

Communications Research Centre

ANIK-B DOC COMMUNICATIONS SYSTEM AND GROUND TERMINALS

by

J.W.B. DAY

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Department of
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CRC TECHNICAL NOTE NO. 704-E

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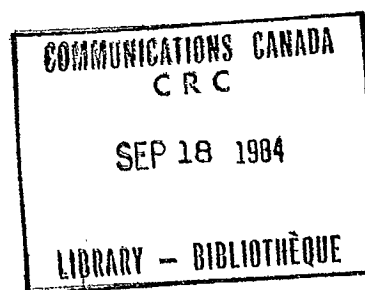
DEPARTMENT OF COMMUNICATIONS
CANADA

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(Space Technology and Applications Branch)



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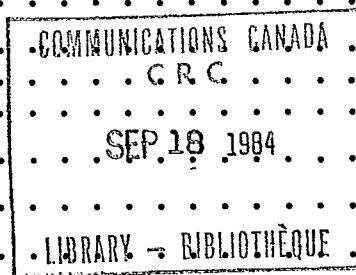
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ABSTRACT

This Technical Note describes the technical and operational aspects of the 12/14 GHz portion of the ANIK-B satellite leased by the Department of Communications from Telesat Canada and DOC owned ground terminals to be used with ANIK-B. Its purpose is to provide information to participants in ANIK-B pilot projects to aid in planning of the technical aspects of these projects.

1. INTRODUCTION

On 15 December, 1978, ANIK-B was launched from Cape Canaveral on a Thor Delta vehicle. ANIK-B is owned and operated by Telesat Canada. It is a dual-band satellite having transponders at 4/6 GHz and 12/14 GHz. The 4/6 GHz system is being used by Telesat as a replacement of operational capacity previously provided by one of the ANIK-A series of satellites. The 12/14 GHz transponder system has been leased from Telesat by the Department of Communications for a series of Pilot Projects.

As of February, 1979, the spacecraft had been successfully placed on station at 109°W longitude in the geostationary satellite orbit. The 12/14 GHz transponder system has been tested and is performing satisfactorily. An initial 30 day period of service to DOC commenced on 12 February, 1979. In March, continuous service to DOC started and on 1 April, Pilot Project activity began. The DOC contract with Telesat calls for 23 months of continuous service with an option for up to three years of further service.

For the ANIK-B Pilot Projects, it is DOC's responsibility to:

- a) determine how the 12/14 GHz transponder system can be used to meet the requirements of approved Pilot Projects;

- b) define a suitable communications system for DOC owned ground stations;
- c) approve all communications usage of the 12/14 GHz system;
- d) schedule all use of the 12/14 GHz transponders within the framework of approved Pilot Projects.

DOC has a number of ground stations that will be loaned to users for Pilot Projects.

The purpose of this Technical Note is to describe the ANIK-B 12/14 GHz communications system and to provide technical details on the capabilities of DOC owned ground stations. An earlier informal version was provided to ANIK-B users for their information.

2. ANIK-B 12/14 GHz TRANSPONDER SYSTEM

Figure 2.1 shows a simple block diagram of the 12/14 GHz transponder system on ANIK-B. There are four travelling-wave-tube amplifiers (TWTA) feeding four spot beams (labelled West, Centre West, Centre East, East). Six frequency channels, each having a bandwidth of 72 MHz, are provided and the channel plan is shown in Figure 2.2. A series of switches and input/output multiplex filters allow changes in channel/TWTA routing to transmit spot beams as indicated on Figure 2.1. DOC will determine and specify transponder configuration to meet the requirements of the Pilot Projects.

Figures 2.3 and 2.4 show spacecraft antenna coverage for transmit and receive respectively. Figure 2.3 shows the four transmit spot beam coverage areas for an e.i.r.p. (effective isotropic radiated power) of 46.5 dBw on the outer contour and 49.5 dBw on the inner contour. The contour on Figure 2.4 characterizes the spacecraft receive beam, which is Canada wide, in terms of G/T (antenna gain to noise temperature ratio) and SFD (saturating flux density). Each TWTA has a switchable attenuator that reduces gain by 5 dB and, therefore, increases the required SFD by this amount.

Although there are four spacecraft TWTA's, it is not generally possible to have all of these operational simultaneously. Because of prime power limitations in the output of the solar arrays, the number of available GHz TWTA's is dependent on loading of the 4 GHz system. Current planning is based on having three TWTA's available at 12 GHz for the first two years of operation.

The ANIK-B spacecraft is 3-axis stabilized and will be station-kept to better than $\pm 0.1^\circ$ North-South and East-West, thus precluding the need to have steerable ground antennas except for those of large diameter.

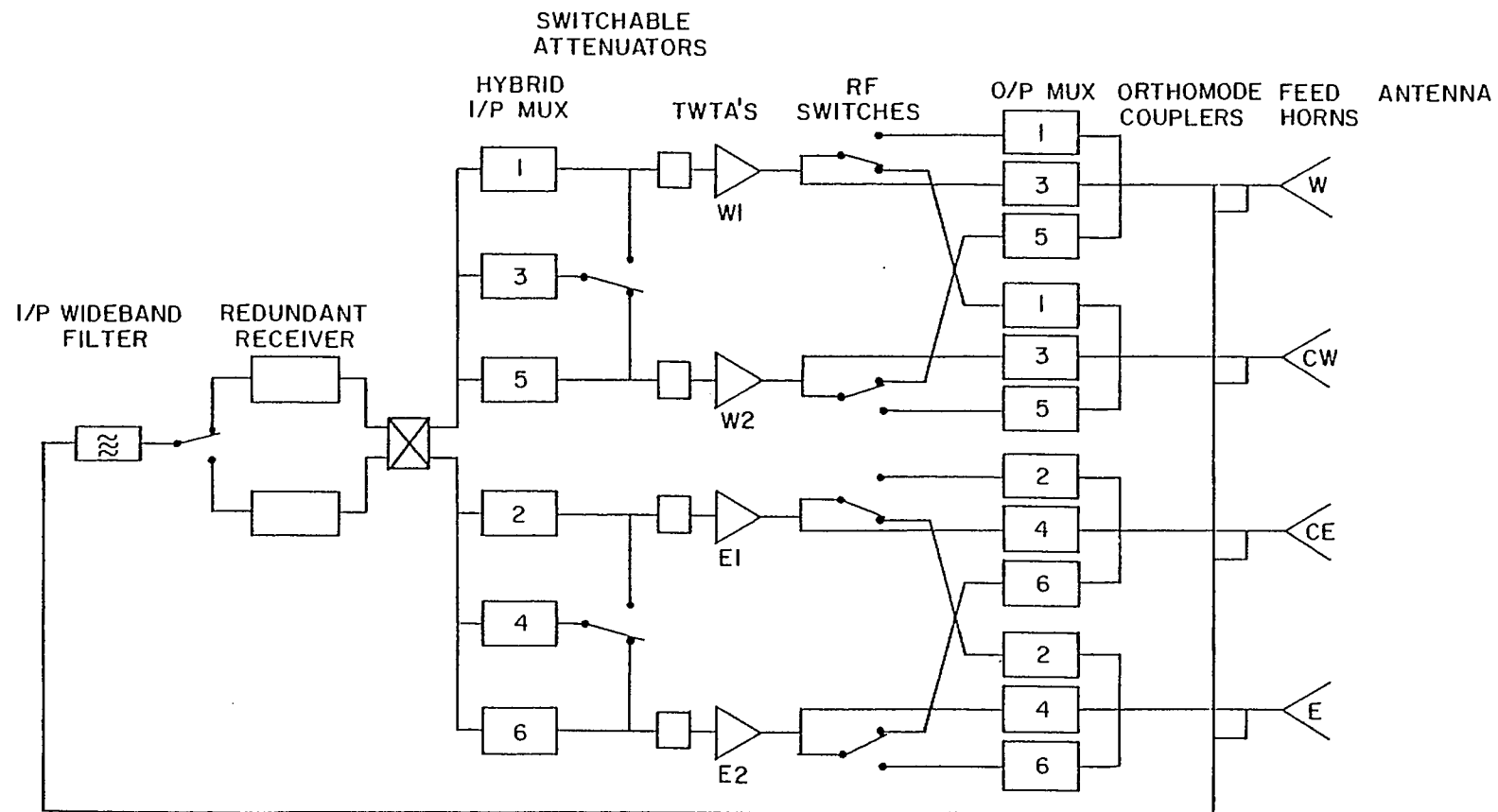
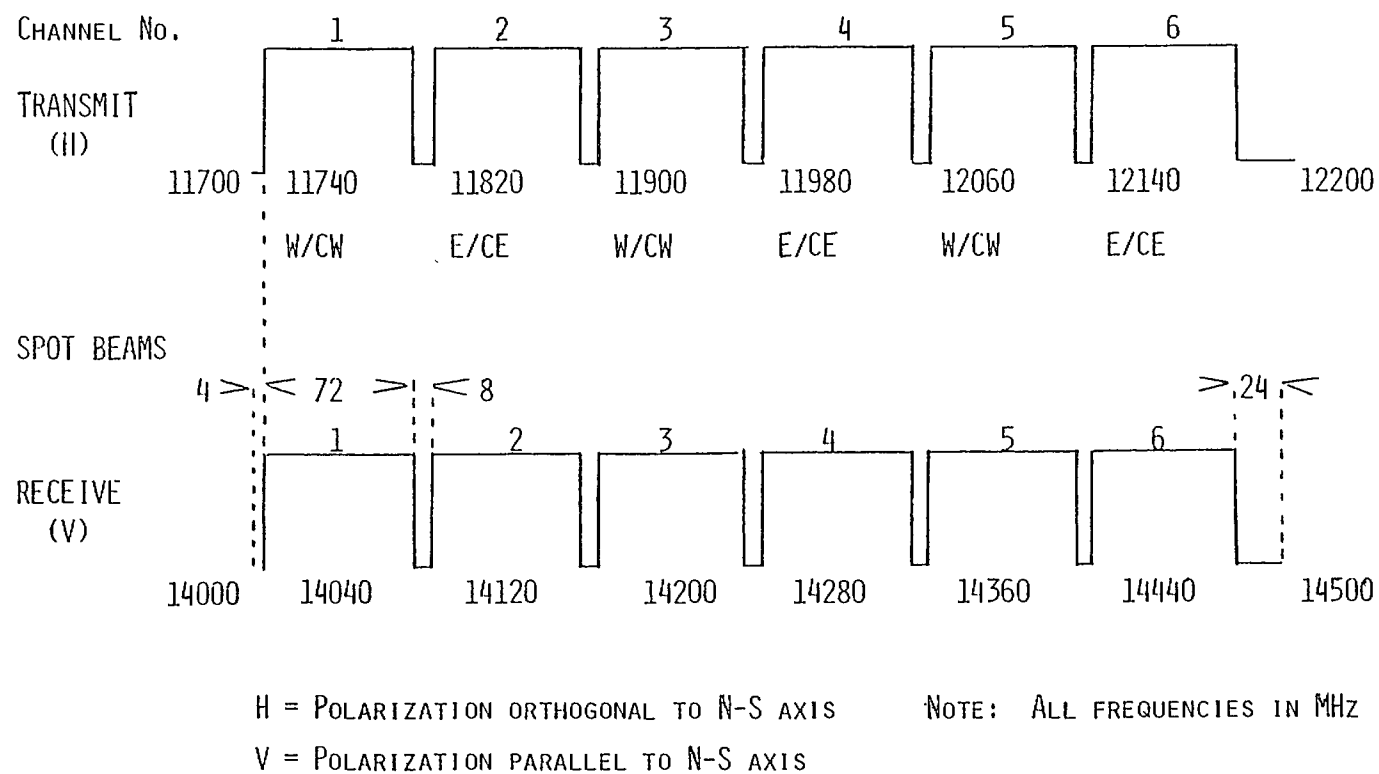


