Libra
Satellite Network

Reference Guide

Nanometrics Inc.
Kanata, Ontario
Canada

Libra Satellite Network Reference Guide

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Part 1 Getting Started

- Introduction
- Libra Communications Overview

Chapter 1 Introduction

This chapter provides a general overview of Libra VSAT-based systems and of this reference guide.

1.1 About Libra VSAT networks

Nanometrics Libra is a Very Small Aperture Terminal (VSAT)-based system. It is designed to collect high volumes of seismic and other environmental data reliably and economically, and to enable data acquisition from remote locations previously considered unreachable.

Libra delivers continuous, 24-bit, 3 ch, 100 sps time series data in near real-time via satellite to the central acquisition facility. Continuous data collection ensures a complete data archive.

Libra networks use the same basic configuration for any application. The nature of VSAT systems eliminates the need for repeaters in a Libra network. Every Libra system uses the same basic elements, making planning, installation, commissioning, and maintenance easy. Networks can be installed and operated after a few days of training. Once the network is installed, there are fewer remote locations to inspect and service. Libra networks have lower operating costs than networks that use telephone lines.

The seismic remote station consists of one or more Trident digitisers connected to a Cygnus remote VSAT transceiver. The instruments and small Ku-band antenna are easy to transport and can be installed in a few hours.

Libra remote stations consume very little power; this allows the stations to be solar-powered and completely self-contained. Remote sites can be installed at any location with a clear view of the satellite, allowing Libra networks to be located in terrain unsuited to telephone or radio communications.

Libra VSAT networks provide a higher level of data integrity by transmitting directly to the central hub, thereby avoiding the interference problems associated with terrestrial radio networks. Sampling is synchronized to UTC with a GPS reference providing near-synchronous sampling across the entire array. Proven event detection algorithms and network-wide data reduce false alarms and permit Libra to provide timely information for disaster response. Sporadic interference from solar eclipses, rain fade, and scheduled maintenance are easily recovered by Nanometrics' error-correcting retransmission protocol.

Libra can be configured with external state-of-health (SOH), serial data, and Ethernet/IP channels. These allow the network to support additional services such as continuous or triggered strong motion, meteorological sensing, auxiliary data communications, and LAN or WAN extension to remote sites.

1.2 About this Reference Guide

This reference guide provides an overview of how a Libra VSAT network operates, guidelines for planning a Libra network, and procedures for installing, commissioning, and maintaining the network. See also related documents, listed in section 1.2.1, for information on the specific instruments in a Libra system, and for detailed information on changing instrument configurations, monitoring operation, and viewing data.

Part 1, “Getting Started”, provides background theory about satellite and IP communications:

- Chapter 1, “Introduction” – a brief introduction to Libra and to this manual, and technical support contact information.
- Chapter 2, “Libra Communications Overview” – an overview of satellite communications, Libra networks, and IP communications.

Part 2, “Planning the Network”, provides guidelines for planning a Libra network:

- Chapter 3, “Selecting Network Sites” – general criteria for selecting Libra network sites.
- Chapter 4, “Configuring Libra IP Connections” – an overview of Libra network IP connections, and Libra IP configuration parameters.
- Chapter 5, “Remote Station Data” – an introduction to the types of data generated by remote stations, Cygnus communications control, data ports, and the related configuration parameters.
- Chapter 6, “Multiplexing Network Data – TDMA” – an introduction to Time Division Multiple Access (TDMA) protocol, how Libra stations use TDMA for shared access to the satellite channel, and guidelines for planning remote site data traffic.
- Chapter 7, “Interpreting Your Satellite Lease” – a general overview of the satellite lease, including typical specifications, and conditions and responsibilities of the network operator and satellite provider.
- Chapter 8, “Determining Satellite Radio Frequencies” – an overview of the frequencies used in Ku-Band satellite communications, and the associated Libra configuration parameters.
- Chapter 9, “Setting Transmit Power Levels” – an overview of the constraints that satellite leases place on transmit RF power levels, and the methods of meeting them.
- Chapter 10, “Aligning Satellite Antennas” – an overview of the basic properties of satellite antennas, and how to align them.

Part 3, “Commissioning the Network”, provides procedures for installing, commissioning, and maintaining the equipment:

- Chapter 11, “Commissioning a Central Station” – an overview of procedures for installing and commissioning a central site, including hardware and acquisition system installation, and network security options.

- Chapter 12, “Commissioning a Remote Station” – procedures for installing and commissioning a remote site.
- Chapter 13, “Maintaining Network Sites” – maintenance guidelines for central and remote sites.

Part 4, “Appendices”, provides additional reference information:

- Appendix A, “Glossary” – terms and acronyms associated with Libra systems.
- Appendix B, “Cable Drawings” – assembly instructions for the Cygnus test cable.
- Appendix C, “Checking instrument settings” – an overview of procedures for checking and changing the configuration of the Cygnus, TimeServer, and Trident.

1.2.1 Related documents

Related documents include configuration sheets specific to the equipment in your shipment, and product manuals for hardware and software.

1.2.1.1 As-shipped configuration sheets

An as-shipped configuration sheet is shipped with each instrument. This sheet lists the serial numbers of the parts shipped, the hardware configuration, IP address for the unit, and any calibration parameters associated with the hardware. The configuration described on the configuration sheet determines how the instrument will operate on the initial startup.

1.2.1.2 Nanometrics product manuals

This is the basic set of Nanometrics product manuals associated with a Libra system:

- Hardware
  - Carina Hub Transceiver
  - Cygnus Remote Transceiver
  - Trident Digitiser
- Software
  - Nanometrics UI – information on monitoring the operation and changing configuration parameters on installed Nanometrics Libra instruments.
  - NaqsServer – information on configuring the data acquisition software.
  - NaqsClient (NaqsView, Waveform Viewer) – information on data monitoring (state of health, and seismic data).
  - Playback – description of utilities for retrieving data (time-series, SOH, and serial).

1.3 Network planning forms

As you plan and configure your Libra network, we recommend that you record the network configuration information on worksheets similar to the examples that are provided in this manual. You may customize these as appropriate for your network:

1. Copy or customize the example system configuration worksheets:
   - Form 1 – Site List, on page 39
   - Form 2 – IP Configuration, on page 47
   - Form 3 – Station Data Configuration, on page 55
   - Form 4 – TDMA Configuration, on page 67
   - Form 5 – Satellite Lease, on page 75
   - Form 6 – Satellite Frequencies, on page 85
   - Form 7 – Transmit Power, on page 93

   Similarly, there are sample installation checklists provided:
   - Central station commissioning checklist – Example, on page 115
   - Remote station commissioning checklist – Example, on page 143
2. Fill in the forms as you are planning and configuring your network.
3. Keep the completed forms as a record of your network configuration.

1.4 Technical support

Read the appropriate sections of this manual and related documents carefully before installing or operating your Libra system. If you need technical support, please submit your request by email or fax. Include a full explanation of the problem, and supporting data.

email: support@nanometrics.ca
FAX: To: Support
+1 (613) 592-5929

Chapter 2 Libra Communications Overview

This chapter provides an overview (as slides) of satellite communications, Libra networks, and IP communications.

2.1 Introduction to satellite communications

Satellite Communications Introduction

- Satellites are repeaters: what goes up comes down
- Large area coverage ("footprint")
- Geostationary satellites have a 24 hour orbit, and remain at a fixed longitude above the equator (36,000km ~ 22,000 miles above surface)
- More than 200 geostationary satellites orbit the earth
- Satellite operators compete to lease bandwidth (Intelsat, PanAmSat, Eutelsat, Hispasat, Telesat, Optus . . .)

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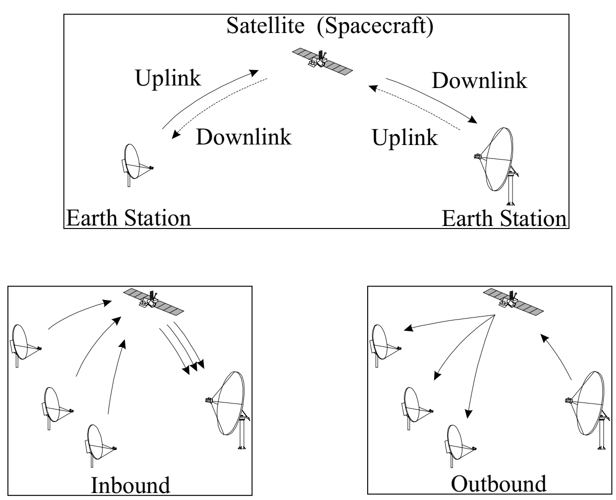
Satellite Terminology



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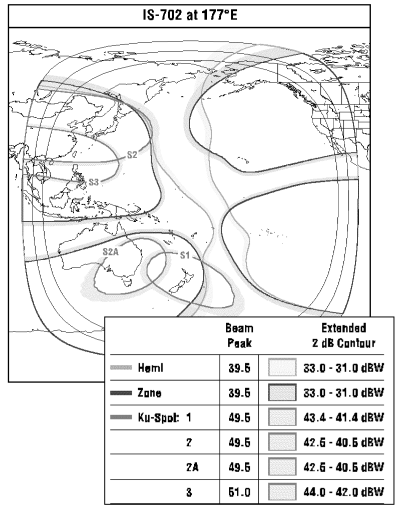
Typical Satellite Footprint

- Intelsat 702 satellite located at 177° East
- Ku-Band Spot beams focus energy in small areas
- C-Band Hemi and Zone beams cover large areas
- C-Band Global beam (outer rings) spread over very large areas



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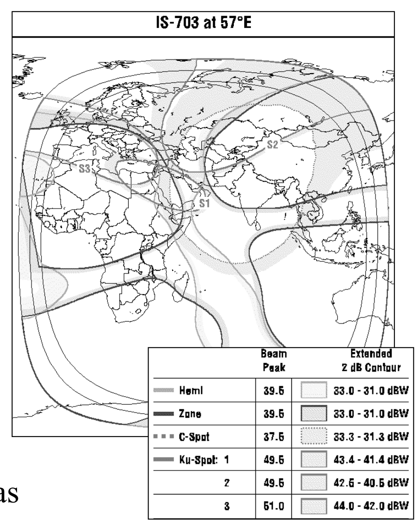
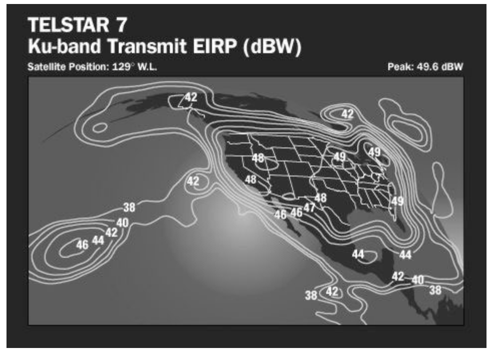
Typical Satellite Footprint

- Intelsat 703 satellite located at 57° East
- Ku coverage in areas of high population density
- EIRP : Effective Isotropic Radiated Power (point source)
- High EIRP allows small receive antennas



Nanometrics

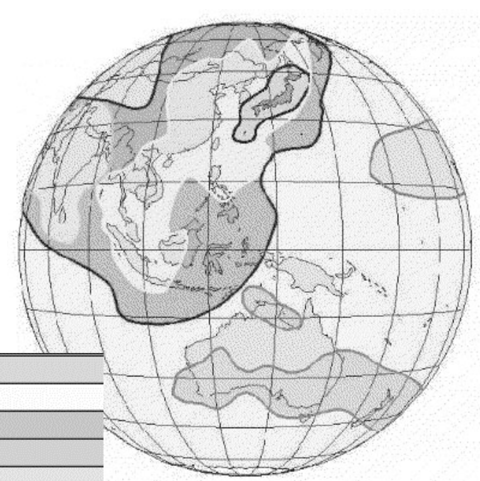
Typical Satellite Footprint



- Telstar 7 satellite located at 129^{o} West longitude
- Ku Band beam shown

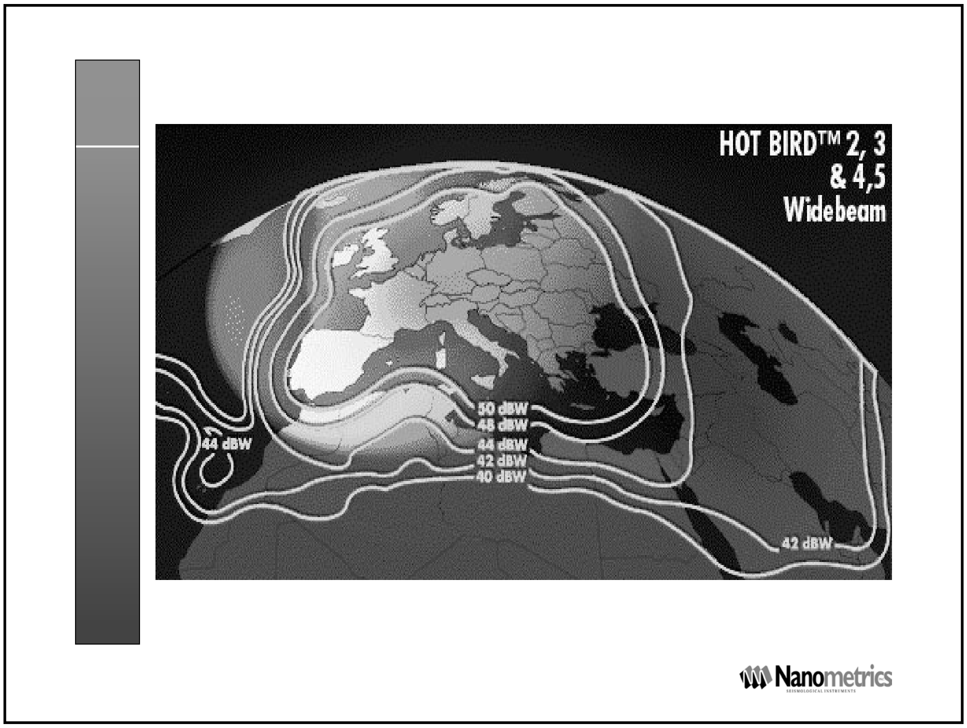
Nanometrics

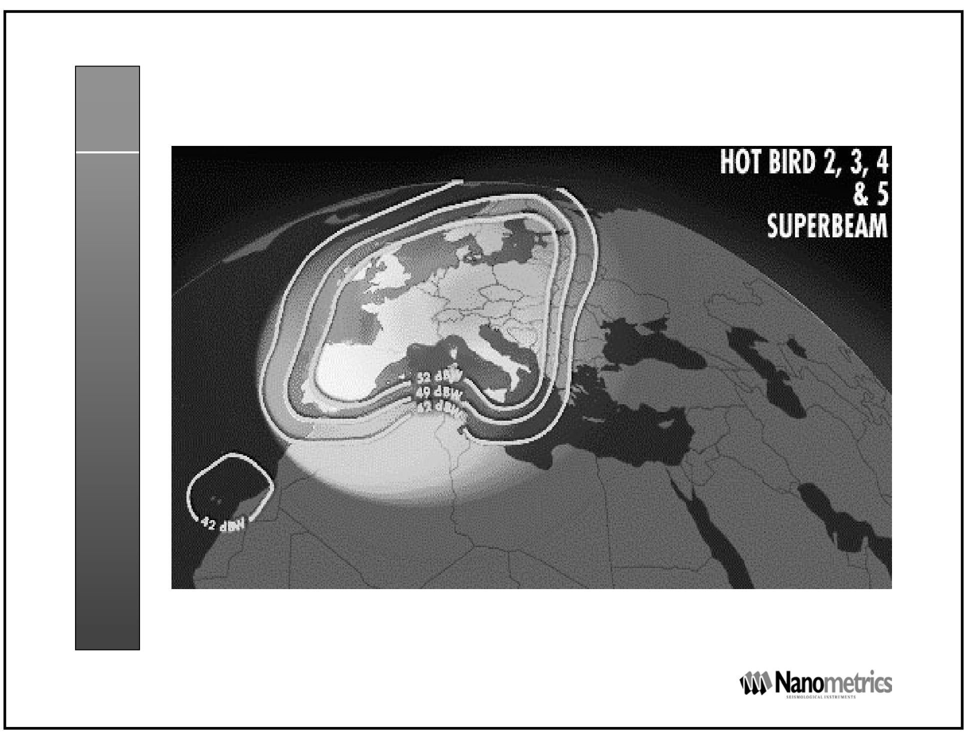
Typical Satellite Footprint

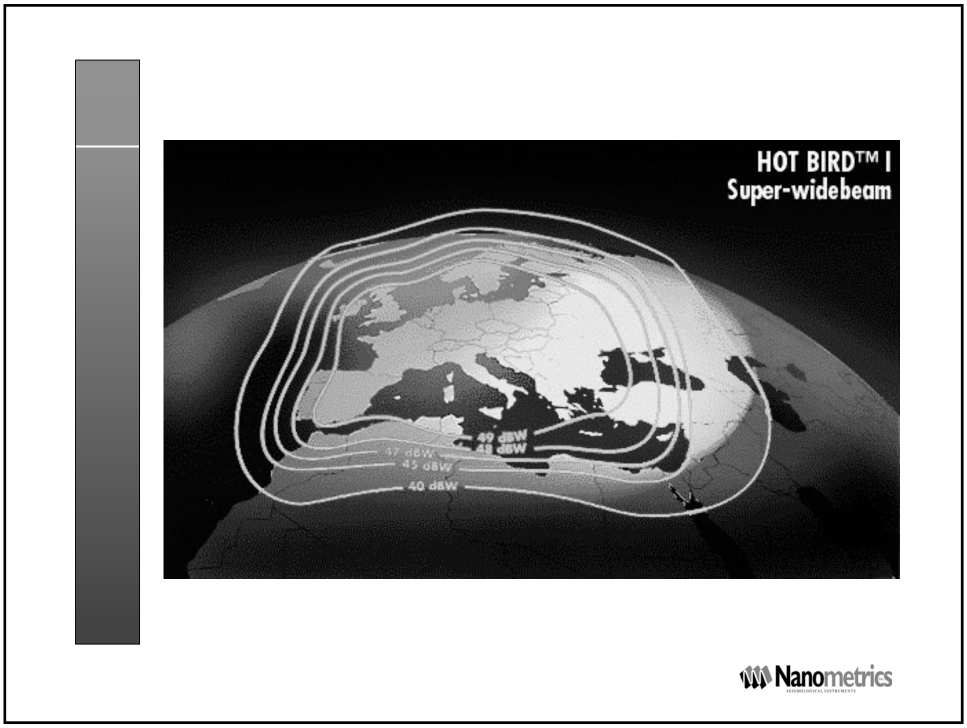


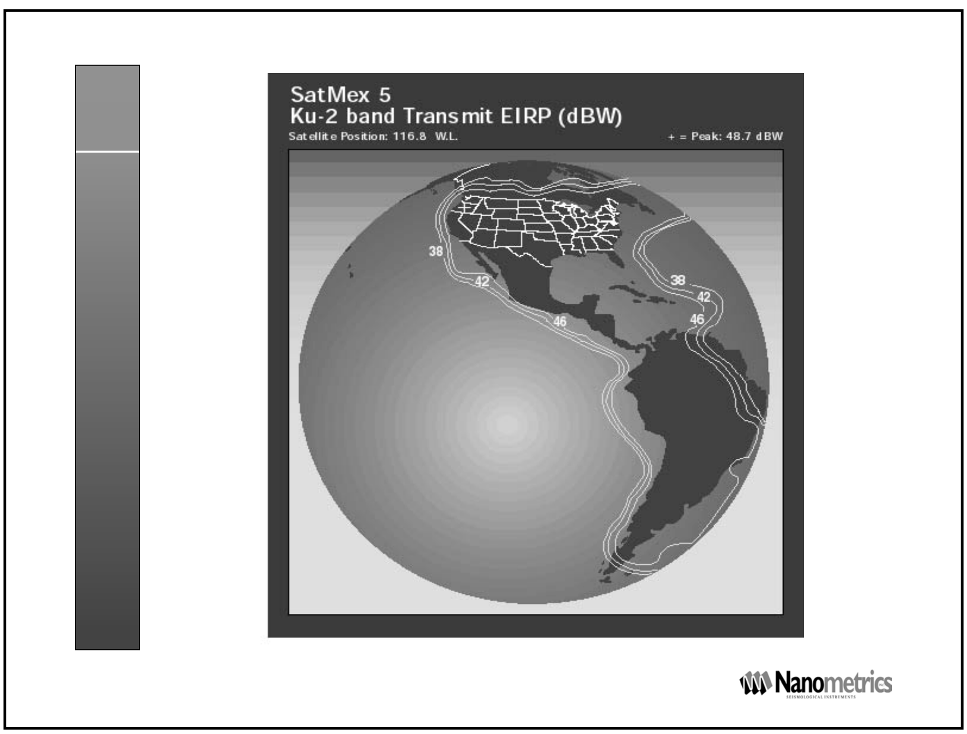
Red	Japan Beam (Ku-band)
Yellow	Asia Zone Beam (Ku-band)
Blue	India Beam (Ku-band)
Purple	Asia Beam (C-band)
Green	Hawaii Beam (C-band)
Orange	Australia/New Zealand Beam (Ku-band)

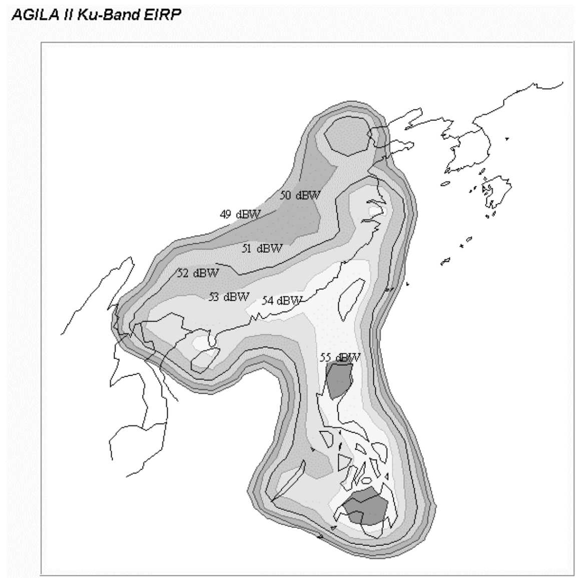
Nanometrics


HOT BIRD™ 2, 3
& 4,5
Widebeam
50 dBW
48 dBW
44 dBW
42 dBW
40 dBW
44 dBW
42 dBW
Nanometrics


HOT BIRD 2, 3, 4
& 5
SUPERBEAM
52 dBW
49 dBW
42 dBW
42 dBW
Nanometrics


HOT BIRD™ I
Super-widebeam
49 dBW
48 dBW
47 dBW
45 dBW
40 dBW
Nanometrics


SatMex 5
Ku-2 band Transmit EIRP (dBW)
Satellite Position: 116.8 W.L.
+ = Peak: 48.7 dBW
38
42
46
38
42
46
Nanometrics



Advantages of Satellite Communications

- Complete freedom of station placement, regardless of terrain (if solar powered)
- Not damaged by large earthquakes
- No repeater sites
- Fewer sites to plan and maintain
- Very low operating cost, from $30 / station / month
- Resistance to lightning damage (conducted)

Practicalities of Satellite Communication

Rainfade

- Typically < 0.5 dB for C-Band
- Typically 3 - 10 dB for Ku-Band
- Typical thunderstorms last 10 - 30 min

Solar Eclipse of the Satellite (sun transit)

- Occurs when sun, satellite and earth station align
- Approx. 15min/day for 3-5 days in spring and fall
- Duration depends on antenna beamwidth (360^0/day =1^0/4min)

C-Band and Ku-Band

	C-Band	Ku-Band
Uplink Frequency (GHz)	5.924 - 6.425	14.0 - 14.5
Downlink Frequency (GHz)	3.7 - 4.2	11.7 - 12.2 12.25 - 12.75 10.95 - 11.7
Rainfade Loss	Low (typ < .5dB)	High (typ 3-10dB)
Antenna Area (α f^{-2})	Large	Small
Interference	Many sources	Few sources

Satellite Bandwidth Lease Issues

- Satellite bandwidth is typically leased in 100kHz increments
- Intelsat published rates *, Ku Spot beam, 100kHz
  - 1 week for $US 400
  - 1 month for $US 1400
  - 1 year for $US 7800
  - 5 years for $US 6900/year
  - 10 years for $US 5800/year
  - 15 years for $US 5100/year
- Preemptible vs non-preemptible leases

Note* Intelsat Tariff Manual, Nov 1995. Taxes and local administration not included.

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2.2 Introduction to Libra networks

Libra VSAT Network Introduction

VSAT: Very Small Aperture Terminal

VSAT's are small satellite terminals used for 2-way communications.

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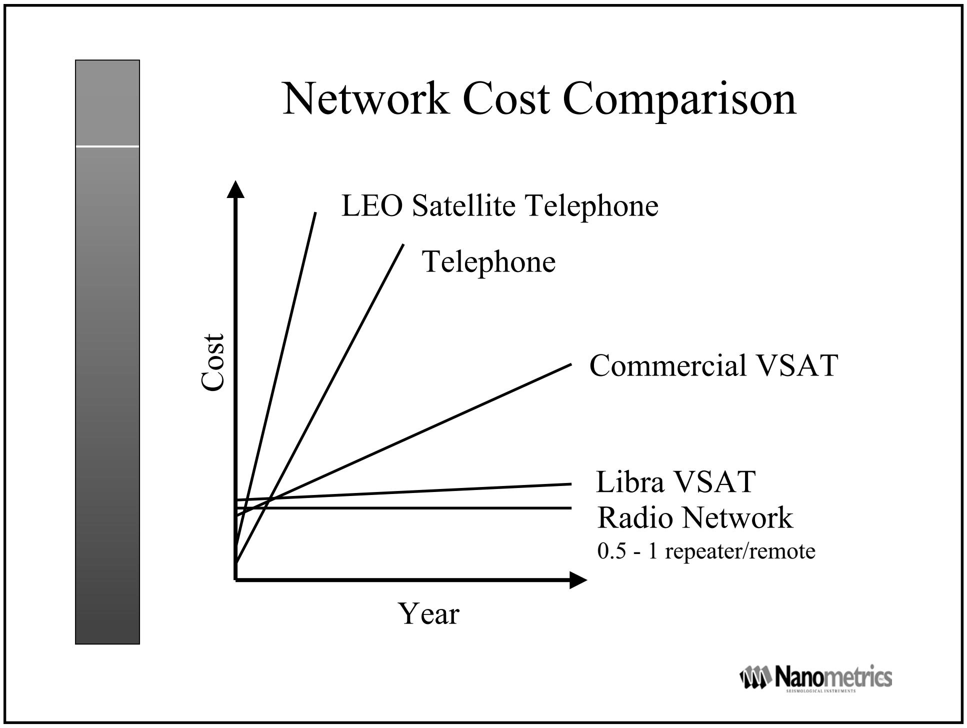
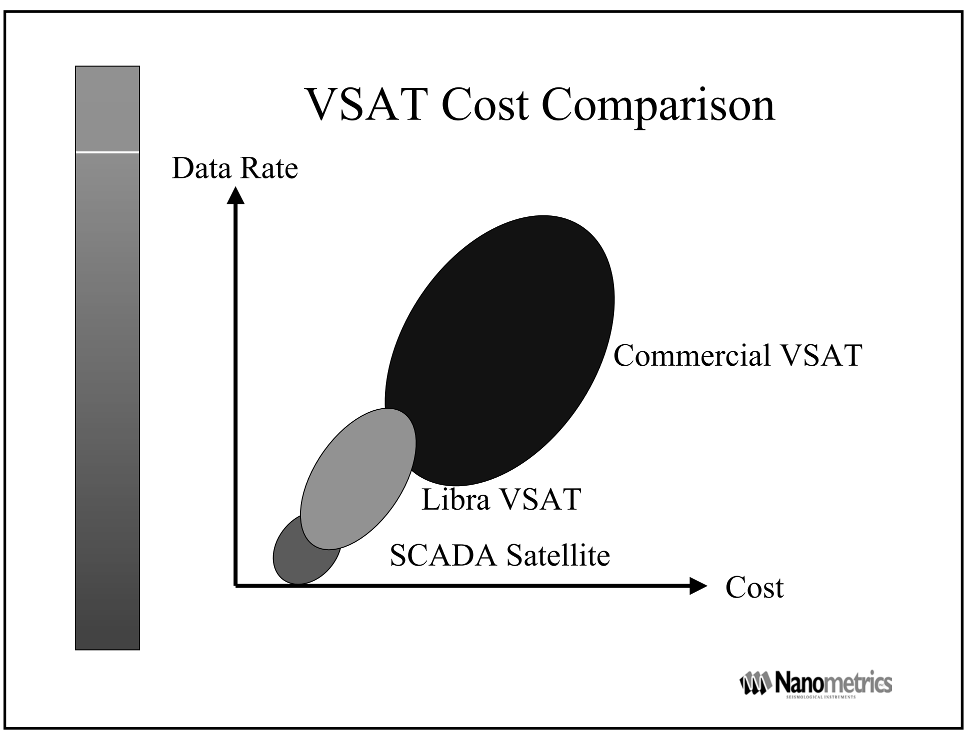
Seismic VSAT Wish List

- Complete freedom of station placement
  - Robust outdoor equipment
  - Solar panels, low power consumption
- Low cost
  - Affordable capital cost
  - minimum operating cost
- Excellent data quality
  - Fully integrated satellite seismograph
  - Robust error correction
  - high data bandwidth
  - infrastructure unaffected by major events

Nanometrics


Network Cost Comparison
LEO Satellite Telephone
Telephone
Commercial VSAT
Libra VSAT
Radio Network
0.5 - 1 repeater/remote
Cost
Year
Nanometrics


VSAT Cost Comparison
Data Rate
Commercial VSAT
Libra VSAT
SCADA Satellite
Cost
Nanometrics

Libra

# of stations	Modulation	Rate per carrier	# carriers inbound	# carriers outbound	Total bandwidth	Cost/Yr
16	QPSK	112 kbps/ 100kHz	1	None	100kHz	$7,500
32	QPSK	112 kbps/ 100kHz	2	None	200kHz	$15,000
64	QPSK	112 kbps/ 100kHz	4	None	400kHz	$30,000
16	FSK	64kbps/ 160kHz	2	1	480kHz	$37,500
32	FSK	64kbps/ 160kHz	3	1	640kHz	$52,500
64	FSK	64kbps/ 160kHz	6	1	1120kHz	$90,000

Blue = Libra
Red = competing VSAT

Libra Factory Integration

- Entirely designed, manufactured and tested by Nanometrics
- Single contact for support
- Guaranteed performance

Noise counts	Dynamic Range
1.9	131 dB
6	121 dB
10	116 dB
18	111 dB

- Digitiser sensitivity is 1.9 microvolts/bit (default)
- RS232 allows +/- 3 Volts noise

Low Power Consumption

- Remote site power consumption (VSAT plus digitizer) typically between 20 and 30 Watts.
- Commerical VSAT remotes typically consume over 200 Watts
- Libra operates from solar panels and accepts battery voltage.

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Libra

- Continuous data, 3ch, 100sps
- Error correction via data re-request
- 132 dB dynamic range (shorted input)
- +/- 5 microseconds timing accuracy
- 2.3 hour data buffer
- <30 watt power consumption

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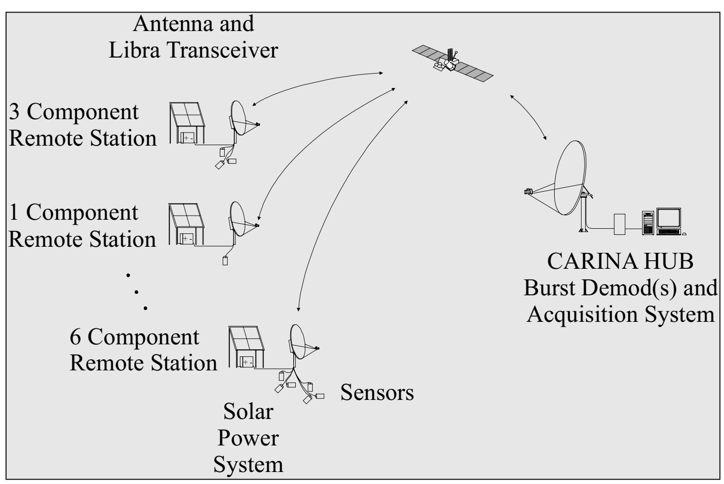
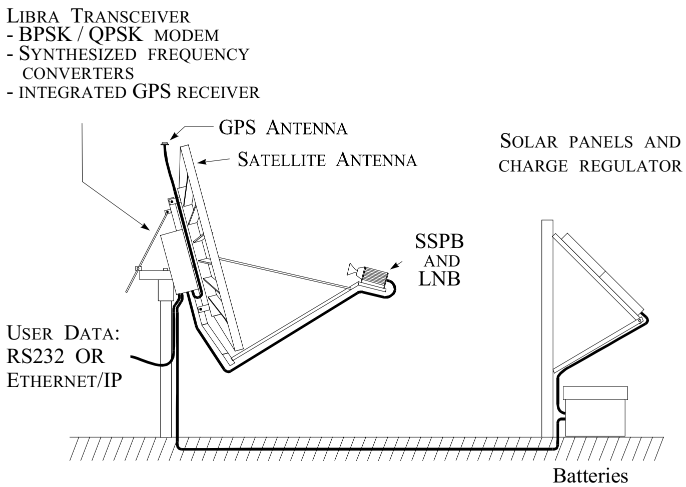
Libra

- QPSK modulation
- 112Kbps per 100KHz carrier
- Time domain multiple access (TDMA)
- Central Hub uses TDMA slot
- Dynamic bandwidth allocation

Libra Satellite Seismograph Network



Libra Remote Site Equipment



Libra Remote Site Antenna

Libra Remote Site Systems

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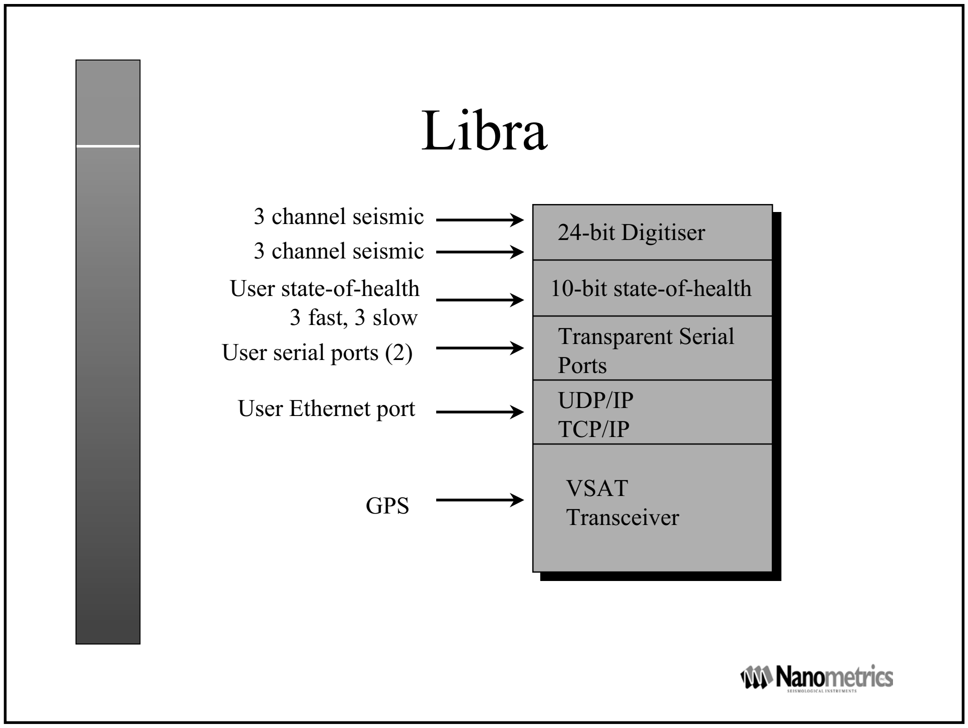
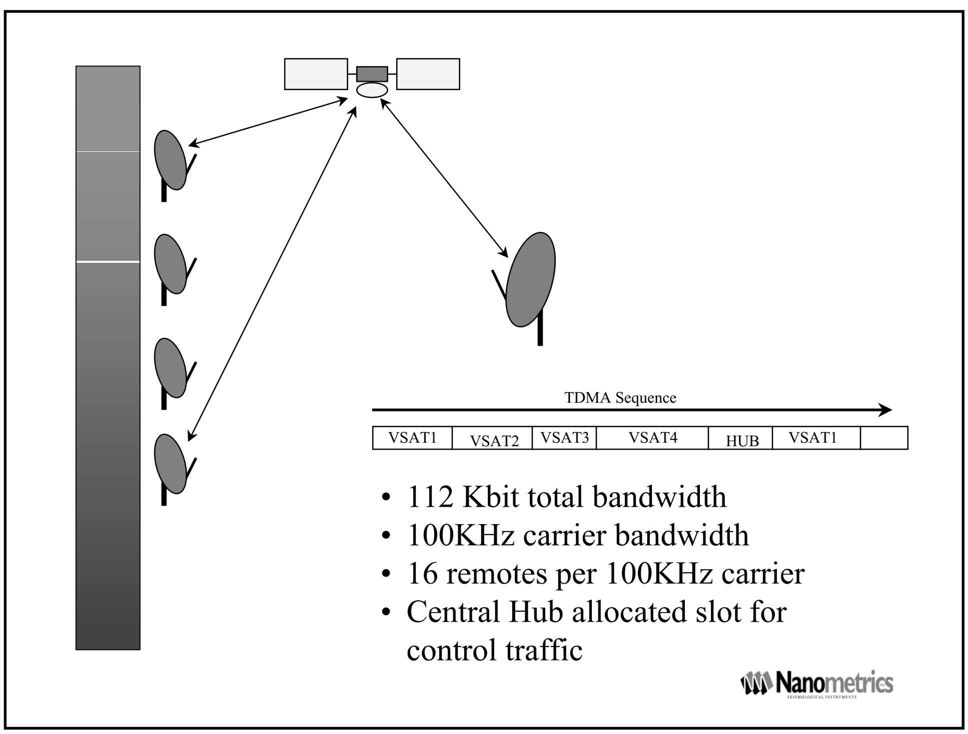
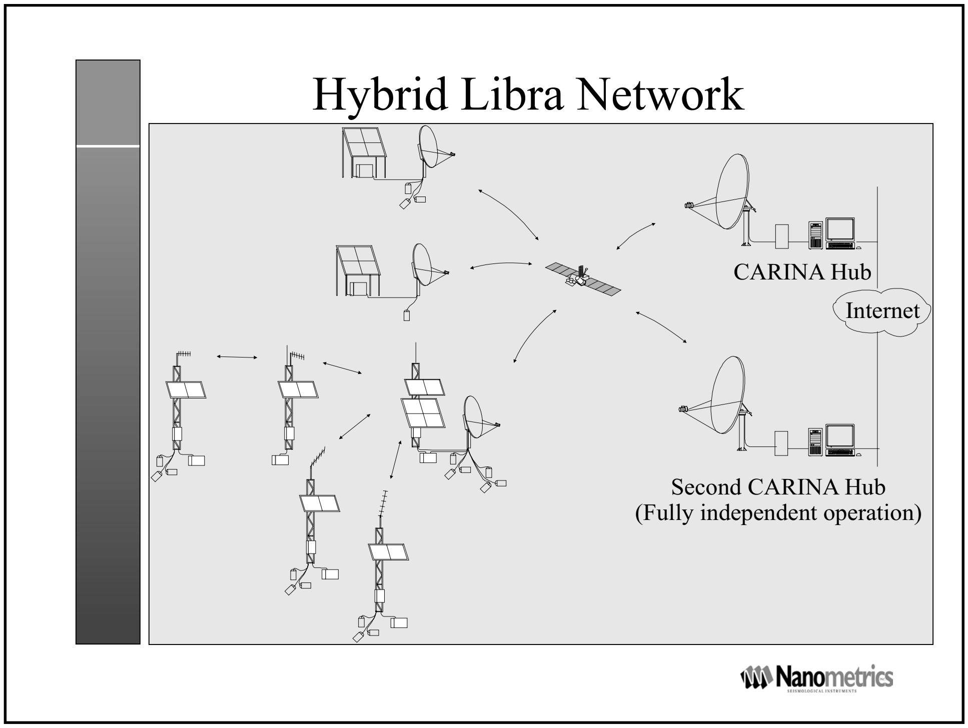
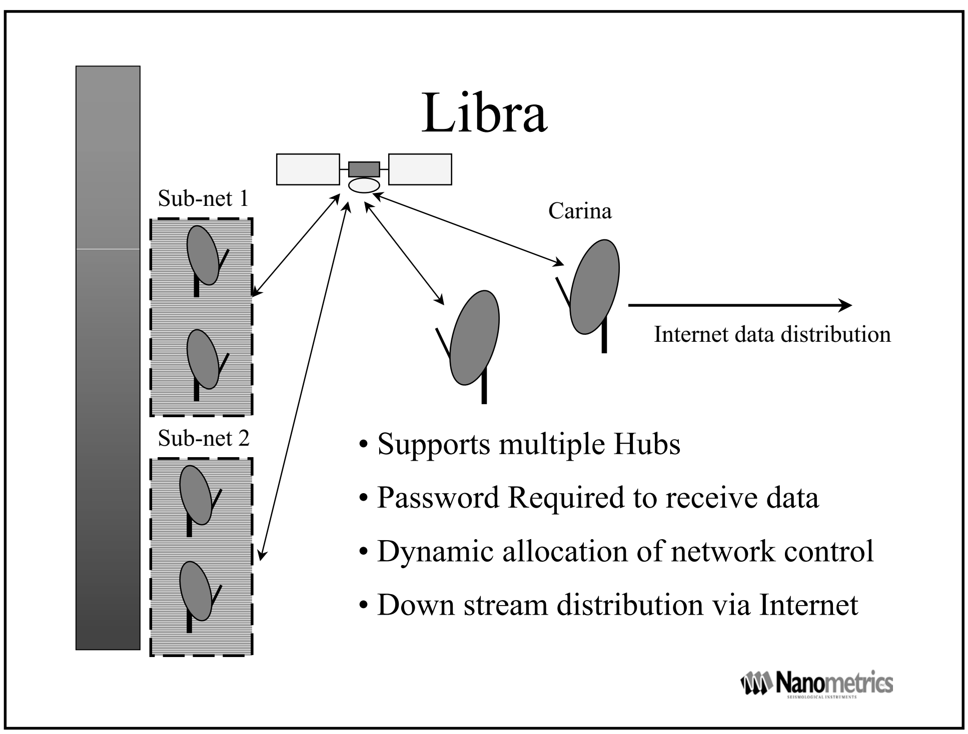
Libra Remote Site Equipment Installation

