

SATELLITE TECHNOLOGY PRIMER

SUMMARY

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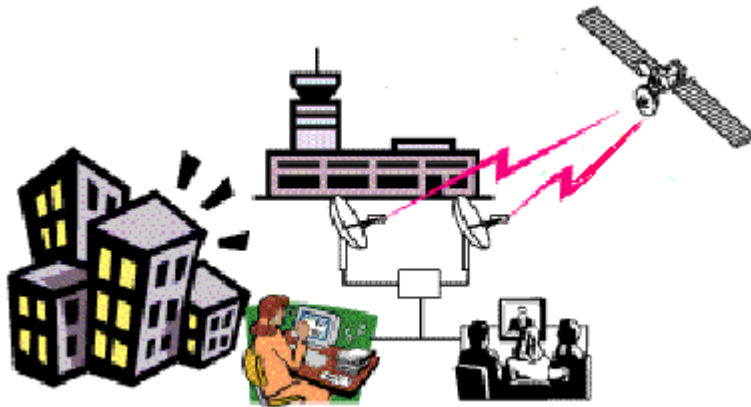
BROADBAND SATELLITE BENEFITS

- The following information reviews the benefits of Broadband Satellite Technology.

Step By Steps

Broadband satellite provides additional benefits over terrestrial access:

- **Ubiquitous** coverage: Unlike other broadband access technologies, satellite-based broadband connectivity provides ubiquitous coverage.
- *Simplicity*: Satellite systems bypass the complex web of landline networks.
- *Bandwidth flexibility*: Configurable satellite systems provide capacity on an as-needed or time-scheduled basis.
- *Rapid deployment*: Quick initiation of Broadband satellite service is possible after the installation of the customer premise equipment.
- *Reliability*: Satellites are among the most reliable of all communication technologies.



TRUE BROADBAND SATELLITE INTERNET ARCHITECTURE

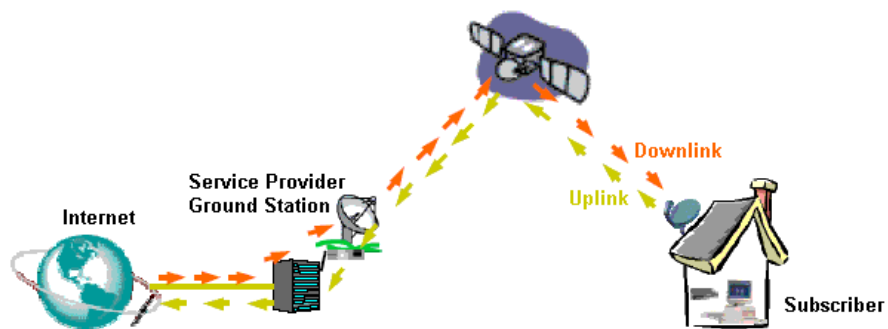
- The following information reviews Broadband Satellite Technology architecture.

Step By Steps

True Broadband-satellite architecture provides satellites and subscriber equipment using a Time Division Multi-Access (**TDMA**)-based uplinks and downlinks:

- New architecture provides Broadband satellite transmission for both uplink and downlink transmission
- The downlink is TDMA-based
- The uplink is TDMA-based
- Typically provide 1 Mbps download and 500 kbps upload

Two-Way Satellite Internet Access



SATELLITE ACCESS EQUIPMENT: THE SPACECRAFT

- The following information reviews the technology the satellite uses to provide broadband services.

Step By Steps

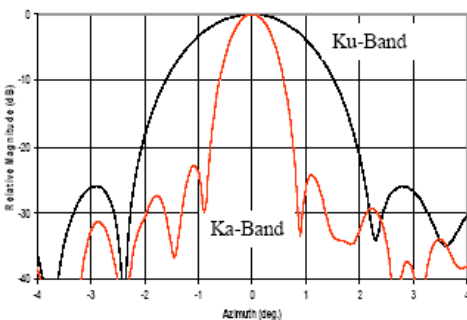
Broadband Satellites are high-powered GEO satellites

- Located at 23,800 mi. above the equator
- Operating in **Ku-band** (11-14 GHz) and/or **Ka-band** (20-30 GHz) mode

Current Satellite Internet Access Satellite Capacity

Multiple-beam antennas (**MBA**) have become a key component in satellite communication systems because they enable frequency reuse. MBA technology maximizes bandwidth capacity while minimizing required frequency allocation. To use the MBA technology efficiently Broadband satellites use the Ka-band frequencies, multiple pencil-like **spot beams** and **bent-pipe** technology.

