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Feasibility Study Utilizing Meteor Burst Communications for Vessel Monitoring

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Final Report

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16. Abstract

This document discusses the feasibility of using meteor burst communications for monitoring vessel position, in particular the Prince William Sound VMS near Valdez, Alaska. This document describes the equipment and operational performance of meteor burst in the telemetry of vessel position data.

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PREFACE

The Prince William Sound Vessel Traffic Service (VTS) was established in 1977 to prevent loss of life and loss of property and to protect both the navigable waters surrounding Valdez and their resources from environmental damage. At the present time, vessels report their arrival at various checkpoints via VHF-FM radio. As the Valdez port area is developed, the number of ships being monitored is expected to increase markedly. To accommodate this growth, a system of automatic vessel position reporting utilizing a meteor-burst communication channel has been proposed. This study details the cost and performance of such a system and presents a plan for a feasibility test.

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1 REQUIREMENT

The Prince William Sound area leading into Port Valdez is expected to have a rapid escalation in vessel traffic in the next ten years. This report is an investigation of using meteor burst communications to perform the interrogation of ships in the Vessel Traffic Service area where they will transpond with their position, thus establishing tracks of interested shipping. Both the Alaskan Meteor Burst Communication System (AMBCS) and a system at or near Valdez will be evaluated.

2 PERFORMANCE ESTIMATE

Performance is defined as the time it takes to receive a data track from a ship with a specified reliability. For a 0.9 reliability, the average waiting time is 4.1 minutes, with a worst case of 12.1 minutes. The worst case time occurs from January to April from 1600 to 2000 in the evenings.

The spacial diversity characteristic of meteor burst communications provides automatic time multiplexing of responses from the ships. Thus, the expected traffic level can readily be serviced.

3 SHIPBOARD TERMINAL

The shipboard terminal will consist of a Meteor Burst Transceiver, Loran C receiver and their antennas. The cost

2) an additional master station receiver would be required at the AMBCS, and

3) a phone line from Anchorage to Valdez would have to be leased.

The use of the mobile system is recommended because of the reduced cost and having dedicated equipment. Operation on the AMBCS is required to be on a non-interference basis with the current owners.

Committment for use of the government mobile system should be made by June 30, 1981 to ensure its availability. Clearance for use of the mobile system's operating frequencies should also be obtained from the Alaska Federal Government frequency coordinator. Frequency authorization is not considered a problem as they have previously been cleared for the Anchorage area.

1.1 REQUIREMENTS

The basic requirements for vessel tracking in the Prince William Sound are:

1) Up to 18 vessels are to be monitored at any given time.

2) A track update is required every six (6) minutes.

3) Each vessel transponds with LORAN C time difference signals (T_D). Time difference signals are preferable over Lat-Lon data because the method of computation varies between manufacturers of LORAN equipment.

4) Each vessel on its first "check-in" responds with its name and identification. All subsequent position reports include just the ship's ID and position.

Detailed requirements are given in Appendix A.

1.2 FUNCTIONAL DESCRIPTION AND PERFORMANCE ESTIMATES

A meteor burst system has two types of terminals; (1) a master or interrogating station and (2) a remote or transponding station. The remote station will be the shipboard terminal. For this investigation, the master station will either be the existing Alaskan Meteor Burst Communication System or a separate one located at the VTC in Valdez. Figure 2-1 is a diagram showing the major elements of the system.

The use of either master station will result in burst times on the average of 30 milliseconds, therefore the