Nanometrics

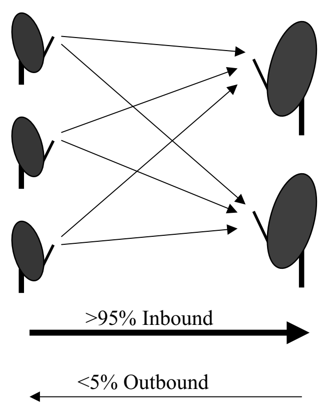

Libra
3 channel seismic
3 channel seismic
User state-of-health
3 fast, 3 slow
User serial ports (2)
User Ethernet port
GPS
24-bit Digitiser
10-bit state-of-health
Transparent Serial Ports
UDP/IP
TCP/IP
VSAT
Transceiver
Nanometrics


TDMA Sequence
VSAT1
VSAT2
VSAT3
VSAT4
HUB
VSAT1
• 112 Kbit total bandwidth
• 100KHz carrier bandwidth
• 16 remotes per 100KHz carrier
• Central Hub allocated slot for control traffic
Nanometrics


Hybrid Libra Network
CARINA Hub
Internet
Second CARINA Hub
(Fully independent operation)
Nanometrics


Libra
Sub-net 1
Carina
Internet data distribution
Sub-net 2
• Supports multiple Hubs
• Password Required to receive data
• Dynamic allocation of network control
• Down stream distribution via Internet
Nanometrics

Seismic Traffic Pattern



- In-balanced traffic pattern
- Ability to allocate bandwidth station-by-station
- Multiple hubs sharing data
- Error correction between multiple hubs and remotes
- 100kHz space segment minimums

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Bandwidth vs. Space Segment

Assuming 100kHz space segment

Modulation	FEC Rate	Data Rate
QPSK	½	64 Kbps
	7/8	112 Kbps
BPSK	½	32 Kbps
	7/8	64 Kbps

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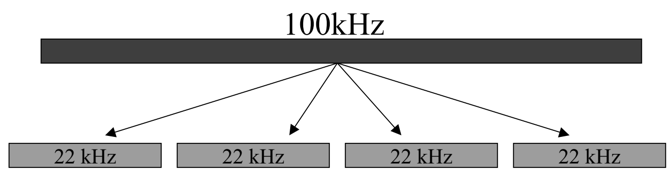
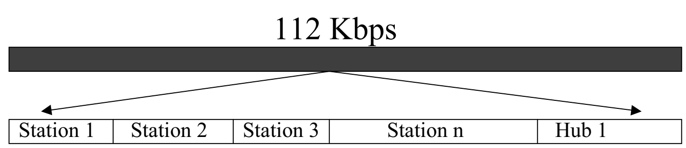
Single Carrier per Channel (SCPC)



At 6.5 Kbps, theoretical total of 10 stations

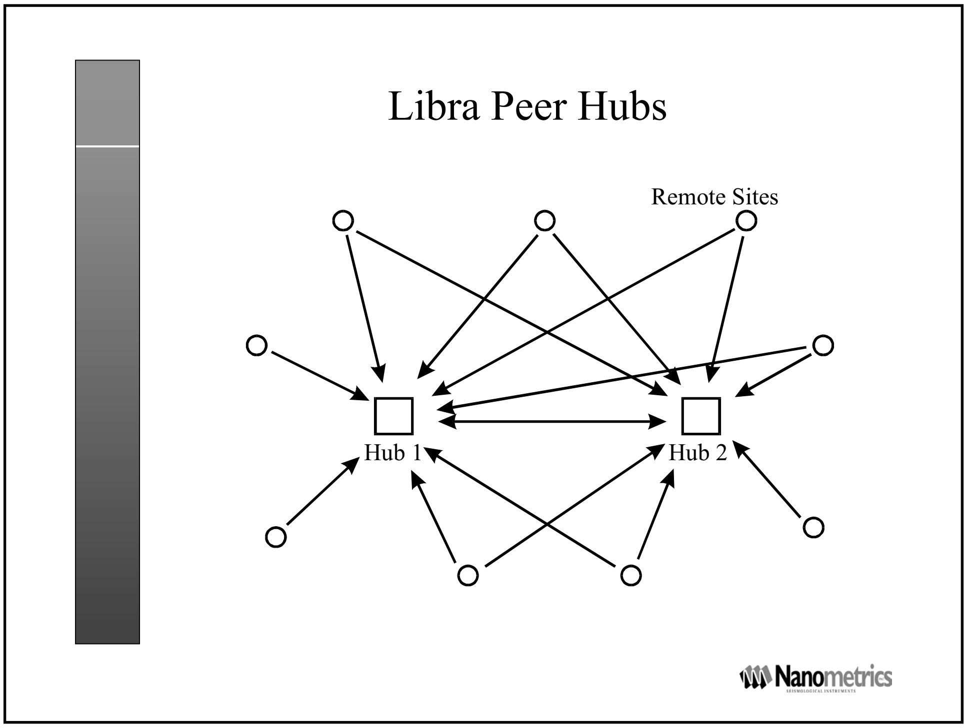
- Advantages
  - Smaller dish size
  - low latency
- Disadvantages
  - Inefficient use of space segment
  - High power consumption (100% Tx duty cycle)
  - One receiver for each remote
  - Fixed bandwidth per station
  - Complicated multiple Hub designs

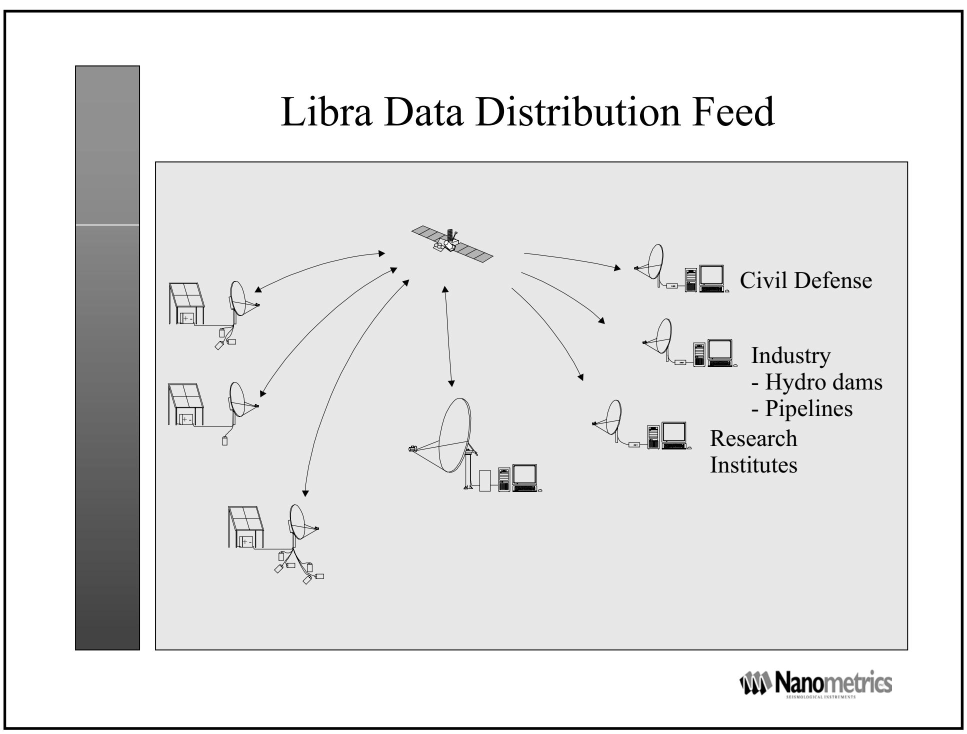
Time Domain Multiple Access (TDMA)



At 6.5 Kbps, maximum of 16 stations and one hub

- Advantages
  - Efficient use of space segment
  - Low power consumption (Tx. Duty cycled)
  - Variable bandwidth per station
  - Dynamic bandwidth allocation
  - Multiple hub support
- Disadvantages
  - larger dish size
  - 4 to 16s latency

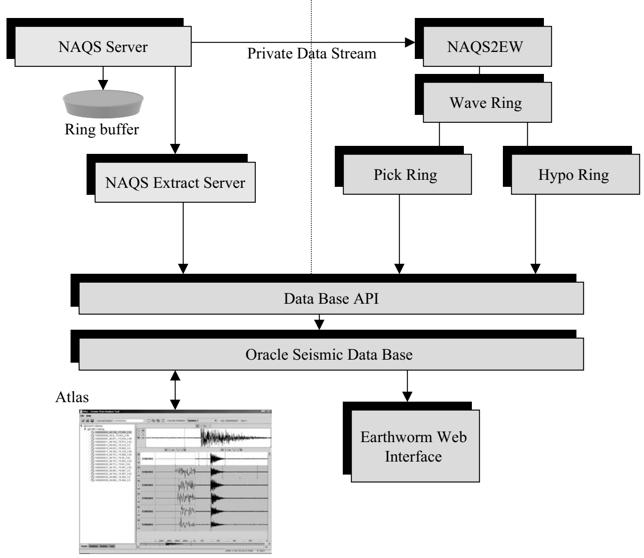

Libra Peer Hubs
Remote Sites
Hub 1
Hub 2
Nanometrics

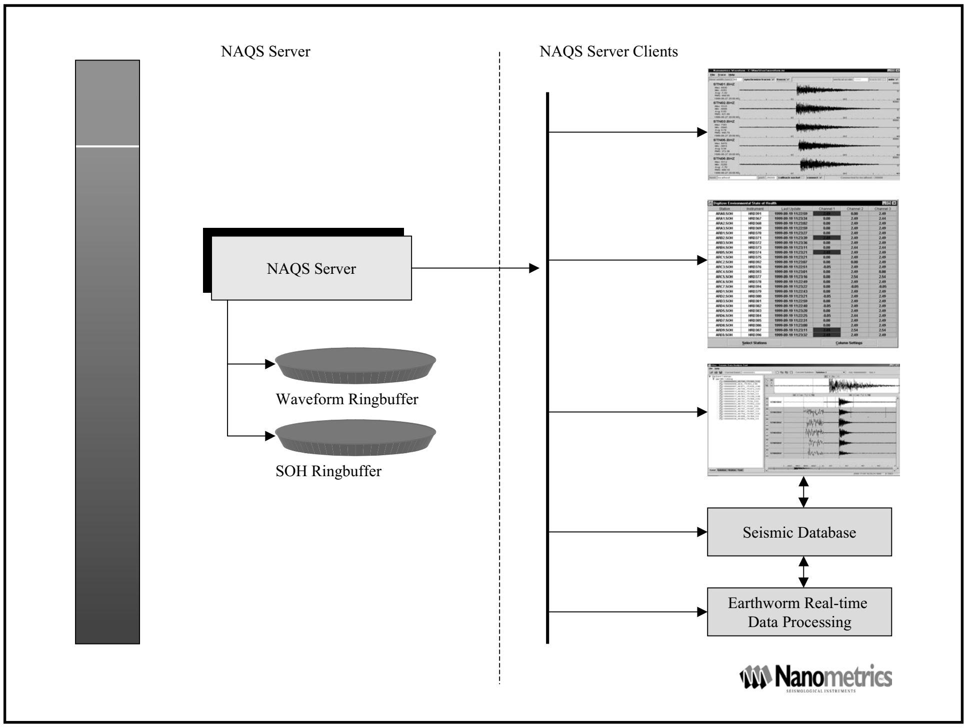

Libra Data Distribution Feed
Civil Defense
Industry
- Hydro dams
- Pipelines
Research
Institutes
Nanometrics

Libra Data Distribution Feed

- Distribution of event data or bulletins
- Uses existing Libra hub systems
- Broadcasts IP-based messages in TDMA timeslot
- Low cost, approximately $US 4000 / remote

Atlas Earthworm Relationships




NAQS Server
NAQS Server Clients
NAQS Server
Waveform Ringbuffer
SOH Ringbuffer
Seismic Database
Earthworm Real-time Data Processing
Nanometrics

2.3 Introduction to IP communications

Introduction to IP Communications

- Transmitters and receivers must use the same data format to understand each other
- Such formats are called PROTOCOLS
- Many protocols are used today
- Internet protocols are widely used in other networks

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Data Protocols

- Protocols can be layered for modularity
- Home: Internet access via telephone modem
  Office: Internet access via LAN, server and T1 line
- OSI model (Open Systems Interconnect) layers are modular allowing upgrades and new configurations

Application	↔	Application
Presentation	↔	Presentation
Session	↔	Session
Transport	↔	Transport
Network	↔	Network
Data Link	↔	Data Link
Physical	↔	Physical

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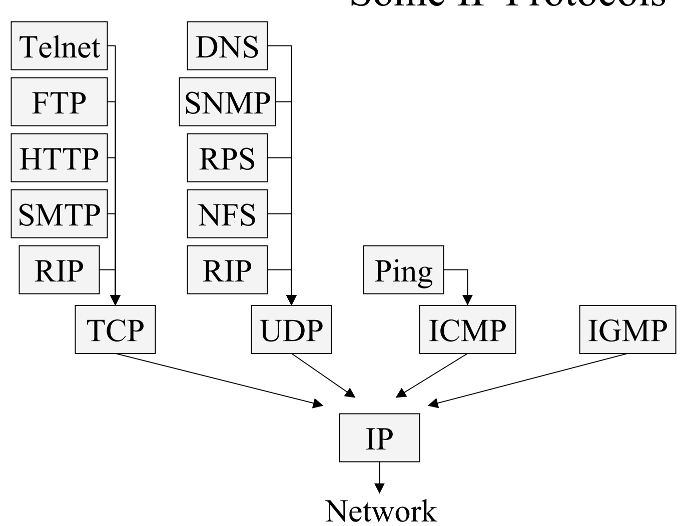
Internet Protocol (IP) Communications

Many different protocols are used on the Internet

- TCP/IP (Transport Control Protocol/Internet Protocol)
- UDP/IP (User Datagram Protocol/Internet Protocol)
- ICMP, IGMP, etc.

Some IP Protocols



IP Packet

IP Header	Payload Data

IP packets transport data on the Internet

Header contains:

- Source IP address (typically a computer)
- Destination IP address (typically a computer)
- Additional fields (version, header length, type of service, total length, time to live, etc.)

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UDP/IP Packet

IP Header	UDP Header	Payload Data

A UDP Packet is encapsulated within an IP packet to form a UDP/IP packet.

IP header ensures delivery on Internet

UDP Header contains:

- Source Port number
- Destination Port number
- Packet length
- Checksum

Nanometrics

TCP/IP Packet

IP Header	TCP Header	Payload Data

A TCP Packet is encapsulated within an IP packet to form a TCP/IP packet.

IP header ensures delivery on Internet

TCP Header contains:
- Source Port number
- Destination Port number
- Sequence number
- Acknowledgement number
- etc. (header length, window size, checksum, urgent pointer, options, etc.)

UDP/IP and TCP/IP Characteristics

	UDP/IP	TCP/IP
IP Network compatible?	Yes	Yes
Overhead	short header	long header and continuous acknowledgements
State	Connectionless	Connected with state
Error correction	No	Packet retransmission
Transmission timeout	No	Within seconds

TCP/IP for Satellite Networks

TCP/IP is poorly suited for satellite networks because:

- TCP/IP packet retransmission will fail. Retransmissions will time out during typical satellite outages (rainfades, solar eclipse).
- TCP/IP connections can corrupt and hang during satellite outages.
- TCP/IP generates a large amount of overhead data which wastes communications bandwidth.

NMXP/UDP/IP

IP Header	UDP Header	NMXP Packet

NMXP Header contains:
- Sequence Number

NMXP Protocol Features:
- Does not require acknowledgment (less overhead)
- Single retransmission request message for individual or blocks of packets (less overhead)
- Recovers corrupt/missing packets after >2 hour outage (appropriate for satellite networks)

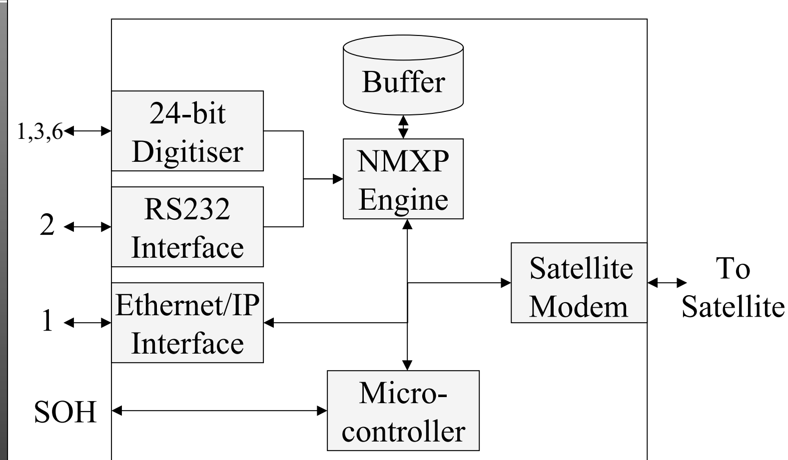
Nanometrics/UDP vs TCP/IP

	NMXP/UDP/IP	TCP/IP
IP Network compatible?	Yes	Yes
State	No	Connection link
Error correction	Progressive Retx within seconds, minutes and hours	Retx within seconds
Timeout	No	Within seconds

Note: NMXP/IP is connectionless, stateless, and has far less return traffic overhead than TCP/IP

Nanometrics

Libra IP Implementation



Nanometrics

Part 2 Planning the Network

- Selecting Network Sites
- Configuring Libra IP Connections
- Remote Station Data
- Multiplexing Network Data – TDMA
- Interpreting Your Satellite Lease
- Determining Satellite Radio Frequencies
- Setting Transmit Power Levels
- Aligning Satellite Antennas

Chapter 3 Selecting Network Sites

The first step in planning a Libra satellite seismograph network is selecting the hub and remote network sites. After the sites are chosen, the configuration of each can be defined.

3.1 Hub sites

A Libra network requires at least one hub site. The hub site gathers seismic data from the remote sites, and must therefore be able to communicate with all other sites. In contrast, the remote sites typically do not need to communicate with each other.

3.1.1 Selecting hub sites

In general, a hub site should be chosen which meets the following requirements:

- The site should allow easy access to the collected seismic data for analysis, typically via a LAN connection.
- The site should be secure. Libra network hubs use valuable satellite antennas and computer systems.
- The site should be easily accessed by maintenance personnel.
- The site should not be subjected to interfering radio signals which may be generated by strong local transmitters.
- The satellite antenna should have an unobstructed view of the entire satellite arc.
- The site civil works should address structural, electrical, and security issues.

3.1.2 Peer hubs

The Libra system can support peer hubs. In this configuration, each remote transmits new data once, and these transmissions are received by both hubs. Each hub can send retransmission requests independently to the remotes, and the remotes combine these requests to determine which data to retransmit. While both hubs can receive the data, only one hub is able to edit the configuration of the remote site equipment, and the second hub must be granted data access by way of a data “key”.

3.1.3 Keeping a record of hub site information

A sample worksheet has been provided to record information about your network hubs (Table 3-1 “Hub site list worksheet” on page 39). See Figure 3-1 for an example.

- Complete a copy of Table 3-1 using the values for your network hub(s).

Figure 3-1 Example network hub worksheet

Hub site reference	Hub name	Latitude	Longitude	Elevation
NMXH	Nanometrics head office hub	46:05N	77:20W	100m

3.2 Remote sites

The remote sites of a Libra network are the sites which include seismic or other environmental sensing equipment. These sites collect, digitise, and transmit data to the Libra hub(s). Transmission to the hub(s) is via an IP connection over satellite.

3.2.1 Selecting remote sites

A Libra network contains many remote sites, and the criteria for selecting these sites depends on seismic, technical, and administrative issues. Some of the key considerations are:

- Seismic sites should have good seismic properties, such as low noise (cultural, water body, wind), access to bedrock, and correct geographic dispersion.
- The sites should be relatively secure from large animals and vandalism. Security can be enhanced by erecting a fence around the site, or erecting equipment huts.
- Sites should have a reliable source of power, for example a solar power system.
- It should be possible to install the antenna dish such that it has an unobstructed view of the sky.

Sites can be added into the Libra network configuration and left “disabled” until they are commissioned.

3.2.2 Keeping a record of remote site information

A sample worksheet has been provided to record information about each of the remote sites for your network (Table 3-2 “Remote site list worksheet” on page 39). Complete the worksheet prior to installing the remote sites. See Figure 3-2 for an example.

Figure 3-2 Example remote site worksheet

Remote Site Reference	Site Name	Latitude	Longitude	Elevation
PER	Perth	44:40N	76:15W	125m
NBY	North Bay	46:13N	79:26W	177m

Figure 3-2 Example remote site worksheet (Continued)

Remote Site Reference	Site Name	Latitude	Longitude	Elevation
KNG	Kingston	44:15N	76:45W	75m
SUD	Sudbury	46:28N	81:00W	300m
THB	Thunder Bay	48:29N	88:52W	325m

3.3 Prepare site plans

Once the network sites have been selected, you can start to prepare a plan for each site, including, for example, equipment location and mounting, electrical power and grounding connections, and signal cable routing. Prior to installing the equipment and commissioning the site, you will need to prepare civil works in accordance with the site plan. This would include, for example, equipment vaults or huts, the antenna foundation, solar power platform, and cable conduits.

3.4 Form 1 – Site List

Use this form to record basic information about the hub and remote sites in a Libra network. See section 3.1 on page 35 and section 3.2 on page 36 for information on how to determine the values. The information on this form applies to one Libra network.

Table 3-1 Hub site list worksheet

Hub site reference	Hub name	Latitude	Longitude	Elevation

Table 3-2 Remote site list worksheet

Remote site reference	Site name	Latitude	Longitude	Elevation

Chapter 4 Configuring Libra IP Connections

Libra uses Internet Protocols (IP) for all of its network communications. Data are collected from the remote sites using the User Datagram Protocol (UDP/IP). Libra transceivers (Cygnus, Carina) communicate with the Nanometrics UI using Transfer Control Protocol (TCP/IP).

Using standard Internet protocols allows Libra to interface easily with infrastructures commonly found at customers' facilities. For example, data collected by the Libra network are output to the Naqs Server acquisition system as UDP/IP packets. This data can be carried to Naqs in the same building through a local LAN, or in a different country through the Internet. Similarly, analysis computers can access data from the Naqs Server ringbuffers via LAN or Internet connections. Nanometrics' customer service engineers can troubleshoot a Libra network connected to the Internet from the factory in Canada.

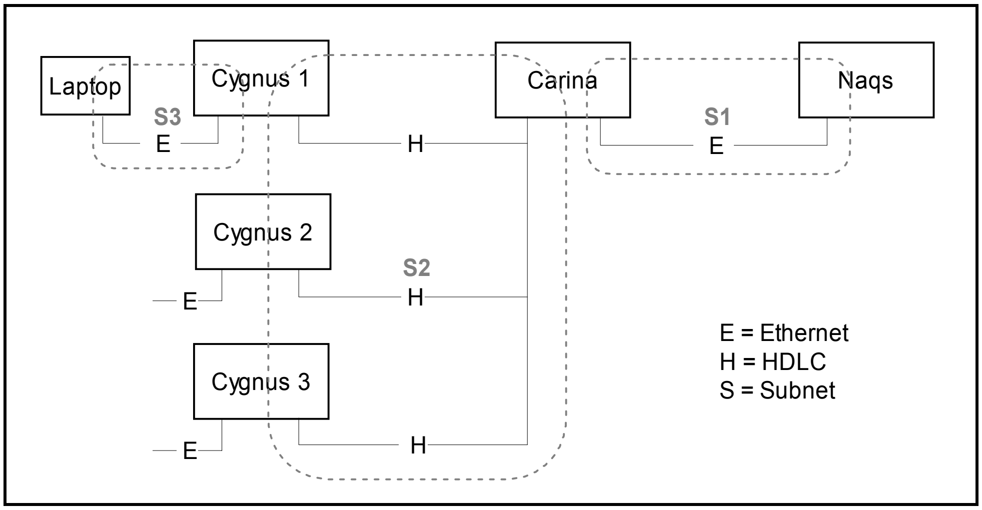
To understand the concepts behind Libra IP configuration, the reader should be familiar with the fundamental concepts of IP network configuration and routing. We strongly recommend that only users experienced in IP network configuration and operation determine a Libra network's IP configuration.

Caution Your Libra network can be reconfigured through IP links. To prevent malicious alteration of your network configuration or disruption of collected data, we recommend that you isolate the Libra hub systems from the Internet with a firewall or similar security measures.

4.1 Libra network IP connections

Figure 4-1 shows a simple star shaped Libra network diagram including a laptop used for Cygnus station configuration.

Figure 4-1 Example of a simple Libra network



Each remote Cygnus transceiver and each central site Carina VSAT modem has two network interfaces:

- An ethernet interface for communications with the acquisition and control computer (for example, a laptop computer at a Cygnus remote)
- The VSAT communications system

A simple Libra network includes three IP sub-networks:

- S1 – The central site sub-network for the Carina VSAT modems and acquisition computers.
- S2 – VSAT communications sub-network
- S3 – Cygnus LAN connection sub-network (this is the sub-network connected to the Cygnus remote site).

The first step in the IP configuration should be selecting the IP addresses of the three sub-networks. If the acquisition LAN is not connected to the Internet, the three sub-networks can be any valid IP sub-network addresses. When the system is connected to the Internet all three sub-networks should be unique in the world using addresses assigned by the Internet service provider.

For packet routing between adjacent sub-networks it is important to include the IP address of the connecting interface in the gateway list. IP packet routing between the central site sub-network and the VSAT communications sub-network is performed by the Carina Hub Transceiver. To route packets from the Naqs Server computer, or other computers on the central site sub-network (S1), the gateway list of the S1 subnetwork must includes the IP addresses of the ethernet interfaces of the Carinas. Similarly, to route packets from the VSAT sub-network S2 to the central sub-network S1, the IP addresses of the Carina-to-VSAT communications interface should be added to the gateway list of the S2 sub-network.

The configuration parameters of the Libra IP network fall into three categories:

- Parameters describing the LAN subnet (S1 for Carina and S3 for Cygnus)
- Parameters describing the VSAT communications subnet (S2)

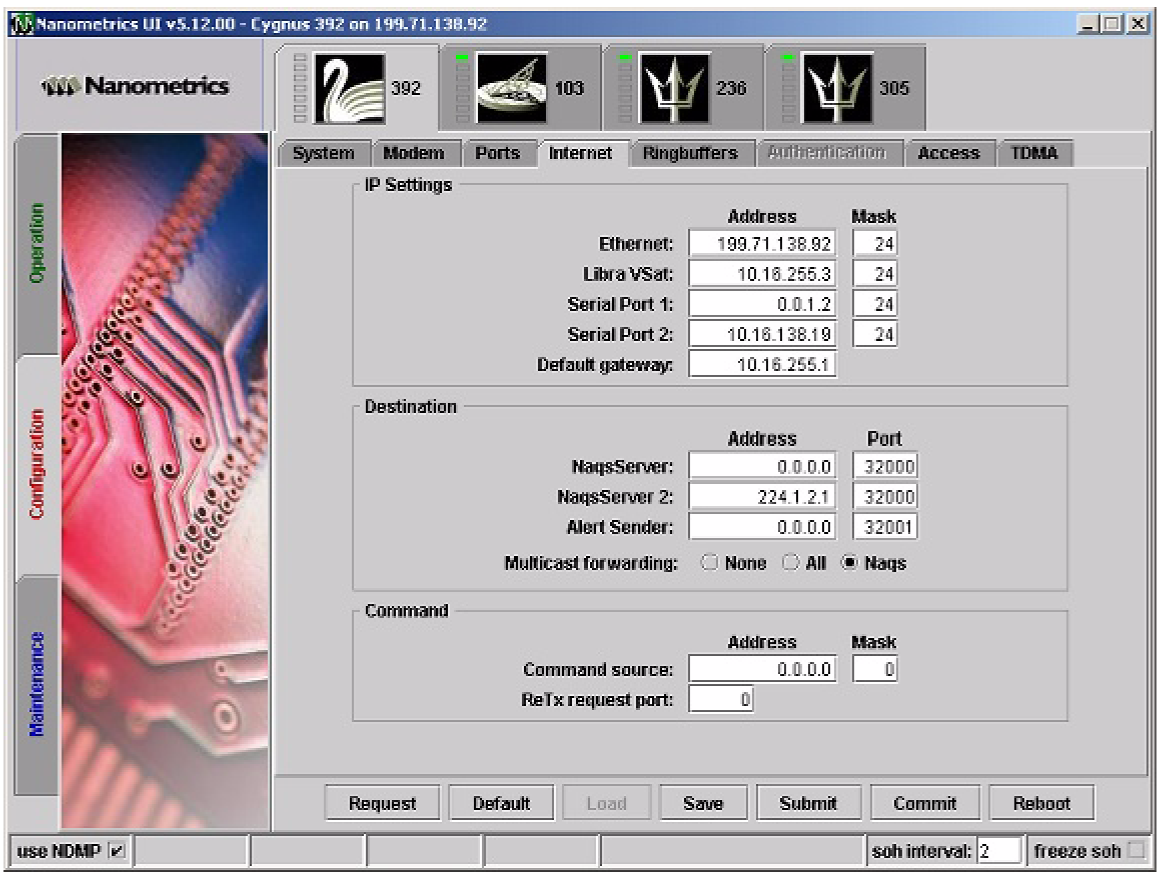
- IP parameters of applications which communicate with the Carina Hub and the Cygnus remotes (Naqs, Nanometrics UI)

  These parameters are: IP addresses and subnet masks assigned to each interface, port numbers for TCP and UDP sessions and applications, and gateway IP addresses for subnetworks.

4.2 Configuring your Libra network IP

Set the Libra network IP parameters for both the Carina and the Cygnus via the Nanometrics UI (Figure 4-2).

Figure 4-2 Configuration > Internet screen



The Libra IP parameters include:

- IP Settings:
  - IP address of the LAN interface of the Cygnus or Carina
  - IP address of the VSAT communications interface of the Cygnus or Carina
  - IP address of serial ports for IPoS, if applicable
  - Network masks, expressed as mask widths, of the LAN subnets at the central site (S3), remote sites (S1), and of the VSAT communications subnet (S2).

The mask width indicates the number of bits, starting at the left of the 32-bit IP address and working right, that are the defining bits for the mask. The remaining bits are not constrained. For example:

16 = 255.255.0.0

24 = 255.255.255.0

28 = 255.255.255.240

- Gateway for the LAN interface of the Carina Hub.

- Destination:
  - IP address of the acquisition computer(s)
  - IP address of the destination computer for alert messages
  - Port number for each of the inbound data links
  - Options for multicast forwarding

    Cygnus supports multicast of data and alert messages. Options are to either unicast data to one or more acquisition systems, or multicast data to a Naqs class address or to all multicast addresses in the network.
- Command:
  - IP address from which calibration commands are accepted
  - Network mask for the command source
  - Port number for the outbound data link(s)

4.2.1 IP configuration table

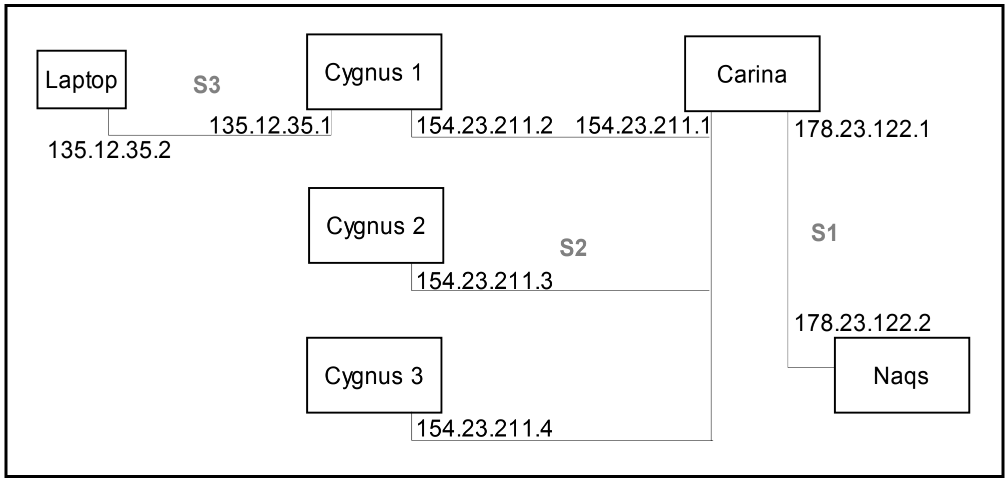
A sample worksheet has been provided for you to record information about the IP configuration of your network (Table 4-1 “Libra network IP configuration worksheet” on page 47). The worksheet is designed for a typical star network consisting of a single hub and a number of remote Cygnus stations. One column is included for each configurable parameter and one horizontal section for the hub and each remote station. See Figure 4-4 on page 45 for an example.

- Before configuring the Libra network, write all of the network IP information on a worksheet similar to Table 4-1.

4.2.2 IP configuration example

Figure 4-3 shows a simple Libra star network having 3 remote Cygnus stations and a single Carina Hub; Figure 4-4 show how IP addresses and routing are assigned in this example network.

Figure 4-3 Example of a three station star Libra network



The Naqs computer is set to IP address 178.23.122.2, subnet mask 255.255.255.0 (that is, width of 24), and gateway 178.23.122.1. If the network is connected to the Internet, the gateway to the Internet should be added to the routing table for the acquisition computer.

Figure 4-4 Example IP configuration worksheet

Carina Hub								
Carina Hub Reference		**IP Address**	**Subnet Mask**	**Gateway**	**Ports**			
					Naqs1	**Naqs2**	**Alert**	**ReTx**
HUB1	LAN Subnet	178.23.122.1	24	178.23.122.2				
	VSAT Subnet	154.23.211.1	24					
	Application	178.23.122.2	*	*	32000	32000	31000	22000
Cygnus Stations								
Cygnus Reference		**IP Address**		**Subnet Mask**	**Ports**			
					Naqs1	**Naqs2**	**Alert**	**ReTx**
STN01	LAN Subnet	135.12.35.1		24				
	VSAT Subnet	154.23.211.2		24				
	Application	178.23.122.2	255.255.255.0*	255.255.255.0*	32000	32000	31000	22000
STN02	LAN Subnet	135.12.35.3		24				
	VSAT Subnet	154.23.211.3		24				
	Application	178.23.122.2	255.255.255.0*	255.255.255.0*	32000	32000	31000	22000
STN03	LAN Subnet	135.12.35.4		24				
	VSAT Subnet	154.23.211.4		24				
	Application	178.23.122.2	255.255.255.0*	255.255.255.0*	32000	32000	31000	22000

* These parameters are configured under the network settings dialog box of the acquisition computer. All other parameters are configured via the Nanometrics UI.

4.3 Form 2 – IP Configuration

Use a form similar to this example to record the IP configuration information—such as IP addresses, gateway addresses, and port numbers—for the sites in a star-type Libra network. Use one copy of the form per Libra network.

Table 4-1 Libra network IP configuration worksheet

Carina Hub								
Carina Hub Reference		**IP Address**		**Subnet Mask**	**Ports**			
					Naqs1	**Naqs2**	**Alert**	**ReTx**
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
Cygnus Stations								
Cygnus Station Reference		**IP Address**		**Subnet Mask**	**Ports**			
					Naqs1	**Naqs2**	**Alert**	**ReTx**
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				

Table 4-1 Libra network IP configuration worksheet (Continued)

	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
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	LAN Subnet							
	VSAT Subnet							
	Application		*	*				
	LAN Subnet							
	VSAT Subnet							
	Application		*	*				

* These parameters are configured under the network settings dialog box of the acquisition computer. All other parameters are configured via the Nanometrics UI.

Chapter 5 Remote Station Data

Data traffic is generated at remote sites by the Cygnus and the associated Trident digitisers and sensors, and then packetized for transmission over the satellite link to the hub. This chapter provides an overview of the types of data generated at remote sites, how data are prepared for transmission, and the associated configuration parameters. See also Chapter 6, “Multiplexing Network Data – TDMA” for information on planning network data traffic.

5.1 Types of remote station data

In standard applications, the remote site instruments are configured to generate these types of data:

- Seismic samples
- Instrument SOH (for example, instrument internal temperatures)
- Satellite communications SOH (for example, number of good packets transmitted since the start of the current TDMA configuration)
- Log data

  Cygnus sends operation log information as log packets to the acquisition center. The verbosity of the logs can be set to various levels ranging from Fatal (low verbosity) to Debug (high verbosity). When set to a certain verbosity level, Cygnus will send only the messages with the configured and higher than the configured verbosity level. For normal operation we recommend setting the verbosity to Info level.

In customized applications, in addition to SOH and log data, the remote station instruments may be configured to collect any of these types of data:

- Other time-series environmental data, in addition to seismic samples
- Serial data (for example, GPS data)
- Analog data, via the external SOH channels (for example, a tamper switch)

In both standard and customized applications the packetized data are accumulated in the Cygnus transmit data ringbuffer, transmitted during the next TDMA slot, and retained in the ringbuffer for retransmission requests.

Time-series, serial, and SOH data are stored in ringbuffer files at the acquisition centre. The log data are stored in separate log files, with a new file created each day. Event data are processed and stored by Naqs at the acquisition computer. See also the NaqsServer manual.

Digitiser sample rate will have the largest effect on data traffic for any given remote site. See Chapter 6 for more information on selecting sample rate as it relates to assigning bandwidth within the satellite channel.

5.2 Cygnus communications control

The Cygnus Comms Controller board receives data from external instruments, and also generates instrument state-of-health (SOH) messages. The Comms Controller prepares these data it for transmission over the satellite link. A 12MB ringbuffer is available to store packets for retransmission.

Data received on the NMXbus and serial ports from Nanometrics digitisers (Trident and HRD) are in NMXP format. At the Comms Controller, the NMXP packets are embedded into UDP packets for transmission over IP. Data received from other devices are converted to NMXP format at the Comms Controller. SOH messages are formatted as NMXP packets and are sent to the Naqs server using UDP, and to the UI using TCP. Packets are passed to the L-band modem before being transmitted to the central site over the satellite link. (See the Nanometrics Data Formats manual for information on the NMXP data format.)

In addition to being transmitted to the central site, each NMXP packet is stored in the Comms Controller memory. The memory is a ringbuffer type in which the oldest packet is continuously overwritten by the newest one. If the data are not received at the central site by the Naqs data acquisition software, a request is generated for retransmission. On receipt of the retransmission request, the Comms Controller fetches the requested packet from its memory and queues it for transmission. Remote station transmit ringbuffers are configured in the Cygnus Configuration > Ringbuffers panel. Retransmission request is configured in Naqs.

5.3 Cygnus data ports

This section gives an overview of the Cygnus ports and channels that are used for most data acquisition applications. These include two NMXbus ports, two serial ports, and three user-configurable analog SOH channels. The Nanometrics UI provides options to configure some of the port and channel parameters.

