high software costs, expected or unexpected.

Total Capital Costs

The approximate total capital costs of the satellite system are given in the following table:

Station Type	Approx. Number of Stations		Total Cost $K
CMC	1		500
IP and Downsview	14		1400
UP	72		1800
Users	148		1776
Collector	155		1860
		Total	7336

Satellite Usage Costs

The estimated satellite circuit costs (based on $2 million per year for a complete transponder) is about $3K per SCPC channel per year. On this basis the cost of the 27 channels required for the total satellite system is about $81K per year.

Maintenance Costs

Estimated as 1% per month of Capital Investment.

$880K per year (including manpower and spares)

2.3.4 Modems

2.3.4.1 Introduction

There are several aspects to the use of modems in a satellite communications network supporting traffic of the type required for AES. These aspects include modem type selection (satellite and terrestrial segments), back-haul nature and cost and performance considerations.

2.3.4.2 Satellite Segment Modem Selection

The system options require equipment to support two signal rates, one in the 4800-9600 b/s range and a second in the 300 b/s range (for the so-called "minicarriers"). The former range of rates can be supported using existing equipment but the latter will probably require a special design or modification.

Insofar as this study is concerned, there are two types of satellite segment modems worthy of consideration, those employing analog modulation and those employing digital modulation techniques. Analog modems (invariably FM for SCPC) offer a voice band interface. Modems using digital modulation provide either voice band or digital interfaces. If a PSK modem is to be compatible with an analog interface, it requires A/D conversion equipment. PSK modems operating with digital interfaces are usually configured to operate with some form of forward error correction in the 48-60 kb/s range. There is no particular advantage to a digital interface unless the signal is already in digital form at the earth station. If the back-haul is supported using a terrestrial modem, this will not be the case unless a modem is placed at the earth station itself.

2.3.4.3 Terrestrial Segment Modem Selection

The type of terrestrial segment modem to be used will depend on the nature and length of the back-haul. If this is over five miles standard telephone line modems with rates up to 9600b/s must be used. If the length of the back-haul is less than 5 miles some type of short-haul modem may be used. These include types suitable for use over telephone pairs or, if the range is less than 6 km, fibre optics modems. Nearly all standard telephone line modems and some short-haul modems are compatible with the analog interfaces of satellite transmission equipment in the sense that their signals can be supported in an "in-band" transmission mode that avoids the placement of modems at the earth terminal.

2.3.4.4 Cost and Performance Considerations

Cost considerations make FM SCPC the choice for the satellite segment modem, as PSK modems are considerably more expensive. Tests carried out a SPAR Aerospace Limited using two different types of standard telephone line modems and one type of short-haul modem showed that 10^{-6} BER could be achieved when using a FM SCPC satellite modem in an in-band mode if the C/No ratio was at least 55 dbHz.

Cost considerations for the terrestrial segment are summarized in the table that follows:

Table 2.3.4.4-1

Terrestrial Segment Cost Considerations

Modem Type	Speed	Line Type	Distance	Modem Cost	Line Cost
Standard telephone	9600	Standard conditioned voice	Not limited	$3,000-5,000	See note 1
Standard telephone	4800	Standard conditioned voice	Not limited	$2,000	See note 1
Standard telephone	300	Standard conditioned voice	Not limited	$ 100-400	See note 1
Short-haul	0-19,200	Unloaded pair	0-5 miles	$ 200-600	$100/mo.
Short-haul	4800	Standard conditioned voice	0-30 miles	$1,600	$300/mo.
Fibre optic	0-19,200	Fibre cable	6 km	$1,800	$5/metre

Note 1: Greatly dependent on arrangement negotiated with telephone company

---

2.3.5 AES Offices and Equipment

2.3.5.1 Collectors (See Figure 2.3.5.2-1)

Receive:

110 b/s Command/Control and Polling Instructions. Administrative Messages.

Transmit:

Meteorological Data at 110 b/s.

Communications Carrier:

Either - Single Channel mini-carriers; or
- Separate Transmit/Receive channels

2.3.5.2 Users (See Figure 2.3.5.2-1)

Receive

- 300 b/s formatted data and messages; or
- 9.6 kb/s general message, channel 1 (Table 2.3.2.1.3-1).

Transmit

- 300 b/s meteorological data plus any required messages.

Communications Carrier

Either - Single Channel mini-carriers;
- Dual Channel separate Transmit/Receive; or
- Transmit and Command and Control on mini-carriers Receive on 9.6 kb/s general message.

COLLECTORS
USERS
A.E.S. OFFICE, COMMUNICATION EQUIPMENT

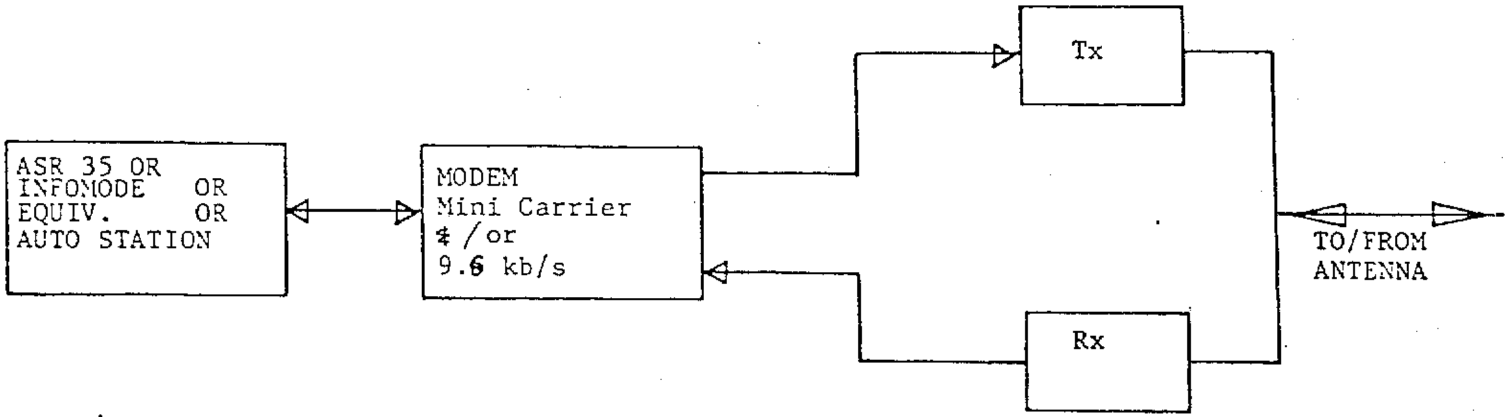


Figure 2.3.5.2-1

2.3.5.3 User Processor (U.P.'s) (See Figure 2.3.5.3-1)

Received Signals

- 300 b/s mini carriers channel or
  9.6 kb/s general message channel and 110 b/s C&C and polling channel;

- local SCPC channel carrying chart data.

Transmitted Signals

300 b/s mini carrier meteorological information, special requests for data and administrative traffic.

2.3.5.4 Intermediate Processor (IP's) (See Figure 2.3.5.4-1)

Received Signals

Message: - Channel 1, 9.6 kb/s general message and 300 b/s mini channel, or
- Channels 1 & 2/27, general message and 'interactive'.

Charts: - Channel 7, CMC charts.

Imagery: - Downsview, and other channels if required.

Transmit Signals

Messages - 300 b/s mini; or
- Channel 2/27 - interactive.

Charts: - One 9.6 kb/s channel - as allocated - time shared

Imagery: - One 9.6 kb/s channel, time shared.

Data Base

Either - Single data base with format compatible with the H.P. 1000 (21MX) processors; or
- Dual data base, one reserved for the communications and one with formatting for H.P. 1000 (21MX).

An optional additional storage unit could be used to contain a record of the relevant recent charts for immediate access by the communications computer.

A.E.S. OFFICE, COMMUNICATION EQUIPMENT

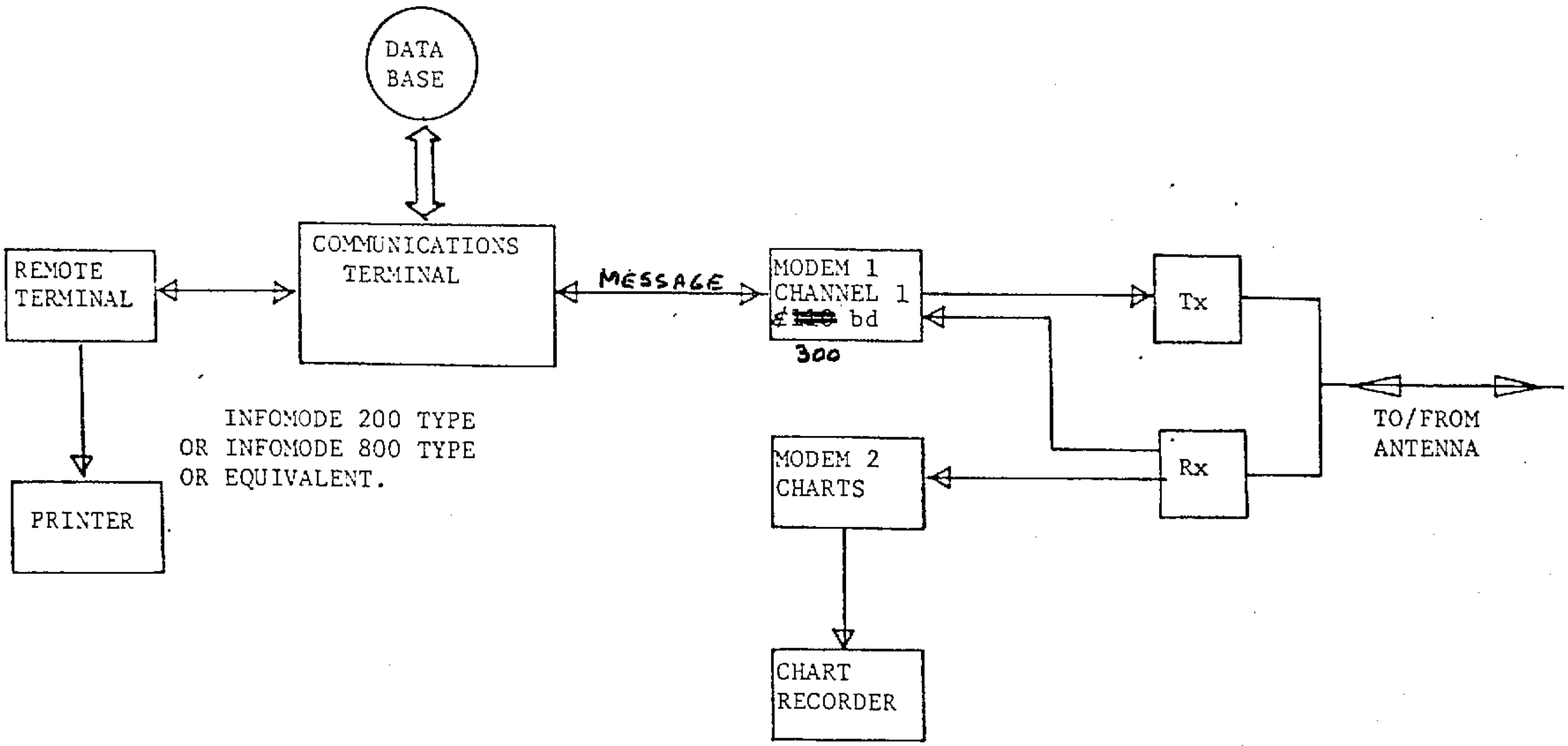


Figure 2.3.5.3-1

Communications Computer

Must handle following functions:

- Select and sort data from 9.6 kb/s general message channel;

- Switch/monitor or otherwise arrange for transmission of local data, forecasts, etc. on 300 b/s link or supervise information exchange on an 'interactive' basis on channel 2;

- monitor and record chart information when transmitted digitally. (Note that for analog transmission of charts - as at present - no computer involvement would be required);

- arrange transmission of satellite imagery, according to schedule, as required;

- make available both local and national data bases to all relevant internal departments. e.g. Training Branch at Downsview;

- arrange immediate display and/or print out of all administrative messages and local weather warnings, etc.

AES SATELLITE COMMUNICATIONS SYSTEM

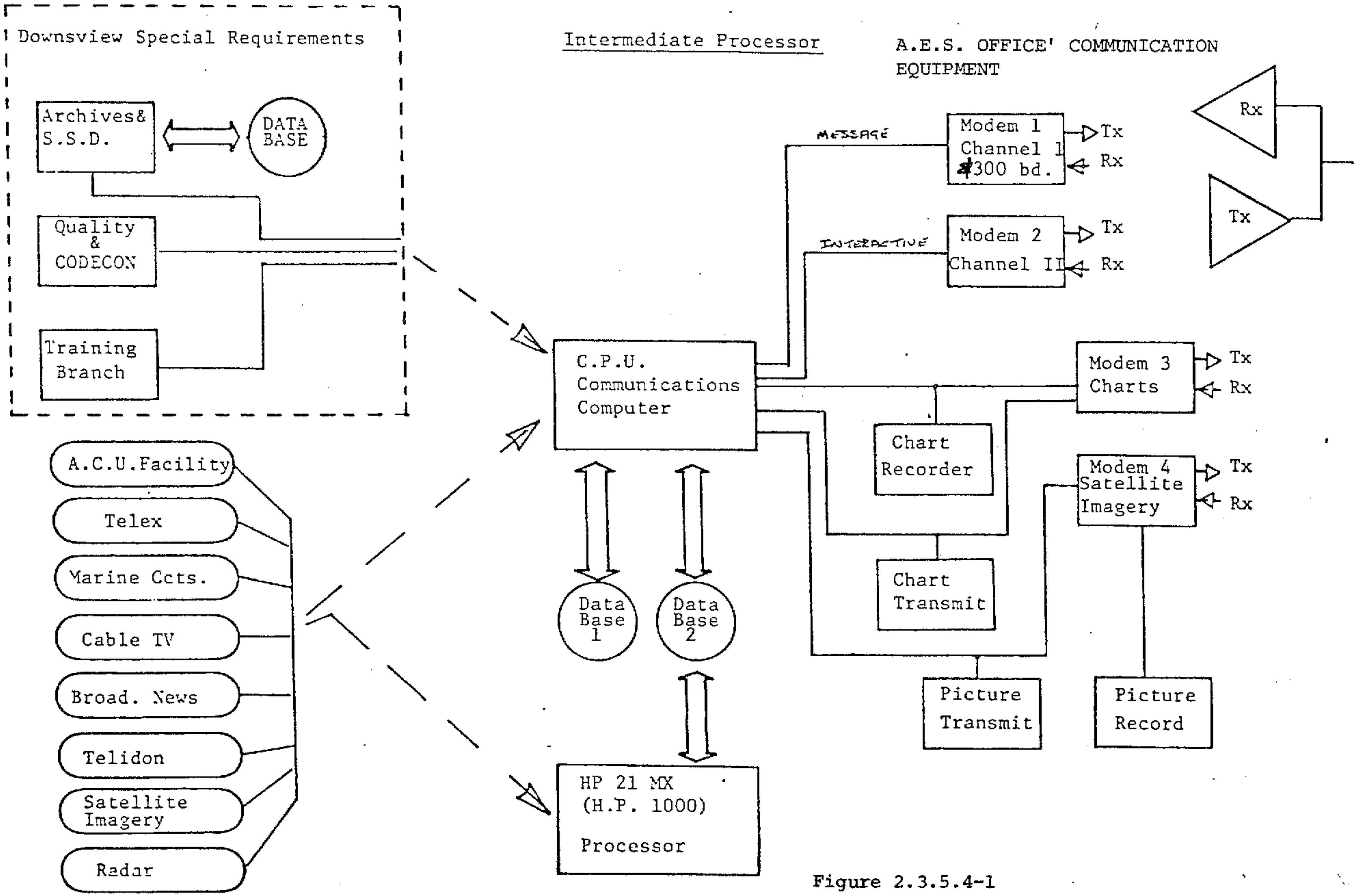


Figure 2.3.5.4-1

2.3.5.5 Network Switching Centre (Major Processor C.M.C.)
(See Figure 2.3.5.5-1)

Received Signals

Either - 26 channels 110 b/s (mini-carrier) and 9.6 kb/s interactive channel (channel 2); or

26 110 b/s channels and 14 300 b/s channels. (Note that all 110 b/s circuits could be upgraded to 300 b/s with no increase in transmission costs. Some hardware replacement costs would be incurred);

- 4 (SCPC) imagery channels.

Transmitted Signals

- 9.6 kb/s general message channel (channel 1)

- CMC generated and NWS charts for general Canadian distribution on channel 7.

  If digital chart transmission is required, then they will be transmitted initially at 9.6 kb/s with provision for an increase in speed to 56 kb/s if required. (Note: 17 1/2" x 17 1/2" chart, 100 lpi and 100 pixels per inch at 5:1 compression takes 63.8 seconds to transmit at 9.6 kb/s.);

- scheduled information on all 40 low speed channels according to program - including Command and Control (polling) information;

- channel 2, 9.6 kb/s interactive, if used.

Data Base

- Data Base to be provided for alpha-numeric messages separate from existing CMC system. Requirement for formatting compatability of data between existing CMC equipment and new communications processor;

- additional storage for CMC transmitted charts to be provided if called for by the AES.

Communications Processor

Must handle, at least, the following functions:

- read, collate, store and format all received information on the 'mini' channel circuits (40);
- "bulletinize" and transmit required information on mini-circuits according to programme;
- re-transmit all this information, suitably processed, on channel 1 - the general message channel;
- provide information required for network control and monitoring panal (not defined here. AES requirements to be made known);
- operate the interactive channel 2 utilizing suitable software package, such as DECnet;
- order and transmit all control functions (such as polling) required for operation of the network;
- maintain and make available complete updated set of weather charts as provided by central CMC processing if required;
- maintain and update central alphanumeric system data base according to program.

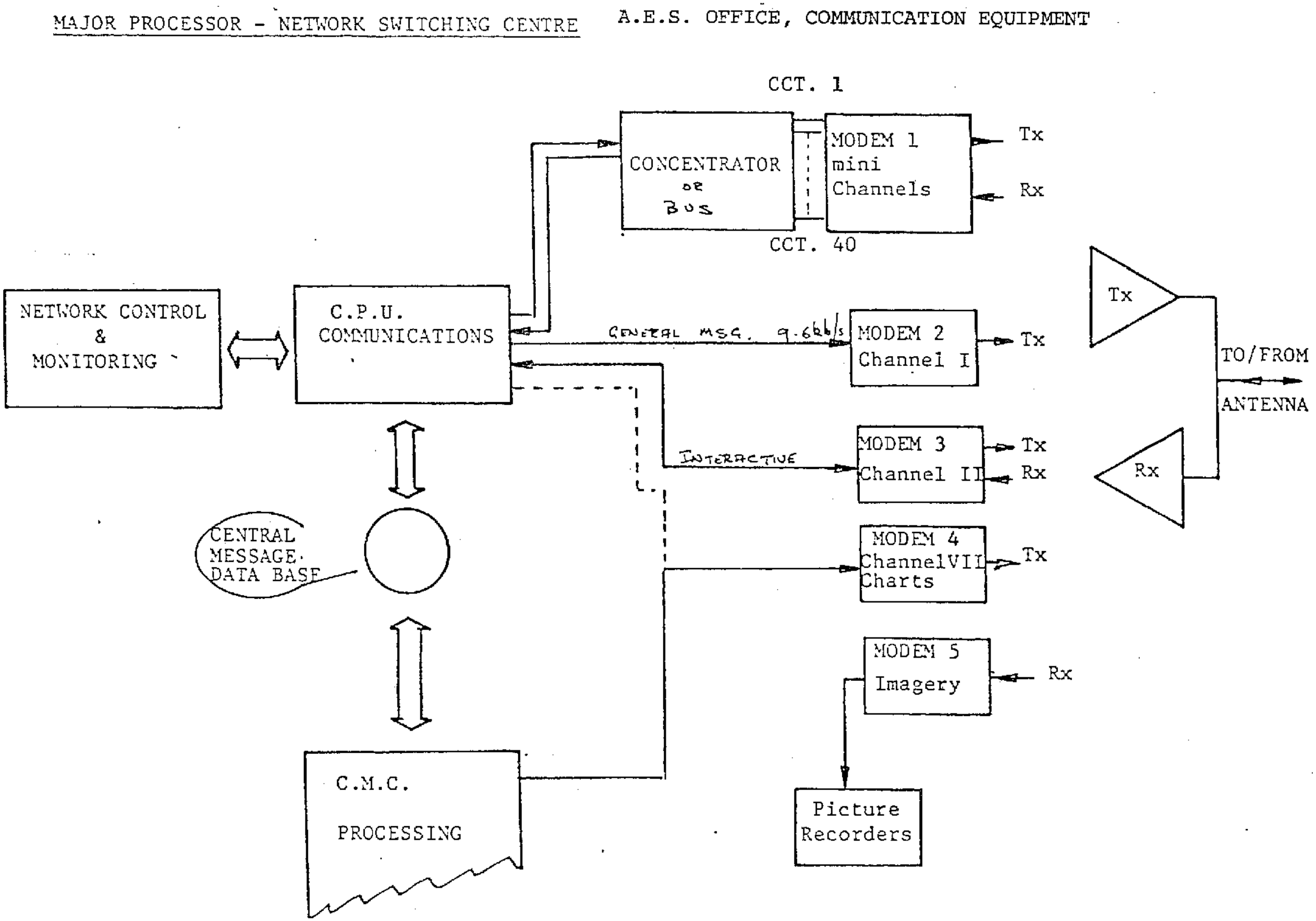


Figure 2.3.5.5-1

2.3.6. **Computer and Software Requirements**

An initial estimate of the required computer hardware and software necessary to operate a system such as that proposed in this section has been made.

Only one company's equipment has been costed, and it is recognized that a competitive bid may result in some savings.

2.3.6.1 **Network Switching Centre (CMC)**

The following equipment has been estimated for CMC:

- PDP11/44 processor and 1/2 MB. memory;
- Operating system RSX11;
- RMO2 Disc drive (67 MByte) and TS11 Tape Drive;
- Console V.D.U. and Decwriter III;
- additional printer (no keyboard);
- proc. KMC 11-A and S/W COMM-JOP-DZ to run the 40 interface circuits (48 cct capacity);
- synchronous interface and programmable real time clock;
- Fortran and DECnet S/W licence;
- box and cabinet;
- battery back-up;
- system sysgen.

Installed cost:	$175,000
with discount:	$120,500

Cost includes duties but not Federal Sales Tax.

2.3.6.2 **Intermediate Processors**

- PDP11/34 processor;
- 2 off RL02 disc drives with 10Mbytes each;
- asynchronous multiplex 8 lines;
- 3 synchronous interface - Decnet
  - Charts
  - Broadcast channel;
- programmable real time clock;
- fortran and Decnet licences;
- cabinet and V.D.U.;
- Decwriter;
- RSX-11M operating system;

Installed cost:	$ 70,000	
with discount:	$ 47,000	(10 systems)

2.3.6.3 **User Processors**

For the User Processors, three options have so far been costed, these taking into consideration the range of work loads to which this category of office is subjected.

2.3.6.3.1 ________

- PDP11/23 processor and 2 floppy drives;
- RT11 operating system;
- programmable real time clock;
- synchronous time interface;
  Decwriter III and V.D.U.;
  Fortran licence.

Installed cost:	$27,500
with discount:	$18,400

2.3.6.3.2 ________

- PDP11/23 processor;
- RL02 disc drive;
- RSX11M operating system software
- programmable real time clock;
- synchronous time interface;
- Decwriter III and V.D.U.:
- Fortran licence.

Installed cost:	$43,700
with discount:	$28,700

2.3.6.3.3 ________

- PDP11/03 LSI 11 series processor;
- dual floppy disc;
- programmable real time clock;
- synchronous line interface;
- Decwriter III and V.D.U.;
- Fortan licence.

Installed cost:	$22,647
with discount:	$16,000

Note: Discount costs estimated on:

10 Intermediate Processors; and
100 User Processors.

Note: The overall system costing has removed all terminal equipment (VDU's, printers, etc.) from the numbers as these have been collated and presented separately in Chapter 3. In addition, all 72 UP's may not want full processing capa- bility. With these considerations, an average basic price of $8K has been estimated for each UP for initial system costing.

2.3.7 Security Requirement and Options

2.3.7.1 General Considerations

The principal difficulty with the data security of a satellite communications system is that the transmission can be intercepted, and monitored, by increasingly simple equipment from any geographical position lying within the "footprint" of the satellite handling the information. This means that the principal recognized means of ensuring data security is the use of general encryption, using a code that is sufficiently complex to give a high degree of probability that it cannot be 'broken' within the useful lifetime of the data it is protecting. As the code has to be changed from time to time, the 'key' has to be distributed throughout the system so that all authorized stations can maintain their access to the system.

In the case of AES, this would be an expensive and moderately complicated operation and would therefore probably not be suitable for serious consideration at the present time. However, there are other simpler means that may be considered for reducing the availability and usefulness of this data to unwanted customers in times of international hostilities and some possibilities are outlined below.

2.3.7.2 Encryption of Processed Information

While full encryption of all the raw data on the system would be an expensive task, encryption of the processed data only and offer of this information to a reduced clientelle, as would be required anyway in times of emergency, would considerably enhance security over an open, uncoded system.

Other interests would then have to aquire, collate and process the raw data themselves which would increase the drain on their resources and considerably slow the process of acquisition of this information. In addition to this, it would be necessary for the agency to intercept the information on, or near, Canadian territory, and the information thus gathered would have to be relayed to the parent organization which itself would pose problems in times of emergency, as these transmissions themselves would be open to jamming or other hinderances.

2.3.7.3 Data Origin Obscuration

Techniques can be used to mask the origin of the raw data, thus making it comprehensible, but nearly useless, to unauthorized recipients. This could be done in various ways, in which the "header" information on the data transmission would be varied or concealed.

- headers could be varied, or 'rotated', from hour to hour as a 'deception' technique, showing weather systems to be moving out of their true position;

- header information could be totally removed, the responding (to polls) stations being scrambled in time and request address so that only the central processor knows where the data is coming from. Fairly simple equipment could be developed to implement this;

- false data could be injected according to program.

The schemes which involve deception techniques are often the most simple and effective to use because, whereas the reception of scrambled transmissions are immediately recognized as such, incorrect data is not and can sometimes be much more difficult to 'de-code'. In this case it would almost certainly give maximum security for minimum dollars.

2.3.8 Future Requirements

2.3.8.1 Graphics

For the purposes of this section, 'graphics' is assumed to refer to the 'soft copy' display of weather charts and satellite pictures on an operator's V.D.U. (Video Display Unit) with the data for this stored either locally or at a distant data base centre. For the purposes of this study, we are assuming the following required resolution for the display at UP's:

256 points on 256 lines with a 4 bit gray scale;

which represents approximately 33 kbytes of information;

which would take approximately 28-30 seconds to transmit at 9.6 kb/s; or 5-5 1/2 seconds at 56 kb/s;

8 to 9 such charts could be stored on a standard floppy disc using today's technology. (Hard disks would normally be used)

In the proposed satellite system there is spare capacity to transmit these graphics from the regional IP's. Further capacity (another SCPC) channel could easily be provided giving a possible increase in capacity of up to 700 pictures per hour (per SCPC channel).

Incorporation of a graphics package into the proposed system would require some detailed discussion with AES personnel as AES operations would be greatly affected by such a system. This can only be satisfactorily accomplished when the AES representatives concerned have gained a better understanding of the operation and constraints of the proposed system from this report. This paragraph gives "orders of magnitude" of capacities and transmission times to further discussion.

2.3.8.2 Weather Radar

Detailed description of the incorporation of weather radars into the satellite communications system will require more detail from AES with respect to their plans for the distribution of this information.

The approximate current costs of Radar Facsimile circuits are as follows:

- Circuitry costs $3,600/month or 2.3 per cent of total circuitry rental;

- Equipment costs $1,200/month or 3/4 per cent of total equipment rental;

  Total costs $4,800/month or 1.3 per cent of total communications costs. (Total comunications costs do not include telephones for these purposes).

Thus, although satellite circuits could be made available directly to radar sites, it is proposed here that radar data be communicated at least as far as the nearest responsible weather office by landline, as at present.

The following options may then be considered:

- Where the 'local' weather office is an IP, the radar information (or image) can be routed directly to cable TV companies and other customers and transmitted on the communications (satellite) channel used for charts, if further distribution is required.

- Where the local weather office is a User Processor and the information requires further distribution, the following communications may be adopted:

  - transfer by landline to nearest IP, probably on a dial-up basis, and then distribute as above;

  - inclusion of the UP on the chart distribution circuits on a time share basis (probably too complicated) and provision of a transmitter;
  - allocation of a separate channel for all radar information, operating at 9.6 kb/s;

  - inclusion of the UP in the 'Interactive Net' on channel 2.

- For any type of local weather office, terrestrial circuits only could be used, with one dedicated circuit to the office responsible for continuous monitoring of the radar and other users connected by 'dial-up' (switched) facilities when required.

  For the existing traffic, it would not appear to be cost effective to install earth stations at radar sites, especially those near major urban centres. The current communications costs are about $3,600 per month (see above) which, for 10 stations, is about $43,000 per station for 10 years service at current rates.

  Assuming a minimum installed cost of a station suitable for handling radar information of about $30,000 and assuming 10 per cent interest rates over 10 years, the investment cost is $47,600 (approximately) per station. Although these are only costs of a "rough order of magnitude", they strongly indicate that there would have to be more than purely financial reasons for installing such equipment and these would have to be clearly defined for the purposes of detailed costing.

2.3.8.3 Long Term New Services

The following comments refer to Appendix A and consider the applicability of a satellite based communications system, as described in this Appendix, with the long term new services identified by the AES Review Panel.

- Digital graphics from CMC and IP's to sites which integrate radar and satellite data will be carried by the system as described with little modification. The A.E.S. will need to feed the relevant modems (channels 7 to 9) with the data at 9.6 kb/s for transmission.

  If sites for the integration of the satellite and radar data are chosen outside the AES communications network, then obviously additional earth stations will have to be provided.

- An environmental support centre could be provided in the Arctic with no modification to the communications channels.

- High quality graphics can be received in the Arctic direct from the communications satellite as long as the ship was within the area covered by the footprint.

- Satellite/Radar processing sites will be on circuit and able to distribute their data with no further system transmission costs involved. It is assumed that data supplied to 'outside' users will be on a cost/recovery basis.

- "Significant increases" in spot forecasts of weather elements from CMC to IP's can be absorbed by the proposed system.

- Means of exchanging data with the U.S.A. would have to be separately considered/negotiated if existing terrestrial method is to be replaced.

- Distribution of weather data by presentation offices to the local communities would in general continue to use the existing methods (weather radio, telex, etc.). This would be expected to be updated from time-to-time in step with new technology applications within the community (Telidon, pay TV, etc.). As the proposed communication system is computer based, alpha-numeric and graphical formats could be easily handled by expansion of the local computer and software packages. It is thus essential to select a suitable computer system to allow future expansion in both data base and processing capacity.

- In the short term, (5-10 years), the best way to continue to provide data to marine interests after the existing H.F. facility is encrypted is to build a duplicate facility.

2.3.9 Satellite Collection

It would also be possible to use satellite channels solely for the purpose of data collection while maintaining a terrestrial distribution network. While this would considerably reduce the current circuit congestion it is considered that it would not be a cost effective means of operating the AES system. Detailed costing has not been done, but would be initiated if it was considered sufficiently important by AES. On the other hand, a terrestrial network could well be supported by a satellite system which carried the "Off-Network" data, that is, the collection of data from remote station DCP's not connected to the AES terrestrial system.

2.3.10 Satellite System Costs Estimate

2.3.10.1 Satellite Earth Station Segment

Station Type	Number	Cost k$	Total Cost
CMC	1	500	500
IP	14	100	1400
UP	72	25	1800
Users	148	12	1776
Collectors	155	12	1860
			$7336K

2.3.10.2 Computers and Software

	Total K$
CMC (Network Switching Centre) 2 x $120,500 hot standby redundant equipment.	241
IP's 14 1 system to run network @ 47K develop S/W etc.	705
UP's 72 @ $8k each	576
	$1522K

Total Capital Expenditure	$8858K
Total Capital less Collectors and Users	$5222K
i.e. Collectors and Users cost $36336K	

2.3.10.3 Operational Costs

Non recurring
S/W development etc. $ 910K

Recurring costs

Circuit
Baseline Transponder cost $2.8K/cct (SCPC) per year
Estimated possible cat costs $206/cct per year

For 17 circuits	Baseline	$ 47.6K/YR
	Estimated	$ 340. K/YR

Maintenance @ 12% of Capital per year

Total system	$1062K
less (collectors and users)	$ 626K

From above:	Maximum costs approx.	$1402K
	Minimum costs approx.	$ 670K

2.3.10.4 Installation Costs

Maximum estimated cost
15% of Sat. H/W Capital:

With 303 Collectors/Users	$1100K
Without the 303 Collectors/Users	$ 783K

2.3.11 Comments on Present Problems

This section compares the characteristics of the proposed Satellite Communication System with the difficulties experienced with the existing system, as expressed by the AES in Appendix A.

