TN2005-610-V1.0.0

GENERAL DESCRIPTION OF MODEL 9601-D

TECHNICAL NOTE

November 15, 2005

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1.0 PURPOSE

This document describes the electrical and mechanical interfaces of the Iridium modem 9601-D. The 9601-D only allows short-burst data (SBD) connectivity to the Iridium satellite network. It does not support voice, circuit switched data, or short message service (SMS). This is a new product and has no functional predecessor. NAL Research offers two mechanical packaging options for the 9601-D with part numbers 9601-D-I and 9601-D-N. They both can be upgraded to include an internal GPS receiver. Any information in this document referred to model 9601-D is applicable to both models 9601-D-N and 9601-D-I.

A data terminal equipment (DTE), when connected to the 9601-D, can communicate with the Iridium satellite by sending AT commands through its serial port. A DTE can be a desktop computer, a laptop computer, a PDA, or even a micro-controller. Model 9601-D-N has the same DB25 multi-interface connector as the A3LA series and, therefore, can be retrofitted into existing SBD only applications that utilize the A3LA-based products. Important differences between the 9601-D series and the A3LA series include:

- 9601-D supports SBD only
- 9601-D does not incorporate nor need a SIM card to operate
- 9601-D has an automatic notification indicating a message is queued at the gateway
- 9601-D offers a maximum mobile originated (MO) message size of 205 bytes (subject to revision)
- 9601-D offers a maximum mobile terminated (MT) message size of 135 bytes (subject to revision)

IMPORTANT: User should not disassemble the 9601-D for repair or services. The warranty is voided if the 9601-D is disassembled. It should be returned to NAL Research for any services.

2.0 SPECIFICATIONS

2.1 Model 9601-D-I

Mechanical Specifications

Dimensions:	4.16” L x 2.21” W x 0.51” D (106 mm x 56.2 mm x 13 mm)
Weight:	~0.26 pounds (120 g)
Cooling:	Convection
Enclosure:	Aluminum/EMI shielding
Multi-Interface Connector:	26-Pin Samtec EHT series
Iridium Antenna:	SMA female

RF Specifications

Operating Frequency:	1616 to 1626.5 MHz
Duplexing Method:	TDD (Time Division Duplex)
Multiplexing Method:	TDMA/FDMA
Oscillator Stability:	±1.5 ppm
Link Margin Downlink:	13 dB average (free space)
Link Margin Uplink:	7 dB average (free space)

Average Power during a transmit slot (max): 1.6W

NOTE: All dimensions are in inches

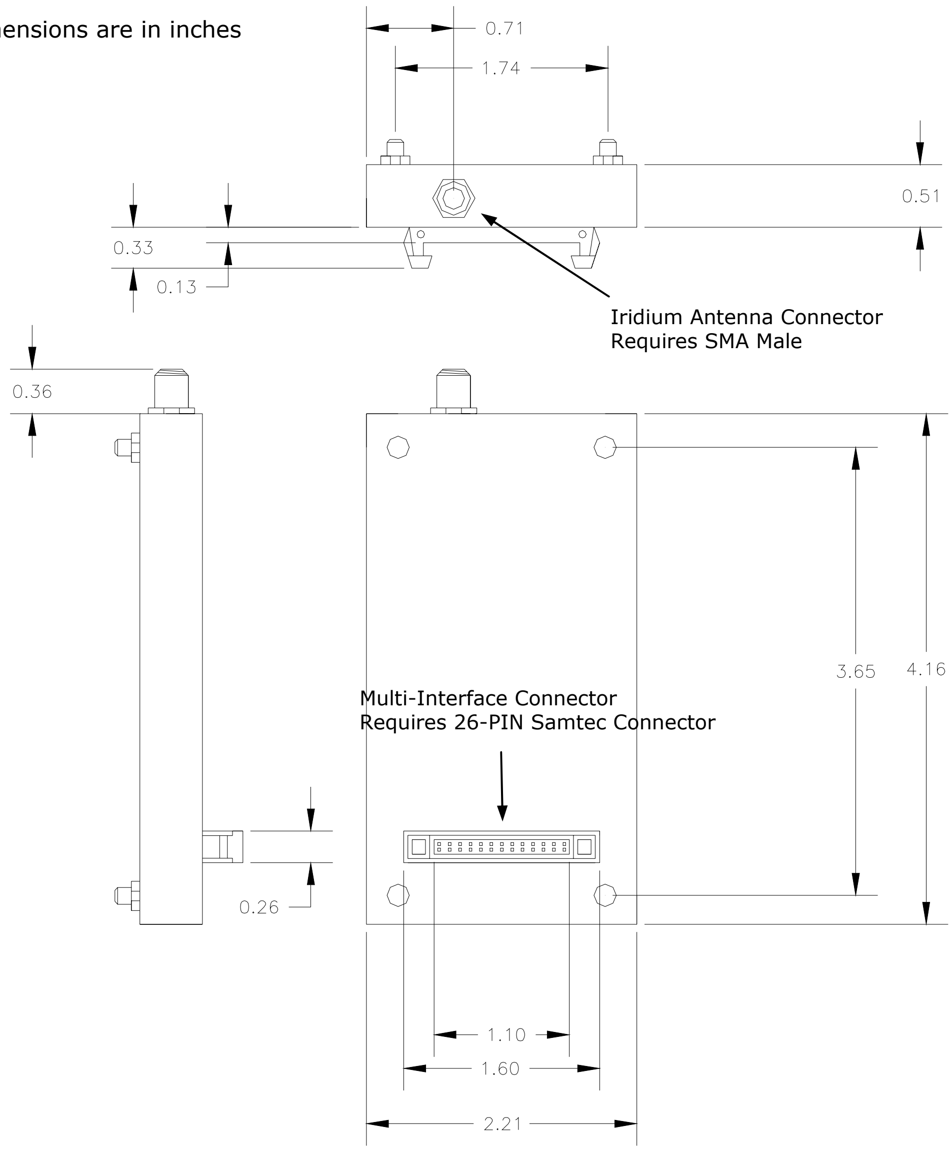


Figure 1. Mechanical drawings of model 9601-D-I.

<u>Electrical Specifications</u>

Main Input Voltage Range:	+4.5VDC to +5.5VDC
Main Input Voltage Nominal:	+5.0VDC
Main Input Voltage Ripple:	40mV peak-to-peak
Average Standby Current:	66mA @ 5.0VDC
Average Current During SBD:	350mA @ 5.0VDC
Peak Current During SBD:	1.5A @ 5.0VDC

NOTE: The DC power requirement was measured at the 9601-D multi-interface connector input and not at the DC power supply. The Average Current During SBD may vary depending on the field-of-view between the modem antenna and the 9601-D. Users must take into account the voltage drop across the power supply cable to ensure adequate current provided to the 9601-D during SBD sessions.

Environmental Specifications

Operating Temperature Range: –22°F to +140°F (–30°C to +60°C)

Operating Humidity Range: ≤ 75% RH

Storage Temperature Range: –40°F to +185°F (–40°C to +85°C)

Storage Humidity Range: ≤ 93% RH

Data I/O Specifications

Short-Burst Data MO: 205 bytes/message (maximum) at a rate of ~70 bytes/second

Short-Burst Data MT: 135 bytes/message (maximum) at a rate of ~70 bytes/second

Hardware Interface: RS232

Software Interface: Standard AT commands

Related Hardware

Antennas: SYN7391 Series, SAF2040 Series, SAF5340 Series, SAF5350 Series

Power Adapters: LA-3098, LA-7021 (with modified connectors)

Battery Pack: SYN-LI-416AH

RF Splitter: SYN-SLC-ALBT

2.2 Model 9601-D-N

Model 9601-D-N and model 9601-D-I share the same Iridium 9601 RF board. They have the same RF, electrical, environmental and I/O specifications. The only differences between model 9601-D-N and model 9601-D-I are in the mechanical specifications. The 9601-D-N has a different housing with a DB25 male multi-interface connector. The 9601-D-N's multi-interface connector has the same pin assignments as the DB25 multi-interface connector on the A3LA series. The intent is to allow direct replacement of SBD applications where A3LA-based products are utilized.