Figure 2.1 ANIK-B Block Diagram



FREQUENCY ALLOCATION AND POLARIZATION PLAN

Figure 2.2 ANIK-B Channel Plan

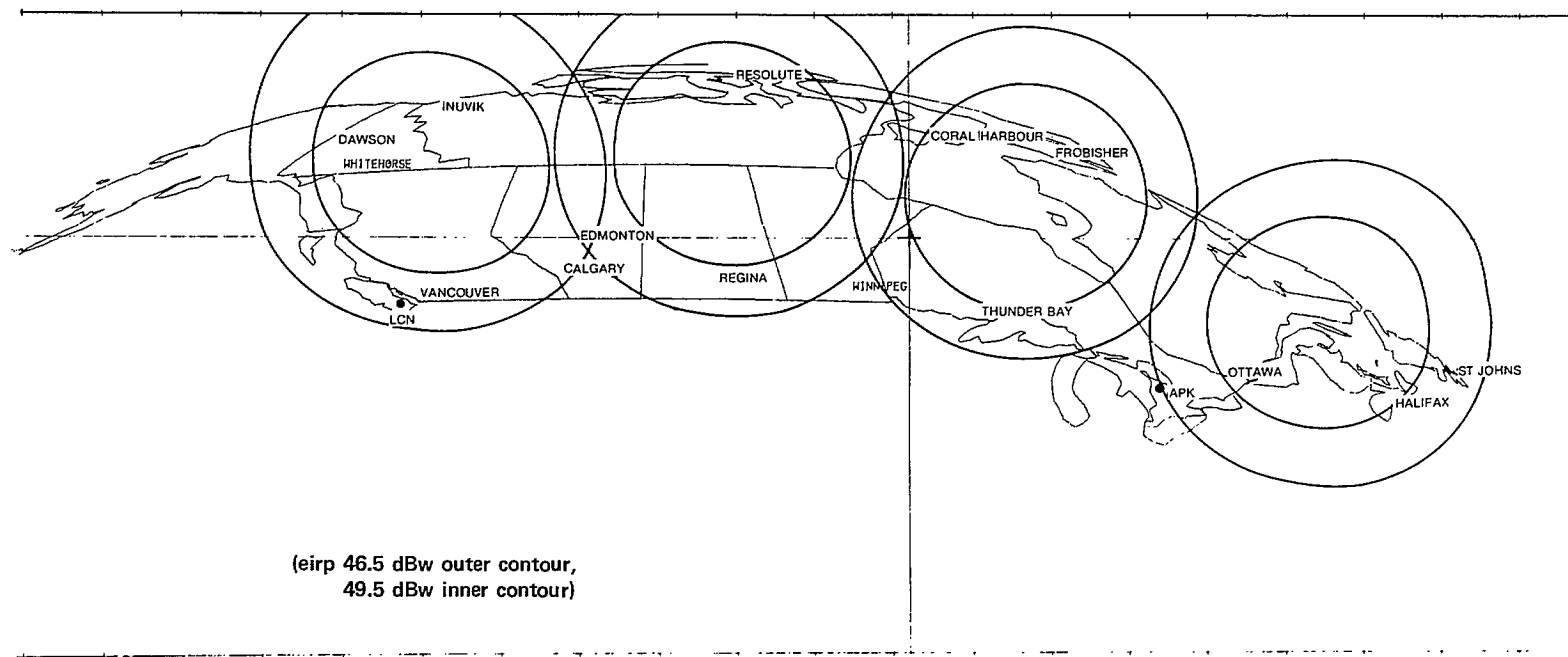


Figure 2.3 ANIK-B Transmit Contours

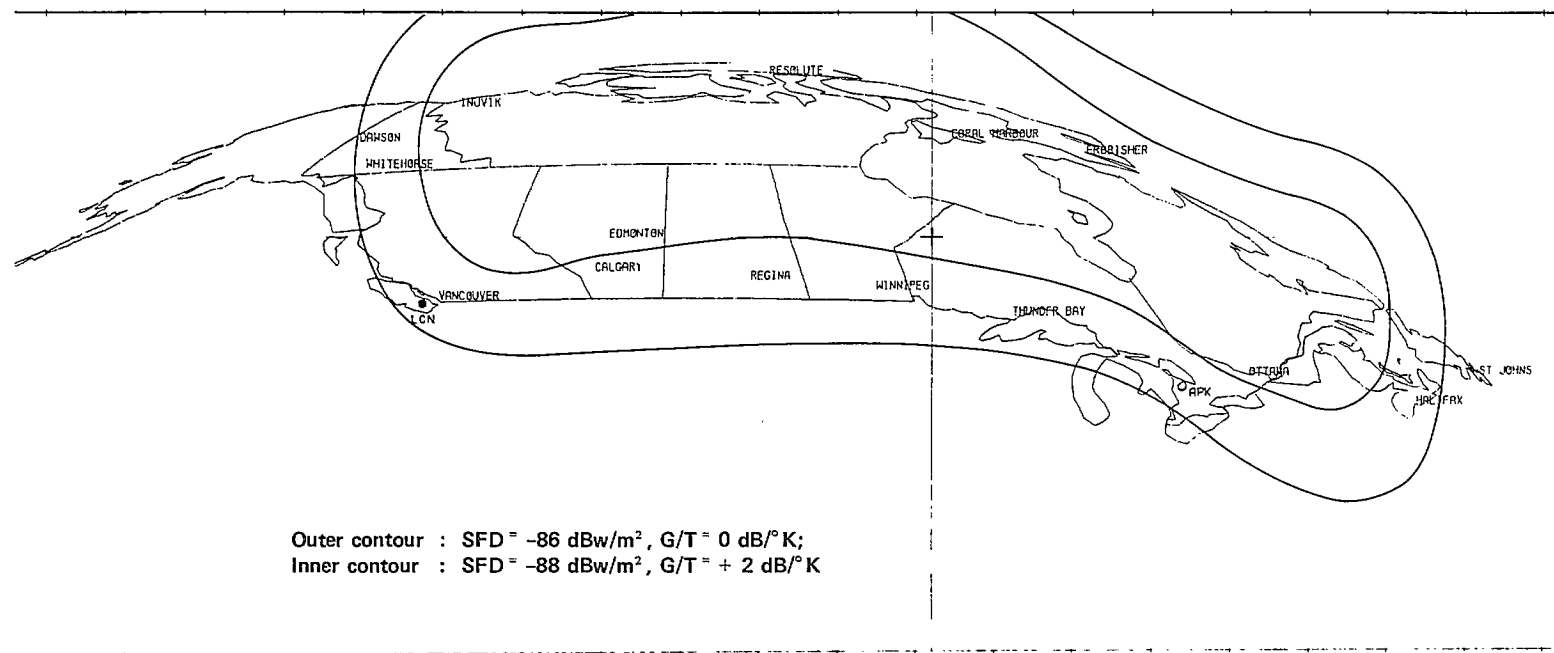


Figure 2.4 ANIK-B Receive Contours

3. COMMUNICATIONS SYSTEM AND DOC GROUND TERMINALS

3.1 GENERAL

The communications system design for ANIK-B is based on an extension of concepts developed through three years of successful Hermes experiments. In fact, twenty-one ground stations used for the Hermes program have been converted for use with ANIK-B. The main differences between Hermes and ANIK-B are transponder output power (one 200 W and one 20 W TWTA for Hermes, four 20 W TWTA's for ANIK-B) and channelling plan (two 85 MHz wide channels for Hermes, six 72 MHz wide channels for ANIK-B).

Two basic services are provided by DOC ground terminals, video with associated audio and narrow-band telephony. A summary of ground terminal capability is given in Tables 1-4 and the terminals are described in more detail in following Sections.

Terminal design for ANIK-B is based on multicarrier operation of a TWTA with a video carrier, multiple telephony carriers, and, possibly, other types of traffic sharing a given transponder channel.

TABLE 1

Ottawa 9m Terminal (Qty 1)

9m Antenna -- steerable

200 watt TWTA

Transmit one video carrier plus audio (3) in any ANIK-B channel

Receive one video carrier plus audio (3) in any ANIK-B channel

Transmit outgoing telephony carriers in any or all six ANIK-B channels

Receive all return telephony carriers in ANIK-B channel 4

Act as NCS for switching two-hop SCPC telephony carriers

Baseband video, audio, and telephony interfaces

TABLE 2

TVT-3m Trailer Terminal (Qty 2)

3m Antenna — non-tracking

1.5 kW Klystron HPA

Transmit one video carrier plus audio (3) in any ANIK-B channel

Receive one video carrier plus audio (3) in any ANIK-B channel

Transmit one telephony carrier (expandable to two) used as order wire, in ANIK-B channel 4

Receive one telephony carrier (expandable to two) used as order wire in same ANIK-B channel as video

Baseband video, audio interfaces

TABLE 3

TVRT 3m TV Receive, Telephony Tx/Rx (Qty 16)

3m Antenna — fixed

20 W TWTA

Receive one video carrier plus audio (3) in any ANIK-B channel (fixed tuned, not operator selectable)

Transmit one telephony carrier (expandable to four) in ANIK-B channel 4

Receive one telephony carrier (expandable to four) in same ANIK-B channel as video

Baseband video, audio, and telephony interfaces

TABLE 4

TVRT-TM-3.7m TV Tx/Rx Telephony Tx/Rx (Qty 2)

3.7m Antenna — fixed

250 W TWTA

Transmit one video carrier plus audio (3) in any ANIK-B channel

Receive one video carrier plus audio (3) in any ANIK-B channel (fixed tuned, not operator selectable)

Transmit one telephony carrier (expandable to two) in ANIK-B channel 4

Receive one telephony carrier (expandable to two) in same ANIK-B channel as video

Baseband video, audio, and telephony interfaces

3.2 VIDEO

Five of the ground terminals can transmit video and all can receive video. Each terminal is currently configured to transmit or receive, as appropriate, only one video carrier at a time. Reference to Figures 2.1, 2.3, and 2.4 will show that:

- a) a video transmit terminal located anywhere within Canada (because of the Canada-wide receive beam) can transmit to video receive terminals located in any *one* of the four spot beams (Figure 2.3) by choice of the appropriate spacecraft TWTA and channel;
- b) a single video transmit terminal cannot transmit video simultaneously to two or more spot beams since the terminals are equipped to transmit in only one channel at a time and Figure 2.1 shows that a given spacecraft channel cannot be connected to more than one spot beam at a time;
- c) simultaneous two-way video can take place between any pair of the five transmit terminals. The two terminals may be located anywhere in Canada, the particular channels required depend on terminal location within given spot beams.