Satellite Frequency Bands



- **Ku-band:** Generally considered to extend from 12 to 18 GHz, in commercial use this frequency band usually extends to the frequency range from 10.7 GHz to 18.4 GHz. Used by most commercial broadcast TV satellites, this is the most commonly used satellite frequency today.
- **Ka-band:** While the Ka-band extends from 27 GHz to 40 GHz, it also includes the upper part of the Super-high Frequency (**SHF**) band and the lower part of the Extremely High Frequency (**EHF**) range, which extends

from 30 to 300 GHz. Broadband satellites systems typically employ the 27.5-30.0 GHz SHF frequency range for uplink transmissions (earth-to-space) and the 17.7-20.2 GHz range for downlink transmissions (space-to-earth). Note that the Broadband application actually overlaps a part of the Ku-band in its downlink frequency band. Because the Ka-band frequency is highly concentrated it provides high **gain** and a narrow beam-width along with the possibility of multiple beams.

The graphic above shows a comparison between the Ku-band and the Ka-band frequency. Note that the degree of **azimuth** is considerably smaller in the Ka-band. This translates to a need for more precise subscriber transmitter/receiver placement.

Satellite Spot Beams

A Broadband satellite, using Ka-band, uses multiple spot beams to provide the same coverage as a Ku-band CONUS beam. On average, a Broadband satellite will provide 35 to 45 **Subscriber spot beams** and 5 to 6 Gateway Earth station (**GES**) spot beams; about one Gateway spot beam for every 7 or 8 Subscriber spot beams. Transmissions in a Subscriber spot beam are to/from the Subscriber Side Terminal. Transmissions in a gateway spot beam are to/from a Service Provider Ground Station.

Satellite Bent-Pipe Architecture

Broadband satellites combine spot beam technology with links that operate on a point-to-point basis. The satellite uses on-board switching to provide two-way data paths between different spot beams. The bent-pipe architecture allows the satellite processor to concentrate on building the data-paths, because the satellite acts as a repeater. The data-path signal is amplified and retransmitted but there is no demodulation, decoding or other type of signal processing.

SATELLITE ACCESS EQUIPMENT: SUBSCRIBER SIDE TERMINAL

- The following information reviews the Satellite Modem-to-Customer premises-equipment Interface (SMCI)

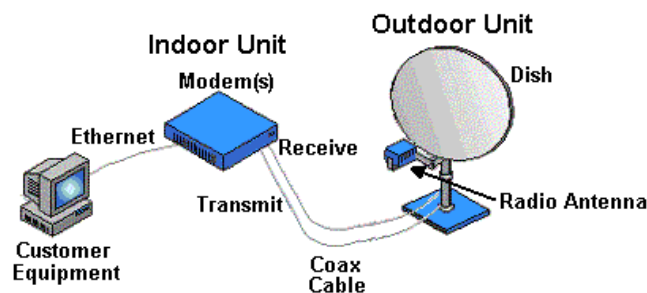
Step By Steps

Four physical components are a part of the **Satellite Modem-to-Customer premises-equipment Interface (SMCI)**.

- **Outdoor Unit (ODU)**
 - A small (~2-3 ft diameter), low-cost dish-type radio antenna with transmit and receive components placed at the focal point of the antenna
 - Receives/sends data from/to the satellite in two-way systems
 - Older one-way systems use a dish for download direction only*
 - Needs to face the southern sky for proper transmission
- **Indoor Unit (IDU)**
 - **Satellite Modem(s) (SM)** serve as an interface between the ODU and subscriber equipment and controls satellite transmission
 - Can be two, separate transmit and receive modems
 - Can be one, integrated transmit and receive modem
 - **Ethernet** connectivity to the Customer Equipment: an **Internet Ready Device (IRD)**

NOTE: Analog Modems, used in older one-way systems, upload subscriber data to the **Internet Service Provider (ISP) via the **Public Service Telephone Network (PSTN)***