Special applications, such as hybrid Libra–Callisto networks that use a Janus as a bridge, would use the Ethernet port. Cygnus also has a factory configuration port that can be used to monitor operation; see section C.1.1 “Using the configuration port” on page 165 for an overview, and step 3 of section 12.6.2 on page 136 for an example.

5.3.1 NMXbus ports

The two NMXbus ports are functionally equivalent. They provide power, time, and data communication means for Trident digitisers. The NMXbus ports do not require configuration; the ports are active when an instrument is connected, and automatically terminate the line when necessary. The NMXbus protocol provides error-correction for data from the Tridents.

Up to three Tridents can be connected to the two NMXbus ports on the Cygnus; multiple Tridents can be daisy-chained on one NMXbus port. Maximum cumulative data throughput using Trident digitisers is 3000 samples per second.

5.3.2 Serial ports

Cygnus has two serial ports. The typical setting for Cygnus is to have the serial ports disabled. Serial port parameters are set in the Configuration > Ports > Port <#> panel.

- If you are using the serial ports on the Cygnus with NMXbus for any reason, ensure that Port 1 is never set to NMXP Transmit.

Serial ports can be configured to operate in any of six modes, or can be set as unused. In practice, not all of the serial port modes apply to Libra networks (see Table 5-1). Basic configuration parameters for all modes include the serial port name, baud rate, and port timeout. Baud rates include all of the standard rates from 1.2–57.6 kbps. Additional parameters, such as data packet length and TDMA slot definition, depend on the mode (see also the Nanometrics UI manual).

Note TDMA configuration for serial ports refers to multiplexing data over a terrestrial radio link, for example a Callisto element in a hybrid Libra network.

Table 5-1 Serial port configuration options

Option	Description
Unused	The port is not enabled. This is the typical configuration for Cygnus.
NMXP Receive	Receives NMXP data packets, typically from a Nanometrics digitiser or possibly from another Nanometrics communications unit, and transmits command packets back to the digitiser or unit.
NMXP Transmit	Do not use this serial port configuration for Cygnus. (Transmits data in NMXP packets, and receives command packets from NaqsServer. Only one port at a time may be configured in this mode.)
Serial Receive	Receives serial data in any format from a device, for transparent relay to the acquisition centre. The Comms Controller packetizes the data as NMXP packets, then prepares the packetized data for transmission. The data are stored in a serial data ringbuffer at the acquisition centre, for extraction using Data Playback utilities.
Interactive	Allows you to communicate via a Telnet session with a device that is connected to the serial port. This would be used, for example, to manage configuration of the data source device.
Console	Allows you to monitor the Comms Controller operation. Connection to the Cygnus is via a test cable (see also section C.1.1 “Using the configuration port” on page 165).
IP	The IP over Serial (IPoS) setting allows the serial port to be used as a network interface running the Serial Line IP protocol (SLIP).

5.3.3 External SOH channels

The three external SOH channels can be used to monitor voltages from analog devices (for example, a meteorological sensor with analog output, a vault tamper switch). There are two parameters that need to be set to calibrate an external SOH channel: scale calibration and offset. Both the calibration factor and offset parameters are set in the Configuration > System > External SOH Calibration panel:

- The scale calibration factor is built from two constants:
  - One constant is the sensitivity of the sensor. This might be expressed as "units" per volt. For example, with a temperature sensor, this might be set to 44 degrees Celsius per volt.
  - The other constant is the actual sensitivity of the ADC, which is a factory setting. (To report the actual voltage on the connector use 0.1, 0.5, and 0.5 respectively for SOH channels 1, 2, and 3.)
- The offset is used to allow for the sensor not producing zero output volts when registering zero sensor measurement units. The offset is expressed in units appropriate to the sensor. For example, for a temperature sensor, the offset is expressed in degrees Celsius.

5.4 Instrument and environmental SOH

The Cygnus monitors a number of non-configurable (fixed) instrument and environmental SOH parameters. Of these SOH parameters:

- Input supply voltage, transmit frequency calibration, and internal temperatures for the modem and Comms Controller boards, are derived from internal SOH channels.
- SSPB temperature is measured by the SSPB temperature sensor.
- The remaining fixed SOH parameters, such as time quality and NMXbus transmission statistics, are derived from various instrument sources and managed by the Comms Controller.

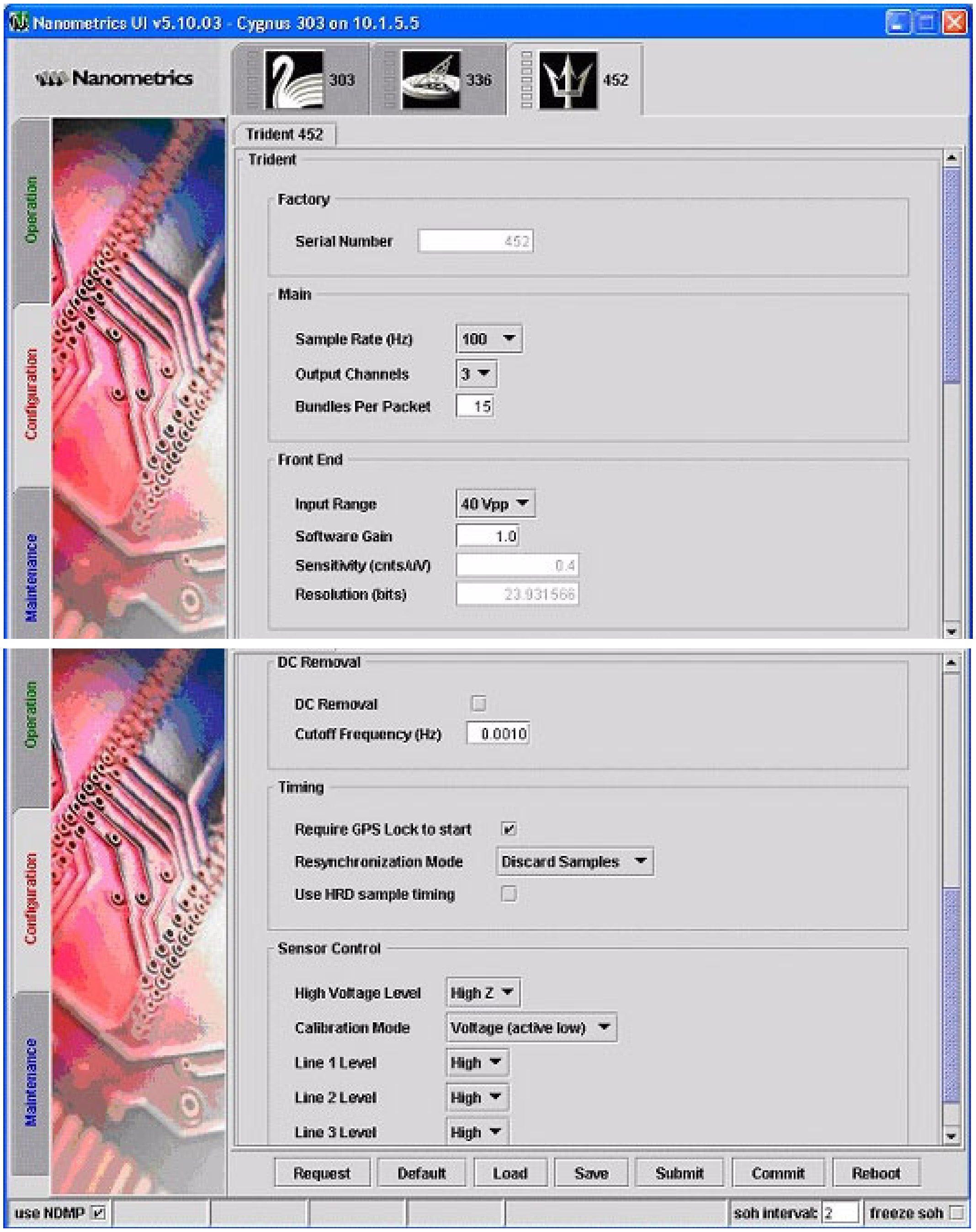
You can manage and view instrument and environmental SOH using various utilities:

- Select the reporting rate for SOH data to Naqs (Report interval) and the packet size (Configuration > System > SOH Report to Naqs panel).
- Select the reporting rate and packet size for TimeServer SOH data to the Comms Controller (TimeServer > Configuration > SOH Report panel).
- Select the refresh rate to the Nanometrics UI (soh interval in the main window).
- Monitor SOH status in real time (under the Operation tab for the instrument).
- View and plot current and historical SOH information in detail, using NaqsView (a NaqsClient utility).

5.5 Digitiser configuration

The digitiser is configured through options in the Trident > Configuration panel (Figure 5-1). See also the Trident manual, and section 6.2.2.1 “Determining the baseline seismic data rate” on page 62.

Figure 5-1 Trident > Configuration screen



5.6 Form 3 – Station Data Configuration

Use a form similar to this example to record the station data information—such as SOH reporting and digitiser sample rates—as applicable for each of the sites in the network. The parameters included in table cells with grey background are factory configured and should not be changed.

Table 5-2 Station data configuration (Cygnus)

Station name				
Cygnus serial number				
External SOH channel calibration	External SOH 1	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
	External SOH 2	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
	External SOH 3	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
Log verbosity	(Set this value in Naqs)		-	
SOH updates	Cygnus SOH report interval to Naqs		seconds	
	Cygnus SOH packet size		bundles/pkt	
	TimeServer SOH report interval to Cygnus		seconds	
	TimeServer SOH packet size		bundles/pkt	
Serial port settings	Port name		-	
	Port type		-	
	Baud rate		bits per second	
	Port timeout		bits per second	
	Packet length		bytes	
	Send timeout		milliseconds	
	Bundles per packet		-	
	Command port		-	
	Telnet port		-	
	Telnet password		-	
	TDMA frame		milliseconds	
	TDMA slot duration		percent	
	TDMA slot start		percent	
	Retransmission request (set in NaqsServer)		-	

Table 5-3 Station data configuration (Trident)

Trident serial number			
Main	Sample rate	samples per second	
	Output channels	-	
	Bundles per packet	-	
Front end	Input range	volts peak-to-peak	
	Software gain	-	
DC removal	DC removal	-	
	Cutoff frequency	hertz	
Timing	Require GPS lock to start	-	
	Resynchronization mode	-	
	Use HRD sample timing	-	
Sensor control	High voltage level	-	
	Calibration mode	-	
	Line 1 level	-	
	Line 2 level	-	
	Line 3 level	-	

Table 5-4 Station data configuration (Trident)

Trident serial number			
Main	Sample rate	samples per second	
	Output channels	-	
	Bundles per packet	-	
Front end	Input range	volts peak-to-peak	
	Software gain	-	
DC removal	DC removal	-	
	Cutoff frequency	hertz	
Timing	Require GPS lock to start	-	
	Resynchronization mode	-	
	Use HRD sample timing	-	
Sensor control	High voltage level	-	
	Calibration mode	-	
	Line 1 level	-	
	Line 2 level	-	
	Line 3 level	-	

Table 5-5 Station data configuration (Carina)

Station name				
Carina serial number				
External SOH channel calibration	External SOH 1	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
	External SOH 2	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
	External SOH 3	Label	characters	
		Units	-	
		Sensitivity	(units/volt)	
		Offset	(units)	
Log verbosity	(Set this value in Naqs)		-	
SOH updates	Cygnus SOH report interval to Naqs		seconds	
	Cygnus SOH packet size		bundles/pkt	
	TimeServer SOH report interval to Cygnus		seconds	
	TimeServer SOH packet size		bundles/pkt	
Serial port settings	Port name		-	
	Port type		-	
	Baud rate		bits per second	
	Port timeout		bits per second	
	Packet length		bytes	
	Send timeout		milliseconds	
	Bundles per packet		-	
	Command port		-	
	Telnet port		-	
	Telnet password		-	
	TDMA frame		milliseconds	
	TDMA slot duration		percent	
	TDMA slot start		percent	
	Retransmission request (set in NaqsServer)		-	

Chapter 6 Multiplexing Network Data – TDMA

A Libra network gathers data from several remote sites over a single, shared satellite channel, and uses this same channel to transmit messages from the hub to the remotes (for example, retransmission requests). The method that is used to multiplex the station data is called Time Division Multiple Access (TDMA).

6.1 Overview of TDMA

In a Time Division Multiple Access (TDMA) network, each station transmits during a precisely defined time window, or slot. The sequence of slots which includes one transmission for each network station is called a frame. This frame cycles repeatedly, giving each station an opportunity to transmit a burst of data every few seconds. TDMA frames change only when new sites are added to a network, or when existing sites are reconfigured. The epoch is the period of time when the TDMA frame remains unchanged.

The basic TDMA terms are:

Slot	The window in time when a Libra station is permitted to transmit. Every Cygnus remote and Carina Hub is assigned one slot. The Carina assigns a slot duration for each station based on the required data throughput for the station.
Frame	One cycle of slots which allows each Libra station to transmit once. Typical Libra configurations use frames of 5 to 10 seconds, containing up to 16 slots. The frame pattern is repeated continuously, giving each site an opportunity to transmit every 5 to 10 seconds.
Epoch	The time period during which all TDMA frames are identical. Libra TDMA epochs typically last a few minutes. Changes to the TDMA configuration are made for the next epoch, giving the network enough time to transmit these changes to all remotes. At the beginning of an epoch, all remotes must have the same TDMA configuration to prevent transmission collisions.

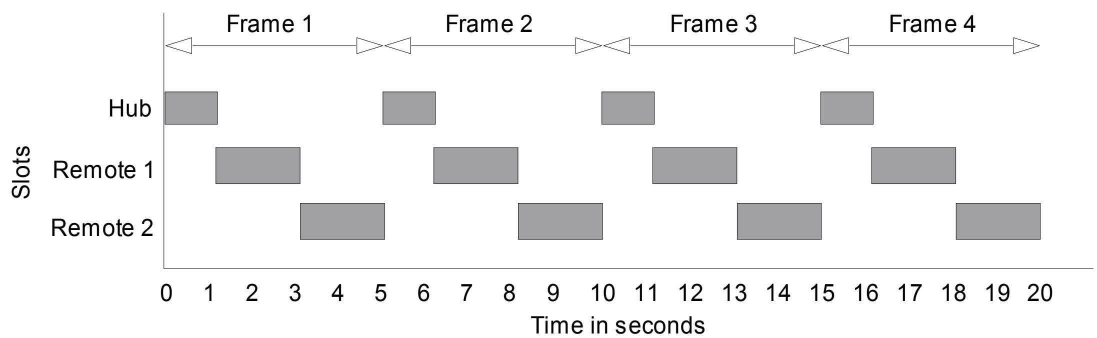
For example, a Libra seismic network with 1 hub and 2 remote sites might have the frame defined as:

- Hub transmits for 1 second, then
- Remote 1 transmits for 2 seconds, then
- Remote 2 transmits for 2 seconds

Therefore, the total frame is 5 seconds long. Figure 6-1 illustrates the TDMA configuration for this example.

Figure 6-1 Example of a simple TDMA configuration

A) Transmission timing diagram:



B) TDMA configuration:

Frame #	Slot #	Which site transmits?	Which site receives?
1	1	Hub	All remotes
	2	Remote 1	Hub
	3	Remote 2	Hub
2	1	Hub	All remotes
	2	Remote 1	Hub
	3	Remote 2	Hub
3	1	Hub	All remotes
	2	Remote 1	Hub
	3	Remote 2	Hub

6.2 TDMA in Libra networks

For a Libra network, a network administrator programs the TDMA configuration for the entire network into the Carina Hub, which transmits this configuration to all network remotes. This centralized control of the network configuration allows the network administrator to fine-tune the TDMA for network optimization.

After the network is installed and operating, the TDMA can be optimized by reassigning bandwidth to each station. For example, a seismically noisy remote site will have less seismic data compression, and will generate larger volumes of data. The network administrator can observe this through the data channel SOH, and assign additional data bandwidth to this remote from the network hub.

Configuring TDMA access for Libra network sites involves choosing values for these parameters:

- Frame length, or duration
- Slot data capacity for each station

Once these are chosen, define secondary parameters, including:

- Epoch duration
- Slot guard time
- Lock duration
- Security keys

6.2.1 Latency: Selecting the frame duration

Latency refers to the time delay between the sample instant and the sample acquisition by Naqs. Typical Libra TDMA configurations will have between 1 and 10 seconds of latency for the initial data transmissions, which is acceptable for the majority of network applications. The Libra TDMA frame length is the greatest contributor to this latency.

The first Libra TDMA parameter to determine is frame length, or frame duration. Frame duration is the time period in which all Libra sites are given one chance to transmit to the satellite. For most applications, Libra networks should be configured with a frame duration of 10 seconds.

The seismic sample is stored in the Cygnus transmit data buffer until the next transmission slot. If the network uses 10-second frames, samples could be stored in the buffer for up to 10 seconds. Once the data is transmitted, the radio signals require an additional 250 milliseconds to propagate to the satellite and back down to earth. These suggest a worst-case latency of 10.250 seconds, and an average latency of approximately 5 seconds.

Some applications such as “Rapid earthquake determination networks” may require lower latency. This can be achieved with some loss of efficiency. As slot length decreases, the seismic data content decreases but overhead times for equipment setup, demodulator lock, and packet synchronization remain constant, resulting in decreased efficiency. For this reason we recommend slot durations greater than 1 second for most network applications.

Latency will be affected occasionally by factors such as large events and meteorological conditions. Under these types of conditions, latency slot capacity is more of a factor than frame length:

- Latency can be caused by large seismic events with reduced data compression, or severe precipitation or solar outages which temporarily disrupt satellite communications. In both cases remotes collect data faster than it can be transmitted, and a data backlog forms in the buffer. The time required to transmit this backlog of data depends on the surplus data bandwidth assigned to the remote. (See also Chapter 5, “Remote Station Data”.)
- Latency will also be affected by the weather. In clear sky conditions the satellite link bit error rate (BER) will be very low, and almost all packets will be accepted during the first transmission. During rainfades the error rate rises, and some pack-

ets will contain bit errors. These packets will be re-requested by Naqs, and will be retransmitted during subsequent frames.

6.2.2 Data bandwidth: Assigning slot capacities

The most important TDMA parameter is the slot capacity, or data throughput, for each site in the network. This one variable affects your network's reliability, efficiency, and TDMA structure.

The purpose of the slot is to allow seismic data to be transferred from the remote site to the network hub. Obviously the rate of data transfer must exceed the rate of data collection, but optimizing this bandwidth requires careful consideration. Excess bandwidth is inefficient, and wastes the satellite link capacity. Insufficient bandwidth can cause data loss or extreme latency.

This section explains how to select an optimal slot capacity for your network application, and is divided into two discussions:

- determining the baseline seismic data throughput
- determining the required satellite channel capacity

6.2.2.1 Determining the baseline seismic data rate

Libra networks are typically configured for 100 sps, 3 channel, 24-bit seismic data sampling with first-difference non-approximating data compression. This stream of samples constitutes the vast majority of the inbound datastream. For the purpose of determining the data rate, other inbound data streams, such as SOH, can be ignored. Libra systems transfer data synchronously, using 8-bit bytes.

A 3 ch, 100 sps digitiser will generate 300 samples each second. Uncompressed samples will occupy 24 bits, or 4 bytes each. The compression algorithm will reduce the number of bytes per sample to 2 or 1 depending on the frequency and amplitude of the seismic signal—quiet sites will often have 1 byte samples, while noisy sites will often have 2 byte samples. Experience indicates that an average compression of 1.2 bytes per sample is achieved in typical remote sites (this value is used for the examples in this manual). Seismically noisy sites will achieve less compression, and require higher data bandwidths.

A typical Libra remote site therefore generates an average of 2880 bits of compressed seismic data each second.

This data is packetized before transmission, which adds addresses, CRC codes and other overheads. We recommend allocating 25% of additional data capacity for these overheads, which is a conservative estimate to ensure reliability. This suggests a baseline average data rate of approximately 3600 bps for 3 ch, 100 sps, compressed and packetized data.

6.2.2.2 Choosing the TDMA data throughput

If the baseline data rate is 3600 bps, the satellite channel throughput should be approximately 6000 bps. This additional bandwidth is required to recover from data backlogs which arise from large seismic events, extreme rainfades and solar eclipse of the satellite. Table 6-1 illustrates this requirement. During a large event the digitiser may generate 20 seconds of 4-byte uncompressed data, which temporarily exceeds the allocated satellite throughput. The excess data is buffered by the Cygnus. If we assume that the seismic data rate returns to 1.2 bytes/sample following the event, we can calculate that the Cygnus will transmit all backlogged information and continue transmitting new samples during the 50 seconds following the event.

Table 6-1 Data recovery time*

Average digitiser output rate (3ch, 100sps) (kbps)	TDMA data throughput (kbps)	20 second event recovery time (s)	10 minute rainfade recovery time (min)
3.6	4	400	90
3.6	5	100	26
3.6	6	50	15
3.6	7	29	11
3.6	8	18	8
3.6	9	11	7
3.6	10	6	6

* Time to recover all accumulated data following a large seismic event (20 seconds of uncompressed data) or a 10 minute communications outage, for given output and throughput.

A similar situation occurs when the communications channel is temporarily disrupted by extreme rainfade or solar eclipse of the satellite. In these cases, all seismic data is buffered during the outages which typically last several minutes. As an example, a 3ch 100sps Cygnus which achieves typical 1.2 byte compression would require 15 minutes to recover all backlogged and new data following a 10-minute outage.

We recommend allocating a minimum of 6000bps satellite channel throughput for each 3ch, 100sps digitiser.

6.2.2.3 Allocating bandwidth in smaller networks

If your 64kbps network has fewer than 8 remote sites, or if your 112kbps network has fewer than 16 remotes, configuring each site for 6000bps will leave unused bandwidth. If this bandwidth is shared among existing remotes, the network will operate more effectively. Use the Nanometrics UI to enter the data throughput for each remote site; it will then calculate the required slot duration.

Table 6-2 Recommended throughputs for 64kbps networks with 10s frames

# Remote Sites	Hub data throughput (bps)	Remote site data throughput (bps)
1	4800	62272
2	5120	30912
3	5440	20459
4	5760	15232

Table 6-2 Recommended throughputs for 64kbps networks with 10s frames (Continued)

# Remote Sites	Hub data throughput (bps)	Remote site data throughput (bps)
5	6080	12096
6	6400	10005
7	6720	8512
8	7040	7392

Table 6-3 Recommended throughputs for 112kbps networks with 10s frames

# Remote Sites	Hub data throughput (bps)	Remote site data throughput (bps)
1	4800	108976
2	5120	54096
3	5440	35803
4	5760	26656
5	6080	21168
6	6400	17509
7	6720	14896
8	7040	12936
9	7360	11412
10	7680	10192
11	8000	9194
12	8320	8363
13	8640	7659
14	8960	7056
15	9280	6533
16	9600	6076

6.2.3 Epoch duration

In a Libra TDMA network, an epoch is the period of time during which the TDMA configuration remains constant. Epochs are important when editing the TDMA configuration: If remotes in a network have conflicting TDMA configurations they could transmit simultaneously, causing data collisions, loss of data, and excess satellite channel power. For this reason, changes to a Libra network TDMA configuration are made in advance and transmitted several times to ensure that all remotes have received and prepared for the new TDMA configuration.

Libra TDMA epochs are defined by the number of frames they contain. Epoch lengths of 10–400 frames are typical, giving an epoch duration range of 1 minute to 1 hour using typical 10-second frames. Epoch length can be reduced during network installation to allow frequent TDMA changes, but should be long enough to allow editing and confirmation before the end of each epoch. Any changes which are not committed to the Cygnus flash before the end of an epoch will not be submitted to the network.

6.2.4 Slot guard time

The slot guard time is the time in milliseconds between two slots. This is used to ensure that there is no data transmission overlap between the current and the subsequent slot.

6.2.5 Lock duration

During the lock duration, the hub does not accept any updates in the TDMA configuration submitted by any client. This is to ensure that each remote station has received the same updated TDMA configuration before it becomes active as the current TDMA configuration.

The lock duration is configured at the hub. It is the product of the Frame duration (in milliseconds) and the value entered in the Lock duration field (in number of frames).

6.2.6 Security keys

Security keys are used to prevent other networks from monitoring your network data without your permission. They are sent to each remote site by the Carina Hub, and used by the Cygnus transceivers to prepare their data transmissions. Any Carina Hub wishing to receive those packets must be programmed with the key; all packets with inappropriate keys will be discarded by the receiving Carina Hub. Each remote can be assigned a unique key by the network operator.

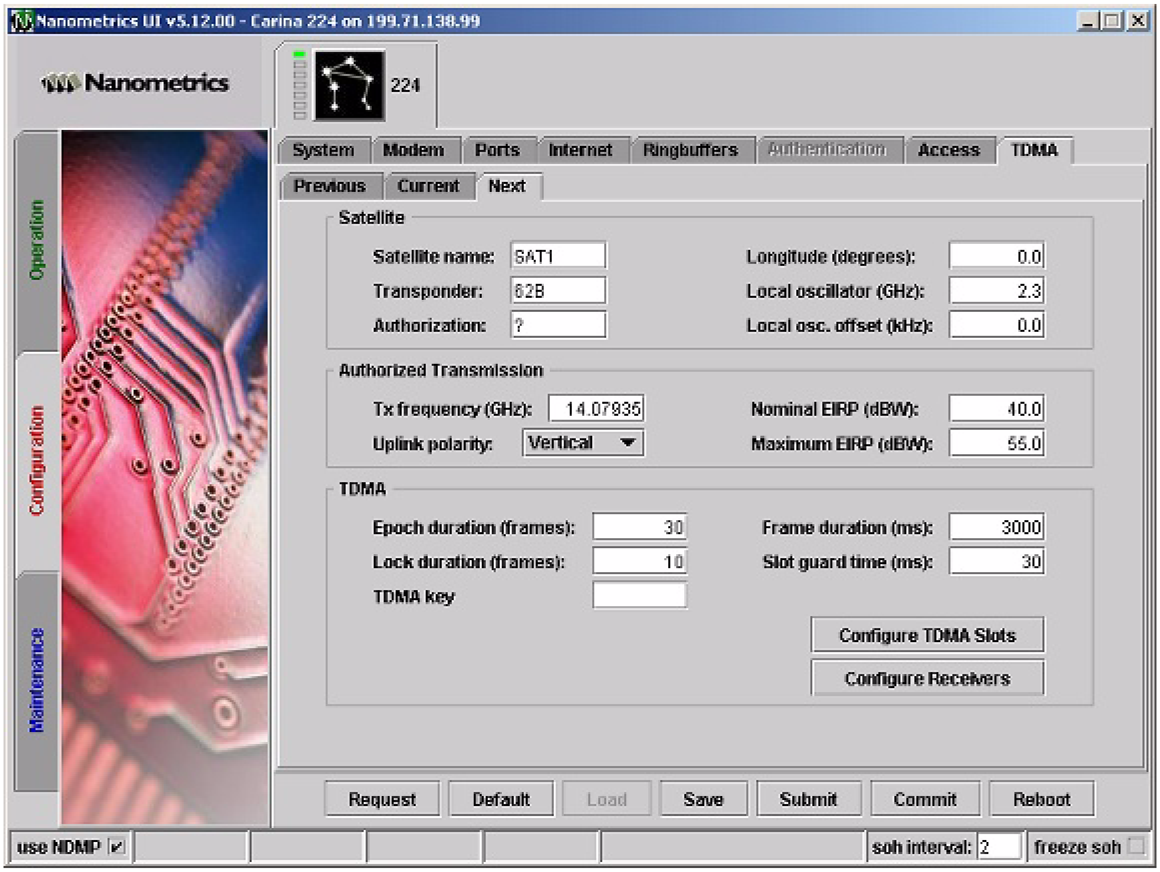
If the network operator wishes to share data with another network, they can provide the keys for the shared sites, to allow that network to receive the transmissions.

6.3 Configuring your Libra network TDMA

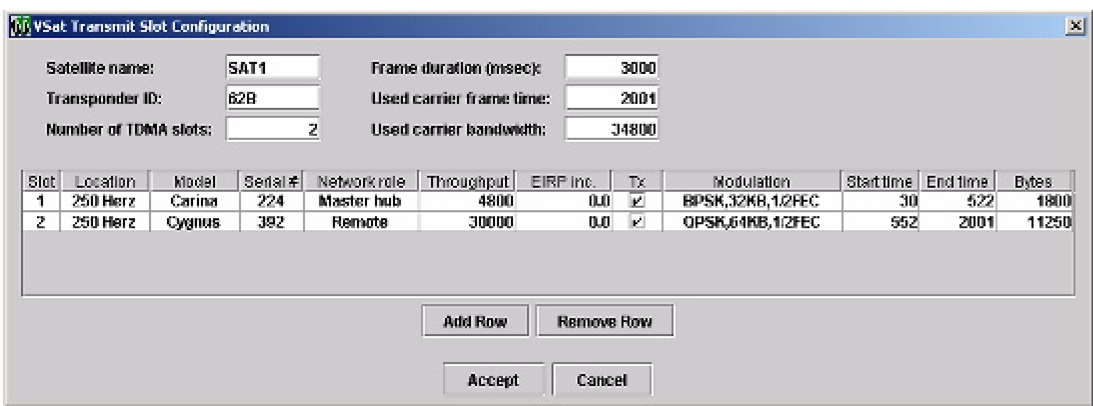
Set the Libra network TDMA configuration via the Nanometrics UI (Figure 6-2).

- Primary parameters:
  - Frame duration (Configuration > TDMA > Create Next TDMA)
  - Slot capacities (Configuration > TDMA > Create next TDMA > Configure TDMA Slots).
- Set the additional parameters after setting frame duration and slot capacities (Configuration > TDMA > Create Next TDMA)
  - Epoch duration
  - Lock duration
  - Slot guard time
  - TDMA key

Figure 6-2 Configuration > TDMA > Create Next TDMA



✧ Configure TDMA slots



6.4 Form 4 – TDMA Configuration

Use a form similar to this example to record the TDMA configuration information for the network and each of the network sites.

Table 6-4 Network configuration details

Parameter	Value	Units
Frame duration		ms
Slot Guard time		ms
Epoch duration		frames
Config locked interval		frames

Table 6-5 Site configuration details

Site Name	Hub or VSAT?	Slot #	Security Key	Site Location	Data Throughput (bps)	Enabled (yes/no)	Modulation: Bitrate (kbps)/ Modulation/ FEC (e.g., 64/QPSK/1/2)
		1					
		2					
		3					
		4					
		5					
		6					
		7					
		8					
		9					
		10					
		11					
		12					
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					

Chapter 7 Interpreting Your Satellite Lease

7.1 What is a satellite lease?

A satellite lease is a contract between the Libra network owner and a satellite provider. Satellite leases generally define:

- The satellite service being purchased
- The responsibilities of the satellite provider
- The responsibilities of the network operator
- The cost of the satellite services

7.1.1 The satellite service

The satellite service is purchased by the Libra network operator, from the satellite provider. In most cases the service will consist of the use of a 100 kHz fraction of a satellite transponder for a private VSAT network.

Note In some cases the satellite provider may prefer selling a service by specifying modulation technique and data rate (for example, 64 kbps BPSK). Be cautious: satellite operators may base these rates on older, less efficient modulation techniques that occupy large amounts of satellite capacity. This can be expensive.

Libra uses very efficient modulation techniques which can carry large amounts of data in a small amount of transponder capacity. For example, a conventional “64 kbps BPSK” network may occupy as much satellite transponder capacity as two Libra 112 kbps QPSK networks.

The two technical parameters which define the transponder utilization are bandwidth and power:

- Bandwidth typically will be 100 kHz for each carrier.
- Power will depend on the power of the satellite and will dictate antenna size. High-powered satellites allow small earth station antennas.

7.1.2 Responsibilities of the satellite provider

The satellite provider may be the company which owns and operates the satellite, its local representative, or a company which has leased a transponder and is reselling small amounts of capacity to various network operators.

Regardless of which type of satellite provider you use it will have similar responsibilities, including to:

- Ensure that other satellite traffic does not interfere with the operation of your network
- Ensure that your satellite traffic does not interfere with the operation of other networks
- Ensure that the various satellite networks don't interfere with each other. They accomplish this by controlling their transmission frequencies and transmit power levels. In some cases the satellite provider will want the ability to shut down the satellite network transmitters from their facilities, and this can be achieved via Internet access to the Libra hub station systems.
- Ensure availability of space segment, should the satellite systems malfunction:
  - Under all circumstances (non pre-emptible lease)

    A non pre-emptible lease makes the satellite provider responsible for providing replacement space segment.
  - Under normal circumstances (pre-emptible lease)

    A pre-emptible lease allows the satellite provider to discontinue access to the satellite.

In addition, some satellite providers may also take responsibility to:

- Ensure that your network will function correctly on its satellite.
- Confirm that your transmission quality requirements (C/N ratio) are met when your antenna systems are combined with the characteristics of their satellite. (Satellite operators coordinate traffic on their satellite and adjacent satellites to minimize interference sources.)

7.1.3 Responsibilities of the network operator

The network operator is the customer who is using the satellite and paying the satellite provider for this service; for example, a Libra network operator. The satellite provider will generally hold the network operator responsible for the following:

- Maintaining transmit power levels and frequencies within strict limits.

  This is a very important requirement, with power limits of +/–1dB and frequency limits of +/–2kHz being common. Libra meets Intelsat Gx requirements, which satisfy these limits.
- Implementing methods to shut down any equipment which violates these limits.

  Most satellite providers require both that the systems automatically stop transmissions if equipment alarms indicate power or frequency errors, and that there is a method to shut down any VSAT station manually from the central station. Libra satisfies both these requirements.

- Providing a telephone contact, available 24 hours a day, for technical inquiries. The satellite provider may reserve the right to call the network at any time, day or night, with inquiries about the network operation.
- Informing the satellite provider any time a carrier is added to or removed from the network.

  Satellite operators must monitor transponder traffic closely to prevent interference between networks.

7.1.4 Cost of the satellite services

A satellite provider will charge for most services that they offer. Some examples are:

- Satellite capacity:

  The cost of accessing 100 kHz of transponder bandwidth costs approximately US$5500 for a 1 year lease (Intelsat example). Lease rates are generally lowest for long-term leases (for example, over 15 years) and larger bandwidths. These Intelsat rates do not include administration charges, which are generally below 15% each year.
- Non pre-emptible lease:

  Most satellite providers will charge more for a non pre-emptible lease than for a pre-emptible lease.
- Network monitoring services:

  In some cases the satellite provider may offer to have their engineers monitor the systems, but generally this is not needed. The Libra network was designed to be monitored easily from the central hub station using Nanometrics UI software. The Libra training courses show technical and non-technical users how to monitor the system to ensure that it operates within the limits of the satellite lease.
- Installation services:

  Some satellite providers offer complete services involving VSAT equipment sales, network planning, installation, commissioning, and operation. Unfortunately these companies have little or no knowledge of seismic networks, and for this reason may not be qualified to select and prepare a site which has exacting seismic requirements.

  Nanometrics has designed the Libra system such that it can be installed and operated by university and government laboratories. Typically, Nanometrics engineers will install the central Carina Hub and a number of remote stations. The customers engineers can then continue the installation process.

7.2 Applying the satellite lease information to your network

Refer to your satellite lease for the information you need to configure your network (or sub-network) components to communicate with the satellites. Record the information from your satellite lease in a table (for example, Figure 7-1), and use this information when completing the sub-network configuration tables (for example, section 7.3 “Form 5 – Satellite Lease” on page 75).

Figure 7-1 Example sub-networks worksheet

Hub site reference	Sub-network 1	Sub-network 2	Sub-network 3	Sub-network 4
Network name (or sub-network name)	Carrier 1	Carrier 2		
Satellite name	ANIK E1	ANIK E1		
Authorization number	ABC123	DEF456		
Transponder	10	10		
Satellite longitude	111.1W	111.1W		
Uplink polarization	Vertical	Vertical		
Satellite local oscillator (GHz)	2.3	2.3		
Satellite local oscillator Offset (kHz)	0	0		
Uplink carrier center frequency (MHz)	14,128.100	14,128.200		
Uplink carrier EIRP (dBW)	41	41		
Uplink max EIRP (dBW)	43	43		
Modulation	QPSK, 112kbps	QPSK, 112kbps		

7.2.1 Network name

A Libra satellite network consists of a number of Cygnus remote stations and a Carina transceiver which share a single 100kHz satellite channel. As a seismic network grows and more remotes are added, this satellite channel will fill up, and a second satellite channel will be added.

The Cygnus remotes and Carina Transceiver using this second channel are considered a new “seismic sub-network” because they function independently of the initial Cygnus remotes and Carina Hub.

A standard Nanometrics digital seismograph network is factory-configured to support up to 4, 100kHz satellite channels, but this can be expanded to meet any user requirement. Each 100kHz sub-network should be given a unique name that is descriptive of your specific network. Some examples of naming conventions are:

- Carrier 1 and Carrier 2 (these identify the data carriers on the satellite)
- East zone and West zone
- Seismic and Seismic + GPS
- C-Band and Ku-Band

7.2.2 Satellite name

This name identifies the satellite used by your network. Some satellite providers operate several satellites, and in such cases this name should identify one satellite only.

7.2.3 Authorization number

Satellite contracts often include an Authorization Number. This is used to identify the Libra network to the satellite provider, for example when preparing for antenna alignment tests.

7.2.4 Transponder

Each satellite is divided into repeater units called transponders. Transponders are identified with a number or alphanumeric name.

7.2.5 Satellite longitude

Geostationary communications satellites are positioned in a ring above the equator, where their orbit matches the earth's 24 hour rotation period. This keeps the satellite stationary when viewed from the earth, and allows earth stations to use simple, non-tracking antennas. Since satellites are located above a fixed point on the equator, their position is described by the Longitude of this point.

7.2.6 Uplink polarization

Satellite transmissions are polarized, such that the electrical waves oscillate in either the horizontal or the vertical plane (for a linearly polarized transponder). Polarized satellite transponders receive on one polarization and transmit on the other to minimize interference between links. For example, a vertical uplink would be combined with a horizontal downlink.

7.2.7 Satellite local oscillator

The satellite acts as a radio repeater; it retransmits to earth whatever was transmitted up to it. The only intentional change in the downlink signal is a frequency change; the downlink is translated to a slightly lower frequency range to prevent interference between received and transmitted signals.

The frequency difference between uplink and downlink signals is dictated by the satellite local oscillator frequency, which is typically in the range of 1750 MHz to 3000 MHz. If your satellite lease doesn't specify this frequency, subtract your downlink frequency from your uplink frequency.

7.2.8 Satellite local oscillator offset

Satellite LO offset is the frequency error in the satellite local oscillator frequency. It is used by Libra to predict the exact downlink frequency. If the satellite oscillator is nominally 2800 MHz but is measured to be 2800.047 MHz, then the satellite local oscillator offset is 47 kHz. In practice most modern satellites maintain this offset between +20 and –20 kHz, and offsets this low do not affect a Libra network.

- If the satellite LO offset is above 25 kHz, include it in the Libra network configuration.

7.2.9 Uplink carrier center frequency

Caution Configuring an incorrect uplink carrier center frequency may cause the Libra system to interfere with other users of the satellite. This will violate the terms of the satellite lease contract.

Uplink carrier center frequency is the frequency of the center of the transmitted carrier. For example, if a single-carrier network has one 100 kHz satellite channel from 14117.100 to 14117.200 MHz, the Uplink carrier center frequency would be 14117.150 MHz.

7.2.10 Uplink nominal EIRP

Caution Excess uplink carrier EIRP will violate terms of the satellite lease contract, while insufficient uplink carrier EIRP will interfere with data collection.

Uplink nominal EIRP is the power (in dBW) of RF beam leaving the transmitting antenna. This is a key parameter of any satellite lease and must be controlled carefully by the Libra network administrator.

7.2.11 Uplink maximum EIRP

Uplink maximum EIRP (in dBW) can be defined with one of two meanings:

- The maximum achievable power of the RF beam leaving the transmitting antenna, dictated by the technical limitations of the equipment.

  or

- The maximum permitted power of the RF beam leaving the transmitting antenna, dictated by the satellite lease agreement.

7.2.12 Modulation

Modulation refers to the method of representing data in the transmitted carrier. Libra uses four modulation methods:

- BPSK, 32 kbps, 1/2 FEC – used for outbound (hub to remote) transmissions
- QPSK, 64 kbps, 1/2 FEC – used for inbound (remote to hub) transmissions with low power satellites or small antennas.
- QPSK, 100 kbps, 3/4 FEC – used for inbound (remote to hub) transmissions with medium power satellites and/or small antennas
- QPSK, 112 kbps, 7/8 FEC – used for inbound (remote to hub) transmissions with high power satellites or medium-sized antennas.

7.3 Form 5 – Satellite Lease

This form is used to record information from your satellite lease. This form includes network-wide and sub-network configuration tables.