Mechanical Specifications

Dimensions: 4.42″ L x 2.42″ W x 1.05″ D (112 mm x 61 mm x 27 mm)

Weight: ~0.41 pounds (185 g)

Cooling: Convection

Enclosure: Hard anodized aluminum/EMI shielding

Multi-Interface Connector: 25-Pin D-SUB connector

Iridium Antenna: SMA female

RF Specifications

Same as model 9601-D-I.

Electrical Specifications

Same as model 9601-D-I.

Environmental Specifications

Same as model 9601-D-I.

Data I/O Specifications

Same as model 9601-D-I.

Related Hardware

Antennas:	SYN7391 Series, SAF2040 Series, SAF5340 Series, SAF5350 Series
Data Kit/Connector:	HRC-24-7, HRC-24-8
Power Adapters:	LA-3098, LA-7021
Battery Pack:	SYN-LI-416AH
RF Splitter:	SYN-SLC-ALBT

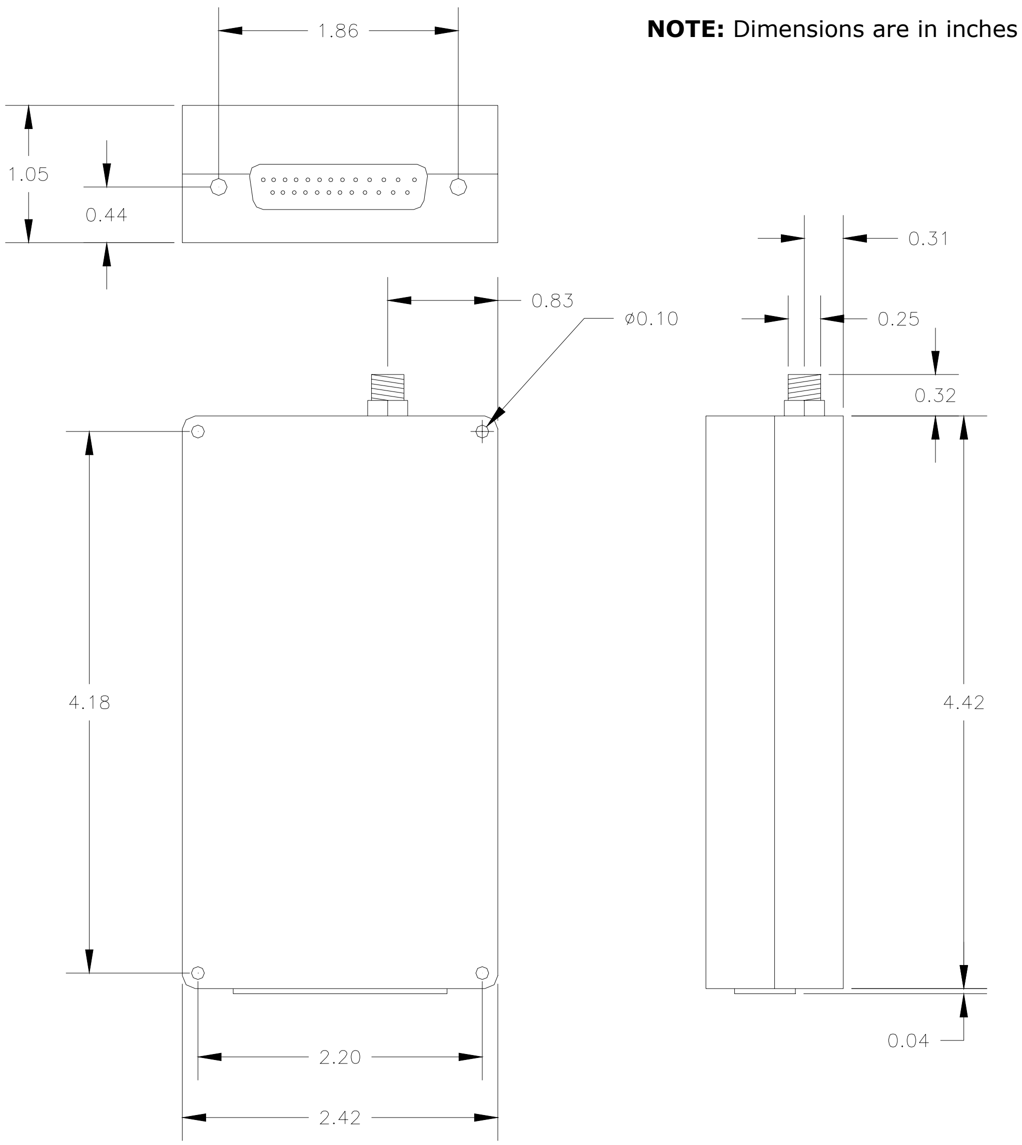


Figure 2. Mechanical drawings of model 9601-D-N.

3.0 MULTI-INTERFACE CONNECTOR

3.1 Model 9601-D-I

The multi-interface connector on model 9601-D-I is a male 26-pin Samtec EHT series. The connector consists of five interfaces with the pin assignments shown in Table 1.

- RS232 data interface
- External DC power input
- Power ON/OFF control input
- Network availability output
- DC power output

PIN #	SIGNAL	DESCRIPTION	INTERFACE
1	EXT_PWR	External Power Input (+4.5VDC to +5.5VDC)	DC Power (+)
2	EXT_PWR	External Power Input (+4.5VDC to +5.5VDC)	DC Power (+)
3	EXT_PWR	External Power Input (+4.5VDC to +5.5VDC)	DC Power (+)
4	EXT_GND	External Power Input (GND)	DC Power (GND)
5	EXT_GND	External Power Input (GND)	DC Power (GND)
6	EXT_GND	External Power Input (GND)	DC Power (GND)
7	EXT_ON_OFF	Power ON/OFF Control Input	DC Power
8	Reserved		
9	Reserved		
10	SIGNAL_GND	Signal ground, 0V signal reference and return	GND
11	TX	RS232 Transmit Data	RS232 Data
12	RX	RS232 Receive Data	RS232 Data
13	SIGNAL_GND	Signal ground, 0V signal reference and return	GND
14	DCD	RS232 Data Carrier Detect	RS232 Data
15	DSR	RS232 Data Set Ready	RS232 Data
16	CTS	RS232 Clear To Send	RS232 Data
17	RI	RS232 Ring Indicator	RS232 Data
18	RTS	RS232 Request To Send	RS232 Data
19	DTR	RS232 Data Terminal Ready	RS232 Data
20	SIGNAL_GND	Signal ground, 0V signal reference and return	GND
21	Reserved		
22	Reserved		
23	SIGNAL GND	Signal ground, 0V signal reference and return	GND
24	NETWORK_AVAIL	Set to logic 1 when Iridium satellite is visible	2.9V CMOS
25	Spare		
26	+2V9	Output voltage to drive external devices	2.9VDC@50mA Max.

Table 1. Pin assignment for the 9601-D-I multi-interface connector.