- **Ethernet Cable** connects the customer IRD to the WildBlue service.. This cable must meet the CAT5 standard and be equipped with RJ45 jacks.
- **COAX Cable** must support the **Intermediate Frequency (IF)** present in the connection between the IDU and ODU:
 - Up to 150 MHz on RX data path (both KA and KU Band)
 - Up to 1450 MHz (KU-Band)
 - Up to 2225 MHz (KA-Band)





Line of sight (LOS) settings for both Ku-Band and KA-Band include four characteristics: the **Azimuth**, **Elevation**, **Polarization**, and **Skew**. In Ka-Band transmissions, combining a fifth characteristic, the **Beam Assignment**, makes data transmission possible.

SATELLITE ACCESS EQUIPMENT: SERVICE PROVIDER GROUND STATION

- The following information reviews the **Satellite Modem Termination System – Network-Side Interface (SMTS-NSI)**

Step By Steps

An integral part of each WildBlue **Gateway Earth Station (GES)** is the **Satellite Modem Termination System - Network-Side Interface (SMTS-NSI)**. The term “SMTS” refers to a single chassis populated with management tools and Satellite DOCSIS blades. The “NSI” refers to the Giga-Ethernet blades in the same chassis. (see Graphic below) The shorten term for “SMTS-NRI” is “**SMTS**”.

- **Outdoor Unit (ODU)**
 - Large dish antenna (15-36 feet), with transmit and receive components placed at the focal point of the antenna
 - Receives/sends data from/to the satellite similar to subscriber terminals
 - Needs to face the southern sky for proper transmission
- **Indoor Unit (IDU)**
 - Satellite Modem(s) demodulates an incoming signal from the ODU to IP packets and sends the packets to local network
 - Can be separate transmit and receive modems
 - Can be integrated transmit and receive modem
 - Access Server/Gateways manages traffic transported to the Internet
 - Network Management System (NMS) manages the server activity and controls satellite transmission

ANTENNA POSITIONING

- The following information reviews the technology used to position the ground satellite to the satellite transmission.

Step By Steps

Azimuth: **Azimuth** is the horizontal angular distance from the **True North** point on the horizon to the point where the satellite intersects the horizon. **Magnetic Declination** defines the offset angle between True North and Magnetic North at a particular location on earth. Modifying the azimuth reading, based on True North, by the Magnetic Declination will provide the correct magnetic compass reading for pointing an ODU transceiver.*

**NOTE: WildBlue service orders provide the Azimuth reading not True North.*

Elevation: The satellites in geostationary orbit are at a right angle (90 degrees) to the earth spin axis. Only at the equator will the **GEO Arch**, the portion of the geostationary belt viewable from a position on earth, have a 90 degrees **Elevation**. All other earth locations use a calculation of angles formed from the relationship between the ODU and satellite locations, along with a calculated line to the center of the earth.

Polarization: **Polarization** is the orientation of a signal wave produced by an antenna on a stationary plane defined by the direction of propagation (transmission) and the associated magnetic and electric fields. WildBlue uses circular Polarization. A corkscrew best visualizes the circular transmission. The wave rotates as it travels along the direction of propagation. If the rotation is counter-clockwise as seen looking in the direction of the propagation, it is **Left-hand Circular Polarization (LHCP)**. If the rotation is clockwise as seen looking in the direction of propagation, it is **Right-hand Circular Polarization (RHCP)**. *

**NOTE: The position of the TRIA Feedhorn determines if the antenna is LHCP or RHCP.*

NOTE: The receive side of the antenna are opposite Polarization. Therefore, a RHCP antenna will use RHCP to transmit and LHCP to receive. Use either two RHCP antennas or two LHCP antennas in a transmission circuit. FCC regulations require American Broadband satellite communications use Circular Polarization.

Circular Polarized Antenna Skew: Because the Broadband satellite ODU dish is **elliptical**, the Skew is used to align the antenna horizontally with the GEO Arch. This adjustment compensates for slight variance in angle between identical senses of polarity generated by two or more satellites. Therefore, the antenna only needs a Skew adjustment if it obtains signals from more than one satellite on the GEO Arch or if the antenna needs to exclude transmission or reception from unnecessary directions. Circular Polarization combined with an elliptical ODU dish allows a precisely positioned antenna to receive the greatest antenna **gain** and ignore competing signals, therefore reducing the **Carrier-to-Interference Ratio (CIR)** and the **Carrier-to-Noise Ratio (CNR)**.