Each video channel has up to three associated audio channels carried by three subcarriers above the video baseband. The video carrier is transmitted in the lower half of the 72 MHz transponder channel, 15 MHz below band-centre.

3.3 TELEPHONY

The telephony system for ANIK-B is similar to that used with Hermes, since much of the equipment is common. It uses companded FM SCPC (single-channel-per-carrier), with fixed, pre-assigned frequencies for remote terminals. A two-hop satellite mode is used, with all channel switching done at the Ottawa 9m NCS (Network Control Station). The Ottawa station transmits outgoing telephony carriers in one or more of the six ANIK-B channels, dependent on remote terminal locations, in the four spot beams. All return carriers are transmitted to Ottawa via transponder E2, Channel 4. Telephony carriers are in the upper half of the transponder channels, approximately 15 MHz above bandcentre and spaced by 70 KHz.

Each remote terminal is equipped with one telephony channel. Four terminals are equipped with a second telephony channel.

Channel switching is accomplished through a manually controlled base-band switching matrix, called a Conference Unit, at the NCS that provides:

- a) interconnection of pairs of remote terminals;
- b) audio conferencing of three or more remote terminals.

The NCS switching system provides flexible interconnections and conferencing of up to eight terminals in a group. Note that interconnection is not automatic, it must be pre-set in accordance with an agreed Operations Plan. Changes in this pre-set configuration can be requested by contacting the NCS operator in Ottawa and requesting a change, which will be done manually.

Each telephony channel on a remote terminal is provided with a telephone set and an external telephony interface (termed 'data jack'). The telephony channel at a remote terminal can be switched to either (but not both) the telephone set or external interface jack. The data jack can be used to interface any appropriate device, such as a data modem, speaker/microphone, facsimile device, etc., that is compatible with a four wire analog telephony channel. Interface requirements, including levels, are given below in the detailed terminal descriptions.

Both the telephone set and the external data jack at a remote terminal are four-wire, i.e., the transmit and receive lines are separate. A capability for interconnection directly to a terrestrial telephone system is not provided. Such interconnection would generally require a hybrid for conversion from four-wire to two-wire telephone operation, plus an echo suppressor to eliminate echos produced at the four-wire/two-wire interface.

The telephone set provided with the remote terminal has a capability for signalling the Ottawa NCS operator by means of touch-tone dialing to report problems or to request a change in telephony channel interconnection.

3.4 VIDEO WITH AUDIO INTERACTION

A common mode of operation during the Hermes experiments and ANIK-B Pilot Projects is one-way video with audio interaction. In this mode, video transmission occurs from one site and this video signal is received by a number of remote terminals. These terminals are able to see the video transmitted and can interact via an audio return over the satellite. All parties will hear all conversations taking place over the satellite circuits, but will see only the video picture transmitted from the site having the video transmit terminal.

This mode of operation can be accomplished with ANIK-B as follows:

- a) all remote sites transmit voice signals via a telephony channel back to the Ottawa NCS;
- b) these telephony channels are conferenced at the NCS and transmitted via a telephony channel to the video transmit terminal in the field;
- c) at the video transmit terminal, the conferenced voice signals are mixed with the outgoing program audio on one of the audio channels accompanying the video.

In this way, all parties hear all of the conversation. Variations on this mode of operation are possible, depending on the application. Particular attention must be paid to the echo problem.

3.5 AUDIO FEEDBACK AND ECHO

One of the problems encountered with audio transmission via satellite is feedback and echo. Experience during Hermes experiments has confirmed that care must be taken in planning audio interfaces, particularly those involving open microphones and speakers, to prevent problems with echo.

Because of the time delay over a satellite circuit (transmission time from earth to satellite is about 1/8 second), a system employing open microphones and speakers at both ends of an audio link can give rise to serious feedback and echo problems. The difficulty this can create cannot be overestimated. It may be possible to locate microphones and speakers in the same room such that acoustic feedback is not a problem, although this is not easy to do in practice. In general, it will be necessary to use one of the following techniques to overcome the echo problem:

- a) use a headset to eliminate acoustic feedback to a microphone;
- b) use a 'push-to-talk' system whereby a switch that activates a microphone cuts off a speaker; this is often the simplest method to implement; or
- c) use an electronic switch for voice activation or as an echo suppressor; this method is effective if

properly implemented, although it is sometimes difficult to adjust levels for proper operation of the device and to prevent noise triggering.

Experience has shown that most problems of interface are encountered with audio systems, not video.

4. OTTAWA 9M NCS TERMINAL (NETWORK CONTROL STATION)

4.1 GENERAL

This terminal provides a capability for television transmit and receive. It transmits a single FM video carrier in any one of the six ANIK-B channels. The transmit channel is tunable and can be set to any of the six. The choice of operating channel is in accordance with an Operations Plan produced by CRC and cannot be changed without authorization.

It will receive a single FM video carrier in any one of the six ANIK-B channels and this is operator selectable. The transmit/receive video channels are independently selectable.

The NCS (Network Control Station) receives all FM SCPC telephony carriers transmitted in ANIK-B Channel 4 from all other terminals (TVT, TVRT, TVRT-TM) across Canada. Switching to connect pairs of small-terminal telephony channels is accomplished in the NCS. The NCS transmits FM SCPC carriers back to terminals across Canada in any of the appropriate six ANIK-B channels. The channel is determined by the ANIK-B spot beam within which the small terminal is located.

The telephony system uses a two-hop mode with all telephony interconnection made by looping through the NCS. The telephony is companded, FM SCPC with fixed-frequency assignment and voice activation. The ANIK-B telephones and telephony interfaces are 4-wire, with separate transmit-receive channels.

In addition to interconnecting two terminals, the NCS has a facility for conferencing a number of terminals by bridging the go and return channels. Interconnection and conference switching is manually controlled by the NCS operator and, therefore, must be pre-set in a given configuration or changed by request to the NCS operator. Telephone sets provided with the user terminals can be used to signal the NCS operator.

4.2 CONFIGURATION

The NCS terminal is a fixed station located at Ottawa. It has a 9m antenna. Figure 4.1 shows a block diagram and Plate 4.1 a photograph of the terminal.

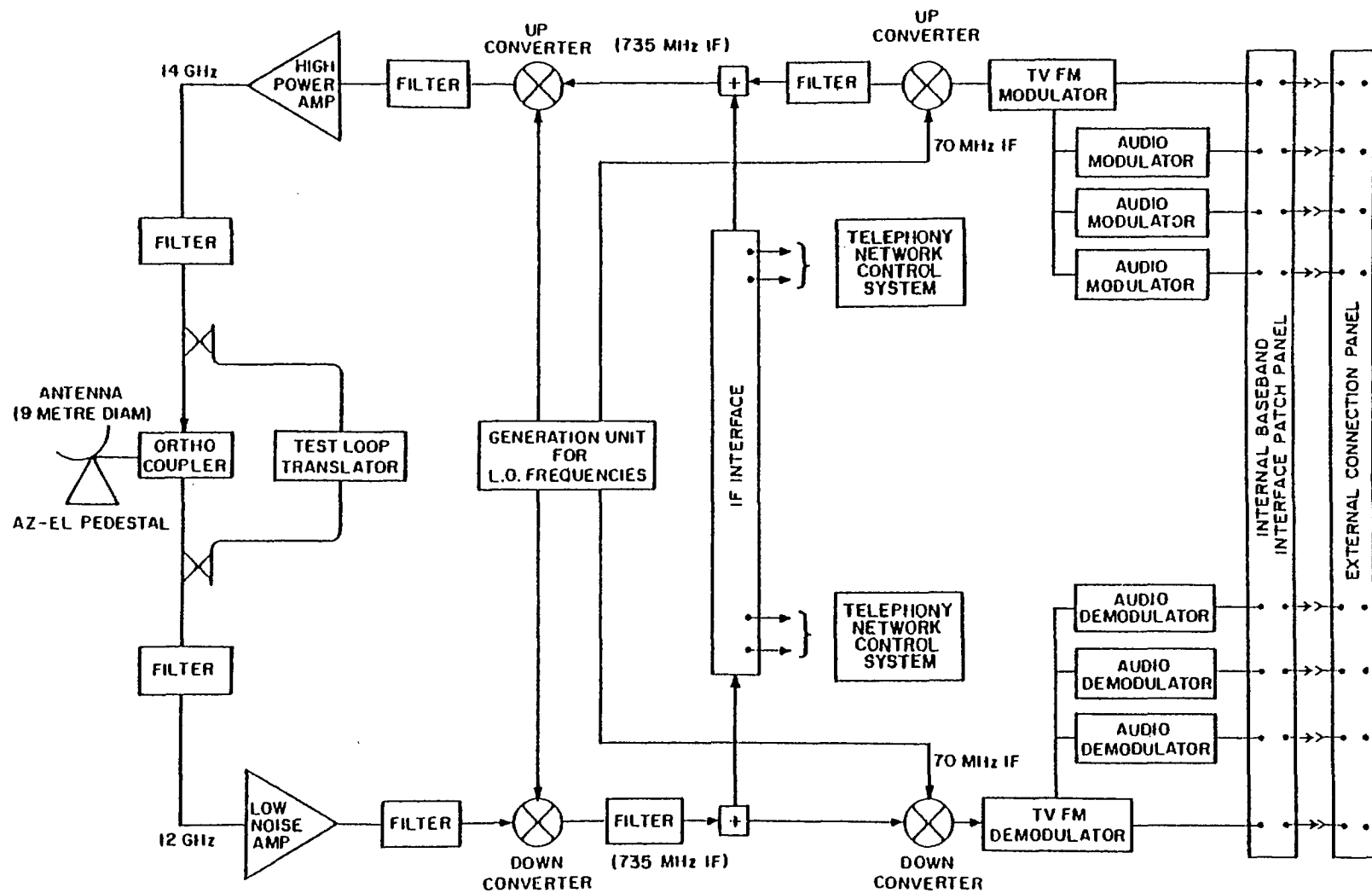


Figure 4.1 9m Terminal Block Diagram



Plate 4.1 9m Terminal

4.3 SIGNALS AND INTERFACE

A Baseband Interface Patch Panel is located in the 9m terminal. The user is responsible for getting all signals from his equipment housed elsewhere to CRC if he wishes to use the 9m video transmit/receive capability.