The multi-interface connector is a two-row 26-way latching header. Figure 3 provides a reference for the pin designation when looking into the multi-interface connector from above. It is not to scale and not representative of the actual connector mechanical layout (for illustrative purposes only). The equivalent mating cable connector is the Samtec TCSD series (e.g., TCSD-13-D-06.00-01-N). The equivalent printedcircuit board (PCB) mating connector is the Samtec ESQT series (e.g., ESQT-113-01-D). Both types of connectors are shown in Figure 4.

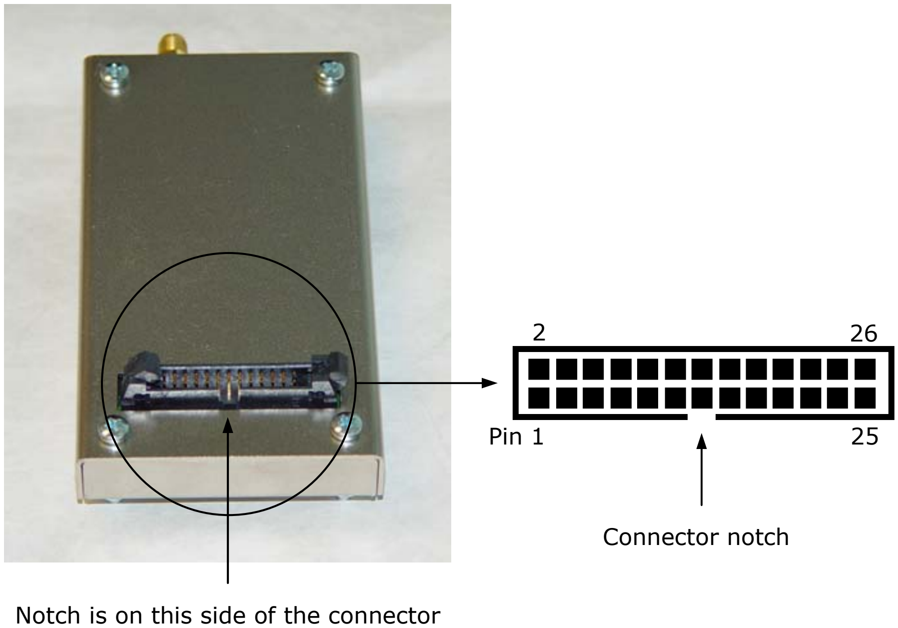


Figure 3. Multi-interface connector pin number designation.

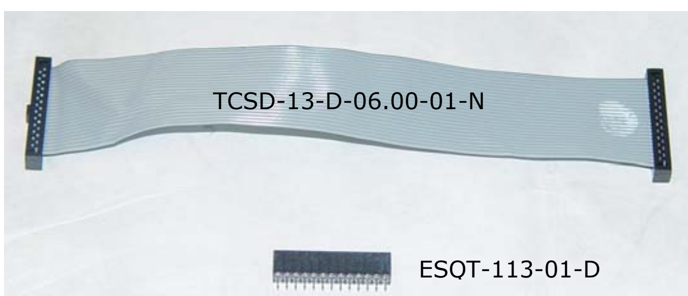


Figure 4. Mating connectors for the multi-interface connector.

<u>RS232 Data Interface (Standard 9-Wire Configuration)</u>

The 9601-D supports a standard RS232 data interface to a DTE incorporating hardware handshaking and flow control. The RS232 data interface comprises of eight standard RS232 data, control and status signals plus a ground level signal reference as shown in Table 1. This interface allows a connected DTE to utilize the 9601-D's modem functionality through standard AT and extended sets of AT commands. These commands are defined in the document TN2005-616-V1.0. The 9601-D does not support auto-baud and the default baud rate is factory set at 19.2 kbits/sec. The baud rate can be changed via the AT+IPR command. The RS232 signals are described in Table 2.

SIGNAL	DESCRIPTION
RX	Active high data input
TX	Active high data output
GND	Signal ground, 0V signal reference and return Multiple signal grounds are provided to reduce cross-talk. The signal grounds on pins 10, 13, 20 and 23 are all tied together at the multi-interface connector and can be joined with any of the signal wires, e.g. RS232 lines, Network Availability Output line
RTS	Active low flow control input
CTS	Active low flow control output RTS and CTS are used together to implement hardware flow control when enabled with AT&K3
DTR	Active low handshaking input AT&Dn controls how the 9601-D uses DTR: • If set to AT&D0, DTR is always ignored • Otherwise DTR set to OFF places the 9601-D data port into UART test mode after 10 seconds, or immediately on boot-up. A subsequent transition of DTR to ON returns the 9601-D data port to modem mode and resets it to its power-on state • The UART test mode is provided for factory testing of the 9601-D data port UART. A DTE should never activate test mode; if it does, the 9601-D will stop responding to AT commands until the 9601-D data port is returned to modem mode
DSR	Active low handshaking output The 9601-D drives DSR ON when the data port is in modem mode, and OFF when the data port is in test mode The DTE may use this signal as an indication that the 9601-D is powered up and ready to receive AT commands
RI	Active low ring indicator output The 9601-D drives RI ON when it receives an automatic notification from the Iridium network (gateway), and drives RI OFF after 5 seconds or when the DTE initiates an SBD session, which ever occurs first
DCD	Active low handshaking output DCD is driven OFF at all times

Table 2. Serial interface signals.

The Ring Indicator (RI) pin is used by the 9601-D to indicate that a Mobile Terminated SBD (MT-SBD) message is queued at the Iridium Gateway. The DTE will need to monitor this pin and use appropriate AT commands to retrieve the MT-SBD message.

<u>RS232 Data Interface (3-Wire Configuration)</u>

The 9601-D supports 3-wire serial interface and several steps must be taken to allow 3-wire configuration. These steps ensure the 9601-D and DTE to work together without having hardware handshaking.

1. AT&Dn must be set to AT&D0 to ignore the DTR input
2. AT&Kn must be set to AT&K0 to disable RTS/CTS flow control

3. Other output signals may be connected and operate as follows:
    a. CTS driven ON (low)
    b. DSR operates as normal
    c. RI operates as normal
    d. DCD driven ON (low)

    NOTE: RTS/CTS flow control, when enabled, is only used when the 9601-D data port is in SBD data mode. In AT command mode, RTS is ignored and CTS is driven ON (low).

<u>Configuration Settings</u>

The 9601-D allows the DTE to configure its data port communication parameters. There are three configuration types—active, factory default and stored. The active configuration is the set of parameters currently in use. They can be changed by the DTE individually via specific AT commands. The factory default configuration is stored in permanent memory. This configuration can be recalled at any time through use of the AT&Fn command.

Two groups of settings, or "profiles", can be stored as user-defined configurations. The DTE first creates desired active configurations and then writes them to memory using the AT&Wn command. The configuration settings are stored in "S-register" locations. These profiles can be designated to be loaded as the active configuration upon 9601-D power-up through the use of the AT&Yn command. The 9601-D can be reset without loss of power to these profiles through the use of the AT&Zn command.

<u>Modes of Operation</u>

The 9601-D is always in one of three modes: (1) command mode, (2) SBD data mode or (3) SBD session mode. When the 9601-D data port is in command mode, AT commands can be entered to control the 9601-D. In command mode, flow control has no effect, with the RTS input ignored and the CTS output driven ON (low).

When in SBD data mode, the 9601-D is transferring binary or text SBD message data to or from the DTE. In SBD data mode:

- All characters from the DTE not forming part of the message data are ignored (i.e. no AT commands may be entered)
- No unsolicited result codes are issued
- RTS/CTS flow control, if enabled, is active. When RTS is OFF (high), the 9601-D suspends transfer of data to the DTE; when CTS is OFF (high), the 9601-D expects the DTE to suspend transfer of data to it.