2.3.11.1 Teletype System

Low Speed

- Overloading of circuits - Excessive Delays in Message Delivery	Off loading of the I.P.'s and the U.P.'s from the low speed circuits will remove congestion and eliminate delays in message delivery caused by communication problems. Main distribution circuit (channel I) has an average utilization of 16.2% for existing traffic.

Inadequate Request/Relay Capability

- Excessive delays in obtaining missing traffic or traffic not regularly scheduled	All traffic will be available at all I.P.'s and U.P.'s in new system. I.P.'s will have a continuously available Request/Reply service available on an interactive basis, and any files at a participating I.P. and at the M.P.'s will be directly available. (Programmes may prohibit access where necessary). Participating U.P.'s may have the same facilities as at I.P.'s. Other U.P.'s will have individual but restricted, local databases. Due to decongestion of the circuits request/reply service for missed traffic will be good - data being available within seconds. Users that only receive scheduled traffic (i.e. those without access to channel I) will operate request/reply service as at present, although decongestion of the circuits will speed turn-around times.
- Excessive Paper Consumption	I.P.'s and U.P.'s will receive data in soft copy format. Hence hard copy will be restricted to required data only. Users will be reduced to 6 to 9 per line and can easily be 'matched' in such a way that all stations on the circuit will require similar data - minimizing the transmission

	of redundant data which generates waste paper. The allocation of Users to any particular circuit will not be restricted by geographical location as no 'physical' circuits will be involved.
- Excessive effort for manual sorting, storing and retrieving information	I.P.'s and U.P.'s will have the ability to do this by computer programme. Choice of suitable circuit allocation for Users will reduce this problem for them.
<u>Lack of Selectivity or Addressing</u>	
- Lack of security	From the military viewpoint, this subject is addressed in Section 6.3.8. From the internal point of view, any U.P. or I.P. can be individually addressable. Users will be addressed collectively in groups of 6 to 9.
- Cannot restore a local data-base if loss of data is due to local failure	Excess capacity of Satellite communication circuits eliminates this problem.
- Does not allow effective interaction between offices in their information production and dissemination	This requirement has not been quantified by the AES. However, excess transmission capacity should eliminate this problem for the U.P.'s. I.P.'s will be operating on an interactive basis between themselves and the M.P.'s, hence problem should not exist.
<u>Inadequate Priority or Priority Handling</u>	
- No input priority - excessive delays in in-putting urgent messages such as weather warnings	I.P.'s and M.P.'s operate interactively over a 'high speed' (9.6kbs) link and will not experience this problem. U.P.'s can receive the priority information immediat-ley via the high speed distribution link Channel I. However, data is <u>input</u> over a polled circuit with 7 to 14 <u>stations</u> per circuit. These type of circuits do not conventionally operate with the priority input mode. However, the problem can be handled in at least two ways. This will be a function of the detailed system design. - After each message has been received, the entire circuit can be sequentially polled for a "level of priority" of the next message; or

	- one, or two, channels can be allocated exclusively for polling data, all participating stations (a sub-set of the whole) inputting a "request for poll" and a priority level for the request. this would require additional, or modified modems for these stations.
	The above schemes may be varied to optimize the design when appropriate.
- Inadequate output priority	This is addressed above.
Inadequate Quality Control	
- "Increased" errors both instrument and human in meteorological messages	A discussion of the Satellite Communications system with regard to Quality Control is found in section 2.3.2.4.4
- Communication, B.E.R.	As above.
Half-Duplex Operation	
- Inefficient use of lines	As the Satellite medium is a broadcast system, this problem is not applicable to the new system.
Lack of Hierarchy	This will no longer be true with the Satellite system as the system capacities are proportional to the size, or requirements of the offices served.
Polled Multi-drop Circuits	
- lack of flexibility	This problem has been resolved by the use of a large increase in communications capacity for M.P.'s, I.P.'s and U.P.'s and a reduction in the number of stations and message traffic on the multidrop circuits serving the Users and Collectors.
Reliability and/or Redundancy	This is discussed in section 2.3.2.4.
Insufficient Real Time Control of Switching System	
- difficult to change distribution and priority of traffic on any one circuit	M.P.'s and I.P.'s will have the ability to exchange data on an interactive basis which avoids this problem altogether. U.P.'s will have access, via channel I, to all the data on circuit, and can make decisions locally as to what traffic is

wanted and what traffic is not wanted on an hour to hour basis. The exception to this would be priority traffic which all relevant stations will be required to receive.

Users operation will not change radically, but reduced line loading and AES control of the distribution should eliminate difficulties in this area.

"Adaptiveness"

Low Speed Circuits cannot Effectively Handle Increased Traffic	Capacity is not limited by proposed communications.
Lack of Adequate Higher Speed Computer Ports	This will no longer be relevant.
- Inflexible interfaces. Does not permit easy interconnection with other network	No special interface equipment other than with N.W.S. has been considered at this point as there are no details available of requirements. However, I.P.'s will be expected to interface with Cable TV Co's, Broadcast News., Telex crts. etc as at present with increased capacity for future expansion. As these interfaces will be under AES control, future planning will be facilitated.
- No alternative routing to handle overload causing delays.	Increased system capacity will eliminate overloads.
Inadequate System Monitoring	Due to broadcast nature of the traffic everything on the network is available at any point in the system. In particular, all message traffic has been designed to pass through the central switch and therefore any monitoring and/or statistical information that is desired may be built into the system by the incorporation of a suitable software package. Some such functions will already be available with the use of the DECnet package. The Ground Station Equipment will be provided with hard-wired monitor alarms operating on all channels and essential transmission equipment at that station.

2.3.11.2 Paper or Weather Facsimile Circuits

Performance

- Traffic Congestion	New system to support 3 channels. More can be made available at minimum cost if traffic studies indicate the requirement. Some details of chart transmission are discussed in section 2.3.2.2.4.
- Analogue Mode of Operation - line Maintenance Difficulty	Time maintenance requirements are eliminated and replaced by satellite paths. Maintenance is restricted to equipment.
- Inefficient Request/Reply	Decongestion of circuits allows greater flexibility of request/reply.

Adaptiveness

- Difficult to transmit charts from one region to another	All chart information is broadcast across Canada (see "Footprint" maps, Figures 2.3.2.1.3-1), therefore any region may transmit to any other. Scheduling would have to be arranged.
- Difficult to satisfy the needs of individual users because of system wide implications	The use of three channels and the decongestion of the circuits should eliminate this problem. A digital transmission facsimile system would directly solve any outstanding problems described above, but if analogue transmission is retained and more capacity is needed, an additional channel could be simply provided at minimum additional cost. There would be minimal effect of this on the system operation, restricted basically to drawing up a new schedule of broadcasts.

2.3.11.3 Photo Facsimile

Performance

- All stations on a particular leg must receive all information on that leg - selection by schedule only	The Satellite broadcast arrangement will, from the point of view of any individual station, remain essentially similar. Selection will still be essentially be schedule. However, the expanded communications facility and the increase in automation (as "computerization") will give a greatly increased scope for "minute-by-minute" scheduling which should eliminate

	the present difficulty.
- Analogue mode of operation - line maintenance problems	As above for paper facsimile circuits. Satellite use eliminates conditioned lines and thus also this problem.
- Ineffective request/reply	Where this is due to excessive line loading the decongestion of the circuits will eliminate the problem. Where the problem is equipment orientated improved communications will not help.

2.3.11.4 Off Network

Performance

- Reliance on radio for Alphanumeric Data	All data currently collected by radio (except buoys) can be received on an interference free satellite channel.
- Reliance on Dial-up Public facilities	No 'dial-up' facilities need be used within the AES Network except for Voice communications.
- Reliance on Radio for analogue facsimile, leading to poor quality	All facsimile information will be carried by Satellite, with three exceptions: 1. Broadcast to ships-at-sea. Although satellite information will be available, the AES will have no control over the replacement of existing shipboard receivers. In particular, merchant shipping useing the existing H.F. equipment will not want to invest in new hardware. Hence H.F. broadcast will have to be continued at Halifax and at Vancouver. 2. High Arctic areas, outside the footprint area of the Geostationary satellites (Figure 2.3.2.1.3-1) will have to be served by H.F. or, if and where possible, by Polar Orbiting satellites. 3. Ice Patrol Aircraft will be expected, at least initially, to continue to use their existing equipment whilst airborne. However, it is considered that considerable improvements could be

made to the existing receiving equipment at Ottawa to improve the current service.

Adaptiveness

- Difficult to interconnect to other facilities	As the 'Off Network' traffic as defined in the existing system will be mainly carried by the satellite channels, this problem will be obviated.

2.4 ONE-WAY SATELLITE BROADCAST OPTION

2.4.1 Introduction

Overview

The One-Way Satellite Broadcast System is a hybrid system composed of a terrestrial public packet network and a satellite one-way network. The terrestrial network carries collection and point-to-point traffic. The satellite network carries broadcast traffic. The rationale behind this system candidate is to devise a system that is cost effective and compatible with the traffic. The strengths of a public packet network is pt-pt and the strengths of a satellite system is its inherent broadcast feature. The public packet network is cost effective on a pt-pt basis. The one-way satellite network is economical for broadcast distribution. The complete system consists of the following networks:

	Network	Traffic	Sites
1.	Satellite Network (One-way Broadcast)	Charts Photos Observations Forecasts Grd Point Soundings	UP's, IP's & MP's
2.	Public Packet Network	Observation Forecasts Inquiry Batch Soundings	UP's, IP's & MP's
3.	Local Teletype Networks (Collection)	Observations	Users and Collectors
4.	Off-Network[1]	Observations	Collectors
5.	Fax Chart Network (One-way collection bus)	Charts	IP's, MP(CMC)
6.	Fax Photo Network (One-way collection bus)	Images	IP's, MP (AES HQ)

All collection (observations and forecasts) and chart traffic is relayed to CMC for broadcast via satellite. All photo image traffic is relayed to AES HQ for broadcast via satellite. All point-to- point type traffic is routed between UP's, IP's and MP's via the packet network. The UP's relay Collectors and Users traffic via teletype multidrop lines.

1 Off-Network is communications to Remote areas where terrestrial private links are not available or not economical; presently radio, TTY, TWX, satellite, etc., are used.

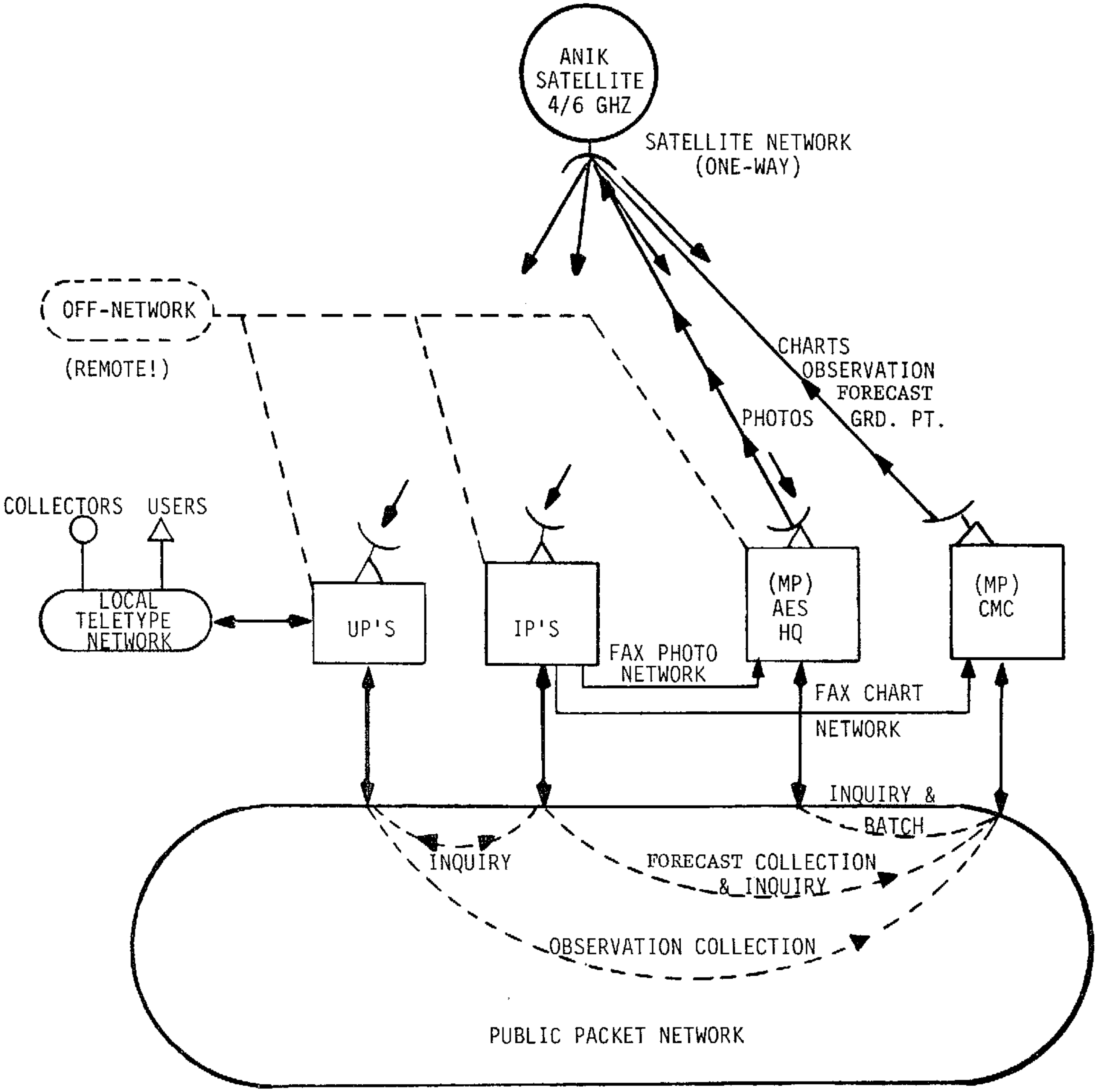


FIGURE 2.4.1-1 ONE WAY SATELLITE CONCEPT

Services and Traffic Specification

As per Appendix A.

2.4.2 Description

1. Satellite One Way Network

The satellite broadcast network consists of two transmitting ground stations, one at CMC and other at AES HQ, as shown in Figure 2.4.1-1. This option is not optimum, but rather the simplest to present at this phase. Many variations of it can be considered in the next phase. The transmitter at CMC broadcasts all observation, forecast, grid point data and charts. The one at AES HQ broadcasts all satellite photo imagery. Channel assignments are as described in Section 2.3.2.3, i.e.:

Channel 1	- Message distribution 9600 bps
Channels 3-6	- Imagery VF Analog or 4800 bps
Channel 7	- CMC Charts VF Analog or 4800 bps
Channels 8-18	- Regional charts VF Analog or 4800 bps

2. Public Packet Network

All UP's, IP's and MP's are interfaced to the Public Packet Network as shown in Figure 2.4.2-1. All interfaces are SNAP (TCTS) or IGS (CNCP) driven.

UP's utilize a microprocessor disk - based data terminal equipment interface (DTE). A DTE supports the following links:

UP DTE Links	Description
Satellite message ingest	9600 b/s asynch. simplex
CRT interface	2-1200 b/s asynch. half duplex
Disk interface	BUS 1 MByte/s transfer rate
Packet interface	1200 b/s synch. full duplex
Local Teletype (multidrop)	200 b/s asynch. full duplex

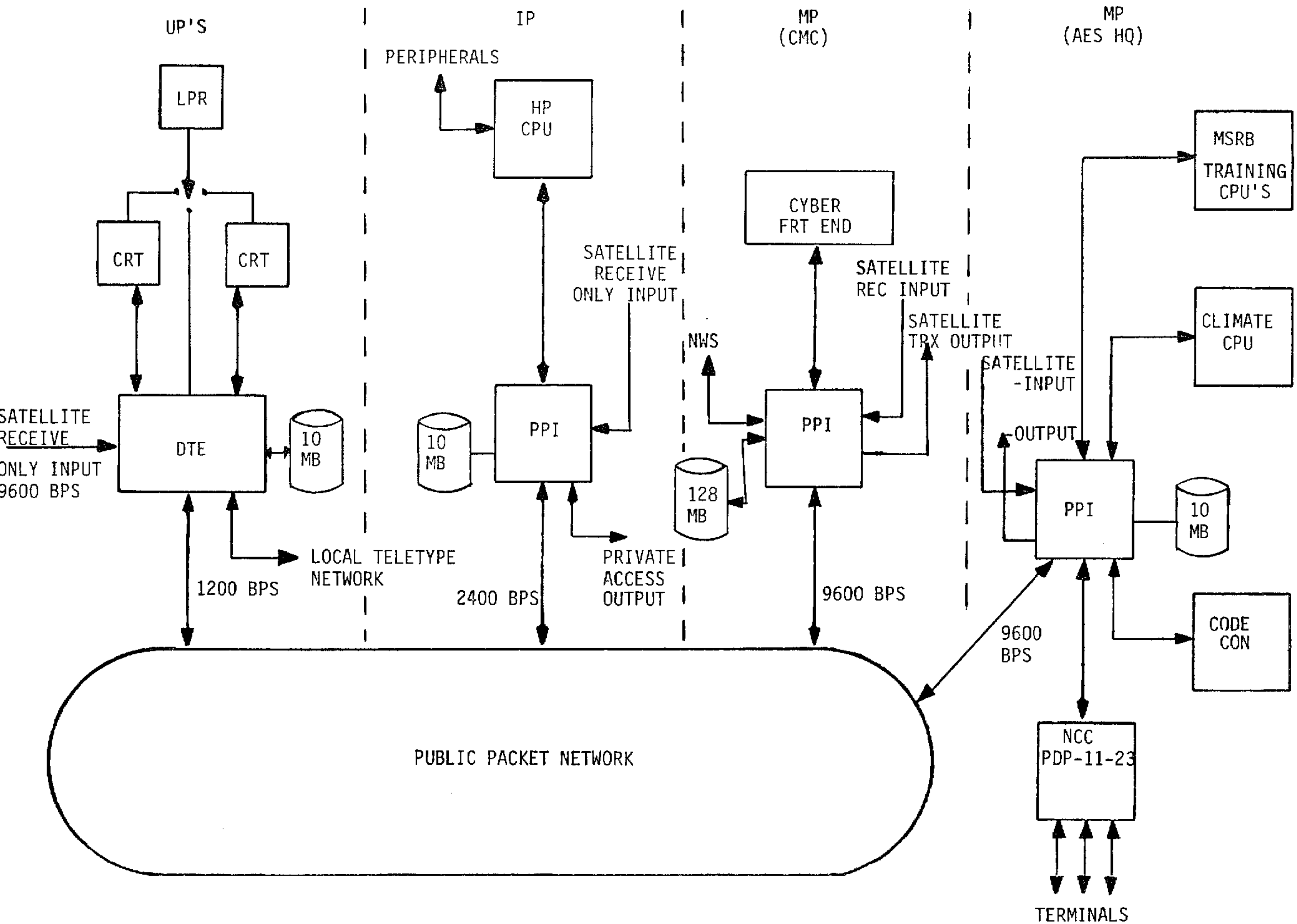


FIGURE 2.4.2.` -1 PUBLIC PACKET NETWORK

IP's and MP's utilize a Parallel Processor Interface (PPI) which consists of a modular processing unit capable of expansion. The PPI supports the following links at IP's:

IP PPI Links	Description
Satellite ingest	9600 b/s asynch simplex
HP CPU I/F	2400 b/s synch full duplex (X25 type)
Disk I/F	BUS 4 MByte/s transfer rate
Packet I/F	2400 b/s synch full duplex
Private User I/F's	5-100 to 600 b/s simplex
Control CRT	2400 b/s asynch half duplex

The PPI supports the following links at CMC (MP) and AES HQ (MP).

CMC PPI Links	Description
Satellite message ingest	9600 b/s asynch simplex
Satellite message output	9600 b/s asynch simplex
Disk I/F	BUS 4 MByte/s transfer rate
CRT console	2-2400 b/s asynch half duplex
CYBER I/F	X25 type-serial
NWS I/F	2400 b/s asynch full duplex
Packet Network I/F	9600 b/s synch full duplex

AES HQ PPI Links	Description
Satellite ingest	9600 b/s asynch simplex
Disk I/F	BUS 4 MByte/s transfer rate
CRT Control Console	2400 b/s asynch half duplex
Climate CPU I/F	X25 serial
HP CPU I/F's	X25 serial
NCC I/F	2400 b/s
Packet Network I/F	9600 b/s synch full duplex

Each PPI is capable of servicing of all present requirements of private users for each region.

3. Local Teletype Network

The local teletype network consists of a multidrop teletype line from a UP to nearby collectors and users as shown in Figure 2.4.2-2.

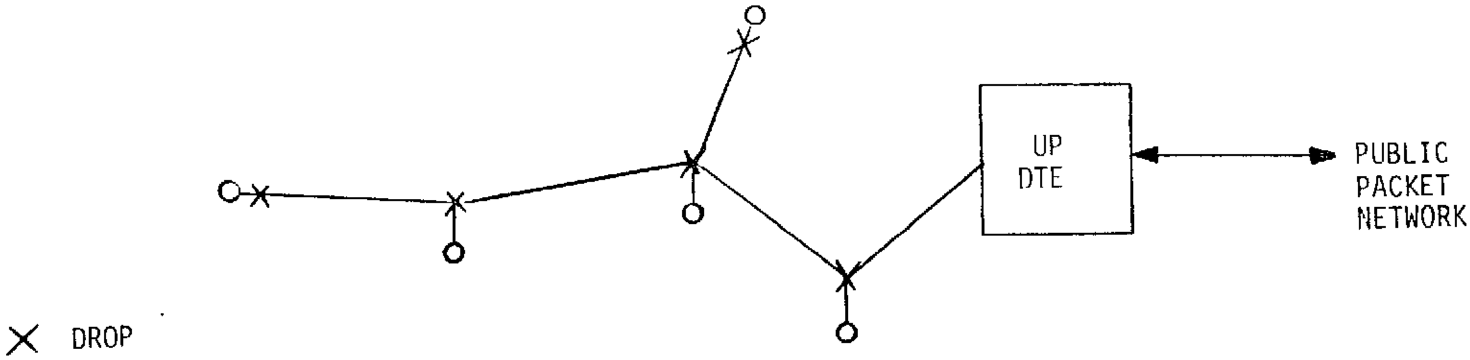


Figure 2.4.2-2 Local Teletype Network

Each UP controls up to 10 collector or user drops. The teletype line is asynchronous, full duplex and operates at 300 bits/s.

4. Off-Network

The off-network consists of the present methods of radio fax and telecopier for distribution of facsimile to remote places. For message traffic, the present method of TTY, TWX, radio, etc. are assumed. (The use of a private two-way 1 kb/s DCP system over ANIK could be used to fulfill the message requirements).

5. Fax Chart Network

The Fax Chart Network consists of a simple analog bus (2 wire, C3 conditioned) inter-connecting all IP's to CMC as shown in Figure 2.4.2-3. This is not the optimum method but the simplest in terms of upgrading from the present. In the future, all sources of chart traffic would send charts to CMC via the public data networks. This mode would be no more expensive to operate and would be limited only by the broadcast capability at CMC.

At CMC a fax switch routes the input charts to the required satellite fax channel.

6. Fax Photo Network

The Fax Photo network consists of a simplex anolog bus (2 wire C3 conditioned) connecting all direct readout ground stations to AES HQ SDL as shown in Figure 2.4.2-4.

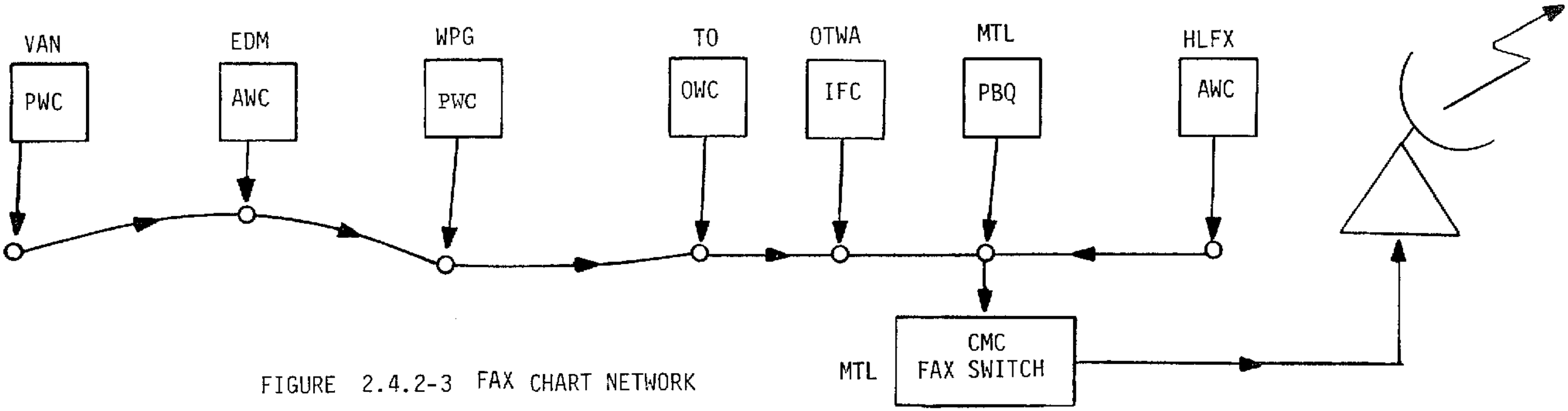


FIGURE 2.4.2-3 FAX CHART NETWORK

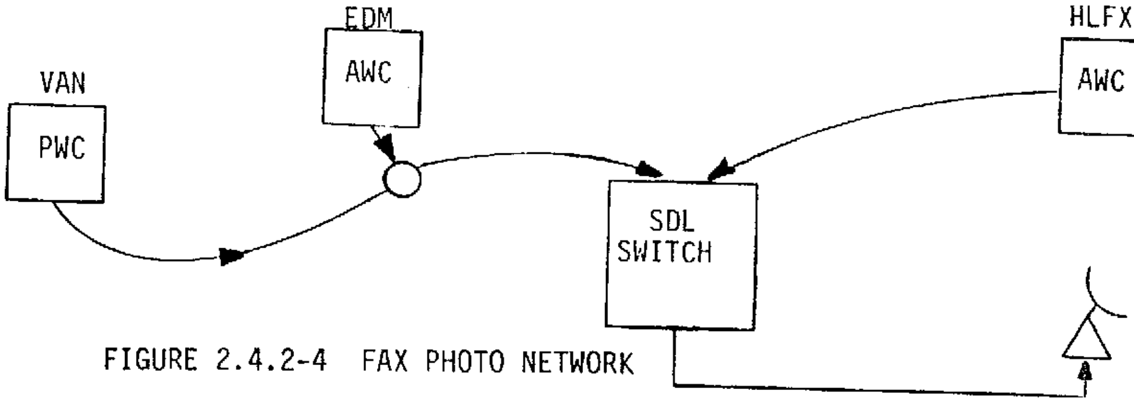


FIGURE 2.4.2-4 FAX PHOTO NETWORK

At SDL a fax switch routes the input charts to the required satellite fax channel. In the future all photos would be forwarded to AES HQ via the Public Data Networks.

2.4.3 Operation

1. Satellite Network

The satellite broadcast network transmits all messages, charts and satellite photo images directly to all MP's, IP's and UP's. The transmission medium is transparent to the users. The circuits accept all input and broadcast it. Scheduling is performed according to current practice, although there are now more parallel channels.

The message channel broadcasts all the data, as assembled at CMC. Receiving sites require enough intelligence to extract pertinent information, as keyed by header information.

2. Public Packet Network

The Public Packet Network performs the following functions:

- relays all collection observations to CMC for one-way satellite broadcast;

- interfaces all UP, IP and MP sites to NCC for network control (diagnostics, polling, traffic statistics, monitoring);

- interfaces all UP, IP and MP sites to all data bases and all processors;

- interfaces AES system to external systems; and

- interfaces private users to the AES system.

- in future would relay all charts and images to CMC and AES HQ transmitters.

3. Local Teletype Network

The Local Teletype Network performs the following functions:

- collects observations from collectors and users; and
- distributes message traffic to collectors and users.

This network is made up of all collectors and users in the proximity of each UP.

4. Off-Network

See description in Section 2.4.2.

5. Fax Chart Network

All regional fax charts plus IFC and DND fax charts are relayed to CMC via this network. Access to the broadcast channels are scheduled for each source permitting about 288 (24 hr x 60 min/hr ÷ 5 min/chart) charts per day or about 40 charts per source per day (288 charts/day/7 sources) at a rate of two per hour per source.

Upgrading the network to digital facsimile would permit a three fold increase in throughput, plus simplified switching and reception selection of the charts.

6. Fax Photo Network

All processed photo images are relayed to AES HQ SDL for satellite one-way broadcast distribution. Access is provided for each source.

2.4.4 Performance Analysis

2.4.4.1 Loading

1. Satellite Network

Loading on the satellite broadcast channels is the same as that defined in Section 2.3.

2. Public Packet Network

Traffic Component	Delivery Times (min)		Baseline & Immediate Services Kchars							
			UP		IP		CMC		AES HQ	
			AV	PK	AV	PK	AV	PK	AV	PK
Observation	10	Source	9	11	–	–	–	–	–	–
		Sink	–	–	–	–	116	138	–	–
Forecast	30	Source	–	–	28	23	–	–	–	–
		Sink	–	–	–	–	110	99	–	–
Sounding	30	Source	–	–	26	40	–	–	26	40
		Sink	–	–	9	40	–	–	–	–
Inquiry		Source	low	?	low	?	low	?	low	?
		Sink	low	?	low	?	low	?	low	?
Interactive (time share)		Source	–	–	low	?	low	?	low	?
		Sink	–	–	low	?	low	?	low	?

- refer to Section 2.3, integrated terrestrial system for backup calculations;
- inquiry, RJE and time sharing taffic to be estimated (most needs satisfied by satellite message reception!)

3. Local Teletype Network

As per Integrated Terrestrial System, for Baseline and Immediate New Services.

	Delivery		AV	PK	K (chars)
Observation	10 min	Source	3	4	
		Sink	17	20	
Forecast	30 min	Source	0	0	
		Sink	28	16	

4. Off-Network

Not available.

5. Fax Chart Network

The total regional loading is approximately 130 charts (average length is 12 inches) per day for all WC's plus IFC and Metoc.

6. Fax Photo Network

The total regional loading is approximately 55 images per day for VAN*, EDM and HLFX.

2.4.4.2 Utilization

Baseline plus Intermediate new services traffic is assumed. See Appendix A (UP's interactive traffic is handled by local storage and reception of broadcast message traffic via satellite).

1. Satellite Network

Utilization of the satellite channels is the same as that defined in Table 2.3.2.1.5-3.

2. Public Packet Network

Link Utilization

	UP (1200 bps)		IP (2400 bps)		CMC (9600 bps)		AES (9600 bps)	
	AV	PK	AV	PK	AV	PK	AV	PK
Source	2%	13%	5%	12%			1%	2%
Sink			1%	7%	5%	23%		

Traffic requirements not defined for point-point services; all spare capacity is available for RJE, time sharing and Inquiry point-point traffic.

3. Teletype Network

Link Utilization (200 bps)

source (from sites)	3% AV	26% PK
sink (to sites)	50% AV	169% PK

4. Off-Network

Not Available.

5. Fax Chart Network

At a scan rate of 240 lpm and with analog transmission the network will carry about 288 charts per day. Thus the utilization is about 130/288 x 100% = 45%.

6. Fax Photo Network

At a scan rate of 120 lpm and with analog transmission the network will carry about 180 images per day. Thus the utilization is about 55/180 x 100 = 30%.

2.4.4.3 Quality/Reliability

1. Satellite Broadcast Network

See Section 2.3.2.4.

2. Packet Network

The public packet network is capable of end-to-end bit error rates of 1 error in 10^{12} bits. This is a result of good error control. The network also operates at a very high reliability due to the capability of redundant nodes and links. The network is operationally maintained to high standards.

3. Local Teletype Network

All collection traffic will be error controlled. Distribution traffic will include FEC. Bit error rates of 1 in 10^{3} are expected on distributed traffic. Bit error rates of less than 1 in 10^{6} is expected for collection.

4. Off-Network

The off-network methods presently used are generally poor in quality and unreliable. Optionally a two way DCP 1 kb/s private satellite system on 6/4 GHz would provide improved quality and reliability.

5. Fax Chart Network

The quality of a 240 lpm analog transmission system is acceptable but an optional digital system would be preferred. The reliability of the analog line is acceptable but the use of Infodat or Dataroute digital lines would be better.

6. Fax Photo Network

The quality and reliability of the analog photo network is acceptable for present applications. However, if digital image analysis is to be carried out in the future at receive sites, digital links would provide a significant improvement in quality.

From a system point of view, the chart and image quality at receive sites would be acceptable but, for digital analysis the use of digital transmission overall would be recommended in the future!.