Table 7-1 Satellite provider contact information

Satellite provider	
Satellite provider administrative contact (name, telephone, fax)	
Satellite provider operations center contact (name, telephone, fax)	

Table 7-2 Sub-networks

Hub site reference	Sub-network 1	Sub-network 2	Sub-network 3	Sub-network 4
Network name (or sub-network name)				
Satellite name				
Authorization number				
Transponder				
Satellite longitude				
Uplink polarization				
Satellite local oscillator (GHz)				
Satellite local oscillator Offset (kHz)				
Uplink carrier center frequency (MHz)				
Uplink carrier EIRP (dBW)				
Uplink max EIRP (dBW)				
Modulation				

Each Libra central site can support up to four 100 kHz networks. Each uses a TDMA satellite data carrier to collect data. Each of these carriers is allocated 100 kHz of transponder bandwidth. The satellite provider will treat each of these carriers as a separate entity; define each one in a separate table.

Table 7-3 Carrier 1 configuration

Parameter	Value	Units
Authorization number		
Transponder number		
Transponder polarization, uplink		Vert. or Horiz.
Transponder polarization, downlink		Vert. or Horiz.
Carrier 1 type	Data carrier, fixed-assignment TDMA	
Carrier 1 inbound modulation (bitrate/modulation/FEC)		
Carrier 1 outbound modulation (bitrate/modulation/FEC)		
Carrier 1 center frequency, uplink		MHz
Carrier 1 center frequency, downlink		MHz
Carrier 1 allocated bandwidth	100	kHz
Carrier 1 uplink EIRP		dBW
Carrier 1 downlink EIRP		dBW

Table 7-4 Carrier 2 configuration

Parameter	Value	Units
Authorization number		
Transponder number		
Transponder polarization, uplink		Vert. or Horiz.
Transponder polarization, downlink		Vert. or Horiz.
Carrier 2 type	Data carrier, fixed-assignment TDMA	
Carrier 2 inbound modulation (bitrate/modulation/FEC)		
Carrier 2 outbound modulation (bitrate/modulation/FEC)		
Carrier 2 center frequency, uplink		MHz
Carrier 2 center frequency, downlink		MHz
Carrier 2 allocated bandwidth	100	kHz
Carrier 2 uplink EIRP		dBW
Carrier 2 downlink EIRP		dBW

Table 7-5 Carrier 3 configuration

Parameter	Value	Units
Authorization number		
Transponder number		
Transponder polarization, uplink		Vert or Horiz.
Transponder polarization, downlink		Vert or Horiz.
Carrier 3 type	Data carrier, fixed-assignment TDMA	
Carrier 3 inbound modulation (bitrate/modulation/FEC)		
Carrier 3 outbound modulation (bitrate/modulation/FEC)		
Carrier 3 center frequency, uplink		MHz
Carrier 3 center frequency, downlink		MHz
Carrier 3 allocated bandwidth	100	kHz
Carrier 3 uplink EIRP		dBW
Carrier 3 downlink EIRP		dBW

Table 7-6 Carrier 4 configuration

Parameter	Value	Units
Authorization number		
Transponder number		
Transponder polarization, uplink		Vert. or Horiz.
Transponder polarization, downlink		Vert. or Horiz.
Carrier 4 type	Data carrier, fixed-assignment TDMA	
Carrier 4 inbound modulation (bitrate/modulation/FEC)		
Carrier 4 outbound modulation (bitrate/modulation/FEC)		
Carrier 4 center frequency, uplink		MHz
Carrier 4 center frequency, downlink		MHz
Carrier 4 allocated bandwidth	100	kHz
Carrier 4 uplink EIRP		dBW
Carrier 4 downlink EIRP		dBW

Chapter 8 Determining Satellite Radio Frequencies

This chapter provides a basic overview of how satellite network frequencies are determined at each stage in the link.

8.1 Ku-Band uplink and downlink frequencies

There are two frequencies which are fundamental to a satellite earth station's operation:

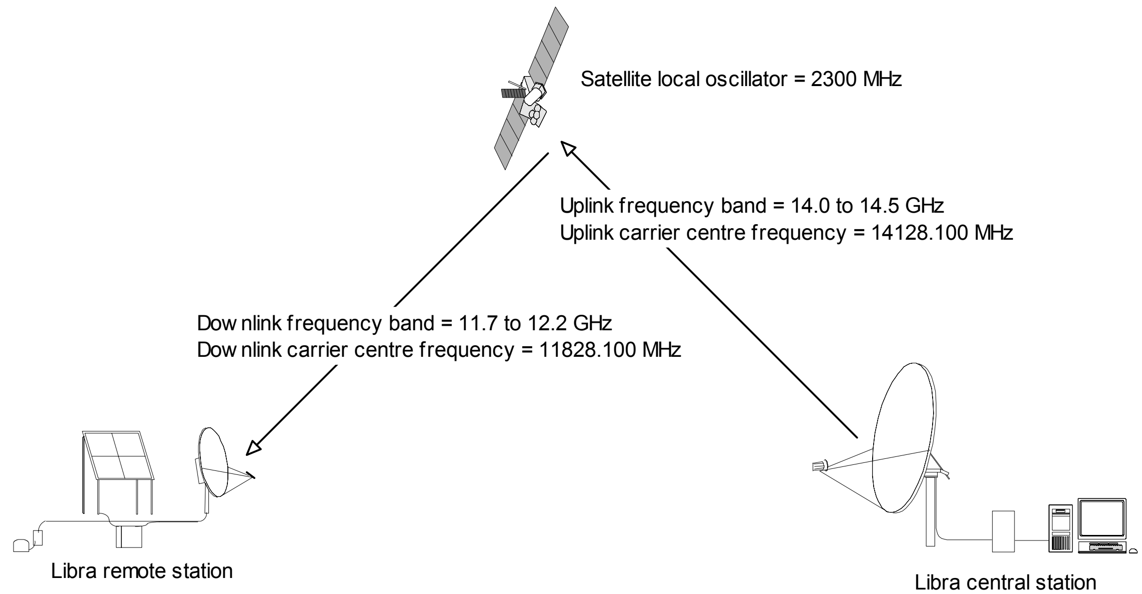
- Transmit frequency (or uplink frequency) – Each station that transmits to a satellite must maintain these transmissions within the limits specified in the satellite lease.
- Receive frequency (or downlink frequency) – In order to receive a transmission from a satellite, the Libra transceiver (Cygnus, Carina) must know the carrier frequency. Several elements in the satellite link can contribute uncertainty to the receive frequency.

Most modern communications satellites use the Ku frequency band. This band has two advantages over the previously-common C-Band (4–6 GHz): It requires much smaller antennas, and is less susceptible to terrestrial radio interference. The Ku-Band is approximately 11–14 GHz:

- Ku-Band satellite networks all have uplink frequencies between 14 and 14.5 GHz
- Downlink frequencies depend on the geographical region:
  - North America uses 11.7 to 12.2 GHz
  - Europe uses 10.95 to 11.7 GHz
  - some Asian satellites use 12.25 to 12.75 GHz

Figure 8-1 shows an example frequency plan for a typical VSAT network.

Figure 8-1 Example VSAT network frequency plan



Remote site	
SSPB LO frequency	13.05 GHz
LNB LO frequency	10.75 GHz
LNB LO max offset	250 kHz

Satellite	
Satellite LO frequency	2.3 GHz
Satellite LO offset	0 kHz

Central hub	
SSPB LO frequency	13.05 GHz
LNB LO frequency	10.75 GHz
LNB LO max offset	100 kHz

8.2 Frequency translation at the satellite

The satellite translates the uplink onto the downlink frequency by mixing the uplink band with a sinusoid generated by the satellite—the satellite Local Oscillator (LO) frequency. The LO frequency is chosen to convert the 14.0 to 14.5 GHz band onto the desired downlink frequency band. For example, to translate the 14–14.5 GHz band onto the 11.7–12.2 GHz band requires an LO of:

- Upper band edge: Satellite LO frequency = 14.5 GHz – 12.2 GHz = 2.3 GHz.
- Lower band edge: Satellite LO frequency = 14.0 GHz – 11.7 GHz = 2.3 GHz.

8.2.1 Satellite LO offset

The satellite LO will have a small frequency error, called the LO offset. This will cause a small error in the center frequency of the downlink carrier. This error is rarely more than 20 kHz and is therefore negligible next to the 200 kHz+ error that can be introduced by the LNB. Libra's ability to accommodate large LNB frequency errors can easily accommodate the much smaller satellite LO error. In most cases the satellite LO error can be rounded to 0 kHz.

In some networks, the hub may use a high-stability PLL LNB which achieves LO offset below 20 kHz. In this case, the satellite LO frequency offset should be included in the network configuration.

8.3 Frequency translation at the antenna

The antenna feed active components include:

- the Solid-state Power Block-upconverter (SSPB) for upconversion and amplification of the transmitted signal
- the Low Noise Block-downconverter (LNB) for amplification and downconversion of the received signal

8.3.1 The SSPB

A Solid-state Power Block-upconverter (SSPB) translates the low-frequency output of the Cygnus remote or Carina Hub transceiver to the high frequencies used by the satellite link, and then amplifies the transmitted carrier before it is output to the satellite antenna:

- Translating the low-frequency output of the Cygnus remote or Carina Hub transceiver to the high frequencies used by the satellite link permits the use of relatively inexpensive coaxial cable between the transmitter and SSPB. This cable carries signals in the L-Band frequency range of 950–1450 MHz, which are upconverted by the SSPB to the 14.0–14.5 GHz Ku-Band uplink range.
- The vast distance to the satellite causes extreme attenuation of the signals, often over 180 dB, which is overcome by transmitting fairly powerful signals from the earth station.

8.3.1.1 SSPB frequency calculations

An SSPB has one frequency characteristic—the LO frequency. The SSPB LO frequency defines the frequency translation: The L-Band input frequency is mixed with the LO, and the sum is the transmit RF frequency.

Ku-Band SSPBs typically use 13.05 GHz for the LO frequency. The LO frequency can be confirmed either by reading the specifications for the unit, or by performing this calculation:

SSPB LO frequency (GHz) = satellite uplink frequency – L-Band frequency

For example, to translate the L-Band of 950–1450 MHz onto the Ku uplink band of 14.0–14.5 GHz, the calculation is:

Lower band edge:

SSPB LO frequency = 14.0 GHz – 0.950 GHz = 13.05 GHz

Upper band edge:

SSPB LO frequency = 14.5 GHz – 1.450 GHz = 13.05 GHz

The Cygnus and Carina transceivers use phase-locked SSPBs which synchronize their LO frequency to the internal RF reference oscillator frequency. The RF Reference Oscillator is frequency-stabilized through comparison with the received GPS clock, resulting in an extremely stable and predictable SSPB LO frequency. Cygnus and Carina transceivers achieve +/–2 kHz accuracy of the transmitted carrier center frequency.

8.3.2 The LNB

A Low Noise Block-downconverter (LNB) amplifies the satellite transmissions at the receive output port of the earth station antenna. The extremely weak signals received from the satellite require amplification by specialized, low noise amplifier stages. Ku-Band LNBs specify their input noise level as Noise Figure in decibels, with typical LNBs falling in the range of 0.6 dB (43 K, –182 dBm/Hz) to 1.0 dB (75 K, −180 dBm/Hz).

After amplification, the LNB downconverts the received spectrum. This is done to allow lower-frequency, low-cost coaxial cable to carry the radio frequency spectrum to the receiver. The satellite industry has standardized on the use of L-Band (950–1450 MHz) as this intermediate frequency.

The LNB requires a local oscillator (LO) to perform this downconversion. LNB LOs are never perfect, and their frequency will vary with time and temperature. Therefore, satellite receive equipment must be capable of finding and tracking a received carrier for which center frequency varies.

8.3.2.1 Types of LNBs

There are two common types of LNB, Dielectric Resonating Oscillator (DRO) and Phase Locked Loop (PLL) oscillator:

- DRO LNBs cost less and consume less power, but have large amounts of phase noise which degrades QPSK reception. For this reason they are used only at Libra remote sites which receive only BPSK carriers.
- PLL LNBs are more expensive and consume more power. However, they are very stable with lower phase noise, and are suitable for reception of QPSK carriers.

8.3.2.2 LNB frequency calculations

An LNB has two frequency characteristics:

- LO frequency (which controls the frequency translation)
- LO frequency uncertainty (which dictates the frequency range the demodulator must search for the carrier)

8.3.2.2.1 LNB LO frequency

LNB LO frequency can be determined by either reading the specifications for the unit, or by performing this calculation:

LNB LO frequency (GHz) = satellite downlink frequency – L-Band frequency

For example, to translate the North American Ku downlink band of 11.7–12.2 GHz onto the L-Band range of 950–1450 MHz, the calculation is:

Lower band edge:

LNB LO frequency = 11.7 GHz – 0.950 GHz = 10.75 GHz

Upper band edge:

LNB LO frequency = 12.2 GHz – 1.450 GHz = 10.75 GHz

8.3.2.2.2 LNB LO frequency uncertainty

The second frequency characteristic of an LNB is its frequency uncertainty. Typical LNBs have LOs which can drift between 50 and 500 kHz in response to temperature fluctuations and aging. An LNB for which the LO frequency can drift over a range of +/–500 kHz is said to have a *maximum offset* of 500 kHz.

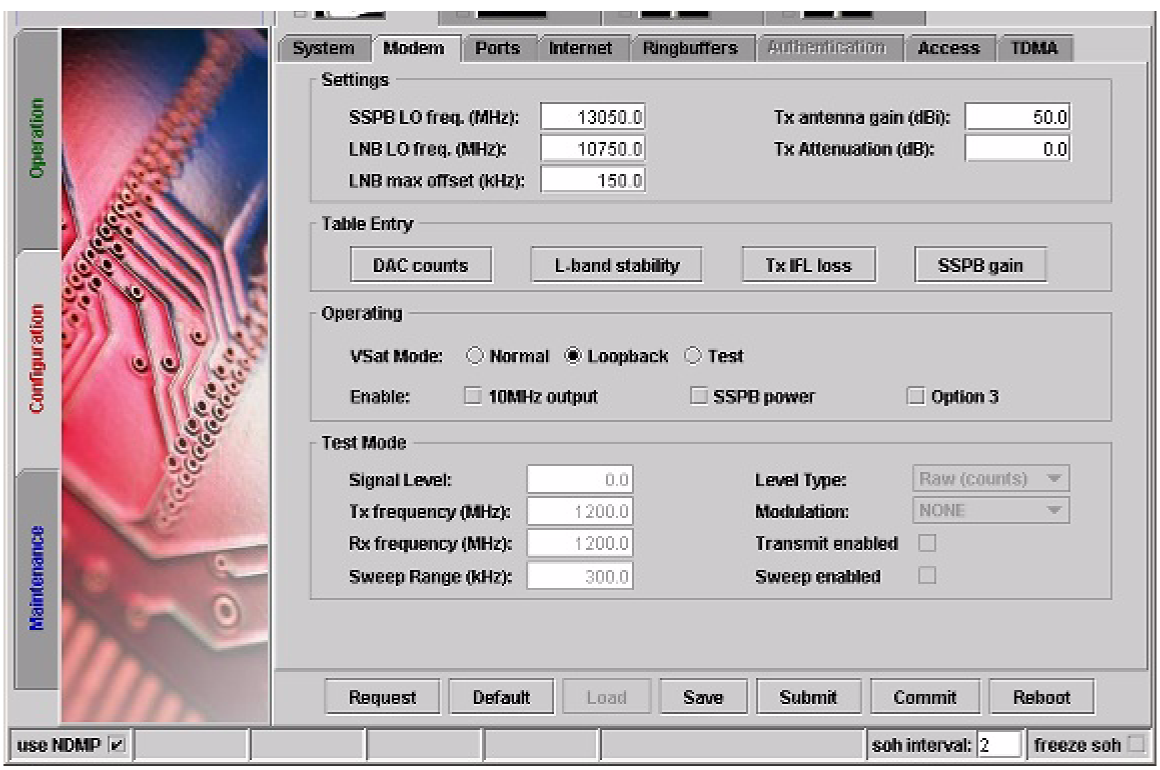
The Libra transceiver accommodates the uncertainty in the received carrier center frequency by sweeping a range of frequencies in search of the desired carrier. When the carrier is acquired and identified, the receiver continually tracks frequency drift, by measuring the center frequency of the carrier during each burst.

8.3.3 Configuring your network with satellite frequency information

Set the Libra network satellite frequency parameters for both the Carina and the Cygnus via the Nanometrics UI. The satellite frequency parameters include:

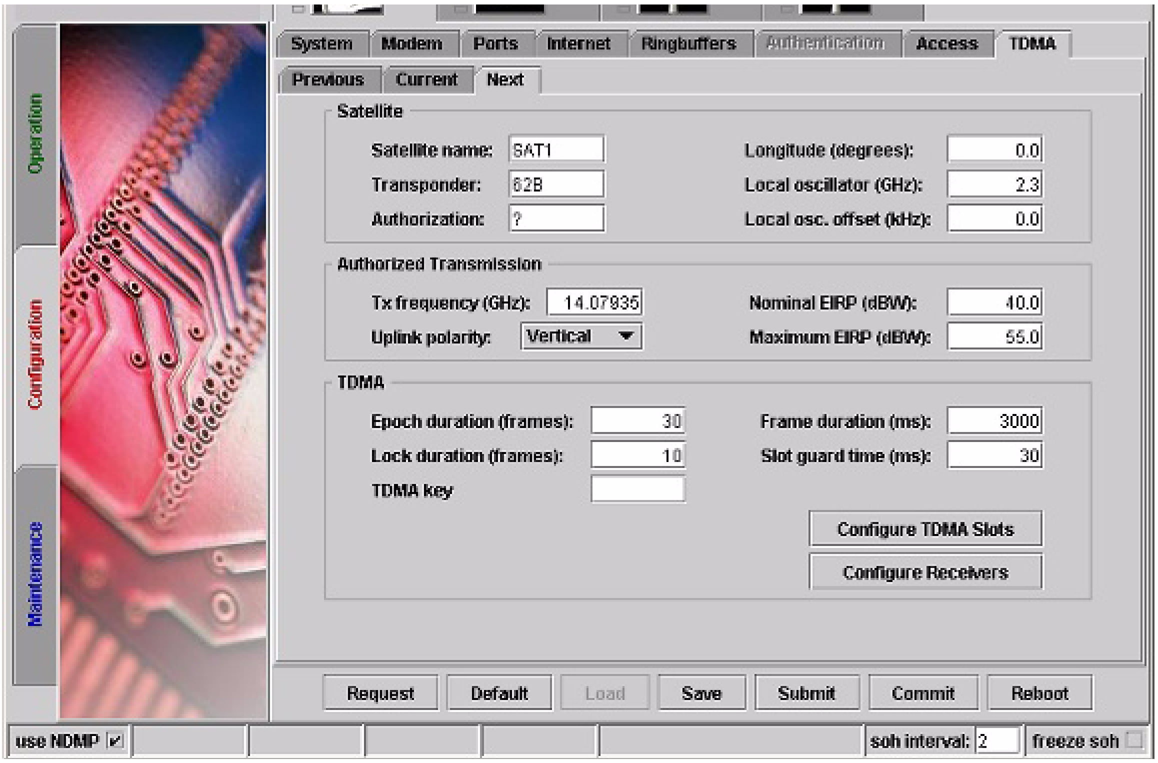
- In the Configuration > Modem screen (Figure 8-2):
  - SSPB local oscillator frequency (GHz)
  - LNB local oscillator frequency (kHz)
  - LNB maximum offset (kHz)

Figure 8-2 Configuration > Modem screen



- In the Configuration > TDMA > Next screen (Figure 8-3):
  - Satellite local oscillator frequency (GHz)
  - Satellite local oscillator offset (kHz)
  - Authorized transmission Tx frequency (GHz)

Figure 8-3 Configuration > TDMA screen



8.4 Form 6 – Satellite Frequencies

Use a form similar to this example to record satellite frequency information for your network. This form includes both network-wide configuration and site-specific configuration.

Table 8-1 Earth station frequency configurations

Parameter	Value	Units
Satellite		
Satellite Local Oscillator frequency		GHz
Satellite Local Oscillator offset		kHz
Carrier 1 center frequency, uplink		MHz
Carrier 1 center frequency, downlink		MHz
Carrier 1 allocated bandwidth	100	kHz
Carrier 1 uplink EIRP		
Carrier 2 center frequency, uplink		MHz
Carrier 2 center frequency, downlink		MHz
Carrier 2 allocated bandwidth	100	kHz
Carrier 3 center frequency, uplink		MHz
Carrier 3 center frequency, downlink		MHz
Carrier 3 allocated bandwidth	100	kHz
Carrier 4 center frequency, uplink		MHz
Carrier 4 center frequency, downlink		MHz
Carrier 4 allocated bandwidth	100	kHz
Central Hub SSPB Local Oscillator frequency	13.05	GHz
Central Hub LNB Local Oscillator frequency		MHz
Central Hub LNB Local Oscillator max offset		kHz
Central Hub LNB frequency band		GHz
VSAT remote site SSPB Local Oscillator frequency	13.05	GHz
VSAT remote site LNB Local Oscillator frequency		MHz
VSAT remote site LNB Local Oscillator max offset		kHz
VSAT remote site LNB frequency band		GHz

Chapter 9 Setting Transmit Power Levels

This chapter gives an overview of the main factors underlying Libra settings for link power. Uplink power levels have to be maintained within the requirements specified in the satellite lease.

9.1 Power and bandwidth versus cost

Satellite providers charge for satellite capacity based on power and bandwidth. Transponders have a fixed bandwidth and a fixed power, so a customer who consumes 1% of the power and 2% of the bandwidth will pay for 2% of the transponder. For this reason it is helpful to calculate link budgets which trade off transponder power against earth station antenna size to find an optimal combination of equipment cost and operating cost. (A link budget analysis accounts for all gains and losses contributed by all elements in the link.)

It is important to maintain transmit power levels within the limits imposed by the satellite lease. Satellite lease agreements specify the allowable transmit power with very tight tolerances, often within ±1 dB. While the satellite provider may not be concerned by power levels which are lower than the lease allows, low levels may increase the Bit Error Rate (BER) of the received data or increase the occurrence of temporary communications outages during heavy precipitation.

Caution Running your Libra network with an incorrect setting affecting transmit power may violate the satellite lease. If components or network frequency are changed, make the corresponding corrections to the Cygnus or Carina configuration, via the Nanometrics UI:

1) If an earth station transceiver, SSPB, or IFL is replaced, update the Cygnus or Carina configuration with compensation information from the new unit.
2) If the transmit frequency changes in a Libra network, update the Cygnus or Carina configuration with the compensation data which applies at the new frequency.

9.2 Uplink power stability

Uplink power must be maintained within the range set by the satellite provider. Excessive uplink power levels may interfere with other users on the satellite, and will concern the satellite provider.

Libra is designed to achieve an uplink power stability of ±1dB under all operating conditions, which satisfies the requirements of most satellite providers. Libra can only achieve this stability if all uplink power parameters are configured correctly. Errors in uplink power configuration will cause errors in the transmitted power level.

9.3 Factors that affect uplink power

The Libra remote and central stations calculate uplink power based on these factors, at a given network frequency:

- Transceiver output gain versus temperature
- Transceiver output power calibration versus temperature
- IFL loss versus temperature
- SSPB gain versus temperature
- Antenna gain

The Libra transceiver (Cygnus, Carina) monitors the temperature of each of the relevant components continuously and corrects gain or loss variations by varying the gain of the modulator stage.

Note These factors vary considerably with frequency. The Libra transceiver is only programmed with gain correction information for one frequency. If a network changes frequency, these values must be reentered for the new frequency before transmission begins.

9.3.1 Transceiver output gain versus temperature

This is a measure of the gain of the output stage within the Libra transceiver. The gain in decibels was measured at the factory at various temperatures across the operating band of –20°C to +55°C. These measurements are recorded on the as-shipped configuration sheets.

9.3.2 Transceiver output power calibration versus temperature

This is a measure of the sensitivity of a power sensing stage within the Libra transceiver. It monitors the power output (in dBm) with an analog to digital converter (ADC) which records in counts. The resulting dBm versus counts curve compensates for nonlinearities in the power sensor, and does not vary with temperature. It does vary with frequency; the factory measurements of power output versus ADC counts at various frequencies are recorded on the as-shipped configuration sheets.

9.3.3 IFL loss versus temperature

The Inter-Facility Link (IFL) comprises the coaxial cables which link the Libra transceiver with the SSPB:

- For the Cygnus, the cables are quite short and have relatively little loss
- For the Carina, the cables can be quite long and therefore may have substantial loss

The cables have a gain versus temperature characteristic which must be programmed into the Libra transceiver. This characteristic varies with frequency, and was measured at the factory during production of the system. These measurements are recorded on the as-shipped configuration sheets.

9.3.4 SSPB gain versus temperature

The SSPB is the transmit power amplifier. It accepts the modulated L-Band carrier from the transceiver, upconverts it to the satellite uplink frequency, and amplifies the carrier to the transmit power level.

The SSPB gain varies with temperature and frequency, and each unit is characterized at the factory before shipment. The as-shipped configuration sheets contain records of SSPB gain versus temperature and frequency for each SSPB in your network.

9.3.5 Antenna gain

The satellite antenna focuses the transmit power into a very narrow beam, less than 1 degree wide, and directs this power towards the satellite.

The conventional way of expressing the antenna focusing capability is to compare it to a point source which radiates in all directions (an isotropic radiator). For example, if a 1000 W point source achieves a certain power flux density, and the center of a satellite antenna's focused 1W beam achieves the same power flux density, the antenna is said to achieve 30dBi (decibel isotropic) gain.

The gain per metre squared of a satellite antenna increases with the square of the frequency. This is why Ku-Band antennas are much smaller than C-Band antennas: the Ku-Band 12GHz downlink band is triple the frequency of the C-Band 4GHz band. This provides 9 times the gain per square metre, thus allowing antennas with 1/3 the diameter.

Uplink power is calculated as the power at the Libra transceiver output less IFL loss, plus SSPB gain and antenna gain. All values are corrected for temperature.

9.4 Site location and uplink power

An additional factor to consider when calculating uplink power is site location within the satellite beam coverage area. Since the satellite has less gain near the beam edge, sites located near the beam edge may need to transmit slightly higher power levels. This additional power is called the EIRP Increase, and should be determined separately for each site in the network.

9.5 Downlink power

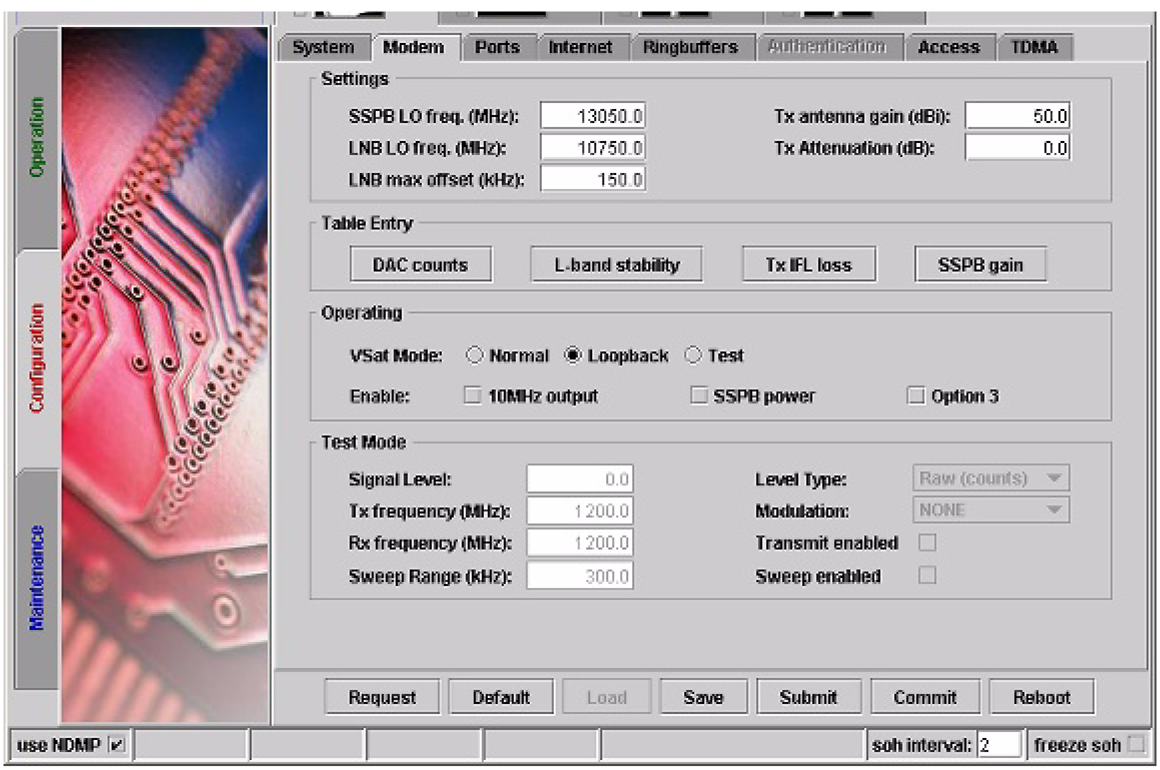
Variations in downlink power will affect the Libra network by varying the received carrier to noise ratio (C/N). As the carrier level falls, the C/N ratio will fall resulting in increased bit error rate (BER). This in turn will cause more packets to require retransmission.

9.6 Configuring your Libra uplink power level

Set the Libra network satellite uplink power parameters for both the Carina and the Cygnus via the Nanometrics UI. The uplink power parameters include:

- In the Configuration > Modem screen (Figure 9-1):
  - Tx antenna gain (dBi)
  - Tx attenuator
- In the gain tables accessible through the Configuration > Modem screen:
  - SSPB gain > SSPB gain vs temperature
  - L-band stability > L-band Tx relative gain vs. temperature
  - DAC counts > L-band Tx DAC counts vs. exciter power

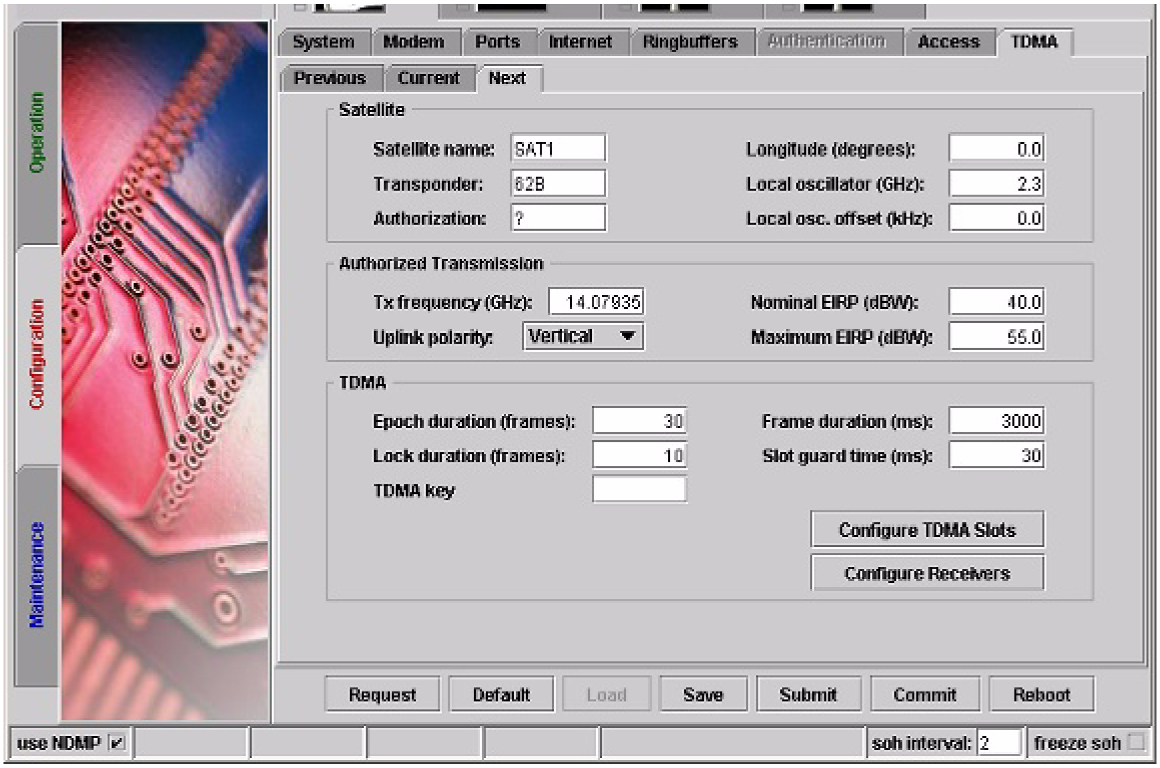
Figure 9-1 Configuration > Modem screen



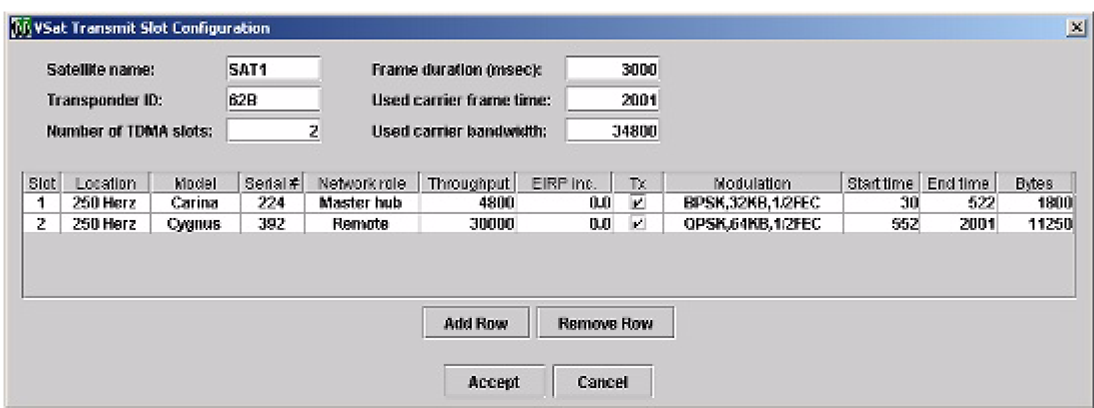
- In the Configuration > TDMA > Next screen (Figure 9-2):
  - Nominal EIRP (dBW)
  - Maximum EIRP (dBW)
- In the Configuration > TDMA > Next > Configure TDMA Slots screen

- EIRP increase
- Enabled

Figure 9-2 Configuration > TDMA > Next screen



✧ Configure EIRP increase, if required, and Tx (enabled)



9.7 Form 7 – Transmit Power

Use a form similar to this example to record satellite frequency information for your network. This form includes both network-wide configuration and site-specific configuration.

Table 9-1 Network uplink power settings

Parameter	Value	Units
Hub transmit antenna gain		dBi
Hub nominal uplink EIRP		dBW
Hub maximum EIRP		dBW
VSAT transmit antenna gain		dBi
VSAT nominal uplink EIRP		dBW
VSAT maximum uplink EIRP		dBW

The sites in your satellite network are located in different areas of the satellite beam coverage area. Since the satellite has less gain near the beam edge, sites located near the beam edge may need to transmit slightly higher power levels. This additional power is called the EIRP Increase, and should be determined separately for each site in the network. These values can be entered in the table below.

Default value for EIRP Increase should be 0.

Table 9-2 Site EIRP increase for satellite footprint variations

Site name	EIRP increase (dB)	Site name	EIRP increase (dB)

Chapter 10 Aligning Satellite Antennas

Aligning a satellite antenna includes pointing the antenna precisely to the correct azimuth and elevation for the satellite from a given earth station, and accurately adjusting the feed to the correct polarization. Alignment tests must be completed under the direction of the satellite provider before the antenna is set to transmit over their satellite. See also Chapter 12, for antenna alignment procedures.

10.1 Antenna alignment factors

The earth station location relative to the satellite and the antenna characteristics are the two main determinants of correct antenna alignment.

10.1.1 Geostationary satellite geometry

Libra networks communicate over geostationary communication satellites. These are located approximately 38000 kilometres (24000 miles) above the earth's equator, and they remain over a fixed location on the earth's surface. For this reason, earth station antennas are pointed at a fixed azimuth and elevation and do not need to move to track the satellites.

10.1.2 The antenna radiation pattern

Satellites can be located as little as 2 degrees longitude apart. To avoid interference with adjacent satellites, earth station antennas are often manufactured with beam widths of less than 1 degree. Typical 1.8 m Ku-Band antennas beams lose 3 dB gain at less than 0.5 degrees offset from the beam center. Typical 3.8 m Ku-Band antennas lose 3 dB gain at less than 0.25 degrees offset from beam center.

Satellite providers are also concerned with the antenna radiation pattern at larger angle offsets. They are interested in knowing how much power your antennas transmit at other satellites, and how much interfering noise your stations receive from those satellites. Radiation patterns must be included in most satellite lease applications (Figure 10-1 and Figure 10-2 show example antenna radiation pattern cuts).

Figure 10-1 Example 3.8 m antenna radiation pattern

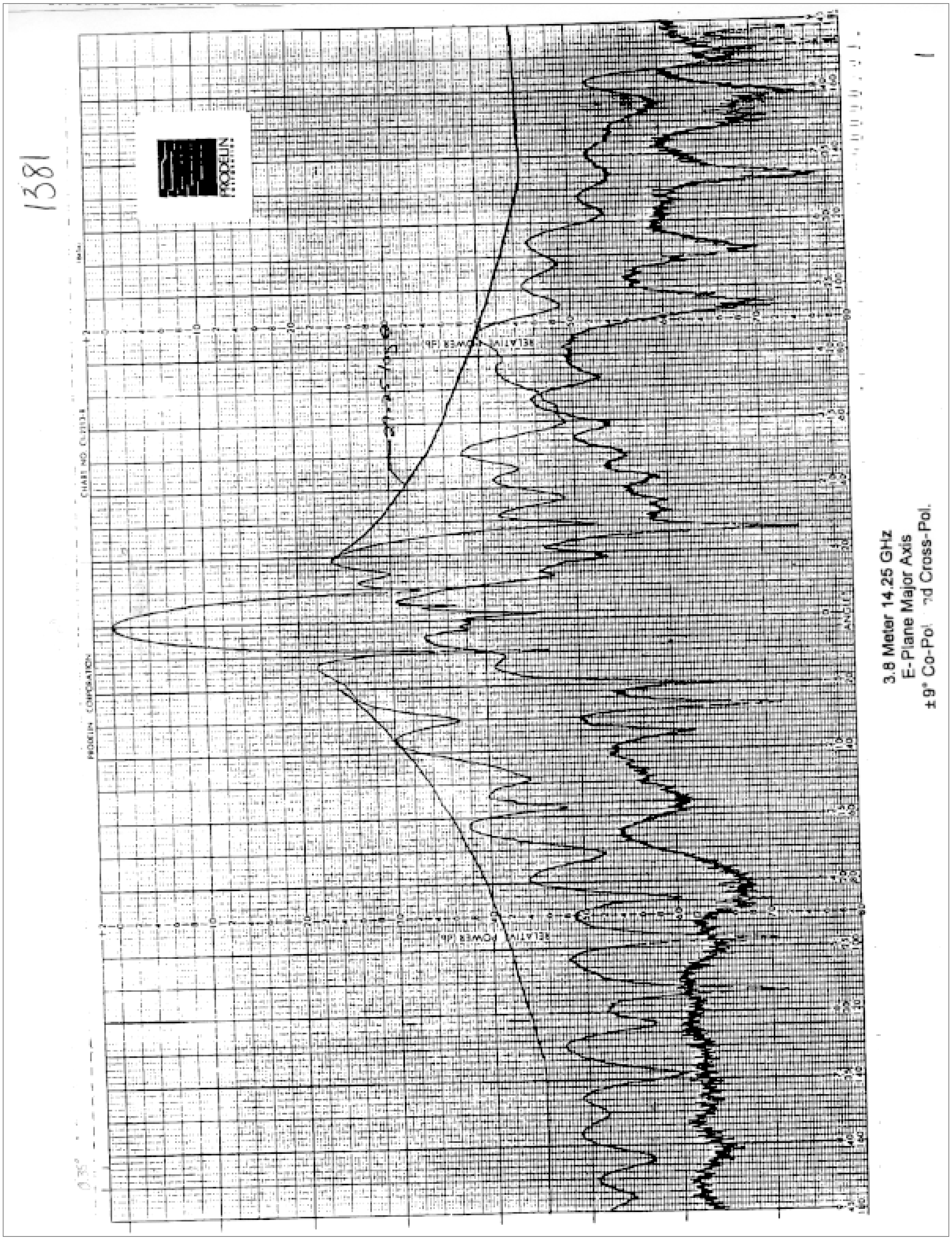
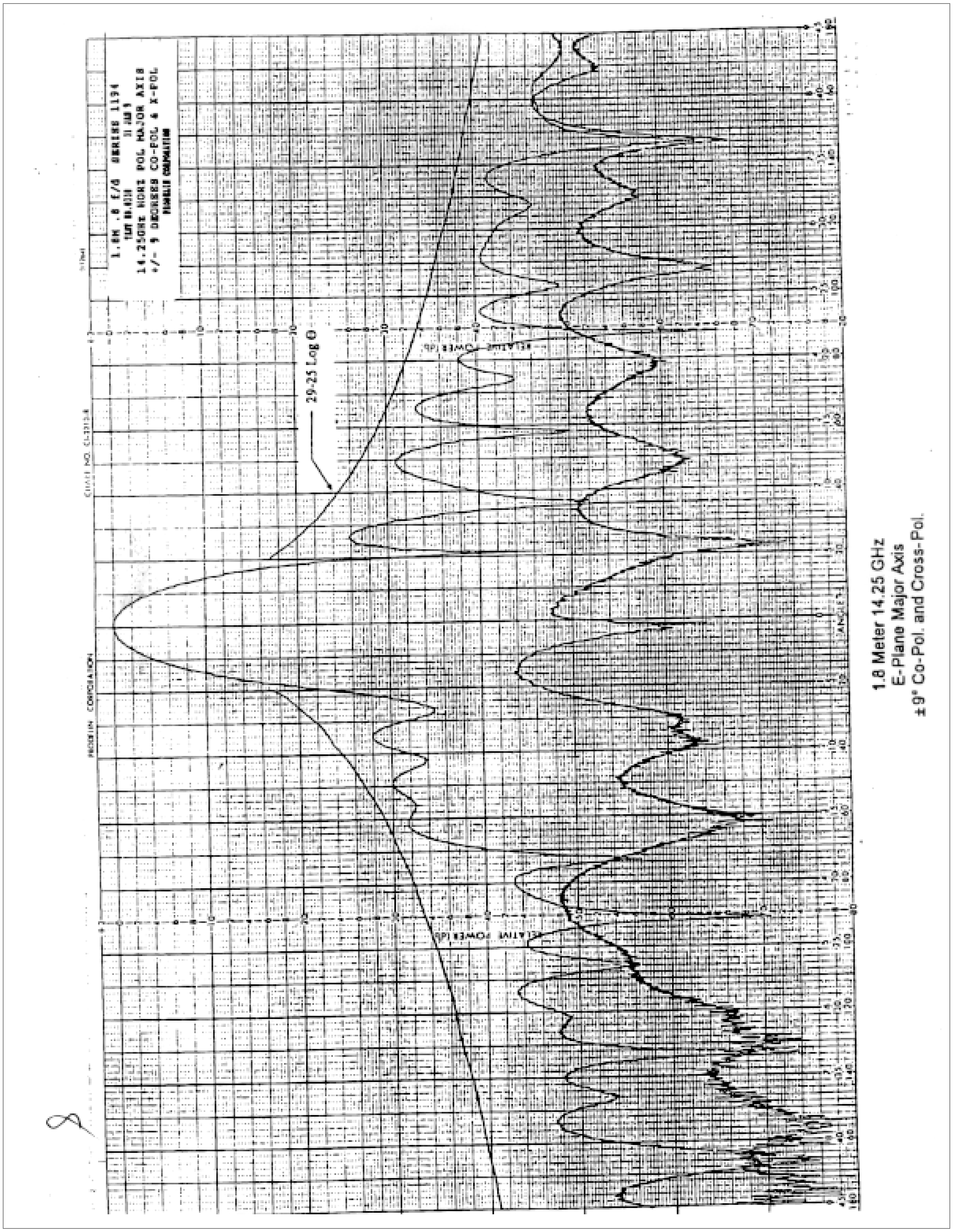


Figure 10-2 Example 1.8 m antenna radiation pattern



10.2 Aligning a satellite antenna

A properly aligned antenna is pointed precisely to the correct azimuth and elevation for the satellite, with the feed set precisely to the correct position for the link polarization. Figure 10-3 and 10-4 illustrate antenna elevation and azimuth parameters.