When in SBD session mode, the 9601-D is attempting to conduct an SBD session with the Iridium network. In SBD session mode:

- The DTE must wait for the +SBDI session result code
- All characters from the DTE are ignored
- Unsolicited result codes are issued where those codes have been enabled

Transitions between the modes of operation are performed automatically by the 9601-D in response to the SBD AT commands; the DTE has no other control over the mode.

Hardware Failure Reporting

If the 9601-D detects a hardware problem during initialization, it may be unable to function properly. The 9601-D then notifies the DTE by issuing an unsolicited result code at the end of the initialization:

HARDWARE FAILURE: <subsys>,<error>

where <subsys> identifies the software subsystem that detected the error, and <error> is the sub-system specific error code. Any AT commands that cannot be handled in the failure condition will terminate with result code 4 ("ERROR").

External DC Power Input

The external DC power input is through pins 1, 2 and 3 (EXT_PWR) and pins 4, 5 and 6 (EXT_GND). Note that three pins are provided for the external DC input. Three pins are also provided for the corresponding external ground input. This is done to distribute the current across the wires, and therefore all six pins should be utilized in the external power connection. Cables used to supply power to the 9601-D should be kept as short as possible to prevent significant voltage drop, which can cause the 9601-D to malfunction during an SBD session. The DC power requirements for the 9601-D are summarized on page 4.

The external DC power supply needs to guarantee the following:

- The supply voltage drop over an 8.3msec burst should not be more than 0.2VDC
- The power supply should limit the in-rush current to 4A maximum
- The power supply noise should be less than in the following profile (linear interpolation between these points):
    1. 100mV peak-to-peak in 0Hz to 50kHz
    2. 5mV peak-to-peak in 50kHz bandwidth at 1MHz
    3. 10mV peak-to-peak in 1MHz bandwidth at 1MHz
    4. 5mV peak-to-peak in 1MHz bandwidth above 5MHz

Power ON/OFF Control Input

The 9601-D starts up when DC power is applied and the Power ON/OFF Control Input line is high. As long as DC input voltage is applied, logic high on this line turns the 9601-D ON and a logic low turns it OFF. If the ON/OFF function is not required, the Power ON/OFF Control Input line must be connected directly to the EXT_PWR line (pins 1, 2 and 3). Unlike the A3LA series, it cannot stay "float". The input logic high threshold is 2.0V and logic low threshold is 0.5V.

NOTE: The ON/OFF control line for the 9601-D is not the same as the ON/OFF control line of the A3LA series.

Network Availability Output

The Network Availability Output pin is set to logic 1 when the 9601-D has visibility to the Iridium satellite network. This is useful in applications where the 9601-D may have full view of the Iridium network intermittently. For platforms where battery life is limited, users can monitor the Network Availability Output pin to determine when to start an SBD session.

DC Power Output

The 9601-D provides a DC Power Output line (pin 26) to drive components such as LEDs, sensors, switches, etc.. This output line could also be used to detect if the 9601-D is ON. The DC output produces 2.9VDC with maximum current of 50mA.

3.2 Model 9601-D-N

The multi-interface connector on model 9601-D-N is a standard male DB25. The connector consists of four interfaces with the pin assignments shown in Table 2.

- RS232 data interface
- External DC power input
- Power ON/OFF control input
- Network availability output

PIN #	SIGNAL	DESCRIPTION	INTERFACE
1	EXT_ON_OFF	Power ON/OFF Control Input	DC Power
2	Spare		
3	EXT_GND	External Power Input (GND)	DC Power (GND)
4	EXT_PWR	External Power Input (+4.5VDC to +5.5VDC)	DC Power (+)
5	Spare		
6	Spare		
7	RI	RS232 Ring Indicator	RS232 Data
8	RTS	RS232 Request To Send	RS232 Data
9	TX	RS232 Transmit Data	RS232 Data
10	DCD	RS232 Data Carrier Detect	RS232 Data
11	Spare		
12	Spare		
13	RX	RS232 Receive Data	RS232 Data
14	SIGNAL_GND	Signal ground, 0V signal reference and return	GND
15	Spare		
16	EXT_PWR	External Power Input (+4.5VDC to +5.5VDC)	DC Power (+)
17	EXT_GND	External Power Input (GND)	DC Power (GND)
18	Spare		
19	DTR	RS232 Data Terminal Ready	RS232 Data
20	Spare		
21	DSR	RS232 Data Set Ready	RS232 Data
22	CTS	RS232 Clear To Send	RS232 Data
23	SIGNAL GND	Signal ground, 0V signal reference and return	GND
24	NETWORK_AVAIL	Set to logic 1 when Iridium satellite is visible	2.9V CMOS
25	SIGNAL GND	Signal ground, 0V signal reference and return	GND

Table 2. Pin assignment for the 9601-D-N multi-interface connector.

As mentioned in Section 2.2, the 9601-D-N's multi-interface connector has the same pin assignments as the DB25 multi-interface connector on the A3LA series. The intent is to allow direct replacement of SBD applications where A3LA-based products are utilized. Note that pin 24 on the DB25 of the A3LA series (DA_RX audio signal) is now replaced with the NETWORK_AVAIL signal. Furthermore, there are a few spares that could be used to hook-up 2.9V power output to drive external devices.

The multi-interface mating connector can be any standard female DB25 connector. There are two side screws on the DB25 of the 9601-D-N. These screws can be removed and re-used to fasten the mating DB25 connector on to the 9601-D-N as shown in Figure 5 below.

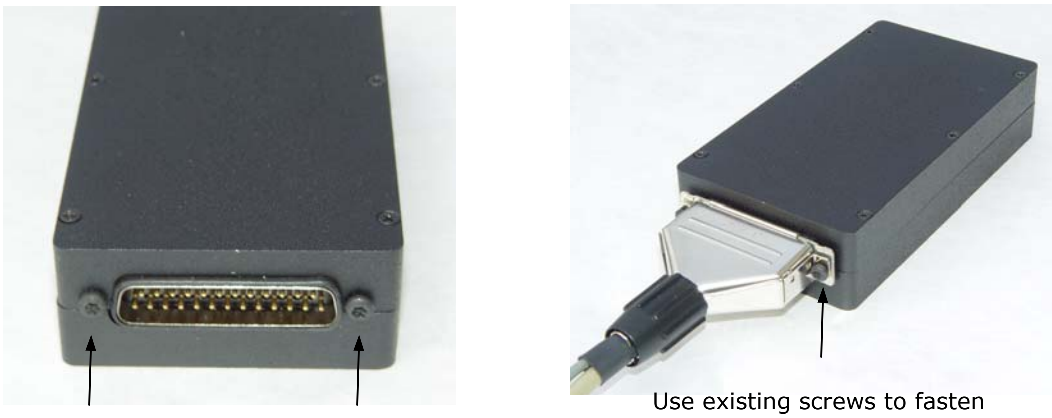


Figure 5. Model 9601-D-N with DB25 mating connector.

<u>RS232 Data Interface (Standard 9-Wire Configuration)</u>

See Section 3.1

<u>RS232 Data Interface (3-Wire Configuration)</u>

See Section 3.1

<u>Configuration Settings</u>

See Section 3.1

<u>Modes of Operation</u>

See Section 3.1

<u>Hardware Failure Reporting</u>

See Section 3.1

<u>External DC Power Input</u>

The external DC power input is through pins 4 and 16 (EXT_PWR) and pins 3 and 17 (EXT_GND). Note that two pins are provided for the external DC input. Two pins are also provided for the corresponding external ground input. This is done to distribute the current across the wires, and therefore all four pins should be utilized in the external power connection. Cables used to supply power to the 9601-D should be kept as short as possible to prevent significant voltage drop, which can cause the 9601-D to malfunction during an SBD session. The DC power requirements for the 9601-D are summarized on page 4.