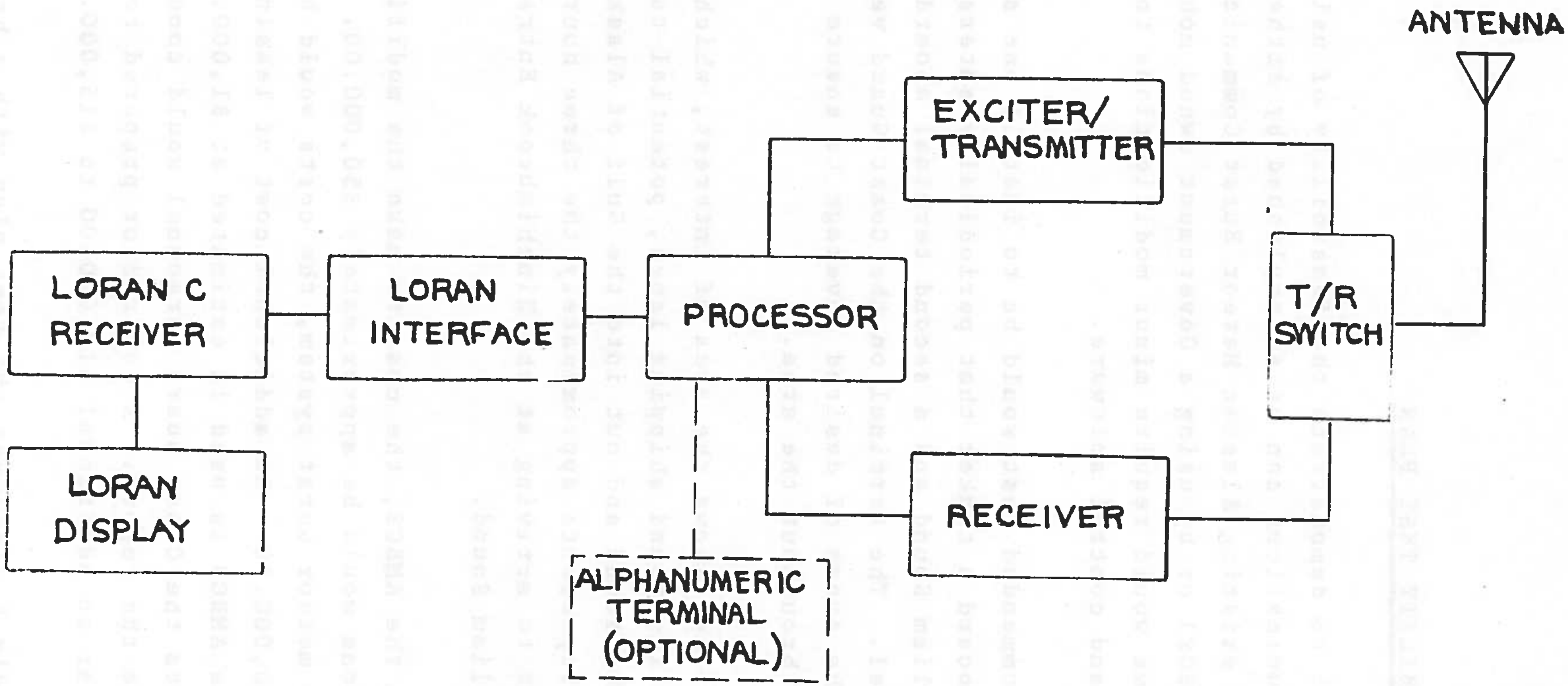

FIGURE 1-1: METEOR BURST SHIPBOARD TERMINAL

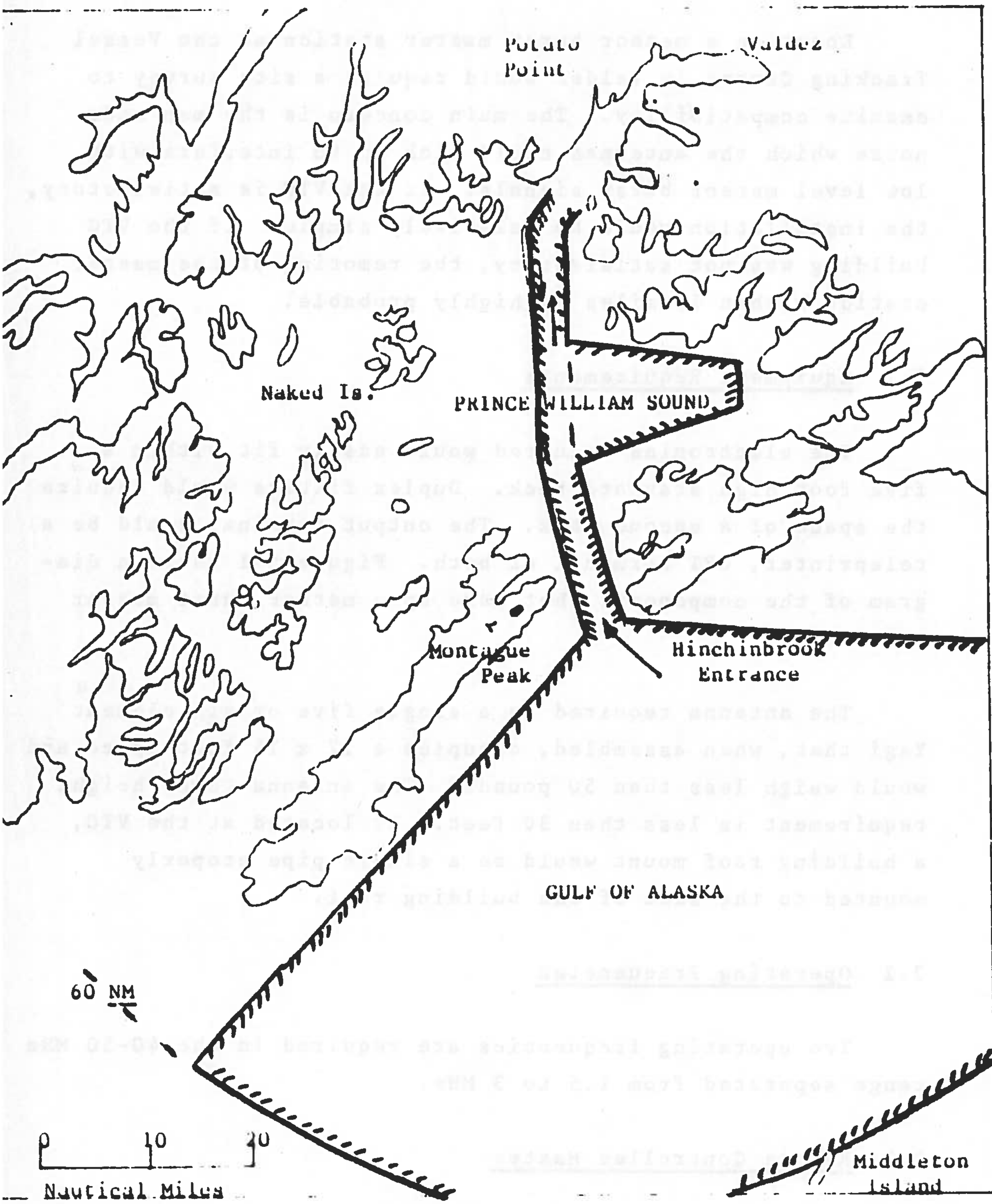

FIGURE 1-2: TEST AREA

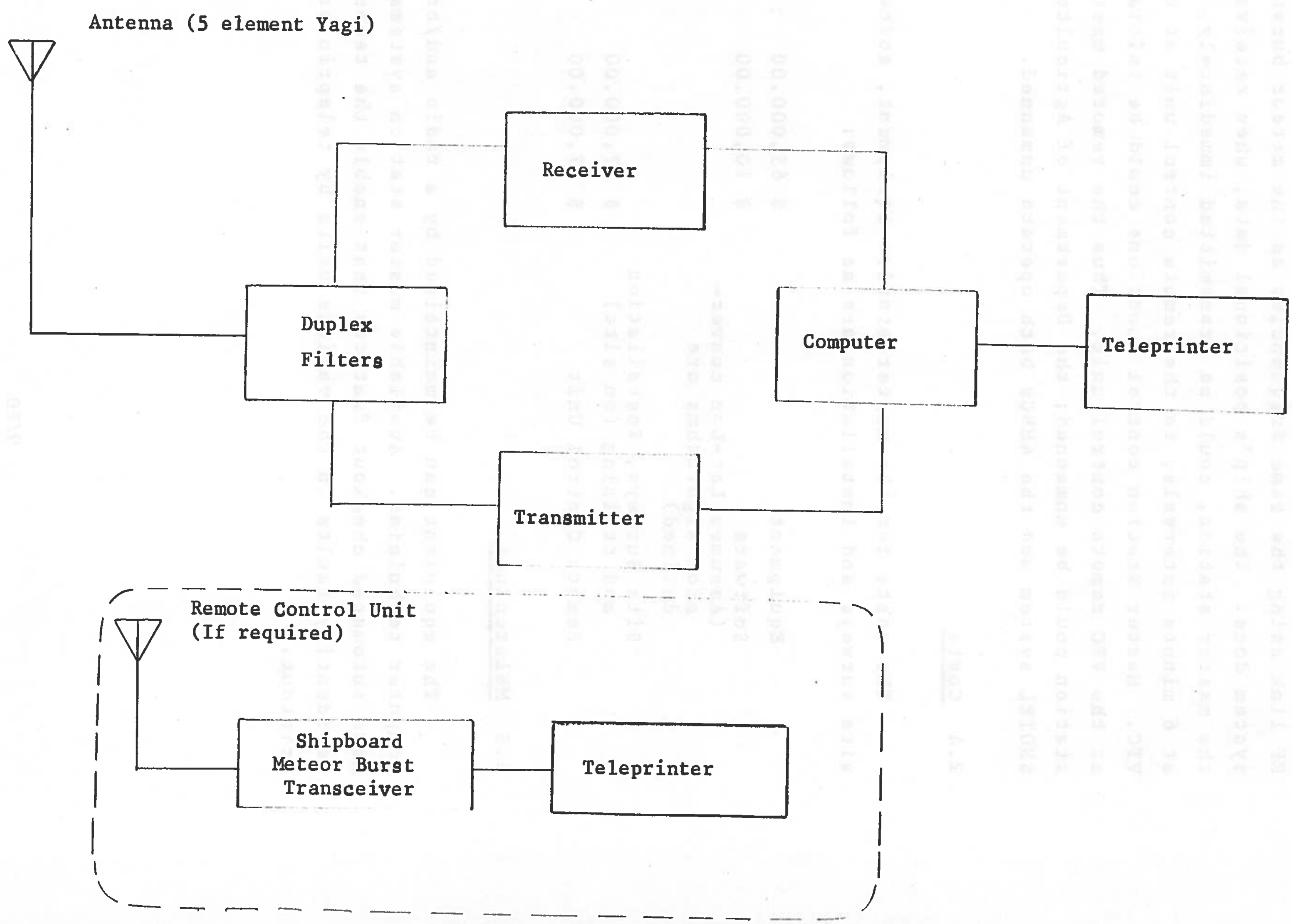

FIGURE 2-1: METEOR BURST MASTER STATION

APPENDIX A
VESSEL TRAFFIC COMMUNICATION SYSTEM REQUIREMENTS
FOR VALDEZ, ALASKA

1. INTRODUCTION

The Prince William Sound Vessel Traffic Service (VTS) in Valdez, AK has been in operation since 25 July 1977. Mandated under the Trans-Alaskan Pipeline Authorization Act (P.L. 93-153) of 1973, the Valdez, AK, VTS was established to prevent loss of life and loss of property and to protect both the navigable waters surrounding Valdez and their resources from environmental damage. The VTS service area includes the waters of Port Valdez, Valdez Narrows, Valdez Arm and Prince William Sound. Figure 1 shows the service area.

The VTS operations center is located in the Coast Guard Marine Safety Office in the town of Valdez, AK. Called a Vessel Traffic Center (VTC), this facility is operated on a 24-hour-a-day, 7-day-a-week basis. From the VTC, all vessel traffic moving in both Prince William Sound and in the Valdez area is continually monitored, and advisories are issued to promote safe traffic movement. The amount of attention paid to any given vessel is a function of the vessel's size, its use and its location in the service area. Oil tankers, calling at the Alyeska Marine Terminal in Valdez, are monitored most closely.

2. BACKGROUND

2.1 VTS OPERATIONS

Participation in the VTS and its monitoring scheme is made mandatory by regulation. Most vessels operating in the service area are required to report their arrival at various checkpoints over VHF-FM radio. However, oil tankers are more closely monitored as they transit in and out of Port Valdez. Tankers are required to make preliminary reports of their arrival both twenty-four hours and three hours prior to arriving at Hinchinbrook Entrance. In addition, they are required to call the VTC at least thirty minutes prior to either entering into or getting underway in the VTS service area.