Video transmit/receive baseband interfaces are provided. A video carrier (transmit and receive) may have from one to three associated audio channels and these also interface at baseband.

4.3.1 Video Interface (both transmit and receive)

impedance:	75 ohms unbalanced
connector:	BNC female type
bandwidth:	30 Hz to 4.2 MHz
level:	1.0 volt peak-to-peak for the composite video. A video clamping amplifier is available with a capability to equalize at least 610 m (2000 ft) of RG-11U cable or equivalent.

4.3.2 Audio Interface (both transmit and receive)

impedance:	600 ohms balanced
connector:	spade lug type terminals
bandwidth:	50 Hz to 10 KHz
test-tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level:	0 Vu corresponds to 0 dBm

4.4 OPERATION

Operation of the 9m terminal is the responsibility of CRC.

5. TVT TRAILER TERMINAL (TELEVISION TRANSMIT TRAILER TERMINAL)

5.1 GENERAL

This terminal provides a capability for television transmit and receive. It transmits a single FM video carrier in any one of the six ANIK-B channels. The transmit channel is tunable and can be set to any of the six. The choice of operating channel is in accordance with an Operations Plan produced by CRC and cannot be changed without authorization.

The TVT will receive a single FM video carrier in any one of the six ANIK-B channels and this is operator selectable. The transmit/receive video channels are independently selectable.

The TVT will receive a single FM SCPC telephony carrier in the same ANIK-B channel used for video receive, i.e. both video and telephony received carriers must be in the same one of the six ANIK-B channels.

The TVT transmits a single SCPC FM telephony carrier in ANIK-B Channel 4 regardless of the location of the terminal across Canada. These Channel 4 SCPC return carriers are all received at the Ottawa 9m Network Control Station (NCS) used for telephony channel switching in the DOC ANIK-B two-hop telephony system.

The single FM SCPC channel may be used as an order wire for the trailer operator to contact the Ottawa NCS or, in some cases, may be required for use by the user.

5.2 CONFIGURATION

The terminal is a self contained transportable terminal in the form of a trailer. It has a 3m antenna that is stowed within the trailer during transport.

Figure 5.1 shows a block diagram and Plate 5.1 a photograph of the installed trailer.

5.3 SIGNALS AND INTERFACE

A weather-proof junction box is located on the exterior of the trailer. All interfaces are to the External Connection Panel in the box. The user is responsible for running all signal cables from his equipment housed elsewhere to this point.

Video transmit/receive baseband interfaces are provided on the External Connector Panel. A video carrier (transmit and receive) may have from one to three associated audio channels and these also interface at baseband on the External Connection Panel.

5.3.1 Video Interface (both transmit and receive)

impedance:	75 ohms unbalanced
connector:	BNC female type
bandwidth:	30 Hz to 4.2 MHz
level:	1.0 volt peak-to-peak for the composite video. A video clamping amplifier is available with a capability to equalize at least 61 Ohm (2000 ft) of RG-11U coaxial cable or equivalent. For applications where AC hum pick-up could be a problem, triaxial cable may be desirable.

5.3.2 Audio Interface (both transmit and receive)

impedance:	600 ohms balanced
connector:	spade lug type terminals
bandwidth:	50 Hz to 10 KHz
test tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level:	0 Vu corresponds to 0 dBm



Plate 5.1 TVT Trailer

5.4 PRIME POWER

It is the responsibility of the user to provide suitable electrical power for the terminal. The user must arrange to bring suitable power to the trailer and arrange to have it connected to a junction box on the trailer.

Prime Power requirements are:

120/240 volts \pm 15 %, three wire

or

120/208 volts \pm 15 %, two wire

30 KVA

60 Hz \pm 5 Hz single phase.

5.5 ENVIRONMENTAL

The trailers are equipped with heating and air conditioning units to maintain operational temperatures inside the trailer within reasonable limits. Continuous prime power must be made available, even when the terminal is not in use, to maintain proper temperatures.

For the overall terminal the limits are:

	Operational	Survivable
Temperature:	-45°C(-50°F) to 35°C(95°F)	-51°C(60°F) to 40°C(105°F)
Relative Humidity:	5% to 100%	5% to 100%
Wind (average):	45 km/hr (30 mi/hr)	
Wind (gusts):	72 km/hr (45 mi/hr)	177 km/hr (110 mi/hr)
Ice:	1.3 cm (0.5 in)	2.5 cm (1 in)

5.6 TRANSPORTATION

In general, CRC will be responsible for transportation between major centres. In some cases, particularly for sites with difficult access, the user may be expected to assume some responsibility for transportation. This will be worked out on a case-by-case basis.

The trailer is normally transported by road (a 3/4 ton truck is supplied as part of the terminal), railway, or flat-bed truck. Total weight of the trailer is about 9000 kg (20,000 lbs).

5.7 SITE REQUIREMENTS AND INSTALLATION

The user has the responsibility for selecting a site, which will in general then be approved by CRC. The site must have unobstructed line-of-sight in the direction of the satellite. Given latitude, longitude, and altitude of a site, CRC can provide azimuth and elevation angle data for the satellite. Figure 5.2 illustrates a terminal set up on a typical site.

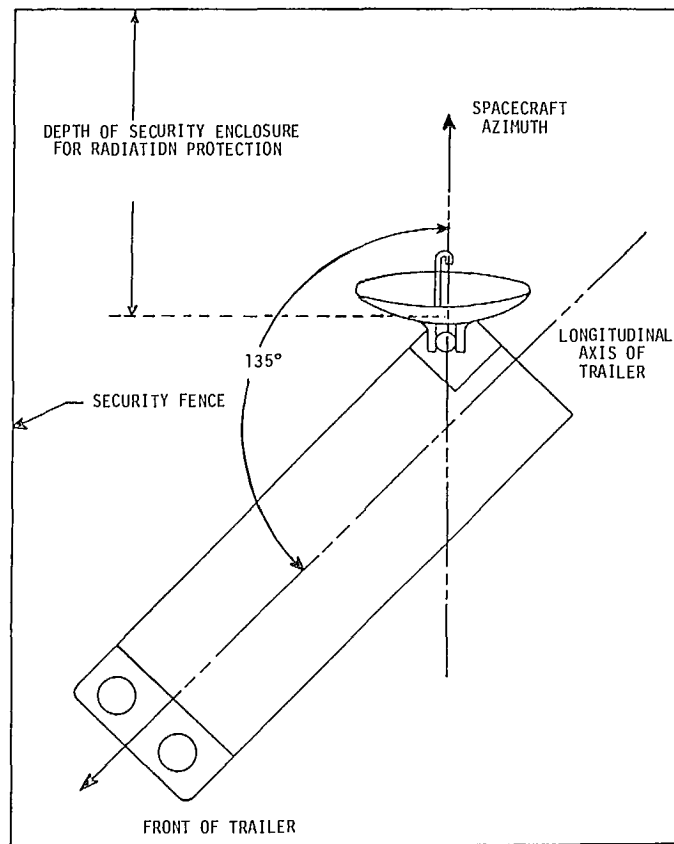


Figure 5.2 TVT Terminal Orientation on Site Locations

The trailers of the TVTs come equipped with foot pads and levelling jacks and should be capable of installation on any reasonable surface (soil, gravel, pavement, etc.) with minimum of site preparation. The site should be cleared, be reasonably level with less than a 5% grade, and have a bearing strength of not less than 14,650 Kg per square metre (3000 lbs per square foot). The total weight of the terminal is approximately 9000 Kg (20,000 lbs). A security fence may be required to restrict access to the area surrounding the terminal for radiation protection and for the physical protection of the terminal. A reasonable access road should be available to the site.

The site must be selected such that a clear line-of-sight to the spacecraft is available. It must be clear of obstacles within a 10° cone of the nominal line-of-sight. In addition, the site must have sufficient room to maneuver the trailer so that it lies with the front of the trailer pointing 135° counter-clockwise to the satellite line-of-sight. Figure 5.2 illustrates the required geometry. This requirement arises because the antenna is located on the rear corner of the trailer and cannot point along the longitudinal or traverse axis of the trailer.

The terminal will be installed on the site by CRC. The user must make arrangements for prime power connections and for installation of a standard terrestrial telephone in the trailer.

The power levels capable of being transmitted by the 3-metre terminal are sufficiently high to present an RF radiation hazard to personnel in the beam of the antenna. Consequently, the user is required to select and protect the site such that persons are prevented from entering areas where the radiation level is too high. Allowable exposure to RF radiation is generally accepted to be a power density of $<1 \text{ mW/cm}^2$ for long exposure. Calculations indicate, however, that maximum power densities up to 64 mW/cm^2 occur at a distance of 82 metres (270 ft) along the boresight of the antenna. Maximum power density right at the antenna is 32 mW/cm^2 and, in the far field, at 860 m (2850 ft) along the boresight, 1.6 mW/cm^2 . Radiation density directly beside the antenna, resulting from spillover from the feed, could be as high as 1.25 mW/cm^2 . Directly behind the antenna all radiation density is less than the acceptable level 1 mW/cm^2 .

It is evident from the above discussion that suitable precautions, such as a security fence, must be taken to ensure that personnel do not accidentally walk into the beam. Fencing on the site must be arranged such that the terminal can still be easily maneuvered to point the antenna along the satellite look angle. Figures 5.2 and 5.3 illustrate a suitable arrangement. Figure 5.4 is a graph which shows recommended distances to extend an enclosed area from the trailer to provide a 3.05 metre (10 ft) beam clearance assuming the immediate surrounding terrain is horizontal. Curves are also shown for terrain that has a +5% slope and a -5% slope.