The external DC power supply needs to guarantee the following:

- The supply voltage drop over an 8.3msec burst should not be more than 0.2VDC

- The power supply should limit the in-rush current to 4A maximum
- The power supply noise should be less than in the following profile (linear interpolation between these points):
    5. 100mV peak-to-peak in 0Hz to 50kHz
    6. 5mV peak-to-peak in 50kHz bandwidth at 1MHz
    7. 10mV peak-to-peak in 1MHz bandwidth at 1MHz
    8. 5mV peak-to-peak in 1MHz bandwidth above 5MHz

Power ON/OFF Control Input

The 9601-D starts up when DC power is applied and the Power ON/OFF Control Input line is high. As long as the DC input voltage is applied, logic high on this line turns the 9601-D ON and a logic low turns it OFF. If the toggle ON/OFF function is not required, the Power ON/OFF Control Input line must be connected directly to the EXT_PWR line (pins 4 and 16). Unlike the A3LA series, it cannot stay “float”. The input logic high threshold is 2.0V and logic low threshold is 0.5V.

> **NOTE:** The ON/OFF control line for the 9601-D is not the same as the ON/OFF control line of the A3LA series.

Network Availability Output

See Section 3.1

DC Power Output

There is no DC Power Output line available on the DB25 multi-interface connector of the 9601-D-N. However upon request, it can be brought out and connected to any or all of the DB25 spare pins as specified by the user. For such case, and similar to the 9601-D-I, the DC output will produce 2.9VDC with maximum current of 50mA.

4.0 ANTENNA CONNECTOR

The 9601-D uses a single SMA female 50-ohm antenna connector for both transmit and receive. The mating SMA male connectors are readily available from many RF hardware providers. Cable loss between the 9601-D and the antenna is critical and must be kept to less than 3dB at the operating frequency of 1616 to 1626.5 MHz. General RF parameters are listed in the table below.

TYPE	DESCRIPTION
Frequency Range	1616 to 1626.5 MHz
Input/Output Impedance	50 Ohms Nominal
Gain	3dBi
VSWR (maximum)	1.5 : 1

NAL Research offers several types of antennas for use with the 9601-D. These antennas include the fixed mast, mobile magnetic/permanent mount and portable auxiliary. If the specific application requires a custom antenna, it must meet the specifications in the following table.

PARAMETER	VALUE
Measurement Frequency Range	1616 to 1626.5 MHz
Return Loss (Minimum)	9.5 dB
Gain	0.0 dBic (weighted average minimum)
VSWR	1.5 : 1
Minimum ‘Horizon’ Gain	–2.0 dBic (82^{o} conic average)
Nominal Impedance	50 Ohms
Polarization	Right Hand Circular (RHCP)
Basic Pattern	Omni directional and hemispherical

5.0 MOUNTING RECOMMENDATIONS

5.1 Model 9601-D-I

The 9601-D-I is provided with four mounting holes, one at each corner. During manufacture four screws are inserted for shipping purposes. These screws need to be removed for mounting. There are two basic options for mounting—stackable as shown in Figure 6 and mounting to a surface such as a mounting plate or enclosure wall as shown in Figure 7.

5.2 Model 9601-D-N

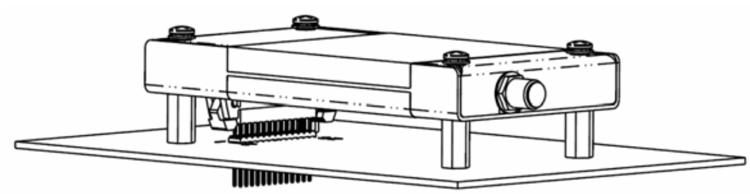
The 9601-D-N is provided with four mounting holes, one at each corner. It is recommended that 6-32 screws be used.

6.0 TECHNICAL SUPPORT

For technical support, please contact us at:

Phone: 703-392-1136 x200 or

E-mail: contact@nalresearch.com



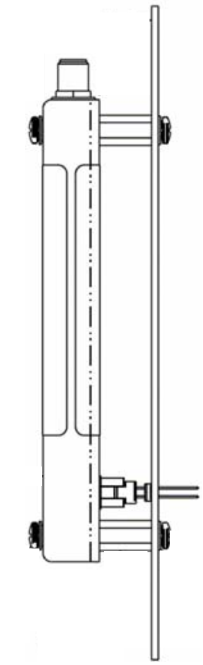
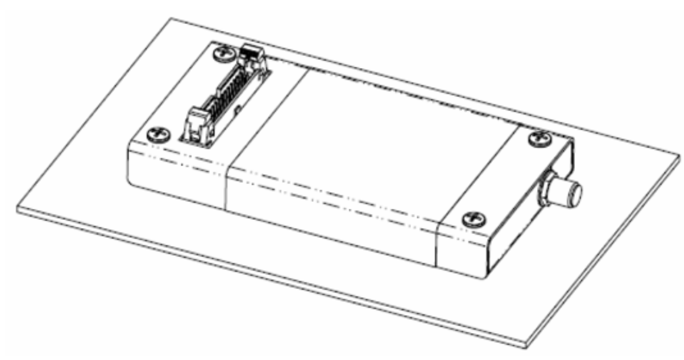


Figure 6. 9601-D-I mounted to an unpopulated PCB.



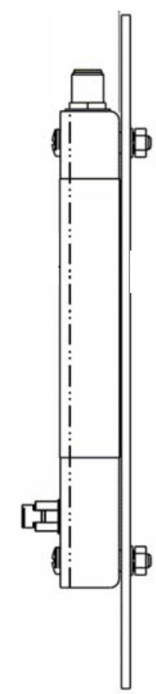
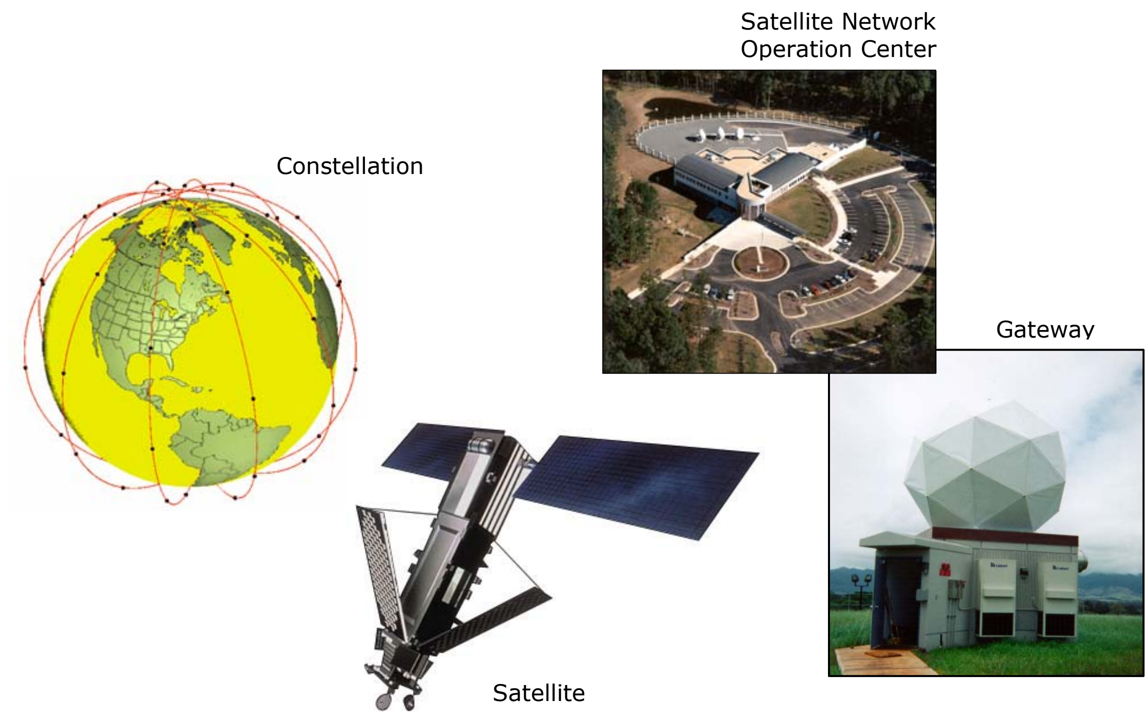


Figure 7. 9601-D-I mounted to a plate or surface.