2.4.5 Costing

(Excludes markups, discounts, taxes) (Man day is senior engineer at 500$/day)

Non-recurring Costs			H/W	S/W
Satellite Network RF H/W				
Transmit stations:		CMC 375K, AES HQ 100K	475K	-
Receive stations:		20K x (72 + 13)	1700K	-
Total			2175K	
Packet Network H/W & S/W				
DTE(UP's)	H/W	12K x 72	865K	-
	Dev	150 MD	75K	-
	S/W	250 MD	-	125K
PPI(IP's)	H/W	30K x 13	400K	-
	Dev	50 MD	25K	-
	S/W	in MP PPI	-	-
PPI(MP's)	H/W	35 x 2	75K	-
	Dev	100 MD	50K	-
	S/W	500 MD	-	250K

Internal redundancy provided.

AES CPU I/F's			H/W	S/W
HP's	H/W	10K x 13	130K	-
	S/W	100 MD	-	50K
CYBER	H/W		25K	-
	S/W	150 MD	-	75K
AES	H/W		25K	-
CLIMATE	S/W	150 MD	-	75K
NCC				
	H/W	175K	175K	-
	S/W	400 MD		200K
		Total	1845K	775K

Recurring Costs

Operation

		$/YR
Satellite	3K to 20K per channel	48K to 320K
Public Packet Network		200K
Local Teletype Network		600K
Off-Network		N/A
Fax Chart Network		100K
Fax Photo Network		100K
	Subtotal	1048 to 1320K/yr.

Includes maintenance of circuitry.

1. Backup calculations are:

Circuits to Packet Service area (modems included)	150K/YR
Access costs	10K/YR
Transmission Packet Costs	15K/YR
Hot line Costs	10K/YR

2. Contract Maintenance (1% per month on H/W)

Satellite Network	261K
Packet Network I/F's	221K
Local Teletype Network I/F's (in Packet I/F's)	NIL
Off-Network	N/A
Fax Chart Network	in opr
Fax Photo Network	in opr
Subtotal	482K

3. Implementation

Description of events (5YR plan)

Phase I - YR # 1 Specification and Test (Capital outlay)

1. System Specification
2. Hardware Specification and System Design
3. Implement Prototype Test Facilities Fax
   - packet I/F to CMC
   - packet I/F to AES HQ
   - packet I/F to IP
   - transmit site at CMC for National Fax and Message Traffic
   - receive site at IP
   - transmit site at AES HQ

4. Monitor Test Facilities and Revise Specs.

Phase II - YR # 2, 3 Reduce switch load; install fax chart network, remove regional chart circuits, remove distribution circuits

1. Install packet I/F's at all IP's to relieve switch load
2. Install receive sites at all IP's and UP's
3. Configure fax chart network
4. Begin removing present fax regional circuits

PHASE III - YR # 3, 4 Reinvest savings and capital outlay Remove collection circuits, remove switch

1. Install local teletype networks
2. Remove present collection circuits
3. Install NCC
4. Remove CNCP switch

PHASE IV - YR # 4, 5 Reinvest savings and capital outlay Add photo images to UP's

1. Reconfigure present photo network to fax chart network
2. Add receive photo capability in receive sites
   Remove all regional circuits for photo imaging.

System Spec

Manpower requirements - for Phase I item 1

- 3 AES persons for 90MD
- 1 Consultant for 90MD

- for Phase I item4

- 3 AES persons for 1 mth
- 1 Consultant for 1 mth.

Hardware and System Design Spec

Manpower requirements
1 Senior Engineer - 90 MD
2 Int. Engineers - 90 MD
2 AES persons - 90 MD

System Checkout and ATP

On completion of each phase the system will be checked out and an ATP run to show the system operates within specifications.

- For Phase I item 4 - 2 Engineers 30 MD
  - 2 AES persons 30 MD

- For Phase II - 3 Engineers 30 MD

		- 3 AES persons 30 MD
-	For Phase III	- 3 Engineers 30 MD
		- 3 AES persons 30 MD
-	For Phase IV	- 2 Engineers 30 MD
		- 2 AES persons 30 MD

Site Preparation

Satellite Network - physical site survey 200 MD
- RF site survey 100 MD
- licensing 100 MD

Public Packet Network)
Local Teletype Network)
Off-Network) Minimal (Not a concern)
Fax Chart Network)
Fax Photo Network)

Installation

Satellite network 500 MD
Terrestrial network similar to Integrated Candidate, approx. 200 MD.

Staffing and Operators (NCC)

The scenario proposed is the NCC staff do all S/W support and fault location. Once a fault is located one of the following people are contacted for action:

- modem supplier
- Telco
- H/W manufacurer

The staffing would be as follows:

Team Persons

	Full Shift (8 a.m. - 4 p.m.)	Partial Shifts (4 p.m. - 8 a.m.)
Manager	2	0
System Diagnostics & Support	3	3
Implementation	2	0
Planning	2	0
Dispatch	1	1
S/W Development	3	0
	13	4

The above persons are total not additional to present staff.

2.4.6 Benefits

1. Phase in program is suited to reinvesting saved money.

2. Low operating and capital costs.

3. Upgradeable to two way satellite.

4. Most suited to traffic.

The one-way satellite broadcast option is a unique approach with the potential of offering the best benefit of satellite and shared public networks communications technology. The system, as described in this section, is not optimum. An optimum system would include the use of narrowband two-way satellite channels for appropriate Users and Collectors, and would include the use of Public Data Networks for the relaying of charts and images to the broadcast transmitters. This could remove most of the expensive leased circuits from the system.

The one-way satellite option avoids many of the current regulatory constraints; reduces circuit costs and is a very simple system. It is amendable to a gradual phase - in program that could provide an immediate return on incremental investments. It is also suitable for upgrading to two-way, when regulations permit private transmitters.

2.4.7 Comments on Present Problems and Future Traffic

Present Problems - Message Data

(i) Performance:

- Speed	The one-way candidate would operate at relatively high speeds with upgradability to higher speeds as required.
- Selectivity Request/Reply	All MP's, UP's and IP's will be capa- - ble of receiving all data. By selection they will limit what they store or access. When unselected data is required, an expedient request/reply operation will be available.
- Priority Handling	No priority handling will be necessary.
- Quality Control	All collection data will be received at CMC then rebroadcast everywhere, hence quality control can be executed at any level of the system but preferably at CMC before the broadcasting occurs.

All terestrial links are error controlled. All satellite links include FEC for messages.

- Half Duplex Operation — No half duplex links are used.

- Heirarchy — All users are interconnected equivalently but the amount of data selected is dependent on the users requirements.

- Polled Multi-drop Circuits — Only the Users and Collectors are on polled multi-drop circuits. These circuits should be first converted to two-way satellite when regulations permit as they are expensive and extensive.

- Reliability or Redundancy — One-way receive only earth stations are very reliable and do not require redundancy. The public packet network is also very reliable and it does inherently have redundancy. The collection and user teletype circuits are the least reliable but, there are a limited number (5 typically) of drops per circuit, hence reliability should be improved. The interface hardware would be DEC or custom CPU's which would require some redundancy at central locations such as CMC and AES HQ.

- Control over Switch — The proposed system requires little operational control but it would be completely operated by AES.

(ii) Adaptiveness

- Flexibility of Interfaces — The proposed interfaces are intended to handle custom private user needs. If this requirement is not necessary then DEC computers would be more suited as expansion would not be needed.

- Speed — Very adaptive to needed changes in speed.

- High Speed Switch Ports — Not relevent.

- System Monitoring: The proposed systems' NCC would monitor the state of all teletype networks, all space radio links and all interface H/W to the public packet network

Present Problems - Charts

(i) Performance

- Broadcast Mode: Excellent utilization of satellite simplex channels. Multi simultaneous sources for charts would be limited to regional plus CMC until the charts are forwarded to CMC via the public packet network.

- Analog: The proposal is to initially start with analog chart transmission but to convert to digital. Without compression an average chart 12" long, would cost about $1.30 to relay from Vancouver, B.C. to CMC. (This would be about 5K per year for 10 charts a day, and require 9600 BPS links). Alternatively with DIFAX transmission, an average chart would cost about 30 cents to relay from Vancouver to CMC and would use 4800 BPS links. (This would cost about 1K per year for 10 charts a day). This would result in a savings of about 100K per year for a capital investment of 1000K$ for encoders and decoders.

- Request/Reply: For retransmissions an expedient request/reply operation would be available.

(ii) Adaptiveness

- National/Regional Structure: See Broadcast Mode above. The proposed system is a centralized system where all broadcast transmissions are centrally sourced. However, all point-to-point transmissions are end-to-end directly thru the public packet network.

Present Problems - Photos

- Broadcast Mode: The candidate is based on the present network hence source input is limited, but all users (UP's, IP's and MP's) can receive all imagery.

With a change over to the public packet network for relaying, all UP's, IP's or MP's can source photo images.

- Analog — The one-way will initially be analog, but, it is proposed to convert to digital, with digital transmission, uncompressed, a photo (32 lines) would cost about $3.00 to relay from Vancouver to AES HQ (This would cost about 40K per year for 40 images a day and require 9600 BPS links).

- Request/Reply — For retransmissions an expedient request/reply operation would be available.

Present Problems - Off-Network

See Section 2.2.6

Future Traffic

(i) Graphics — The one-way candidate is excellent for the distribution of graphics products. Prepared products would be relayed to CMC over the public packet network and rebroadcast to all users.

The collection of radar images for product generation would be treated as for photos or charts. Radar images would be relayed to CMC or AES HQ and rebroadcast via satellite to all users. With digital transmission, uncompressed, a radar image of 8 levels, 240 lines x 270 pixels, would cost about $.30 per image to relay from Prince George to CMC. (This would cost about 2500$/yr to relay 24 images per day). The beauty of this candidate is you pay for usage, hence during average weather conditions you transmit less and save money. A graphics overlay product of 5 levels, and 256 x 256 resolution would cost about 25¢ per product to relay from Vancouver to CMC. (This is a cost of about 2200$/yr to relay 24 products per day).

(ii) Marine Transportation Support	See same heading in Section 2.2.6.
(iii) Dissemination to Users	All broadcast data is sent by one-way satellite hence all non marine users have access to all data.

2.5 SUMMARY

2.5.1 Basis of Comparison

This section contains a summary of the cost estimates included in the previous four sections. The cost estimates are aggregated in terms of non-recurring and recurring costs.

Non-recurring costs include hardware purchase (at cost), installation and one-time software development. Hardware costs are broken down into transmission circuit components (transmitters, receivers, antennas, modems), data terminal equipment, where possible. Most of the data terminal equipment performs a switching function in connecting many input/output units to a common data circuit.

Recurring costs include hardware maintenance, at 1% per month of the purchase cost, and circuit costs.

	CURRENT	UPGRADE	INTEGR. TERREST.	ALL SATELLITE	ONE-WAY SATELLITE
NON-RECURRING COSTS					
HARDWARE					
CIRCUIT EQUIPMENT		-	1775K	7336K	2175K
DATA TERMINAL INTERFACE EQUIPMENT		427K	1580K	576K	1120K
SWITCHING EQUIPMENT		900K	590K	946K	725K
INSTALLATION		-	80K	1100K	326K
SUB-TOTAL		1327K	4025K	9958K	4346K
SOFTWARE DEVELOPMENT		650K	1035K	910K	775K
TOTAL		1977K	5060K	10868K	5121K
RECURRING COSTS					
CIRCUIT		3477K	1345K	81K to 540K	1048 to 1320K
MAINTAINANCE		159K	475K	1063K	482K
TOTAL/YEAR	2340K/YR	3636K	1820K	1144 to 1603K	1530 to 1802K

TABLE 2.5.1 COST SUMMARY

3.0 GENERAL TERMINAL EQUIPMENT REQUIREMENTS

3.1 INTRODUCTION

Terminal equipment is the most visible part of a communications system, to both users and operators. Its selection and configuration will affect the implementation and acceptance of the system. In this discussion, summary results of a general survey of the equipment presently in use in the AES communications system, and its cost will be presented. However, computer interfaces, at CMC and at the IP's as well as the tape drives, switching and CFI equipment at the Satellite Data Laboratory will not be included. Since replacement equipment will depend, to a large extent, on the communications system and operational scenario implemented, only generic types of this equipment and ball park costs will be presented. Wherever capital or purchase cost is given, this cost will be reduced to monthly payments, with and without monthly maintenance (1% of capital cost per month to provide 8 hours a day five days a week coverage, additional cost for off hours) cost, using two and five year amortization periods and 15% and 20% interest. These monthly costs should provide a basis for comparison with the current equipment rental costs.

Software development cost (about 1 PY for AN terminals for the Collector/User sites) and project management cost, which could be part of the total communications planning project, are not included in the terminal equipment cost.

The use of interactive graphics terminals is not included here because it is part of a larger problem in graphics processing and should be looked at together with computer requirements in a total graphics processing system.

3.2 ALPHANUMERIC TERMINALS

3.2.1 Existing Equipment

The alphanumeric terminals used in the AES Meteorological Communications System (teletype) consist of in general, Teletype 35 ASR or R/O equipment or equivalent. The 35 ASR, including a paper tape perforator/transmitter, is used on collection circuits for the transmission and reception of meteorological information whereas the R/O equipment is used on distribution circuits or on collection circuits at receive-only sites. The 35 ASR and R/O equipment, other than the Extel and Centronics printers, because of their age and mechanical nature are generally very noisy. As presently configured, they also lack the selective printing capability. However, by the use of perforated paper tape as a transmission buffer, they do have the advantage of having a permanent copy of any transmitted message which could be repeated without re-keying or re-punching. Because of this same medium, there is only very limited editing capability. (At CMC and the

I/P's where computers are used for message preparation and transmission, this disadvantage does not exist).

Columns 2, 3 and 4, under TELETYPE, in Table 3.1, summarizes the existing equipment and rental costs at the various types of offices. We have not included in our equipment summary the 12 INFOMODE 200R's that are being evaluated in the Regions. These units are leased at about the same cost as the 35 ASR's and do not affect the estimated costs. (At sites where there is an INFOMODE 200R, we pay the rental for this equipment and not for the 35 ASR).

It should be noted that a number of UP's, because of their location and because of the nature of their operation, are served by a collection circuit only and not by any distribution circuits. These sites include Inuvik, Yellowknife, and Frobisher. There are also sites, both Collectors/Users and UP's because of their remote location have their equipment, or some components, backed- up.

Although the IP's and CMC have their computers connected to the teletype circuits, they still have their teletype terminals for manual back-up or other purposes. Some IP's also have an ROTP (Receive-only tape perforator) which was intended for producing tapes by the computer for transmission using the 35 ASR. An ROTP is also used at CMC for the same purpose.

In addition to terminating the two 600 b/s circuits on the computer and on Centronics R/O terminals, CMC also has tape units connected to these circuits as back-up.

3.2.2 Possible Replacement Terminal Equipment

3.2.2.1 Collector/User Sites

The type of replacement equipment will depend on the communication system and operational scenario implemented. However, at the Collector/User sites, it is expected that an intelligent terminal (VDU) with a keyboard and a hard-copy device, such as a printer with a keyboard, would be adequate. The cost of this equipment is about $10 K ($5K for the VDU and $5K for the printer). This equipment could be used as interactive terminals or termininals on multi-drop broadcast lines. If not used in an interactive mode, this equipment must be capable of being programmed to provide selective printing capability or capable of being addressed for data reception purposes. For data entry, it must have adequate transmission buffer space and be able to provide editing, form filling, data validation, quality control capabilitities. About one PY may be needed to develop the software for this data entry/reception function. An example of this device would be the CNCP marketed INFOMODE 200R with a printer.

	TELETYPE			PHOTO FAX		WX FAX			RADAR	OTHERS	
	TTY ASR	R / O	CNTRNC 306C	MUIR-HEAD K560	MUIR-HEAD K470	ALDEN 9271 H/AE	ALDEN 9165L	ALDEN 9500D	ALDEN 9290S		
M/P (CMC)	1 300		3 600	1 900 600		4 2400 1200	3 3000 2100	2 2000		4 TDR 1600	1 ROTP 10
I/P	1-2 300-600	2 * 200		1 ** 900 600	1 ++ 400	2 + 1200 600	2 2000 1400		1 # (US 6K)		1 ROTP 10
U/P	1 300	100				1 600 300			1 ## (US 6K)		
COLLECTOR / USER	1 300										
COLLECTOR	1 300										
USER###		1 100									

* DEPENDING ON THE NUMBER OF COLLECTION CIRCUITS SERVING SITE.
** VANCOUVER HAS TWO.
\+ EDMONTON HAS THREE.
++ VANCOUVER, EDMONTON, AND HALIFAX ONLY.
\# HALIFAX HAS NONE AND MONTREAL HAS TWO.
\## NOT ALL U/P'S HAVE RADAR RECORDERS.
\### USERS (PRIVATE) MAY HAVE ANY NUMBER OF ANY RECEIVING EQUIPMENT DEPENDING ON THEIR REQUIREMENTS.

LEGEND:

NUMBER
MAX. COST/MONTH MIN. COST/MONTH

OR

NUMBER
COST/MONTH

NOTE: COSTS IN BRACKETS ARE PURCHASE PRICES.

TABLE 1. EXISTING EQUIPMENT AND COST AT VARIOUS TYPE OF OFFICES.

Because of the geographical distribution of the Collector/Users sites, static might be a problem at some locations, these terminals, either through hardware or firmware, must be able to overcome interruptions caused by static discharge otherwise air-conditioning and humidity control may be required.

Figure 3.1 shows a possible configuration of this equipment.

3.2.2.2 User Processor Sites

The choice of possible replacement equipment at the user/processor sites will depend on the communications system and operational scenario. Two possible scenarios are:

(1) interactive access to Regional Computer database, and

(2) local database for on-site use.

3.2.2.2.1 Interactive access to Regional Database

Under the interactive access scenario, no on-site magnetic storage-retrieval facility is required. This system will depend on the reliable operation (availability) of the regional facilities and does not provide the UP sites with meaningful capability for data collection/distribution (other means such as telephone, telex etc. could be used). Figure 3.2A shows a possible configuration of equipment at a UP with a single work station. It consists of a VDU and a printer. The latter, provided with a keyboard, could be used as a back-up for the VDU by a switching arrangement. Figure 3.2B shows a configuration for a station with two work stations, consisting of two VDU's sharing one printer. The printer in this case needs not have a keyboard because the VDU's can provide back-up for each other. Figure 3.2C shows a possible configuration for a station with three work stations, consisting or three VDU's sharing two printers.

The cost for this equipment for a site with one work station is about $8 K, with two work stations $11K and with 3 work stations $19K giving an average of $8.6K per site.

3.2.2.2.2 Local Database for On-Site Use

Under the local database for on-site use scenario, alpha-numeric information is generally distributed from some central or regional location in a broadcast mode and extracted and stored on local magnetic storage devices for local enquiry/response use. Information not generally available could be requested from a central or regional site. The intelligence and storage required and their cost are included with the various communications system candidates and need not be discussed here. With the required facilities already provided or included as part of the communication system, the terminal equipment required under this

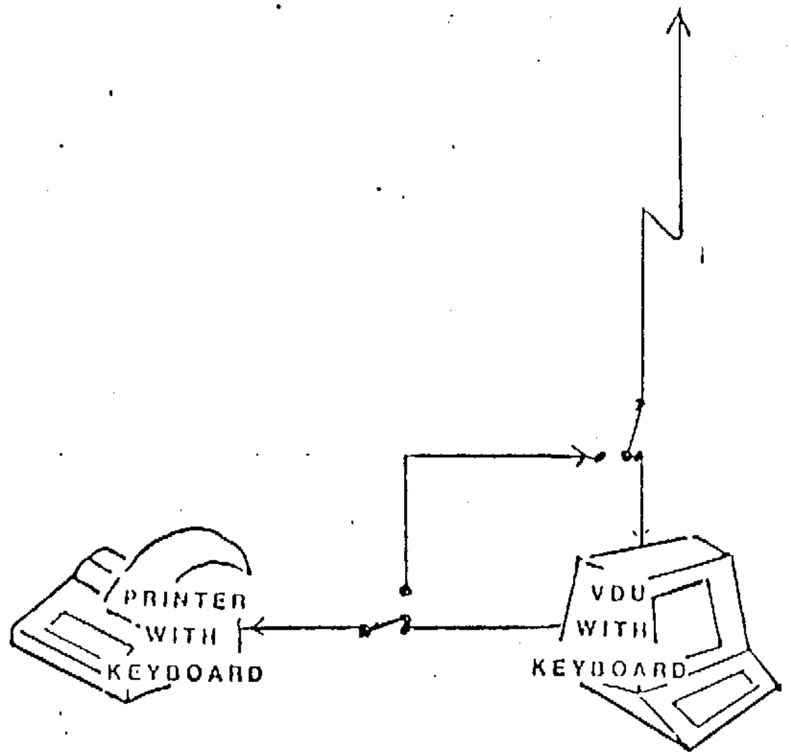


FIGURE 3.1. POSSIBLE ALPHANUMERIC TERMINAL EQUIPMENT CONFIGURATION AT COLLECTOR/USER SITES. SWITCHING ARRANGEMENT WOULD ALLOW PRINTER TO BE USED AS BACK-UP.

scenario is similar to that required under the inter-active scenario discussed in the previous section and are shown in Figures 3.2A to 3.2C for sites with one, two and three work stations.

The equipment cost is the same as for the interactive scenarial or about $8.6K per site.

3.2.2.3 Intermediate Processor Sites

Most IP sites are already equipped with dual processor Hewlett-Packard systems. This facility already provides interactive access to computing power and to the regional data-base for operational and developmental work, both for the IP and co-located UP and SSD units. We have therefore not included the terminal equipment requirements in this discussion. The added computing facilities to handle other communications functions are included in the candidate systems and are also omitted.

3.2.2.4 CMC

Terminal equipment requirements for CMC is not considered because interactive terminals are already available there (AES owned) and because of other activities currently underway to up-grade their facilities. Switching and control facilities at CMC for the various candidate systems are discussed separately in the various proposals.

3.2.3 Cost Comparison

Table 3.2 summarizes the cost for AN terminals. In order to provide a basis for comparison, the estimated purchase costs for the two options, based on the discussion in paragraphs 3.2.2.2.1 and 3.2.2.2.2, have been converted to monthly payments, with and without maintenance (1% of purchase price per month) at 15% and 20% interest amortized over two and five years. From these figures, it can be seen that the monthly cost, including the 1% maintenance costs, for both options A/N1 and A/N2 are comparable to the present monthly rental cost if the capital costs are amortized over five years, at 15% or 20%. However when amortized over two years, the monthly payment is 60% to 70% greater than the current cost.

3.3 GRAPHICS EQUIPMENT

3.3.1 Existing Graphics Equipment

AES is currently using analog facsimile equipment for the transmission and reception of weather charts and other pictorial information over paper facsimile circuits. The scanner or transmitter is Alden 9165L (CMC also has three computer facsimile interfaces or CFI's, made by Muirhead, which allow direct facsimile transmission using the NOVA 3/D minicomputer. The cost

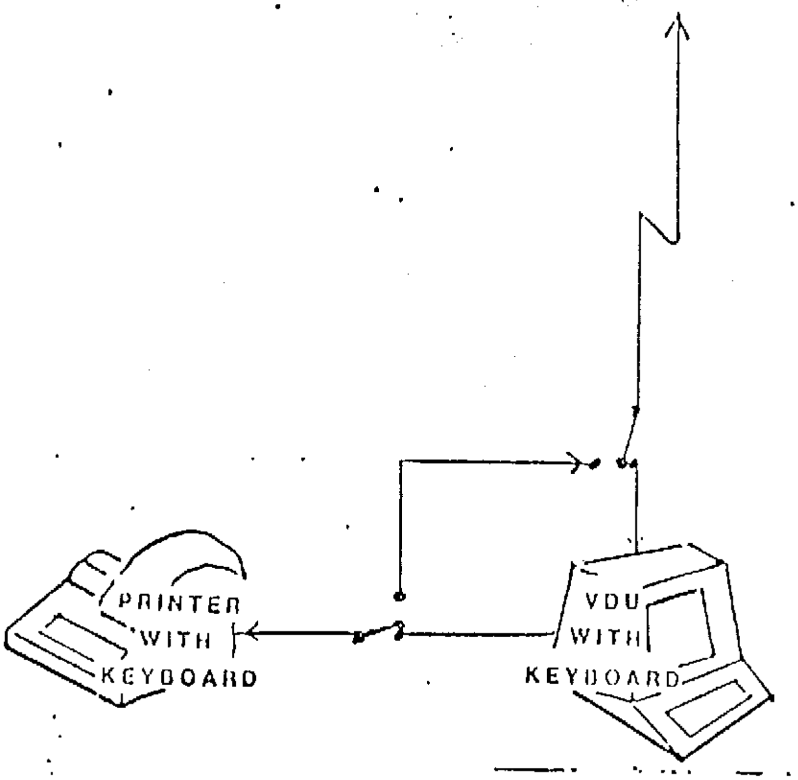


FIGURE 7.2A. POSSIBLE ALPHANUMERIC TERMINAL EQUIPMENT CONFIGURATION AT U/P SITES FOR ENQUIRY/RESPONSE OPERATION. U/P SITE HAS ONE WORK STATION.

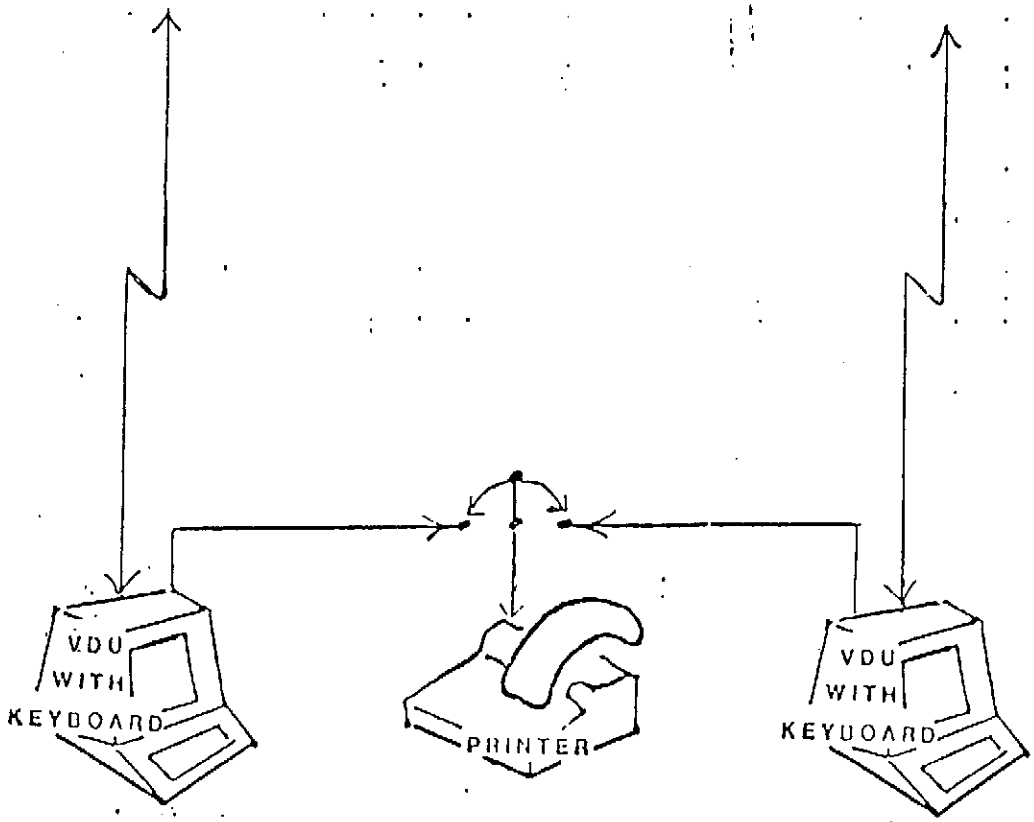


FIGURE 3.2B. AS FOR 2A BUT FOR U/P SITE WITH TWO WORK STATIONS.

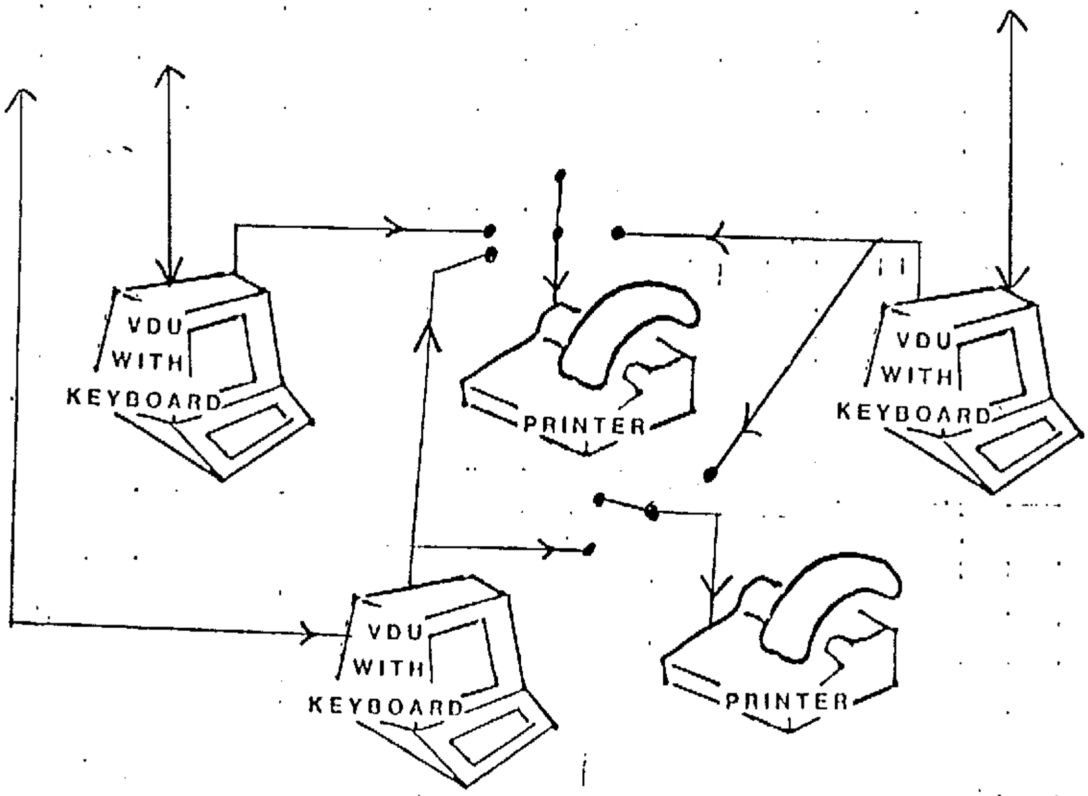


FIGURE3.2C. AS FOR 2A BUT FOR U/P SITE WITH THREE WORK STATIONS.

	NO.	PRESENT COST	OPTION A/N 1 COST	OPTION A/N 2 COST	
M/P (CMC)	1	2.6K/M	-	-	Cost Per Site
		2.6K/M	-	-	Sub-Total
I/P	13	0.8K/M	-	-	Cost Per Site
		10.4K/M	-	-	Sub-Total
U/P	72	0.4K/M	8.6K	8.6K	Cost Per Site
		28.8K/M	619.2K	619.2K	Sub-Total
COLLECTOR USER	298	0.3K/M	10.0K	10.0K	Cost Per Site
		89.4K/M	2980.0K	2980.0K	Sub-Total
TOTAL		131.2K/M	3599.2K	3599.2K	
15% INT. 2 yr. AMORTIZATION			210.5K/M	210.5K/M	Monthly Payment with maintenance
			174.5K/M	174.5K/M	Monthly Payment
15% INT. 5 yr. AMORTIZATION			121.6K/M	121.6K/M	Monthly Payment with maintenance
			85.6K/M	85.6K/M	Monthly Payment
20% INT. 2 YR. AMORTIZATION			219.2K/M	219.2K/M	Monthly Payment with maintenance
			183.2K/M	183.2K/M	Monthly payment
20% INT. 5 YR. AMORTIZATION			131.4K/M	131.4K/M	Monthly Payment with maintenance
			95.4K/M	95.4K/M	Monthly Payment

Table 3.2 ESTIMATED A/N TERMINAL EQUIPMENT COST

OPTION A/N 1 - BROADCAST TO U/P AND COLLECTOR/USER SITES
OPTION A/N 2 - BROADCAST TO COLLECTOR/USER SITES. U/P SITES HAVE INTER-ACTIVE ACCESS TO I/P's

about $14K, for this facility is not included). The analog facsimile recorders are Alden 9271H/AE's. These are also two Alden 9500D digital facsimile recorders connected to the U.S. digital facsimile circuit at CMC. The cost for this equipment is given in columns 6, 7, and 8, under wx fax, in Table 1. There is a range for the cost of the Alden 9271H/AE and the Alden 9165L equipment because of the difference in age of the sets. Most sets in the AES/DND sites are leased at the lower cost.