When underway in the service area, tankers are monitored by two means: (a) radar and (b) a Vessel Movement Reporting System (VMRS). Radar coverage is available from Naked Island into Port Valdez (see Figure 1-2). While a tanker is under radar surveillance, personnel at the VTS plot its position every six minutes. The VMRS is used to monitor each tanker's transit from Naked Island to Hinchinbrook Entrance. Under the VMRS scheme, a tanker reports its position via VHF-FM radio when it arrives at either of two checkpoints: (a) abeam of Naked Island and (b) abeam of Schooner Rock at Hinchinbrook Entrance. In traveling between these two checkpoints, the tanker is required, by regulations, to follow the lanes of a Traffic Separation Scheme (TSS). The TSS lanes are shown in Figure 1-2.

2.2 TRAFFIC VOLUME

Currently, an average of two tankers per day call at Valdez. Each tanker makes two transits of the route from Valdez to Hinchinbrook Entrance, for a total of four transits. There are presently approximately fifty vessels that are involved in this particular trade.

In addition, the Valdez port area is being expanded to include an oil refinery and a container port. Further, the volume of tanker traffic will increase, because the Alyeska Terminal is capable of accomodating four oil tankers simultaneously. Also, an anchorage has been established in Prince William Sound in the vicinity of Knowles Head. These developments will markedly increase the number of ships that would have to be monitored. A worst-case estimate is that there could be eighteen ships in Prince William Sound, not under surveillance, that would have to be monitored by some means.

3. PROJECT OBJECTIVE

The basic objective is to provide increased position monitoring capability during a vessel's transit through the current VMRS monitoring area in Prince William Sound. It is felt that this objective can be met by periodically telemetering each vessel's position to the VTC as it proceeds along the TSS lanes. Since oil tankers are required, by regulations, to carry Loran-C receivers, it is anticipated that, in the near term, the increased monitoring can be accomplished by transmitting the Loran-C time difference readings to the VTC for processing and display. In addition to monitoring tankers as they transit the VMRS surveillance area, it is desirable to have similar monitoring extending seaward to the area of the three hour pre-arrival report.

In the future, when container carriers and petroleum refinery product carriers begin calling at Valdez, they may also come under the monitoring scheme. At present, there is no requirement that these types of vessels carry Loran-C receivers; however, by 1982 they will be required to carry some device that will provide a continously updated position readout, probably in terms of latitude and longitude. These types of navigation equipment could be used to telemeter position information in the same manner as the Loran-C receivers.

4. CONCEPT FOR IMPROVED VESSEL MONITORING

The geographical area in which improved vessel monitoring is required includes the portion of Prince William Sound from Naked Island to Hinchinbrook Entrance and the portion of the Gulf of Alaska within a sixty mile radius of Hinchinbrook Entrance. The concept of operation is that as a vessel transits this area, it transmits its current position and an identification number to the VTC for processing and display. A time annotation is appended to this report immediately upon receipt. The period between successive reports will be: (a) not longer than six minutes apart when the vessel is in Prince William Sound and (b) not longer than fifteen minutes apart when the vessel is in the Gulf of Alaska.

The system check-in/check-out procedure will start and end the proposed monitoring sequence. Upon either arriving at the check-in area three hours from Hinchinbrook Entrance or prior to getting underway to depart from Valdez, a vessel will enter the system by transmitting its name and identification number to the VTC. After successful receipt of the check-in message has been assured, it will begin transmitting its ID number and current position readout from the Loran-C receiver. When a ship either moors at Valdez or departs the three hour check-in area, the ship will simply stop transmitting the monitor data.

5.2 SHIPBOARD OPERATIONS

The shipboard equipment will operate automatically. The meteor burst communications device will be connected to a Loran-C receiver. Each time the Loran-C receiver display is updated, the same information will be input to the communications device. In addition to the Loran-C data, the shipboard equipment will store the ship's name and identification number. Assuming that the Loran-C receiver is turned on and operating properly, the shipboard operator need only turn on the meteor burst communications device to place the shipboard system in operation. The following features are required:

(a) The capability to transmit two types of messages:

(1) The initial entry message which consists of a twenty five character alphanumeric ship name block and a five character numeric ship identification number block.

(2) The position report message which consists of a five character numeric ship identification number block and a fourteen character alphanumeric postion information block.

(b) An indicator that shows the shipboard operator that his equipment is operating properly.

(c) An indicator that shows the shipboard operator that communications are being carried out in the expected manner.

5.3 COMMUNICATIONS PROCEDURES

Communications between the VTC and each vessel will be automatic. A shipboard operator will be able to energize his equipment and have communications established without further effort on his part. When a vessel is outside of the monitoring area, communications will be terminated by the shipboard operator switching off his equipment. Information from each ship will be relayed to the VTC in the following manner:

(a) When each vessel sends its initial entry messages, the messages will be time annotated and immediately printed out at the VTC.

(b) When each vessel sends the first position report message after the entry message, the message will be time annotated and immediately printed out at the VTC.

(c) All messages received will be immediately time annotated and stored. Storage will be in a manner that allows retrieval by calling out either a ship's name or its identification number.

(d) Timing of the message print out at the VTC will begin with the print out of the first position report message.

the ionized trails exist for only short periods of time, (usually for a few milliseconds to a few seconds), communication linkage is intermittant and high speed digital pulse transmission techniques must be used to transfer the information. Billions of ionized meteor trails are produced daily in the earth's atmosphere, providing many potential reliable message exchanges per hour.

At the present time there are several methods of data communication over long ranges. These methods include HF ionospheric scatter links, VHF repeater links, microwave links, telephone lines, and satellites.

HF scatter systems are plagued by ionospheric losses which are frequency dependent. This requires that the operating frequency be variable in order to minimize these losses. Another problem with HF systems is that they suffer from large amounts of fading which can be due to several ionospheric phenomena; e.g., movements of the ionosphere causing interference fading, rotation of the axis of the polarization ellipsis, time variations in ionospheric absorption, focusing, and skipping of the signal due to maximum usable frequency (MUF) failure. Periods of this fading are highly irregular and can vary from a fraction of a second to a few hours depending upon the cause. Fading and ionospheric losses can render an HF system useless for long periods of time.

Microwave and VHF links are line-of-site, thus requiring the use of repeaters if over the horizon ranges are to be covered. This presents an installation and maintenance problem especially in remote, mountainous areas. Initial cost of the system is also high. Microwave systems are also geographically fixed, thus preventing system changes or expansion without extra cost.

Telephone lines suffer from all the same problems as microwave links with respect to installation, maintenance and flexibility.

in favor of the satellite's higher performance in long range, wide bandwidth operations.

In the 1970's, with the advances in solid state and processor technology, meteor burst equipment became economically feasible for many low data rate applications. Systems that were developed and are currently in operation are:

1) Department of Agriculture's SNOTEL system,
2) Alaska Meteor Burst Communications System (AMBCS),
3) Military vehicle following/short message system.

The SNOTEL system meteor burst network is for telemetry of snow pack data from sites through the 11 Western States. Over 400 data sites are installed, with the master or interrogating stations located at Boise, Idaho and Ogden, Utah.

The AMBCS has a master or interrogating station at Anchorage, with data sites through the state of Alaska. Five Federal Agencies (Corps of Engineers, BLM, Dept. of Agriculture, USGS, and National Weather Service) jointly own and operate the system. The AMBCS uses the same type production equipment as the SNOTEL system. An alphanumeric message capability is also integrated into this system.

The military flight following/short message traffic system was designed for mobile applications. The master station is installed in a small van to be transported to any desired location and quickly set up for operation. The remote terminal was designed to interface with a navigational unit (LORAN C) and provide automated flight tracking in conjunction with a short message capability.