APPENDIX A: DESCRIPTION OF THE IRIDIUM NETWORK

Description of the Iridium Network

The Iridium satellite network is owned and operated by Iridium Satellite LLC (ISLLC). It was constructed as a constellation of 66 satellites in low-earth orbit, terrestrial gateways and Iridium subscriber units (ISU). An ISU can either be an Iridium satellite phone or any of NAL Research's A3LA-D series and 9601-D series modems. The satellites are placed in an approximate polar orbit at an altitude of 780 km. There are 6 polar planes populated with 11 satellites per orbit constituting the 66 satellite constellation. The near polar orbits of the Iridium constellation provide truly real-time and global coverage from pole-to-pole.



The Iridium is designed to operate in the band of 1616 to 1626.5 MHz although the exact frequencies used depend on the local regulating authorities and issued licenses in any particular region. Each satellite projects 48 beams on the surface of earth, which may be viewed as providing coverage cells on the ground similar to terrestrial systems. Each beam is approximately 600 km in diameter. The 66-satellite constellation has the potential to support a total of 3,168 spot beams; however, as the satellite orbits converge at the poles, overlapping beams are shut down. The satellite footprint is ~4,700 km in diameter. Under each footprint, a satellite is power limited to ~1,100 simultaneous circuits.

The Iridium network uses a time domain duplex (TDD) method and transmits and receives in an allotted time window within the frame structure. Since the system is TDD, the ISU transmit and receive in the same frequency band. The access technology is a FDMA/TDMA (frequency division multiple access/time division multiple access) method whereby an ISU is assigned a channel composed of a frequency and time slot in any particular beam. Channel assignments may be changed across cell/beam boundaries and is controlled by the satellite. The system will provide an average link margin of 13.1 dB.

Although there are multiple gateways, a user is registered to a single gateway. The gateways perform call connection setup and administrative duties such as billing and resource management. The satellite constellation provides connectivity between users, from a user to the Iridium system gateway, and between gateways. Within the Iridium network architecture, the satellites are cross-linked which allows ISU to ISU communication independent of gateway intervention once the call connection is established.

There are currently two commercial Iridium gateways located in Arizona, United States and Fucino, Italy. The U.S. government owns and operates an Iridium gateway located in Hawaii, United States. Each gateway generates and controls all user information pertaining to its registered users, such as user identity, geo-location and billing items. The gateway also provides connectivity from the Iridium system to the terrestrial based networks such as the PSTN.

<u>Description of the Iridium Network Data Capabilities</u>

For data communications, the Iridium network supports five different modes of operation as shown in Figure A1—dial-up data service, direct Internet connection, short-burst data (SBD), short-messaging service (SMS) and router-based unrestricted digital internetworking connectivity solution (RUDICS).

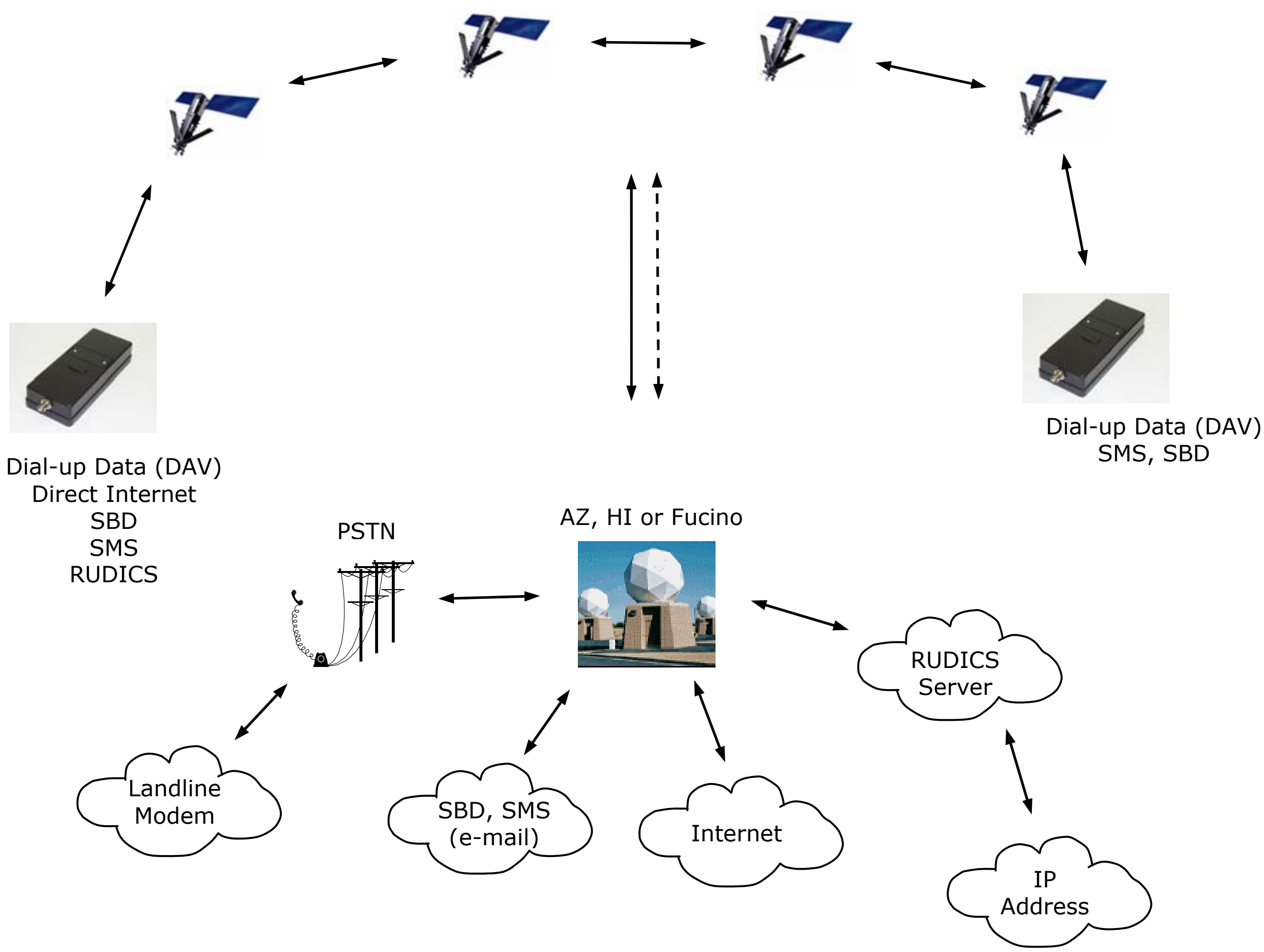


Figure A1. Iridium Network Data Capabilities.