3.3.2 Possible Replacement Graphics Equipment

In this discussion, only facsimile equipment will be considered. Graphics display devices and digital plotters are not included because they belong properly in the analysis of graphics processing and should be looked at together with computer requirements in a total graphics processing system.

There are basically two types of facsimile equipment, namely analog and digital. Digital equipment, because of the need for encoding and decoding devices tends to be more expensive than the analog type. Table 3.3 summarizes the present cost and the cost for the analog and digital options. It may seem that the cost for the analog option should be the same as the present cost, because it involves no change in equipment and no increase in service. However, if a new system is installed, it is not likely that the current rental costs can be retained. For both options, we have allowed three transmitters at CMC, and two at each IP. The cost for an analog transmitter is about $29K and a digital transmitter, including an encoder is about $75K. The analog facsimile recorder is about $8K and the digital facsimile recorder, including a decoder is about $26K. We have allowed four recorders for CMC and two for each of the IP's as well as one per UP. The number of transmitters and recorders for costing purposes are similar to those presently available at each site.

In order to provide a basis for comparison, the capital costs have been reduced to monthly payments (with and without maintenance, 1% of capital cost per month) by amortizing them over two years and five years at 15% and 20% interest. The monthly payment of the digital option, with the 1% maintenance, when the cost was amortized over five years is more than three times the current cost of $52.9 K/M and when amortized over two years, this goes up to more than five times. The increase in cost for the analogue option, on the other hand, is minimal when the cost was amortized over five years and is nearly double when amortized over two years. This increase in cost for the analogue option reflects the increase in equipment purchase price.

It is perhaps worth mentioning that the encoder and decoder for the digital equipment quoted are hardwired devices and accounts for about one half of the cost for the transmitter and recorders (in other words the encoder is about $37K and the decoder is about

	NO.	PRESENT COST	OPTION W1 COST	OPTION W2 COST	
M/P (CMC)	1	5.3K/M 5.3K/M	119K/M 119K/M	329.0K 329.0K	Cost Per Site Sub-Total
I/P	13	2.0K/M 26.0K/M	74.0K/M 962.0K/M	202.0K 2626.0K	Cost Per Site Sub-Total
U/P	72	0.3K/M 21.6K/M	8.0K/M 576.0K/M	26.0K 1872.0K	Cost Per Site Sub-Total
COLLECTOR USER	298	0	0	0	Cost Per Site Sub-Total
TOTAL		52.9K/M	1657.0K/M	4827.0K	

15% INT. 2 yr. AMORTIZATION	96.9K/M	282.3K/M	Monthly Payment with maintenance
	80.3K/M	234.0K/M	Monthly Payment
15% INT. 5 yr. AMORTIZATION	56.0K/M	163.1K/M	Monthly Payment with maintenance
	39.4K/M	114.8K/M	Monthly Payment
20% INT. 2 YR. AMORTIZATION	100.9K/M	294.0K/M	Monthly Payment with maintenance
	84.3K/M	245.7K/M	Monthly payment
20% INT. 5 YR. AMORTIZATION	60.5K/M	176.2K/M	Monthly Payment with maintenance.
	43.9K/M	127.9K/M	Monthly Payment

Table 3.3 ESTIMATED WEATHER FAX EQUIPMENT COST

OPTION W1 – ANALOG AS IS
OPTION W2 – DIGITAL

$13K). It is reasonable to assume that a micro-based encoder and decoder would be considerably less expensive.

Depending on the communications system implemented and depending on how charts from CMC and NMC are to be delivered to the UP's, some retransmitting or relaying or switching mechanism may be needed at the IP's. This cost is not specifically included in the estimated cost here and allowances could be made in the switching facilities (either centrally or regionally) for this function. Also depending on the communications system implemented and how charts from CMC and NMC are to be delivered to the UP's, some larger UP's may require more than one recorder.

3.4 IMAGERY EQUIPMENT

3.4.1 Radar Imagery Receiving Equipment

3.4.1.1 Existing Radar Imagery Receiving Equipment

Radar imagery recording devices currently in use within AES/DND are made by ALDEN and owned by AES/DND. These units currently sell for about $9K each. There are currently 16 units, excluding those at the radar sites (22 including those at the radar sites), in operational sites, both UP and IP's. The disposition of these units are shown in Table 3.4.

3.4.1.2 Possible Replacement Radar Imagery Receiving Equipment

In the proposed equipment distribution, as shown in Figure 3.3, each UP will have a receiving device connected (or having access) to the radar site which best serves its area of responsibility. A dial-up facility would provide back-up information from another site if regular information was not available for any reason. One receiver with dial-up facility at each IP would allow the latter to access any site within the office's area of interest or responsibility.

Two different types of receiving equipment are considered, these are digital imagery display devices and anolgue facsimile recorders. Under the analogue option, the present Alden type of recorder is used for costing although a smaller version, using dial-up and producing a 6" X 6" image, costing about $4.5K is also available. The cost of $14K per unit for the digital imagery display device is based on a quote from a manufacturer for a one of a kind unit based on the system presently used in the AES Downsview lobby. Since the manufacturer must recover its R & D cost, and since the estimated cost for parts is only about $7K ($4K for the monitor and $3K for other parts), it might be reasonable to assume that the actual cost for these units could be much less than the $14K quoted. It should be noted also that this device does not provide hardcopy facility but that it can be provided.

Table 34. Location of radar imagery receiving equipment.

	LOCATIONS	CIRCUIT STATUS	EXISTING RECORDER/CRT	TO BE INSTALLED RECORDER/CRT
	RAYTHEON RADAR SITES			
1.	CARP	OQWRF001	ALDEN	-
	OTTAWA I/AIRPORT	IN	ALDEN	-
	CFB OTTAWA (DND)	IN	ALDEN	-
	C.P.Q.	IN	ALDEN	-
	PETAWAWA (DND)	IN	ALDEN	-
	E.P.S. OTTAWA	IN	MUIRHEAD (LEASED)	-
	ALDEN MONTREAL	IN	ALDEN	-
	NEPEAN OHAWA	--	MUIRHEAD (LEASED)	-
2.	ABBOTSFORD	VQWRF002	MUIRHEAD (AES OWNED)	ALDEN
	VANCOUVER (P.W.C.)	IN	(2) MUIRHEADS (LEASED)	ALDEN
3.	TREPASSEY	SNFD639	ALDEN	-
	ST. JOHN'S	IN	ALDEN	-
4.	VILLEROY	RAWRF004	ALDEN	-
	QUEBEC AIRPORT	IN	ALDEN	-
	C.P.Q.	IN	ALDEN	-
	BAGOTVILLE (DND)	IN	ALDEN	-
	VALCARTIER (DND)	IN	ALDEN	-
5.	EXETER	TXWRF003	ALDEN	-
	MALTON (O.W.C.)	IN	ALDEN	-
	LONDON	IN	ALDEN	-
	ONTARIO HYDRO	IN	MUIRHEAD (LEASED)	-
	CFPL TV S	IN	MUIRHEAD (LEASED)	-
6.	WOODBRIDGE	CCFDC85613	MUIRHEAD (DRYPAPER)	-
	MALTON (O.W.C.)	IN	ALDEN	-
	ONTARIO HYDRO	IN	MUIRHEAD (LEASED)	-
	O.M.N.R. QUEENS PARK	IN	MUIRHEAD (LEASED)	-
	METRO TORONTO ROADS	--	MUIRHEAD (LEASED)	-
7.	WOODBRIDGE (DIGITAL)	CCFDC12068		
	A.E.S. HQ. (LOBBY)	IN	CRT	-
	MALTON (O.W.C.)	IN	CRT	-
	ROGERS CABLE TV	IN	-	CRT
	O.M.N.R. QUEENS PARK	IN	-	CRT
8.	A.E.S. SCEPTRE LAB	-	ALDEN	-
	AES MAINTENANCE BRANCH	-	ALDEN	-
	CURTISS-WRIGHT RADAR SITES			
1.	HALIFAX AIRPORT			-
	BEDFORD			-
2.	WINNIPEG AIRPORT	MTS-73FDC602	ALDEN	-
	WINNIPEG PRWC	IN	ALDEN	-
3.	EDMONTON AIRPORT	UXWRF005	ALDEN	-
	ARGYLL CENTRE	IN	ALDEN	-

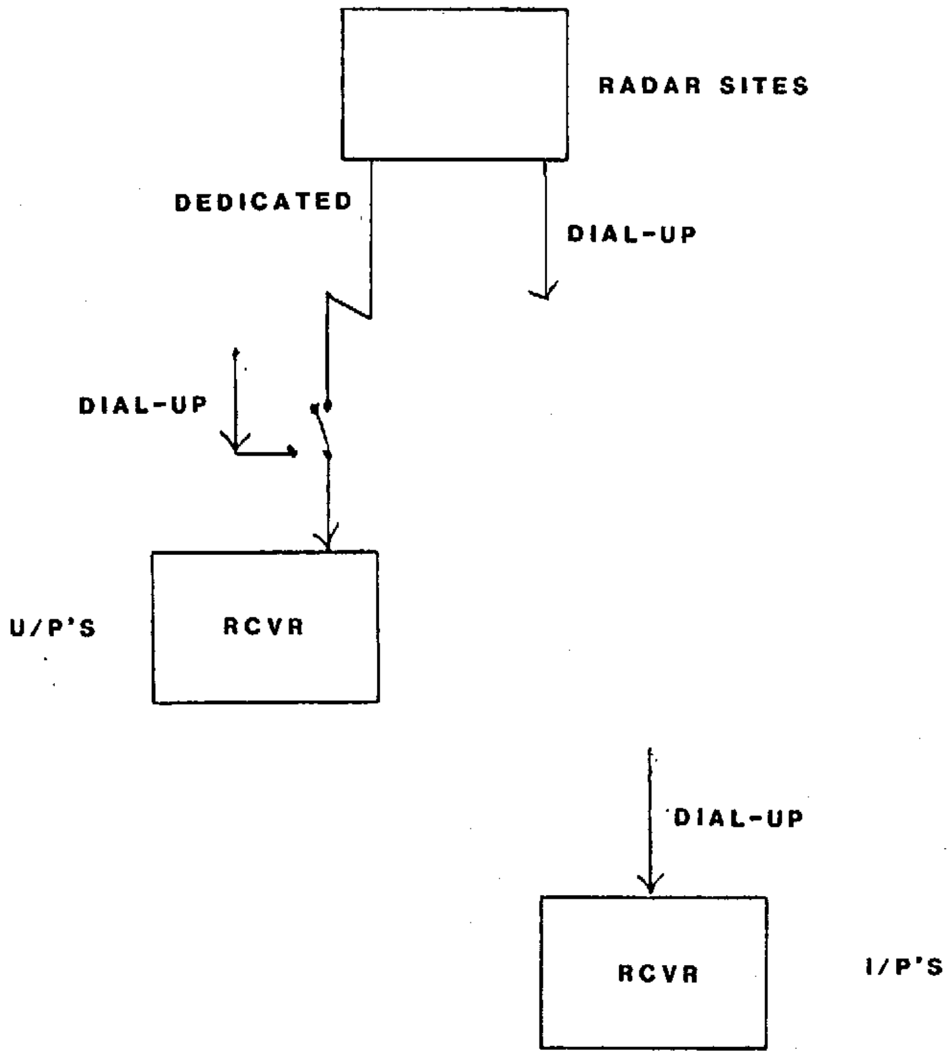


FIGURE 3.3 POSSIBLE ARRANGEMENTS OF RADAR IMAGERY RECEIVING EQUIPMENT.

Table 3.5 summarizes the cost for radar receiving equipment. Of the 13 IP and 72 UP sites, there are some 25 locations where radar coverage is not available. The estimated cost can therefore be reduced by nearly one third. There are IP's, such as le Centre des Prévisions du Québec and the Ontario Weather Centre, where, because of the availability of or proximity to radar sites or other reasons, have more than one radar receiver now. Consideration will have to be given to providing these centres with the same level of service as presently available.

3.4.2 Photo-facsimile Equipment

3.4.2.1 Existing Photo-facsimile Equipment

SDL currently interfaces to the photo-fax circuit using two tape units and five computer facsimile interfaces. Other transmitting sites such as Vancouver, Edmonton and Halifax each have one Muirhead K470 transmitter. Display units are Muirhead K560 photo recorders. Unifax II recorders are currently under evaluation. These units are cheaper to purchase or lease and to operate and may eventually replace the K560's. Photo-facsmilie equipment, excluding those at the Satellite Data Laboratory, and cost are summarized in columns 4 and 5 under photo-fax, in Table 3.1.

3.4.2.2 Possible Replacement Photo-facsimile Equipment

There are basically two types of photo-fascimile recording devices, namely, analog and digital. Because of the information content of a satellite photgraph, unless a very effective means of data compression is available, transmission in a digital mode is not very practical. Even if digital mode is used, analog receiving equipment will still be usable through the use of a decoder or digital-to-analog converter. Therefore, only costs for analog equipment is given.

Table 3.6 summarizes the cost for the photo-facsimile equipment. Under option P1, where the current equipment (i.e. Muirhead K470 transmitters and Muirhead K560 recorders) are retained and the service is extended to all 72 UP sites by adding a K560 to each site ($30K each), the total purchase price, including the cost for the K470 transmitters at $9K each, is $2697.0K. Under option P2 where the K560's are replaced by the less expensive UNIFAX II at $18K each, the total cost is only $1665.0K. It can be seen that the cost for P1 is more than $1\frac{1}{2}$ times the cost for P2. When reduced to monthly payments using 15% and 20% interest, amortized over five years and 1% of capital cost for maintenance, the cost for P1 is some 7 times the current cost and for P2 the cost is just over 4 times the current cost. When amortized over two years, these figures become approximately 12 times and just over 7 times.

	NO.	PRESENT COST	OPTION R1 COST	OPTION R2 COST	
M/P (CMC)	1		0 0	0 0	Cost Per Site Sub-Total
I/P	13		9.0K 117.0K	14.0K 182.0K	Cost Per Site Sub-Total
U/P	72		9.0K 648.0K	14.0K 1008.0K	Cost Per Site Sub-Total
COLLECTOR USER	298		0	0	Sub-Total
TOTAL		(16 X 9.K) 144.0K	765.0K	1190.0K	
15% INT. 2 YR. AMORTIZATION		8.4K/M 7.0K/M	44.8K/M 37.1K/M	69.6K/M 57.7K/M	Monthly Payment with maintenance Monthly Payment
15% INT. 5 YR. AMORTIZATION		4.8K/M 3.4K/M	25.9K/M 18.2K/M	40.2K/M 28.3K/M	Monthly Payment with maintenance Monthly Payment
20% INT. 2 YR. AMORTIZATION		8.7K/M 7.3K/M	46.6K/M 38.9K/M	72.5K/M 60.6K/M	Monthly Payment with maintenance Monthly payment
20% INT. 5 YR. AMORTIZATION		5.2K/M 3.8K/M	28.0K/M 20.3K/M	43.4K/M 31.5K/M	Monthly Payment with maintenance Monthly Payment

Note: There are currently 16 AES/DND sites (both I/P and U/P sites) with radar recording equipment. Of the 85 I/P and U/P sites there are some 25 sites where radar coverage is not available. The estimated cost for options R1 and R2 can therefore be reduced by 1/3.

Table 35 ESTIMATED RADAR RECORDER COST

OPTION R1 – ANALOG
OPTION R2 – DIGITAL

	NO.	PRESENT COST	OPTION P1 COST	OPTION P2 COST	
M/P (CMC)	1	0.6K/M	30.0K/M	18.0K	Cost Per Site
		0.6K/M	30.0K/M	18.0K	Sub-Total
I/P	13	1.0K/M	39.0K/M	27.0K	Cost Per Site
		13.0K/M	507.0K/M	351.0K	Sub-Total
U/P	72	0.	30.0K/M	18.0K	Cost Per Site
			2160.0K/M	1296.0K	Sub-Total
COLLECTOR USER	298	0	0	0	Cost Per Site Sub-Total
TOTAL		13.6K/M	2697.0K/M	1665.0K	
15% INT. 2 yr. AMORTIZATION			157.8K/M	97.4K/M	Monthly Payment with maintenance
			130.8K/M	80.7K/M	Monthly Payment
15% INT. 5 yr. AMORTIZATION			91.2K/M	56.3K/M	Monthly Payment with maintenance
			64.2K/M	39.6K/M	Monthly Payment
20% INT. 2 YR. AMORTIZATION			164.3K/M	101.4K/M	Monthly Payment with maintenance
			137.3K/M	84.7K/M	Monthly payment
20% INT. 5 YR. AMORTIZATION			98.5K/M	60.8K/M	Monthly Payment with maintenance
			71.5K/M	44.1K/M	Monthly Payment

Table 3.6 ESTIMATED PHOTO FAX EQUIPMENT COST

OPTION P1 - ANALOG WITH SERVICE EXTENDED TO THE 72 U/P's
OPTION P2 - AS IN OPTION P1 BUT REPLACE K560's WITH UNIFAX II's

3.5 TELIDON TERMINALS

Telidon is a Canadian videotex system incorporating graphics and imagery capabilities using PDI (Picture Description Instructions). AES is currently evaluating this system for internal and external communications. As part of this evaluation, work is in progress to adapt (or convert) graphics software packages in use within AES to produce images described by PDI code. A report from the Telidon project team on the possible uses of this system would be appropriate.

Current prices for an elaborate user terminal including a modem, decoder and TV RGB input is about $3.5K. Adding an average quality monitor at $4K (as the one used for the radar display device in the lobby at AES Downsview) would bring the cost to $7.5K. Lower quality mass produced terminals including a 13 inch colour monitor might be available this year for about $3K.

For comparison purposes, the radar display device presently in use in the AES HQ lobby is $14K. This device has a maximum of eight frames of imagery for fast display. To add this facility to a Telidon terminal could increase the cost by $10K per unit.

3.6 OTHER DEVELOPMENT

A Canadian manufacturer is presently preparing an unsolicited proposal to develop a system whereby information received over an analog facsimile circuit can be digitized and stored on magnetic storage devices for later output to a hard copy device such as a facsimile recorder or to a soft copy monitoring device. It is understood that this system will likely provide the capability to overlay various fields and/or images for display. However, no other detail is presently available.

Depending on the ultimate cost and capability of this system, it might be applicable at IP and larger UP sites as a weather facsimile, radar facsimile and/or photo facsimile recorder/ display device.

3.7 SUMMARY

3.7.1 Comparison of Total Costs

Tables 3.7(a) and 3.7 (b) summarize the comparison between the estimated present cost and two options for possible replacement equipment. Wherever applicable, the costs have been reduced to monthly payments using a 5 year amortization period at 20% interest plus a monthly maintenance cost of 1% of the capital cost. This 1% maintenance cost is understood to be the minimum, providing an eight hours a day, five days a week parts and labour service. Work done at off hours will be chargeable at over time rates.

	Present Equipment Cost	Proposed Equipment Cost	Increase	Percentage Increase
Alphanumeric	131.2K/M	131.4K/M	0.2K/M	0
Weatherfax	52.9K/M	60.5K/M	7.6K/M	14
Photofax	13.6K/M	60.8K/M	47.2K/M	347
Radarfax	5.2K/M	28.0K/M	22.8K/M	438
TOTAL	202.9K/M	280.7K/M	77.8K/M	40

Table 3.7 (a) Summary Cost Comparison of Terminal Equipment - Analogue Equipment for Weatherfax

	Present Equipment Cost	Proposed Equipment Cost	Increase	Percentage Increase
Alphanumeric	131.2K/M	131.4K/M	0.2K/M	No
Weatherfax	52.9K/M	176.2K/M	123.3K/M	233
Photofax	13.6K/M	60.8K/M	47.2K/M	347
Radarfax	5.2K/M	28.0K/M	22.8K/M	438
TOTAL	202.9K/M	396.4K/M	193.5K/M	95

Table 3.7 (b) Summary Cost Comparison of Terminal Equipment - Digital Equipment for Weatherfax

In arriving at the costs for the replacement equipment in Table 3.7 (a), we have assumed:

1. VDU(s) and hard copy device(s) at UP and Collector/User sites;

2. analog equipment for weather facsimile;

3. UNIFAX II type recorders for photo facsimile; and

4. analog recorders for radar facsimile.

In arriving at the costs shown in Table 3.7 (b), we have replaced the analog equipment with digital equipment for the weather facsimile network. The other figures are the same as those in Table 3.7 (a).

The total cost for the replacement equipment in Table 3.7 (a) is $280.7K/M and in Table 3.7b (b) is $396.4K/M, whereas the estimated current cost is only $202.9K/M. This represents a $77.8K/M or 40% increase for the analog option and a $193.5K/M or 95% increase for the digital option. The $123.3K/M increase to change the weather fax to digital represents the greatest increase (if analog facsimile is retained, the increase in cost for weather fax equipment is only $7.6K/M).

3.7.2 Increases or changes in Services or Facilities

For a $77.8K/M or 40% increase in equipment cost, the following changes or increases in services or facilities will result:

1. improved information handling capability at UP and Collector/User sites;

2. some back-up capability for alphanumeric equipment at UP and Collector/User sites;

3. photo facsimile at all UP sites ($47.2K/M or 61% of increase);

4. radar facsimile to all UP's and IP's ($22.8K/M or 29% of increase).

The increase of $7.6K/M for the weather facsimile equipment results from changes in costing and will not provide any increase or improvements in services. To change from analog to digital for the weather facsimile would further increase the cost by $115.7K/M to a total monthly cost of $396.4K/M giving a 95% increase in the current cost, with the increase ($123.3K/M) in weather facsimile equipment cost accounting for about 64% of this increase.

4.0 NETWORK OPERATIONS

Two basic aspects of networks operations will be reviewed in this chapter. They are:

1. Operational maintenance, the monitoring of system function, circuit (or the equivalent) status and quality, doing preventative maintenance, diagnostic testing, fault location, repair dispatch, trouble-report response, and so on. Experience in similar networks has indicated a staff of approximately 30 for seven-day-a-week, twenty-four hour a day operations.

2. Functional update, the addition and deletion of users, processors and collectors; rerouting and rescheduling of traffic; network software maintenance, debugging and updating; creation of new application programs for the networks, and so on.

5.0 SYSTEM ASSESSMENT WITH RESPECT TO CRITERIA

5.1 INTRODUCTION

This section of the Phase II Report presents quantiative and qualitative assessments of the Upgrade, Terrestrial and Satellite options. They are assessed and compared on the basis of:

- cost;
- flexibility;
- implementation;
- risk;
- Canadian interests;
- reliability;
- security;
- constraint;
- acceptability.

as well as measures of system utilization and solutions to currently outstanding problems.

The systems have been described in Chapter 2 and the above criteria in the Introduction.

The cost of implementing a new system, from approval for detailed design, to introduction of new equipment in the field, to complete changeover has not been calculated. It is dependent of the duration of the planning and phase-in periods, and the degree of committment.

	CRITERION	UPGRADE	TERRESTRIAL	SATELLITE	ONE-WAY SATELLITE
1.	Cost				
a)	Capital				
	HW - Switching functions - station equipment except for terminals (costed separately)	1327K	3945K	8858K	4020K
b)	Non-recurring				
	SW development		1035K	910K	775K
	Site preparation	650K	-		
	Installation		80K	1100K	326K
		1977K	5060K	10868K	5121K
c)	Recurring				
	Circuit costs	3477K/yr	1345K/yr	81 to 540K	1048 to 1320K
	Maintainance (1 per cent per month of HW)	159K/yr	475K/yr	1063K/yr	482K/yr
		3636K/yr	1820K/yr	1144 to 1603K/yr	1530 to 1802K/yr
2.	Flexibility				
a)	potential to accomodate growth in existing traffic or number of current locations	- little excess capacity - depends on the switch - increments are difficult for fax and imagery - new users can be easily added	- two-fold increase within current capacity, then step increase in cost - increments are difficult for fax and imagery - new users can be added	- large excess capacity - expands very easily via increased data rates and/or circuits - all services can be expanded - new sites can be added easily	- Broadcast channels have large capacity - extra channels easily added - any user with appropriate ground station equipment can receive - message/interactive obtainable by drop on existing circuits - access to central switch through PPN straightforward - addition requires reprogramming of switch
b)	ease of accomodating changes in traffic routing and scheduling	- not as difficult as before - depends on switch - centrally controlled - changes at one location only	- provides regional flexibility - may require inter-regional coordination - changes must be communicated to all switches affected	- centralized control - changes at one location - broadcast mode provides flexibility at local levels	- central switch reprogrammable, downloading of interface program - satellite content easily changed
c)	ability to accomodate new (unknown) services	- accomodated piece-meal by adding to system - internal PY - separate networks - interface problems	- easily accomodated if digital, to limit of excess bit capacity - integrated with other traffic	- new channels easily added - both analog and digital available	- terrestrial network has point-to-point flexibility - satellite can broadcast any traffic
d)	provision for non-AES user access	- flexible CNCP, fax, dial-in	- drop from nearest IP or UP	- user-owned ground station, geographic independence - land-line drop to	- access to central switch through PPN and receive only ground stations or via land-line from nearest ground station

CRITERION	UPGRADE	TERRESTRIAL	SATELLITE	ONE-WAY SATELLITE
3. Implementation				
a) Ease of transition (phase-in)	- circuits easily added - new switch can pick up services one-by-one - change of carrier difficult - pragmatic response to problems	- step-wise, CMC I/F to IP - regional development; IP I/F to UP - run in parallel with existing system until region covered	- step-wise, CMC I/F - can proceed site-by-site, not regionally limited - max. economic benefits - can introduce broadcast (one-way) to start - follow by replacement of most expensive land-lines	- satellite component can be introduced with current system
b) Training requirements	- few	- little, system would appear similar to operators - more digital HW at regions - network control is new	- little, system would appear very similar to operators - introduces RF equipment: on-site tech training required	- little, users of broadcast data would have to learn how to extract relevant data
4. Risk				
a) Potential investment loss	- may not be compatible with long-term goals	- moderate - significant development (IP I/F and UP DTE) required before first operation	- moderate - 'CMC' ground station plus one or two smaller stations required - have re-sale value - service can be demonstrated with existing facilities - possible use of land-lines for interactive use	- as with all-satellite
b) Probability of actually meeting needs within budget costs and estimated times (at RFQ)	- high - depends on AES resources - upgrade cannot meet all requirements perfectly	- moderate - both HW and SW development required - distributed system software is complex	- high - HW can be accurately priced - switching software development required, but much simpler than distributed data network	- accurately budgetable
c) confidence in technical feasibility	- high	- medium	- high	- proven technology
d) effect of errors in traffic estimates	- high for fax, CNCP to I.P.'s - low for U.P.'s and Batch	- low, due to worst case design - IP-UP lines might be increased from 4800 to 9600	- virtually none, system has considerable excess capacity - interactive traffic may result in growth of land line use until carried by satellite channels	- as with all-satellite, terrestrial carries reasonable data load

CRITERION	UPGRADE	TERRESTRIAL	SATELLITE	ONE-WAY SATELLITE
5. Serving of Canadian Interests				
a) shared services and facilities, possibility, impact	- private line service from carrier - sharing effected by carrier	- sharing feasible within backbone - regions limited by capacity, but can be shared to capacity - sharing could lead to development of extended government data network	- sharing of most ground stations essential to economical system - potential government satcom system (AES, MOT, RCMP, DND, etc.)	- large potential for ground station sharing - terrestrial makes maximum use of shared public services
b) potential for "contracting out"	- leased facilities - switch is contracted - design, planning is internal	- high - must contract IP I/F and DTE's	- high	- high
c) Canadian content	- Canadian carrier - US equipment	- Canadian suppliers could provide IF and DTE HW and SW	- Canadian contractor - majority of equipment available through Canadian manufacturers	- high
d) Industrial/government policy	- nil	- Data communications is currently a major Canadian industrial priority (CNCP, TCTS, BNR, Telidon, etc.)	- space communications is currently a major component of Canadian government policy	- matches current carrier/ government priorities
e) Export potential	- nil	- high, for developed system	- high	- high
6. Reliability				
a) Component - redundancy	- two systems: switch and regions - carrier circuits	- computer - like equipment: diagnostic programs, spares	- all receivers and transmitters redundant, auto-switched - 'CMC' switch has hot stand-by - ground stations all to international space standards (Hi-rel)	- satellite components are all high reliability; terrestrial involves highly reliable network
b) Vulnerability to critical failure	- single central switch	- no single critical component - region is "lost" if IP I/F goes down	- central switch - if satellite "lost", whole system goes out (likelihood remote) - dial-up telephone best emergency back-up	- system has central switch but two satellite transmitters
c) Maintainability (see Chapter 4)	- carrier responsibility (adequate)	- special HW/SW requires in-house expertise	- simple - modular equipment - all critical S/W "under one roof"	- equipment is all modular and can be centrally monitored

CRITERION	UPGRADE	TERRESTRIAL	SATELLITE	ONE-WAY SATELLITE
7. Security				
Confinement of information within national boundaries in times of emergency.	- adequate	- adequate	- border spillover problem	- Collection data is "secure", satellite transmission have spill-over problem, unauthorized users could receive broadcast: possibility of encryption
8. Constraints				
a) Regulatory	- interconnection with other carriers is a problem (i.e. (TCTS)	- no problem	- private transmitting systems currently not allowed - availability of single channels not certain	- should be no problem with new receive-only ground station licensing
b) Tariffs	- no constraint	- no constraint - costs porportional to traffic	- "equivalent land-line" charging negates many of satellite's advantages re station locations - costs independent of traffic	- all services could be tariff items
c) Interconnectability DND, NWS, etc.	- no problem	- no problem	- very flexible	- standards employed throughout
9. Acceptability				
a) To AES operational, development and managerial personnel	- moderate - not seen as solving problems - familiar	- moderate - involves changeover from circuit based network to integrated - interactive capability would be most welcome to computer users	- high - could solve many problems	- could satisfy many requirements
b). Need for training	- none	- system understanding requires education - new system procedures must be learned	- system understanding requires education - new system procedures must be learned	- operation very similar to current system - network control function would be new activity if in-house

	CRITERION	UPGRADE	TERRESTRIAL	SATELLITE	ONE-WAY SATELLITE
c)	Perceived as threat or enhancement of work function	- neutral, to hostility because of continued lack of flexibility	- seen as enhanced interactive ability - complexity is apparent - supports regional autonomy	- seen as enhanced collection and dissemination - supports centrality	- enhances image distribution and interactive data base access
d)	Backwards compatible with respect to operations	- yes	- yes	- yes	- yes
e)	Compatibility with personnel capabilities	- yes	- new network management and operation	- new network operation - new technologies (RF)	- yes, see b) above
f)	Compatibility with AES plans (central/regional)		- supports regional diversity, control	- supports central control and user flexibility	- yes
g)	Compatibility with trends in communications, computers and terminals	- no	- yes	- yes	- yes

6.0 INTERPRETATION AND ANALYSIS

6.1 INTRODUCTION

6.1.1 AES Requirements

This interpretation of the characteristics, capabilities, capacities and costs of the various candidate communication systems is based on the following observations about AES current and future communication requirements.

a) Many users of AES data desire access to the same information such as observational data, forecasts, grid point data, charts, radar and satellite photo imagery; implying a requirement for broadcast (point-to-multipoint) transmissions.

b) Much of the AES traffic is routed routinely to fixed destinations, i.e., to fixed addresses; implying the requirement for fixed, or automatically addressed or predetermined circuits.

c) There is a growing requirement for on-demand, interactive and query/response access to stored information, i.e. point-to-point communications.

d) AES services are widely dispersed across the country; implying a requirement for nation-wide communications, often in under-populated areas.

e) AES traffic is currently of two distinct types: short messages and bulk transfers of substantial information content (charts and photos), and they are carried on separate networks.

f) There is a continuing requirement for large-scale computation (modelling) best served by a centralized mainframe computer; and for a number of users who require access to all of the information; implying at least one central data repository, or its replication at a number of locations.

g) There is a desire for storage of relevant infor- mation to support localized processing at the UP's, a requirement that could be easily met by currently available storage devices, but which would create a software development and management problem of substantial magnitude.

6.1.2 Technological Trends

Assessment of the various options is also influenced by the fact that communications technology is developing at a remarkable pace, expecially in the area of data communications. Current trends, aimed towards fruition in the 1990's, indicate an increasing capability to accomodate a variety of digital communications (voice, messages, data and facsimile) in integrated networks providing circuit and packet switching over a mix of transmission media employing both terrestrial and satellite paths.

Developments in communications technology are paralleled by developments in switching equipment, modems and intelligent terminals, together with major acceptance of standardization in interfaces and network protocols. These developments mean that very flexible communication systems may be designed, and steps taken towards their implementation, with the assurance of the compatibility of each component with a future total system.

The study group has concluded that:

- public data networks will become widely available in the next decade; that they will be accessible in an ever increasing number of locations; that they will provide a variety of services, including circuit switching for bulk data and voice, packet switching for interactive traffic and short messages, store and forward messaging and broadcast; and that the internal technology and transmission media will be transparent to the user.