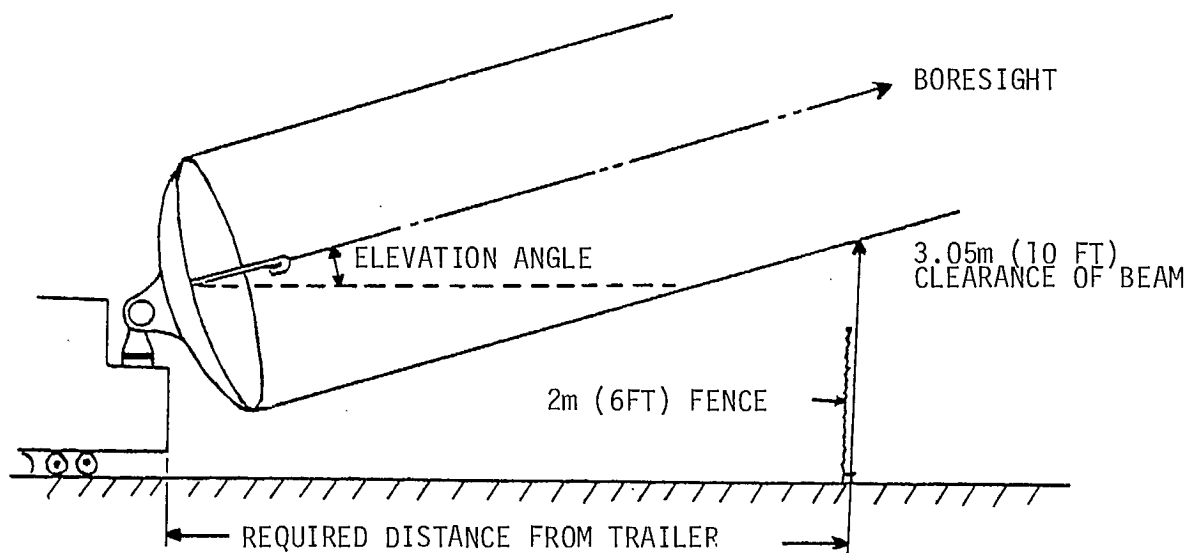


Figure 5.3 Protection from Radiation Hazards

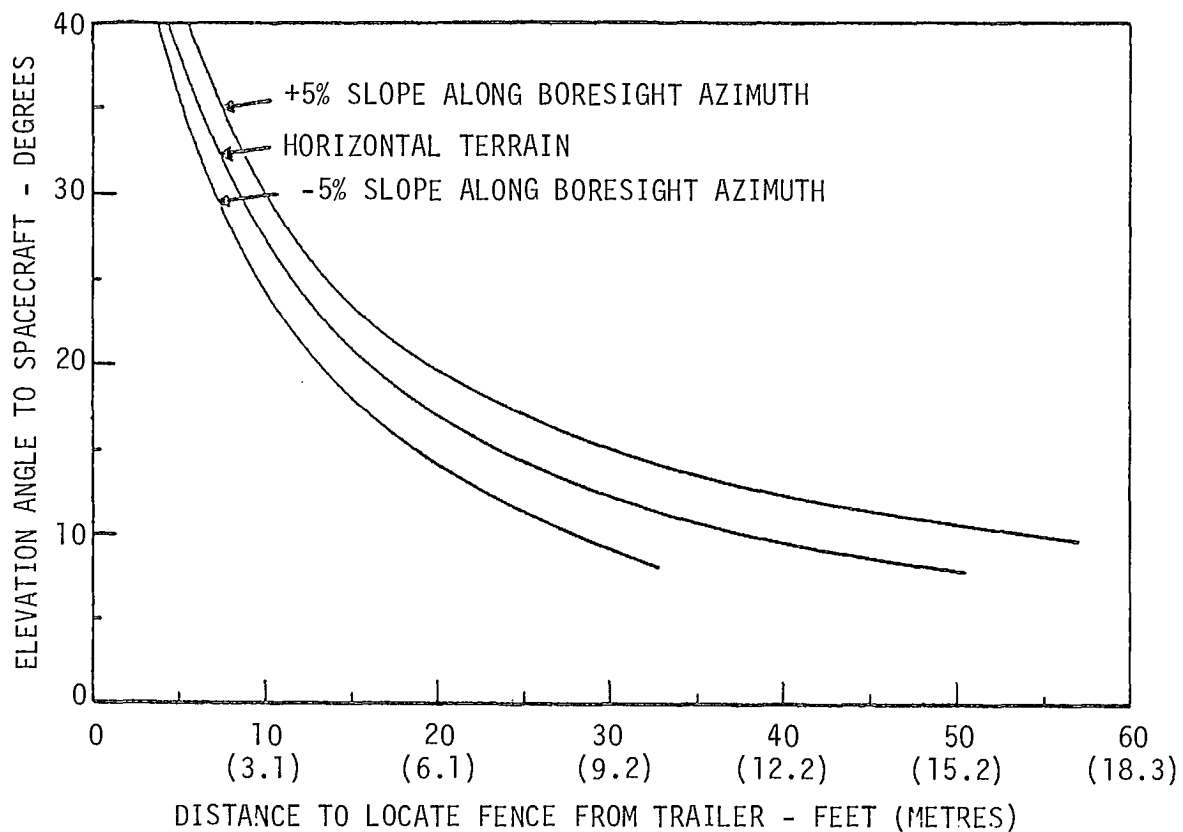


Figure 5.4 Depth of Safety Enclosure as a Function of Elevation Angle

5.8 OPERATION AND MAINTENANCE

CRC will provide one skilled technician to operate the terminal. The user may be asked to provide some technician assistance during operation, and particularly for safety during maintenance when hazardous voltages may be encountered by the operator making repairs to the equipment.

6. TVRT TERMINAL (TELEVISION RECEIVE WITH TELEPHONY TRANSMIT/RECEIVE)

6.1 GENERAL

This terminal provides a capability for television receive with telephony transmit/receive. The TVRT receives a single FM video carrier in any one of the six ANIK-B channels. However, it is fixed tuned to one of these six channels and cannot be re-tuned to another by the operator. The single channel of operation is determined by crystal oscillators in the RF Unit.

The TVRT will receive a single FM SCPC telephony carrier in the same ANIK-B channel used for the video, i.e., both video and telephony carriers

must be in the same one of the six ANIK-B channels. Because of the fixed frequency operation, it is generally necessary to change crystal oscillators in the RF Unit if the terminal is moved between different ANIK-B spot beams.

All TVRT terminals transmit a single SCPC FM telephony carrier in ANIK-B Channel 4, regardless of their location across Canada. These Channel 4 SCPC return carriers are all received at the Ottawa 9m Network Control Station (NCS) used for telephony channel switching in the DOC ANIK-B two-hop telephony system.

Terminal design provides for the addition of up to three more Tx/Rx telephony carriers, and four terminals are equipped with two telephony channels.

6.2 CONFIGURATION

The terminal has a 3m (10 ft) antenna with two electronic boxes mounted on the back of the antenna. The antenna may be installed on the ground adjacent to a user's building or on a flat roof with suitable load bearing capability. There are three indoor electronic units that must be located in a building or shelter supplied by the user. The indoor/outdoor electronics units are interconnected by a 30m (100 ft) cable run and, therefore, the indoor units must be located within 30m of the antenna. These cables carry an IF of 735 MHz and cannot be extended in length.

Figure 6.1 shows a block diagram and Plates 6.1 and 6.2 give photographs of the antenna and indoor units respectively.

6.3 SIGNALS AND INTERFACES

6.3.1 Video-General

Two video baseband outputs are provided on the back of the TV Receive Unit. A video carrier may have from one to three associated audio channels and three audio outputs (one for each audio channel) are provided on the back of the TV Receive Unit. Video or audio monitors are not provided with the terminal and these are the responsibility of the user.

6.3.2 Video Interface

Video

impedance:	75 ohms unbalanced
connector:	BNC female
bandwidth:	30 Hz to 4.2 MHz
level:	1 volt peak-to-peak for the composite video

Audio

impedance:	600 ohms balanced
connector:	spade lug type with screw terminals
bandwidth:	50 Hz to 10 KHz
test-tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level:	0 Vu corresponds to 0 dBm