Dial-Up Data Service

Dial-up data service provides connectivity through the Iridium satellite network to another Iridium modem, to the public switch telephone network (PSTN), to the Defense Switch Network (DSN), to a remote LAN (e.g., a corporate network) or to an Internet Service Provider (ISP) at a nominal data rate of 2.4 kilobits per second (Kbps). The connection time involving user authentication and handshaking (or modem training) can range from 15 to 30 seconds. For an Iridium-to-Iridium call, dial-up data service offers an additional option known as data after voice or DAV. Similar to a voice call, a DAV call is routed directly from one Iridium modem to another Iridium modem without going through the gateway.

Many desktop and laptop computers are equipped with either an internal or external modem to perform dial-up data applications across the landline telephone network (PSTN). On these computers, terminal emulator software or a dial-up networking connection can be configured to a specific modem with a phone number to dial, user identification and password. The modem can then be used to call another computer, a remote LAN or an Internet service provider as shown in Figure A2. The handshaking and protocols are established between the modems independent of the landline.

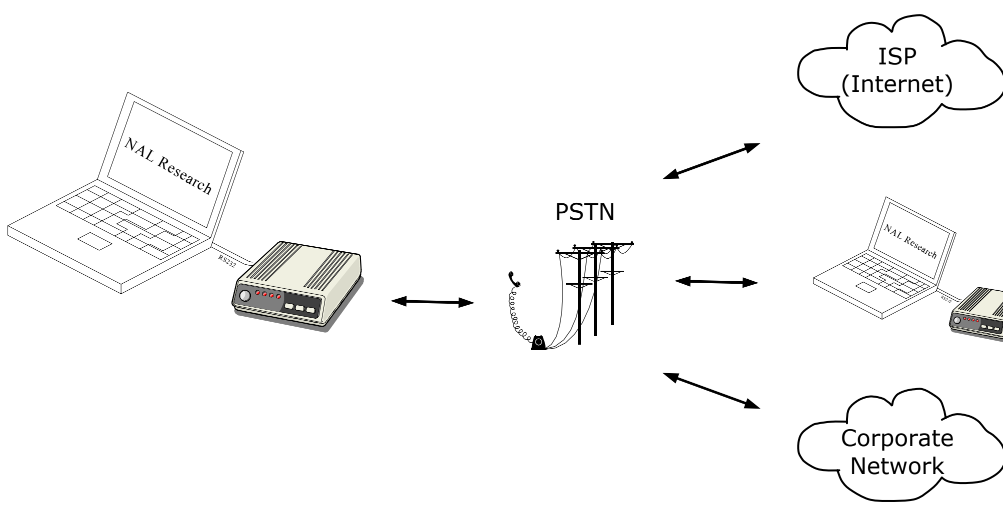


Figure A2. PSTN Dial-Up Connectivity.

The Iridium dial-up data service functions in much the same way as the PSTN dial-up connectivity. From the perspective of a computer, the Iridium modem is just another external modem. The only difference is that the dialed telephone number must conform to the international dialing pattern used by Iridium. When a data call is placed, the Iridium modem actually dials and initiates a connection with the Iridium gateway through the Iridium satellite constellation. Since the Iridium modem is requesting to establish a data connection, the switch at the gateway routes the call through another modem. The modem at the Iridium gateway then dials into and connects to another modem at the other end. Figure A3 illustrates how an Iridium dial-up data service call is routed. The handshaking and protocols established between the modems independent of the Iridium network.

For those ISU-to-ISU dial-up calls where data transmission delay is critical such as the application of TCP/IP protocol, DAV should be considered in the design. This option eliminates the Iridium gateway once authentication and registration is completed allowing ISU-to-ISU communication without the gateway in the loop.

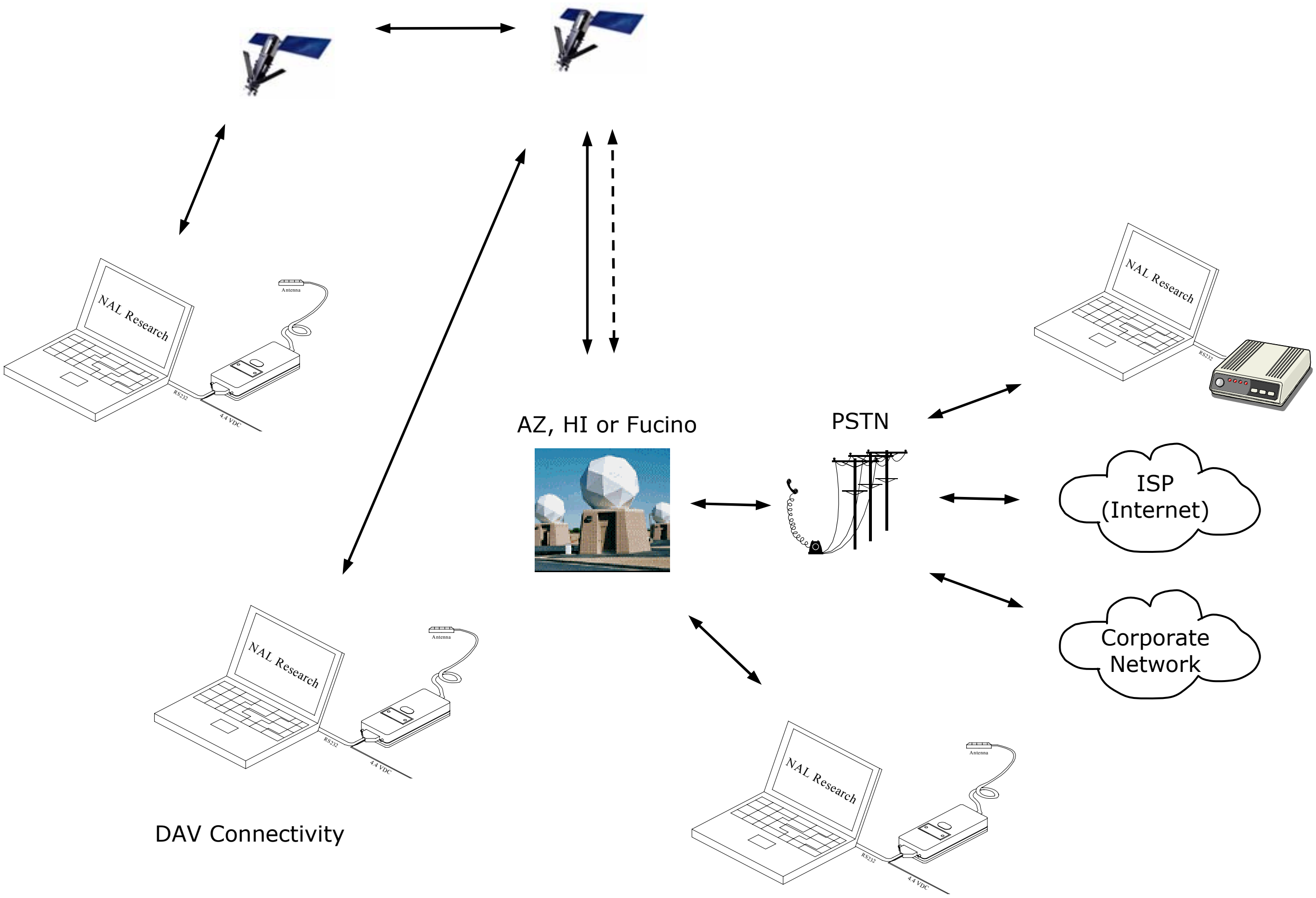


Figure A3. Iridium Dial-Up Data Service.