6.2 COMMENTS ON THE OPTIONS

Each of the options is reviewed in the section in terms of its architecture and strenghts and weaknesses relative to the criteria introduced in Chapter 1.

6.2.1 The Upgrade Option

The upgrade option is based on a continued separation of data and facsimile traffic. Leased, dedicated circuits would continue to be used for facsimile distribution, with a move to digital transmission to improve throughput. The message and other data traffic would be carried by an optimal interconnection of all sites to a central message switch, utilizing the nearest, most economical public data communications offerings of the common carriers. It is assumed that a modern, flexible, easily programmed central message switch would be introduced almost immediately. It is also assumed that all computers in the system would be interfaced to public-packet- switched networks through standard protocols (X25). Inter- active access to stored data would be effected through public data communications facilities, in parallel with normal traffic.

This option can be phased-in smoothly, and can provide the service required, provided high enough transmission speeds are used on the collection and dissemination trunks and drops. It is well within the state-of-the-art, although geographically constrained in many ways. It does not differ fundamentally from the present system except for the possibility of widespread access to computer data bases once the machines they are on are interfaced to a public data communications system.

The upgrade option depends on circuit operating costs: it has a large number of dedicated circuits, which are expensive.

Thus, the upgrade option has the advantages of feasibility, ease of phase-in, familiarity, and commercial availability. It involves substantial continuing circuit costs, and requires very close cooperation with the common carrier to ensure optimal utilization of his facilities.

6.2.2 The Integrated Terrestrial System

The proposed terrestrial system is an all-digital system, with digitized facsimile information integrated with message traffic. It consists of a hierarchy of packet-switched and multidrop lines carrying the traffic. It represents the extreme development of a single system capable of satisfying all current and future needs. It has distributed switching, and may be controlled regionally or centrally. It is designed to make efficient use of the transmission media by utilizing available bandwidth and time for the sharing of the network resources among various services. The terrestrial option makes extensive use of public and private packet switching networks. Widespread broadcast operations, which form a large part of AES communications are not compatible with packet switching. They can be carried out, but it is a misuse of the network.

The terrestrial option provides the complete flexibility of a point-to-point network: any piece of data can be sent to any other point. This flexibility results in significant complexity in the programming of the network. The complexity is further increased by the distributed nature of the network: each component can be affected by changes in other parts, although the regional networks can be optimized locally without affecting other regions.

The integration of traffic makes it difficult to significantly alter the traffic volumes on different services, particularly facsimile, without changing many network parameters; each circuit has been optimized vis-a-vis it capacity. The proposed system utilizes high-speed voice-frequency data rates on the regional networks (9600 b/s). Increases, to say 19,200 b/s, on these circuits would be difficult to obtain.

Thus, the integrated terrestrial option provides great flexibility in the routing of traffic, carries all traffic on the same facilities and allows regional optimization but does so at the expense of a high degree of complexity and a limit on ultimate growth capacity.

To phase-in an integrated network involves the development of packet-switching nodes and user processor data terminal interfaces, and digitization of chart and photo imagery facsimile. It could be installed on a region-by-region basis, but during implementation both old and new systems would have to be maintained.

6.2.3 The Satellite Option

The all satellite option maintains separate circuits for each service; incorporates broadcast channels for commonly used information that can be received anywhere in the country; maintains a central switching capability; could be used to maintain regional or user data bases in a current state; provides a unique circuit to and from each site (that could easily handle voice); but requires satellite ground terminal equipment at each site and could be severely hampered by current regulatory constraints.

The satellite option provides flexibility and growth potential at low cost. Extra channels can be added with little marginal cost. The separation of services means that changes can be made to any one of them without affecting the others. Intelligence at the receiving sites allows every user to extract as much or as little of the total AES data base as is desired, for on-site processing or display.

The major drawback to the all-satellite option (provided that permission to transmit to the satellite from all the Collectors, Users, and Processors could ever be obtained) is the cost of so many ground stations. Obviously, the possibilities of shared ground station use would have to be seriously considered. Also, the geographical distribution of stations would come into play: many sites are close together and not all would require their own ground terminals.

The satellite system could be phased-in simply. The system would be in operation as soon as information was transmitted and received, e.g. observation data could be transmitted to a satellite port on the central switch and the land-line to that site removed; or chart facsimile could be broadcast and the fax circuit to the receiving site discontinued.

There is virtually no new technology in the satellite proposal, operations would be very similar to the current modes, and future needs for more (radar) imagery would be easily accommodated. Interactive, on-demand data base access and time-shared computing could be handled by the proposed system or by interactive digital satellite systems under development (e.g., Slim TDMA), or by public data communication offerings.

It is, however, extremely unlikely that permission for all sites to own transmitters would ever be granted, especially in a shared-transponder SCPC environment. Transmitters for broadcast and remote collectors are eminently possible though. Thus, shared services (provided by GTA perhaps) or common carrier offerings would have to be employed to achieve an all-satellite option. It is not at all clear that significant reductions in circuit costs would result if the satellite option were provided by a common carrier.

The all-satellite option has a certain basic simplicity about it in addition to its capacity for growth. All communications are to and from a single central location, so that network monitoring and control are carried on from one responsibility centre. Likewise, routing changes and network switching software are carried out by one group at one point. Additions and deletions are treated similarly. The independence of channels and services means each can be modified or repaired without interference to the others. The multidrop collection circuits and user mini-channels are handled by a multiport asynchronous TTY peripheral on the central computer: well developed technology, and the essense of simplicity to program. New users need "only" put up an antenna to join the network, whereever they are located.

6.2.4 One-Way Satellite Broadcast

The one-way satellite broadcast option is a communication system which uses the natural strengths of both modern data communications and satellite communications. In this option, all information required by most users is broadcast, digital information and fax on separate channels; collection and inter-regional traffic is carried (as well as possible) on the public packet-switched network and multidrop lines from the UP's.

The proposal in Section 2.4 is extreme in the sense that it assumes a receive-only ground station for each fax user (IP's and UP's) rather than an optimal mix of ground stations and local distribution networks.

It is more than likely that receive-only ground stations for this application would be licensed without trouble. Their introduction could be used to roll-up long-haul facsimile circuits. It would be reasonable to investigate alternate, satellite, data collection from very remote sites as well.

The connection of all UP's, IP's and MP's to a public packet network provides the potential of point-to-point inter- active, query/response, and message traffic.

In the proposal for this hybrid system it is assumed that a single centralized message switch is retained: to feed information to the satellite transmitters and to the modelling processor at CMC, and to simplify network monitoring and control. This does not preclude local data base information at IP's or UP's, in fact, they are included in the costing.

6.3 COMPARISONS OF THE SYSTEMS

In this Section, the options are compared to one another in terms of the requirements and criteria, and appropriate conclusions are drawn.

6.3.1 Services to AES Sites

Collector and User sites are the most numerous (155 and 148) and most remote, with peak throughput requirements of approximately 50 b/s (point-to-point) and 300 b/s (broadcast). These sites can be served well and economically by very low cost earth terminals, and somewhat less well by low speed terrestrial circuits. They are not suited to the one-way satellite approach because they have no need for broadcast information, but do require satellite communications for their data transmissions.

User Processor sites are numerous (72); are situated in small cities, typically near airports, and have peak source and sink throughput requirements as follows:

source (point-to-point)	sink (broadcast)	comments
1000 b/s	4000 b/s	utilizing IP data base
50 b/s	4500 b/s	accessing local data base

The expensive hardware at the UP's should be minimized because there are a large number of these locations (72); they currently have little or no processing H/W and few technical personnel; and communication between UP's and IP's is becoming more economical with packet switching. Thus, access to remote data is generally an economical alternative to storing the data locally. This is true for approximately 60% of the UP's. It would be necessary to consider each UP in detail to determine whether local storage would be used there or not.

UP sites with remote data access can use the public packet-switched network to provide (source) collection data and access to the IP's data base. For input (sink) of charts and imagery the UP's are suited to use of a one-way broadcast network via satellite. This approach minimizes circuit costs and manpower requirements as it is simple and virtually maintanance-free. The interface to the public data network should initially be very simple, both to minimize costs and to ensure the operability of the system.

Intermediate Processor sites are small in number (13); are situated in major cities; and have peak source and sink throughput requirements of 4500 b/s (50 b/s point-to-point plus 4350 b/s broadcast) and 5500 b/s (broadcast). These sites are most suited to a terrestrial system because they are located in primary public data network serving areas. For communication with the UP's, the IP's should be interfaced to the public packet-switched network. This also provides them the means for relaying observations traffic that they have collected. The IP's should receive all broadcast traffic via the one-way satellite network, if one were in place.

The Major Processor sites are few (2), and located in major metropolitan areas (Montreal and Toronto). The peak source and sink throughput requirements are approximately 20,000 b/s (broadcast) and 20,000 b/s (800 b/s point-to-point and 1200 b/s broadcast) for CMC plus 20,000 b/s (broadcast) and 10,000 b/s (broadcast) for AES HQ. These sites are well situated for the use of the public data networks for point-to-point traffic and the use of the one-way satellite network for broadcast.

The study group has concluded that:

- Collector and User sites should be served by two-way, narrow-band satellite communications.

- processing and switching hardware at UP sites should be minimized, and that the UP interfaces to the communications network should be as simple as possible.

- UP and IP sites are suited to the reception of common traffic via a broadcast mode.

- Inter-regional point-to-point traffic should be carried on the public data neworks, especially on the public packet-switched networks.

- the MP and IP processors should be interfaced to the public packet networks and that internationally recognized packet switching protocols (X.25) should be adopted as standards.

6.3.2 Cost

The costs, as summarized in Section 2.5.1 and in Chapter 5, indicate clearly that, if the system is to be improved at all, some money must be spent. They also show that substantial savings may be realized on operating costs by the investment of capital in new systems. It would appear that for this reason alone, new approaches to the AES communication requirements should be initiated.

During the study it has become apparent that there are a number of factors that can contribute to the economy of the chosen system. For example, it is far more economical to move data across Canada on the East-West axis, i.e., inter-regionally between major urban centres, than it is to move it intra-regionally in rural areas. This is a result of the demography of the country: there is a much greater volume of flow in that direction and the public data networks are organized accordingly. The conclusion that may be drawn from this observation is that it is cost effective to route regional traffic laterally across the country to a central broadcast site, rather than distributing it on regional leased circuits.

Another fact that has emerged from the study is that a major portion of the operating costs of the current AES communications system is created by the extensive use of leased lines; this regional circuitry should therefore be minimized.

There are so many Users and Collectors that any large expenditures on each of them results in a very large overall cost; therefore it is necessary to keep the costs of the equipment at these sites low. The number of User Processors is also fairly large so that a similar observation can be made about the equipment supplied to them.

The all-satellite system is much more expensive than the others. This is because of the assumption that every single site has a transmit-receive earth station purchased for it. If satellite communications were to be used, a very careful look would have to be taken at each site to determine whether or not it really required its own earth station.

The integrated terrestrial and the one-way satellite options cost roughly the same amount of money, as far as the components included in the cost estimates are concerned. The differences, and they would manifest themselves in very real dollars if the systems were to be implemented, lie in the costs of system design, operation and control;and particularly in software costs. The one-way satellite system is much simpler than the integrated terrestrial network, and that would be reflected in initial and recurring costs.

The study group has concluded that:

- the use of leased circuits should be minimized;
- leasing terminal equipment is expensive;
- common traffic (observations, forecasts, grid point data, charts, satellite photo and radar imagery) be routed to one, or more, central broadcasting sites, and broadcast from there to all users who require this information or any part of it;
- it is necessary to have detailed information about the particular situation at each site regarding access to public communications facilities, the potential for shared services, specific traffic requirements, layout and accomodations, power, and other factors affecting the optimization of communications to that site.

6.3.3 Flexibility

The upgrade option is the least flexible because it is designed as an extension of the present system. Experience has shown AES that the present system has been inflexible in the sense that its basic structure could not accomodate new services such as interactive computer access nor could it expand to accomodate increases in traffic. Its inflexibility alone might be cause enough to reject it although there are several other reasons.

The two satellite options are most capable of accomodating new services and procedures, changes in traffic routing and scheduling, growth in traffic and the addition of new users including those far from access to normal communication facilities. These options must be seriously considered from the point of view of flexibility.

All of the systems can provide access for non-AES users, but in different ways. The upgrade can provide access to the central message switch, or a drop on a facsimile circuit, as at present. The only difference would be that access to the message switch would be through the public packet network, rather than a leased line. The cost implications to the user would depend on the extent of the switch's serving area, a point that is not clear at this time. In the satellite options, access could be gained to the broadcast data by the acquisition of a ground station, or a land-line link to one. AES could provide standard terminal software for the extraction of required information from the broadcast message streams and interactive operation through the public data network in the one-way satellite system or the satellite mini-carriers in the all-satellite system.

Non-AES users would have to be provided with either software or very explicit instructions for access to the nearest data base or facsimile port in the terrestrial system. Users of this system would probably be required to acquire an interface that could be connected to the nearest UP DTE or IP DIF.

Access is simplest for the user who is capable of installing a satellite ground terminal in the satellite system, and who would be supplied with AES software to acquire the information he desires. One of the reasons is that each user is dealing directly with a single data base that contains all of the information, whereas any particular local data base in a distributed system may not.

The study group has concluded that:

- present operational procedures, especially for the distribution of facsimile, are not a good basis for comparison of the systems because they are based on characteristics of the present system;

- the simplicity of the architecture of the future system is an important criterion in its own right.

- satellite communications offers the greatest flexibility.

- non-AES users could be served best by access to a single data base.

- flexibility of the new system can be maximized if AES is not dependent on a single common carrier or telecommunications supplier and can take advantage of competition in geographical coverage, tariffs and service offerings.

6.3.4 Implementation

The one-way satellite option is the most favourable in terms of phase-in because it would create a minimum disturbance of current operations and is compatible with current traffic patterns, and because of the quick return that can be realized on initial capital investments. The initial steps of implementation of this system (collection of facsimile and photo signals at a single point, and acquisition of the earth stations) can easily be contracted out and done in parallel with ongoing operations. On the other hand, the integrated terrestrial system, with its three-tiered hierarcy is the most complex and requires the largest initial investment.

The study group has concluded that:

- the one-way satellite option is the most favourable, of those described, in terms of implementation.

6.3.5 Risk

There are two aspects to the risk involved in the initial investment in a new system. The first is whether initial acquisitions will be applicable to future systems, and the second is whether initial acquisitions will ever be used at all. In the first sense, the Upgrade could be risky. It solves only the problems identified today, and its adoption could lead to an endless series of ad hoc upgrades, each designed to solve one more current problem. The integrated terrestrial system is also risky, in the second sense. It depends on a number of different state-of-the-art technologies, and it is a complex network of a hierarchy of sub-networks with distributed switching; both facts adding to the risk of successfully developing it. As well, the integrated system, based as it is on packet switching, is not really compatible with the multi-destination message/fax traffic that makes up the bulk of AES communications. This in turn would increase the risk associated with the terrestrial option because the network would be being programmed to accomplish communications that are not consistent with its natural strengths.

The two-way satellite system provides certain services as soon as two ground stations are implemented and interfaced to the data base and the message switch. However, propagation delays of one-half second will always limit the use of satellite communications for very rapid response interactive traffic. As well, it is not clear just how the IP computers would be interfaced to the CMC computer or to each other in the all-satellite network, so that there is some risk in not being able to accomplish all of the requirements well with this network, in particular a requirement that has been predicted to become more important as time goes on.

The one-way satellite system, providing interactive and query/response communications through a public packet network, avoids the risk involved in accomplishing it through the satellite; and yet this option makes full use of low risk satellite broadcast: a fully developed technology.

The terrestrial system is vulnerable to changes or errors in estimation of the volume of traffic because it was designed to make optimum use of the time and bandwidth available in each part of the system. The satellite options can easily expand (or contract) as the traffic demands and are not as jeopardized by planning errors as are the purely terrestrial systems. The one-way satellite option is the least threatened because it has the capacity of the satellite broadcast for the multi-destination bulk traffic (including CMC to IP processor dumps) and the public data network to carry the bursty message and interactive point-to point traffic.

The study group has concluded that:

- the one-way satellite option has the lowest risk,of those described, involved with its implementation.

6.3.6 Canadian Interests

The upgrade, terrestrial and one-way satellite options all make use of shared public facilities in one way or another. The all-satellite option would require the use of shared earth station facilities in many locations to make it economically feasible. There is a large potential for sharing satellite services through Telesat, GTA, DND, MOT, RCMP, CBC and cable TV systems. Thus, adoption of satelite communication components in a future AES communication system could enhance the demand for, the quality of, and perhaps the very provision of high quality, reliable communications to many locations in Canada.

Contracting out to Canadian industry is possible for all systems, the degree depending on the AES/contractor interface, i.e., on the extent of internal AES communications planning, design and specification. Options, such as the satellite system, with separate services are more easily implemented and operated under external contract than the integrated systems.

Canadian export sales in data and satellite communications equipment are already large; but, an innovative AES initiative utilizing both could significantly enhance exports by providing a domestic market that supports development and production and, more important, provides a domestic endorsement of the Canadian technology.

There are a number of areas in which new product development could be supported during the implementation of a new AES communication system. For example, a 9600 b/s data-stream decoder; encryption/decryption equipment for broadcast data and charts; new compression hardware for chart and photo scanners (the Alden DIFAX scanner is overpriced by at least $20,000 because of the archaic compression and addressing logic in it); local UP data bases; the automatic direct convesion of AES products to videotex format, and so on.

Considering current Canadian "high technology" priorities, a satellite system, co-ordinated with optimal use of public data networks, should receive enthusiastic support from both government and industry.

The study group has concluded that:

- a satellite communications system, augmented by the optimal use of the public data networks, best satisfies Canadian interests.

6.3.7 Reliability

Reliability is inversely porportional to complexity; the simpler a system, both in architecture and construction, the fewer components and interfaces in it, the more reliable it is. It is also true that while digital hardware is much more reliable than analog, it is computer peripherals like disks, memories and terminals that tend to be unreliable. In addition, a major source of unreliability is software, particularly that operating in a complex interrupt-driven enviroment. Thus, the terrestrial option, with distributed switching and extensive, geographically disbursed computer hardware, would be the least reliable. On the other hand it has the advantage of distributed systems that a failure in any part of it does not affect the entire system but only the region or area in which the fault occurred. It also has the advantage of substantial use of the public data networks which are maintained to a very high degree of reliability by the carriers.

The satellite options are totally dependent on the satellite of course; if it goes, everything goes. This is obviously a matter of grave concern to the satellite owner and is one which is taken care of with the use of spare satellites, spare transponders and redundant equipment. It should be noted that the one-way satellite option has a messaging capability to all sites via the reliable public data networks and ancillary terrestrial circuits, which can be used in an emergency should the satellite transponder fail.

Questions of redundancy, specifications, alternate routing, maintainance procedures, software specification production and distribution methods, and other factors affecting reliability should be carefully considered as a part of future planning.

It has been implicitly assumed in all of the options that a central Network Control Centre would be part of each. It has been assumed that network status would be monitored from this centre. This centre has also been assumed to be responsible for continuous diagnostic preventative maintainance. Most, if not all, of the equipment in the system should be capable of remote monitoring and automated fault diagnosis, and much of it should contain remotely activated redundant components.

In terms of simplicity, central monitoring, and back-up routing the one-way satellite option should be the most reliable; but even it has an unnecessary level of complexity in the attachment of User/Collector multidrop circuits to the UP's, rather than directly to the public data network.

The study group has concluded that:

- the new communications system should be as simple as possible, centrally monitored, make maximum use of the public data networks, utilize redundant equipment where appropriate, incorporate remote diagnostics, and otherwise be designed to ensure reliability and the ease of maintainance.

6.3.8 Security

The only security problem arises in the satellite options. In view of the acceptance of the security of current systems, it seems reasonable to assume that the use of the developing commercial data encryption standards should suffice to ensure acceptability of satellite broadcast. It is a reasonably simple matter to introduce encryption in digital links; if security were an over-riding consideration it could hasten the move to digital facsimile. In a related matter, it has been suggested that public/ private key encryption could be used as the addressing method on broadcast networks: if a receiver can decode a broadcast it is meant to be received at that site.

The study group has concluded that:

- all traffic in the new system should be in digital form.

6.3.9 Constraints

The all-satellite option is severely constrained by current restriction on the ownership of private transmitters. The one-way receive only satellite earth stations(the acronym for which is ROSES?)should be licensed without much problem. However, placing earth stations at remote sites to receive charts, photos and broadcast messages will not be economical if the service ends up being charged for as through it were being provided by a leased land-line, which is the present situation.

It is imperative that AES be familiar with the telecommunications regulatory situation and that they be in a position to present their requests for changes to the licensing regulations. They must also maintain an awareness of the tariffs of the common carriers and be in a position to intervene on behalf of their own interests during tariff applications.

AES must establish a mechanism for liason with the appropriate regulatory bodies, and with the common carriers.

The study group has concluded that:

- a knowledge of telecommunications regulations and the activities of the regulatory agencies is essential for the planning and implementation of a new system.

- a knowledge of data communications standards and protocols, and of developments in these areas, is essential for the planning and implementation of a new system.

6.3.10 Acceptability

All of the systems described in this report will provide improved operational capability for the meteorological service with few overt changes in operational procedures or terminal equipment and hence should be acceptable, and in fact welcome.

There will be an increased involvement in telecommunications on the part of AES if any of the options described or modifications thereof are adopted. Some parts of the organization will be working in new areas of network planning, design, specification, procurement, installation and operation. There will also be a requirement to work on the modification of those current operational procedures that have resulted from limitations in the present communications facilities and not because of meteorological necessity. The new system will require some adjustments in operational procedures for its efficient operation, but it should be stressed that these would be minimal and introduced only when it is clear that the entire function of the service is enhanced.

The one-way satellite option provides widespread access to the public data networks and, by broadcast, to virtually the entire AES database. If the capability to handle this flexibility is well planned, properly developed and managed a new communication system, based on satellite broadcast and the use of public data network for collection, messaging, and interactive traffic, should be viewed by users as a major advance in meterological services.

The study group has concluded that:

- AES requirements would best be met by a communications system that provides for AES control over its operations.

- a new communications system based on satellite communications and the use of the public data networks would be acceptable to the AES and to non-AES users.

6.4 SUMMARY

The upgrade candidate is an obvious extension of the present system, designed to handle the AES present and immediate new communication requirements but it is expensive, inefficient, inflexible and limited in growth potential. If this option were to be adopted, future changes in AES requirements would necessitate a continual review of system design and implementation. This option is not suitable as an interim solution because it could not evolve into any of the other systems, easily or cost effectively.

The study group has concluded that:

- upgrading the present system would not lead to a future system that would be suitable for AES requirements.

The Terrestrial system is a state-of-the-art approach to satisfying requirements with a completely terrestrial system.

It is a cost effective and flexible approach, but is most compatible with point-to-point traffic, whereas a great deal of the AES traffic is broadcast (point-to-multi- point). The system has been designed to accomodate substantial increases in throughput, as described in the traffic requirements; however, increases in broadcast traffic, especially of image origin, could be severely limited by the lack of growth potential in this system.

The system would require the maximum manpower to operate due to its sophistication.

The study group has concluded that:

- an integrated terrestrial communications network is not appropriate as a future system.

The all-satellite option is attractive as a goal because it provides growth, flexibility and low operating cost. It is expensive in terms of hardware and software costs; and it is currently the option of highest risk to AES because of the regulatory constraints on private transmitters; distance sensitive tariffing (which negates the geographical indifference of the technology); uncertainty regarding site preparation, frequency co-ordination, licensing procedures; and need for the development of interactive access protocols.

The study group has concluded that:

- the all-satellite system is not a realistic option to adopt as a future system.

The one-way satellite broadcast option is the basis for an excellent compromise between the terrestrial and the all-satellite approaches, because it utilizes the strengths of each and minimizes the risks. This system is amenable to upgrading to an improved satellite system at some time in the future. The one-way system provides low operating costs for fax distribution, minimal maintainance (but with central monitoring), is affordable, and is compatible with current operating procedures. The system is simple in concept, modular in design, and would be the easiest of the new systems to phase-in.

The study group has concluded that:

- the one-way satellite broadcast option is suitable to be used as the basis for planning of a future AES communication system.

6.5 SUMMARY OF PHASE II CONCLUSIONS

The study group has concluded that:

- public data networks will become widely available in the next decade; that they will be accessible in an ever increasing number of locations; that they will provide a variety of services, including circuit switching for bulk data and voice, packet switching for interactive traffic and short messages, store and forward messaging and broadcast; and that the internal technology and transmission media will be transparent to the user.

The study group has concluded that:

- Collector and User sites should be served by two-way, narrow-band satellite communications.

The study group has concluded that:

- processing and switching hardware at UP sites should be minimized, and that the UP interfaces to the communications network should be as simple as possible.

The study group has concluded that:

- UP and IP sites are suited to the reception of common traffic via a broadcast mode.

The study group has concluded that:

- inter-regional point-to-point traffic should be carried on the public data networks, especially on the public packet-switched networks. They conclude, further, that the MP and IP computers should be interfaced to the public data networks and that internationally recognized packet switching protocols (X.25) should be adopted as the standard.

The study group has concluded that:

- the use of leased circuits should be minimized.

The study group has concluded that:

- leasing terminal equipment is expensive.

The study group has concluded that:

- common traffic (observations, forecasts, grid point data, charts and satellite photo and radar imagery) be routed to one, or more, central broadcasting sites, and broadcast from there to all users who require this information or any part of it.

The study group has concluded that:

- it is necessary to have detailed information about the particular situation at each site regarding access to public communication facilities, the potential of shared services, specific information requirements, layout and accomodations, power, and other factors affecting the optimization of communications to that site.

The study group has concluded that:

- present operational procedures, especially for the distribution of facsimile, are not a good basis for comparison of the systems because they are based on characteristics of the present system.

The study group has concluded that:

- the simplicity of the architecture of the future system is an important criterion.

The study group has concluded that:

- satellite communications offers the greatest flexibility.

The study group has concluded that:

- non-AES users could be served best by access to a single data base.

The study group has concluded that:

- flexibility of the new system can be maximized if AES is not dependent on a single common carrier or telecommunications supplier and can take advantage of competition in geographical coverage, tariffs and service offerings.

The study group has concluded that:

- the one-way satellite option is the most favourable, of those described, in terms of implementation.

The study group has concluded that:

- the one-way satellite option has the lowest risk, of those described, involved with its implementation.

The study group has concluded that:

- a satellite communications system, augmented by the optimal use of public data networks, best satisfies Canadian interests.

The study group has concluded that:

- the new communications system should be as simple as possible, centrally monitored, make maximum use of public data networks, utilize redundant equipment where appropriate, incorporate remote diagnostics, and otherwise be designed to ensure reliability and ease of maintainance.

The study group has concluded that:

- all traffic should be in a digital form, and that the system should be a digital communications system.

The study group has concluded that:

- a knowledge of telecommunications regulations and of the plans and activities of the regulatory agencies is essential for the planning and implementation of the new system.

The study group has concluded that:

- a knowledge of data communications standards and protocols and of developments in these areas is essential for the planning and implementation of the new system.

The study group has concluded that:

- AES requirements would best be met by a communications system that allows AES control over its operation.

The study group has concluded that:

- a new communications system based on satellite communications and the use of the public data networks would be acceptable to the AES and to non-AES users.

The study group has concluded that:

- upgrading the present system would not lead to a future system that would be suitable for AES requirements.

The study group has concluded that:

- an integrated terrestrial communications network is not appropriate as a future system.

The study group has concluded that:

- the all-satellite communication system is not a realistic option to be adopted as a future system.

The study group has concluded that:

- the one-way satellite broadcast option is suitable to be used as the basis for planning of a future AES communication system.

7.0 CONCLUSION

The key conclusion reached by the study group is that a single approach to the specification of a new communication system for the Atmospheric Enviroment Service is not reasonable.

This is not an unexpected result. The upgrade option would modernize the components of an old system that was never designed to accomodate many of the current demands, either in kind or in volume. The integrated terrestrial option is an example of the ultimate in communications efficiency, but it is not compatible with a large portion of the traffic and it is much too complicated for an organization like AES to own and operate. The all-satellite option might appear as a utopian goal with all of its advantages but it is restricted by regulations, and in many locations it would not make sense to use a satellite ground terminal if adequate terrestrial services were available.

The one-way satellite broadcast system is one example of a system in which network characteristics are matched to different traffic types. However, it does not minimize the leased circuits linking the Collectors and Users to the UP's and it requires switching equipment at the UP's to handle the polled multidrop lines to the Collectors and Users. Thus, it too has been rejected as a future system; but, it does indicate the goal towards which AES should strive.

While fully recognizing that communications technology is changing rapidly and that the very nature of facilities available fifteen years from now cannot be predicted with any degree of accuracy, consideration of the analyses and conclusions has led the study group to propose that:

<u>AES establish, as a goal, the implementation of a communications system which is an optimal mix of satellite communications and public data networks.</u>

The study group has identified the current optimal mix as:

- the introduction of satellite broadcast, and interconnection of MP's and IP's via public packet networks, in two years; and

- the introduction of two-way satellite communications to Collectors and Users, and the direct connection of UP's to the public data network, in three to five years.

It is difficult to predict what the optimal mix will be beyond five to ten years because of advances in technology and changes in requirements.

To re-cap, the rationale for the proposal of a satellite broadcast/terrestrial data network is based on economics, control and the fulfillment of other criteria.

The system is economic because it eliminates expensive leased circuits, has no sophisticated processing hardware at the UP's that would require software and personnel support, and makes best use of favourable common carrier tariffs.

The sytem is designed to provide AES control over operations.

The system is simple in concept. It is compatible with traffic types, with geographical distribution of sites, and technological trends.

The risk associated with this goal is low. Initial investments are modest and there is a high probability that they will be useful regardless of the future direction in which the system develops.

The reliability of the system and of the information it carries will be high.

The goal can be achieved with the full participation of Canadian industry.

...and most important of all,

the system can be designed,

and built,

and,

IT WILL DO THE JOB.

APPENDIX A

1.0 REQUIREMENTS

After presenting generalized nodal and traffic classifications and a summary of negative characteristics of today's networks operations, key service requirements are stated for three temporal classifications; today's services, immediate new services, and long-term future services. The latter two classes have been arranged in order of AES priority as determined by a survey of the members of the AES Communications Study Review Panel during the course of the study. Generalized traffic figures are presented for today's services and estimates of increases in traffic resulting from immediate new services are also outlined. Because of the intended use of this information, the traffic values presented will be higher than similar values contained in the Traffic Study Parameter Report of the Phase I Report. Wherever possible comparative values will be cited.

No attempt is made to combine the traffic of the various components as their interaction with each other will likely depend on how a communications sytem to carry this information is implemented.

2.0 HIERARCHY

The AES network nodes can be classified into the following five hierarchical levels in descending order of hierarchy:

Name	Example	Criteria
Major Processor (MP)	CMC, Downsview, NWS	Large volumes, National Traffic
Intermediate Processors (IP)	Regional Weather Centres DND forecast Offices Ice Central	Regional type traffic and level of processing. Lower traffic volumes
User Processors (UP)	WO4's, DND Wx Offices Private users requiring alpha-numeric and graphics	Any user node requiring graphics and alphanumeric data, possibly some additional proces-sing done. Restricted area of coverage.
Users (U)	WS, WS1, FSS	Any node requiring alphanumeric infor-mation only. Restricted area of coverage.
Collectors (C)	WS2, DOT, DND obs sites	Nodes characterized by small volume, alphanumeric input to the system only.

In addition, there are special nodes, such as radar sites, satellite receiving stations, Training Branch, which require special attention.

3.0 PRINCIPAL TRAFFIC COMPONENTS

AES traffic can be broadly classified into five components.

3.1 MESSAGE TRAFFIC

This includes most of the traffic currently carried on the AES Teletype Network and the off-network. This traffic is characterized by:

- delivery time requirements within 30 minutes in general, within five minutes for warnings and special observations;
- multipoint distribution;
- (relatively) short length; and
- direct human interpretability.

3.2 BATCH TRAFFIC

This is mainly numeric data transferred between computers in relatively large volumes. This traffic is characterized by:

- delivery time requirements within 30 minutes;
- numeric or machine readable code; and
- computer to computer communications.

3.3 INTERACTIVE TRAFFIC

This is traffic resulting from real time interaction with a remote computer or data base. This traffic is characterized by:

- delivery times within 10 seconds;
- 1-80 character inquiry traffic; and
- 1 to 100 line responses

3.4 CHART TRAFFIC

This is traffic resulting from the transmission of weather maps or charts. This traffic is characterized by:

- delivery times of 10 minutes;
- line oriented, black and white information; and
- subject to higher compression ratios than imagery (see below) for digital transmission using such techniques as vector coding.

3.5 IMAGERY

This is traffic resulting from the transmission of Satellite and Radar imagery.

3.5.1 Satellite Imagery

Characterized by:

- delivery times of 10 minutes;
- grey scale (or colour) pixel information; and
- national or regional distribution.