Figure 10-3 Example offset-feed antenna, showing elevation parameters

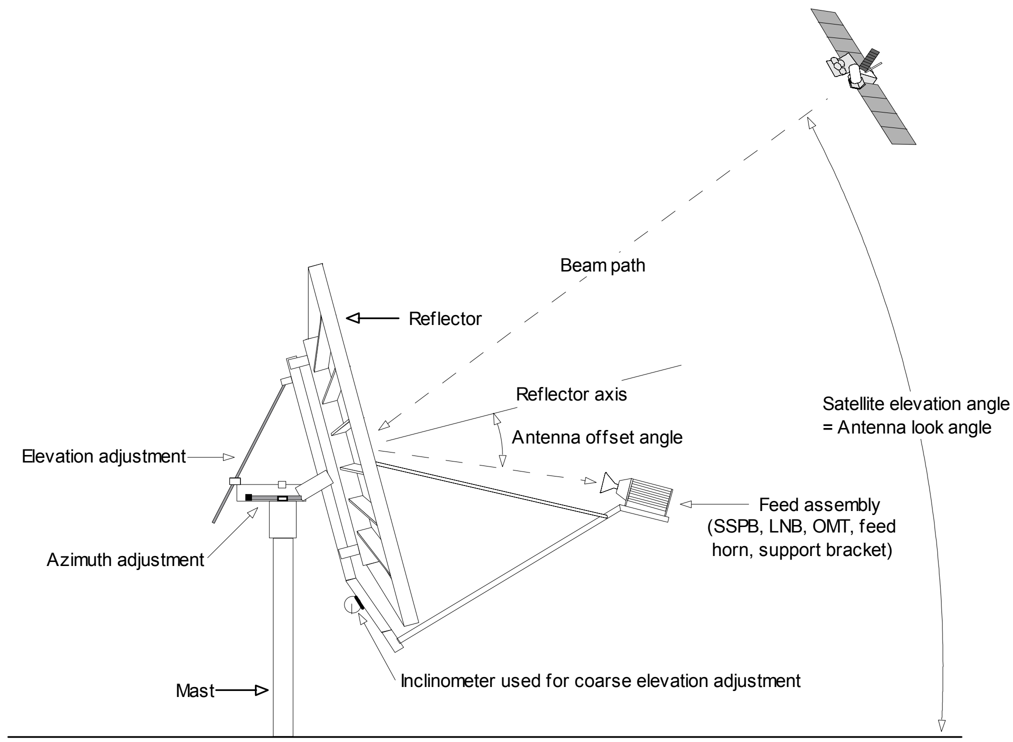
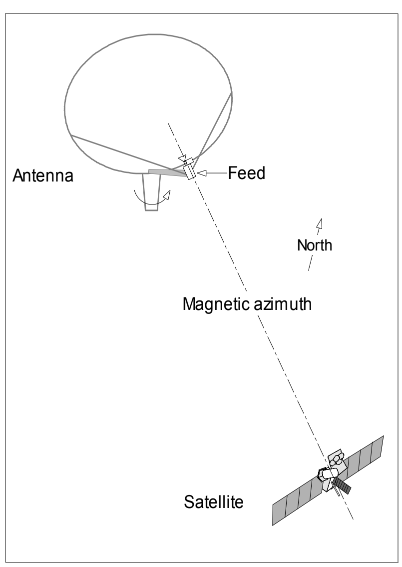


Figure 10-4 Antenna azimuth



Antenna alignment includes these general tasks:

1. Point the antenna accurately to the correct azimuth and elevation for the satellite from a given earth station, and confirm that this is the correct satellite.

   Identifying the satellite for the initial hub installation requires information supplied by the satellite provider, such as frequency and polarization information for your link, and the satellite spectral signature. (Figure 10-5 shows an example satellite frequency plan, showing frequencies and polarizations for each of the satellite transponders. Figure 10-6 shows an example satellite spectral signature.) To identify the satellite for subsequent station installations, you can also use the bursting carriers from existing stations in the network (for example, Figure 10-7).

2. Fine-tune the azimuth and elevation with incremental adjustments until you obtain the peak signal strength on the main lobe of the antenna, and then adjust the feed angle to achieve the required cross-polarization (cross-pol) isolation as required by the satellite provider. (Cross-pol isolation is required only for antennas with linearly polarized feeds.)

Figure 10-5 Example satellite frequency plan

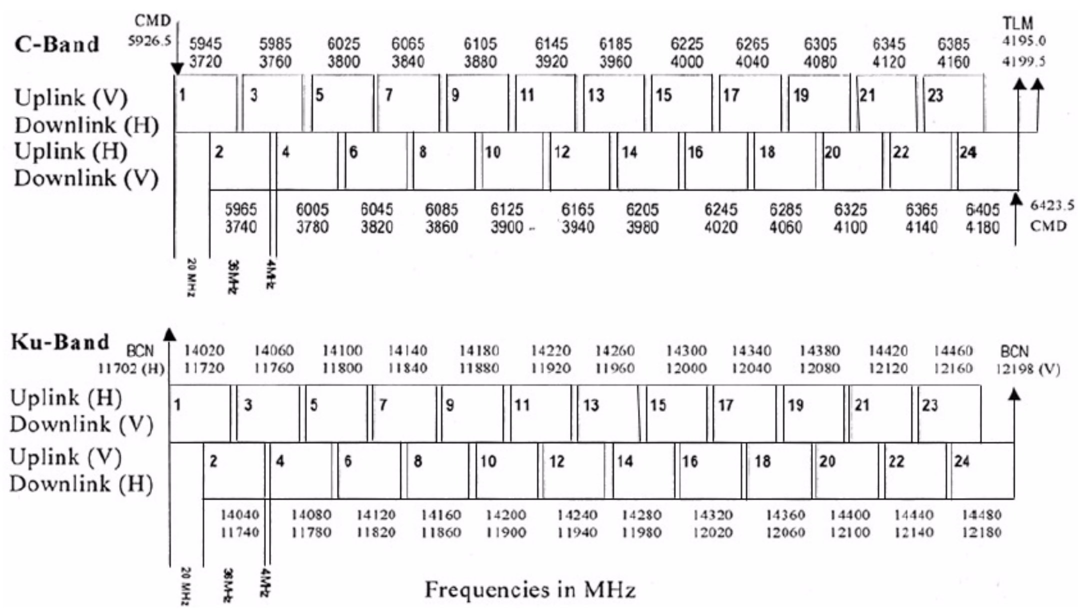


Image courtesy of LORAL Skynet®

Note The polarization refers to the orientation of the electric field component (the E-plane) of the electromagnetic wave. The associated waveguide orientations are as shown (the waveguide orientation will only appear to be truly vertical or horizontal if the station is due north of the satellite):

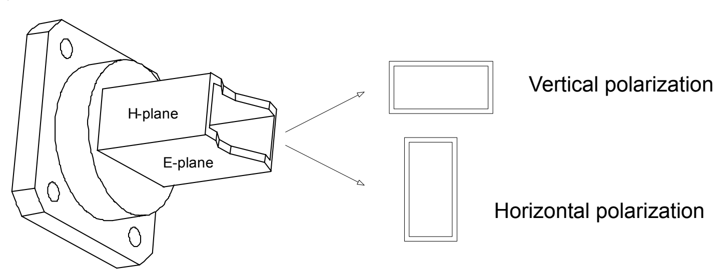
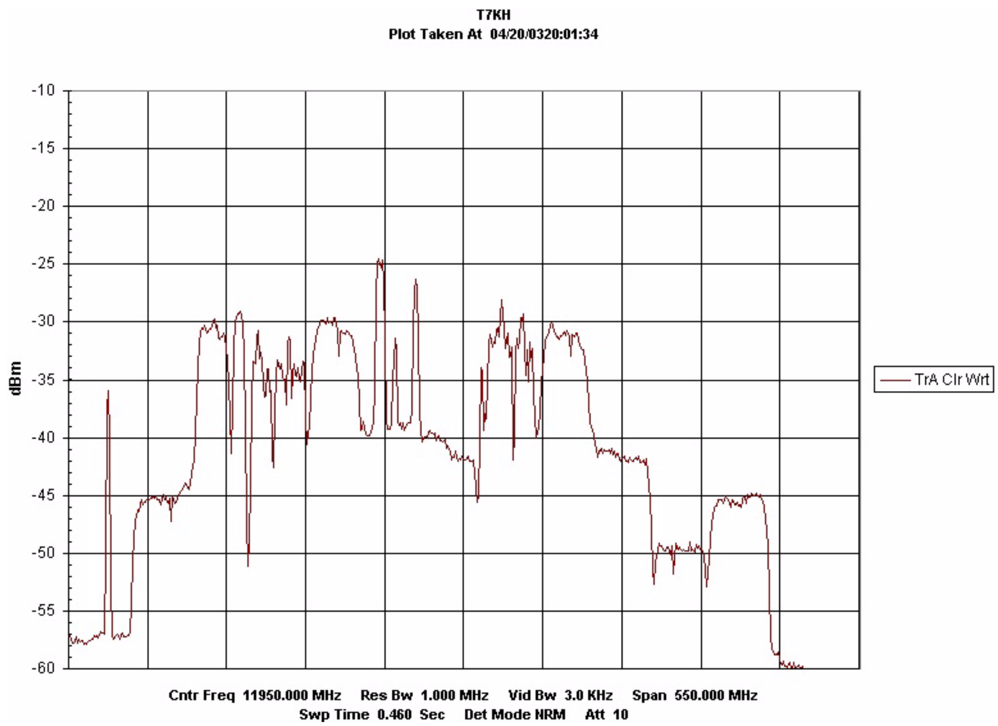
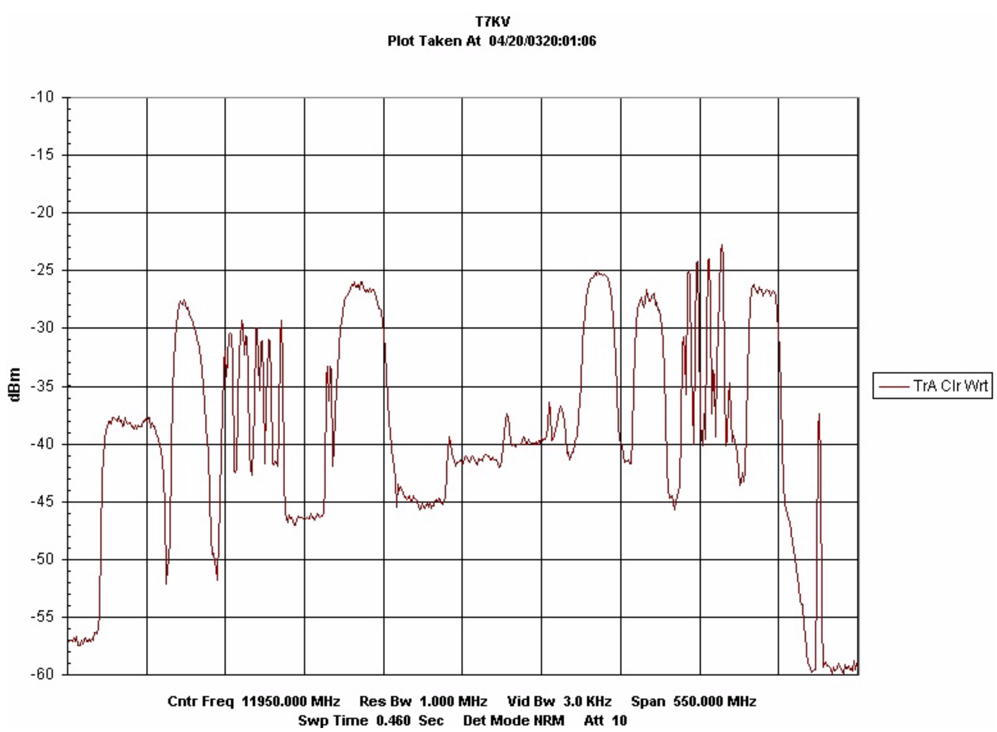


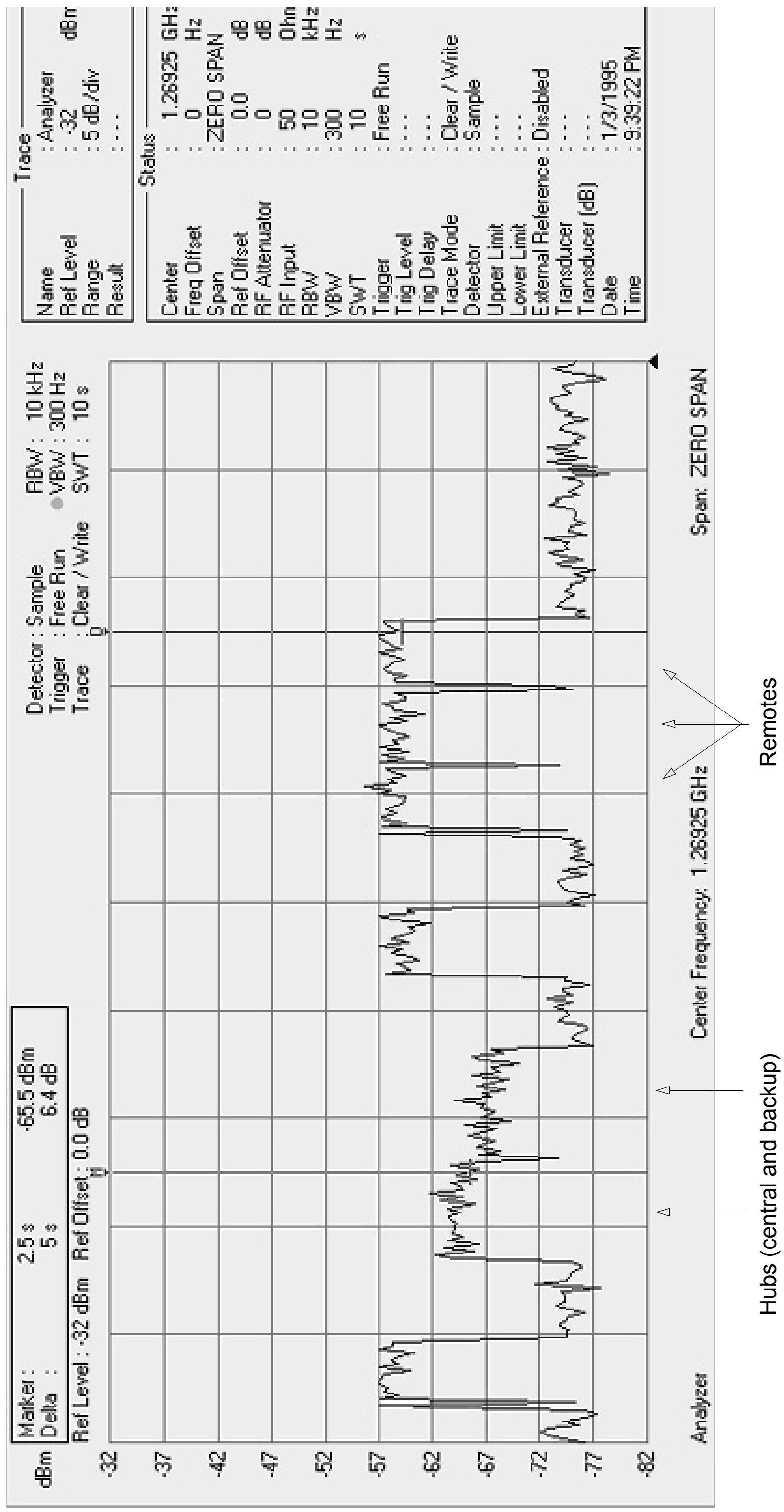
Figure 10-6 Example satellite spectral signature





Images courtesy of LORAL Skynet®

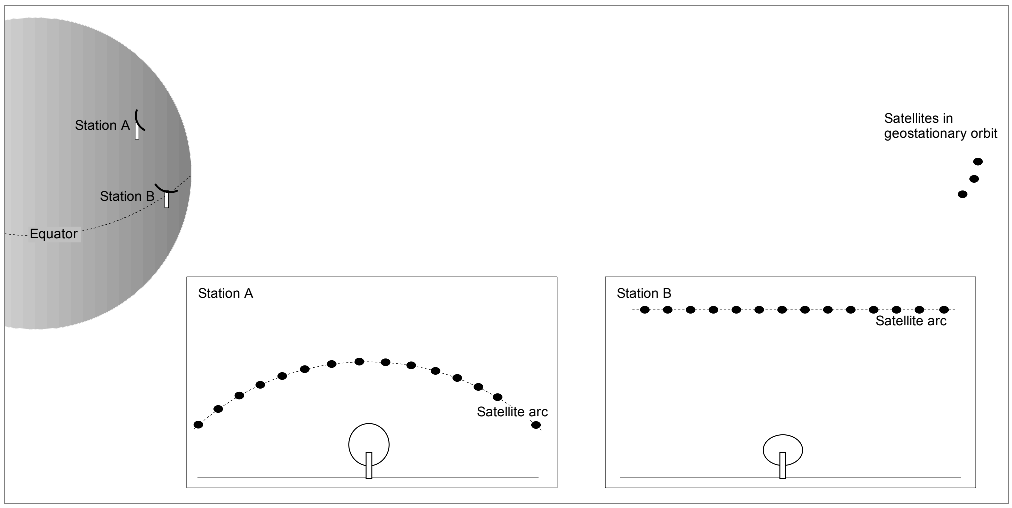
Figure 10-7 Example spectrum segment showing Libra stations



10.2.1 Where to point the antenna?

Pointing an earth station antenna to the correct azimuth and elevation for the satellite is the first step in antenna alignment. The azimuth (Az) and elevation (El) of the satellite will vary from site to site in a network (Figure 10-8). Values for the station can be calculated by the satellite provider or by Nanometrics. Values calculated by Nanometrics are included in an Antenna Pointing Chart (section 10.2.1.1 on page 102). See section 12.5.1 on page 123 for the antenna pointing procedure.

Figure 10-8 Satellite azimuth and elevation varies by station location



10.2.1.1 Satellite antenna pointing chart

The Satellite Antenna Pointing Chart (Figure 10-9 on page 104) shows the azimuth and elevation angle required to point a satellite antenna at any satellite visible from the earth station. The chart applies at one earth station location identified by Earth Station Name, Latitude, and Longitude at upper right. The first column identifies the satellite arc longitude, and subsequent columns contain pointing information.

Latitude, Longitude, Azimuth, and Elevation angles are shown in decimal degrees. For example, 267.5 degrees True Azimuth is a bearing 265 degrees 30 minutes clockwise from True North. “El 17.3” refers to an antenna look angle 17 degrees 18 minutes above horizontal.

Note that the elevation angle expresses the angle of the beam path above horizontal. Antennas with offset feeds have an offset angle between beam path and reflector tilt. The reflector will not align with the beam path on offset antennas (Figure 10-3 on page 98).

Azimuth and elevation angles are calculated for 2 degree increments from horizon to horizon. In practice, satellites may be located at intervals ranging from 0 degrees (co-located) to over 10 degrees. To determine azimuth and elevation for a specific satellite, linearly interpolate between the closest orbital positions on the graph.

An estimated magnetic declination has been used determine magnetic azimuth. This is useful when adjusting antenna azimuth with a magnetic compass. Local conditions may vary the declination by several degrees, so use accurate local data when available.

When aligning an antenna the elevation angle is set as accurately as possible and the antenna azimuth is slowly varied until the satellite is located. This allows for small errors in the azimuth measurements caused by declination or magnetic compass reading inaccuracies, and simplifies antenna pointing in the field. (See also section 12.5 “Align the antenna” on page 123.)

The chart contains a column titled “Visible from site?”. This can be filled in during the site survey to identify which portions of the satellite arc can be seen from the site. This information may be useful if the network operator decides to change satellites in the future.

Figure 10-9 Example satellite antenna pointing chart

Earth Station Name	Ottawa	Latitude (N/S)	45.3	N
		Longitude (E/W)	75.9	W
		Magnetic Declination	12.0	W

Satellite Longitude	True Az	Mag Az	El	Slant Range (km)	Visible from site?
153 º W	260.7	272.7	0.3	41643	
151 º W	259.3	271.3	1.7	41488	
149 º W	257.8	269.8	3.1	41335	
147 º W	256.3	268.3	4.5	41183	
145 º W	254.8	266.8	5.9	41032	
143 º W	253.3	265.3	7.2	40883	
141 º W	251.7	263.7	8.6	40735	
139 º W	250.2	262.2	10.0	40589	
137 º W	248.6	260.6	11.3	40445	
135 º W	246.9	258.9	12.7	40303	
133 º W	245.3	257.3	14.0	40164	
131 º W	243.6	255.6	15.3	40027	
129 º W	241.9	253.9	16.6	39894	
127 º W	240.1	252.1	17.9	39763	
125 º W	238.4	250.4	19.2	39635	
123 º W	236.5	248.5	20.4	39511	
121 º W	234.7	246.7	21.7	39391	
119 º W	232.8	244.8	22.9	39274	
117 º W	230.8	242.8	24.0	39161	
115 º W	228.8	240.8	25.2	39053	
113 º W	226.8	238.8	26.3	38948	
111 º W	224.7	236.7	27.4	38848	
109 º W	222.5	234.5	28.4	38753	
107 º W	220.3	232.3	29.4	38662	
105 º W	218.0	230.0	30.4	38577	
103 º W	215.7	227.7	31.3	38496	
101 º W	213.4	225.4	32.2	38421	
99 º W	210.9	222.9	33.0	38350	
97 º W	208.5	220.5	33.8	38286	
95 º W	206.0	218.0	34.5	38226	
93 º W	203.4	215.4	35.1	38173	
91 º W	200.8	212.8	35.7	38125	
89 º W	198.1	210.1	36.2	38083	
87 º W	195.4	207.4	36.6	38046	
85 º W	192.7	204.7	37.0	38016	
83 º W	189.9	201.9	37.3	37991	
81 º W	187.2	199.2	37.5	37973	
79 º W	184.4	196.4	37.7	37960	GE5
77 º W	181.5	193.5	37.8	37954	

Satellite Longitude	True Az	Mag Az	El	Slant Range (km)	Visible from site?
75 º W	178.7	190.7	37.8	37954	
73 º W	175.9	187.9	37.7	37960	
71 º W	173.1	185.1	37.6	37971	
69 º W	170.3	182.3	37.3	37989	
67 º W	167.6	179.6	37.0	38013	
65 º W	164.9	176.9	36.7	38043	
63 º W	162.2	174.2	36.2	38079	
61 º W	159.5	171.5	35.7	38120	
59 º W	156.9	168.9	35.2	38168	
57 º W	154.3	166.3	34.5	38221	
55 º W	151.8	163.8	33.8	38279	
53 º W	149.3	161.3	33.1	38344	
51 º W	146.9	158.9	32.3	38413	
49 º W	144.5	156.5	31.4	38488	
47 º W	142.2	154.2	30.5	38568	
45 º W	139.9	151.9	29.5	38654	
43 º W	137.7	149.7	28.5	38744	
41 º W	135.6	147.6	27.5	38839	
39 º W	133.5	145.5	26.4	38938	
37 º W	131.4	143.4	25.3	39042	
35 º W	129.4	141.4	24.2	39150	
33 º W	127.4	139.4	23.0	39263	
31 º W	125.5	137.5	21.8	39379	
29 º W	123.6	135.6	20.6	39499	
27 º W	121.8	133.8	19.3	39623	
25 º W	120.0	132.0	18.0	39750	
23 º W	118.3	130.3	16.8	39880	
21 º W	116.6	128.6	15.5	40014	
19 º W	114.9	126.9	14.1	40150	
17 º W	113.2	125.2	12.8	40289	
15 º W	111.6	123.6	11.5	40431	
13 º W	110.0	122.0	10.1	40574	
11 º W	108.4	120.4	8.7	40720	
9 º W	106.9	118.9	7.4	40868	
7 º W	105.3	117.3	6.0	41017	
5 º W	103.8	115.8	4.6	41168	
3 º W	102.3	114.3	3.2	41320	
1 º W	100.9	112.9	1.9	41473	
-1 º W	99.4	111.4	0.5	41627	

Notes: All angles expressed in decimal degrees.
A Magnetic declination of 10° West means Magnetic North is 10° counter-clockwise from True North.
True Azimuth is expressed in degrees measured clockwise from True North
Magnetic Azimuth is expressed in degrees measured clockwise from Magnetic North
Elevation is expressed in degrees above horizontal
Slant range is the distance from the earth station to the satellite

10.2.2 The importance of maintaining the antenna alignment

Once correct antenna alignment is achieved, it must be maintained while the station is transmitting.

10.2.2.1 Maintaining the correct azimuth and elevation

If a 3.8m antenna moves more than 0.25 degrees, it will lose 3dB of signal-to-noise ratio and the network may begin to experience data errors. The antenna and its mounting structure are very strong, and can easily withstand common stresses such as wind loading and aging. The civil works which support these structures should be strong enough to withstand these stresses also. Nanometrics can provide wind loading data to aid in architectural stress analysis.

Similarly, if a 1.8m Ku-Band antenna moves more than 0.5 degrees it will lose 3dB of signal-to-noise ratio for its reception from and transmission to the central site.

Remote sites which are located in active seismic regions may temporarily lose data communications due to antenna deflections during severe wind storms or extreme seismic activity. Communications will return when the deflection stops, and the data will be recovered with the Naqs retransmission requests. If the earth's surface is permanently deformed by 0.5 degrees, the remote station will suffer slightly degraded error rates which can be corrected by realigning the antenna. Permanent deformations beyond 0.5 degrees may cause intermittency in the communications which can be corrected by realigning the antenna. Note that activity causing this level of deformation may also cause damage to the seismometer vaults or power systems.

10.2.2.2 Using the correct link polarizations

Communications satellites use two polarizations to increase the number of available channels: One carrier frequency can be used on each of the two polarizations. The type of polarization is either linear (with vertical and horizontal pols) or circular (with left-hand and right-hand pols); Libra networks use linearly polarized satellite links. One customer can transmit uplink signals to the satellite using horizontal polarization, and receive downlink signals from the satellite using vertical polarization. Another customer can transmit at the same carrier frequency using vertical uplink and horizontal downlink.

Any transmit power which leaks onto the opposite polarization for a link can interfere with other customers who are using that polarization. To prevent interference between these customer links, the satellite provider requires that all transmit antennas have very accurate polarization alignment: Transmit power on the correct polarization must be approximately 30dB stronger than unwanted transmit power on the opposite polarization. The ratio of power between two polarizations is called the cross-pol isolation.

Part 3 Commissioning the Network

- Commissioning a Central Station
- Commissioning a Remote Station
- Maintaining Network Sites

Chapter 11 Commissioning a Central Station

The central sites of a Libra network typically consist of the following subsystems:

- Antenna system, including base, antenna, and feed
- The cable entry kit and mounting enclosure, Carina Hub(s), and interfacility link (IFL)
- Acquisition and analysis systems

This chapter provides a summary of the procedures for installing, testing, and commissioning a central station for a typical Libra VSAT network. Several of the procedures are similar to remote site installation—for example, antenna alignment. In these cases, there is a reference to the applicable procedure.

The values provided in these procedures are examples only:

- Replace the parameter values and instrument settings provided in these example procedures with values appropriate to the remote site that is being installed.

Caution Transmitting from the remote site before the site has been configured correctly will violate the satellite lease. Do not connect the transmit RF cable (Carina RF OUT) to the SSPB until the antenna is aligned and the Carina is configured correctly.

11.1 Contact the satellite provider

You will need to contact the satellite provider at these three points (refer to your satellite lease for contact information):

- At least 24 hours before you commission the central station, to exchange required information. For example, the satellite provider will verify information such as your customer ID and your station location.
  - You should request that they send you these items:
    - Your network uplink and downlink frequencies and polarizations
    - Spectral plots for the satellite on both polarizations
    - Spectral plots for the transponder on both polarizations
    - The centre frequency of both of the linearly polarized satellite beacons, if the satellite has these beacons

- After you have aligned the antenna, but before you start transmissions from the station. The satellite provider will ask you for information about your station, and will then guide you through the transmission tests.
- Before you modify aspects of a commissioned station that may affect transmissions (for example, replacing the feed assembly), and then after you have made the modifications (for assistance with the transmission tests).

11.2 Install the indoor-mounted hub components

The Carina Hubs, IFL (Inter-Facility Link), and Cable Entry Kit, are the indoor-mounted components of a Libra central site:

- The Carina Hub transceivers include a satellite modem, timing subsystem, data processing, TDMA management, and a local data buffer.
- The IFL is the set of cables which connect the antenna system to the Carina Hubs.
- The Cable Entry Kit is the system for mounting Carina Hubs and sharing access to the antenna system between them.

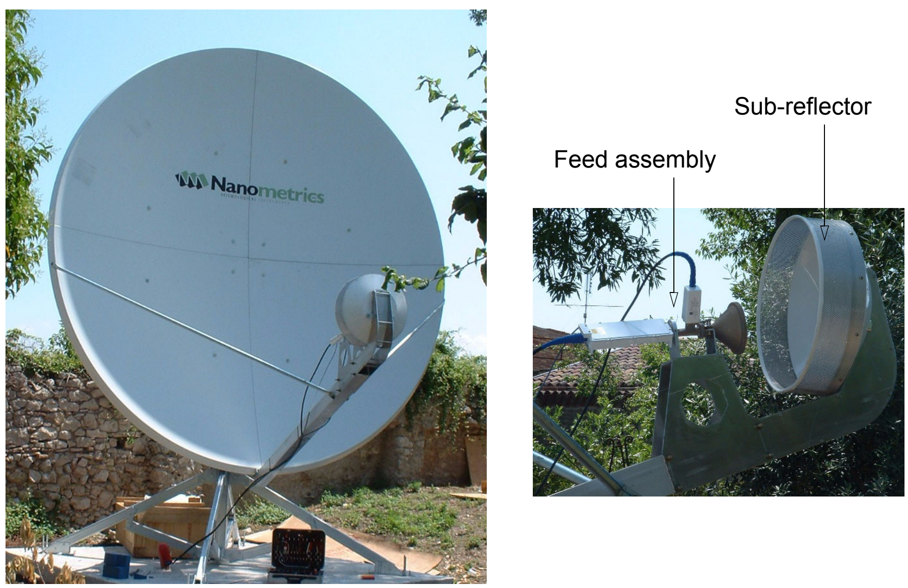
The installation process is:

1. Select the mounting location for the enclosure. The area should be secure, it should avoid temperature extremes or water entry, and the wall should be capable of supporting a 100 kg load using 4 mounting bolts. Allow space to the left of the unit so the doors can open.
2. Select a cable path to the enclosure. Protect cables from damage due to movement or exposure to the elements.
3. Mount the enclosure and run the cables.
4. Install the Carina Hubs and Splitter shelf.
5. Connect the power cables and LAN cables. Do *not* connect the RF transmit cable yet.
6. Configure the Carina Hubs with the Nanometrics UI software.
7. Determine the uplink frequency to be used during the initial satellite tests. This may be different from the leased network frequency, and will be chosen by the satellite provider.
8. Ensure that all Carina Hubs are configured with the correct gain compensation maps for SSPB, IFL, and transmitter sections. These vary with frequency: ensure that the equipment is programmed with values that apply at the uplink frequency.
9. Ensure that the transmit carrier center frequency and power levels have been programmed correctly.
10. Install the antenna systems and do the alignment tests as outlined in section 11.3.
11. Secure all cables, connections, and fasteners, and lock the equipment enclosure. The enclosure should not be opened in normal operation.
12. Regularly check the Carina Hub internal SOH temperatures during the first year of operation to confirm that the enclosure does not require additional cooling.

11.3 Install and test the antenna subsystem

1. Select a site for the antenna. The site should have an unobstructed view of the satellite arc, be clear of high-power radio transmitters, and have a foundation which can maintain the antenna within 0.1 degrees of its initial alignment.
2. Install the antenna systems in accordance with the manufacturer's documentation. See also section 12.4 "Install the antenna subsystem" on page 121. Differences in the procedure for installation of a central site antenna include:
   - Attaching the feed assembly: For prime focus antennas, the feed is mounted as shown in Figure 12-1 on page 121. For dual-optic antennas, the feed is mounted toward the sub-reflector, as shown in Figure 11-1.
   - The Carina Hub is mounted on a rack indoors, therefore there is no transceiver mounting bracket to install on the antenna.
   - The GPS antenna typically is not mounted on the antenna. It can be mounted in any suitable location with a clear view of the sky.

Figure 11-1 Feed assembly (dual-optic antennas)



3. Align the antenna. See section 12.5 on page 123. Differences in the procedure for aligning a central site antenna include:
   - Carina is an indoor unit. If a temporary LAN connection cannot be made to the indoor Carina (for example, conduit access only) and weather does not permit use of the Carina during antenna alignment, you may use a Cygnus instead.
   - If a waveguide combiner is being used on the hub antenna, the maximum repeatable twist angle for the flex/twist waveguide is ±90°. Therefore, when adjusting antenna polarization remain within the range ±90°.
4. Do the antenna alignment tests. See section 12.6 on page 135.
5. Secure the cables to the antenna structure and conduit at regular intervals.
6. Ensure that the cable connections are tight. Weatherproof the SSPB and LNB coaxial cable connections with rubber tape and then vinyl tape.

11.4 Install the acquisition system

Libra central sites include the Naqs acquisition system. The Naqs system connects to the Carina Hubs via Ethernet LAN.

11.4.1 Install Naqs acquisition computer systems

1. Ensure that the power supplies are correctly configured for your AC power source (110 or 220 V AC) before applying AC power to the acquisition hardware.
2. Install acquisition computer hardware in accordance with the manufacturer's instructions.
3. Refer to the appropriate software manuals for installation and operating instructions for Nanometrics acquisition and analysis software.

11.4.2 Connect Naqs to the Carina Hubs

The Naqs computer is attached to the Carina Hubs through Ethernet LAN connections. The Cable Entry Kit includes an 8-port Ethernet hub, and these ports can be used to connect any combination of Carina Hubs, Naqs computers, or other devices.

While the Libra central site LAN can be shared on the facility's LAN, we recommend isolating these two for reliability reasons.

11.4.3 Configure Naqs

For data to be received by a Naqs server, the Carina, and the Cygnus and associated Trident digitisers must be included in the Naqs station file (naqs.stn). Table 11-1 provides an overview of the basic configuration tasks. See the NaqsServer manual for more detailed information, such as descriptions of parameters in the naqs.stn file sections.

Table 11-1 Overview of basic Naqs configuration tasks

Task	Description	Section type in the naqs.stn file
▸ Add the instruments to the **naqs.stn** file	▸ Define "Carina" as an instrument prototype for the network, if it is not already defined. ▸ Define "Cygnus" as an instrument prototype for the network, if it is not already defined. ▸ Define "Trident" as an instrument prototype for the network, if it is not already defined.	[InstrumentPrototype]
	▸ Add each Carina and Cygnus to Naqs. ▸ Add the Trident(s) associated with each Cygnus to Naqs.	[Instrument]

Table 11-1 Overview of basic Naqs configuration tasks (Continued)

Task	Description	Section type in the naqs.stn file
▸ Add the data channels to the **naqs.stn** file	▸ Define seismic channel(s) of the type that will be processed by the digitiser, if applicable and if these channel types are not already defined.	[ChannelPrototype]
	▸ Define seismic channel(s) from the digitiser associated with each Cygnus.	[Channel]
	▸ Define serial channel(s) from data sources associated with each Cygnus, if applicable and if these channel types are not already defined.	[SerialChannelPrototype]
	▸ Define serial channel(s) from data sources associated with each Cygnus.	[SerialChannel]
▸ Apply the changes to the **Naqs Server**	▸ Restart NaqsServer to start using the changes in the configuration.	

11.5 Configure network security

11.5.1 Levels of user access

Caution Commands available to operators of Libra satellite networks can disrupt data collection or violate terms of the satellite lease contract. Tech access for Libra systems should only be used by operators having a thorough understanding of Libra systems and satellite link design.

There are two levels of access for network instrument operation and configuration:

- user – allows a user to monitor system operation and configuration settings.
- tech – allows a user with tech access to change network instrument settings and upload new software. Tech level access should be restricted to those who are responsible for installing, configuring, and maintaining the network, and who have a detailed understanding of network requirements (for example, satellite lease restrictions for Libra networks).

Configure operator access through the Nanometrics UI Configuration > Access screen.

11.5.1.1 Log in as user

The User level prevents an operator from accidentally corrupting network configuration, which could lead to data loss or violation of the satellite lease agreement. The default Login for this access level is **user** and default password is **nmx**. We recommend changing the password immediately upon system installation.

11.5.1.2 Log in as tech

The Tech login account has access to network configuration options. The default Login for this access level is **tech** and default password is **nmx**. We recommend changing the password immediately upon system installation.

11.5.2 Sharing data: Security keys

Security keys control data access in the satellite link, and do not control data access on the central site LAN. We recommend using security keys in all TDMA configurations to prevent unwanted data access. See also section 6.2.6 “Security keys” on page 65.

Configure the security key in the Nanometrics UI Configuration > TDMA > Create Next TDMA panel.