The development and operation of the above major systems has proven the applicability of meteor burst communications

The meteor, as it enters the upper atmosphere traveling at speeds of 10 to 75 Km/second, possesses a large amount of kinetic energy. As it begins colliding with air molecules, much of this kinetic energy is converted into heat which effectively vaporizes atoms from the surface of the parent meteor. These vaporized atoms, which are traveling at about the same speed as the meteor, are further restricted by air molecules as they progress further into the atmosphere. This results in the transformation of kinetic energy into the energy of ionization which effectively strips electrons from the atoms leaving a trail of positive charged ions and free electrons. It is the electrons that reflect or re-radiate radio waves.

This ionization is distributed in the form of a long, thin paraboloid with the particle at the head. The electron line density (electrons/meter) is proportional to the mass of the meteor, and ranges from 10^{18} electrons/meter to about 10^{10} electrons/meter. Typical trails are 25 Km long and have an initial trail radius of about 1 meter.

2.3.2 Physical Properties of Meteors Meteors are defined as extraterrestrial objects that travel in orbits (elliptical) around the sun, and at some point in these orbits enter the earth's atmosphere. These objects can be divided into two basic classes:

Shower Meteors - These are groups of particles all moving with the same velocity in fairly well-defined orbits around the sun. To an observer on earth, they are the most spectacular and appear to radiate from a common point in the sky (called the radiant). Shower meteors account for only a small fraction of the total incidence of meteors.

Sporadic Meteors - These are particles that move in random orbits around the sun and account for the vast majority of meteors that are used in radio work.

Their radiants and times of occurance are random and cannot be catalogued as shower meteors can; however, it is known that they are not uniformly distributed in the sky but are mostly confined to within about 20° of the elliptic plane (the plane of the earth's orbit about the sun). Also, the intersection of the meteor orbits with the earth's orbit are not uniformly distributed but are concentrated so as to produce a maximum of intersections in August and a minimum in February, with about 3:1 variation. The rate of incidence of sporadic meteors is further dependent upon the time of day with the morning hours being more active. On the morning side of the earth, meteors are swept up by the forward motion of the earth in its orbit around the sun. On the evening side, the only meteors reaching the earth are those which overtake it. A daily variation of about 4:1 can be expected. The reason for this variation is illustrated in Figure 2.

Another interesting and useful fact about sporadic meteors is their mass distribution. This distribution is such that there are approximately equal total masses of each size of particle (i.e., there are 10 times as many particles of mass 10^{-3} grams as there are particles of mass 10^{-2} grams). Table 1 lists the approximate relationship between mass, size, electron line density, and number.

2.3.3 <u>Characteristics of Reflected Signals</u> Radio signals received on a meteor-burst link are basically of two forms, the most prevalent of which is the underdense trail reflection. In this case, the reflecting meteor is characterized by a relatively low electron line denisty ($q \leq 10^{14}$ electrons/meter). An underdense trail does not actually reflect energy; instead, the radio wave passes through the trail, exciting individual electrons as it does. These excited electrons act as small dipoles re-radiating the signal at an angle equal but opposite to the incident angle of the trail and radio signal. Signals from underdense trails rise to an initial peak value in a few hundred microseconds and have typical durations as long as a few seconds. The decay in signal strength is due to destructive phase interference caused by the radial expansion of diffusion of the trail's electrons.

Meteor trails with electron line densities greater than 10^{14} electrons/meter actually reflect signals and are called overdense. Here, the line density is so great that radio signals cannot penetrate them and are reflected instead of being re-radiated. There are no distinctive signal patterns associated with overdense trails except that the signals usually reach higher amplitudes than underdense meteors and last longer. Signal fading often occurs due to reflections from two parts of the trail constructively and destructively interfering. Ionosphere winds also blow the trails around, causing some of the fading. Thus, due to the unpredictable nature of the overdense signals, no useful theory has been developed to describe them.

Other means of communication over a typical MBCS are aircraft reflections and sporadic "E". The airplane reflections usually last many seconds and are characterized by a great deal of signal fading. The aircraft's altitude limits the range of useful communications. Sporadic "E" is a transient or irregular layer of the ionosphere, which results in a reflecting surface, providing a low loss continuous communication path. Sporadic "E", in the mid-latitudes, is more prevalent during the summer months of June and July, and has been observed to occur for periods of time up to several hours.

TABLE B-2. METEOR BURST PERFORMANCE CONSTRAINTS

Parameter	Comment
Communication Type	Digital, voice is not practical.
Operating Range	0-1200 statue miles, relays can extend this range.
Operating Frequency	30 to 200 MHz. The most practical range is 35 - 50 MHz. At higher frequencies, performance is reduced, however, privacy and survivability is enhanced.
Burst Time/Duty Cycle	The time available for communications on each "burst" varies with operating frequency and range. Average burst time duration increases as range increases and decreases as operating frequency is increased.
Space Diversity	Signal footprint is relatively small, a few miles at short ranges (100-400 miles), and becomes increasingly larger at longer ranges (30-50 miles).
Diurnal Variations	Meteor rate (meteors per hour) varies as to time of day. This rate will vary at an average between 3 and 4 to 1 between morning and evening hours. The morning hours have the higher rate.
Annual Variations	The maximum meteor rate is in the summer-fall months and the minimum meteor rate time is the winter-spring periods. The variation of the rates is in the region of 3 to 1.

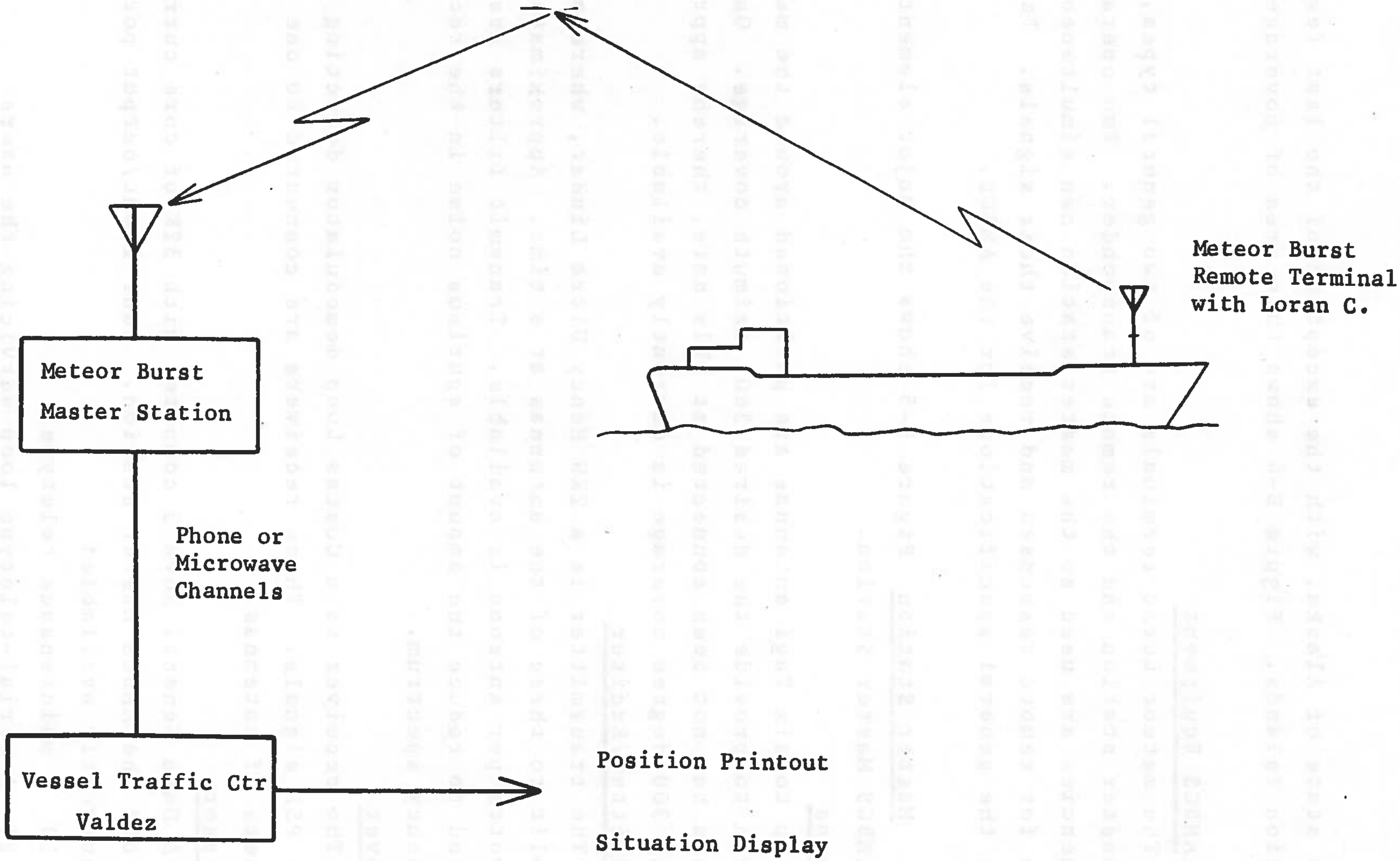

FIGURE B-3: VESSEL MONITORING (DATA TELEMETRY BY METEOR BURST)