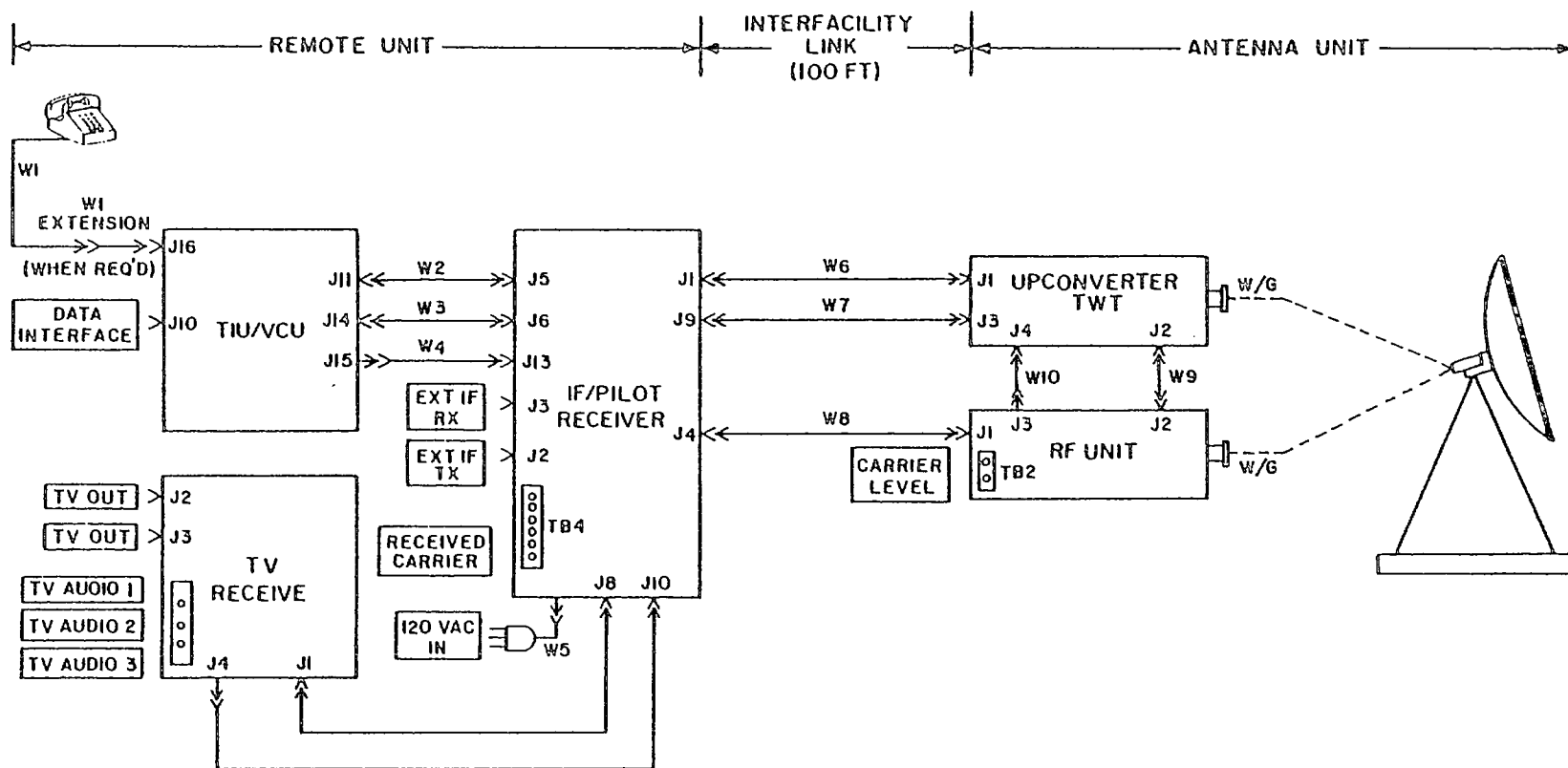


Figure 6.1 TVRT Block Diagram



Plate 6.1 TVRT Terminal

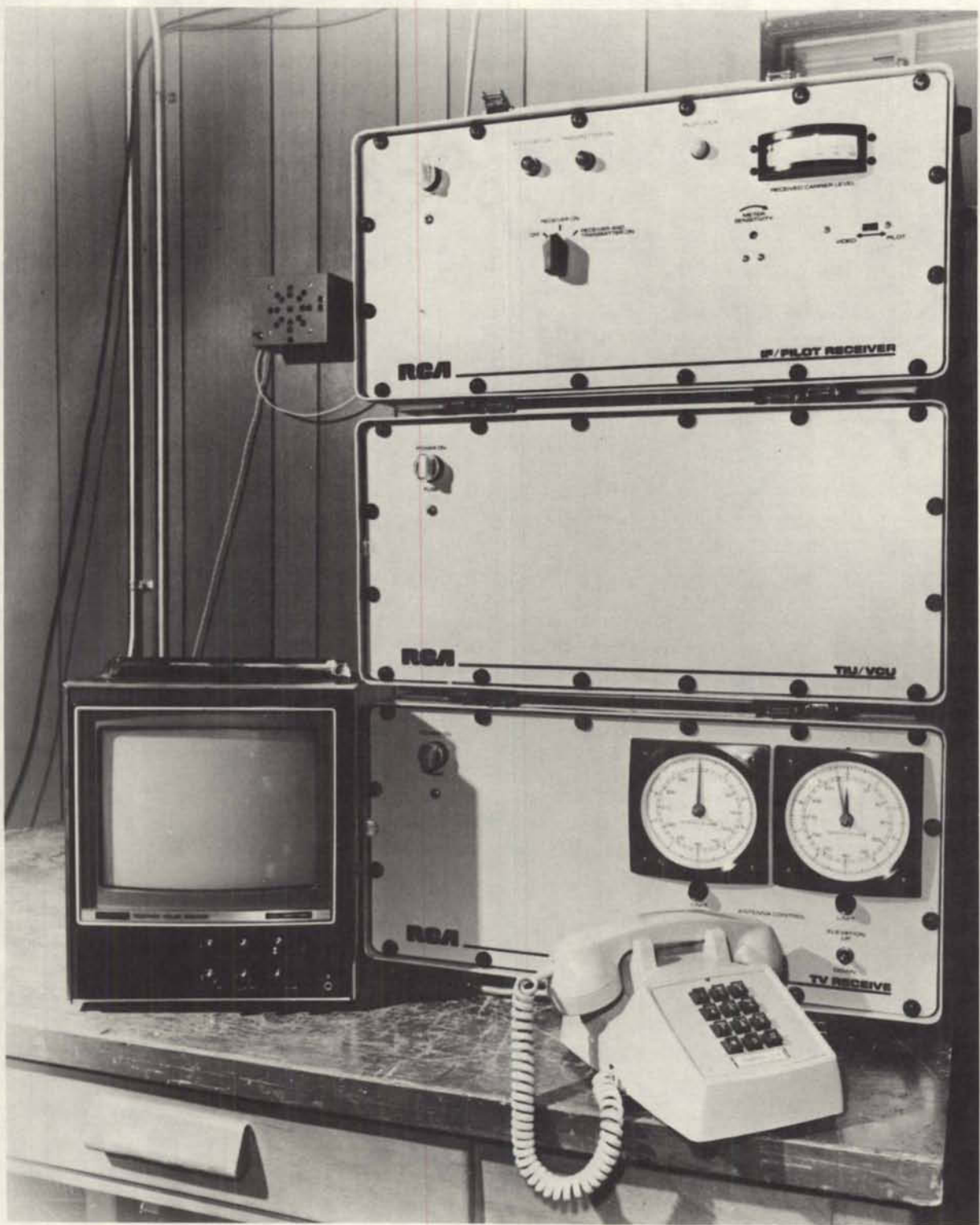


Plate 6.2 TVRT Indoor Electronics

6.3.3 Telephony-General

A special 4-wire telephone set is provided. This is a desk-top telephone equipped with a touch-tone dial pad. The set has a 3m (10 ft) cord attached to the back of the TIU/VCU Unit and can be provided with a 30m (100 ft) extension, if required.

An external interface is provided for the telephony channel on the back of the TIU/VCU Unit. This has been called a Data Jack, but it can be used to interface any appropriate device that will operate over the 4-wire analog telephony channel. Only one of the telephone set or Data Jack may be operational at one time. Switching between these is accomplished by shorting a pair of pins on the Data Jack.

6.3.4 Telephony Data Jack Interface

impedance:	600 ohms balanced
connector:	matching plug to Data Jack is Cannon XLR-7-12C
pin connections:	pins 1-2 input to jack pins 5-6 output from jack pins 3-4 short for external, open for telephone
bandwidth:	300 Hz to 3400 Hz
test-tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level for audio interface:	0 Vu corresponds to 0 dBm

6.4 PRIME POWER

It is the responsibility of the user to provide suitable electrical power for the terminal. Power is supplied through a single power cord connected to the IF Pilot Receiver Unit. Normally, this is plugged into a standard 120 volt, 15 amp circuit. The terminal can also be operated from portable electric generators having suitable capacity. It is normal practice to leave the equipment powered continuously; if it is turned off, there may be some time required for warm-up in cold weather.

Prime Power requirements are:

120 volts \pm 15%
1 KVA (about 400 W of this is for outdoor unit heaters)
60 Hz \pm 10% single phase, two wire plus ground.

6.5 ENVIRONMENTAL

Indoor electronics units operational limits are:

Temperature: 4°C (40°F) to 35°C (95°F)
Relative Humidity: 5% to 75%

Indoor electronics units survivable limits are the same as for the rest of the terminal.

Outdoor electronics plus antenna:

	Operational	Survivable
Temperature:	-45°C (-50°F) to 35°C (95°F)	-51°C (-60°F) to 40°C (105°F)
Relative Humidity:	5% to 100%	5% to 100%
Wind (Average):	48 km/hr (30 mi/hr)	
Wind (Gusts):	72 km/hr (45 mi/hr)	160 km/hr (100 mi/hr)
Ice:		140 km/hr (87 mi/hr)
Altitude:	to 3 km (1000 ft)	to 9 km (3000 ft)

The antenna reflector must be kept clear of snow and ice for proper operation. A soft brush or anti-freeze spray can be used. Care must be taken not to damage the antenna reflector or feed system. The transmitter *must be turned off* when standing directly in front of the antenna because of the potential microwave radiation hazard.

6.6 TRANSPORTATION

In general, CRC will be responsible for transportation between major centres. In some cases, particularly for sites with difficult access, the user may be expected to assume some responsibility for transportation, this will be worked out on a case-by-case basis. Shipping containers are as follows:

Unit	Size (inches)	Weight (lbs)
Antenna	L X W X H	
Box 1	122 X 14 X 6	91
Box 2	88 X 56 X 6	53
Box 3	132 X 7 X 6	68
Box 4	72 X 13 X 5	39
Box 5	48 X 16 X 15	86
Box 6	76 X 35 X 9	118
Box 7* (Reflector)	128 X 31 X 54	170
Box 8* (Reflector)	128 X 31 X 54	176
Box 9* (Reflector)	132 X 34 X 60	192
Box 10	64 X 11 X 11	62

* Note: For air shipment, the reflector sections can be fitted into a Twin Otter without the shipping containers. During transport, storage, or installation, the reflector sections **must always** be placed on edge. The sections or assembled reflectors **must never** be placed so that the curved area is on the ground.

Electronics

UC/TWT	23.5 X 27.5 X 15.5	90
RF Unit	23.5 X 27.5 X 15.5	80
IF/Pilot Rx.	23.5 X 27.5 X 15.5	90
TIU/VCU	23.5 X 27.5 X 15.5	80
TV Receive	23.5 X 27.5 X 15.5	110
Cable Assembly	23.5 X 27.5 X 15.5	80
Telephone Set	11 X 10 X 9	10

6.7 SITE REQUIREMENT AND INSTALLATION

The user has the responsibility for selecting a site, which will in general then be approved by CRC to ensure adequately clear look angle to the satellite, area for terminal installation, power, buildings, etc.

The site must have an unobstructed line of sight within a 10° cone in the direction of the satellite. Given latitude, longitude, and altitude of a site, CRC can provide azimuth and elevation angle data for the satellite.

The antenna can be installed on the ground or on a flat roof with sufficient load bearing strength. Weighted platform foundations have been used successfully in the past by CRC for short-term installations. CRC has designs for suitable foundations. It is the user's responsibility to provide a foundation, and to ensure in the case of a roof top mount that the roof can support the necessary weight.

Weights of the terminal *excluding* foundation platform or shipping containers are:

Antenna plus outdoor electronics:	277 Kg (610 lbs)
indoor electronics:	59 Kg (130 lbs)

CRC will be responsible for installation, check-out, and removal, of CRC supplied terminal equipment. The user may be asked to provide some manpower assistance during terminal installations or removal.

Microwave radiation levels in the main beam of the antenna should not exceed levels considered safe for human exposure. However, sufficient precautions should be taken to ensure that, when transmitting, access to the front of the antenna is prevented, and that long periods of exposure in the beam of the antenna are avoided. Radiation levels between the antenna horn feed and the subreflector, within the structure of the antenna, *will exceed* safe levels and access to this area *must be avoided* when transmitting.