11.5.3 Other network security issues

Libra is an IP communications network. Connection of the central station to the Internet can expose the entire network to malicious interference.

- Use safety measures such as firewalls to protect the Libra network from the open Internet.

11.6 Central station commissioning checklist – Example

Central site name: ____________________________ Installation date: ________________

Satellite elevation angle: _______ Satellite azimuth (magnetic): _______

11.6.1 Installation equipment checklist

- ❑ Antenna pointing chart
- ❑ Carina as-shipped sheets
- ❑ Carina Transceiver, SN:_______
- ❑ Antenna feed assembly:
  - ❑ SSPB, SN:_______
  - ❑ LNB, SN:_______
- ❑ Tx and Rx RF cable
- ❑ GPS antenna, brackets
- ❑ GPS antenna cable
- ❑ Installation kit (tape, fasteners, etc.)

11.6.2 Installation tools checklist

- ❑ Laptop computer
  - ❑ Cygnus data port test cable
  - ❑ Cygnus Ethernet port cable
  - ❑ Ethernet null (crossover) cable
  - ❑ LAN extension cable
  - ❑ Nanometrics UI software
  - ❑ Terminal emulation software
  - ❑ Naqs application components: Nanometrics DLLs, NaqsServer, NaqsClient, Java
  - ❑ NaqsServer configuration files (Naqs.ini and Naqs.stn)
  - ❑ Waveform monitoring software (DataServer and Waveform, or ViewDat)
- ❑ Oscilloscope and probes
- ❑ Multimeter (V/I/R)
- ❑ Spectrum analyser or radio test set
- ❑ Gravity inclinometer
- ❑ Magnetic compass with mirror reflector
- ❑ All tools listed in the antenna manual
- ❑ 10mm socket
- ❑ 10mm wrench
- ❑ Adjustable wrench
- ❑ 3mm Allen key
- ❑ Splitter, F connectors 2-way with DC path
- ❑ F(m)/F(m) cable, 1m
- ❑ F(m)/F(m) cable, 10m
- ❑ F(f)/N(m) adapter (x2)
- ❑ N(f)/N(m) DC block, 2GHz
- ❑ Telephone access to satellite provider
- ❑ Spare fuses for Carina

11.6.3 Procedures checklist

1. Acquisition system installation

- ❑ Ensure that the power supplies are correctly configured for your AC power source.
- ❑ Install acquisition computer hardware in accordance with the manufacturer's instructions.
- ❑ Install Nanometrics acquisition and analysis software.
- ❑ Configure Naqs.

2. Satellite equipment installation

- ❑ Install the antenna and feed assembly
- ❑ Feed horn membrane is intact
- ❑ GPS antenna installed
- ❑ Attach the RF cables to the Carina

Caution Transmitting before the antenna is aligned and tested will violate the satellite lease. Do not connect the transmit cable to the SSPB yet.

- ❑ Connect the GPS cable to the Carina

3. Satellite antenna alignment and testing

- ❑ Set the elevation angle (El) to _____ degrees
- ❑ Set the azimuth angle (Az) to ______ degrees magnetic
- ❑ Set up the test equipment
- ❑ Power up the Carina
- ❑ Adjust the azimuth as required until Rx RF shows traffic
- ❑ Identify the satellite by spectral signature
- ❑ Peak the antenna to within ±0.1 dB and verify cross pol isolation
  - ❑ Find a reference signal on the cross-pol
  - ❑ Fine-tune azimuth and elevation to maximize signal strength on the main lobe
  - ❑ On the co-pol, adjust polarization until the minimum null has been achieved
  - ❑ Confirm cross-pol isolation of at least 30 dB
- ❑ Do the antenna alignment tests
  - ❑ Are different frequency gain tables required? Y N
  - ❑ Configure the Carina Test mode
  - ❑ Contact the satellite provider and follow their instructions

Notes:

3. Satellite antenna alignment and testing (Continued)

- ❑ Power down the Carina
- ❑ Disconnect the transmit RF cable from the SSPB
- ❑ Power up the Carina and log on through the Nanometrics UI
- ❑ Set the Carina to Normal mode and restore the configuration from the test settings, if applicable, to route the IP traffic through the satellite link
  - ❑ Normal mode
  - ❑ GPS/PLL timing FINE_LOCK
  - ❑ Uplink frequency correct
  - ❑ Satellite longitude correct
  - ❑ Satellite LO frequency correct
  - ❑ TDMA table correctly identifies the Carina hub
- ❑ # GPS satellites received: _____ (need 4+)
- ❑ Confirm Carina receives remote site transmissions
- ❑ Time1 (hh:mm):_____
  Number of Bad Rx bursts:_____
  (a) Number of Bad Rx Packets: ______
  (b) Number of Good Rx Packets: ______
- ❑ Observe seismic data trace on computer.
- ❑ Confirm traces are continuous without excessive noise.
- ❑ Time 2 (hh:mm):_____
  Number of Bad Rx bursts:_____
  (c) Number of Bad Rx Packets: ______
  (d) Number of Good Rx Packets: ______
- ❑ Confirm receive >99% good packets from Carina: (c-a)/(d-b) < 0.01

4. Transmission tests

- ❑ ! Power down Carina (! Warning - shorting Tx RF cable will blow an internal Libra fuse)
- ❑ Attach Tx RF cable to SSPB
- ❑ Power up Libra terminal
- ❑ Confirm remotes are transmitting packets
- ❑ Disconnect data cable from Acquisition Computer, reconnect and confirm that gaps are filled in (Use Waveform) - This test proves that ReTx requests are generated by the Acquisition Computer and serviced by the remotes.

5. Hub station tests

- ❑ Successfully ping one remote's satellite (LIBRA) IP from Naqs
  (extend wait time, i.e. Ping 10.1.0.xxx -w 15000)
- ❑ NAQS receives seismic data (Waveform)

5. Hub station tests (Continued)

❑ Seismic data is being written into the ringbuffers.

❑ Lost packets are being retransmitted and inserted in the ringbuffers. (Use RBFSUM)

❑ NAQS receives current SOH.

6. Secure the site

❑ Configure network security such as passwords and security keys

❑ Secure all mechanical fasteners

❑ Secure all cable connections

❑ Weatherproof all exposed cable connections

❑ Lock the hub enclosure

7. Confirmation (>2 hours later)

❑ NAQS contains complete data after ReTx interval (RBFSUM)

8. Confirmation (>12 hours later)

❑ NAQS contains complete data with no gaps (RBFSUM)

❑ ReTx / hour < 5%

Chapter 12 Commissioning a Remote Station

This chapter provides the procedures for installing, testing, and commissioning a remote station for a typical Libra VSAT network. A prerequisite for these procedures is that a site plan has been completed, and the civil works for the site—such as equipment vaults, antenna foundation, and cable conduits—have been prepared in advance. An example of an installation checklist is provided in section 12.10 on page 143.

The values provided in these procedures are examples only:

- Replace the parameter values and instrument settings provided in these example procedures with values appropriate to the remote site that is being installed.

Caution Transmitting from the remote site before the site has been configured correctly will violate the satellite lease. Do not connect the transmit RF cable (Cygnus RF OUT) to the SSPB until the antenna is aligned and the Cygnus is configured correctly.

12.1 Preinstallation

We recommend that you do a preinstallation check of the remote site equipment at the central site.

1. Unpack the equipment and check for shipping damage.
2. Install a remote antenna at the central site and use this to test all remote station equipment, using the applicable installation procedures described in this chapter. Check functionality:
   - Equipment was not damaged in transit
   - The satellite link from the central site
   - Correct configuration of the remote site equipment and central site equipment

   You may leave this antenna installed to use for training at the central site.

   Once the remote site installations and training sessions are completed, this antenna can be installed at the final remote site, or it can be installed permanently at the central site and used for Cygnus maintenance.

3. Prepare the laptop that will be used during the remote site installation:
   a) Check for and install as required:
      - Nanometrics UI software
      - Terminal emulation software
      - Naqs application components: Nanometrics DLLs, NaqsServer, NaqsClient, Java
      - Waveform monitoring software (DataServer and Waveform, or ViewDat)
   b) Copy the NaqsServer configuration files from the central hub Naqs acquisition computer:
      - C:\nmx\user\Naqs.ini
      - C:\nmx\user\Naqs.stn
4. Re-pack the equipment carefully before transporting it to the remote site.

12.2 Contact the satellite provider

For remote site commissioning, you will need to contact the satellite provider at these two points (refer to your satellite lease for contact information):

- At least 24 hours before you go to the remote station, to exchange information that will be needed to commission the station. For example, the satellite provider will verify information such as your customer ID and your station location.
- After you have aligned the antenna, but before you start transmissions from the station. The satellite provider will ask you for information about your VSAT station, and will then guide you through the transmission tests.

12.3 Install the power subsystem

Warning Installing a power system incorrectly may cause injury, or damage to equipment. Before installing the solar array or connecting any of the electrical components, review all applicable local and national codes, and all relevant manuals.

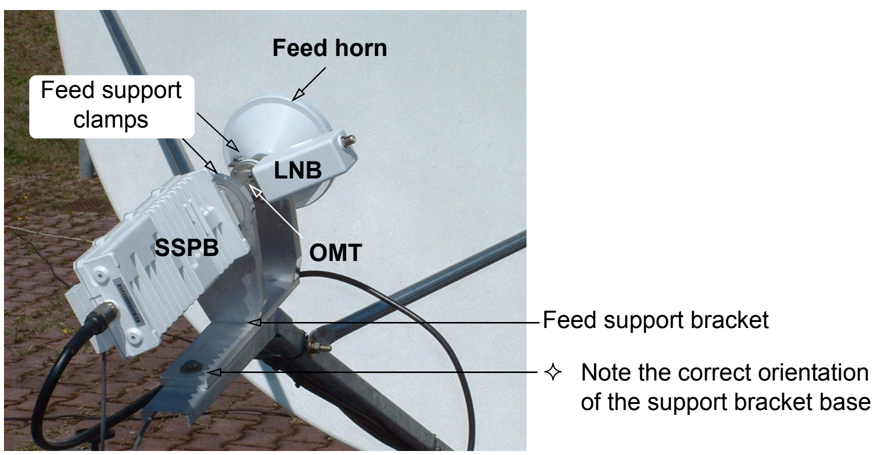
1. Install the solar power system components in accordance with the manufacturers' recommendations. Supplementary information is provided in the Nanometrics Solar Power System Installation Guide.
2. Before you connect the DC power cord to the Cygnus, ensure that the power supply connection uses the expected values for the Cygnus DC power connector, to avoid damaging the Cygnus:
   - Pin A, +12V
   - Pin B, ground
   - Pin C, 12V return

   ▸ Put the positive probe of a voltmeter in Pin A and the negative probe in Pin B, and confirm DC voltage is between +11 and +16V DC.
3. Ensure that the batteries are fully charged before powering up the VSAT equipment.

12.4 Install the antenna subsystem

1. Physically install the antenna subsystem in accordance with the manufacturers' recommendations.
   a) Install the antenna support or foundation. Ensure that the antenna mast is as close to vertical as possible. If not otherwise specified in the antenna manual, ensure that the antenna mast is within ±2°of vertical.
   b) Assemble the antenna. Use a compass and the values from the antenna pointing chart to orient the antenna support azimuth. If not otherwise specified in the antenna manual, ensure that the azimuth is within ±10° of the expected position of the satellite. (See also section 12.5.1.2 "Coarsely adjust the antenna azimuth" on page 124, for information on determining the magnetic azimuth.)
   c) Assemble and install the feed (Figure 12-1):
      i. Lubricate all feed component threads before assembly, using the oil capsules that are provided.
      ii. Use gaskets on all feed component connections to prevent moisture from entering the waveguide. Apply a thin layer of silicone grease on the gaskets to further improve the seal. Do not allow this grease to seep into the waveguide cavity.
      iii. To mount the SSPB, use the mounting bolts supplied by Nanometrics. Do not use the bolts supplied by the antenna manufacturer.
      iv. Keep the SSPB calibration data sheet that is included in the SSPB shipping box. You will need the calibration information for future maintenance.

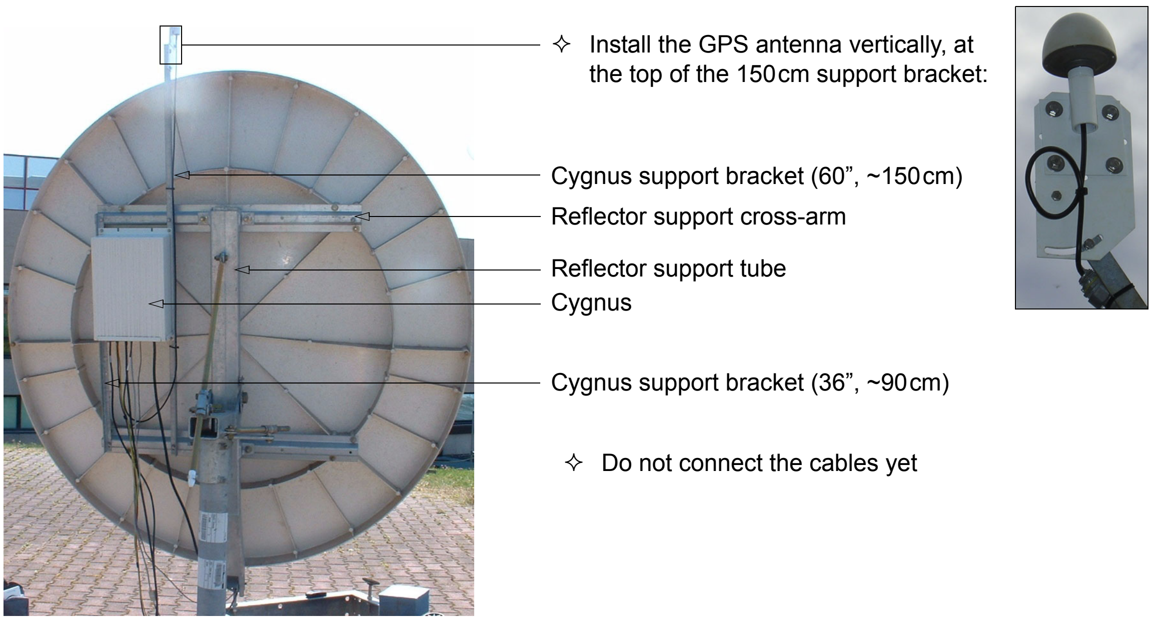
Figure 12-1 The feed assembly



   d) Ensure that the feed is in the correct position relative to the antenna reflector. For Prodelin offset feed antennas:
      i. Loosen the 2 feed assembly mounting bolts and slide the feed towards the reflector as much as possible (typically, the feed can be moved at least 2mm).
      ii. Tighten the feed assembly mounting bolts.
2. Install the GPS antenna vertically, at the top of the 150cm Cygnus support bracket (Figure 12-2).

3. Install the Cygnus support bracket on the back of the antenna.
4. Mount the Cygnus either on the back of the antenna (the typical installation), or in an equipment hut or vault.
    - To mount the Cygnus on the back of a standard 1.8 m antenna, use the mounting bracket included in the installation kit 12047 (for example, Figure 12-2). Do not connect the cables yet.
    - To mount the Cygnus in an equipment hut or vault, attach the Cygnus to the wall using a universal mounting plate, if one was ordered. Do not connect the cables yet.

Figure 12-2 Standard mounting of Cygnus and GPS antenna on a 1.8 m antenna



5. Install the SSPB temperature sensor according to the installation sheet included.
6. Run the cables from the equipment hut or vault to the antenna location. Protect cables from sources of abrasion, electrical discharge, and crushing force. Typically, outdoor runs of cable should be protected by conduits (Figure 12-3).
7. Tighten all antenna assembly bolts.

Figure 12-3 Cable conduits

12.5 Align the antenna

Warning The Cygnus and Carina transceivers output DC power on RF cable center conductors. Shorting either the transmit or receive cable to the transceiver chassis may damage the unit. Power down the transceiver before connecting or disconnecting these cables.

Antenna alignment includes these tasks:

1. Point the antenna (section 12.5.1) – Point the antenna accurately to the correct azimuth and elevation for the satellite from a given earth station, and confirm that this is the correct satellite.
2. Peak the antenna (section 12.5.2) – Fine-tune the azimuth and elevation with incremental adjustments until you obtain the peak signal strength, and then adjust the feed angle to achieve the required cross-polarization (cross-pol) isolation as required by the satellite provider. (Cross-pol isolation is required only for antennas with linearly polarized feeds.)

You should have:

- Completed configuration worksheets appropriate for the site (see section 1.3 “Network planning forms” on page 4 for the list of example forms)
- The information requested from the satellite provider (section 11.1 on page 109 for remote stations, section 11.1 on page 109 for central stations)
- Installation tools and equipment appropriate for your site (see the example checklists: section 12.10 on page 143 for remote stations, section 11.6 on page 115 for central stations)

12.5.1 Point the antenna

Point the antenna toward the expected location of the satellite, and confirm that this is the correct satellite.

See also: For information on using an antenna pointing chart, see section 10.2.1.1 “Satellite antenna pointing chart” on page 102.

12.5.1.1 Coarsely adjust the antenna elevation

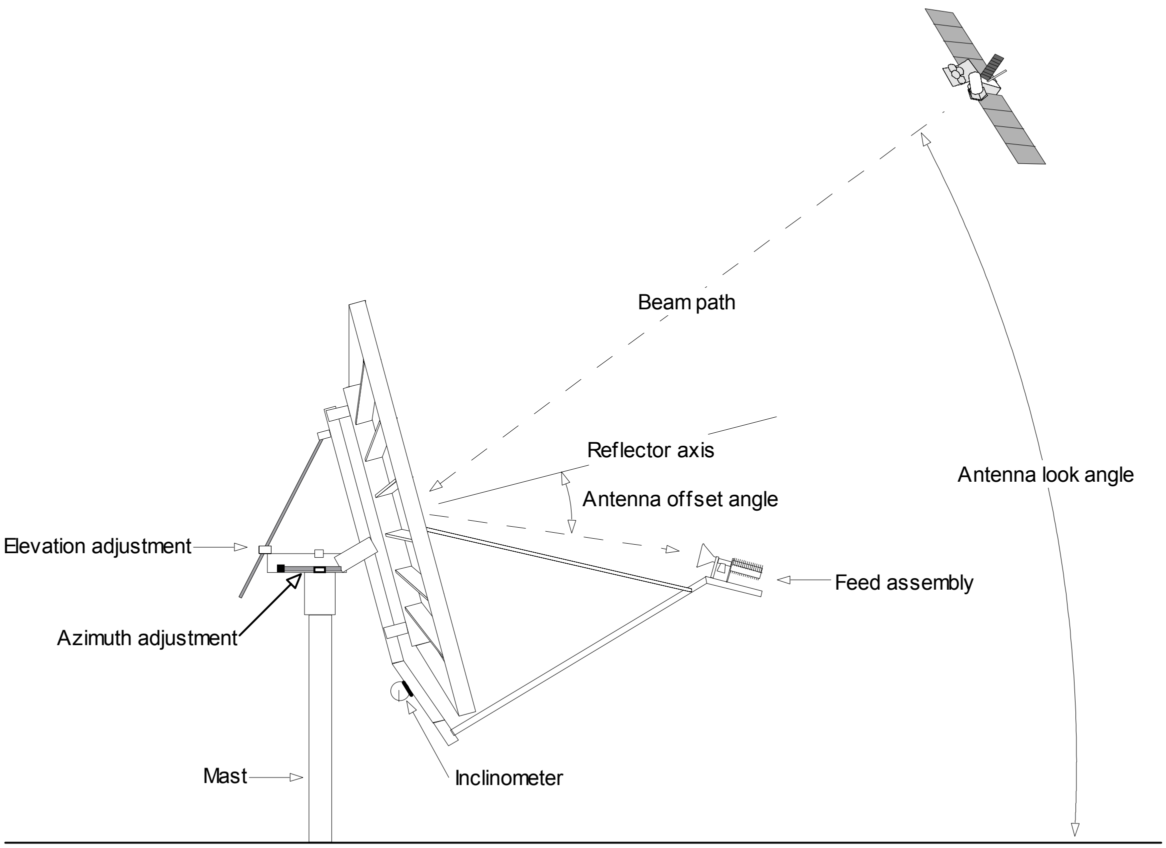
Set the antenna elevation as accurately as possible (±1°). If the antenna elevation is outside the recommended range, the received signals may be so weak that you will not find the satellite.

1. Loosen the elevation adjustment nuts to allow sufficient movement of the reflector along this axis (Figure 12-4; see also the satellite antenna manual).
2. Attach the inclinometer to the reflector. See the antenna manual for the recommended placement of the inclinometer.
   - For offset feed antennas, there might be an attachment point provided that compensates for the offset angle. If this is not available, attach the inclinometer perpendicular to the reflector axis.
     - If the inclinometer is attached perpendicular to the reflector axis, compensate for the antenna offset angle when setting the antenna look angle (for

example, Figure 12-4). See the antenna manual for the offset angle value.

3. Using the inclinometer as a guide, set the antenna look angle to the elevation angle (El) given in the antenna pointing chart.
   - Set the antenna elevation as accurately as possible, within ±1°.
4. Snug the elevation adjustment nuts. (That is, tighten the nuts just enough to hold the reflector at the correct elevation while you make the next adjustments. You will need to loosen the nuts again in subsequent procedures.)

Figure 12-4 Coarse elevation adjustment



12.5.1.2 Coarsely adjust the antenna azimuth

1. Loosen the azimuth adjustment nuts to allow sufficient movement of the reflector along this axis (see also the satellite antenna manual).
2. Confirm the local magnetic declination.
   - If the antenna pointing chart for your site does not include magnetic declination correction for the azimuth reading, then find out the magnetic declination for the location and take this into account for the antenna pointing chart.

     To use magnetic declination information:
     - Subtract East declination from true azimuth
     - Add West declination to true azimuth

For example:

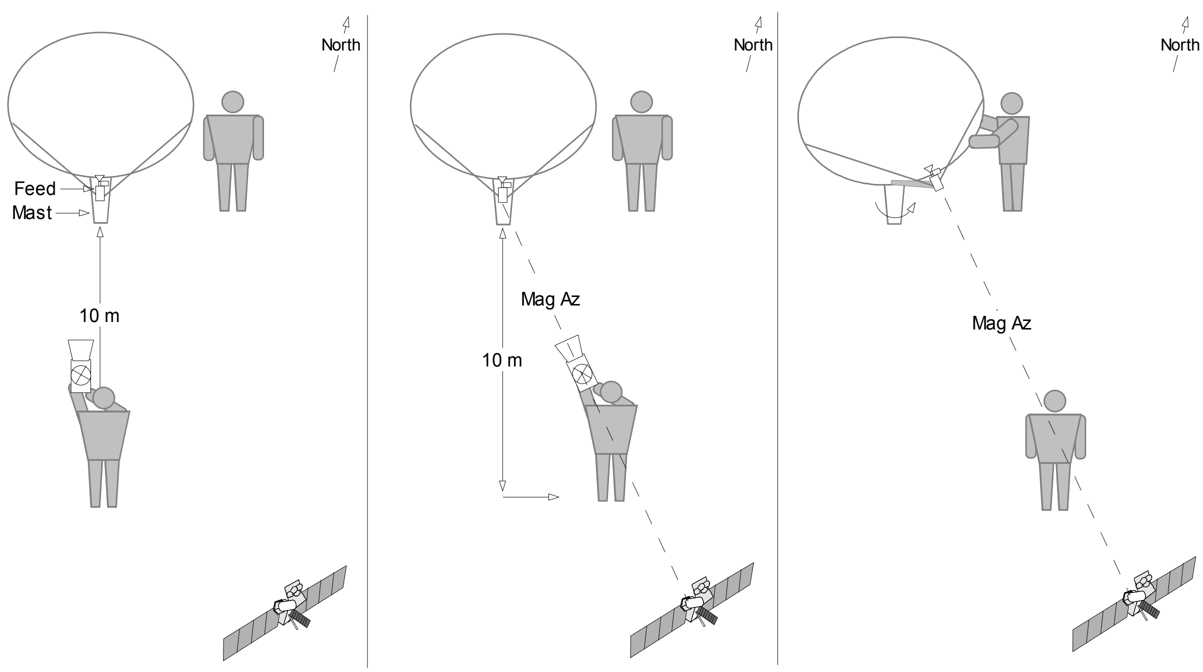
- If azimuth from true north is 160 degrees and local magnetic declination is 8 degrees East, azimuth from magnetic north is 152 degrees.
- If azimuth from true north is 160 degrees and local magnetic declination is 8 degrees West, azimuth from magnetic north is 168 degrees.

Note Check the area for sources of magnetic fields, for example electric motors, that may interfere with compass readings.

3. Adjust the antenna azimuth to match the magnetic azimuth value (Mag Az) in the antenna pointing chart.
   a) Stand 10 m in front of the antenna, and then move sideways until you are directly in front of the feed (Figure 12-5).
   b) Sight through a compass to determine the azimuth from the antenna mast to you. Use a magnetic compass with a mirror reflector.
   c) Using the compass reading as a guide, move left or right until you are located precisely between the antenna and the satellite.
   d) Have a helper adjust antenna azimuth until the antenna points directly at you.

   This should set the antenna azimuth to within 1 or 2 degrees.
4. Snug the azimuth adjustment nuts.

Figure 12-5 Example of coarse azimuth adjustment



12.5.1.3 Set up the alignment test equipment

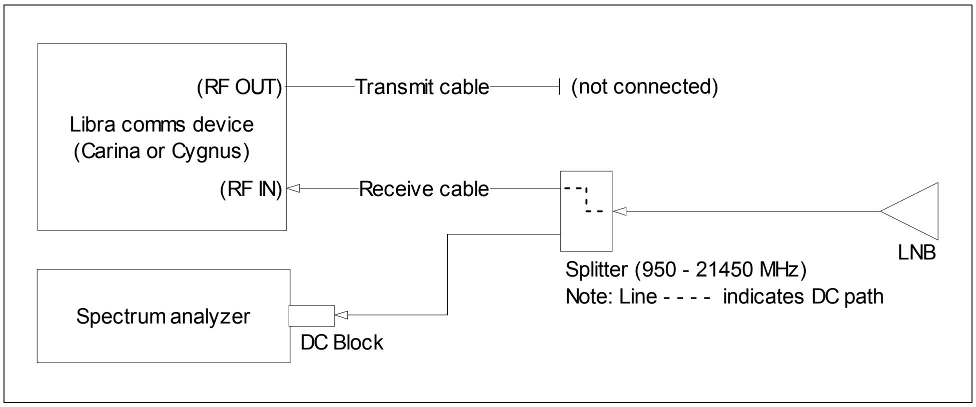
1. Ensure that the power supply is *not* connected to the Cygnus.
2. Connect the Cygnus and the test equipment (Figure 12-6):
   a) Connect the RF receive cable to the Cygnus (RF IN).

b) Connect the RF transmit cable to the Cygnus (RF OUT). Do *not* connect the RF transmit cable to the SSPB.

Warning The spectrum analyzer may be damaged by DC voltage—protect it with a DC block as needed.

c) Connect the splitter and the spectrum analyzer to the Cygnus RF receive cable, and the LNB to the splitter.

Figure 12-6 Connect the test equipment for antenna alignment



3. Power up the spectrum analyzer and set the configuration (for example, as shown in Figure 12-7).

Figure 12-7 Spectrum analyzer* settings for test equipment setup and satellite identification

Parameter	Setting
Span	1 GHz across screen (= 100 MHz per division)
Center frequency	1200 MHz
Reference level	–40 dBm
Amplitude	10 dB/division
Resolution bandwidth	automatic
Video bandwidth	automatic
Sweep time	automatic
Video averaging	off

* Spectrum analyser recommended capabilities:
Frequency Range 10 MHz to 1.5 GHz
Minimum resolution bandwidth (RBW) less than 1000 Hz (100 Hz preferred)
Noise floor below –130 dBm/Hz (required) or –140 dBm/Hz (preferred)
Averaging which can be enabled for successive sweeps
Display trace “peak hold” capability
Capability to capture spectral plots

4. Confirm that the LNB powers on:

a) Note the noise floor level on the spectrum analyzer screen.

b) Connect the power supply to the Cygnus, and observe the noise floor level. If the noise floor level rises, this indicates that the LNB is powered on.

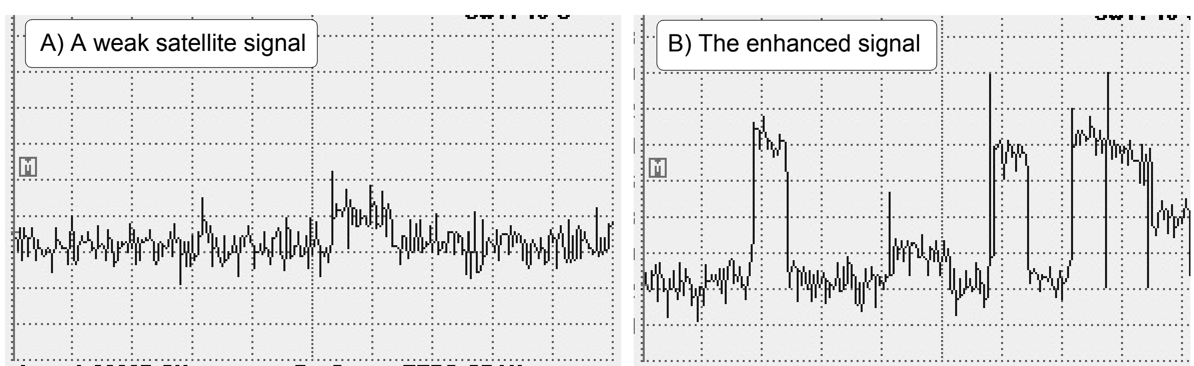
12.5.1.4 Identify the satellite

To identify the satellite, roughly peak the antenna and monitor the received signal with a spectrum analyzer. Compare the signal with these references:

- Compare the received spectrum with the printout of the spectral signature supplied by the satellite provider (for example, Figure 10-6 on page 100).
- View other Libra carriers from your network, if your network is already transmitting on the satellite (for example, Figure 10-7 on page 101).

1. Use the test equipment setup described in section 12.5.1.3 on page 125. Set up the spectrum analyzer as required to view the entire downlink spectrum (for example, Figure 12-7).
2. Look for a satellite signal on the spectrum analyzer. These will look like “bumps” in the noise floor (for example, Figure 12-8 A).
   - If you do not see a satellite signal, search for a satellite using the procedure described in section 12.5.1.5.
3. Roughly peak the antenna on the received signal, until the displayed signal is strong enough to be used to identify the satellite (for example, Figure 12-8). (Do not spend too much time peaking the antenna until you are sure this is your satellite. Within a few seconds you should be able to align the antenna within 5–10 dB of beam peak.):
   a) Loosen the azimuth nuts and adjust the azimuth to peak these signals. Snug the azimuth nuts.
   b) Loosen the elevation nuts and adjust the elevation to peak these signals. Snug the elevation nuts.

Figure 12-8 Example of a weak received signal enhanced by roughly peaking the antenna



Note Ensure that you are using a recent spectral signature, as the signature will change as customer links are added to the satellite.

4. Compare the spectrum displayed by the analyzer to the printout of the spectral signature for your network downlink polarization (if you are uncertain of the comparison, set your spectrum analyzer to the same settings shown on the printout of the spectral signature):
   - If they are the same, you are looking at the correct satellite and pol. Snug the adjustment nuts.

- If the spectrum displayed by the analyzer does not match the spectral signature, loosen the feed support clamps (Figure 12-1 on page 121), rotate the feed 90 degrees, and check again.
  - If the spectrum still does not match, then this is probably the wrong satellite. Search for the correct satellite (see section 12.5.1.6 “Find adjacent satellites – Supplementary procedure” on page 130).

5. Change the spectrum analyzer settings to be able to view the Libra carriers (for example, Figure 12-9).

Figure 12-9 Spectrum analyzer settings to identify the satellite with Libra carriers

Parameter	Setting
Span	1MHz
Center frequency	1269.15MHz* center frequency = uplink frequency (14.38715GHz) – satellite local oscillator frequency (1.818GHz) – LNB local oscillator frequency (11.3GHz) = 1.26915GHz. *The values for the uplink frequency and the satellite local oscillator frequency are written on the satellite lease or are supplied by the satellite provider. The value for the LNB local oscillator frequency is stamped on a label on the LNB.
Reference level	adjust as required
Amplitude dB/division	10dB
Resolution bandwidth	automatic
Video bandwidth	automatic
Sweep time	automatic
Video averaging	off

6. Look for bursting Libra carriers with 100kHz width (for example, see Figure 10-7 on page 101), if stations from your network are already transmitting.
   - If the Libra carriers are present, you are looking at the correct satellite and pol. Snug the adjustment nuts and continue with antenna alignment, starting with section 12.5.2 “Peak the antenna” on page 131.
   - If you do not see the Libra carriers, then loosen the feed support clamps, rotate the feed 90 degrees, and check again.
     - If you still cannot find the Libra carriers, then this is probably the wrong satellite. Search for the correct satellite (see section 12.5.1.6 “Find adjacent satellites – Supplementary procedure” on page 130).

12.5.1.5 Find a satellite – Supplementary procedure

Use these procedures to find a satellite, for example if a satellite signal is not evident following the coarse adjustments.

12.5.1.5.1 Confirm the expected location

1. Ensure that the antenna is pointed toward the expected location of the satellite. Confirm that:
   - Antenna elevation is set within 1 degree for this latitude and longitude (section 12.5.1.1 on page 123).
   - Antenna azimuth is set within 1 degree for this latitude and longitude (section 12.5.1.2 on page 124).
2. Correct the azimuth and elevation if required, and check again for a satellite signal.
   - If a weak signal is evident:
     i. Loosen the azimuth and elevation adjustments.
     ii. Make small adjustments to the elevation and then to the azimuth to enhance the signal.
     iii. Once the signal is strong enough to be identifiable, return to pointing the antenna, starting at section 12.5.1.4 “Identify the satellite” on page 127.
   - If there is still no signal evident, try searching the expected area to find a satellite (section 12.5.1.5.2).

12.5.1.5.2 Search the expected area for a satellite

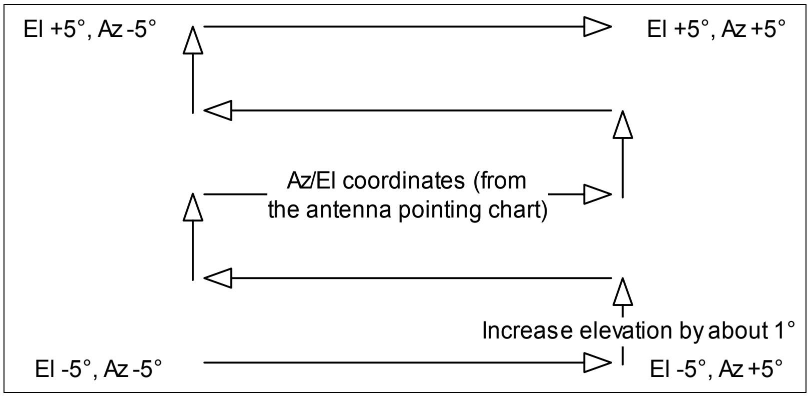
Adjust the antenna position using a sweep pattern to search the area that should contain the satellite (for example, Figure 12-10) while watching the spectrum analyzer for a signal.

1. Use the test equipment setup described in section 12.5.1.3 on page 125. Set up the spectrum analyzer as for identifying the satellite, for example Figure 12-9 on page 128.
2. Lower the antenna elevation to approximately –5 degrees from the expected elevation, and move the azimuth to approximately –5 degrees from the expected azimuth.
3. Slowly move the azimuth through small changes in position to approximately +5 degrees of the expected location, while monitoring the spectrum analyzer screen for a signal.

   Change the position of the antenna by at most a few millimetres, or fractions of a turn of the adjustment nut, for each increment. This will allow the spectrum analyzer to display a signal if available.
   - If you find a satellite, snug the adjustment nuts and continue with the antenna alignment, starting with section 12.5.1.4 “Identify the satellite” on page 127.
   - If you do not find a satellite:
     i. Increase the antenna elevation angle by approximately 1 degree.
     ii. Slowly sweep the azimuth again, from +5 degrees to –5 degrees across the expected azimuth.
     iii. Repeat this sweep pattern until a satellite is found, or until you have searched to a point at approximately +5 degrees from the expected elevation and +5 degrees from the expected azimuth.

4. If you do not find the satellite in the expected area, rotate the feed 90 degrees and sweep azimuth and elevation again.
   - If you still cannot find the satellite, carefully repeat the antenna pointing procedure starting with the coarse adjustments (section 12.5.1.1 on page 123).

Figure 12-10 Example sweep pattern to find a satellite



12.5.1.6 Find adjacent satellites – Supplementary procedure

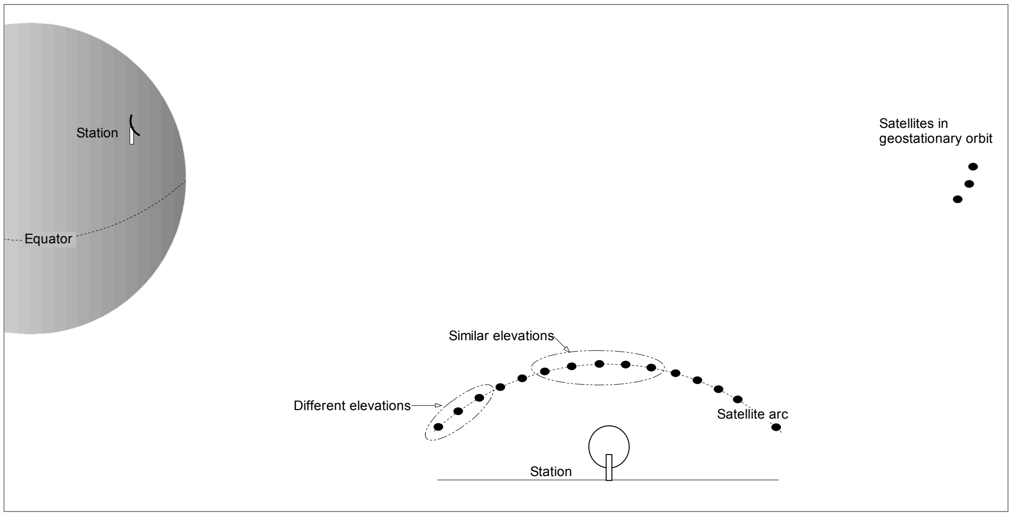
Use this procedure to search for the correct satellite along the arc, for example if the satellite found after the initial antenna alignment is not the correct satellite. Adjust the antenna position to search along the satellite arc for adjacent satellites while watching the spectrum analyzer for a signal.

1. Use the test equipment setup described in section 12.5.1.3 on page 125. Set up the spectrum analyzer as for identifying the satellite, for example Figure 12-9 on page 128.
2. Loosen the adjustment nuts.
3. Slowly change the antenna azimuth by about 2 degrees.
4. Slowly adjust the elevation by a small amount towards the satellite arc, and watch the spectrum analyzer for the next satellite spectrum.

   The appropriate size and direction of the elevation adjustment will depend on two factors (for example, Figure 12-11):
   - The station location – The shape of the satellite arc depends on the station latitude. The elevation depends on the station longitude relative to the satellite, therefore the relative position of the satellite along the arc.
   - The location of the satellite along the arc relative to the initial azimuth and elevation of the antenna.
5. When you find a satellite, identify it. Compare the received spectrum to the spectral signature, and identify other Libra carriers (see also section 12.5.1.4 on page 127).
   - If this is still not the correct satellite, continue to search along the arc until you find the correct satellite.

6. Once you have found the correct satellite, snug the adjustment nuts. Continue with the antenna alignment procedure: Go to section 12.5.2.

Figure 12-11 Example of satellite elevations along the satellite arc



12.5.2 Peak the antenna

To peak the antenna, use a reference signal to maximize the main lobe of the antenna, and then minimize the null very accurately. Rotate the feed as required to achieve proper isolation between the vertical and horizontal links (cross-pol isolation), to avoid interfering with another uplink that may exist on the opposite polarization at the same frequency.

A properly peaked antenna will have these characteristics:

- It will be aligned accurately on the satellite, within ±0.1–0.2 dB of accuracy on the peak of the main lobe of the antenna
- It will have the polarization adjusted to have proper cross-pol isolation as required by the satellite provider. Typically, this is 30 dB.)
  (Polarization adjustment is required only for antennas with linearly polarized feeds, which is typically the case for Libra systems. Antennas with circularly polarized feeds do not require polarization adjustment.)

12.5.2.1 Find a suitable reference signal

Try to find a suitable reference signal on the opposite polarization (cross-pol) to your network polarization (co-pol).

- If you can find a suitable reference signal only on the co-pol, adapt the peaking procedures as required.