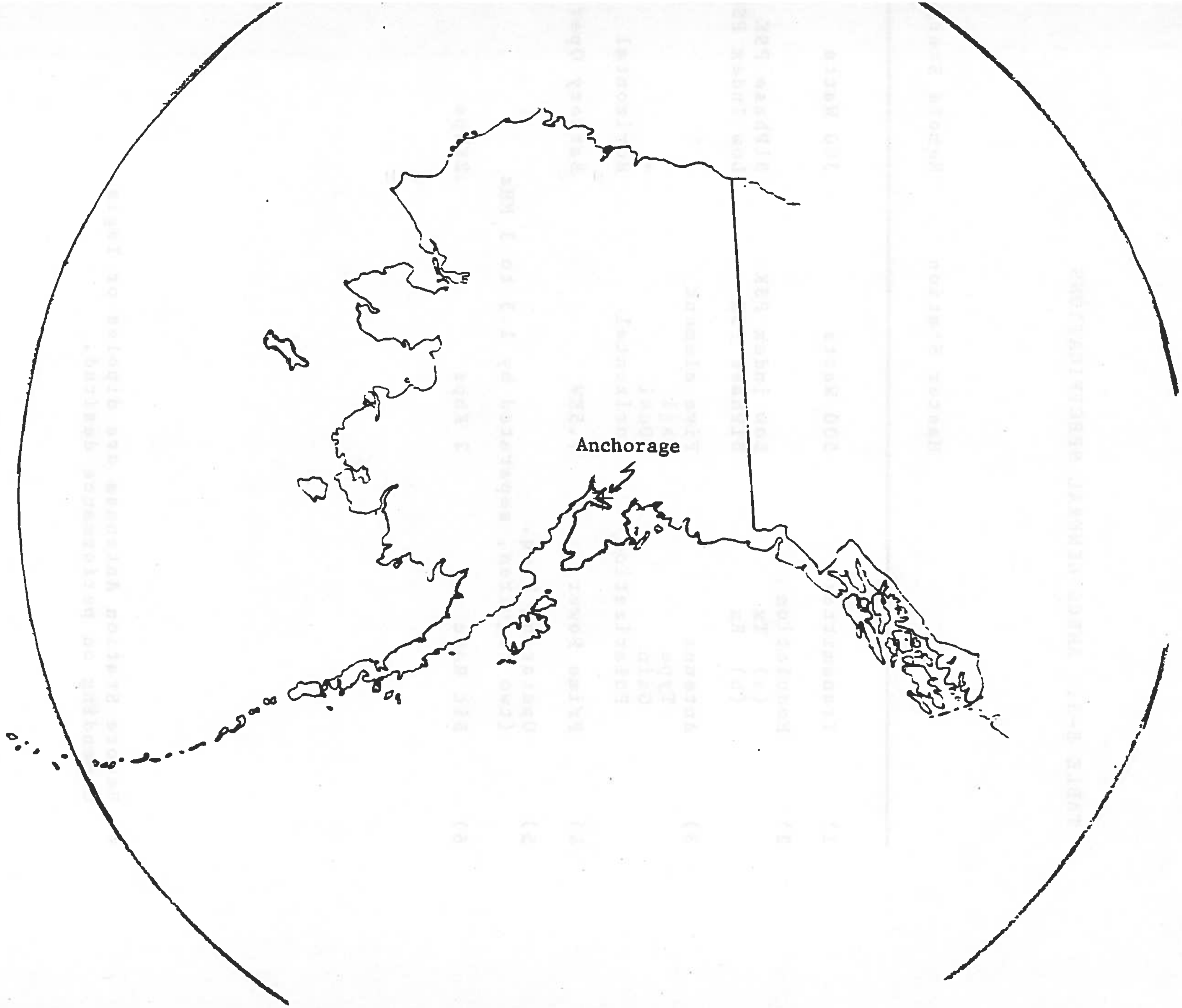

FIGURE B-4: ALASKA METEOR BURST COMMUNICATION SYSTEM (AREA OF COVERAGE)

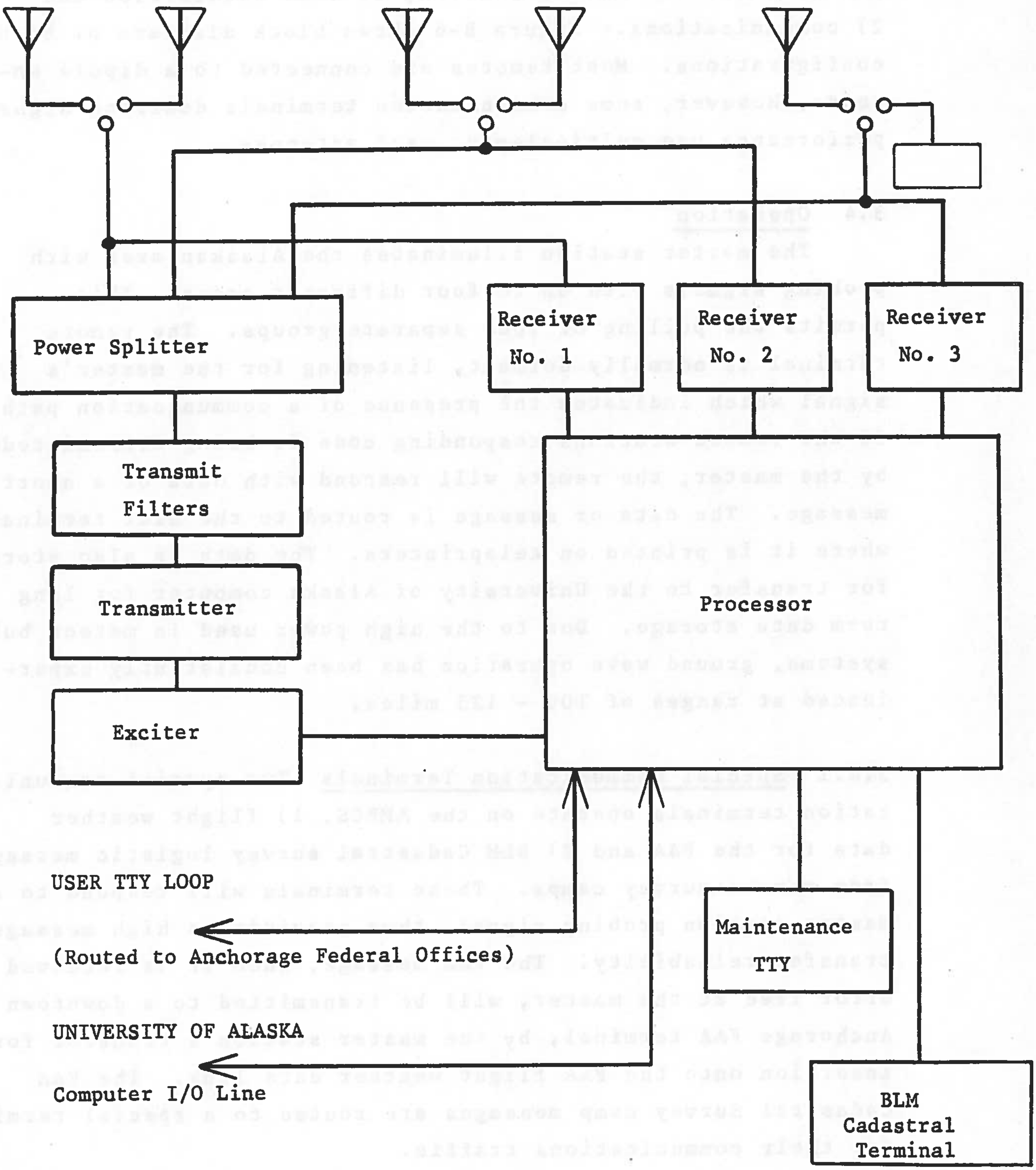

FIGURE B-5: ALASKAN METEOR BURST COMMUNICATION SYSTEM (MASTER STATION)