3.5.2 Radar Imagery

Characterized by:

- delivery times of less than 5 minutes;
- grey scale (or colour) pixel information; and
- regional or local distribution.

4.0 NEGATIVE CHARACTERISTICS OF TODAY'S NETWORK OPERATIONS

The following lists were compiled from information contained in the Phase I Report from notes prepared by Weather Centre (IP) managers, as well as from information gathered from other sources. Only the information from the Phase I Report has been referenced. The negative or undesirable manifestations and implications are presented; it is hoped that the positive or desirable attributes are self-evident and need not be enumerated here.

4.1 TELETYPE NETWORK

4.1.1 Performance

CHARACTERISTICS	PHASE I REPORT REFERENCES	MANIFESTATIONS/IMPLICATIONS
Low speed	4.4.1.2 Page 4-12	1. Overloading of circuits.
		2. Excessive delays in message delivery.
Lack of selectivity or addressing	4.5.2.2 Page 4-18	1. Lack of security.
		2. Excessive paper consumption.
		3. Excessive effort for manual sorting, storing and retrieving of information.
Inadequate request/reply capability	4.5.2.2 Page 4-19	1. Excessive delays in obtaining missing traffic or traffic not regularly scheduled.
		2. Cannot restore a local data base if loss of data is due to local failures.
		3. Does not allow effective interaction between offices in their information production & dissemination functions (e.g. interaction between UP's and IP's).
Inadequate priority or priority handling		
No input priority		1. Excessive delays in inputing urgent messages such as weather warnings while other less urgent messages are being distributed and input.
Inadequate output priority		1. Only two levels of priority for the distribution of traffic and these priority levels are time and circuit independent. This means that an urgent message for one circuit if distributed to another will carry the same high priority and this priority will not decrease with time resulting in possible delays in the collection and distribution of more urgent messages on the latter circuit.
First-in, First-out within a given priority		1. After circuit outages or other problems resulting in long queues, this feature causes excessive delays for more recent messages unless old messages are dumped.
Inadequate Quality Control		
Content		1. Increased errors, both instrument and human errors, in meteorological messages.
Communications		1. Increased BER (without error correction)

	CHARACTERISTICS	PHASE I REPORT REFERENCES	MANIFESTATIONS/IMPLICATIONS
	Half-Duplex Operation		1. Less effective
			2. Increased input and output delays (similar to low speed lines).
	Lack of Hierarchy		1. Lines serving all levels of offices are nearly the same speed (although CMC has 2 600 baud lines, one of the overhead circuits is 300 baud and the Toronto-suitland link is 2400 baud, all others are 110 baud), this does not reflect the hierarchical nature of the AES operation with differing data needs at each level.
	Polled Multi-drop Circuits		1. Possible decrease in throughput because of continuous polling of all stations in a pre-determined sequence regardless of amount of input at a given time.
	Reliability or Redundancy	4.5.2.2 page 4-18	1. Centralized switching is vulnerable to breakdown of central switch and of the communications channels to the central switching facilities.
	Insufficient Real-Time Control of Switching System		1. Extremely difficult to change the distribution and priority on a circuit by circuit basis in real time causing possible delays in more recent and possibly more useful information.
4.1.2	Adaptiveness		
	Low Speed		1. Cannot effectively handle increased traffic.
	Lack of Adequate Higher Speed Computer Ports		1. Cannot effectively increase line speed to handle increased traffic to certain centres.
	Inflexible Interfaces		1. Does not permit easy interconnection with other networks. For example, no dial-up facilities, except through AES computing centres or by manual relay at input sites, causing increased delays and error rates.
			2. No alternative routing to handle overloads causing increased delays.
	Inadequate System Monitoring		1. Only limited systems performance statistics available and only one circuit can be monitored for loading, at a time. This makes it very difficult to evaluate system performance and changing user needs.
			2. No effective method of tracing a message through the system.

	CHARACTERISTICS	PHASE I REPORT REFERENCES	MANIFESTATIONS/IMPLICATIONS
4.2	PAPER OR WEATHER FACSIMILE		
4.2.1	Performance		
	Spine Structure for National Distribution with Broadcast Mode	4.4.2.1 Page 4-14	1. Overloading of circuit because a chart needed by one region or office will take up transmission time on the entire circuit-lack of user control.
			2. Selection of charts must be based on a schedule; unreliable.
	Analogue Mode of Operation		1. Difficulty in maintaining line and equipment quality results in poor quality charts which in turn necessitates retransmissions and further loading on the circuit.
			2. Relatively slow and poor in quality compared to digital facsimile.
			3. Lack of effective chart selection mechanism (by schedule only).
	Inefficient Request/Reply		1. Difficult to get repeats because of overloading.
4.2.2	Adaptiveness		
	National and Regional Structure	4.2.2 Page 4-4, 4-5	1. Difficult to transmit charts from one region to another except in Western Canada.
	Broadcast Mode of Operation	4.4.2.1 Page 4-14	1. Difficult to satisfy needs of particular users because of system-wide implications.
4.3	PHOTO FACSIMILE		
4.3.1	Performance		
	Multi-drop Star Network with Broadcast	4.4.2.1 Page 4-14	1. All station on a particular leg must accept information transmitted on that leg-lack of user control.
			2. Selection by schedule only-unreliable.
	Analogue Mode of Operation		1. Difficulty in maintaining line and equipment quality results in poor photographs.
			2. Lack of effective chart selection mechanism (by schedule only).
	Ineffective Request/Reply	4.5.2.2 Page 4-20	1. Difficult to get repeat of charts specifically tailored to a particular user's needs.

	CHARACTERISTICS	PHASE I REPORT REFERENCES	MANIFESTATIONS/IMPLICATIONS
4.3	OFF-NETWORK		
4.3.1	Performance		
	Reliance on Radio for Alphanumeric Data	Page 4-21	1. Reliance on manual relay of traffic results in errors and delays-unreliable
	Reliance on Dial-up Public Facilities	Page 4-21	1. Unreliable-must contend with other users for service.
			2. Inconsistency in quality of lines.
			3. Manual relays, if applicable, introduces delays and errors.
	Reliance on Radio for Analogue Facsimile		1. Poor quality because of atmospheric and other interference.
4.4	ADAPTIVENESS		
	Special Purpose Facilities		1. Difficult to inter-connect to other facilities.

5.0 KEY SERVICES OF TODAY

5.1 MESSAGE INFORMATION

Although message traffic is highly complex due to the many types of messages carried, the key message traffic can be identified by looking at the primary message output by classes of nodes.

For the purpose of this analyses, message information includes all observational data such as SA's, SM's, UA's, UF's, etc., either singly or in the form of bulletins; forecast information such as FP's, FA's, FT's, FX's, etc. Strictly speaking, hourly weather bulletins from CMC are observational data, but in the interest of simplicity, they have been included as forecast information. Similarly, all alphanumeric information relayed from NWS have been grouped into one category and will be considered as a separate group.

Table A.1 will be used as a guide in estimating the distribution of the alphanumeric information. The values in this table are based on the assumption that nearly all forecasts, observations, etc. from one Region are required in the adjacent Regionals and this requirement decreases with distance.

5.1.1 Observational Data

A large volume of message traffic is generated by observations of meteorological parameters. All levels except the Major Processors generate this traffic. (Canadian collection responsibility only). Messages generally vary in length from some tens of characters to four or five lines and must be delivered within five to ten minutes. An observation at any particular location must receive immediate distribution within 500 to 700 km, including the nearest Intermediate Processors. They must be formatted into appropriate bulletins for national delivery and international delivery as required.

The bulk of the observational traffic is scheduled at hourly, 3 hourly, 6 hourly or 12 hourly intervals depending on the type. Peak input to the system occurs on the hour to 5 minutes past the hour.

Unscheduled observations such as specials receive mainly regional distribution and must be delivered within five minutes.

Most scheduled and some unscheduled observations must be formatted and delivered internationally (to Washington) within 30 minutes.

Observational data include all synoptic reports from some 230 Canadian synoptic stations, aerological reports from the 33 aerological reporting stations, hourly reports and specials from some 350 hourly reporting stations as well as reports in alphanumeric format from other fixed or moving observing sites. Figure A.1 gives the general flow of the observational data as well as five minute peak and normal one hour traffic volumes, and the average message length of this type of traffic.

For easy calculation, we have assumed that the various types of stations are equally distributed amongst the regions and that this number is the maximum found within any region at the present time. For example, the Western Region has 56 synoptic stations, thus all regions are assumed to have this number. This will give an over-estimate of traffic as compared to figures obtainable from the Traffic Parameter Report, but for our purpose, this is much more acceptable than an underestimate. The 13.6K five minute peak traffic per region is obtained by assuming that all 56 synoptic stations and 69 hourly stations are inputing their SA and SM reports during the same five minute period. We have decided not to include the upper air reports in this estimate because these reports and the SM's are not expected at the same time. The same apply to ship reports. Other reports will likely contribute little to this peak value. The normal one hour traffic of 11.0K characters is estimated to be due to the hourly SA reports plus a certain number of SA SP's and some other reports. The average message length of 88 characters per message is obtained from the monitoring of the collection traffic as reported in the Traffic Parameter Report.

For the purpose of this analysis, the CODCON System at AES Downsview is considered to be a separate Region, bring the total number of Regions to seven. This is done because the 52 automatic stations currently processed at this site generate nearly as much information as the manual observation sites at the other Regions.

5.1.2 Forecast Information from Intermediate Processors

Forecast and warning messages are generated at Intermediate Processors for regional, national, and international distribution. Message lengths of five to 100 lines are generated. Scheduled forecast traffic is produced at six or twelve hourly intervals based on local time. Unscheduled messages are mainly in the form of warnings or advisories which require Regional distribution and must be delivered within five minutes. Most forecast traffic must be distributed to Users and User Processors within the region and neighbouring regions. Forecasts in bilingual areas must be translated; this is currently done at CMC and then distributed.

Forecast information from Intermediate Processors includes forecasts for aviation and for the general public, special products for the information industry as well as forecast for agriculture, forestry and tourism, etc. Weather warnings, though infrequent and small in volume are also included. Figure A.2 gives the general flow, five minute peak and normal one hour traffic volume as well as the average length of this type message information.

Each Intermediate Processor is responsible for the issuance of FA's, FT's and FP's for the general public as well as for marine interest. In addition, other forecast products are also produced but these are generally of smaller volume. In arriving at the five minute peak volume of 7.2K characters, we have assumed one FA, one FT, one FP inland and one FP marine, each of 300 words in length are issued over a five minute period. This 7.2K figure is somewhat higher than the 6.5K value obtained by examining the forecast production and transmission schedule from Winnipeg. However, since we are interested in a peak value, the higher value was accepted. The 8.0K average one hour volume is not very meaningful since forecasts are not generally issued every hour but it is reasonable to assume that no more than four major forecasts plus a small number of shorter forecasts are issued per hour. The above figures compares reasonably with the 6.6K average per region per hour between 1200Z and 1700Z over a two day period, as derived from numbers in Table 2.1.1-2 of the Traffic Study Parameter Report. The average length of 385 characters is also derived from the same values.

5.1.3 Forecast Information from CMC

All alphanumeric output from CMC including weather bulletins, temperature forecasts, upper winds and translated forecasts are included here. These have specific distribution patterns as they are divided into bulletins, specific to a region or two neighbouring regions. Delivery times are of the order of 20 minutes except for translated forecasts and warnings. These must be delivered within five minutes.

Forecast information from CMC, for the present anlysis will include all products such as hourly weather bulletins, FM's, FD's and the forecasts translated at CMC and edited by the Secretary of State Translators, but do not include grid point data which will be covered under batch traffic. Figure A.3 gives the peak, normal traffic volume and average message length as well as the general flow of the message information from CMC. The volume of 25K characters is some 100% higher than the value from currently available statistics, but with more line capacity, information from two to four other five minute intervals could be transmitted so that this figure is not unreasonable. The 30K normal one hour traffic is more nearly the current maximum one hour traffic, which is a much more meaningful value than the much smaller normal because of the uneven distribution of the traffic.

5.1.4 Alphanumeric Information Relayed from NWS

Alphanumeric information relayed from the NWS, for the purpose of this study includes all meteorological or environmental information from the U.S. as well as from all other W.M.O. member countries particularly those in the northern hemisphere. Figure A.4 shows the general flow of this information as well as the peak and normal volumes and the average message length. The 80K five minute peak volume is just 30K higher than an actual maximum five minute volume obtained during two days of monitoring of the Suitland-Toronto link, and is just under 90% of the capacity of this link. The normal value of 300K is near the top of the average observed values.

5.2 BATCH TRAFFIC

Under batch processing, we are only considering the grid point data from CMC which are primarily destined for the use of the Regional Weather Centres or equivalent operations (Intermediate Processors). There is other batch processing taking place at CMC such as the Ice Forecast Central, Centre de Prévision du Québec and Downsview links with the CMC. We do not as yet have an adequate understanding of these operations. We are therefore not considering them at this time.

CMC currently sends out just under 55K characters of grid-point information per 12 hours. Of this number, 32.5K are scheduled during one five minute period (at 0340Z and 1540Z) and the rest some 25 minutes later. It is possible that the entire volume could be scheduled at the same time. The average length of these messages is 1.8K characters (the longest 4.5K characters). The above information is derived from a 24 hour profile of the transmissions on circuit 273. Figure A.5 shows the flow and volume of this information.

5.3 INTERACTIVE TRAFFIC

There are currently three operations within AES which involves interactive access to computer systems (not including on-site access). These are Weather Office-Weather Centre interaction, Translation Bureau-CMC interaction, Downsview-CMC interaction. The last of this is not yet well understood but we believe that the volume is minimal except when there is file transfer for chart plotting purposes. We will therefore concentrate on the former two operations.

5.3.1 Weather Office-Weather Centre

Currently there are four User Processors (WO4's) having interactive access to regional computers. These are: (1) Dorval and Centre de Prévision du Québec; (2) Toronto Weather Office and the Ontario Weather Centre; (3) Winnipeg Weather Office and the

Prairie Weather Centre and (4) Regina Weather Office and the Prairie Weather Centre. The DND office at Namao also has a connection to the Arctic Weather Centre computer. In this analysis, we assume that the operations of each WO4 is similar to the other so that their information requirement are similar. For the estimate of the five minute peak and normal one hour response traffic, the lengths of 700 (10 lines) and 210 (3 lines) respectively are used.

Figure A.6 shows the volume and connections for the Prairie Weather Centre, Regina and Winnipeg operation. The inquiry values are based on a maximum of 10 inquiries per five minutes and an average of 60 inquiries per hour per station with each inquiry requiring 10 characters to complete this giving a five minute peak volume of 100 characters per office and an average of 600 characters per hour per station. The responses can vary between less than one line to about 30 lines (about one page), the average is three 60 to 70 character lines.

5.3.2 Bureau des Traducteurs - CMC

The Bureau des Traducteurs of the Secretary of State, located at the Centre de Prévision du Québec is responsible for the manual editing of the automatically translated forecasts. Current statistics indicate that the maximum number of forecasts processed per hour is 7 and all of these could in theory be available within any five minute period during the hour. Assuming a maximum length of 300 words per forecast, the maximum number of characters for a five minute period is then 12.6K characters. This is just over two times the maximum number of characters processed during any hour under normal conditions. The average hourly volume is 3.1K characters. The average length of just under 1.0K (.943) characters per forecast is taken from the total 75.4K, on the average per day divided by the 80 messages processes every 24 hours. Figure A.7 shows the volume and flow of this interactive traffic.

5.4 CHARTS

Chart traffic is primarily one way down the nodal hierarchy encompassing the MP's, IP's and UP's. CMC is the prime originator with charts being sent from there to IP's and UP's on a six hourly basis with major peaks at 03 and 15Z. Today, this traffic is scheduled, however, a significant fraction could be sent on a demand basis. Approximately fourty percent of nationally distributed charts originate at NWS and are relayed by CMC to IP's and UP's. Delivery time for charts is less than ten minutes. IP's also originate charts which receive mainly regional distribution.

Charts or graphics information can be divided into two basic types, namely, national and regional. The national charts are for the use of forecasters at the the IP's and/or for presentation purposes at the UP's. The regional charts are produced by the IP's for the use at the UP's or at other IP's. Other users not fitting into the above hierarchy may also use the national and regional charts. In addition, the Ice Forecasting Central in Ottawa transmits charts as well as receives ice charts from field operations.

5.4.1 National Charts

There are two major sources of national charts, namely the CMC and the NMC. Table A.2 summarizes the total volume of this traffic and Figure A.8 shows its distribution. The five minute peak volume of 62.5" or 10.9M bits is based on the assumption that CMC can produce four 12.5" charts and that one 12.5" chart can be recieved from NWS on the existing NMC-CMC link in 5 minutes. The conversion from inches to bits is based on an assumption of 100 pixels per inch.

5.4.2 Regional Charts

Table A.3 summarizes the volume and type of Regional facsimile transmissions. Vanvouver's 208 minutes of transmission per day is the largest amongst the Intermediate Processor transmissions. However, only 77 minutes is for the transmission of charts, the other 131 minutes is for the transmission of satellite imagery to the User Processor. Other centres also transmit radar and relay satellite imagery over the facsimile network.

There is currently a requirement for Vancouver to transmit a certain number of charts to the Western Region, and for the Ice Forecasting Centre to transmit to MetOc Centre, to Edmonton as well as to some northern sites. However, these volumes are small. The Ice Forecasting Centre also needs a small number of charts from Edmonton.

5.5 IMAGERY INFORMATION

5.5.1 Satellite

Satellite imagery consists of 10" x 10" photograph quality images of 64 levels of grey and 100 pixels per inch (an equivalent of 6.0M bits). There are presently four sources of information from AES, namely SDL, Edmonton, Vancouver and Halifax. The Ice Forecast Centre also acquires images from commercial sources, at Prince Albert, Sask. and Shoe Cove, Nfld. Figure A.9 shows the distribution and volume of this traffic.

The volume is one picture per 10 minutes per source. Thus for sites receiving photos from more than one source, the maximum possible 10 minute volume is one times number of sources. For example, Edmonton could be receiving two photos in 10 minutes, one from Vancouver and one from SDL (the one from Edmonton is assumed to be already available on site).

Imagery is also re-scanned by IP's and relayed to UP's via regional analogue facsimile. The resulting quality at UP's sites is not adequate.

5.5.2 Radar

AES currently operates three Curtis-Wright and six Raytheon Radar sites. Of the six Raytheon sites, Woodbridge is considered to be a development site and digital information is currently available from this site. Current traffic volume is one to three 10" x 10" images, with four to eight levels of grey (or colours), for 10 minutes from each site. The bit equivalent is some 200K bits per image. Table A.4 gives a detailed breakdown of the radar sites as well as the locations of the remote receivers.

6.0 IMMEDIATE NEW SERVICES

6.1 SERVICE DESCRIPTIONS

The following listing is in decreasing order of priority as expressed by the AES Communications Study Review Panel. Section 6.2 following gives traffic figures.

(1) Radar information, increasingly in digital form, needs to be made available to weather centres which have responsibility for severe weather:

- At this point in time, the communication of radar data is usually on a point-to-point dedicated basis on a regional scale.
- Eventually, all major population centres in severe storm prone areas will have radar coverage.

(2) Increase in data from climatological and special networks to weather centres in real time (20 to 40% of available):

- will involve 250 sites per region;
- one alphanumeric line input twice per day;
- fifteen minute delivery time;
- remote sites may be accessed via satellite;
- methods restricted by volunteer nature of program and provincial participation.

(3) Regional SSD's need one day response from climate archives computer as a result of processing requests or archive subset transfer:

- 6-7 SSD type organizations;
- batch traffic to terminals or IP's computer;
- five requests each per month, one day response;
- highly variable amount of traffic (5K to 50K bytes).

(4) Significant (20X) increase in gridpoint model output from CMC to IP's. Some on a request basis.

(5) Significant increase in chart output from CMC to a variety of users, especially IP's. Some need for selective and on-demand transmissions:

- estimate initally 100% increase for each IP;
- some 30% on request basis;
- after five years, decrease due to Regional production of graphics.

(6) Quality control of meteorological data requires improvement (parts decentralized). Meet WMO requirements:

- function of network design (centralized/regional switching);

- function of transmission error rates and correction procedures;

- function of degree of entry point intelligence in terminal;

- to be determined once basic design decisions made.

(7) Weather presentation offices need better access to weather information, including radar imagery (could be on-demand from sites covering their area of responsibility):

- see also 6.1 (1);
- specific and detailed problem for later analysis.

(8) Weather presentation offices need better, more flexible access to weather information (charts). Some need for user selected or on-demand transmission. Mostly scheduled:

- could be a redistribution of chart traffic on a regional basis from today (most basic needs are met today);

- for later, more detailed analysis.

(9) AES must be able to respond to increasing demands from CATV industry for graphical information to be delivered electronically:

- distribution of digital graphics products from IP's;

- could be 4 analyses, 2 x 3 forecasts, 8 special charts per day.

(10) Regional SSD's need access to standard regional climatic data base:

- This capability now being introduced via remote CRT to IP's.

(11) Weather presentation offices (UP's) need better more flexible access to weather information:

- demand access to IP's current data base contents - flexible formatting;

- 10 AES UP's, 20 other UP's per Region;

- could be met by intelligent terminals with on-site storage plus request/reply capability for normally unscheduled data.

(12) AES must be able to respond to increasing demands from CATV industry for imagery information, both radar and satellite, to be delivered electronically. Other special-user demand for this data is increasing.

- mainly regional/local demand;

- data requires processing by IP's before relay for annotation, time information, monitoring, etc;

- could be as often as 1/10 minutes for Radar, 1/3 hours for satellite data;

- cities with radars and UP's will want similar service for Radar.

(13) AES needs to be able to better serve outside users who require small volume, on-demand, access to weather information using electronic means. Also includes access to climate archive subset.

- Now via regional computers, in future via home information data bases?
- potentially large number of users (250 per IP);
- primarily dial-in;
- cost recovered?
- peak during bad weather and during business hours;
- wide variety of volumes and frequencies.

(14) Regional forecast Centres need access to computer power at CMC for purpose of Regional Modelling.

- method not defined

(15) Interface ADRES directly to network.

- now being done piecemeal

(16) Regional SSD's need access to Downsview computer for RJE.

- see 6.1 (3) above

(17) AES needs to be able to better serve outside users who require small volume, on-demand, access to weather maps.

- few users due to requirement for graphics terminals;
- could be satisfied in future by home information system data bases;

- dial in, 10 users per IP, 6 per day per user;
- cost recovered?

(18) Other items extracted from the Phase I Report received low priority including the requirements for Ice Forecast Central (these ranked highly in the long term services however; see Section 7.0).

6.2 INCREASES IN TRAFFIC RESULTING FROM IMMEDIATE NEW SERVICES

6.2.1 Message Traffic

6.2.1.1 Observational Data

Increase in observational data is expected to result from (1) the potential requirement to have an increased number of reports from climatological and special network available at the IP's, (2) an increase in the number of automatic stations with data requiring off-site processing and (3) the expected change in the SM code. The requirement to interface ADRES directly to the communication network will not likely increase the total volume of traffic but might increase the peak loading on the network.

- Increases resulting from a potential increase in the number of reports from climatological and special networks.

  The volume per station per day is rather small, only 2 x 50 or 100 characters. However, because of the large number (250 per region) the total volume per day per region can be as high as 25K characters or 12.5K characters twice per day.

- Increases resulting from an increased number of automatic stations.

  The increase in traffic resulting from an increase in the number of automatic stations will depend on the location of the processing site. Assuming that an automatic station must transmit to an off-site processor which in turn must transmit to a distribution centre or switch for distribution, and that diagnostic information will also be included in the automatic station reports, the total traffic volume resulting from an automatic station could be as high as three times that from a manned station. Thus, an introduction of 10 to 15 additional automatic stations in each region (60 to 90 nationally) could increase the total traffic due to observational data by as much as 30%.

- Increases due to the expected changes in the SM code.

  The proposed changes in the SM code is expected to increase the SM traffic by some 50%. This would have the effect of increasing the total message traffic by some 5%.

- Total increase in observational traffic.

  The possible increase of 25K of information from climatological and special networks, per region per day is equivalent to some 10% of the total message traffic. This, together with the possible 30% increase resulting from an increase in automatic stations, and then 5% increase in SM traffic could increase the total traffic by some 45%.

- Other increases message traffic.

  No major increases in other message traffic is expected. However, for planning purposes, some 10% - 30% increase is a reasonable assumption.

6.2.2 Batch Traffic

The increase in batch traffic is expected to come about as a result of (1) Regional SSD's access to the Downsview computer's climate data base, (2) an increase in model grid-point output from CMC to IP's, (3) IP's access to CMC for computing power and (4) the introduction of satellite sounding information.

6.2.2.1 Regional SSD's Access to the Downsview Computer

This traffic is primarily due to the SSD's need for better access to climate processing and outputing (or formatting) procedures and for the transfer of a subset of the national climate data base for local use. It is expected that this traffic would be highly variable, ranging from 5K to 50K characters per month for each of the 6-7 SSC type organizations.

6.2.2.2 Increases in Model Grid-Point Output from CMC

The growing need for grid-point information for local forecast production or for display purposes at the IP's is expected to increase this type of traffic some twenty-fold. CMC currently transmits some 55K characters of grid-point information per 12 hours with some 35% of this going to each IP. With the increased demand, the total volume is expected to go to 1100K characters per 12 hours with distribution similar to that of today. This amounts to a twenty-fold increase, and some of this could be on an as rquired basis. (It should be remembered that the above amounts do not include information for the Centre des Prévisions du Québec).

6.2.2.3 IP's Access to CMC for Processing Power

The volume of traffic resulting from this type of activity is not known, but it might be reasonable to assume that the volumes given in 6.2.2.2 include this traffic.

6.2.2.4 Increases due to the Introduction of Satellite Sounding

The introduction of satellite sounding in the form of pseudo-RAOB's could produce as much as 40K characters of traffic per one and one-half hour per ground station (possibly SDL for Eastern Canada and Vancouver or Edmonton for Western Canada).

This information could be transmitted in a batch from a satellite station and/or processing site to an IP and/or MP. Initially, this information may be transmitted in the form of analysis field in chart form, possibly 3 or 4 in 8½" x 11" format every one and one-half hour, transmitted on a point-to- point basis and later enlarged to some 17" x 22".

6.2.2.5 Total Increase in Batch Traffic

The 5K to 50K characters per SSD per month amounts to only some 5% to 10% increase in the batch traffic. The 40K characters per one and one-half hour (per ground station, possibly two stations) is equivalent to 1280K characters per day or some 12 times the current batch traffic. This together with the some 20-fold increase in grid-point traffic is equivalent to some 33 fold increase in the total batch traffic.

6.2.3 Interactive Traffic

In addition to the UP-IP and Bureau des traducteurs-CMC interaction, a large number (25 per IP?) of other users is expected to need access to weather information on a small volume, on demand basis. This latter class of users might be served electronically (possibly on a cost-recovered basis?).

6.2.3.1 UP-IP Interaction

The estimated volume per site, for this type of operation is not expected to change much. However, only a small numer of the UP's are currently served this way and because of the large number of UP's (9-13 per region) and other users, the total volume is expected to increase many-fold.

6.2.3.2 Bureau des Traducteurs - CMC Interaction

The estimated current traffic volume represents that resulting from the manual editing of the automatically translated forecasts (not including synopses and warnings, which are translated manually). Plans are underway to move the translation function from the CMC computer to a Secretary of State dedicated system so that current operations might be discontinued in the near future.

6.2.3.3 Total Increase in Interactive Traffic

The number of UP's having interactive access to a data base is expected to increase with the volume per site remaining little changed. (However, this may change if the UP's were to have their own data base).

6.2.4 Charts

Charts are divided into two classes, national and regional. In general, the IP's require national charts intended for forecast purposes and the UP's require national charts intended for presentation purposes and regional charts. (A very small number of regional charts might require inter-regional distribution).

6.2.4.1 National Charts

CMC currently transmits nearly seven hours of charts for use at the IP's and UP's representing some 155M bits of uncompressed raster information per day. An estimated 100% increase would bring this to 330M bits. another estimated 30% of charts to be made available on an as required basis would further increase this to 380M bits (assuming 100 lines per inch, 100 pixels per inch, black and white only, if shades of gray are required, this must be multiplied by a factor). However, with the expected increase in grid-point information from CMC, the total number of charts may eventually decrease. It is also expected that the present 7 hours or so of charts from NMC for UP use may decrease by 50% in about 2 years.

6.2.4.2 Regional Charts

The regions are presently sending from just under one hour (Montreal) to nearly 3 hours (Vancouver) over the Weather fax circuit. In many cases over half of the transmission is in the form of imagery (satellite or radar) by rescanning. Unless major changes occur in the structure an operation of the AES forecast system, only 10% - 20% increase in regional chart output is expected.

6.2.4.3 Total Increase in Charts

The expected 130% increase in CMC chart product and a possible decrease of 50% of charts from NMC amounts to some 10% - 15% increase in the total national charts (CMC issued and NMC issued). The 10% - 20% increase in regional charts should be considered a very rough estimate.

6.2.5 Imagery

6.2.5.1 Satellite Imagery

The increase in satellite imagery traffic is expected to result from an increase in the number of sites (namely UP's or WO4's and WO3's) needing this type of information and a need to make available to the CATV industry imagery suitable for TV display purposes.

6.2.5.1.1 Satellite Imagery for UP's

Imagery available at the IP's is expected to meet the needs of the UP's. The increase, therefore is in the number of receiving sites, not in the volume of traffic. Tables A.5-1 and A.5-2 show list of UP's.

6.2.5.1.2 Satellite Imagery for CATV

Assuming that the imagery is already available at the UP's, it is reasonable to assume that this same imagery information could be made available, after some processing and/or annotating, to the CATV industry at 256 x 256 pixels per image and at 16 colours or levels of gray. This is equivalent to some 263K bits of uncompressed raster information per image. This amount of information might be required every three hours per outlet.

6.2.5.2 Radar Imagery

The increase in radar imagery traffic is expected to result from: (1) the need to have more radar information in the regional weather centres (IP's); (2) the need to provide better access to radar information at presentation offices and (3) the demand for access by CATV industry to radar information.

6.2.5.2.1 Radar Information to IP's

In Tables A.6-1 and A.6-2, column 1 shows the weather centres or weather offices, column 3, radar sites providing coverage for the weather centre's or weather office's area of responsibility and column 4 whether imagery information is presently available at the appropriate sites. Column 5 shows the location of future sites. The Ste-Anne-de-Bellevue site is operated by McGill and outputs 256 x 256 x 3 or some 200K bits of information per image and is capable of producing forecasts. (This site is presently sending some 7K characters per image for line printer output). We can assume 2 to 3 images per site per 10 or 30 minutes.

6.2.5.2.2 Radar Imagery for UP's (Presentation Offices)

Tables A.6-1 and A.6-2 show a list of Weather Centre/Weather Offices and radar sites providing coverage for their areas of responsibility. For presentation offices covered by more than one radar site, perhaps only one is required, preferably the one to the west, or the one providing the best coverage.

6.2.5.2.3 Radar Imagery for CATV

Radar imagery with 256 x 256 pixels per image with an appropriate number of colours or levels of grey (4 to 8?) might be required by the CATV industry once every 10 minutes.

6.2.5.3 Summary of Increases in Imagery Traffic

The increases in imagery traffic is expected to be primarily due to the increased number of sites requiring this information, plus the possible added service to provide the CATV industry with imagery suitable for TV display.

6.2.6 Summary of Traffic Increases

Table A.7 summarizes the increases in traffic resulting from proposed immediate new services. The most significant increases are those due to the proposed increase in the number of sites needing imagery information, the 10% - 15% increase in national charts and the 33-fold increase in batch traffic. However, with the exception of the increase due to the proposed change in SM code and possibly the increase due to the increase in automatic stations, all others are generally discretionary (cost dependent?)

Radar Information - Medium Capability Assumptions

1. 3 Pictures per 10 minute cycle (could be 2 with 1 additional on an as required basis)

2. 240 lines x 270 pixels per picture

3. 8 levels of gray or colours

(3 - bits per pixel)

1	picture	194.4K bits
10	minutes	583.2K bits
1	hour	3,499.2K bits

*Present analog system transmits each line, each pixel 3 times, i.e. a mosaic with 3 x 3 squares.

Radar Information - Sceptre Assumptions

1. 3 pictures per 10 minute cycle

2. 240 lines x 270 pixels per picture

3. 4 (5) - 8 levels of gray or colours

(3 - bits per pixel)

1 picture	194.4K bits
10 minutes	583.2K bits
1 hour	3,499.2K bits

*Present analog system transmits each line, each pixel 3 times, i.e. a mosaic with 3 x 3 squares.

<u>Radar Information - Proms Assumptions</u>

1. 1 picture per 10 minute cycle

2. 240 lines x 270 pixels per picture

3. 4 (actually 5) levels of gray

(3 - bits per pixel)

Note: 3 - bits is required for 8 colours also.

1 picture	194.4K bits
10 minutes	194.4K bits
1 hour	1,166.4K bits

*Present analog system transmits each line, each pixel 3 times, i.e. a mosaic with 3 x 3 squares.