An ideal reference signal, such as a (linearly polarized) satellite beacon, has all of these characteristics:

- It is linearly polarized
- It is strong, stable (that is, it does not use TDMA), and unmodulated (therefore, it will have a well-defined peak amplitude)

- The frequency on the opposite polarization is not occupied by another carrier (that is, the reference signal null is visible)

You can use any of these signals as a reference:

- The linearly polarized satellite beacon
- A carrier that is strong, unmodulated, and stable
- A carrier that is strong, modulated, and stable (it may have a less well-defined peak than an unmodulated carrier)

Note If neither a beacon nor a suitable carrier is available, and if you have the hub or another VSAT station available to use in test mode, use an unmodulated test signal from the Carina or other Cygnus as a reference. Do not use this method unless there are no other options. This method may exceed your power budget for the transmitting Libra unit, and the signal will drift with temperature change (temperature is checked only once per burst). This signal will be on the co-pol, so adapt the antenna peaking instructions as required.

1. Use the test equipment setup described in section 12.5.1.3 on page 125. Set up the spectrum analyzer as for identifying the satellite.
2. Loosen the feed support clamps (Figure 12-1 on page 121).
3. Find the cross-pol to your network downlink: Rotate the feed as required to receive a signal on the cross-pol. Compare the signal with either of these options as a reference:
   - The printout of the satellite spectral signature for the cross-pol
   - The satellite beacon at the correct frequency for the cross-pol (if available)
4. Look for a suitable reference signal on the cross-pol (adjust the spectrum analyzer span and reference level as required; for example Figure 12-12):
   - Use the satellite beacon at the appropriate frequency, if available.
   - If a beacon is not available, look for a suitable carrier on the cross-pol.
     - To check whether a carrier has a null visible on the co-pol, rotate the feed back 90° to the co-pol, and see if the signal almost disappears.

Figure 12-12 Spectrum analyzer settings to find a reference signal

Parameter	Setting
Span	1 MHz
Center frequency	955.775 MHz* center frequency = beacon (or carrier) frequency (12.255775 GHz) – LNB local oscillator frequency (11.3 GHz) = 0.955775 GHz. *The center frequency will change according to the beacon frequency provided or which carrier is being used.
Reference level	adjust as required
Amplitude dB/division	10 dB
Resolution bandwidth	automatic
Video bandwidth	automatic

Figure 12-12 Spectrum analyzer settings to find a reference signal (Continued)

Parameter	Setting
Sweep time	automatic
Video averaging	off

5. Adjust the spectrum analyzer center frequency until the reference signal is exactly in the center of the screen. (Because the LNB local oscillator can drift by ±100 kHz, the signal as observed on the spectrum analyzer may not fall exactly on the calculated center frequency.)
6. Snug the feed support clamps.
7. Note the azimuth and elevation positions.

12.5.2.2 Maximize on the main lobe

Fine-tune the antenna to maximize the signal level on the main lobe with ±0.2 dB of accuracy for a remote site antenna, and with ±0.1 dB for a central site 3.8 m antenna.

1. Search azimuth for the main lobe:
   a) Loosen the azimuth adjustment.
   b) Swing the antenna approximately 10 degrees East. The satellite should not be visible.
   c) Slowly swing the azimuth West until a peak is found, and note its power.
   d) Continue decreasing the azimuth until another peak is found, and note its power. Repeat this step until the azimuth is too low to see the satellite.
   e) Increase the azimuth to the position at which you found the strongest peak. (You should not see two “strongest” peaks with equal strength. If this happens, align the antenna halfway between these peaks.)
   f) Snug the azimuth adjustment.
2. Search elevation for the main lobe:
   a) Loosen the elevation adjustment.
   b) Raise the elevation by approximately 10 degrees.
   c) Lower the elevation slowly until a peak is found, and note its power.
   d) Continue lowering the elevation until another peak is found, and note its power. Repeat this step until the elevation is too low to see the satellite.
   e) Raise the elevation to the position at which you found the strongest peak. (You should not see two “strongest” peaks with equal strength. If this happens, align the antenna halfway between these peaks.)
   f) Snug the elevation adjustment.
3. Repeat steps 1 and 2 until no stronger peak can be found on either azimuth or elevation.
4. Adjust the spectrum analyzer to view the signal in more detail, for example as shown in Figure 12-13.

Figure 12-13 Spectrum analyzer settings to view an unmodulated carrier and null in detail

Parameter	Setting
Span	0.1 MHz
Center frequency	955.775 MHz* center frequency = beacon (or carrier) frequency (12.255775 GHz) – LNB local oscillator frequency (11.3 GHz) = 0.955775 GHz. *The center frequency will change according to the beacon frequency provided or which carrier is being used.
Reference level	adjust as required
Amplitude	1 dB/division
Resolution bandwidth	<1 kHz for an unmodulated carrier
Video bandwidth	automatic
Sweep time	automatic
Video averaging	on • Try averaging over 500–1000 ms. For example: • If your sweep time is 50 ms, then average 10–20 sweeps. • If your sweep time is 100 ms, then average only 5–10 sweeps.

Note The power level of the signal will vary with atmospheric conditions. For example, the signal level may fluctuate more on a cloudy day than on a clear day.

5. Make small adjustments to the antenna azimuth and then to the elevation as required to maximize the signal on the main lobe. Your accuracy should be ±0.2 dB.
   a) Loosen the azimuth adjustment.
   b) Fine-tune the azimuth angle to maximize the signal level with ±0.2 dB of accuracy.
   c) Record the signal level.
   d) Snug the azimuth adjustment carefully. Confirm that the signal level did not change. If it changed, fine-tune the antenna azimuth again.
   e) Loosen the elevation adjustment.
   f) Fine-tune the elevation angle to maximize the signal level with ±0.2 dB of accuracy.
   g) Record the signal level.
   h) Snug the elevation adjustment carefully.Confirm that the signal level did not change. If it changed, fine-tune the antenna elevation again.
6. Repeat step 5 until no further increase in signal level is possible.
7. Loosen the feed support clamps.
8. Rotate the feed in small increments as required to maximize the signal.
9. Confirm that the noise floor appears at least 35 dB below the signal peak level—this is necessary for minimizing the null.

- If the noise floor is too high, adjust the spectrum analyzer settings until 35 dB is achieved (reduce the resolution bandwidth, reduce the video bandwidth, increase the trace averaging, or decrease the input attenuation).
  - If 35 dB is not possible, adapt the procedure for minimizing on the null as required.

10. Record the maximized signal level, and mark the feed position on the support bracket.

12.5.2.3 Minimize on the null

If you have a reference signal that has a null visible on the co-pol, minimize on the null.

1. Use the same spectrum analyzer settings as for maximizing the peak. To accurately see the cross-pol leakage near the noise floor, you may need to reduce the reference level 20–25 dB.
2. Rotate the feed 90°, to the position of the null on the co-pol.
3. Rotate the feed in small increments as required to minimize the null.

Note If attenuation of the signals due to permanent atmospheric effects causes the null to be hidden in the noise floor (for example, if the station is located at an extreme latitude), then use an estimate of the cross-pol isolation.

4. Compare the reference signal and null power levels, and ensure that the reference signal null is at least 30 dB below the reference signal peak power level (or the isolation required by the satellite provider).
   - If there is insufficient cross-pol isolation, peak the antenna again.
     - If the required cross-pol isolation cannot be achieved, you will have to correct the problem before proceeding to the transmission tests. Possible causes are that the antenna is misaligned, or it has an incorrect adjustment that affects the focus (for example, incorrect position of the feed).
5. Tighten the feed support clamps, and confirm that the cross-pol leakage has not increased.
6. Record the minimized signal level.
7. Ensure that all bolts in the antenna structure, and all azimuth, elevation, and polarization adjustments are tightened properly.

12.6 Do the transmission tests

The satellite provider will require that the antenna passes their alignment tests before your station begins transmitting.

12.6.1 Check the antenna assembly

- Hold the rim of the antenna reflector and shake it hard. The antenna structure should flex but not rattle or change position.

- If the antenna changes position, peak the antenna again and confirm that the cross-pol is still rejected at >30 dB (or at the level required by the satellite provider).

12.6.2 Set the Cygnus to Test mode

Set the Cygnus configuration to test mode before you contact the satellite provider operations center.

1. Set your laptop IP subnet to the same subnet as the Cygnus:
   a) Go to Control Panel > Network Connections > Local Area Connection > Properties > Internet Protocol > Properties
   b) Change the properties to use this IP address:
   IP address 199.71.138.100; Subnet mask 255.255.255.0.

   You may have to reboot your laptop in order for these changes to be applied. You can check whether your changes have been applied: Open a Command Prompt window and type **ipconfig <Enter>**. This will display the current IP address and subnet of the laptop.
2. Connect your laptop to the Cygnus Ethernet port using the LAN cables and a null-LAN (crossover) adapter.
3. Log on to the Cygnus with the Nanometrics UI (see also the Nanometrics UI software manual). The IP address of the Cygnus is recorded on the as-shipped configuration sheet.

   If for some reason you need to check the IP address of the Cygnus, use the Comms Controller configuration port:
   a) Obtain a serial configuration cable; it has a circular connector on one end and three DB-9 connectors on the other end.
   b) Connect the circular connector to the Cygnus, and connect the DB-9 connector that is labelled CONTROLLER CONFIG to the laptop serial port.
   c) Set up a HyperTerminal session:
      i. Go to Start > Programs > Accessories > Communications > HyperTerminal.
      ii. Configure the session with 38400 bps, 8 data bits, no parity, 1 stop bit, no flow control.
   d) Power up the Cygnus and note that the Cygnus displays a sequence of messages.
   e) Power down the Cygnus.
   f) Scroll towards the top of the HyperTerminal page; the IP address of the Cygnus will be displayed.
4. Configure the gain maps as required for this SSPB and transmit cable (see section C.3.2.2 “Modem” on page 170 for information on changing these values.)
5. Set the Cygnus configuration to test mode. Make these changes to the Cygnus through the Nanometrics UI:
   a) On the Configuration > Modem screen, set:
      - VSAT Mode = Test (

)

        - Transmit Enabled = off (no check mark ☐)
        - Modulation = None
        - Tx frequency = either a test frequency or your network uplink frequency, as assigned by your satellite provider
        - 10 MHz output = on (☑)
        - SSPB power = on (☑)
    b) On the Configuration > Internet screen, set:
        - NaqsServer Address = your laptop IP address.
    c) Click Submit, click Commit, and then click Reboot.

6. When the Cygnus boots, click Request to refresh the Nanometrics UI. Confirm that:
    a) The system internal clock state (Operation > Timing > Lock State) is FINE_LOCK. If it is not in FINE_LOCK state yet, wait until it is.
    b) The test configuration is correct, as described in step 5.
7. Power down the Cygnus.
8. Connect the transmit RF cable to the SSPB, and then power up the Cygnus.

12.6.3 Contact the satellite provider and follow their test instructions

1. Contact your satellite provider operations center. (See your satellite lease for contact information.)
2. When they give you permission to transmit at the frequency they specified for testing:
    a) On the Configuration > Modem screen, set:
        - Transmit Enabled = on (☑)
    b) Click Submit.
    c) Ask the test engineer if they can see your transmission.
3. During testing:
    - The operations center engineer may instruct you to adjust the antenna azimuth, elevation, and polarization. They will guide you over the phone.
    - The engineer will ask you to tighten all antenna adjustments before they make their final measurements.
    - They must measure at least 30dB of cross-pol isolation.
4. After the operation center approves the antenna alignment:
    a) Disable your transmission:
        i. On the Configuration > Modem screen, set Transmit Enabled = off (☐).
        ii. Click Submit.
    b) Ask the test engineer to confirm that your transmission has ended.
    c) Thank them for their help, and ask them to please fax a copy of the test result to your office.
    d) End the phone conversation.
5. Power down the Cygnus, and then disconnect the transmit RF cable from the SSPB.

6. Power up the Cygnus, and log on through the Nanometrics UI.
7. Set the Cygnus to Normal mode:
   a) On the Configuration > Modem screen, set:
      - VSAT Mode = Normal (VSat Mode: ◉ Normal)
   b) Click Submit.

12.7 Test the sensor connection

Cygnus is already sending the seismic data to your laptop through the Ethernet connection. You can view the sensor traces if you have NaqsServer and Waveform installed on your laptop. Otherwise, you can use the VIEWDAT utility.

12.7.1 View traces with Waveform

See also the NaqsServer and Waveform Viewer manuals.

1. Ensure that this software is installed on your laptop:
   - Nanometrics DLLs, NaqsServer, DataServer, NaqsClient, and Java
2. Ensure that a copy of the two NaqsServer configuration files from the central hub Naqs acquisition computer are on the laptop:
   - C:\nmx\user\Naqs.ini, and C:\nmx\user\Naqs.stn
3. Ensure that the Naqs.stn file [Station] entry for this station contains the correct Cygnus serial number, so that Waveform can display the data for this station.
4. Start NaqsServer on your laptop. Wait until Naqs is running.
5. Start Waveform on your laptop.
6. Connect to NaqsServer:
   a) In the host field at the bottom left of the Waveform window, enter **localhost**.
   b) Click the connect checkbox to connect to NaqsServer.
   c) Check the connection status bar and confirm that Waveform connects to Naqs. For example, status bar might show Connected to localhost: 28000

Note Some sensor require many hours to stabilize after power-up. Noise floor, DC offset, and mass position may be elevated until the sensor has stabilized.

7. To view the sensor traces:
   a) In the Trace menu, choose Subscribe.
   b) In the Select Channels dialog box, click the Select boxes ☑ for each of the seismic channels for your station.

      After a few seconds you should see the seismic traces.
8. Tap on the sensor and confirm that it reacts on each axis.

12.7.2 View traces with VIEWDAT

1. Log on to the Cygnus.

2. Configure the serial port:
   a) Go to Configuration > Ports > Port 2.
   b) Select NMXP Transmit. Select Baud rate = 9600 bps.
   c) Save this configuration: Click Submit, then click Commit.
3. Log out from the Cygnus.
4. Obtain a serial configuration cable:
   a) Connect the circular connector to the Cygnus.
   b) Connect the EXTERNAL DIGITIZER connector to the laptop serial port.
5. Start VIEWDAT (click on the VIEWDAT shortcut on the laptop desktop). Transmission activity is indicated by the byte count near the bottom of the page.
6. To use the VIEWDAT options:
   - To toggle between the graphic waveforms page and the text page, press <V>.
   - To increase the scale of the waveforms, press <+>.
   - To decrease the scale of the waveforms, press <–>.
   - To exit VIEWDAT, press <ESC>.
7. When you have finished using VIEWDAT, restore the serial port configuration:
   a) Disconnect the serial configuration cable from the Cygnus and the laptop.
   b) Log on to the Cygnus.
   c) Go to Configuration > Ports > Port 2, and select the Unused configuration.
   d) Click Submit, then click Commit.

12.8 Check transmission to the central hub

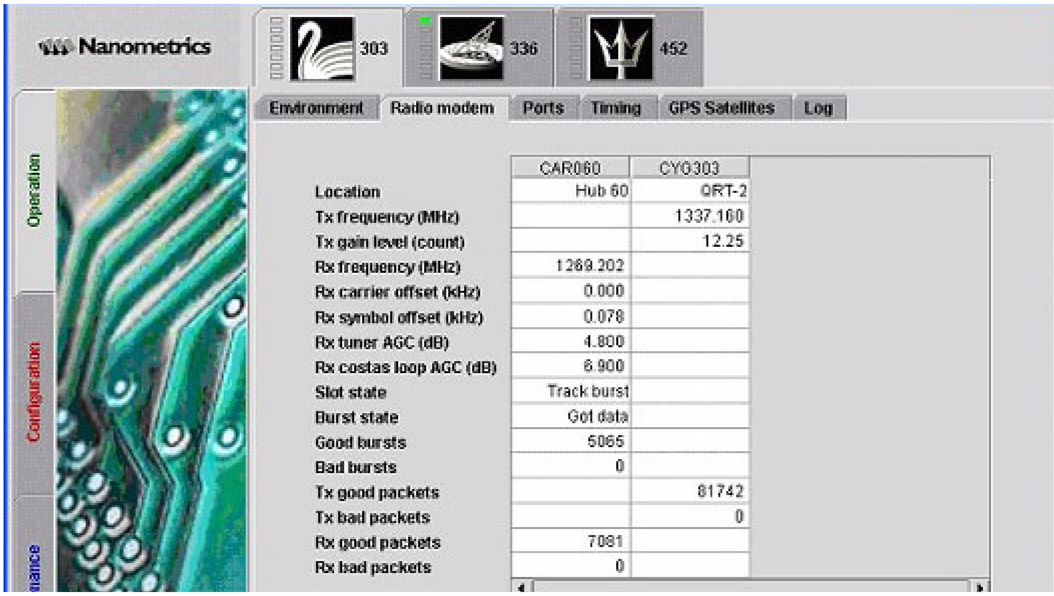
See also: For specific instrument settings, see the as-shipped configuration sheet. For general information on changing instrument settings, see Appendix C, “Checking instrument settings”, and the Nanometrics UI user guide.

1. Change the Cygnus configuration to route data through the satellite modem instead of the Ethernet port. On the Configuration > Internet screen, set:
   - NaqsServer Address = the network NaqsServer destination address for this station (for example, 224.1.1.1).
2. Confirm that the Cygnus is receiving from the Carina and is transmitting packets to the Carina. Go to the Operation > Radio Modem screen (for example, Figure 12-14), and confirm:
   a) In the Carina column:
      - Slot State = Track burst
      - Burst State = Got data
      - Good bursts increases every few seconds (that is, every TDMA frame)
      - Bad bursts are not increasing, or are increasing much more slowly than Good bursts.
      - Rx good packets is increasing every few seconds

- Rx bad packets are not increasing, or are increasing much more slowly than Rx good packets.

b) In the Cygnus column:
- Tx good packets should increase every few seconds.

Figure 12-14 Example display of transmit and receive activity



3. Carina transmits one TDMA authorization packet in every burst. Check for this activity on the Carina Operation > Radio Modem screen:
   - If the Cygnus Rx good packets is greater than Good bursts, Cygnus is receiving additional packets from Carina, probably Naqs retransmission requests. This suggests Naqs is receiving data from this Cygnus.
   - If the Cygnus Rx good packets equals Good bursts, it is receiving TDMA authorizations only. This suggests Naqs is not receiving data from this Cygnus.

4. Find this Cygnus transmission on the spectrum analyzer:
   a) Observe the bursting carrier with the spectrum analyzer connected to the LNB output (see also section 12.5.1.3 on page 125).
   b) Center the carrier very accurately on the screen.
   c) Reduce the span to 0 Hz.
   d) Manually set the resolution bandwidth to 30 kHz.
   e) Manually set the video bandwidth to 300 Hz.
   f) Manually set the sweep time to the TDMA frame duration (typically 10 s).

   You will see a series of square pulses on the screen (for example, Figure 10-7 on page 101). Each pulse is a satellite transmission from one station in the network. The stations transmit in the order shown in the TDMA table.

   g) Identify the Cygnus transmission by comparing the pulses to the TDMA table.

5. Compare the power of the Cygnus burst with the power of the Carina burst. These bursts should have equal power. If the Cygnus burst power is not equal to the Carina burst power, adjust the Cygnus transmit power as appropriate:

- If the Cygnus power is greater than the Carina power, then reduce the Cygnus transmit power:
  i. Go to the Configuration > Modem > SSPB gain table, and increase each of the SSPB Gain values by an equal amount.
  ii. After you have changed the last gain value, click in any other field in the table before you click Accept, to ensure that the change to the last value is accepted. Click Accept.
  iii. Click Submit.
- If the Cygnus power is less than the Carina power, then increase the Cygnus transmit power:
  i. Go to the Configuration > Modem > SSPB gain table, and decrease each of the SSPB Gain values by an equal amount.
  ii. After you have changed the last gain value, click in any other field in the table before you click Accept, to ensure that the change to the last value is accepted. Click Accept.
  iii. Click Submit.

Repeat this step as necessary until the Cygnus and Carina bursts have equal power.

6. Contact the central hub and confirm that they can see the seismic traces from this site on Waveform.

The Cygnus may transmit very large quantities of data for a few hours following installation. This data includes samples acquired during antenna alignment but before the Cygnus was set to transmit.

- If you wish to eliminate this backlog before checking transmission to the central site, delete the Cygnus ringbuffers that contain the backlog of packets, and then use Auto Config to create new ringbuffers (see section C.3.2.5 “Ringbuffers” on page 176).

If there are a lot of high-amplitude vibrations in the sensor passband being created (for example, as the sensor settles, or as you move around the site), central hub operators may see gaps in the new seismic data. This is normal; gaps will be recovered with retransmission requests.

12.9 Secure the site

1. Click Commit to save the Cygnus configuration.
2. Make a record of the Cygnus configuration:
   a) Go to the Configuration > TDMA screen.
   b) Click Request to capture the most recent TDMA table.
   c) Click Save, and then save the Cygnus configuration as a text *.cfg file with a meaningful name (for example, Cygnus415.cfg).
3. Make a record of the TimeServer and Trident configurations:
   a) Go to the TimeServer () > Configuration screen.
   b) Click Save, and then save the TimeServer configuration as a binary *.cfg file with a meaningful name (for example, TS456.cfg).

c) Repeat with the Trident ( ) configuration.

- To save a TimeServer or Trident configuration file as a text file for viewing:
  i. Open a command prompt and go to the directory where the configuration file is stored.
  ii. Use the viewcfg command to save this binary file as a text file. For example, type the command **viewcfg TS456.cfg > TS456.txt**

4. Disconnect and store the laptop.
5. Ensure the RF cable connections to the SSPB and LNB are properly tightened, and are weatherproofed with rubber tape and vinyl tape.
6. Ensure the spectrum analyzer monitoring cables are disconnected. Store the cables and analyzer.
7. Ensure the dust caps, if applicable, are installed on all unused Cygnus connectors (typically Ethernet, 1 NMXBus, and Comms connectors).
8. Ensure all cable connections to the Cygnus are tight.
9. Check the data transmissions:
   a) Power down the Cygnus.
   b) Wait 10 seconds, and then power up the Cygnus.
   c) Ask the central hub operator to confirm that seismic data are still received with Waveform. (The Cygnus may require a few minutes to resume transmissions.)
   d) Jump a few times and confirm that the traces show a response.
   e) Ask the central hub operator to run RBFSUM for the ringbuffers for this station. Ask them to confirm >0% ReTx during at least one hour in at least one component.
   f) End the phone conversation.
   g) After a few hours, ask the central hub operator to run RBFSUM again. They should see a few hours of continuous data (3600 seconds per hour, 0 gaps and no breaks) for all 3 channels, and a few hours with >0% retransmissions.

12.10 Remote station commissioning checklist – Example

Remote site name: ____________________________ Installation date: ________________

Satellite elevation angle: _______ Satellite azimuth (magnetic): _______

12.10.1 Installation equipment checklist

- ❑ Antenna pointing chart
- ❑ Cygnus as-shipped sheets
- ❑ Cygnus Transceiver, SN:_______
- ❑ Antenna feed assembly:
  - ❑ SSPB, SN:_______
  - ❑ LNB, SN:_______
- ❑ Sensor, SN:_______
- ❑ Trident Digitiser, SN:_______
- ❑ Installation kit (tape, fasteners, etc.)
- ❑ Cable kit
- ❑ GPS antenna, brackets
- ❑ Photovoltaic charge controller (solar controller)
- ❑ DC power cable
- ❑ Sensor cable and NMXbus cable
- ❑ Spares: Cygnus, digitiser, sensor (spares are optional)

12.10.2 Installation tools checklist

- ❑ Laptop computer
  - ❑ Cygnus data port test cable
  - ❑ Cygnus Ethernet port cable
  - ❑ Ethernet null (crossover) cable
  - ❑ LAN extension cable
  - ❑ Nanometrics UI software
  - ❑ Terminal emulation software
  - ❑ Naqs application components: Nanometrics DLLs, NaqsServer, NaqsClient, Java
  - ❑ NaqsServer configuration files (Naqs.ini and Naqs.stn)
  - ❑ Waveform monitoring software (DataServer and Waveform, or ViewDat)
- ❑ Oscilloscope and probes
- ❑ Multimeter (V/I/R)
- ❑ Spectrum analyzer or radio test set
- ❑ Gravity inclinometer
- ❑ Magnetic compass with mirror reflector
- ❑ All tools listed in the antenna manual
- ❑ 10 mm socket
- ❑ 10 mm wrench
- ❑ Adjustable wrench
- ❑ 3 mm Allen key
- ❑ Shorting plug for digitiser
- ❑ Splitter, F connectors 2-way with DC path
- ❑ F(m)/F(m) cable, 1 m
- ❑ F(m)/F(m) cable, 10 m
- ❑ F(f)/N(m) adapter (x2)
- ❑ N(f)/N(m) DC block, 2 GHz
- ❑ Telephone access to satellite provider
- ❑ Spare fuses for Cygnus

12.10.3 Procedures checklist

1. Power subsystem installation

❑ Install the batteries in the equipment hut or vault

❑ Interconnect the batteries

❑ Install the solar controller

❑ Connect the batteries to the solar controller

Warning The solar panels will generate voltage (typically around 20V DC) immediately upon exposure to the sun, and may present a shock hazard if shorted. To avoid charge buildup, cover the panels with an opaque sheet until they are wired to the solar charger box.

❑ Install the solar panels

❑ Interconnect the solar panels

❑ Connect the panels to solar controller

❑ Confirm that the batteries are charging

2. VSAT equipment installation

❑ Install the antenna and feed assembly

❑ Install the GPS antenna vertically at the top of the longer Cygnus support bracket

❑ Install the Cygnus support brackets on the back of the antenna

❑ Install the Cygnus on the support brackets

❑ Attach the RF cables to the Cygnus

Caution Transmitting before the antenna is aligned and tested will violate the satellite lease. Do not connect the transmit cable to the SSPB yet.

❑ Connect the GPS cable to the Cygnus

❑ Connect the Trident digitiser to the Cygnus

❑ Attach the shorting plug to the Trident sensor input

❑ Connect the laptop to the Cygnus via Ethernet

❑ Confirm that the voltage at the battery terminals is > 11V DC and <16V DC: _____ V DC

3. Station power-up tests

❑ Ensure that the power supply connection uses the expected values for the Cygnus DC power connector

❑ Attach the power cable to the Cygnus

❑ Launch the Nanometrics UI on the laptop and log on to this Cygnus

❑ Record the Cygnus DC power reading: _____ V DC

❑ Calculate battery V DC – Cygnus V DC = _____ V DC. This must be < 0.5V DC.

3. Station power-up tests (Continued)

- ❑ View the shorted-input seismic traces on the laptop
- ❑ Confirm that the traces are continuous and the noise is <1 count rms
- ❑ Disconnect the DC power from the Cygnus
- ❑ Remove the shorting plug, and attach the sensor to the digitiser

4. Satellite antenna alignment and testing

- ❑ Set the elevation angle (El) to _____ degrees
- ❑ Set the azimuth angle (Az) to ______ degrees magnetic
- ❑ Set up the test equipment
- ❑ Power up the Cygnus
- ❑ Adjust the azimuth as required until Rx RF shows traffic
- ❑ Identify the satellite by spectral signature or Libra network traffic
- ❑ Peak the antenna and verify cross pol isolation
    - ❑ Find a reference signal on the cross-pol
    - ❑ Fine-tune azimuth and elevation to maximize signal strength on the main lobe
    - ❑ On the co-pol, adjust polarization until the minimum null has been achieved
    - ❑ Confirm cross-pol isolation of at least 30dB
    - ❑ Confirm that hub bursts can be seen
    - ❑ Confirm that hub carrier Co/No > 6dB
- ❑ Do the antenna alignment tests
    - ❑ Are different frequency gain tables required? Y N
    - ❑ Configure the Cygnus Test mode
    - ❑ Contact the satellite provider and follow their instructions

Notes:

- ❑ Power down the Cygnus
- ❑ Disconnect the transmit RF cable from the SSPB
- ❑ Power up the Cygnus and log on through the Nanometrics UI
- ❑ Set the Cygnus to Normal mode and restore the configuration from the test settings, if applicable, to route the IP traffic through the satellite link
- ❑ Test the sensor connection
- ❑ Confirm that the Cygnus configuration allows reception from the Carina:
    - ❑ Normal Mode

4. Satellite antenna alignment and testing (Continued)

- ❑ GPS timing source
- ❑ Uplink frequency
- ❑ Cygnus Internet “Libra subnet” IP address and mask
- ❑ Satellite longitude
- ❑ Tx Freq Calibration stabilized (<50 ppb/min)

❑ Confirm GPS Fine Lock, and # satellites: _____

❑ Confirm that the Cygnus receives Carina transmissions

❑ Time1: _____ Good Bursts: ________ Bad: ________

❑ Time1: _____ Good Pkts: ________ Bad: ________

❑ Observe seismic data trace on the laptop

❑ Confirm that the traces are continuous without excessive noise

❑ Jump to create vibrations and verify that the trace responds

❑ Time2:_____ Good Bursts:________ Bad:________

❑ Time2:_____ Good Pkts: ________ Bad: ________

❑ Δ Good Bursts = ________ Δ Bad Bursts = ________ >90% good? _____

❑ Δ Good Pkts = ________ Δ Bad Pkts = ________ >90% good? _____

❑ Contact the Libra central station, and inform them of progress

6. Data transmission tests

❑ Power down the Cygnus

❑ Attach the Tx RF cable to the SSPB

❑ Power up the Cygnus

❑ Observe transmissions on the spectrum analyzer at the LNB output

❑ Confirm that the carrier spectral density is as expected

❑ Central station: confirm that the Carina receives bursts within 5 minutes

❑ Central Station: confirm that Naqs receives seismic data

❑ Central Station: confirm that data has gaps in the ringbuffer

❑ Central Station: confirm that Naqs receives current SOH from the Cygnus and Trident

❑ Central Station: confirm that Waveform displays seismic traces (Z, N, E)

Notes:

7. Central station confirmation (>2 hours later)

- ❑ Confirm that Naqs contains complete data after the ReTx interval
- ❑ Confirm that Cygnus SOH shows reliable battery voltage
- ❑ System installation and testing is complete

8. Secure the site

- ❑ Secure all mechanical fasteners
- ❑ Secure all cable connections
- ❑ Weatherproof all exposed cable connections
- ❑ Secure vaults and huts as required

Chapter 13 Maintaining Network Sites

Libra is a robust network which can provide years of reliable operation with minimum scheduled maintenance. Standard upgrades are done by downloading new software or files via the satellite link, without visiting the remote sites. Libra's use of Internet protocols allows the factory to connect to the network to assist with maintenance.

13.1 Maintenance guidelines

This section provides guidelines for antenna system and site maintenance.

Caution Replacing certain Libra system components may affect transmit power and other parameters restricted by the satellite lease. Contact the satellite provider before and after you modify aspects of the station that may affect transmissions; for example, replacing the feed. Refer to your satellite lease for contact information.

13.1.1 Antenna systems

Libra system antennas provide a long service life in harsh, outdoor environments. A few simple precautions will ensure years of reliable operation:

- Never clean the antennas with harsh cleansers which could harm the finish. The antennas have an outer finish which sheds water and resists dirt accumulation.
- Avoid touching the plastic membrane covering the feed horn.
  - If a membrane is punctured, replace it immediately to prevent corrosion of the OMT, LNB, and SSPB inner surfaces.
- Central site antennas have very narrow beams, and alignment must be maintained within 0.1 degrees of the satellite.
  - Peak central site antennas:
    - 6 months after initial installation, and then every 6 months until antenna settling has ceased. (Make before and after measurements each time to determine how much settling has occurred.)
    - After any storm with winds exceeding 80 km/h
    - Any time the antenna alignment is in question

- Remote site antenna pointing typically must be maintained within 0.3 degrees of the satellite.
  - Peak remote site antennas:
    - 6 months after initial installation, to check for settling. If peaking achieves more than 1 dB improvement in received level, the antenna should be peaked again 6 months later to check for further settling.
    - After any storm with winds exceeding 80 km/h.
    - Any time the antenna alignment is in question.
- Check antennas for damage after any storm with winds that exceed 150 km/h.

13.1.2 Central stations

Failure of a central station can result in loss of the entire network's data. Libra central station systems should be maintained as follows:

- Review the Carina SOH weekly for out-of-spec conditions (such as extreme temperature or voltages), as these conditions can damage the equipment. Examine each occurrence to determine the cause. Take remedial action if out-of-spec conditions occur frequently.
- Check cables for photo-degradation, mechanical damage (for example, from animals or chafing), connector corrosion, and lightning strikes.
- Check equipment enclosures yearly for animal or insect intrusion, water intrusion or condensation, and structural integrity.
- Maintain computer systems in accordance with the manufacturer's recommendations.

13.1.3 Remote stations

At Libra remote sites the Cygnus transceivers, power subsystems, and sensors should be maintained as follows:

- Remote site power systems cause more data loss than any other system in a Libra network. These systems should therefore receive added attention:
  - If batteries are undersized, poorly maintained or beyond their service life the remote site will not operate reliably.
    - Maintain batteries according to the manufacturer's recommendations.
  - Solar power system sizes are determined by statistical analysis of insolation data. Local microclimates may dictate larger or smaller array sizes at specific sites.
    - During the first few low-insolation seasons, observe the battery voltage SOH behaviour to determine if the array size should be adjusted.
- Review the Cygnus SOH weekly for out-of-spec conditions (such as extreme temperature or voltages), as these conditions can damage the equipment. This review can be done from the central station. Study each occurrence of out-of-spec conditions to determine the cause. Take remedial action if out-of-spec conditions occur frequently.

- Remote sites should be visited yearly to inspect the components and repair as needed:
  - Check antennas for damage, dirt accumulation, loose bolts and corrosion. Inspect SSPB cooling fins for blockage.
  - Check solar arrays for damage from falling debris, accumulation of dirt on the solar surface, and corrosion of structural or electrical components.
  - Check cables for photo-degradation, mechanical damage (for example, from animals or chafing), connector corrosion, and lightning strikes.
  - Check the Cygnus transceiver for mechanical damage (cracked or dented case), corrosion, and loose cable connections.
  - Check battery enclosures and equipment enclosures for animal or insect intrusion, water intrusion or condensation, and structural integrity.
  - Maintain sensors in accordance with the manufacturer's recommendations.

13.2 Maintenance equipment

This section lists recommended spare parts, tools, and equipment for reparative maintenance.

13.2.1 Spare parts

Keep spare parts on hand to allow quick repair and recovery from unexpected equipment failure. To decide which types of parts to keep on hand, in general:

- If failure of a part will prevent the network from achieving its purpose, keep a spare of this part on hand. For example, failure of parts that contain active electronics will result in the loss of a complete network's data (for a hub failure) or site data (for a remote failure).
- If failure of a part will not prevent the network from achieving its purpose, a spare of this part may not be needed.

Note If you replace the SSPB, you must reconfigure the gain settings as appropriate. Refer to the specification sheet included with the SSPB; see also section C.3.2.2.4 "SSPB gain table" on page 173.

13.2.2 Central site spares

In normal operation, the central site does not require replacement of consumable parts.

The following spare parts are recommended for central site reparative maintenance:

- Central site LNB
- Central site SSPB
- Antenna feed assembly
- Antenna feed windows and adhesive
- L-Band splitter (if used)
- Carina Hub (may be configured for hot standby)
- Cable kit

- GPS antenna
- Ethernet hub
- Naqs data acquisition computer system (may run in parallel with primary Naqs)

13.2.3 Remote site spares

In normal operation the remote site does not require replacement of consumable parts.

These spare parts are recommended for remote site reparative maintenance:

- Remote site LNB
- Remote site SSPB
- Antenna feed assembly
- Antenna feed windows and adhesive
- Cygnus Remote Transceiver
- Faceplate screws for Cygnus
- Fuses for Cygnus
- Cable kit
- Solar array charge regulator

In addition, we recommend installation of a remote antenna at the central site (see also section 12.1 “Preinstallation” on page 119), requiring:

- Remote site antenna
- Remote site antenna base (either kingpost for ground mount, or non-penetrating for roof mount)
- Remote site AC power supply

Once the remote site installations and training sessions are completed, this antenna can be installed at the final remote site, or it can be installed permanently at the central site and used for Cygnus maintenance.

13.2.4 Tools

The tools, instruments, test cables, and other accessories which are required for the antenna installation are also useful for troubleshooting and repair. See section 12.10 on page 143 for the remote site list, and section 11.6 on page 115 for the central site list of recommended tools.