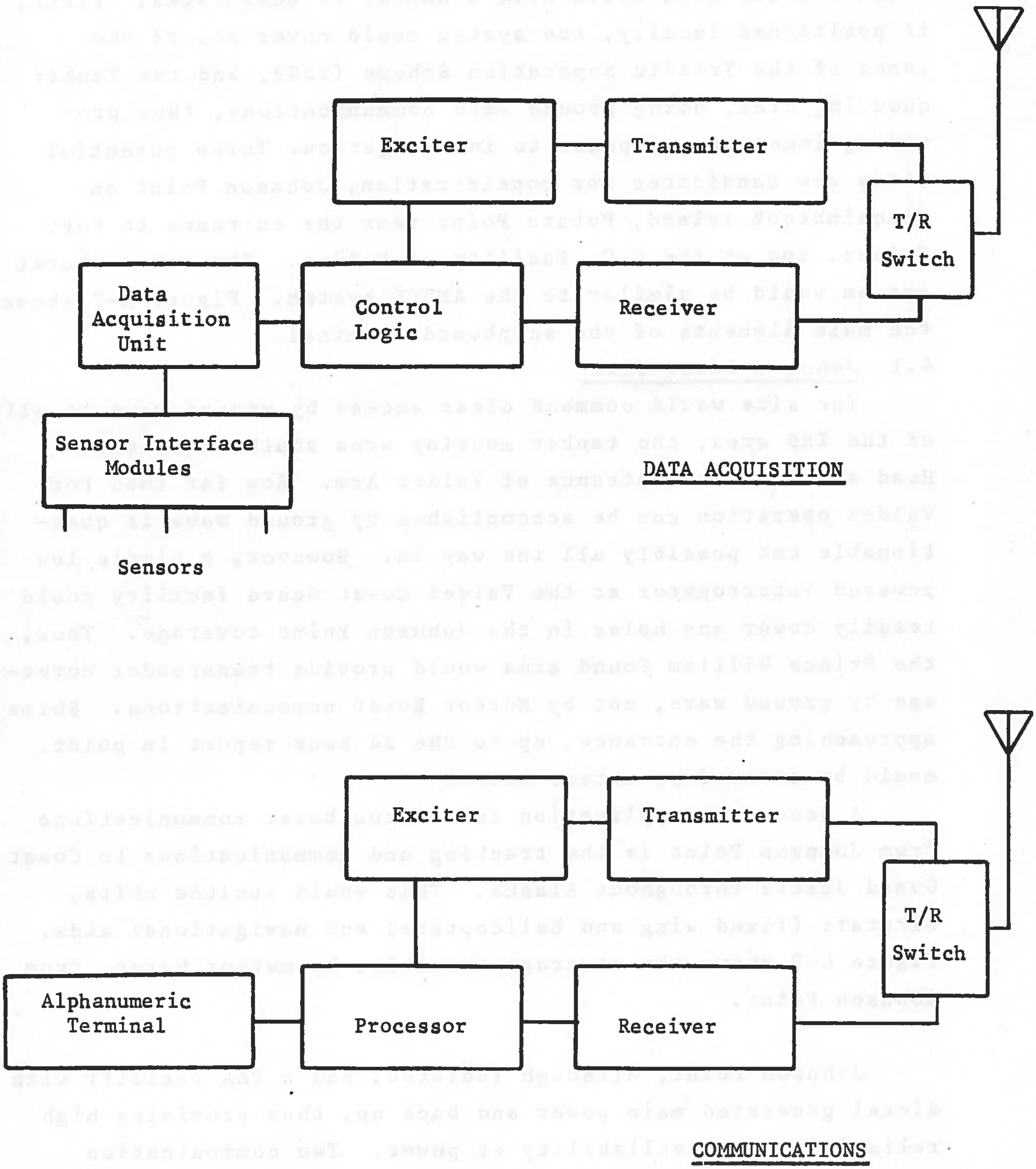

FIGURE B-6: ALASKAN METEOR BURST COMMUNICATION SYSTEM (REMOTE TERMINALS)

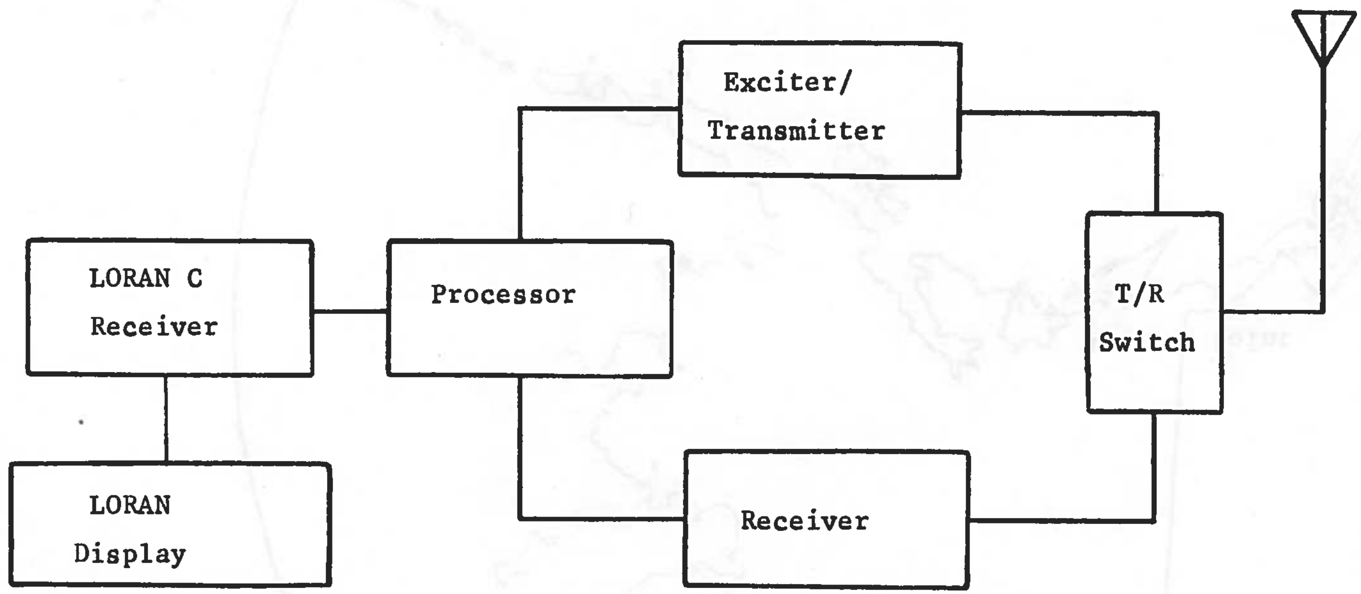

FIGURE B-7: METEOR BURST SHIPBOARD TERMINAL

Valdez. The second, a FAA VHF link to Strawberry Point, connecting to an Alascom terminal, then into Valdez on the Alascom network. Thus primary back up communication links to Valdez are available from Johnson Point.

4.2 Potato Point

The Potato Point facility currently houses the radar used in the current VTS, thus power and communications are available. Ground wave coverage by meteor burst would be possible throughout the VTS area, including Valdez Channel and Port Valdez. Coverage at the moorage, tanker queueing area, is probable but questionable.

Communications to Valdez could also be implemented within the meteor burst system. A remote receiver could be located at the Coast Guard facility at Valdez, and have the meteor burst master station transmit tracking and message data to that particular remote for printout or computer entry.

