



BEYOND LINE OF SIGHT (BLOS) HF SYSTEM

Introduction

The Beyond Line of Sight (BLOS) High Frequency (HF) System was designed, developed, integrated, installed, and commissioned by Thales Canada, Systems Division, a Division of Thales Canada Inc., for the Canadian Department of National Defence (DND). The BLOS HF System is used to provide secure voice Advance Narrowband Digital Voice Terminal (ANDVT) and Link-11 data communications between the Canadian NORAD Region Sector Air Operations Centre (SAOC) in North Bay, Ontario, Canada, and operational units located in Canada and offshore. Operational units include Airborne Warning and Control System (AWACS) patrol aircraft and ships at sea.

The BLOS System serves to retrieve radar, electronic warfare, and other sensor track information detected by AWACS and other surveillance aircraft and ships and shares this information with naval ships and distant command centres. The system can therefore contribute to the development of a “wide area picture” which, through the Link-11 network, is distributed to all participants. The system also provides a secure voice link between the ships, the aircraft, and the control centre.

The system consists of equipment installed at the SAOC in North Bay, as well as seven remote Ground Entry Stations (GES). As initially deployed, the GES, each consisting of a transmit shelter, a receive shelter, and

associated antennas, are located in Edmonton, Debert, Resolute Bay, Inuvik, and Iqaluit. The remaining two GES are designated as transportable and are initially deployed at Tofino and at Shearwater but can be easily relocated elsewhere.

The SAOC installation consists of the Remote Control & Monitoring System (RC&MS) running over a two client, one server Transmission Control Protocol/Internet Protocol (TCP/IP) network under WindowsNT version 4.0, landline modems, multiplexers, and switching equipment necessary to establish connectivity to up to four remote sites simultaneously to allow control and monitoring of those sites as well as the local Link-11 Data Terminal Set (DTS), and to provide for the passage of secure voice and Link-11 data. The SAOC also contains secure voice terminals connected to ANDVT cryptos and a tactical data system connected to a KG-40A crypto, in order to generate and display Link-11 data.

Key Features

- Turnkey HF radio communications system;
- Long delay, split-split (queued satellite) Link-11 (TADIL-A) architecture;
- Automatic Link Establishment (ALE) in accordance with MIL-STD-188-141A;
- Adaptive digital beamforming receive system for interference reduction;

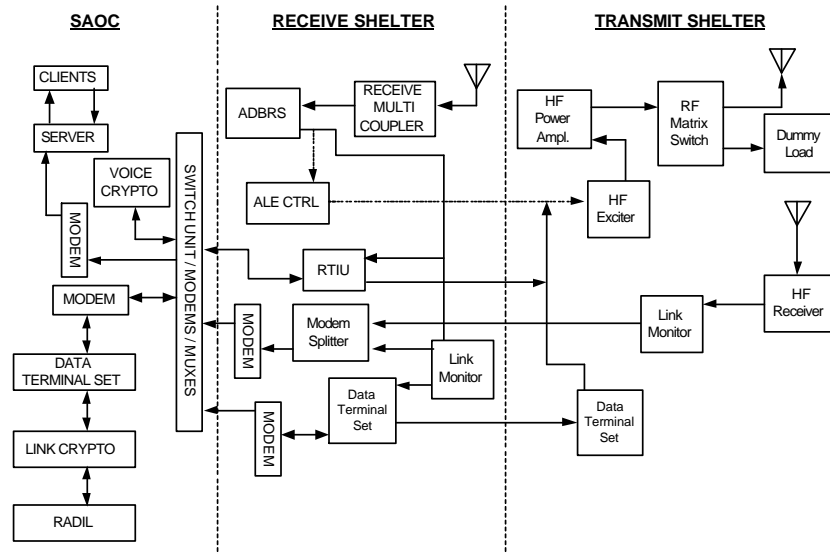


Figure 1: BLOS HF System Block Diagram

- Automatic link to ICEPAC high frequency (HF) propagation prediction;
- User friendly RC&MS for central control of all operations;
- Transportable GES shelters (commercial aircraft, CC-130, road transport, etc.);
- Environmental control and monitoring of GES shelters, including security alarms and automatic callback from “unconnected” sites;
- Flexible and expandable rear link communications subsystem.

System Description

The BLOS system may be characterized into seven subsystems:

- the Remote Control & Monitoring System (RC&MS);
- the Ground Entry Stations (GES), in turn consisting of:
 - a receive shelter;
 - a transmit shelter;
 - the antenna subsystem;
- the rear link communications;
- the inter-site communications; and
- the power subsystem.

These areas are described in the following sections.