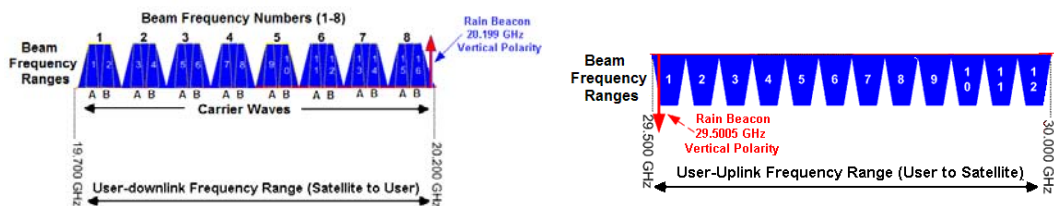
BEAM ASSIGNMENT

- The following information reviews Spot Beam technology.

Step By Steps

Broadband satellites use **Spot Beam** technology. The Spot Beam Ka-band frequency is much smaller than the traditional broadcast TV beam frequency. The frequency defines a beam's width.

The subscriber **Beam Assignment**, expressed in frequency, allows each subscriber terminal to connect to the appropriate sub-network. **User-downlinks use frequencies within the 19.700 GHz to 20.200 GHz range.** Each Spot Beam will use one of eight frequency ranges for its User-downlinks. Each subscriber within a Spot Beam uses one of the two **Carrier Waves** within the Beam. Each subscriber assignment includes the Beam Frequency Number. **Peaking** the ODU antenna requires the use of the Beam Frequency Number in order to align to the proper frequency. (see graphic below)



User-uplinks use frequencies with the 29.500 GHz to 30.000 GHz range. Each subscriber will use one of the twelve frequency ranges for its User-uplink. If the Broadband satellite dish is properly peaked, the SMCI will link to the appropriate frequency range. (see Graphic above)

BROADBAND SATELLITE PROTOCOLS

- The following information reviews the transmission and transport protocols used in Broadband Satellite transmissions.

Step By Steps

Subscriber Segment:

The Subscriber Side Terminal provides the Satellite Modem-to-Customer premises-equipment Interface (**SMCI**). The part of the interface connected to the subscriber's PC uses standard **TCP/IP Ethernet protocol**. The SMCI communicates with the Broadband satellite using TDMA transmission protocol. The terminal can employ the traditional Single-Frequency Time Division Multiple Access (**SF-TDMA**) or the emerging Multi-Frequency TDMA (**MF-TDMA**) as their uplink access scheme. MF-TDMA can more efficiently adapt to widely varying multimedia transmission requirements. Using either of the TDMA protocols, the terminal transmits on a set of carrier frequencies, with each frequency divided into time slots. The terminal can send several **packets** in each time slot. While the format of the packets can use several protocols, one of the most common is Data Over Cable System Interface Specification (**DOCSIS**). This protocol provides compatibility with cable modem standards, in terms of bandwidth and packet structure.

Satellite Segment:

The satellite uses on-board processing to develop the up/downstream data-paths. Recall that the satellite data-path signal is amplified and retransmitted but there is no demodulation, decoding or other type of signal processing.

Gateway segment:

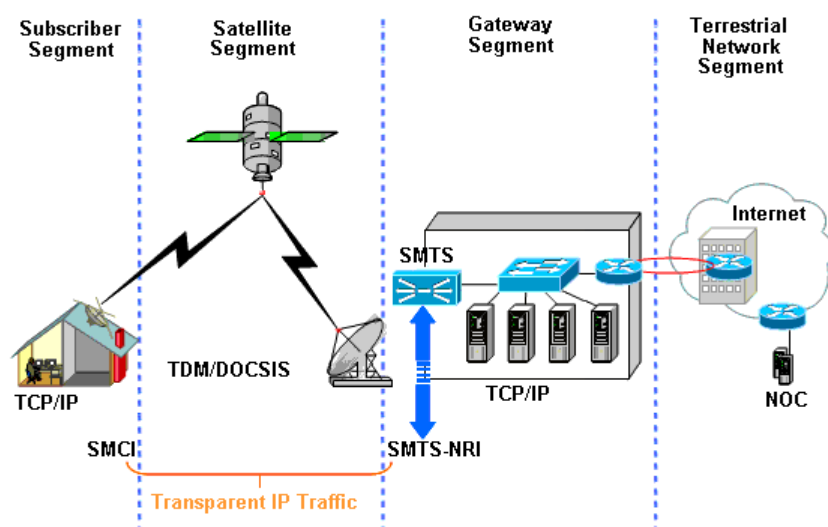
The Service Provider Ground Station provides the Satellite Modem Termination System - Network-Side Interface (**SMTS-NSI**). Like the SMCI the SMTS-NSI uses TDMA protocols and DOCSIS packets to communicate with the satellite. The gateway SMTS houses multiple SMTS-NRI. Each interface connects to the Gateway server using standard TCP/IP Ethernet protocol.

Terrestrial Network Segment:

This segment works like any service provider network using terrestrial network and standard TCP/IP Ethernet protocols.

The reason for this protocol mix is to provide *transparent IP traffic between the interfaces*. This traffic includes, but is not limited to, **DHCP** and **datagrams**, along with **ICMP** to allow the Network Management Center (**NOC**) to receive error messages from the subscriber modem.

The graphic below shows the relationship between the various protocols.



NETWORK ADDRESSES

- The following information reviews the network addressing computers and **Internet Ready Devices (IRD)** use to communicate on computer networks.

Step By Steps

MAC Address



For a computer, or **Internet Ready Device (IRD)**, to have access to a network it will need a **Network Interface Card (NIC)**. This card supplies the physical connection and contains a hardware-embedded **Medium Access Control (MAC) Address**.

The MAC Address consists of 6 hexadecimal numbers, separated by colons, and is unique to every card manufactured. The first numbers of the MAC Address identifies the manufacture of the card. A MAC Address looks like this:

00:A0:BC:01:AB:48

The MAC Address is usually used to:

- Send messages between local devices on a **Local Area Network (LAN)**
- For device identification

IP Address Format

The TCP/IP Address, commonly called the IP Address, is used to identify **Internet Ready Devices (IRD)** [i.e. PCs] on both Private and Public networks. This address is a four field number, displayed in the following format.

Field1 . Field2 . Field3 . Field4

212 . 58 . 240 . 110

IP Address Assignment

- **Static IP Address:** A Static IP Address requires manual modification of a network device (i.e. subscriber's computer) configuration-file. *The IP Address is stored permanently in the device and rarely changes.*
- **Dynamic IP Address:** A Dynamic IP Address is not stored permanently in the network device. This is a common assignment method for Personal Computers. When the computer is set up to use Dynamic IP Addressing, it requests a new IP Address every time it connects to the LAN. The Dynamic Host Configuration Protocol (**DHCP**) server responds to this request. This server resides on the LAN. It is responsible for tracking and assigning all IP Addresses on the LAN. *A PC may have a different IP Address every day.*

Public and Private IP Addresses

In order to simplify network administration and to conserve IP addresses certain blocks from each address class have been set aside for private network use.

- **Private IP Addresses:** The Internet Assigned Numbers Authority (**IANA**) has reserved the following three blocks of the IP address space for private networks:
 - ***Private IP Addresses:***
10.0.0.0 - 10.255.255.255 (10/8 prefix)
172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

The addresses in these blocks are used by many networks and are only unique within each LAN. Internet Routers consider these Private addresses as un-routable, therefore do not forward IP packets with these addresses in the header to the Internet. In addition, ISP Routers filter out routing information about Private networks.

- **Public IP Addresses:** All other IP Addresses are Public and have a globally unique Network ID.

WHAT ALL COMPUTERS SHOULD KNOW

- The following information outlines the general configuration setting that all computers need to communicate with the network properly.

Step By Steps

TCP/IP protocols allow the subscriber PC to communicate with the network. From the standpoint of the PC, four items define network access.