7.0 LONG TERM NEW SERVICES

The AES Communications Study Review Panel, more or less unanimously, placed high importance on the following long term new services:

(a) Digital graphics from CMC to IP's to sites which integrate radar and satellite data. Also required at IP's (weather centres) for further in-house computer manipulation and display.

(b) Possible environmental support centre in Arctic requiring ice and weather data.

(c) Future legal requirement for high quality graphics to shipping in the Arctic. May be served by environmental support centre in Arctic.

(d) Sites which integrate radar, satellite and other data will be established which will most likely be co-located with satellite receiving ground stations. These sites will require digital radar data and may output processed and integrated imagery to AES and other users within the area of coverage.

(e) Significant increase in spot forecasts of weather elements from CMC to IP's as guidance.

(f) AES needs national/regional/local interfaces to home information system data bases.

(g) Need to find alternative methods (T.V.) of providing marine interests with charts when HF radiofax goes encrypted.

(h) AES IP's will want to manipulate and overlay graphics. Digital graphics from CMC will need to be available for this purpose.

(i) By late 1980's could be a need to distribute satellite imagery (ocean, ice related) from processing centres in U.S..

(j) Exchange radar data with U.S.

(k) UP's (weather presentation offices) will need fast access to up-to-date radar, satellite, and integrated imagery processed to highlight their area of interest and their requirements (similar requirements will exist for special user groups).

(l) possible environmental support centre in the Arctic would require satellite imagery (or equivalent ice information).

(m) Alternative methods of providing data to marine interests when HF facility goes digital and encrypted.

(n) Weather presentation offices will need a variety of ways to reach local community: Weatheradio, Telex, Cable TV, etc.

It can be seen that these new services fall into several broad categories:

- Category 1: Graphics Processing (a, d, h, i, j and k)
- Category 2: Arctic Marine Transportation Support (b, c, i and e)
- Category 3: Other Marine Transportation Support (g, i and m)
- Category 4: CMC production of automated sport forecasts (e)
- Category 5: Dissemination of alphanumeric and graphic data to users (f and m)

7.1 GRAPHICS PROCESSING

It must be recognized that the transmission requirements related to the processing of imagery and graphics data are important not only from a cost point of view, but also from a system design and expandability point of view.

It is also true that the graphics processing requirements are intimately related to the short range forecasting problem and the dissemination or service problem.

It is beyond the scope of this paper to do an in depth analysis of the pros and cons of a variety of methods. On the other hand, a reasonable scenario or set of scenarios must be assumed in order to derive traffic and communications requirements.

The Study Team will use the following assumptions concerning future graphics processing in the AES. It is recommended that AES begin an in depth study of graphics processing as soon as possible.

1. The focus of graphics production and manipulation will shift from a basically centralized system of today to a regional system in order to provide the analysis capability for short range mesoscale meteorological processing and to process larger and larger amounts of data mainly in the form of satellite and radar imagery in the appropriate man/machine mix.

2. All planning should center around the provision of digital data for this purpose at the regional weather centres.

3. Graphics production at CMC will decline to that required by local CMC use. all model output will be transmitted in gridpoint format to IP's where appropriate regional products will be prepared for further processing or dissemination.

4. The decline of graphics transmissions from CMC will not take place until 1985 or when the appropriate communications and processing capability is available for the regions.

5. Satellite data required for graphics processing at the centers will need to be transmitted digitally if there is no receiver on site.

6. Radar data from sites within the IP's area of responsibility will need to be available to the IP in digital form.

7. Most products required by regional UP's and special users, as well as CATV etc. will be prepared at weather centres and delivered regionally either by regional analogue fax or via digital means. It will be essential during the trade-off phase to estimate the resolution, and grey scales sufficient for these users. We will use 256 x 256 and four bits per pixel for now. This will give reduced resolution from current photofax.

8. The interfacing requirements to internal and external users will result in AES adopting a standard graphics transmission code such as the Telidon PDI Code.

9. Some UP's and special users will be receiving unprocessed or partially processed radar output directly from the radar sites by dedicated or dial up means.

10. There will be a need to send considerable amounts of data resulting from regional processing to the CMC from the Weather Centres for model initialization by the late 80's.

11. Capacity for transmission of some national graphics in compressed or coded form will continue to be required for some users. Some graphics products prepared at regional sites will need to be transmitted to other IP's across the country, especially to Ice Forecast Centre and to special dissemination points outside the particular Region.

12. Number of IP's, not basic concept, will be function of cost.

13. There will be a need to transmit both gridpoint and graphics from CMC during the changeover phase in the first half of the decade.

Reasons for the above assumptions are as follows:

1. Short range, small scale forecasting function is regional and requires man/machine mix involving considerable manipulation of graphics.

2. Cost of processing and graphics technology hardware is declining faster than cost of communications. Software costs will be high and will result in centrally produced and supported software (or standard package).

3. User community demand for local and regional graphics is much larger than national graphics.

4. Teletext and cable media will be in a position to offer local services.

5. USAF, NWS, U.S. Navy all have significant plans for integration of imagery, graphics, and man at forecasters work station (vis. Profs).

6. Data volumes will increase substantially at IP's over ten years due to satellite/radar and other remote sensing techniques.

7. UP's and users will require products which include pixel graphics but can live with the resolution offered by television.

7.2 ARCTIC MARINE TRANSPORTATION SUPPORT

Several aspects:

(i) Data Collection

- Satellite data, (U.S. and Canadian), Aircraft, conventional

(ii) Processing

- Ice Status System, Arctic Environmental Support Centre, Regional Products, CMC Products, Special modelling, Close in support, longer range support

(iii) Dissemination

- HF replacement (DOT/AFS) Broadcast by other means Local broadcasts

It is likely that a system design study will be undertaken for Arctic support. Such questions as the acquisition by IFC of northern data including Satellite Data, the function and coms requirements of a northern centre, the combined AES/DOT plans for dissemination; are not known. It is likely that a separate network will need to be established for this purpose, interfacing at IFC, METOC, Northern site etc; and to the AES operational nets.

7.3 OTHER MARINE TRANSPORTATION SUPPORT

- replacement of HF radio (DOT-AES planning);
- broadcast by video channels from satellites?;
- output from CMC, IFC' METOC's (2), Gander, Halifax, Vancouver, for offshore needs;
- AES DOT co-ordination required.

7.4 CMC PRODUCTION OF AUTOMATED SPOT FORECASTS

- CMC to all IP's (eventually UP's);
- total output traffic could be as high as 400 sites 10 elements per site x 24 part periods (3 hourly) 4 issues per day 1 MBYTE per day;
- some needs could be served by demand access, however, large portions would be scheduled;
- probably issued as batch, some message or bulletins.

7.5 DISSEMINATION OF ALPAHNUMERIC AND GRAPHIC DATA TO USERS

- key issue here is local distribution of local data;
- weather presentation offices serving population centres or agricultural and other local users;
- further decentralization of dissemination function;
- impacts degree of intelligence on site at weather presentation offices for:
  - driving local cable feeds;
  - driving telex, twx; and
  - support dial in access to local data base.
- requires further study, however, assumptions are:
  - A subset (30% or about 20) of the UP's serve commun-

ities large enough to warrant investing money to enhance local distribution of alphanumerics and graphics.

These sites will have to have electronic storage of alphanumerics and charts either locally produced or transmitted from IP's.

Lower overall priority was assigned to the following long term services by the Review Panel:

- CMC, weather centres and some special users will require processed satellite sounding data from international and domestic sources (e.g. SDL, Vancouver and Edmonton)[1].

  Volume estimates to be obtained but not likely to be large.

- Data from increasing numbers of automatic stations must be processed off site, likely at regional centres. Also diagnostics, program changes etc.[1]

  - priority likely should be higher due to advanced planning - processing can be done separately;

  - impact of satellite communication to remote sites;

  - polling required to initiate special obs.

- AES needs national/regional/local interfaces to home information system data bases.

- AES network to be used to carry other environmental data:

  - impact not known but likely small for real time.

- Need for cpu-cpu exchange CMC - Downsview Centres for load sharing.

- The ice status system will require digital satellite imagery to be available where it is run, most probably at Ice Forecast Central.

- Data from 20-40 ships operating automatic stations will need to be acquired and processed:

  - depends on means of communication.

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1 The AES Communications Study Review Panel indicated that these services should be considered of higher priority.

The following are somewhat controversial and received both a high and a low priority vote.

- May need to be data input from IP's to CMC for special purpose processing, analysis etc.

- By late 1980's, could be a need to distribute charts (digital) from U.S. processed satellite data.

- AES will want to manipulate and overlay graphics. Imagery would need to be available in digital form for this purpose[2].

- Global data set to CMC for global mode.

- By late 1980's could be a need to distribute data resulting from processing of new satellite sensors (ocean, ice related).

- WS1 and WS3 will need access to limited set of graphics (subset of W04).

- Transmission of other administrative data and information not strictly dealing with operations.

    - Interfacing word processors to network;
    - All regional centres and CMC and downsview.

Other factors not priorized:

- NOSS experiment could be separate from operational network.

- Need for a better access to data stored at Carswell (primarily DND).

- Need for much better documentation on system (Teldis is inadequate).

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2 The AES Communications Study Review Panel indicated that this service would be high priority depending on the cost of achieving it.