Remote Control and Monitoring System (RC&MS)

The Remote Control and Monitoring System was custom developed by Thales Canada, Systems Division. The RC&MS has two major components:

- The RC&MS server which runs on the server workstation located at the SAOC; and
- The RC&MS client program, which normally runs on the RC&MS client workstations, but may also be run on the RC&MS server.

The RC&MS server and client program each use a Microsoft WindowsNT 4.0 workstation and communicate via TCP/IP using a 100 BaseT network hub. The RC&MS server also hosts a commercial Structured Query Language (SQL) database operating over the TCP/IP network.

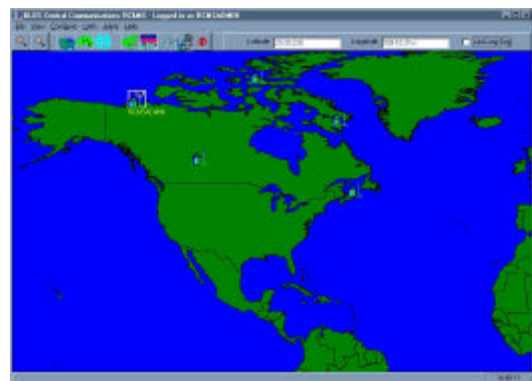


Figure 2: Main Window

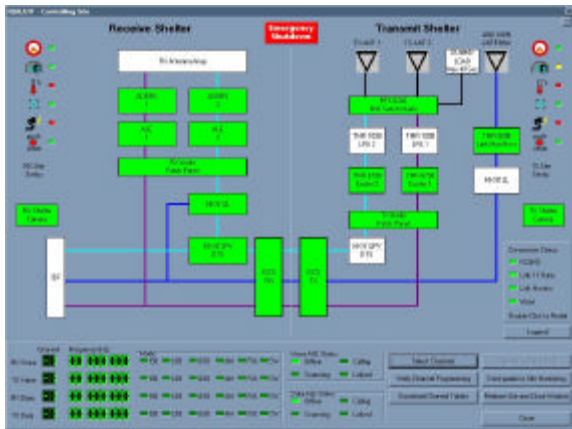


Figure 3: Site Configuration Window

The Remote Control and Monitoring System allows for the control and monitoring of all parameters at the GES which can be controlled or monitored.

Ground Entry Station (GES)

Each ground entry station comprises a pair of shelters (transmit and receive) separated by a distance of typically 5 to 15 kilometres, and connected via the Inter-site Communications System described later.



Figure 4: Ground Entry Station at Edmonton

Receive Shelter

The receive shelter contains two Adaptive Digital Beamforming Receive Systems (ADBRs) each of which is essentially four individual receivers, each connected to its own antenna, allowing the array to be beamformed for the purpose of steering nulls against (natural or man made) interfering signals. The beamforming is done using powerful digital signal processing, and is based on *a priori* knowledge of the (ANDVT or parallel tone Link-11) waveform being sought.

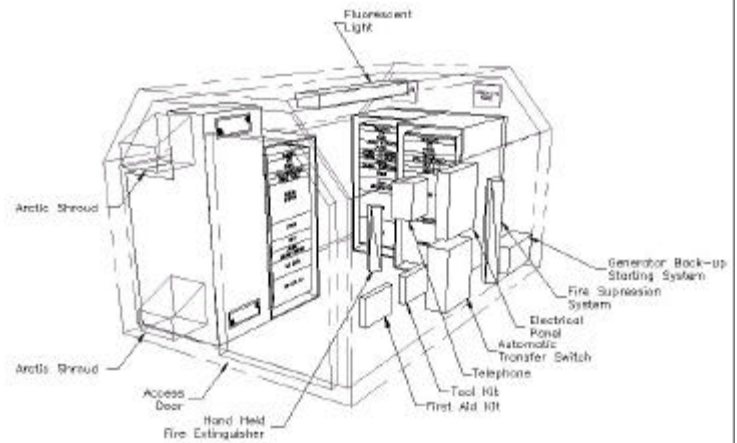


Figure 5: Receive Shelter

In addition, the receive shelter contains a Link-11 data terminal set, Link-11 monitoring system, digital Ultra High Frequency (UHF) radio for intersite communications, a radio telephone interface unit to automatically answer and equalize the voice circuit from the SAOC to the shelter, and an Automatic Link Establishment (ALE) controller/modem for frequency management.

Finally, the receive shelter also contains an environment monitoring and status system; security system (including digital camera for transmission of still pictures to the RC&MS); fire detection and suppression system; Heating, Ventilation, and Air Conditioning (HVAC); lighting; and other “hotel” systems.