1. The **MAC address** is the “physical” address of the PC’s NIC card. The card has this number built into it.
2. The **IP Address** defines the PC’s network address and IP Class. The PC network configuration defines the IP Address or, if the PC network configuration uses DHCP, it requests an IP Address when connecting to the network.
3. The **Subnet Mask** defines the Network ID and the Host ID within the IP Address. The PC network configuration defines the Subnet Mask or, if the PC network configuration uses DHCP, the DHCP server provides a Subnet Mask when the PC requests an IP Address.
4. The **Default Gateway** is the Router port attached to the LAN where the PC resides. The PC network configuration defines the Default Gateway or, if the PC network configuration uses DHCP, the DHCP server provides a Default Gateway when the PC requests an IP Address.

Proxy Servers

A proxy server sits between a client application, such as a Web browser, and a real server. It intercepts all requests to the real server to see if it can fulfill the requests itself. If not, it forwards the request to the real server.

Proxy servers have two main purposes:

1. Improve Performance by holding recently requested web pages in memory in order to have faster access to them for the users
2. Filter requests: Proxy servers can also be used to filter requests. For example, a company might use a proxy server to prevent its employees from accessing a specific set of Web sites.

PC APPLICATIONS USED TO ACCESS THE INTERNET

- The following information provides general information about the Internet and the WWW, along with providing an overview of the Web-based tools; the Browser and the Email client.

Step By Steps

Recall the following facts about the Internet and the World Wide Web (WWW):

Internet: The **Internet** is a network of networks, linking computers to computers. This world-wide network uses a common set of **TCP/IP protocols** to transport messages between computers.

WWW: The Internet supports the **World Wide Web (WWW)**. The WWW is a universe of **hypertext (HTTP)** servers, often called Web-servers, which allow PC users access to information resources using Web-based tools.

The two basic Web-based PC application tools used to navigate the Internet and access Web-pages are:

Browser applications: The PC **Browser** application is a Web-based tool that allows the PC user to view WWW documents, called **Web-pages**, which reside on Web-servers. While the Internet provides access to the Web-servers, the Browser allows the PC user to view the Web-page information by translating **HyperText Markup Language (HTML)** code.

***NOTE:** The HTML code embedded in the Web-page contains commands read by the Browser. These commands tell the Browsers how to display the Web-page on the PC monitor.

In addition, the Browser has the functionality to help speed up the PC internet connection. This function requires the use of a **Proxy Server** within the Internet, usually provided by the **Internet Service Provider (ISP)**.

Email Client applications: The **Email client** PC application is the Web-base tool enables the PC to create, read, and organize Email messages residing on the PC. Based on client-server architecture it can only generate requests to send or receive Email messages. It must rely on a specific Email-server residing on the Internet to actually send and receive Email messages to or from other PC users. The customer's **Internet Service Provider (ISP)** provides the Email server.

WildBlue Service supported Email Clients:

- Outlook
- Outlook Express
- Netscape Mail
- MacMail

BASIC TCP/IP TROUBLE SHOOTING TOOLS

- The following information outlines the basic purpose and use of the two TCP/IP tools: PING and TRACEROUTE.

Step By Steps

Basic TCP/IP connectivity troubleshooting consists of two common command functions: **ping** and **tracert**.

- **PING:** The ping command only tests connectivity to a host's NIC. It does not test whether the computer is functioning properly. Ping bounces a message off a computer: if a reply comes back, the computer is connected. The ping test can fail, but the problem may not be at the computer, it could be the gateway or a DNS server that is not available. You can ping to check the availability of a specific computer by pinging the *IP Address* or of a domain by the domain name such as *wildblue.com*. The ping test will tell the response time from the host. Summary information provides the number of packets *sent*, *received*, *lost* and the *percent lost*. Also included are *Minimum*, *Maximum*, and *Average*, round trip times represented in milliseconds.
- **TRACEROUTE:** Traceroute is a program that helps you identify where problems exist on a network. Traceroute displays both the route that packets follow on their way to a destination and the time in milliseconds for each round-trip hop. Each place a packet goes through is a *hop*. Traceroute tests each hop along the way three times and displays the minimum, average, and maximum time for a round trip.

Notes

- **NOTICE:** *This primer will help the installer be better equipped to accomplish the Satellite Provisioning and service trouble shooting required of a WildBlue Installer.*