6.8 OPERATION AND MAINTENANCE

During the period of the Pilot Project, the user will be expected to operate the terminal. This is quite simple and instructions and demonstrations will be given by the installation crew.

Suspected terminal problems should be reported to CRC as soon as possible. Maintenance is the responsibility of CRC.

7. TVRT-TM TERMINAL (TELEVISION RECEIVE AND TELEPHONY TRANSMIT/RECEIVE WITH TELEVISION TRANSMIT MODULE)

7.1 GENERAL

This terminal is essentially the TVRT, with an added high power amplifier (HPA) and slightly larger antenna to give a capability to transmit a video carrier. It also provides television receive with telephony transmit/

receive. It receives a single FM video carrier in any one of the six ANIK-B channels. However, the receive channel is fixed tuned to one of these six channels and cannot be re-tuned to another by the operator. The single channel of operation is determined by crystal oscillators in the RF Unit.

The terminal will receive a single FM SCPC telephony carrier in the same ANIK-B channel used for the video, i.e., both video and telephony carriers must be in the same one of the six ANIK-B channels. Because of the fixed frequency operation, it is generally necessary to change crystal oscillators in the RF Unit if the terminal is moved between different ANIK-B spot beams.

All TVRT terminals transmit a single SCPC FM telephony carrier in ANIK-B Channel 4, regardless of their location across Canada. These Channel 4 SCPC return carriers are all received at the Ottawa 9m Network Control Station (NCS) used for telephony channel switching in the DOC ANIK-B two-hop telephony system.

Terminal design provides for the addition of one more Tx/Rx telephony channel, but this additional channel equipment is not available at this time.

The high power transmit module can transmit one video carrier in any of the six ANIK-B channels. This channel can be selected and is independent of the fixed tuned receive channel. The choice of operating channel is in accordance with an Operations Plan produced by CRC and cannot be changed without authorization.

7.2 CONFIGURATION

The terminal has a 3.7m (12 ft) antenna with two electronics boxes mounted on the back of the antenna. The antenna may be installed on the ground adjacent to a user's building or on a flat roof with suitable load bearing capability. There are three indoor electronics units that must be located in a building or shelter supplied by the user. The indoor/outdoor electronics units are interconnected by a 30m (10 ft) cable run and, therefore, the indoor units must be located within 30m of the antenna. These cables carry an IF of 735 MHz and cannot be extended in length.

The high power amplifier transmit module is contained within a 6' X 6' X 6' fibreglass Transmit Module (TM) hut mounted adjacent to the antenna. The hut contains an airconditioner, heater, 250 watt TWTA, and other electronics associated with transmitting a video carrier. A remote control unit is available for controlling the HPA. This may be located up to 30m (100 ft) from the TM hut.

The three indoor TVRT electronics units may be installed in a user supplied building at a distance of 30m as discussed in a previous paragraph, or, alternatively, mounted inside the TM hut. In this latter case, the complete terminal is self-contained and no user-supplied building is needed. However, all baseband interface cabling must be brought by the user to the TM hut.

Figure 7.1 shows a block diagram and plates 7.1 and 6.2 give photographs of an antenna, TM hut, and indoor units respectively.

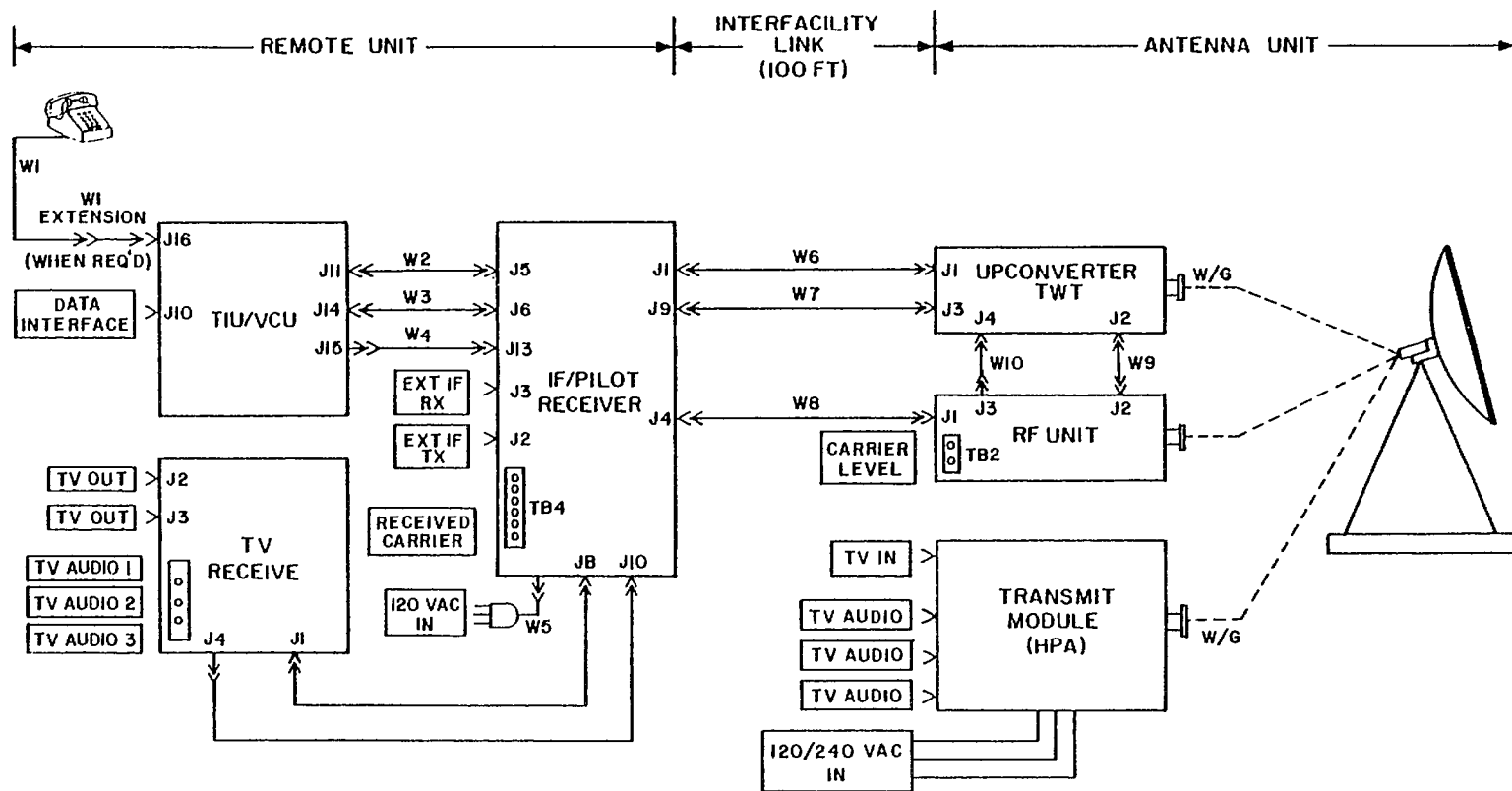


Figure 7.1 TVRT-TM Block Diagram



Plate 7.1 TVRT-TM Terminal with TM Hut

7.3 SIGNALS AND INTERFACE

7.3.1 Video-General

Two video baseband outputs are provided on the back of the TV Receive Unit. A video carrier may have from one to three associated audio channels and three audio outputs (one for each audio channel) are provided on the back of the TV Receive Unit. Video or audio monitors are not provided and these are the responsibility of the user.

Video and audio cabling must be supplied by the user to interface with a junction box on the TM hut. Video baseband and one to three associated audio inputs are fed to the TM. There are no video monitors supplied with the TM.

7.3.2 Video Interface (Receive and Transmit)

Video

impedance:	75 ohms unbalanced
connector:	BNC female
bandwidth:	30 Hz to 4.2 MHz
level:	1 volt peak-to-peak for the composite video

For transmit, a video clamping amplifier is available in the TM hut with capability to equalize at least 610m (2000 ft) of RG-11U coaxial cable or equivalent. For applications, where AC hum pick-up could be a problem, triaxial cable may be desirable.

Audio (each channel)

impedance:	600 ohms balanced
connector:	spade lug type with screw terminals
bandwidth:	50 Hz to 10 KHz
test-tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level:	0 Vu corresponds to 0 dBm

7.3.3 Telephony-General

A special 4-wire telephone set is provided. This is a desk-top telephone equipped with a touch-tone dial pad. The set has a 3m (10 ft) cord attached to the back of the TIU/VCU Unit and can be provided with a 30m (100 ft) extension, if required.

An external interface is provided for the telephony channel on the back of the TIU/VCU Unit. This has been called a Data Jack, but it can be used to interface any appropriate device that will operate over the 4-wire analog telephony channel. Only one of the telephone set or Data Jack may be operational at one time. Switching between these is accomplished by shorting a pair of pins on the Data Jack.

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7.3.4 Telephony Data Jack Interface

impedance:	600 ohms balanced
connector:	matching plug to Data Jack is Cannon XLR-7-12C
pin connections:	pins 1-2 input to jack pins 5-6 output from jack pins 3-4 short for external, open for telephone
bandwidth:	300 Hz to 3400 Hz
test-tone level:	+10 dBm for a 1 KHz full load test-tone
nominal program level for audio interface:	0 Vu corresponds to 0 dBm

7.4 PRIME POWER

It is the responsibility of the user to supply suitable electronics power for the terminal.

7.4.1 Indoor Electronics Separate from TM

Power for indoor electronics is fed through a single power cord connected to the IF Pilot Receiver Unit. Normally, this is plugged into a standard 120 volt, 15 amp circuit. Prime power requirements are:

120 volts \pm 15%
1 KVA (about 400W of this is for outdoor unit heaters)
60 Hz \pm 10% single phase, two wire plus ground.

Power for TM hut is supplied to an electrical interface on the hut. Power requirements are:

120/240 volts \pm 15%
5.5 KVA (2.3 KVA of this is for air conditioning)
60 Hz \pm 10% single phase, three wire.

It is normal practice to leave the equipment powered continuously (except HPA); if it is turned off, there may be some time required for warm-up in cold weather.

7.4.2 Indoor Electronics Inside TM

Power for complete terminal is supplied to an electrical interface on the hut. Power requirements are:

120/240 volts \pm 15%
6.5 KVA
60 Hz \pm 10% single phase, three wire.

7.5 ENVIRONMENTAL

Indoor electronics units, when operated indoors, operational limits are:

Temperature: 4°C (40°F) to 35°C (95°F)
Relative Humidity: 5% to 75%

Indoor electronics units survivable limits are the same as for the rest of the terminal.