4.3 Valdez Site

A site at or near the Coast Guard facility at Valdez would be partially screened by the local horizon, however effective meteor burst communication coverage can be expected out to 500 miles. Line-of-sight, or ground wave, operations would occur inside the Port of Valdez in the vicinity of Potato Point. The advantage of this site is that the meteor burst master could be directly tied to the VTC for data printout or display.

5. PERFORMANCE

By locating a meteor burst master station in the Prince William Sound area, all vessel tracking will be on ground wave, thus response will be immediate. Using the AMBCS, the range is short, 100 - 150 miles, in covering the Prince William Sound area from Achorage. The mountainous terrain between the two make ground wave unlikely, however, from experience, that range is capable of ground range operation.

APPENDIX C

SYSTEM SPECIFICATIONS AND COST ESTIMATES

1. System Considerations

Prior to preparing a shipboard terminal specification, a number of system definitions have to be considered. Task I, by Technical Memorandum, provided a system description and a performance estimate, thus providing the basis for the system considerations leading to requirements. Table C-1 lists these considerations and requirements.

2. Shipboard Terminal Specifications

The shipboard terminal will combine a LORAN C receiver to a meteor burst transceiver with their required power supply and antennas. Appendix D provides this specification.

3. Cost Estimates

Equipment, installation, operation and maintenance make up the cost elements to be considered in having and using a shipboard terminal.

Equipment

The equipment is composed of a LORAN receiver, Meteor Burst Transceiver, power supply, and antennas for each. Assuming quantities of 50 to 100 units,

Item	Cost Estimate
Loran Receiver and Antenna (includes Lat-Lon Converter)	\$ 2,000.00
Meteor Burst Transceiver	\$2,500.00-\$3,000.00
Power Supply	\$1,200.00
Teleprinter	\$1,000.00

Installation

The major task in the installation will probably be the routing of the coaxial cables for the two antennas. Assuming the equipment will be located in a room on topside, this task should require minimal routing problems. The antennas are physically small and light in weight, therefore they should be readily mountable to existing structures. The LORAN C MPS describes recommended installation of LORAN antennas.

Technicians, experienced in the installation of radio equipment, would be fully capable of installing and checking out the shipboard terminal. Two men should be able to install the terminal within four houus.

Operation

The operation of the shipboard terminal would be no more demanding than that currently required to perform the voice check into the Valdez Control Center and operate the current LORAN C receivers. Meteor Burst transceivers operate on fixed frequencies with "automatic" operation. No adjustments or channel selections are required.

Maintenance

A spare LORAN C receiver and MB transceiver should be carried. However, failure rates on this type of equipment, all solid state, is low. The SNOTEL MB transceiver failure rates have been in excess of a year.

APPENDIX D

TECHNICAL MEMORANDUM II

SHIPBOARD TERMINAL SPECIFICATION

PRINCE WILLIAM SOUND VESSEL TRAFFIC SERVICE

1. Description

The function of the Shipboard Terminal is to generate and telemeter a ship's positional data to the Vessel Traffic Center (VTC) at Valdez, Alaska. The data is to be transmitted by meteor burst communications to a master (interrogating) station. The master station in turn, transmits the data to the VTC by phone line or wire line (if the master is located at or near the VTC building). This equipment is to operate on board ships and should be properly designed for the marine environment.

The shipboard terminal is comprised of two units, (1) a LORAN C receiver and (2) a Meteor Burst Transceiver. Each unit requires its own antenna. The Loran C receiver detects LORAN signals from the LORAN transmitting terminals, then determines the positional data. An alphanumeric terminal is included to initially enter the ship's name and identification when it enters the Prince William Sound Vessel Traffic Service. A power supply is required to convert the prime power of 115 or 230 VAC to required D.C. power to operate the units. Figure D-1 is a functional block diagram of the shipboard terminal.

The LORAN C receiver, at specified time intervals, transfers the positional data to the MB transceiver. The MB transceiver stores this data, ready for transmission whenever the master station interrogation is received.

The meteor burst telemetry system will primarily operate at ranges under 300 miles. Thus, it is important to minimize the time to send the positional data. Data bit rates, in the range of 4 to 8 Kbits will be required to provide data transmittal times compatable with meteor burst channel availability time.

2. Operations Requirements

The electronic equipment will be required to operate in a marine environment, however not directly exposed (heated rooms). The antennas will be required to operate when installed where they will be directly exposed to the outside marine environment.

The shipboard terminal must:

1) Detect LORAN station signals and determine the two time differences of these signals (TDs) or (optionally) calculate Lat-Lon position data.
2) Update the positional data to a meteor burst transceiver at 0.5 to 1.0 minute intervals.
3) Detect and recognize the meteor burst master station's interrogation code.
4) Respond with the ID message or LORAN data.
5) Detect and recognize the master station's acknowledgement code indicating error free reception of the shipboard terminal's message.
6) Inhibit response transmissions for a predetermined period of time after a master station's "ACK" is received.

2.1 Prime Power

The shipboard terminal shall operate on either 115 or 230 VAC $\pm$ 15%, 50-60Hz.

2.2 Communication Formats

Three formats are required:

1) The master station's probing signal
2) The shipboard station's response
3) The master station's acknowledgement, indicating

2.2.3 Master Station's "ACK" - This format will contain the bit synchronization pattern, (ten milliseconds maximum), a frame sync pattern and a code indicating the "ACK". The ACK code could be the ship's address or a repeat of the check code received from the shipboard station.

2.3 Interrogation and Response Cycle

The following make up the significant events which make up the operational interrogation and responses cycle.

2.3.1 Master Station Probe Recognition - The shipboard terminal continually monitors for the master station's coded polling signal. When detected, the code is examined and if commanded, a response is given.

2.3.2 Shipboard Terminal's Response - The master station receives the shipboard terminal's response and checks the error detection code for errors. If errors are detected, the message is rejected or flagged as an error message and not acknowledged.

2.3.3 Master Station's Acknowledgement - If the error detecting code at the end of the shipboard terminal's response indicates no errors, the "ACK" signal is transmitted within 1 millisecond of the error code's detection.

2.3.4 Shipboard Station's Inhibit - The shipboard station, on reception of the master station's ACK, will ignore all further master station requests for data for a period of two minutes. This inhibit time is to be a programmed parameter, and modifiable by teleprinter entry.

2.3.5 Timing - At 200 miles range, the cycle between the remote station's response and reception of the master station ACK shall not exceed thirty (30) milliseconds.

3.1 Operating Temperature

The equipment shall be capable of operating at temperatures between -10 and 50°C. The antennas shall be capable of operating in -40 to +50°C.

3.2 Meteor Burst Transceiver

The meteor burst transceiver is composed of a transmitter, receiver and control microprocessor. Operation is simplex, controlled by the Transmit/Receiver Switch. Figure D-1 is a block diagram of the MB Transceiver.

3.2.1 Transmitter/Receiver - The requirements for the Transmitter/Receiver are given in Table D-1.

3.2.2 Control Microprocessor - The control firmware within the microprocessor and the interfacing circuitry to the MB Transmitter/Receiver and LORAN C receiver, performs the following functions:

1) Receives message data from the alphanumeric terminal and stores for transmission. This message data has priority over LORAN data.
2) Receives periodic updates of LORAN data from the LORAN receiver. The new data is stored for transmission in place of the old data.
3) Assess quality of data from LORAN status message and format a code indicating good, questionable or invalid LORAN data.
4) Monitors the receiver for incoming signals from the master station.
5) Generates the shipboard station's response format, message or LORAN data and interfaces to the transmitter. Also generating an error detecting code to be attached to the end of the message.
6) Controls the Transmit/Receive Switch.
7) Performs all other necessary timing, controls and self-test functions.
8) Controls display indicators.