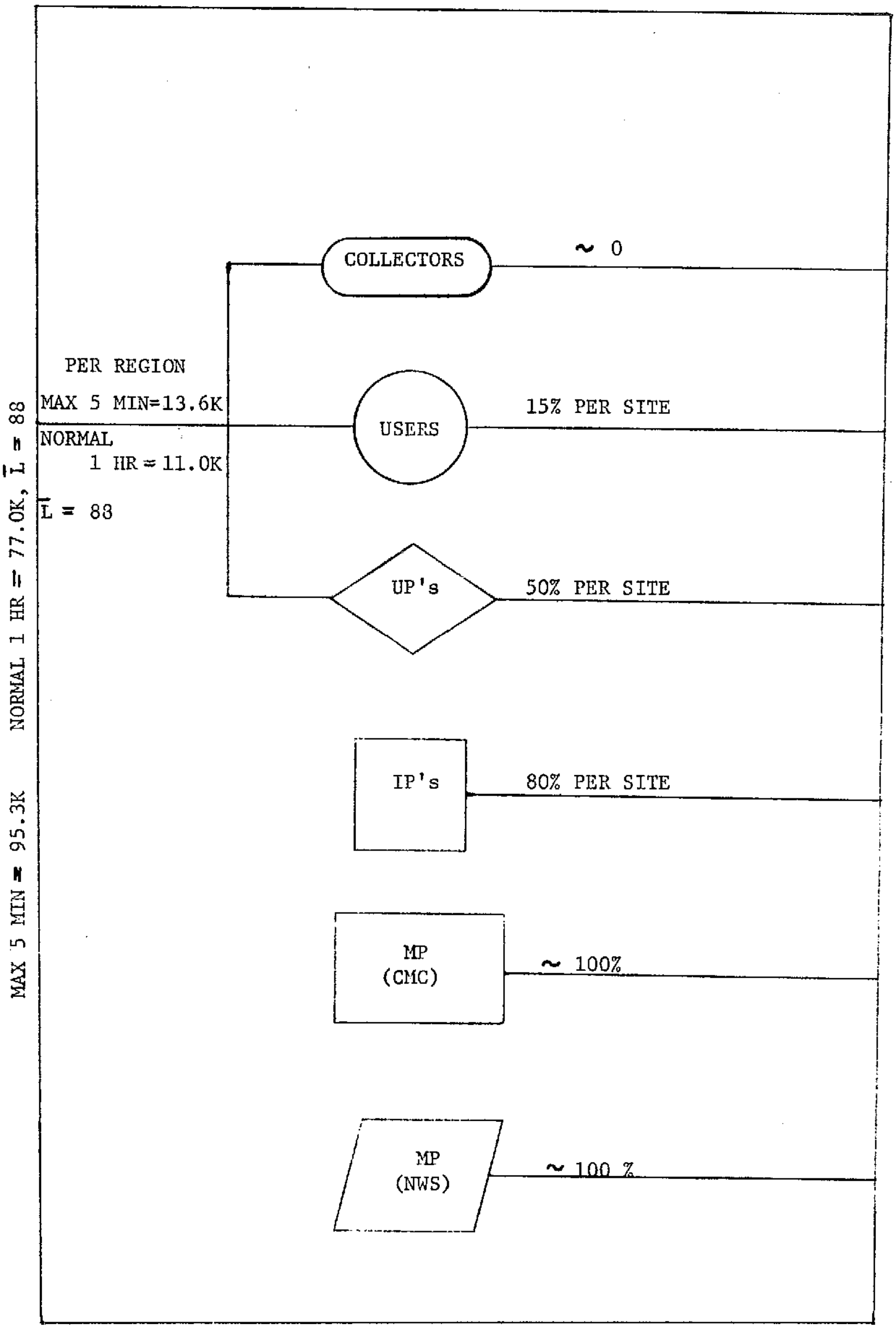

Figure A.1 VOLUME AND DISTRIBUTION OF OBSERVATIONAL DATA - IN CHARACTERS

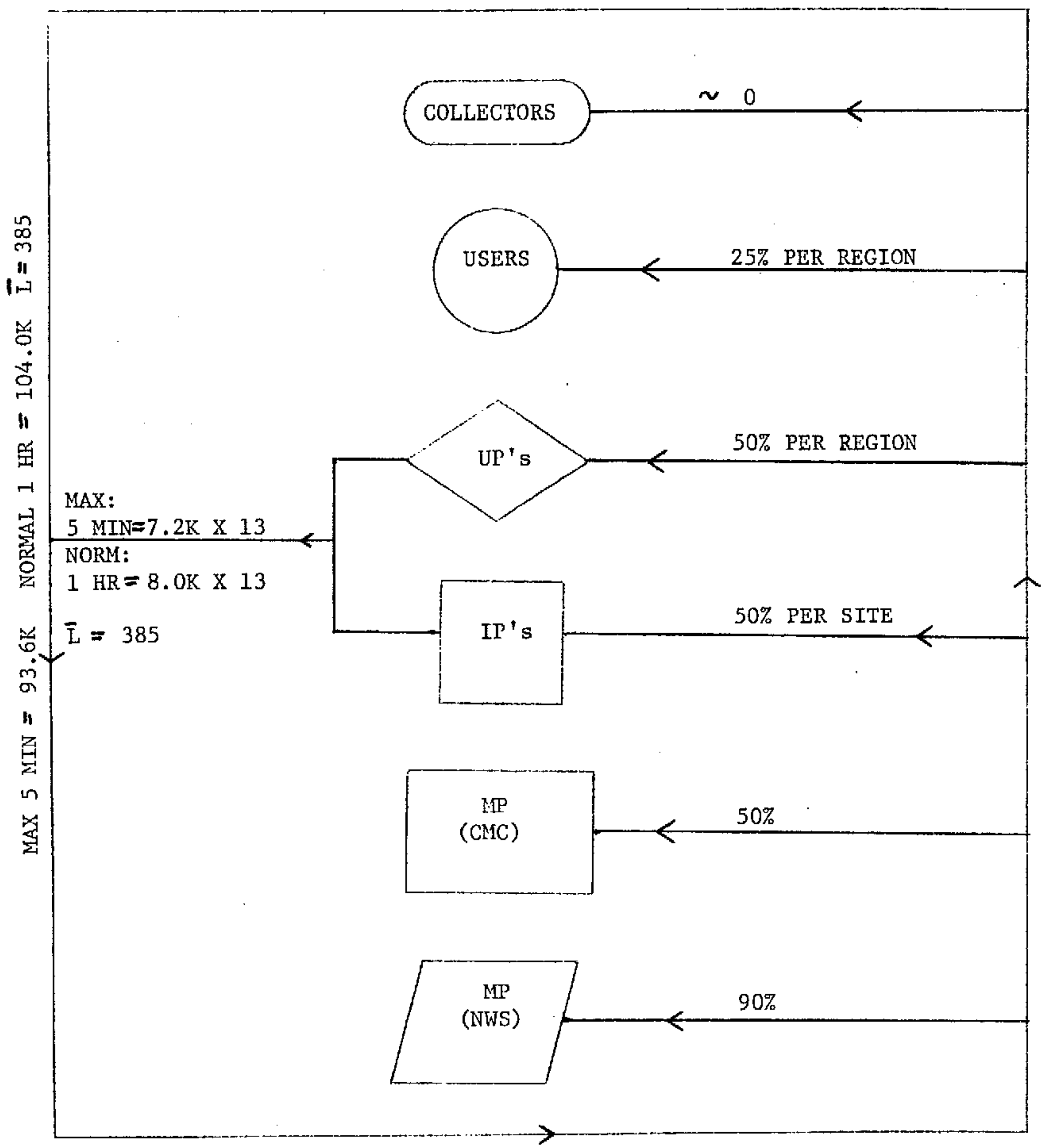

Figure A.2 VOLUME AND DISTRIBUTION OF FORECAST INFORMATION FROM INTERMEDIATE PROCESSORS - IN CHARACTERS

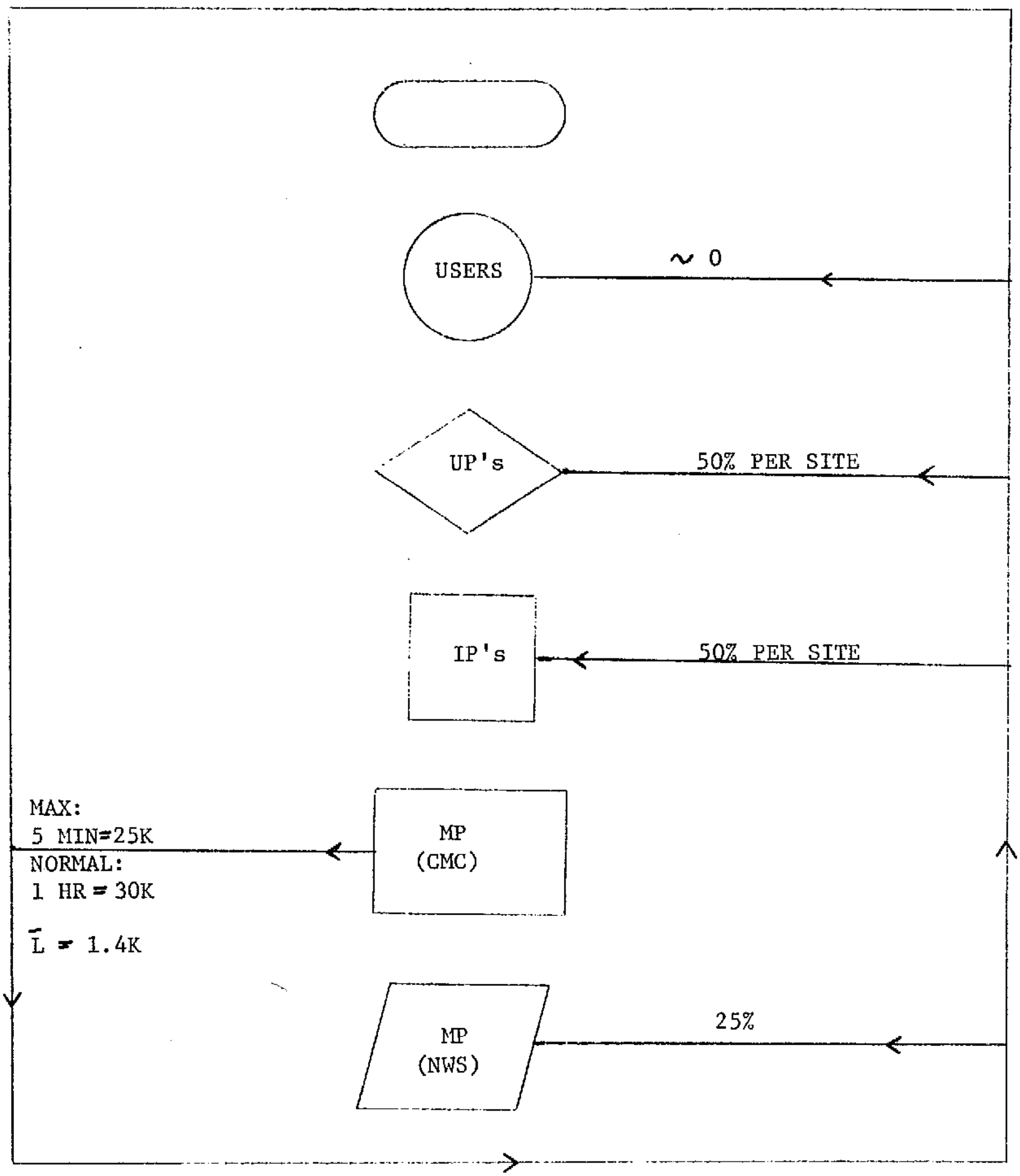

Figure A.3 VOLUME AND DISTRIBUTION OF FORECAST INFORMATION FROM CMC - IN CHARACTERS

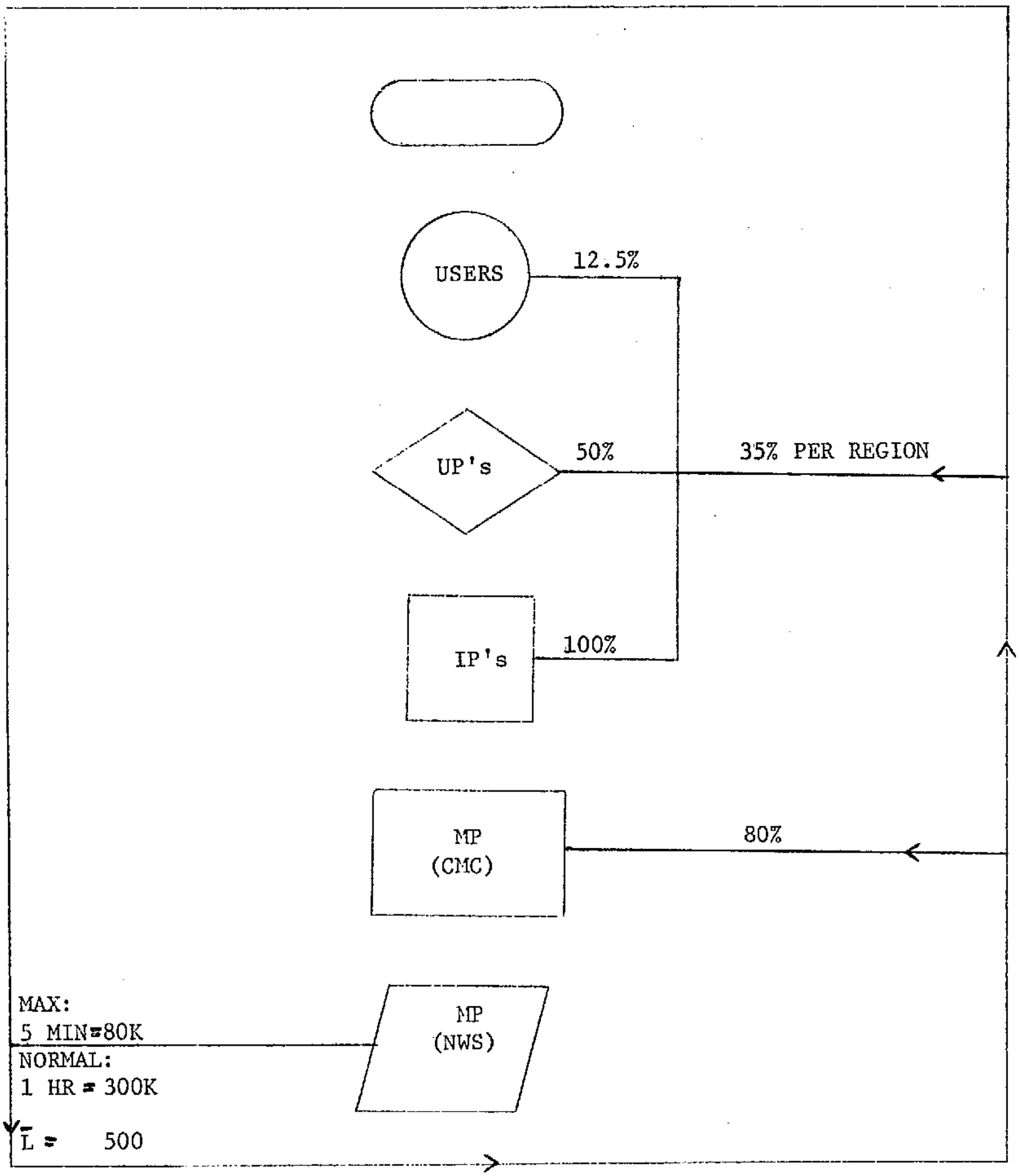

Figure A.4 VOLUME AND DISTRIBUTION OF NWS RELAYED INFORMATION - IN CHARACTERS

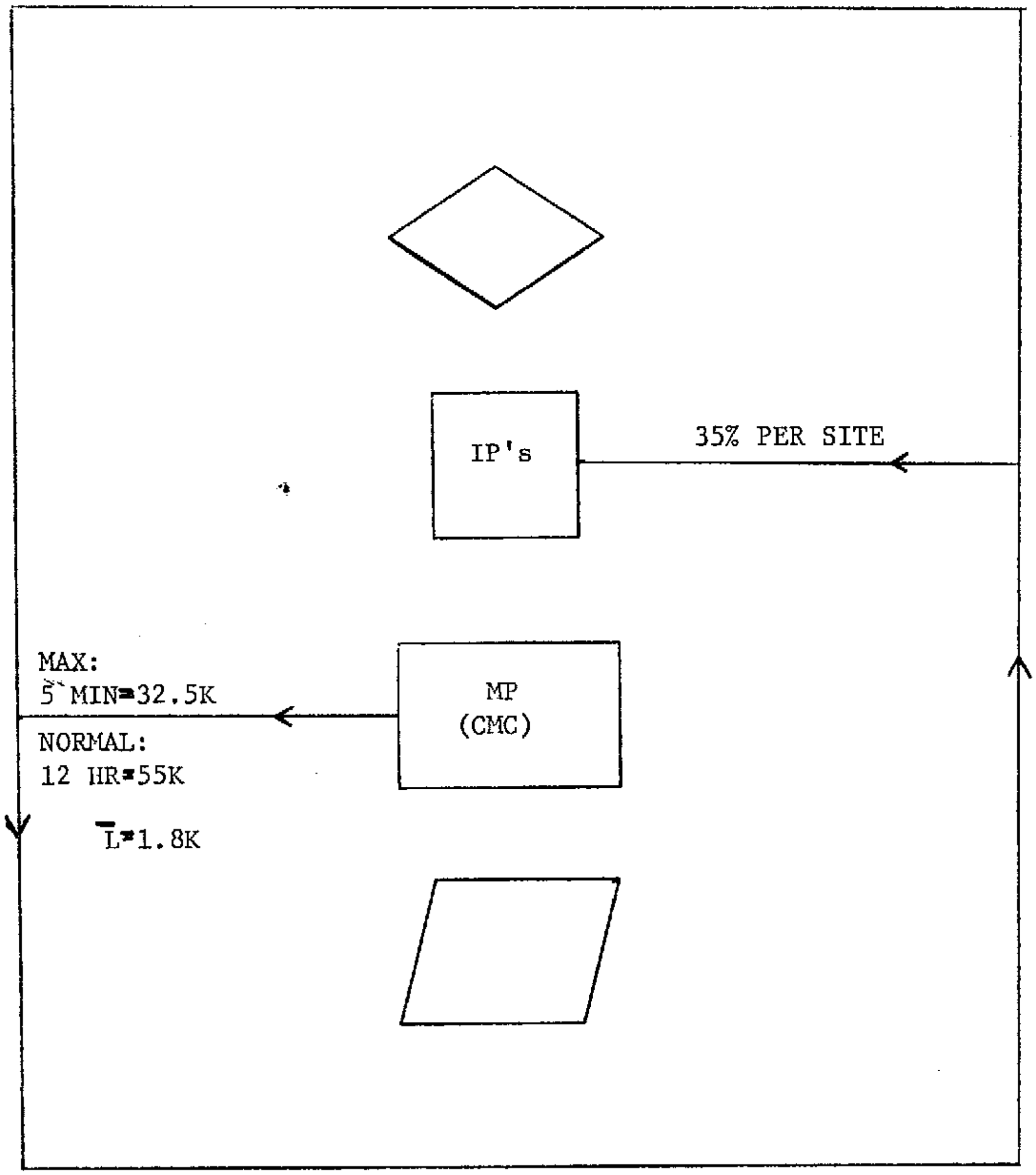

Figure A.5 BATCH TRAFFIC IN CHARACTERS

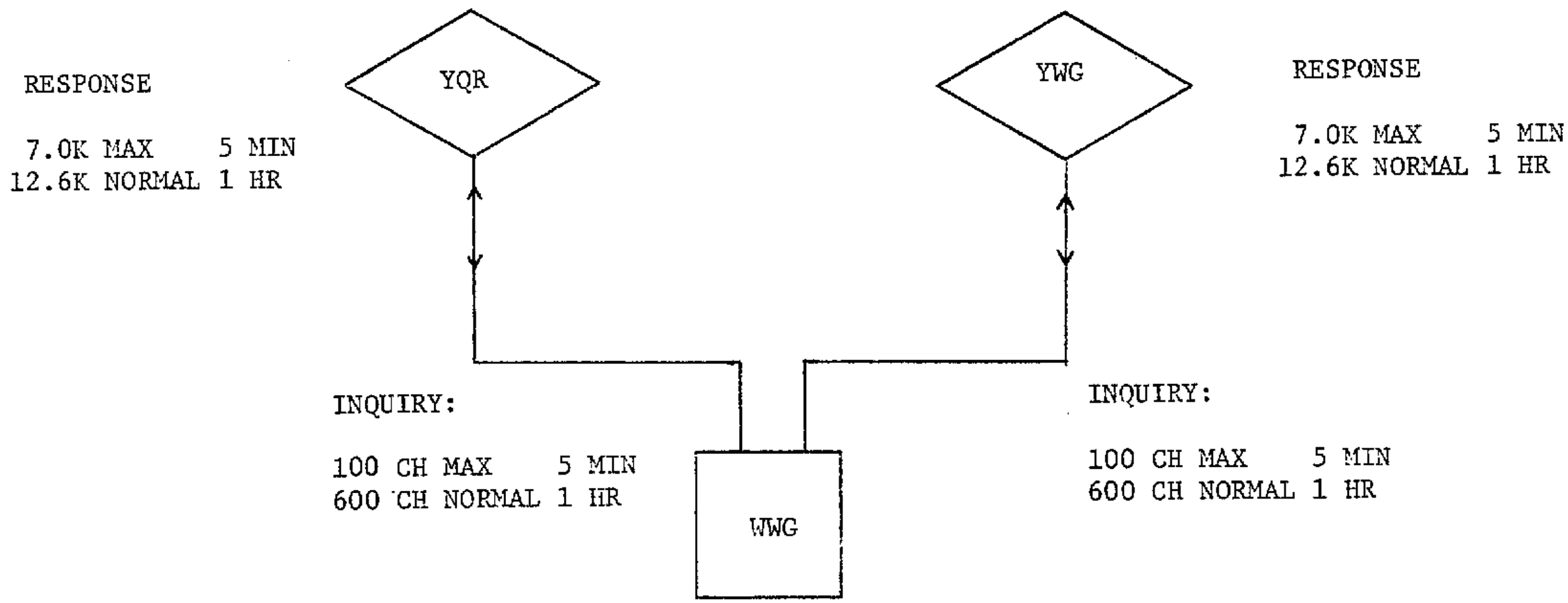

Figure A.6 INTERACTIVE ACCESS BY THE REGINA AND WINNIPEG WEATHER OFFICES TO THE PRAIRIE WEATHER CENTRE DATA BASE

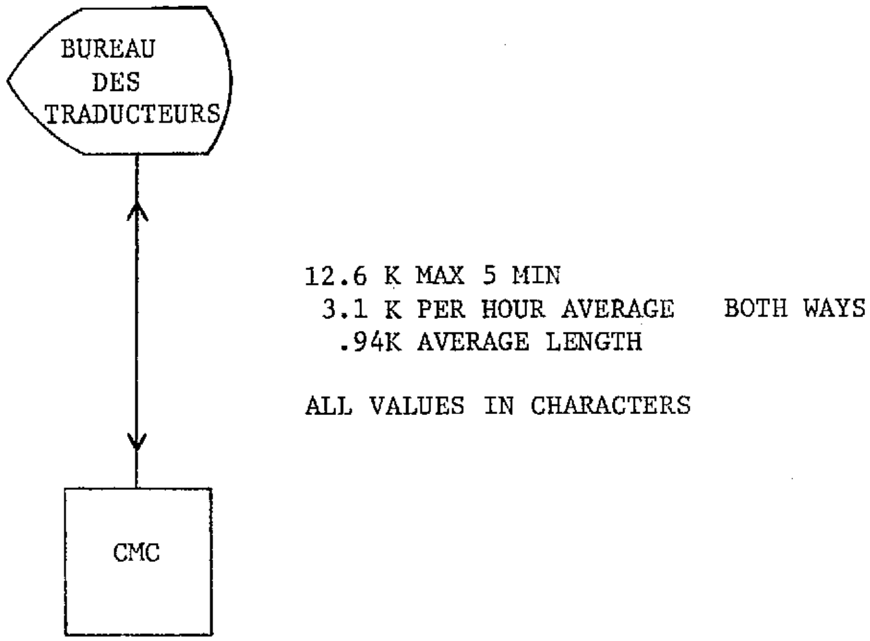

Figure A.7 BUREAU DES TRADUCTEURS - CMC
INTERACTIVE EDITING OF AUTOMATICALLY
TRANSLATED FORECASTS

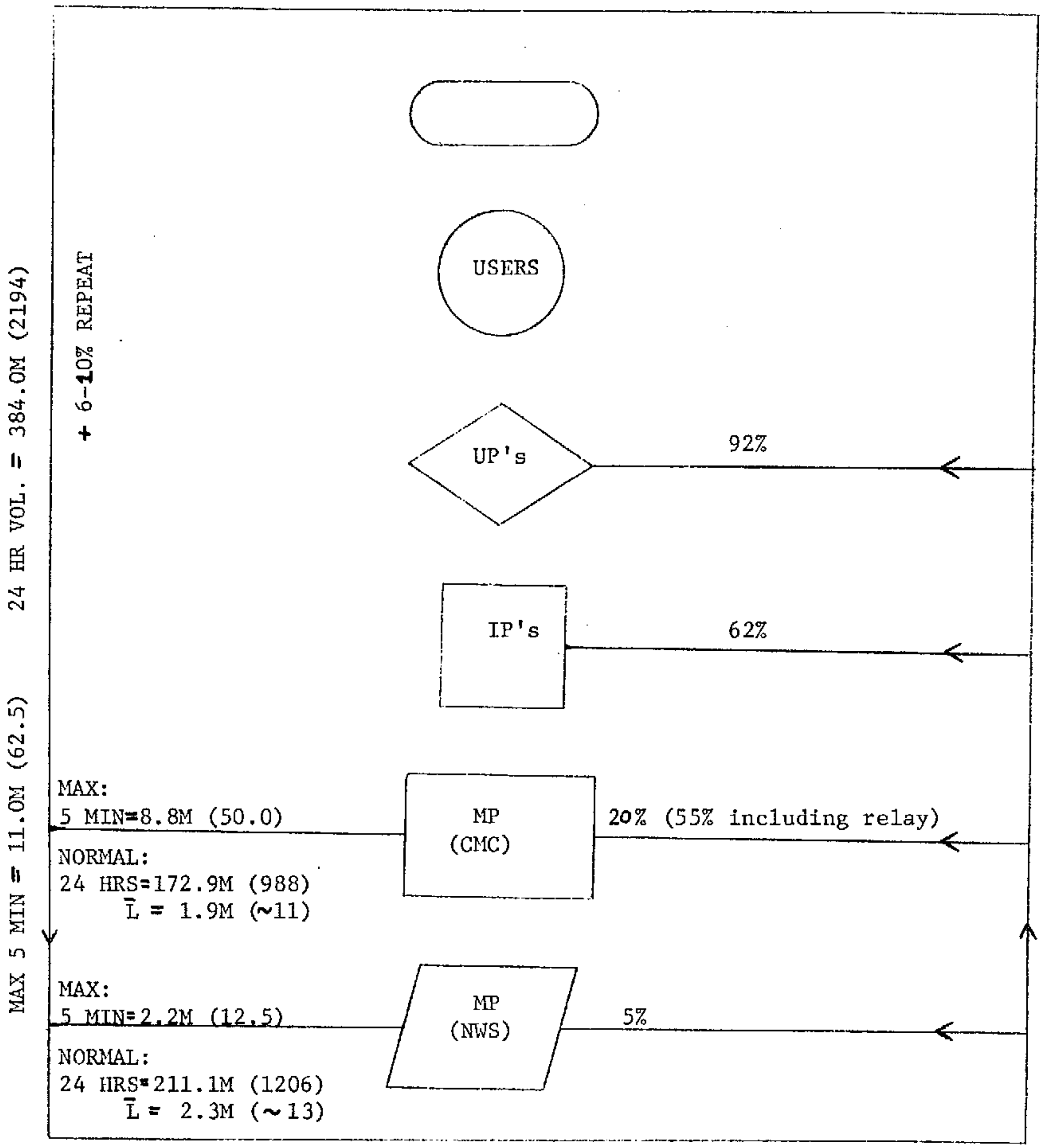

Figure A.8 VOLUME AND DISTRIBUTION OF NATIONAL CHARTS - IN BITS. NUMBERS IN BRACKETS ARE IN INCHES

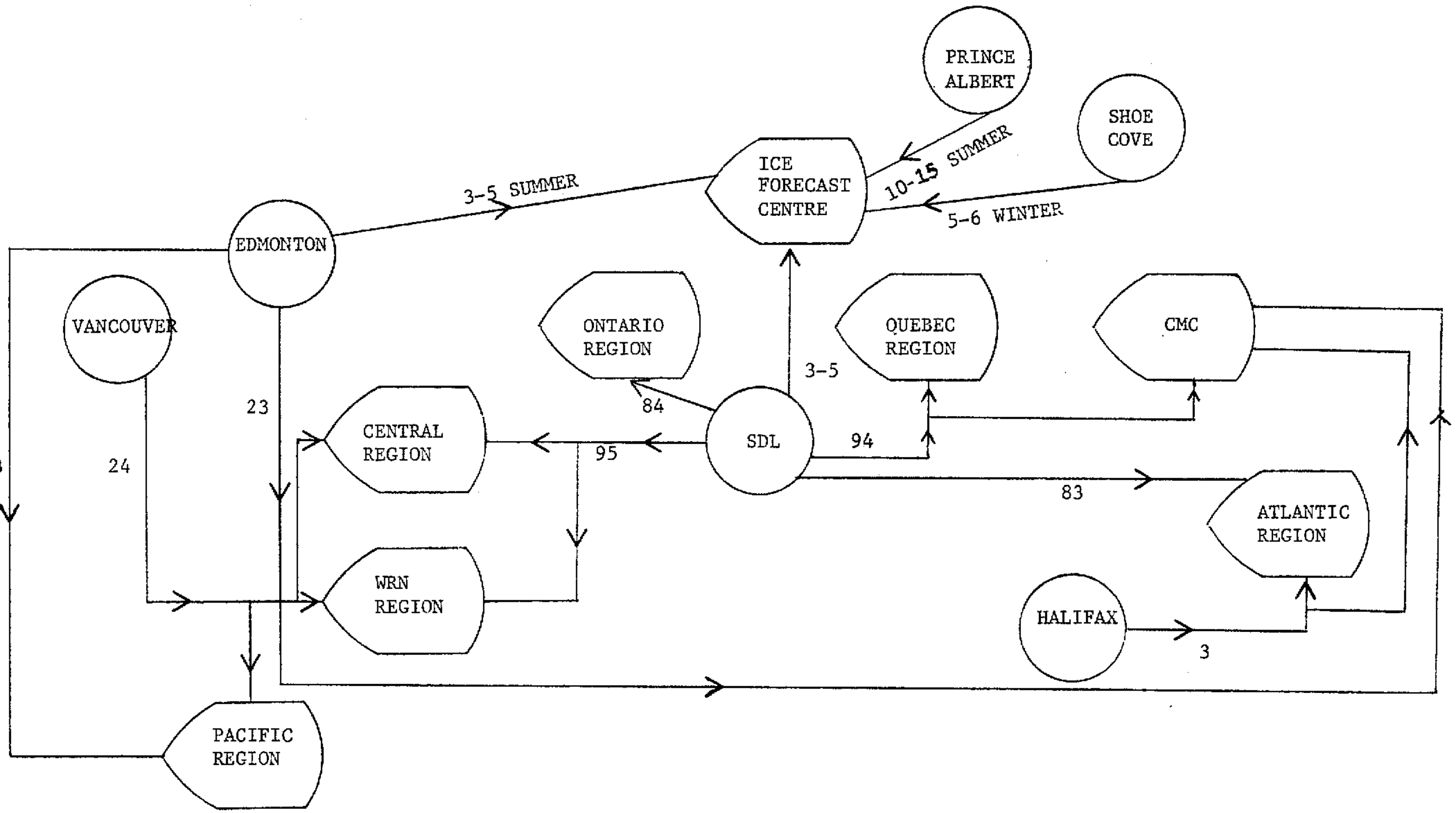

Figure A.9 DISTRIBUTION OF SATELLITE IMAGERY
NUMBERS INDICATE THE NUMBER OF PHOTOS PER DAY

TABLEAU 1. GUIDE FOR THE INTER-REGIONAL DISTRIBUTION OF ALPHA-NUMERIC INFORMATION.

	PACIFIC	WESTERN	CENTRAL	ONTARIO	QUEBEC	ATLANTIC
PACIFIC	1	.95	.75	.50	.25	.10
WESTERN	.95	1	.95	.75	.50	.25
CENTRAL	.75	.95	1	.95	.75	.50
ONTARIO	.50	.75	.95	1	.95	.75
QUEBEC	.25	.50	.75	.95	1	.95
ATLANTIC	.10	.25	.50	.75	.95	1
TOTAL	3.55	4.40	4.90	4.90	4.40	3.55

TABLE A.2. SUMMARY OF NATIONAL CHARTS

	CANADIAN MET. CENTRE				NATIONAL WEATHER SERVICE			
	TIME	LENGTH	CHARTS	*FIELDS	TIME	LENGTH	CHARTS	*FIELDS
TOTAL	408 MIN	988"	90		503 MIN	1206"	122	
FORECAST	388 MIN	941"	82		173 MIN	409"	34	
PRESENTATION	370 MIN	339"	70		463 MIN	1113"	106	

	VANCOUVER		EDMONTON		WINNIPEG		TORONTO		ICE FOREC.		MONTREAL		HALIFAX		METOC C.	
	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH	TIME	LENGTH
TOTAL	208 MIN	520"	171 MIN	428"	145	363"	170	425"	108 MIN	264"	53	145"	110 MIN	275"	76 MIN	190"
CHARTS	77 MIN	193"	30 MIN	75"	145 MIN	363"	47 MIN	118	108 MIN	264"	58 MIN	145"	85 MIN	213"	76 MIN	190"
SATELLITE	131 MIN	328"	141 MIN	353"	0	0	73 MIN	183"	0	0	0	0	25 MIN	63"	0	0
RADAR	0	0	0	0	0	0	50 MIN	125"	0	0	0	0	0	0	0	0

TABLE A.3. SUMMARY OF REGIONAL WEATHER FACSIMILE TRANSMISSIONS.

RAYTHEON RADAR SITES

	LOCATIONS	LINE STATUS	PRESENT TYPE OF RECORDER/CRT	PROPOSED TYPE OF RECORDER/CRT
1.	CARP		ALDEN	–
	OTTAWA I/AIRPORT	IN	ALDEN	–
	CFB OTTAWA (DND)	IN	ALDEN	–
	C.P.O.	IN	ALDEN	–
	PETAWAWA (DND)	IN	ALDEN	–
	E.P.S. OTTAWA	IN	MUIRHEAD (LEASED)	–
	ALDEN MONTREAL	IN	ALDEN	–
2.	ABBOTSFORD		MUIRHEAD (AES OWNED)	ALDEN
	VANCOUVER (P.W.C.)	IN	(2) MUIRHEADS (LEASED)	ALDEN
3.	TREPASSEY		ALDEN	–
	ST. JOHN'S	IN	ALDEN	–
4.	VILLEROY		ALDEN	–
	QUEBEC AIRPORT	IN	ALDEN	–
	C.P.O.	IN	ALDEN	–
	BAGOTVILLE (DND)	IN	ALDEN	–
	VALCARTIER (DND)	IN	ALDEN	–
5.	EXETER		ALDEN	–
	MALTON (O.W.C.)	IN	ALDEN	–
	LONDON	IN	ALDEN	–
	ONTARIO HYDRO	IN	MUIRHEAD (LEASED)	–
	CFPL TV S	IN	MUIRHEAD (LEASED)	–
6.	WOODBRIDGE		MUIRHEAD (DRYPAPER)	–
	MALTON (O.W.C.)	IN	ALDEN	–
	ONTARIO HYDRO	IN	MUIRHEAD (LEASED)	–
	O.M.N.R. QUEENS PARK	IN	MUIRHEAD (LEASED)	–
7.	WOODBRIDGE (DIGITAL)			
	A.E.S. HQ. (LOBBY)	IN	CRT	–
	MALTON (O.W.C.)	IN	–	CRT
	ROGERS CABLE TV	IN	–	CRT
	O.M.N.R. QUEENS PARK	IN	–	CRT
8.	A.E.S. SCEPTRE LAB	–	ALDEN	–
	AES MAINTENANCE BRANCH	–	ALDEN	–
			MUIRHEAD (LEASED)	–

TABLE A.4 SUMMARY OF RADAR SITES AND RECEIVING SITES.

CURTISS-WRIGHT RADAR SITES

LOCATIONS		LINE STATUS	PRESENT TYPE OF RECORDER/CRT	PROPOSED TYPE OF RECORDER/CRT
1.	HALIFAX AIRPORT			-
	BEDFORD	-		-
2.	WINNIPEG AIRPORT		ALDEN	-
	WINNIPEG (P.O.) PRWC	IN	ALDEN	-
3.	EDMONTON AIRPORT		ALDEN	-
	ARGYLL CENTRE	IN	ALDEN	-

TOTAL ALDENS ON SITE 22
TOTAL ALDENS REQUIRED 2
TOTAL MUIRHEAD LEASED 3

TABLE A.4 CONTINUED FROM THE PREVIOUS PAGE

TABLE A.5-1 AES SITES WITH K560 RECEIVERS HAVE ACCESS TO SATELLITE PHOTOS

OFFICE	TYPE	K560 RECEIVER		K470 XMTR	
PACIFIC WEATHER CENTRE	W01	2 (AES OWNED)		1	
ARCTIC WEATHER CENTRE	W01	1			
ALBERTA WEATHER CENTRE	W01				
YUKON WEATHER CENTRE	W01				
PRAIRIE WEATHER CENTRE	W01	1			
ONTARIO WEATHER CENTRE	W01	1			
CENTRE DES PREVISION DU QUEBEC	W01	1			
ATLANTIC WEATHER CENTRE	W01	1		1	
GANDER	W01	1			
VICTORIA	W03				
YELLOWKNIFE	W03				
SASKATOON	W03				
REGINA	W03				
RESOLUTE	W03				
CASTLEGAR	W04				
KAMLOOPS	W04				
KALOWNA	W04				
PENTICTON	W04				
PORT HARDY	W04				
PRINCE GEORGE	W04				
TERRACE	W04				
VANCOUVER	W04				
CALGARY	W04				
EDMONTON INT A/P	W04				
EDMONTON MUNIC. A/P.	W04				
FORT NELSON	W04				

TABLE A.5-1 CONTINUE

OFFICE	TYPE	K560 RECIEVER			
FORT ST. JOHN	W04				
GRANDE PRAIRIE	W04				
INUVIK	W04				
LETHBRIDGE	W04				
BRANDON	W04				
CHURCHILL	W04				
DAUPHIN	W04				
PRINCE ALBERT	W04				
THOMPSON	W04				
THUNDER BAY	W04				
WINNIPEG INT A/P	W04				
HAMILTON	W04				
KINGSTON	W04				
WATERLOO - WELLINGTON	W04				
LONDON	W04				
NIAGARA DISTRICT (ST CATHARINES)	W04				
NORTH BAY	W04				
OTTAWA	W04				
PETERBOROUGH	W04				
SARNIA	W04				
SAULT STE. MARIE	W04				
SUDBURY	W04				
TORONTO W.O.	W04				
WINDSOR	W04				
QUEBEC	W04				
[illegible]ABEL	[illegible]				
DORVAL	W04				
SEPT ILES	W04				

TABLE A.5-1 CONTINUE A51

OFFICE	TYPE	K560 RECEIVER			
SHERBROOKE	W04				
ST HUBERT	W04				
TROIS RIVIERES	W04				
VAL D'OR	W04				
FROBISHER	W04				
CHARLOTTETOWN	W04				
FREDERICTON	W04				
GOOSE BAY	W04				
HALIFAX INT. A/P	W04				
MONCTON	W04				
SAINT JOHN	W04				
ST. JOHN'S	W04				
SYDNEY	W04				
[illegible]		1			
ICE FORECAST CENTRE					

TABLE A.5-2 AVAILABILITY OF SATELLITE PHOTOS AT DND - SITES

1 = YES, OTHERWISE NO

OFFICE	TYPE	K560 RECEIVER		
EDMONTON	CFFC	1		
NORTH BAY	CFFC	1		
METOC CENTRE HALIFAX	CFMETOC	1		
MET.. CENTRE ESQUIMAL	CFMETOC	1		
COMOX	CFWO	1		
TRENTON	CFWO	1		
GREENWOOD	CFWO	1		
BAGOTVILLE	CFWO			
CHATHAM	CFWO			
COLD LAKE	CFWO			
GAGETOWN	CFWO			
MOOSE JAW	CFWO			
PORTAGE LA PRAIRIE	CFWO			
PETAWAWA	CFWO			
TORONTO	CFWO	1		
[illegible]	CFWO			
OTTAWA	CFWO			
SHEARWATER	CFWO			
SUMMERSIDE	CFWO			
WINNIPEG	CFWO			

TABLE A.6-1 CONTINUED

OFFICE	(REGION)	TYPE	RADAR SITES (PRESENT)	RCVD NOW?	FUTURE SITES
PRINCE GEORGE	(P)	W04			
TERRACE	(P)	W04			
VANCOUVER A/P	(P)	W04	ABBOTSFORD	NO	
CALGARY	(W)	W04	EDMONTON	NO	
EDMONTON INT A/P	(W)	W04	EDMONTON	YES	
EDMONTON MUN. A/P	(W)	W04	EDMONTON	NO	
FORT NELSON	(W)	W04			
FORT ST. JOHN	(W)	W04			
GRANDE PRAIRIE	(W)	W04			
INUVIK	(W)	W04			
LETHBRIDGE	(W)	W04			
BRANDON	(C)	W04	WINNIPEG	NO	BRANDON REGINA
[illegible]	(C)	W04			
[illegible]	(C)	W04	[illegible]	[illegible]	[illegible]
PRINCE ALBERT	(C)	W04			
THOMPSON	(C)	W04			
THUNDER BAY	(C)	W04			THUNDER BAY
WINNIPEG INT A/P	(C)	W04	WINNIPEG	YES	BRANDON
HAMILTON	(O)	W04	EXETER	NO	
			WOODBRIDGE	NO	
[illegible]	(O)	W04	CARP	NO	
			WOODBRIDGE	NO	
[illegible]-WELLINGTON	(O)	W04	EXETER	NO	
			WOODBRIDGE	[illegible]	
[illegible]		W04	EXETER	[illegible]	
			WOODBRIDGE	[illegible]	

TABLE A.6-1 CONTINUE

OFFICE	(REGION)	TYPE	RADAR SITES (PRESENT)	RCVD NOW?	FUTURE SITES
NIAGARA DISTRICT W.O (ST CATHARINES)		W04	WOODBRIDGE	NO	
	(O)		EXETER	NO	
NORTH BAY	(O)	W04			NORTH BAY
OTTAWA	(O)	W04	CARP	YES	
PETERBOROUGH	(O)	W04	WOODBRIDGE	NO	
SARNIA	(O)	W04	EXETER	NO	
SAULT STE MARIE	(O)	W04			SAULT STE MARIE
SUDBURY	(O)	W04			NORTH BAY
TORONTO W.O.	(O)	W04	WOODBRIDGE	YES	
			EXETER	YES	
WINDSOR	(O)	W04	EXETER	NO	
QUEBEC	(Q)	W04	VILLEROY	YES	
MIRABEL	(Q)	W04	CARP	NO	
			STE-ANNE-DE-BELLEVUE	NO	
			VILLEROY	NO	
MONTREAL (DORVAL)	(Q)	W04	CARP	NO	
			STE-ANNE-DE-BELLEVUE	?	
			VILLEROY	NO	
SEPT ILES	(Q)	W04			
SHERBROOKE	(Q)	W04	VILLEROY	NO	
ST. HUBERT	(Q)	W04	VILLEROY	NO	
			CARP	NO	
			STE-ANNE-DE-BELLEVUE	?	
[illegible] RIVIERES	(Q)	W04	VILLEROY	NO	
[illegible]	[illegible]	[illegible]			[illegible] BAY
[illegible]	[illegible]				

TABLE A.6-1 CONT'D AL1

OFFICE	(REGION)	TYPE	RADAR SITES (PRESENT)	RCVD NOW?	FUTURE SITES
CHARLOTTETOWN	(A)	W04	HALIFAX	NO	
FREDERICTON	(A)	W04	HALIFAX	NO	
GOOSE	(A)	W04			
HALIFAX INT A/P	(A)	W04	HALIFAX	YES	
MONCTON	(A)	W04	HALIFAX	NO	
SAINT JOHN	(A)	W04	HALIFAX	NO	
ST. JOHN'S	(A)	W04	TREPASSEY	YES	
SYDNEY	(A)	W04			

TABLE A6-2 DND OFFICE AND RADAR SITES

OFFICE	TYPE	RADAR SITES (PRESENT)	RCVD NOW?	FUTURE SITES
EDMONTON	CFFC	EDMONTON	NO	
NORTH BAY	CFFC	CARP	NO	
		WOODBRIDGE	NO	
		EXETER	NO	
		STE-ANNE-DE-BELLEVUE	NO	
METOC CENTRE HALIFAX	CFMETOCC	HALIFAX	NO	
		TREPASSEY	NO	
METOC CENTRE ESQUIMALT	CFMETOCC	ABBOTSFORD	NO	
COMOX	CFWO	ABBOTSFORD	NO	
TRENTON	CFWO	CARP	NO	
		WOODBRIDGE	NO	
GREENWOOD	CFWO	HALIFAX	NO	
BAGOTVILLE	CFWO	VILLEROY	YES	
CHATHAM	CFWO			
COLD LAKE	CFWO	EDMONTON	NO	
GAGETOWN	CFWO	HALIFAX	NO	
MOOSE JAW	CFWO			REGINA
PORTAGE LA PRAIRIE	CFWO	WINNIPEG	NO	BRANDON
PETAWAWA	CFWO	CARP	YES	NORTH BAY
TORONTO	CFWO	WOODBRIDGE	NO	
		EXETER	NO	
VALCARTIER	CFWO	VILLEROY	YES	
OTTAWA	CFWO	CARP	YES	
SHEARWATER	CFWO	HALIFAX	NO	
[illegible]	CFWO	[illegible]	NO	
[illegible]	CFWO	WINNIPEG		[illegible]

[illegible] 1Hb-2 [illegible] OFFICE AND RADAR SITES

OFFICE	TYPE	RADAR SITES (PRESENT)	RCVD NAD?	FUTURE SITES
EDMONTON	CFFC	EDMONTON	NO	
NORTH BAY	CFFC	CARP	NO	
		WOODBRIDGE	NO	
		EXETER	NO	
		STE-ANNE-DE-BELLEVUE	NO	
METOC CENTRE HALIFAX	CFMETOC	HALIFAX	NO	
		[illegible]	NO	
METOC CENTRE ESQUIMALT	CFMETOC	ABBOTSFORD	NO	
COMOX	CFWO	ABBOTSFORD	NO	
TRENTON	CFWO	CARP	NO	
		WOODBRIDGE	NO	
GREENWOOD	CFWO	HALIFAX	NO	
BAGOTVILLE	CFWO	VILLEROY	YES	
[illegible]	CFWO			
[illegible]	CFWO			
[illegible]	CFWO	[illegible]		
[illegible]	CFWO			[illegible]
PORTAGE LA PRAIRIE	CFWO	WINNIPEG	[illegible]	[illegible]
[illegible]	CFWO	CARP	[illegible]	[illegible]
[illegible]	CFWO	[illegible]	[illegible]	
		EXETER	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	

TABLE A.7. SUMMARY OF ESTIMATED TRAFFIC AND INCREASES

TRAFFIC COMPONENT	PRESENT		INCREASES
	5 MIN. PEAK	NORMAL	
Message			
Obs. Data - Per Person	13.6K	11.0K/Hr.	45%
Fcsts from IP's - per IP	7.2K	8.0K/Hr.	Little change (10% - 20%?)
Fcsts from CMC	25.5K	30.0K/Hr.	Little change (10% - 20%?)
NWS relayed	80.0K	300.0K/Hr.	Little change (20% - 30%?)
Batch	32.5K	55.0K/12 Hrs.	20 ≠ 13 ≥ 33-Fold
Interactive			
UP-IP per site	*100/7.0K	*600/12.6K/Hr.	Increase in no. of sites. See Table 8
S.-F.S.-CMC	**12.6K	3.1K	Little change, possibly becoming obsolete
Charts			
National	11.0M(62.5")	384.0M(2194")/Day	10 - 15% increase (more initially but decreasing)
Fcst		62%	
Presentation		92%	
Regional Per IP		91.0M(520")/Day	10 - 20% (?) Increase
Imagery			
Satellite		See Fig. 9	See Table 5 for additional sites
Radar		See Table 4	See Table 6 for additional sites for CATV: Satellite - 1 image/3 hrs.

* NN/MM NN Inquiry
MM Response

** Both ways

APPENDIX B - SCPC SYSTEMS

1.0 INTRODUCTION

The purpose of this appendix is to acquaint the reader with some of the characteristics of different SCPC systems in use now in various satellite systems. The pros and cons of the various systems are given and the reason for the choice of analog FM type for the AES communication system is given.

2.0 SINGLE CHANNEL PER CARRIER (SCPC)

The system proposed will be relayed by using SCPC (Single Channel per Carrier) techniques.

SCPC is a transmission system designed to allow a satellite transponder to be used in a multiple access mode by a number of different users. SCPC is most economic compared with other multiplexing methods such as Frequency Division Multiplex (FDM) or Time Division Multiplex (TDM) in situations where the traffic load offered by the users is small. SCPC is used in the Intelsat network as well as in a number of domestic satellite systems operating in the world today. These systems are designed basically for voice communications with a two-way (full duplex) voice circuit using two SCPC satellite carriers (one per direction).

The modulation system employed in SCPC may be digital or analog FM.

2.1 ANALOG FM SCPC

In the analog FM system, the analog voice signal is used to modulate a carrier directly. The carrier, after having been translated to the appropriate RF frequency, is transmitted via the satellite to the distant receiving earth station, and is demodulated, the voice signal being recovered. The quality of the voice signal corresponds to "toll" quality, i.e. the quality normally specified for long distance telephone operation. Data may be carried on an FM SCPC system in the same way that it may be carried over terrestrial telephone connections. For example data modems may be connected at the VF (voice frequency) interface and operated at speeds up to 9600 b/s. Alternatively, the voice frequency circuit may be used to carry up to 24 separate 75 b/s voice frequency telegraph (VFT) signals.

Analog FM systems are operating in many parts of the world including Alaska, Indonesia and Brazil. Channel frequency spacings commonly employed are 45 kHz, 30 kHz or 22.5 kHz, yielding 800, 1200 or 1600 carriers per 36 MHz satellite transponder. Note the number of two-way duplex circuits in each case is one half the number of carriers, i.e. 400, 600 or 800 circuits respectively.

Table I shows a summary of the characteristics of the different SCPC systems described. An important parameter to note from the table is the C/No required for each of the systems for a bit error rate of 1 in 10^6. C/No is a measure of the regional carrier-to-voice density ratio and as such determines important parameters in the satellite system such as transmit power, antenna diameters, low noise receiver sensitivity, etc. It may be seen from the table that analog FM, although restricted to a data rate of 9.6 kb/s, requires a lower value of C/No than the digital systems (which can operate at up to 56 kb/s). Consequently for a given set of satellite parameters, an analog FM system can operate with cheaper earth stations (e.g. smaller antennas, smaller transmitters, lower quality receivers).

This fact, together with the fact that in general Analog FM SCPC is cheaper to manufacture than it's digital counterpart has led to the section of analog FM for the AES communication system.

The earth stations considered for the AES system have been designed to deliver the C/No required (55 dBHz) when used with a Telesat Anik D satellite.

2.3 MINI-CARRIERS

The 9.6 kb/s bit rate capability of analog FM is more than is required by some of the AES Users or Collectors. For this reason, a narrow-band version of the SCPC system has also been proposed to form part of the system. The narrow band SCPC operates at a maximum bit rate of 300 b/s and the channel spacing is such that 5 carriers can occupy the 45 kHz bandwidth allocated for the "regular" analog FM SCPC. This system has been dubbed "mini-carrier" SCPC. For the equivalent bit error rate (1 in 10^6) the mini carrier system requires a C/No of 45 dBHz (i.e. 10 dB less than the regular carriers). The earth station transmit power for the mini carriers is therefore 10 dB less than for the regular SCPC.

In the proposed AES Communication Network, the manner in which the mini carriers are used is different to the way in which the regular carrier is used in an important respect. Whereas the regular (9.6 kb/s) carrier is "one-way" broadcast from CMC, the mini carriers are used as two-way half-duplex circuits. The circuits are configured in such a way that they connect CMC radially to all other stations. Circuits may be dedicated to a particular station or else may serve a group of stations which access the circuit on a time-shared basis. "Half-duplex" means that one frequency slot (one fifth of a "regular" 45 kHz slot) is used for communication from CMC to the User (for example) and communication from the User to CMC. Clearly the communication can only be in one direction at a time so that the communication is "half-duplex".

Full duplex is the arrangement already described where two frequency slots are allocated for a two-way circuit and communication can be two-way simultaneously. The "half-duplex" nature of the mini-carrier system is particularly suitable for AES since with a group of stations sharing a half duplex circuit, each station is able to receive and monitor the transmissions of other stations' data being input to AES. This corresponds to the present arrangement of stations on multidrop lines.

2.4 56 kb/s OPERATION

The possibility exists that the AES communication system may require, initially or at a later date, bit rates in excess of 9.6 kb/s. The basic satellite system configuration may be used with analog FM SCPC (up to 9.6 kb/s) or digital SCPC (up to 56 kb/s) or a mix of the two. Although the system is designed (i.e. antenna sizes, transmitter power selected) for the analog FM system, upgrading to digital SCPC is possible by:

- replacing analog FM SCPC channel units by digital ones; and
- replacing transmitter high power amplifiers (HPAs) by more powerful ones.

	Analog FM	Intelsat	Digital	
			Telesat	
			2-phase	4-phase
Channel spacing (kHz)	45 typical	45	60	30
Transmission rate (kb/s)	analog	64	40	40
Data rate (kb/s)	9.6	48 or 56	40	40
Encoding	N/A	7 bit PCM	40	40
C/No at operating point (dBHz)	55	61.3	59.2	59.7
Bit error rate @ operating point	1x10-6	1x10-6	1x10-6	1x10-6
C/No at threshold	49	59.3	53	53.5
Bit error rate @ threshold	1x10-2	1x10-4	1x10-2	1x10-2
Number of carriers per 36 MHz	800	800	600	1200

Table I   Comparison of SCPC Systems

APPENDIX C - OFF-NET IMPROVEMENTS

AES should undertake, or commission a study of the use of modern channel evaluating adaptive HF radio systems and meteor-burst communication systems in "off-net" communications. The combination of microprocessors, LSI, and other solid state electronics has led to the resurrection of HF, a technology subject to the vagaries of the upper atmosphere. Likewise, propagation via the ionized trails left by meteors has received renewed interest lately, particularly for data collection from DCP's.

One suspects that very few of the many HF radio links in the AES communication network operate with the automatic assistance that is available.

APPENDIX D - FAX SCHEDULE

AES should carefully review its chart distribution schedule. At the present time it is desireable to have all regional charts distributed simultaneously while the fax network is configured as a series of regional nets; or, from another point-of-view, the fax network is switched into a number of regional nets at certain times so that charts can be distributed regionally. Use of a limited number of satellite broadcast channels would be much more effective if charts from different regions could be transmitted consecutively on a scheduled basis (or from buffer storage). The maximum delay would be a function of the number of channels, the number of charts, and the duration of the transmission. It could be minimized without seriously interferring with operational procedures, if, adjustments in those procedures were made part of the overall system design.

APPENDIX E - DIGITIZATION

The conclusion that the communication system should be digital is based on a number of reasons. Information may be transmitted with greater reliability and with control over transmission errors if it is in digital form, even on poor channels. Information in digital form may be stored and manipulated with much more flexibility than information stored in an analog form, i.e., it may be processed with digital computers. Major technological advances in integrated circuits are pushing the move to all-digital electronics. Digital equipment is more reliable, stable and versatile than analog equipment. The equipment is amendable to remote and self-diagnosis and fault location.

The trend towards digital communication is receiving significant impetus from the adoption of international standards and protocols for terminals, network access, signalling, and switching which will permit a subscriber who conforms to these standards to utilize world-wide facilities and a host of services.