Transmit Shelter

At the heart of the transmit shelter are two 1 kilowatt HF transmitters, comprising a Digital Signal Processor (DSP)-based exciter, and a solid-state, modular linear power amplifier. In addition, the transmit shelter contains a Link-11 data terminal set, Link-11 monitoring system (including an HF monitoring receiver), digital UHF radio for intersite communications, and 6x6 radio frequency matrix switch to connect the transmitters to a variety of antennas or dummy loads.

As with the receive shelter, the transmit shelter also contains an environment monitoring and status system, security system, fire detection and suppression system, HVAC, lighting, and other “hotel” systems.

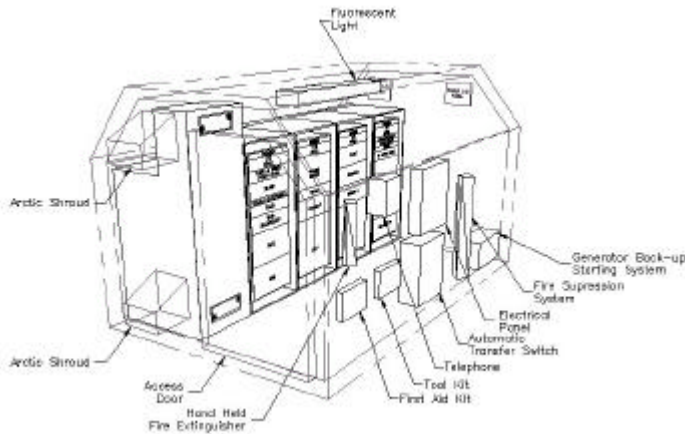


Figure 6: Transmitter Shelter

Antennas

The best HF radios in the world would be worthless without antennas which have been selected to optimize system performance. Considerable effort went into the design and selection of the BLOS antennas.

The fixed GES and the transportable GES use different types of antennas, due to the need for the transportable GES to have antennas which can be deployed relatively easily in the field by a few people working under often adverse conditions.

At the fixed GES receive site, the antenna system comprises an array of four monopole/loop antennas laid out in a precise geometry. Four antennas are used in order to permit the adaptive digital beamforming receive system to steer up to three nulls against interfering signals. The monopole/loop antenna consists of a sleeve monopole with two orthogonal loops supported by the monopole as well as by four guy wires. A switching unit near the base of the antenna allows the antenna element to be operated in one of three modes: vertically polarized, left-hand circularly polarized, or right-hand circularly polarized, for reception of HF skywave signals from the lowest elevation angles (0°) to the highest elevation (90°).

At the fixed GES transmit shelter, two broadband, elliptically polarized, omni-directional antennas ensure reliable short- to medium-range skywave communications over the full HF band. The use of elliptical polarization has proven to be effective in avoiding deep fading because of polarization nulls caused by ionospheric rotation of the electric field.

For the transportable GES, the receive antennas are a transportable version of the fixed receive antennas described above. The transmit antennas are crossed broadband dipole antennas supported on four 12.5 metre



Figure 7: Fixed Receive Antenna

masts. These antennas feature horizontal polarization, an omni-directional pattern in azimuth, and a relatively small installed ground area. They are packed in reusable, lockable transport cases (less mast sections). The receive array can be made operational by two persons in four hours or less, and the transmit antennas can be made operational by three persons in 16 hours or less.

The system also includes a pair of “Arctic transportable” antennas which are horizontally polarized, omni-directional antennas designed for tactical use where rapid deployment and transportability are of prime importance. Installation and teardown times are kept to a minimum even under adverse conditions of wind, snow, and cold temperatures.

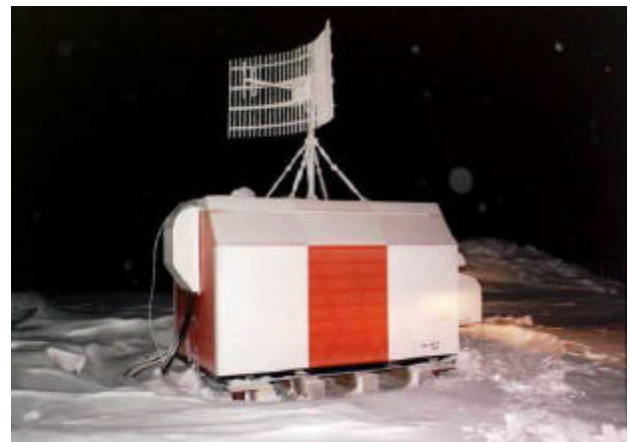


Figure 8: Shelter with ISCS Antenna Deployed

Inter-site Communications

The Inter-site Communications Subsystem (ISCS) provides the connectivity between the GES transmit and receive shelters, which are typically separated by a distance of 5 to 15 kilometres to minimize co-site

interference problems. This is provided by a full duplex digital UHF radio link operating at a frequency of approximately 390 MHz. The link has a capacity of 384 kilobits per second (kbps). Once the shelters have been placed in position, a corner reflector antenna is secured to the roof of the shelter and aligned to point at the adjacent shelter. Where the combination of distance and intermediate terrain precludes line of sight operation, the corner reflector antennas can be placed on towers. In extreme cases, a repeater may be required at an intermediate point. The following information is sent between transmit and receive shelters:

- RC&MS health monitoring polls and responses;
- Individual equipment operation commands;
- Digitized voice and ALE tones;
- Link-11 tactical data;
- Link-11 monitoring data.

As an optional method of achieving intersite communications, or as an automatic backup circuit, landline modems operating at 128 kbps over two twisted pair lines (at distances up to 5 kilometres) are also provided.

Rear Link Communications

Rear Link Communications between the GES and the SAOC is achieved over various types of telecommunications circuits. The system can be configured to use any one of four types of service:

- Public Switched Telephone Network (PSTN) – up to 9.6 kbps;
- Fast PSTN – 19.2 kbps;
- Integrated Services Digital Network (ISDN) – 64 kbps “B” channel;
- Defence Integrated Services Digital Network (DISDN) – 64 kbps channel.

The BLOS system requires that the Rear Link Communication System (RLCS) provide for the following data rates and bandwidths:

- RC&MS Data – 4.8 kbps;
- Link-11 Data Terminal Set Data – 2.4 kbps;
- Link-11 Link Monitor Data – 9.6 kbps;
- Secure Voice (ANDVT) – 300 – 3300 Hz analog channel.

RLCS communications terminate at the GES Receive Shelter. Onward communication to the Transmit Shelter is carried over the ISCS.

Power

The GESs are designed to operate from 208/240 volt, split phase, 60 Hz utility power, where it is available. In the event of non-availability, an automatic transfer switch switches over to auto-start a diesel generator (the system has been designed to interface with the Canadian Forces 5-kW or 10-kW tactical quiet generator) which will supply power as long as fuel is available. During switchover, or when the generator is shut down for maintenance or refueling, an uninterruptable power supply (UPS) maintains power to key pieces of equipment for approximately one half hour.

System Operation

The system is “operated” from the SAOC using the RC&MS client workstations, as well as an SVPA(V) 1 secure voice terminal connected to an ANDVT crypto, and a tactical data system connected to a KG-40A crypto, in order to generate and/or display Link-11 tracks.

RC&MS functionality permits SAOC personnel to:

- Login as an Operator or System Controller as authorized;
- Control two GESs simultaneously while monitoring an additional two GESs;
- Remotely control all GES radio equipment;
- Remotely control all GES ALE functions;
- Remotely control all GES ADBRS functions;
- Display and control GES status and faults;
- Interface with the Frequency Management System for the utilization of the ICEPAC HF Propagation Prediction;
- Display, control, and monitor shelter environmental conditions; and
- Log, archive, print, and shutdown the system.



Figure 9: AWACS Aircraft



Figure 10: Canadian Patrol Frigate

System Performance

- Control of up to 12 BLOS HF GESs, with control of two GESs and monitoring of two other GESs simultaneously;
- A/G/A communications performance optimized for communication with aircraft operating at up to 12,500 metres above sea level (ASL) at distances of between 500 and 1200 km from GES;

- Shore/ship/shore communications performance optimized for communication with ships operating at distances of between 0 and 500 km from GES;
- Air transportable (Boeing 727, 737, and Lockheed C-130);
- >30 dB of interference rejection at azimuthal separations as small as 10 degrees from desired signal;
- initial adaptation rate less than 200 msec for Link-11 and ANDVT waveforms.

Easily Expanded to New Mission Roles

The BLOS HF system can be easily and economically expanded to meet new HF mission requirements. The open architecture and control software have built-in flexibility to add next-generation capabilities such as multi-media and multi-band operations. The Link-11 system can be upgraded to the single-tone Link-11 waveform (SLEW), and the ADBRS is capable of having beamforming algorithms added for other STANAG and military standard waveforms, including MIL-STD-188-110A or B, STANAG 4285, and even frequency shift keying (FSK) teleprinter/teletype/teletypewriter (TTY).

The growth capacity built into the matrix switch allows the addition of other types of HF antennas for different applications. Rack space exists for the addition of V/UHF radio equipment should the need arise.

Finally, with the use of appropriate data terminal sets and modems, the system could be adapted for use with other tactical data information links such as Link-16 or Link-22.

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