TABLE D-1. SHIPBOARD TERMINAL SPECIFICATIONS (TRANSMITTER/RECEIVER)

Frequency	40-50 MHz
Transmitter	
Power	200-300 watts
Modulation	BiPhase PSK, MSK,DPSK,QPSK
Bit Rate	4-5Kbps
Duty Cycle	10%
Harmonic/Spurious Suspension	80db below full power
Receiver	
Modulation	Non Coh. FSK, Lon Index PSK
Bit Rate	4-8 Kbps
Sensitivity (BER=10^{-3})	-123dBm (Receiver Noise Only)
Noise Figure	4dB Max
Signal Acq. Time	10 milliseconds Max.
Selectivity	60 dB Minimum
Spurious Response Attenuation	50 dB Minimum
Image Response Attenuation	50 dB Minimum
Intermodulation Spurious Response Attenuation	50 dB Minimum
T/R Switch	
Switch Time	1 microsecond
RF Power	300 watts

APPENDIX E

FEASIBILITY TEST PLAN

1. TASK DESCRIPTION

Over the horizon communications by traditional HF radio has been unreliable in auroral regions such as encountered in the State of Alaska. A Meteor Burst Communication System (MBCS) has been installed in the State of Alaska and demonstrated reliable operation for over the horizon communications for the past several years. The objective of this feasibility test is to demonstrate the capability of telemetry of ships'positional data, by using Meteor Burst Communications, to the requirements of the Vessel Tracking System for Valdez, Alaska. These requirements are given in Attachment A of this test plan.

Two potential meteor burst systems can be utilized for a feasibility test,

1) The existing Alaska Meteor Burst Communication System (AMBCS), with its master station located at Anchorage, and 2) An existing government owned mobile system with its master station installed in a small van. The mobile meteor burst system was developed for flight following applications, thus its design and configureation, both software and hardware, are similar to the requirements of ship tracking.

A secondary objective is to determine the ease of installing meteor burst antennas aboard ships to provide full omni coverage to the master station.

2. TEST GEOMETRY

The area in which shipboard terminals will operate during the feasibility test was shown in Figure 1-2. This covers the route taken by the tankers while in Prince William Sound, both in and out of the port of Valdez, and the allocated

4.1 Master Station

The modifications to the master station are mainly the increase of the data bit rate, control software and the connection of a phone line interface at the AMBCS Master. Figure E-1 is a block diagram of the Alaskan Master Station with the areas requiring modification shown. The mobile master station will not require the phone line output, since it can be cabled directly to the VTC terminal.

4.2 Shipboard Terminal

The shipboard terminal will be configured similarly to the existing mobile MB transceivers. Figure E-2 is a block diagram of the shipboard terminal denoting the MB transceiver, the LORAN receiver, (GFE from the Coast Guard) and the new items required for the feasibility test. The Coast Guard LORAN C equipment is assumed to be a Teledyne 708 and will require an interface unit to insert the data into the meteor burst control microprocessor.

4.3 VTC Terminal

The VTC terminal for the feasibility test will be a teleprinter, providing a printout of the ship's position. If the AMBCS is used, a telephone line and modems are required.

4.4 Alphanumeric Terminal

The existing mobile Meteor Burst Communication System uses a Termiflex Handheld HT/4 alphanumeric terminal, however none are available currently with the system. The meteor burst transceiver can be interfaced to virtually any alphanumeric teleprinter with a EIA-RS232 interface. The alphanumeric terminal can provide the shipboard station operator status information on link operation and the capability of sending and receiving short messages.

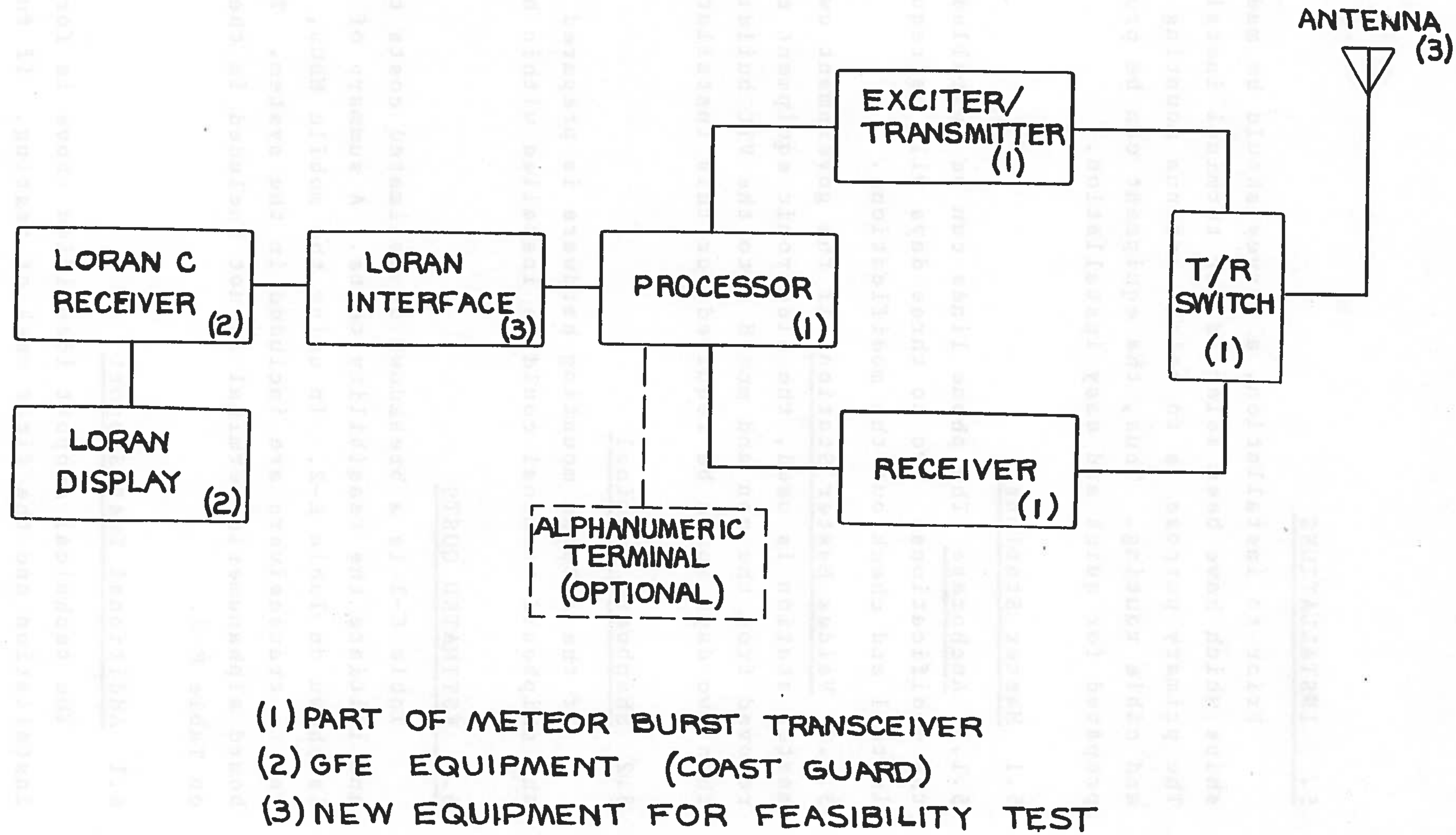

FIGURE E-2: METEOR BURST SHIPBOARD TERMINAL

TABLE E-1. FEASIBILITY TEST COST BREAKDOWN

TASK	COST	
	AMBCS	VALDEZ
Master Station Site/Ship Survey	$ 2,000.00	$ 2,000.00
Master Station		
Modifications, Developmental (Software and Hardware)	15,000.00	2,500.00
Phone Line (Anchorage-Valdez)	1,000.00/mo	-
Shipboard Terminal		
Modifications, Developmental (LORAN Interface/Software)	13,000.00	13,000.00
Transceiver	5,000.00	5,000.00
Alphanumeric Terminal (optional)	1,500.00	1,500.00
LORAN C Interface	200.00/each	200.00/each
M.B. Antennas	500.00	500.00
LORAN Receiver	GFE	GFE
LORAN Antenna	GFE	GFE
Installation and C/O		
3 man weeks of support	6,500.00	6,500.00
VTC Terminal	1,500.00 (GFE)	1,500.00 (GFE)
Additional Test Support	2,300.00 /week	2,300.00/week

APPENDIX F

REPORT OF NEW TECHNOLOGY

The work performed under this contract, while leading to no new invention, has determined the feasibility of utilizing meteor burst communications for monitoring vessel position at the Valdez, AK, Vessel Traffic Center. Communication link capacity, antenna siting, and equipment specifications were considered in developing alternative systems meeting Coast Guard Requirements.