Direct Internet Connection

The Iridium Direct Internet service allows users to connect to the Internet via the Iridium gateway without having to sign up with an Internet service provider. This service utilizes a dedicated Apollo Server at the Iridium gateway, which provides high-speed connectivity to the Internet and optimizes server-to-Iridium modem communications. The dial-up networking setup is similar to the dial-up networking setup for landline telephone. The only difference is that the dialed telephone number is an international number provided by Iridium. Figure B3 illustrates how Iridium Internet (NIPRNet) call is routed.

Direct Internet service can be enhanced using Windows-based emulated point-to-point protocol (PPP) called the Apollo Emulator. With the use of the Apollo Emulator software instead of Microsoft Windows® dial-up networking, Direct Internet service can reduce connection time and improve data throughput. In addition, the Apollo Emulator offers a feature called Smart Connect™, which manages airtime by seamlessly connecting and disconnecting a user through the Iridium system. Airtime charges accumulate only while the call is connected. Improved effective data throughput is achieved through the use of user-transparent data compression. The channel rate is still 2.4 Kbps. However, 10 Kbps effective throughput can be achieved depending on content (graphics and images will result in lower effective throughput).

Short-Burst Data (SBD)

SBD is a simple and efficient bi-directional transport capability used to transfer messages with sizes ranging from zero (a mailbox check) to 1960 bytes for the A3LA series and zero to 205 bytes for the 9601 series. SBD takes advantage of signals within the existing air interface, without using the dedicated traffic channels. As a result, small amounts of data can be transferred more efficiently than those associated with circuit-switched data calls. Messages that originate from an Iridium modem can be delivered to a variety of destinations. Commonly, data are delivered across terrestrial communications networks (NIPRnet and Internet) to servers and applications that process data from one or multiple fielded Iridium modems. SBD service also supports the transfer of messages to Iridium modems, where messages may originate from terrestrial sources. Delivery methods and options are initially configured when the Iridium modem is first purchased and may be easily modified via web pages at a later time.

Short Messaging Service (SMS)

SMS is a mechanism to deliver short data messages over the Iridium satellite network to the NIPRNet/Internet. Iridium SMS service incorporates a subset of the GSM SMS features. Each SMS message can be up to 160 text characters (7-bit coded) in length. The text characters are based on a 7-bit alphabet, which is encoded and transmitted as 8-bit data, hence the 140 octet (byte) maximum message size.

SMS service is a store and forward method of transmitting messages to and from an Iridium modem. The short message from the modem is stored in a central Short Message Center (SMSC) which then forwards it to the destination. In the case that the recipient is not available, the SMSC will attempt to deliver the SMS until it is delivered or the validity period expires. SMS supports a limited confirmation of message delivery**.** The sender of the short message can request to receive a return message notifying them whether the short message has been delivered or not. With this option, the originator gets a confirmation that the message was delivered to the SMSC. Unlike standard GSM, the Iridium SMS can only acknowledge that the message was delivered to the SMSC and not the end-destination.

SMS messages can be sent and received simultaneously while a voice call is in progress. This is possible because SMS messages travel over and above the radio channel using the signaling path, whereas the voice call uses a dedicated “traffic” radio channel for the duration of the call.

RUDICS

RUDICS is an enhanced gateway termination and origination capability for circuit switched data calls across the Iridium satellite network. When an Iridium modem places a call to the RUDICS Server located at the Iridium Gateway, the RUDICS Server connects the call to a pre-defined IP address allowing an end-to-end IP connection between the Host Application and the Iridium modem. There are three key benefits of using RUDICS over the conventional PSTN circuit switched data connectivity or mobile-to-mobile data solutions: (1) elimination of analog modem training time, (2) increased call connection quality, reliability, and maximized throughput and (3) protocol independence. Figure below shows all possible scenarios for connectivity to RUDICS at the Iridium gateway. The remaining sections of this Appendix display examples of various types of connections using RUDICS.

Iridium Geo-Location

The Iridium network makes calculations of the geographical location (geo-location) of an ISU each time a call is placed. The technique employed to determine the geo-location of an ISU is based on measurements of the ISU and satellite propagation delay and Doppler frequency shift. These measurements are used to estimate cosines of spherical angles that identify the ISU's location relative to the satellite by the gateway.

The Iridium network can locate an ISU to within 10 km only about 78% of the time. The so-called error ellipse can have a large eccentricity with the major axis oriented in the azimuth dimension and the minor axis oriented in the radial dimension. The position of the ISU in the radial dimension relative to the satellite can almost always be determined to within 10 km with just one measurement. Errors in the azimuth dimension relative to the satellite are largest along the satellite's ground path and tend to increase with distance from the satellite. Geo-location errors in the east-west dimension, therefore, are sometimes more than 100 times greater than in the north-south dimension.

APPENDIX B: STANDARDS COMPLIANCE

The 9601-D is tested to the regulatory and technical certifications shown below:

REGULATORY APPROVALS	RADIO TESTS	EMC TESTS	MECHANICAL/ ELECTRICAL TESTS
CE FCC Industry Canada	ETSI EN 301 441 V1.1.1 (2000-05) FCC CFR47 Parts 2, 15, and 25 Industry Canada RSS170 Issue 1, Rev 1, November 6, 1999	ETSI EN 301 489-1 V1.4.1 (2002-08) ETSI EN 301 489-20 V1.2.1 (2002-11) EN61000-4-2: 1995/A2:2001 Part 4.2 EN61000-4-3: 2002 Part 4.3 EN61000-4-4: 1995/A1:2001/A2:2001 Part 4.4 EN61000-4-6: 1996/A1: 2001 Part 4.6 EN55022: 1998/A1: 2000/A2: 2003	EN60950-1:2001 Part 1 UL60950-1 Part 1

The 9601-D has been tested to the environmental specifications listed below.

TEST NAME	TEST REFERENCE	TEST DESCRIPTION
Thermal Shock	EN60068-2-14:2000	Change of Temperature, –25°C to +70°C, 5 cycles of 1 hour each
Humidity	IEC60068-2-2:1996	Damp heat steady state +40°C 93% RH for 4 days
Shock	EN60068-2-27:1993 (NF c20-727)	
Shock	J1455 SAE	
Vibration	EN60068-2-36:1996	Sinusoidal Vibration 0.96 m^2/s^3 from 5Hz to 20Hz
Vibration	IEC60068-2-36:1996	Sinusoidal Vibration 21Hz to 500Hz –3dB per octave
Vibration	J1455 SAE	

APPENDIX C: EXPORT COMPLIANCE INFORMATION

The 9601-D is controlled by the export laws and regulations of the United States of America (U.S.). It is the policy of NAL Research to fully comply with all U.S. export and economic sanction laws and regulations. The export of NAL Research products, services, hardware, software and technology must be made only in accordance with the laws, regulations and licensing requirements of the U.S. Government. NAL Research customers must also comply with these laws and regulations. Failure to comply can result in the imposition of fines and penalties, the loss of export privileges, and termination of your contractual agreements with NAL Research.

The export and re-export of NAL Research products and services are subject to regulation by the Export Administration Regulations (15 CFR 730-744), as administered by the U.S. Department of Commerce, Bureau of Industry and Security ("BIS"). See: http://www.bxa.doc.gov for further information on BIS and the Export Administration Regulations (EAR). Additional export restrictions are administered by the U.S. Department of the Treasury's Office of Foreign Asset Controls ("OFAC"). See: http://www.ustreas.gov/ofac for further information on OFAC and its requirements.