Outdoor electronics plus antenna and Transmit Module:

	Operational	Survivable
Temperature:	-45°C (-50°F) to 55°C (95°F)	-51°C (-60°F) to 40°C (105°F)
Relative Humidity:	5% to 100%	5% to 100%
Wind (Average):	48 km/hr (30 mi/hr)	160 km/hr (100 mi/hr)
Wind (Gusts):	72 km/hr (45 mi/hr)	140 km/hr (87 mi/hr)
Ice:		5 cm (2 in) of ice
Altitude:	to 3 km (1000 ft)	to 9 km (3000 ft)

The antenna reflector must be kept clear of snow and ice for proper operation. A soft brush or anti-freeze spray can be used. Care must be taken not to damage the antenna reflector or feed system. *Both* HPA and TVRT 20W transmitters, *must be turned off* before personnel access areas directly in front of the antenna because of the potential microwave radiation hazard.

7.6 TRANSPORTATION

In general, CRC will be responsible for transportation between major centres. In some cases, particularly for sites with difficult access, the user may be expected to assume some responsibility for transportation, this will be worked out on a case-by-case basis. Shipping containers are as follows:

Unit	Size (inches)	Weight (lbs)
Antenna	L X W X H	
Box 1	118 X 15 X 16	91
Box 2	90 X 56 X 6	70
Box 3	132 X 7 X 6	68
Box 4	72 X 13 X 5	39
Box 5	60 X 16 X 17	94
Box 6	90 X 34 X 9	125
Box 7* (Reflector)	146 X 30 X 58	185
Box 8* (Reflector)	156 X 30 X 58	185
Box 9* (Reflector)	160 X 38 X 44	195
Box 10* (Reflector)	160 X 38 X 44	195
Box 11	78 X 11 X 11	70

* For air shipment, the reflector sections can be fitted into a Twin Otter without the shipping containers. During transport, storage, or installation, the reflector sections must always be placed on edge. The sections or assembled reflector must never be placed so that the curved area is on the ground.

Electronics (TVRT)

UC/TWT	23.5 X 27.5 X 15.5	90
RF Unit	23.5 X 27.5 X 15.5	80
IF/Pilot Rx.	23.5 X 27.5 X 15.5	90
TIU/VCU	23.5 X 27.5 X 15.5	80
TV Receive	23.5 X 27.5 X 15.5	110
Cable Assembly	23.5 X 27.5 X 15.5	80
Telephone Set	11 X 10 X 9	

Transmit Module (TM)

TWTA	36 X 24 X 30	180
Air Conditioner	30 X 24 X 24	90
Electronics	36 X 24 X 30	175
Miscellaneous	48 X 24 X 24	60
Shelter (3 containers)	72 X 36 X 36 (each)	300
Total Weight (TM)	1225 lbs. installed.	

7.7 SITE REQUIREMENT AND INSTALLATION

The user has the responsibility for selecting a site, which will in general then be approved by CRC to ensure an adequate clear look angle to the satellite, area for terminal installation, power, buildings, etc.

The site must have an unobstructed line of sight within a 10° cone in the direction of the satellite. Given latitude, longitude, and altitude of a site, CRC can provide azimuth and elevation angle data for the satellite.

The antenna can be installed on the ground or on flat roof with sufficient load bearing strength. Weighted platform foundations have been used successfully in the past by CRC for short term installations. CRC has designs for suitable foundations. It is the user's responsibility to provide a foundation, and to ensure in the case of a roof top mount that the roof can support the necessary weight.

Weights of the terminal *excluding* foundation platform area:

Antenna plus outdoor electronics:	340 kg (750 lbs)
indoor electronics:	59 kg (130 lbs)
TM hut:	556 kg (1225 lbs)

CRC will be responsible for installation, check-out, and removal of CRC supplied terminal equipment. The user may be asked to provide some manpower assistance during terminal installations or removal. The user shall provide necessary prime power hook-up and a standard terrestrial telephone accessible to the HPA operator.

The power levels capable of being transmitted by the TM are sufficiently high that an RF radiation hazard to personnel in the beam of the antenna may exist. Consequently, the user is required to select and

protect the site such that persons are prevented from entering areas where the radiation level may be too high. Allowable exposure to RF radiation is generally accepted to be power densities of 10 mw/cm^2 for short exposure and $<1 \text{ mw/cm}^2$ for long exposure. Calculations indicate that a maximum power density could exist of up to 7 mw/cm^2 in the antenna aperture, 13 mw/cm^2 at a distance of 118 metres (390 ft) along the boresight axis of the antenna, and $<0.3 \text{ mw/cm}^2$ in the far field 1250m or more (4100 ft) along the axis. Levels behind the antenna should be less than 1 mw/cm^2 .

The user must take suitable precautions, such as installing a security fence, to ensure safety of personnel. Figures 7.2 and 7.3 illustrate a suitable arrangement.

7.8 OPERATION AND MAINTENANCE

During the period of the Pilot Project, the user will be expected to operate the terminal. This is quite simple and instructions and demonstrations will be given by the installation crew.

Suspected terminal problems should be reported to CRC as soon as possible. Maintenance is the responsibility of CRC.

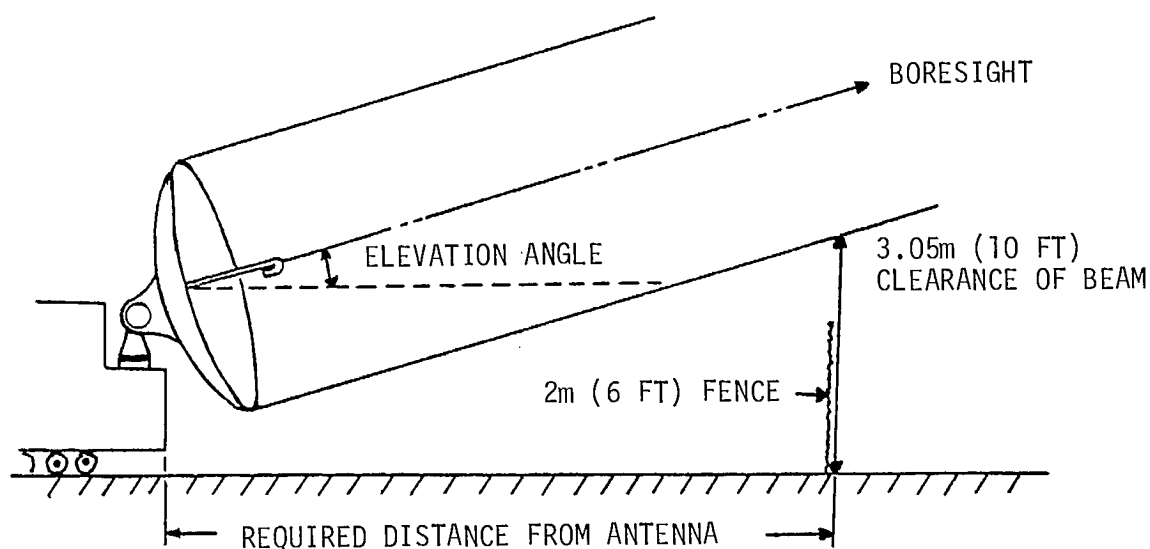


Figure 7.2 Protection from Radiation Hazards

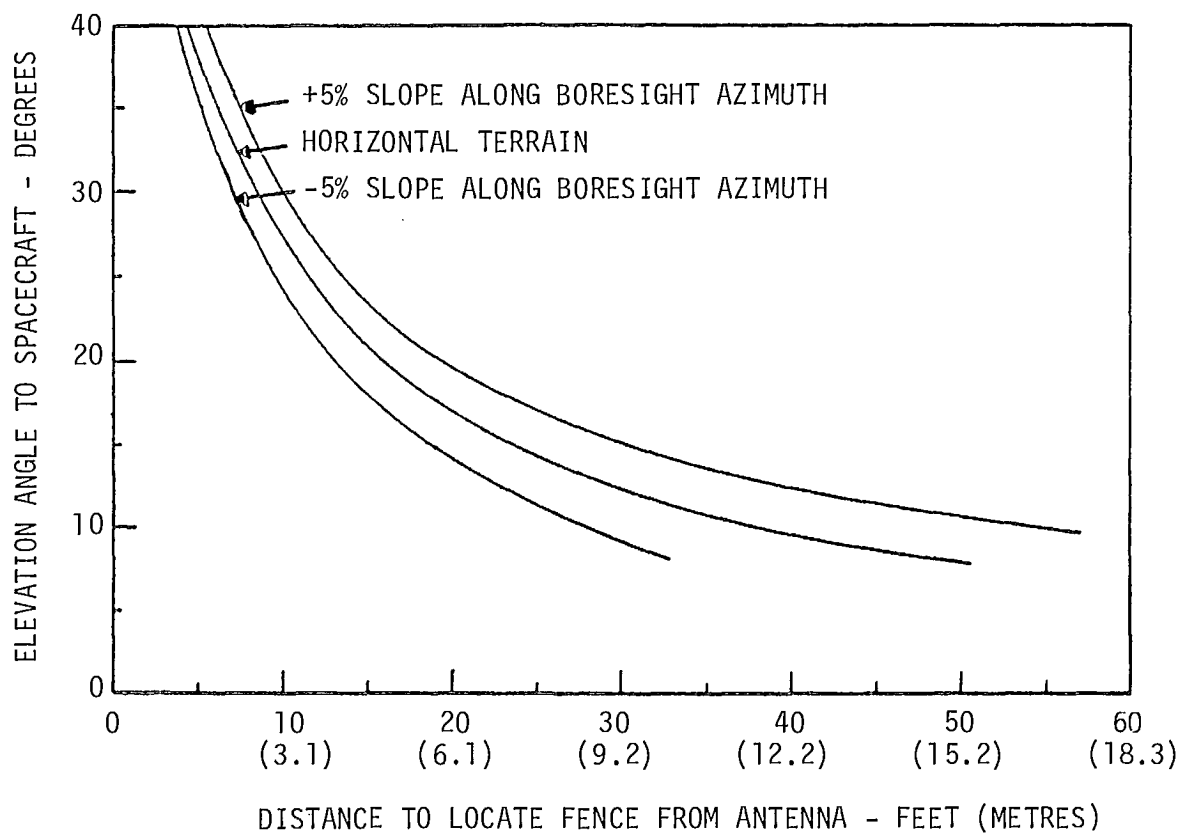


Figure 7.3 Depth of Safety Enclosure as a Function of Elevation Angle

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8. ABSTRACT: This Technical Note describes the technical and operational aspects of the 12/14 GHz portion of the ANIK-B satellite leased by the Department of Communications from Telesat Canada and DOC owned ground terminals to be used with ANIK-B. Its purpose is to provide information to participants in ANIK-B pilot projects to aid in planning of the technical aspects of these projects.

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