Recommended features of the spectrum analyser include:

- Frequency range 10 MHz to 1.5 GHz
- Minimum resolution bandwidth (RBW) less than 1000 Hz (100 Hz preferred)
- Noise floor below –130 dBm/Hz (required) or –140 dBm/Hz (preferred)
- Averaging which can be enabled for successive sweeps
- Display trace “peak hold”
- Capability to capture spectral plots (preferred serial data port to output electronic image files, but a printer port is adequate)

Part 4 Appendices

- Glossary
- Cable Drawings
- Checking instrument settings

Appendix A Glossary

A	Attenuation
$\mathbf{A}_{rain}$	Attenuation due to rain
ACI	Adjacent Channel Interference
AGC	Automatic Gain Control
ALC	Automatic Level Control
AM	Amplitude Modulation
analog	A method of signal transmission in which information is relayed by continuously altering some combination of amplitude, frequency, and phase.
AOR	Atlantic Ocean Region
ASI	Adjacent Satellite Interference
ASYNC	Asynchronous data transfer
band	The frequency spectrum between two defined limits
bandwidth	The difference between the high and low frequency of a band
baud	A unit measuring the rate of information flow in units per second
beam	The transmission pattern of a satellite
BER	Bit Error Rate
bird	Communications satellite
block	A group of characters handled as a group
body stabilized	Satellite control system which allows the entire body of the satellite to hold a fixed orientation (attitude) towards the earth.
BPSK	Binary Phase Shift Keying, a digital modulation scheme used in transmission communications
broadcast	One way transmission of information generally from a hub site to all receive-only sites
buffer	Temporary storage used to accommodate differences in speed of data flow

byte	A group of 8 bits
C/N	Carrier to Noise power ratio
carrier	The basic radio signal that transfers the information signal. It occupies a single radio frequency.
C-band	A band of frequencies used for satellite and terrestrial communication. C-band includes the range of frequencies from 4–6 Ghz and is used by most older communications satellites. Requires larger ground antennas than Ku-Band.
CCI	Co-Channel Interference
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CDMA	Code Division Multiple Access
channel	A single path for transmitting RF signals
CNR	Carrier to Noise Ratio
compression	A term used to denote reducing the amount of bandwidth needed to transmit data thus increasing the capacity of a satellite transponder.
CONUS	Continental United States; used to describe satellite beam coverage
CPU	Central Processing Unit
CW	Continuous Wave; a signal consisting of a single frequency
D/C	Down Converter
DAC	Digital to Analog Converter
DAMA	Demand Assigned Multiple Access; access schemes that allow multiple communication users to share a discrete portion of the bandwidth.
dB	Decibel; an analog unit of measure of signal strength, volume or signal loss due to resistance as expressed in logarithmic form.
DCE	Data Communications Equipment
demod	Demodulator
demodulation	The process for retrieving an information signal that has been modulated onto a carrier.
digital	A method of storing, converting and sending data in the form of binary digits.
dish	Informal term for a satellite antenna
downlink	To receive from a satellite; also the equipment used for reception
DRO	Dielectric Resonant Oscillator
DSP	Digital Signal Processor
DSS	Digital Satellite System
DTE	Data Terminal Equipment

duplex	A communications link that transmits data independently in both directions simultaneously
duplex (half)	Transmission in both directions but not simultaneously
Earth station	Either the remote or the central hub
Eb/No	Ratio of “Energy per bit” to “Noise power per Hz”. An expression of signal to noise ratio for digital communications.
EIA	Electronics Industry Association
EIRP	Effective Isotropic Radiated Power
elevation	Satellite location in degrees above the horizon
epoch	The time during which all TDMA frames are identical. A new TDMA configuration can be submitted for the next epoch.
ES	Earth station
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standard Institute
FA	Fixed Assignment
FCC	Federal Communications Commission (USA)
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
feedhorn	Device that collects the signal at the focus of the dish and channels them to the LNBF.
FM	Frequency Modulation
footprint	Geographic area of the earth surface where a satellite signal is transmitted
frame	The set of slots which includes one transmission for each of the stations in a network using TDMA
FSK	Frequency Shift Keying
FSS	Fixed Satellite Service
gain	A measure of the ability of an antenna to receive RF signals
GHz	Gigahertz (one billion cycles per second)
GPS	Global Positioning System
GSO	Geosynchronous Orbit, satellites that travel around the earth at the same rate that the earth turns, at an altitude of approximately 22,300 miles
HDLC	High Level Data Link Control
HEMT	High Electron Mobility Transmitter
Hertz	Cycles per second
HPA	High Power Amplifier
hub	Networks operations center for a VSAT system

hybrid	A satellite which carries 2 or more communication payloads
IBO	Input Back Off
IDU	Indoor Unit
IF	Intermediate Frequency
IFL	Inter Facility Link
IM	Inter Modulation
Intelsat	International Telecommunications Satellite Organization
IOR	Indian Ocean Region
IP	Internet Protocol
ITU	International Telecommunication Union
Ka-band	The band of frequencies from 18–31 GHz (i.e., higher than Ku); not yet commercially available.
kHz	Kilohertz (1 thousand cycles per second)
Ku-band	The band of frequencies from 11–14 GHz, commonly used by satellites; uses smaller antennas than C Band.
LAN	Local Area Network; Ethernet is one type of LAN
LEO	Low Earth Orbit; i.e., less than 22,300 miles above the earth
link budget	A calculation of the minimum technical resource requirements for a satellite communication system
L-land	The range of frequencies from 1–1.7 GHz
LNA	Low Noise Amplifier
LNB	Low Noise Block; downconverter which reduces the microwaves to lower frequencies and then sends them to the satellite receiver.
LNBF	LNB with integrated feed
LO	Local Oscillator
look angle	The angle between the horizon and a satellite
LST	Lease Transmission Plan
MCPC	Multiple Channels Per Carrier
MHz	Megahertz (1 million cycles per second)
mod	Modulator
modem	A device that transforms a signal into a form suitable for transmission.
modulation	The superimposing of an information signal on a carrier frequency
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
multicast	One way transmission of UDP/IP information from a single node to specific group of destination nodes.

multiplex	A method of sending/receiving multiple signals over a single communication channel
MUX	Multiplexer
NMS	Network Management System
NOC	Network Operation Center
OBO	Output Back Off
ODU	Outdoor Unit
OMT	OrthoMode Transducer
OSI	Open System Interconnection
packet	A grouping of data into a discrete unit allowing for more efficient use of capacity and reliability of transfer.
PAD	Electronic device that attenuates signals to protect a transponder
PC	Personal Computer
PCM	Pulse Code Modulation
PFD	Power Flux Density
PLL	Phase Lock Loop
pol	Polarization
POR	Pacific Ocean Region
protocol	Any set of standard procedures that allows devices to communicate
PSD	Power Spectral Density
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
QPSK	Quadrature Phase Shift Keying; a digital modulation scheme used in transmission communications that allows increased sending capacity
rain fade	Attenuation due to rain (A_{rain})
RF	Radio Frequency
RFI	Radio Frequency Interference
RX	Receiver
S/C	Space Craft (same as satellite)
SCADA	Supervisory Control And Data Acquisition system
SCPC	Single Channel Per Carrier, use of an entire satellite carrier to transmit a single datastream.
scrambling	Altering a data stream transmission so it can't be received without an authorized operating decoder
shared hub	An operations center shared among a number of separate network users
SKW	Satellite station Keeping Window half width

slot	The time window during which a station transmits in a network using TDMA
SMC	Sheet Molding Compound
SNMP	Simple Network Management Protocol
SNR	Signal to Noise Ratio
spectrum	The range of electromagnetic radio frequencies
spot beams	A focused small footprint transmission which concentrates limited available radiated power.
SS	Spread Spectrum, a method of transmission where information is encoded into packets then spread over a wide bandwidth to specific receivers which decipher the coded material.
SSPA	Solid State Power Amplifier
SSPB	Solid State Power Block; upconverting amplifier which includes a frequency upconversion stage.
sun outage	Interference caused by the energy of the sun interfering with the satellite signals. This happens twice per year when the satellite is between the sun and the earth.
TCP/IP	Transmission Control Protocol/Internet Protocol
TCXO	Temperature Controlled Crystal Oscillator
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access; a simultaneous datastream time sharing method
teleport	Satellite ground station
terrestrial	Earth based telecommunications network
transceiver	A combined transmitter and receiver
transponder	One of the radio repeaters in a satellite. Most transponders have a bandwidth between 32 MHz and 76 MHz and join one uplink beam to one downlink beam.
TRF	Transmit Reject Filter
TTC	Telemetry Tracking and Command
TTL	Transistor-Transistor Logic
TVRO	Television Receive Only, receiving dish
TWT	Travelling Wave Tube
TWTA	Travelling Wave Tube Amplifier; high power RF amplifier
TX	Transmitter
UC	Upconverter
UHF	Ultra High Frequency, 500–900 MHz range
UPC	Uplink Power Control

uplink	The transmission to a satellite for relay purposes
UPS	Uninterruptible Power Supply
VASPS	Value Added Service Providers
VHF	Very High Frequency, 30–300 MHz
VSAT	Very Small Aperture Terminal
XPD	Cross Polarization Discrimination
XPI	Cross Polarization Isolation
XPOL	Cross-Polarization; a vertical and a horizontally polarized signal transmitted on the same frequency such that they do not interfere with each other.
XPONDER	Transponder

Appendix B Cable Drawings

- Optional test and configuration cable (14217)

Figure B-1 Test and configuration cable

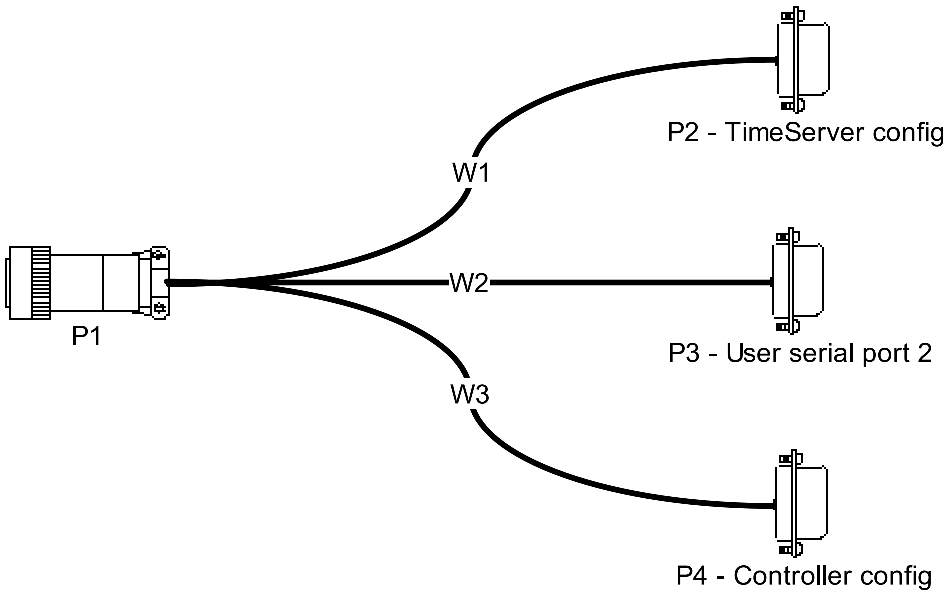


Table B-1 Test and configuration cable parts

Nanometrics part number	Manufacturer part number	Quantity	Description
WIR0058	BELDEN, 8443-500	3 x 1.5m	22 AWG, 3 conductor, unshielded
CON0907	SOURIAU, 851-06JC14-19P-N50	1	Plug, straight plug, shell 14, 19P
CON0011	ESONIC, AMP DE09-S	3	Dsub 9-pin female

Table B-2 Test and configuration cable connector pin wiring

From			To			Wire	Run
Conn	Pin	Description	Conn	Pin	Name	Colour	
P1	H	TimeServer Config Tx	P2	2	Rx	green	1
P1	G	TimeServer Config Rx	P2	3	Tx	red	1
P1	T	DGND	P2	5	Gnd	black	1
P1	K	User serial port 2 Tx	P3	2	Rx	green	2
P1	J	User serial port 2 Rx	P3	3	Tx	red	2
P1	A	DGND	P3	5	Gnd	black	2
P1	L	Controller config Tx	P4	2	Rx	green	3
P1	V	Controller config Rx	P4	3	Tx	red	3
P1	U	DGND	P4	5	Gnd	black	3

Appendix C Checking instrument settings

Use the Nanometrics UI to view and change the configuration of the Cygnus and associated Trident(s). Instrument parameters are grouped onto screens by function in the UI. This section provides procedures for typical configuration changes for Cygnus (see also the Nanometrics UI User Guide):

- View or update versions of firmware, EPLD code, and saved configurations through the screen under the Maintenance tab.
- Change instrument configuration through screens under the Configuration tab.

C.1 Log on to the Cygnus

1. Connect your laptop to the Cygnus Ethernet port using the LAN cables and a null-LAN (crossover) adapter.
2. Set your laptop IP subnet to the same subnet as the Cygnus:
   a) Go to Control Panel > Network Connections > Local Area Connection > Properties > Internet Protocol > Properties
   b) Change the properties to use this IP address:
   IP address 199.71.138.100; Subnet mask 255.255.255.0.

      - You may have to reboot your laptop in order for these changes to be applied.

      You can check whether your changes have been applied: Open a Command Prompt window and type **ipconfig <Enter>**. This will display the current IP address and subnet of the laptop.
3. Start the Nanometrics UI and log in to the Cygnus.

C.1.1 Using the configuration port

The Cygnus has an RS-232 port that can monitored via a terminal emulator reading the COM port. It is a three-pin port on the COMMS connector:

- TX: pin L
- GND: pin U
- RX: pin V

Although the Cygnus configuration cannot be changed from its monitoring port, accessing the unit via this port is a means of finding out the IP addresses configured in Cygnus, and for monitoring basic unit operation. The IP address of the Cygnus is displayed as the unit boots up.

Configure the terminal emulator for 38400 Baud, 8 bits, no parity, and 1 stop bit (8N1), and no hardware or software handshaking.

- To access the port, connect the test cable (Appendix B) to the COMMS connector of the Cygnus, and the Controller Config connector to the serial port of a computer. (See step 3 of section 12.6.2 on page 136 for an example.)

C.2 Check the firmware versions

You can check the firmware version and configuration file names on Cygnus, TimeServer, and Trident, and the EPLD code version on the TimeServer and Trident.

C.2.1 Cygnus firmware

1. Log onto the Cygnus and go to the Maintenance screen (Figure C-1 on page 167). Confirm that the Cygnus is running the correct firmware version. (For example, check the as-shipped configuration sheet for the shipped version, or a specifically recommended version if this is an upgrade.)

   There are two firmware partitions; each will contain a version of the firmware. For example:

   - Firmware A LibraV57005A.bin
   - Firmware B LibraV57005B.bin

   The firmware that is running will show attributes “active, default” for the partition.

2. If the correct versions are not installed, install the correct versions:

   a) Click to select the firmware partition that is NOT “default, active”.

   b) Click the Send file button.

   c) Find the firmware file on your hard drive. We recommend storing these files in a folder called C:\nmx\updates\

   Be careful to install files only of the type LibraVxxxxxA.bin and LibraVxxxxxB.bin. Do not install hex files (for example, LibraV56201.hex) or authentication files (for example, LibraV56201_auth.bin).

   d) Click the Open button.

Note Uploading files through the Ethernet interface takes approximately 1 minute for each file. Uploading files through the satellite link from the central hub takes approximately 20 minutes for each file.

   e) In the Confirm file upload window, click the Continue button. This sends the file to the Cygnus.

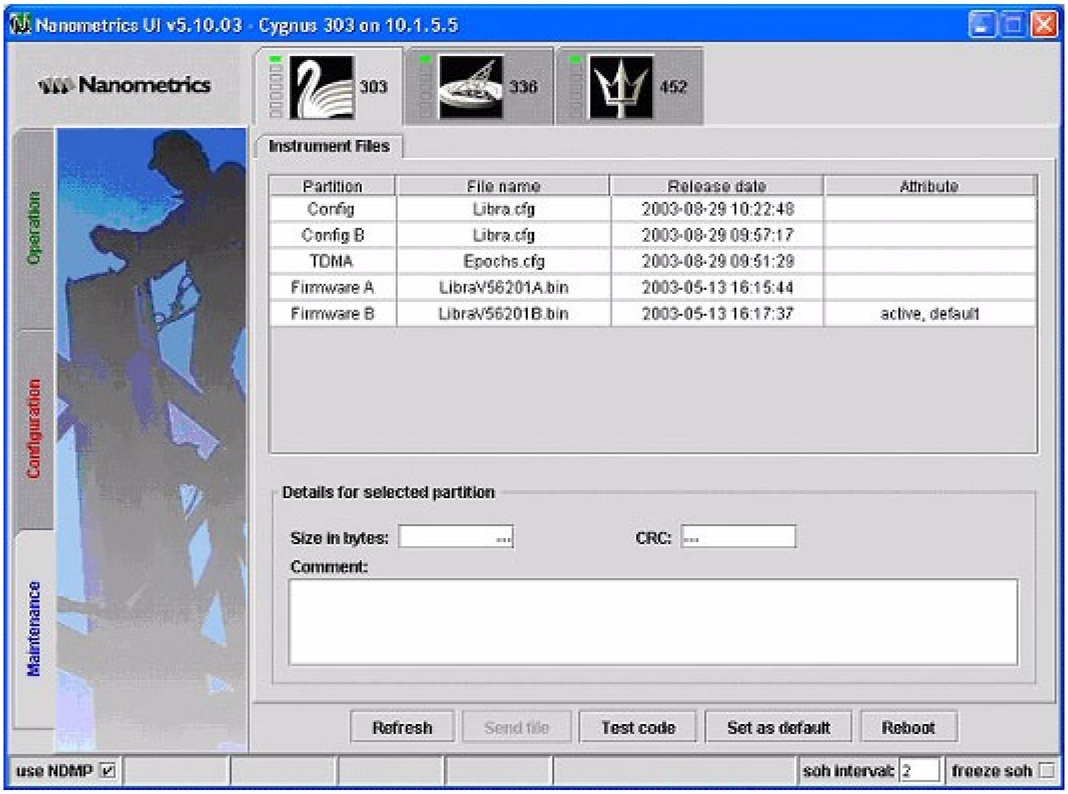
   f) Click the Test Code button. Cygnus will boot with the non-default code.

Note If the Cygnus boots again before you make this code default, it will run the old code in the other partition.

g) Click the Set as default button to make this new code the default boot code.

h) Repeat step 2 to install new code in the other partition.

Figure C-1 Cygnus Maintenance > Instrument Files page



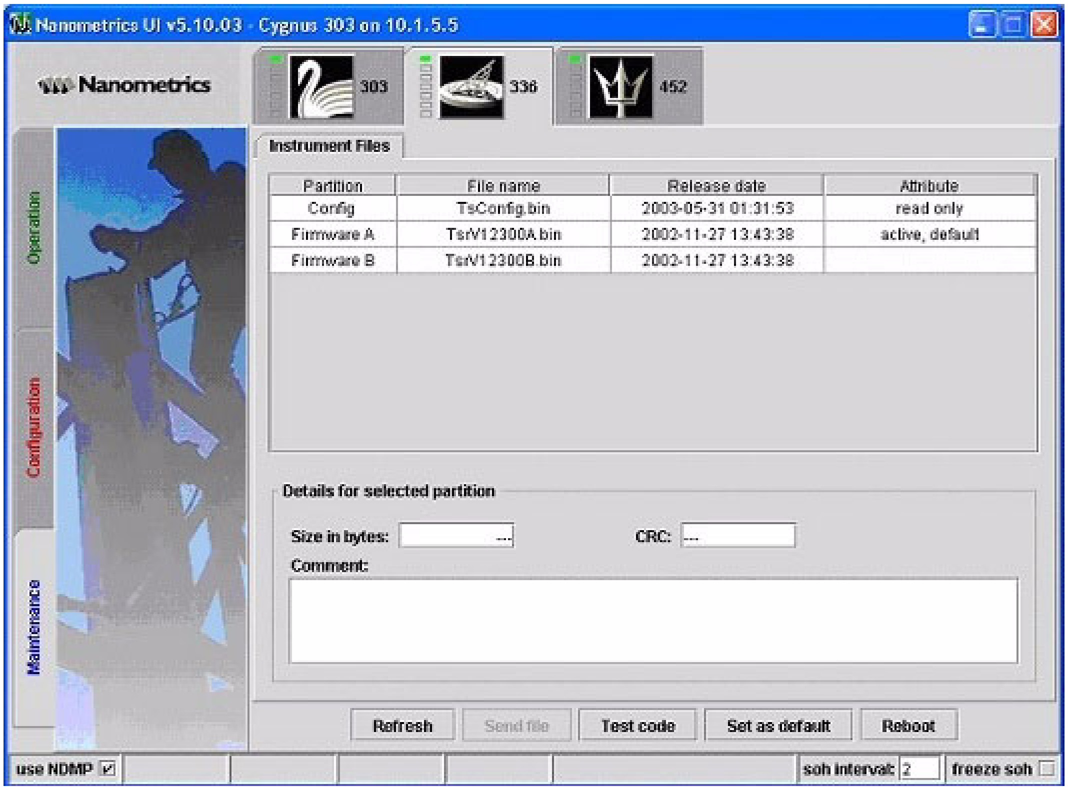
C.2.2 TimeServer firmware

This is the same basic procedure as for the Cygnus (section C.2.1 on page 166).

1. Click on the TimeServer tab (Figure C-2) and confirm that it is running the correct firmware versions. For example:
   - FirmwareA = TsrV12300A.bin
   - FirmwareB = TsrV12300B.bin

2. If required, upload the correct version. This is the same basic procedure as for the Cygnus (section C.2.1 on page 166).

Figure C-2 TimeServer Maintenance > Instrument Files page

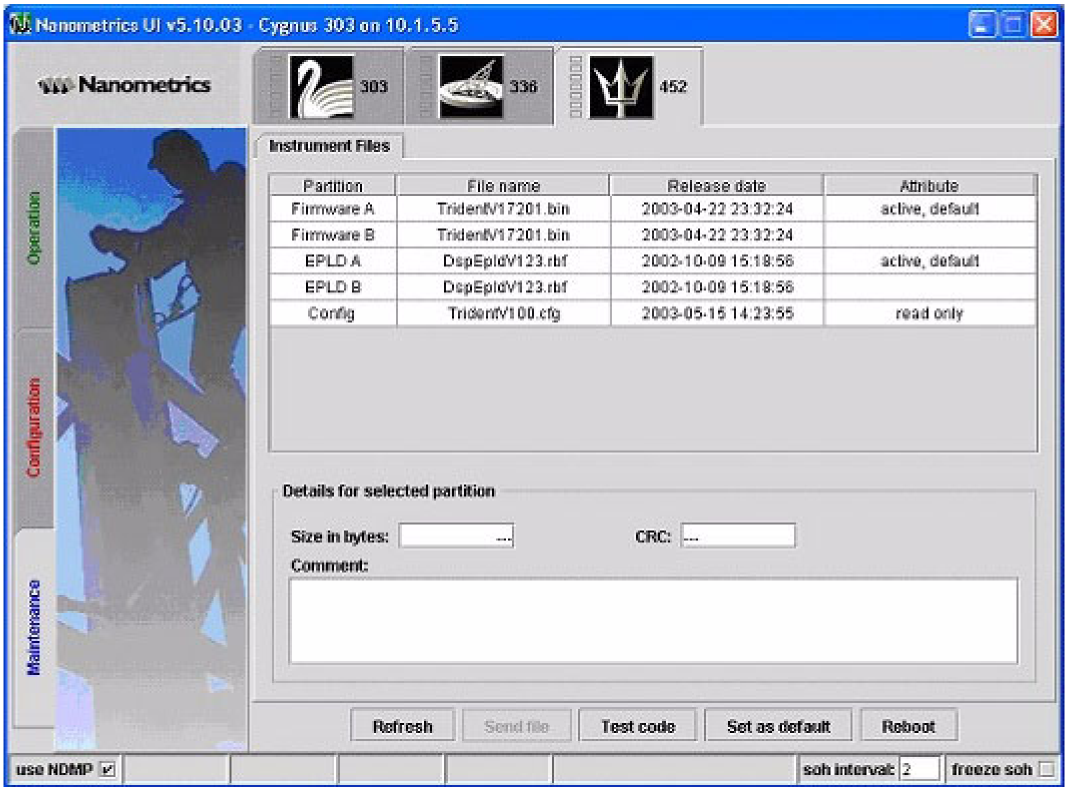


C.2.3 Trident firmware

This is the same basic procedure as for the Cygnus (section C.2.1 on page 166).

1. Click on the Trident tab (Figure C-3) and confirm that it is running the correct firmware and EPLD versions. For example:
   - FirmwareA = Trident17201.bin
   - FirmwareB = Trident17201.bin
2. If required, upload the correct version. This is the same basic procedure as for the Cygnus (section C.2.1 on page 166), except that the Trident firmware and EPLD code should be upgraded at the same time. For example:
   a) Send files:
      i. TridentV17201.bin to partition Firmware A.
      ii. DspEpld123.rbf to partition EPLD A.
   b) Test code.
   c) Set as default.
   d) Repeat for Partition B code set.

Figure C-3 Trident Maintenance > Instrument Files page



C.3 Check the instrument configuration

Configure the Cygnus as required. The sections below provide an overview, by configuration screen, of conditions that might require that you change configuration parameters. (For example, changing the SSPB gain settings if you replace the SSPB.)

C.3.1 Change a configuration – General procedure

In general, to change a configuration:

1. In the Cygnus > Configuration screen (for example, Figure C-4), click the Request button to obtain the current configuration.
2. Click the appropriate tab to open the configuration screen (for example, System).
3. Click in the field you want to modify and type in or select the new value.
4. Click the Submit button.

   The Cygnus will begin using the new configuration, but will not store this configuration in permanent memory—if the Cygnus reboots, the configuration change will be lost.
5. To store the new configuration in permanent memory, click the Commit button.

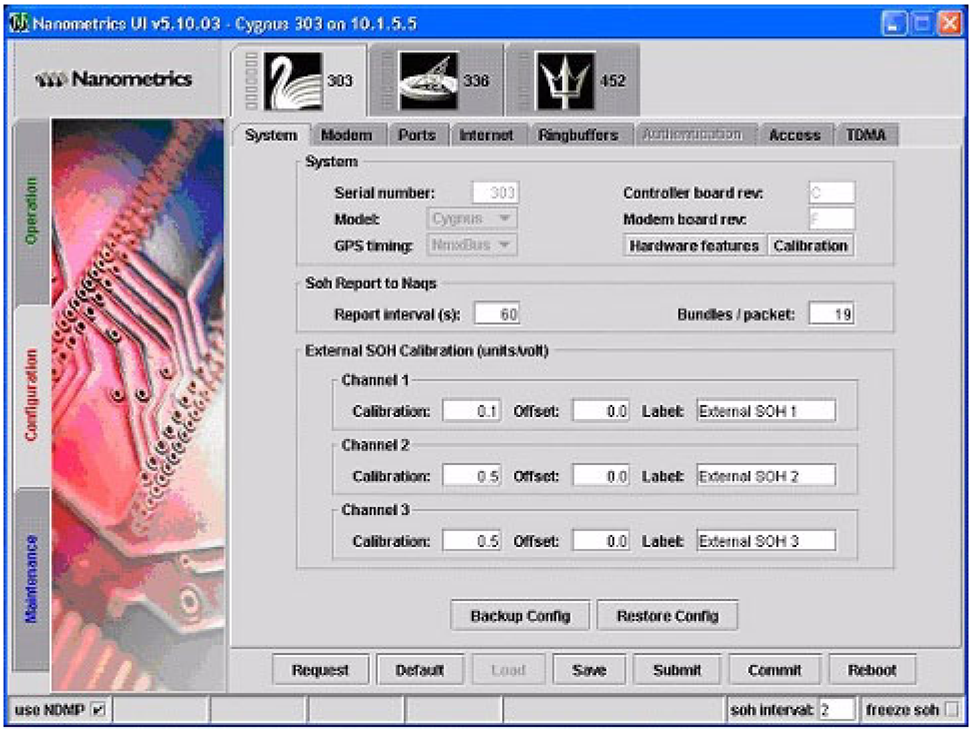
   If the Cygnus reboots it will run with this new configuration.

C.3.2 Cygnus configuration

C.3.2.1 System

Typically, no changes are required on the Cygnus > Configuration > System page.

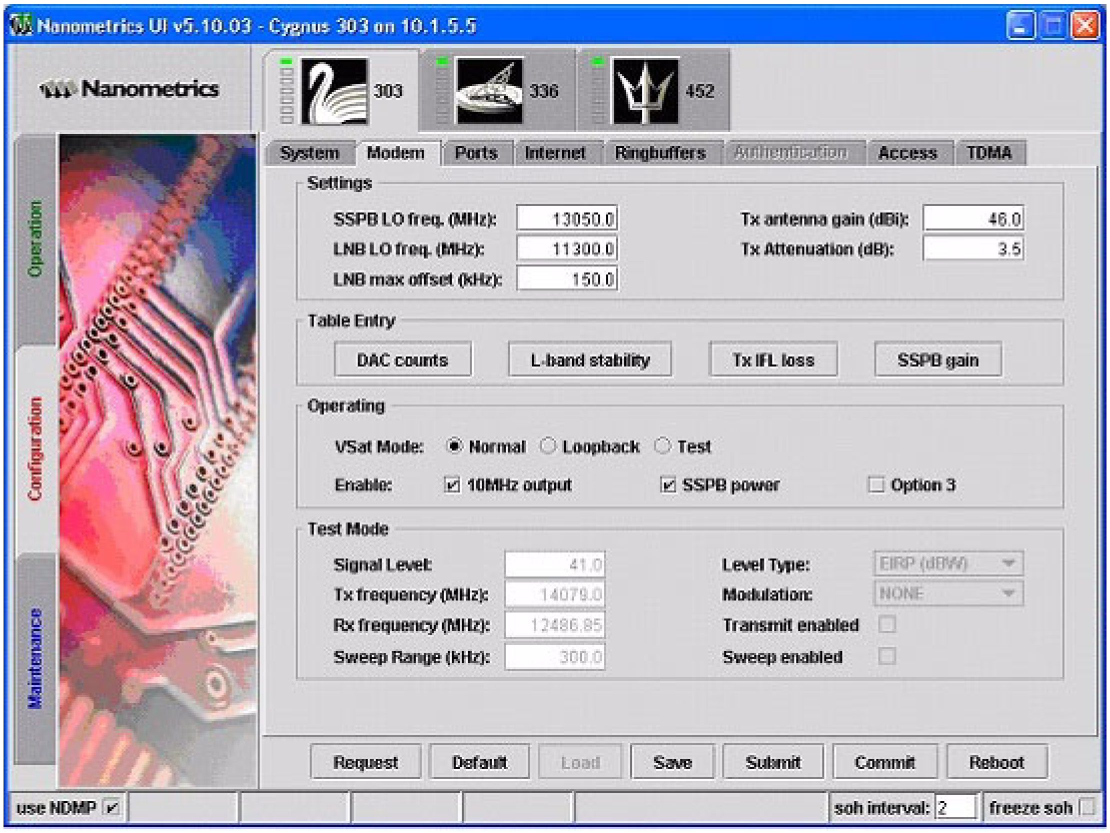
Figure C-4 Cygnus > Configuration > System screen



C.3.2.2 Modem

The Modem screen has general parameters on the main screen, and four gain settings tables accessible from buttons on the main screen (DAC counts, L-band stability, Tx IFL loss, and SSPB gain).

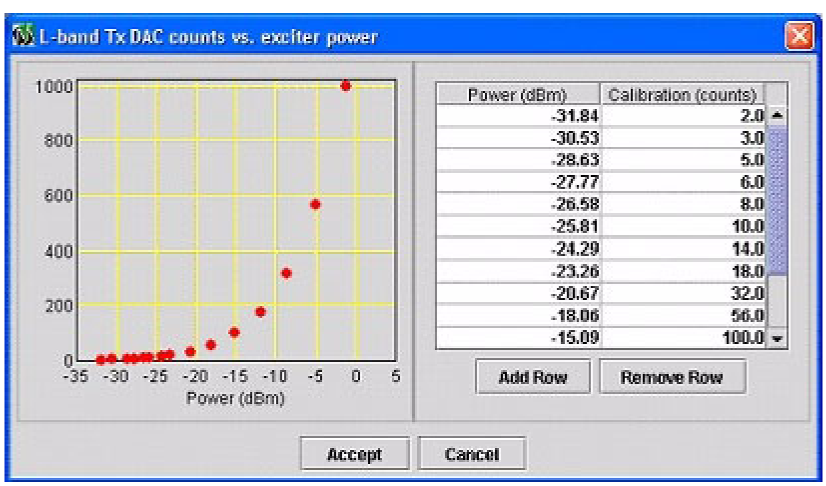
Figure C-5 Cygnus > Configuration > Modem screen



C.3.2.2.1 *DAC counts table*

Typically the DAC counts table will not require modification.

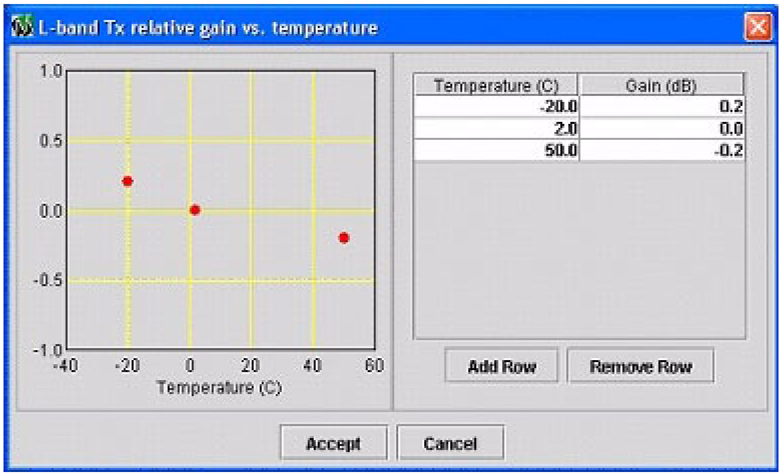
Figure C-6 DAC counts table



C.3.2.2.2 L-band stability table

Typically the L-band stability table will not require modification.

Figure C-7 L-band stability table

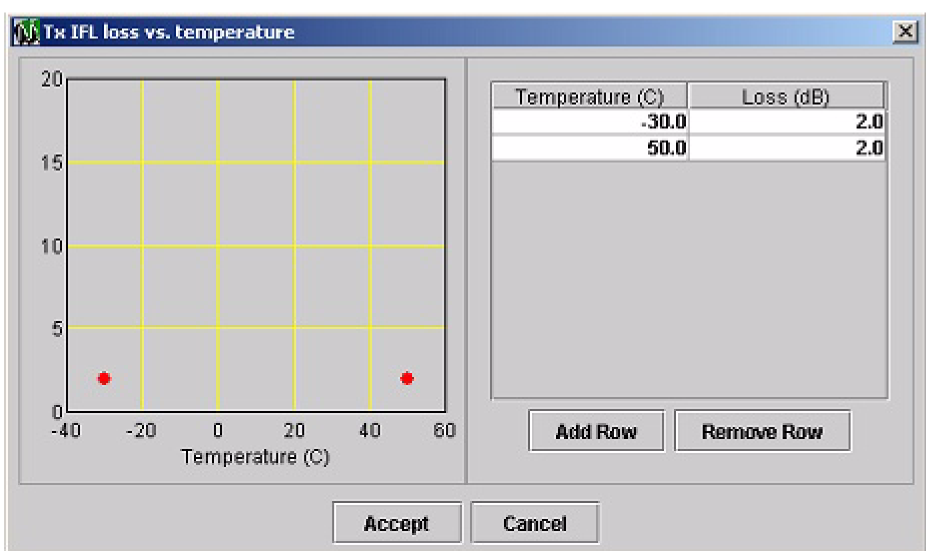


C.3.2.2.3 Tx IFL loss table

You will probably need to edit the Tx IFL loss table for most sites. (IFL refers to the cables between the Cygnus terminal and the feed assembly.)

- Installations which include a 15m Transmit RF cable (SSPB coax cable) should use 2.5dB insertion loss at both temperatures
- Most remote sites will have 3m long cables and therefore should only have 1dB insertion loss.

Figure C-8 Tx IFL loss table

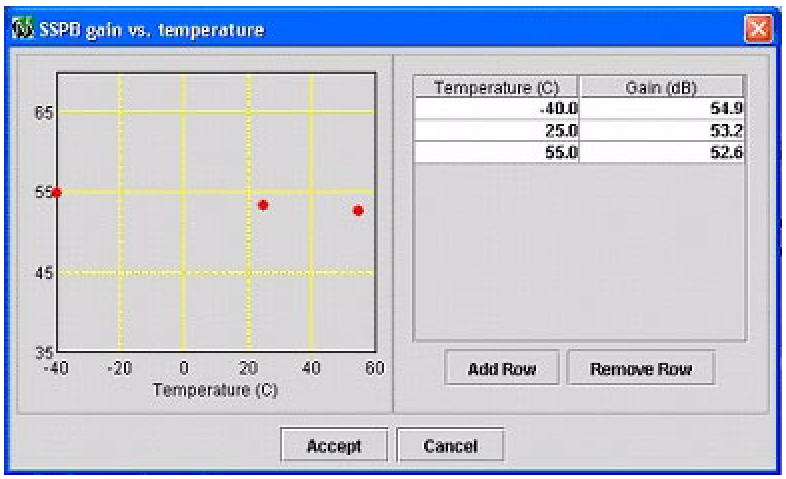


C.3.2.2.4 SSPB gain table

Typically the SSPB gain table will require modification (Figure C-9). You must follow this procedure if you replace the SSPB.

1. Find the SSPB calibration data in the SSPB shipping box. Keep this sheet—you will need it for future maintenance.
2. From the calibration sheet find the maximum and minimum gain at –40°C. Average these two values to find typical gain at –40°C. Enter this value in the table.
3. Repeat step 2 at 25°C and 55°C.
4. After you have changed the last gain value, click in any other field in the table before you click Accept, to ensure that the change to the last value is accepted.
5. Click Accept to close the table with the new values.
6. Click Submit, then click Commit. Open the table again and confirm that the values were recorded correctly.

Figure C-9 SSPB gain table

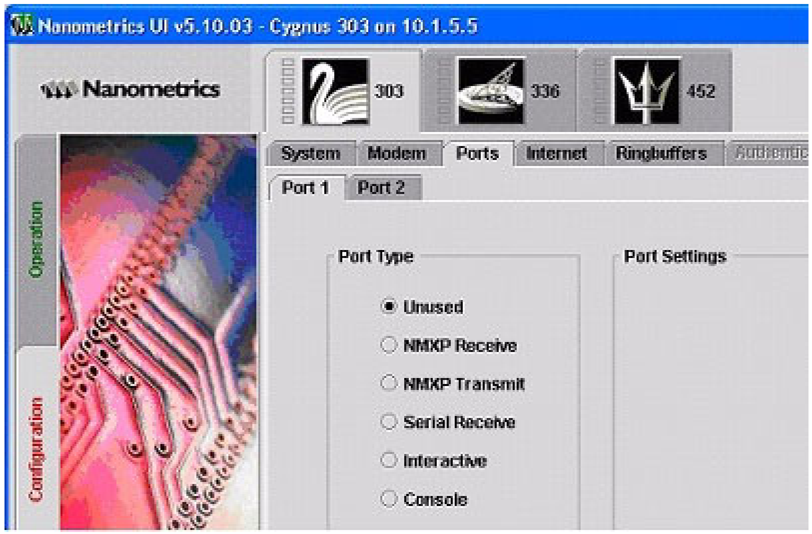


C.3.2.3 Ports

The typical setting for Cygnus with NMXbus is to have the serial ports disabled (Figure C-10).

- If you are using the serial ports on the Cygnus with NMXbus for any reason, ensure that Port 1 is never set to NMXP Transmit.

Figure C-10 Cygnus serial ports set to Unused



C.3.2.4 Internet

You will need to configure the Cygnus network IP settings (Figure C-11). The Internet configuration is very important—confirm that all values are correct. See the as-shipped configuration sheets for preconfigured systems, or worksheets that you have prepared for your system (for example, Figure C-12).

In general, to configure network IP:

1. Change the Cygnus LAN port IP address if necessary (see also section C.1 “Log on to the Cygnus” on page 165).
2. Click Submit, and then click Commit. You may need to change your laptop IP address and log on again before you can commit.
3. Change the remaining Internet configuration variables.
4. Click Submit, and then click Commit.

Figure C-11 Cygnus > Configuration > Internet screen

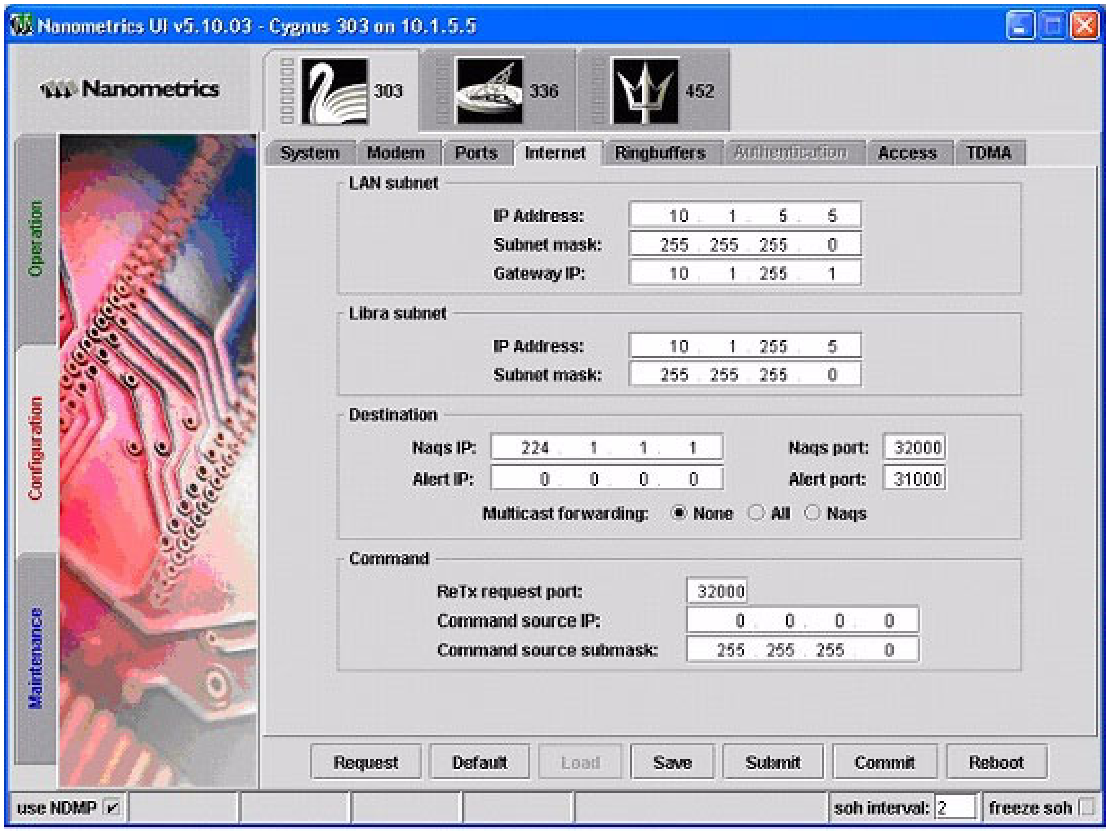


Figure C-12 shows an example IP configuration for a Libra network. You can also set up one large subnet to include every Cygnus if you wish.

Figure C-12 Internet Configuration, Carrier 1—Example

Terminal	LAN port configuration	Libra port configuration	Destination	Command
Carina 60 Hub 1	Addr: 192.168.100.100 Mask: 255.255.255.0 Gateway: 0.0.0.0	Addr: 10.1.255.1 Mask: 255.255.0.0	Naqs: 224.1.1.1 Naqs port: 32000 Alert: 0.0.0.0 Alert port: 31000 Multicast fwd.: None	ReTx req port: 0 Cmd IP: 0.0.0.0 Mask: 255.255.255.0
Carina 66 Hub 2	Addr: 192.168.100.101 Mask: 255.255.255.0 Gateway: 0.0.0.0	Addr: 10.1.255.2 Mask: 255.255.0.0	Same as above	Same as above
Cygnus 331 Remote 1	Addr: 10.1.3.3 Mask: 255.255.255.0 Gateway:10.1.255.1	Addr: 10.1.255.3 Mask: 255.255.255.0	Same as above	Same as above
Cygnus 303 Remote 2	Addr: 10.1.4.4 Mask: 255.255.255.0 Gateway:10.1.255.1	Addr: 10.1.255.4 Mask: 255.255.255.0	Same as above	Same as above
Cygnus 359 Remote 3	Addr: 10.1.5.5 Mask: 255.255.255.0 Gateway:10.1.255.1	Addr: 10.1.255.5 Mask: 255.255.255.0	Same as above	Same as above

Figure C-12 Internet Configuration, Carrier 1—Example (Continued)

Terminal	LAN port configuration	Libra port configuration	Destination	Command
Cygnus 403 Remote 10	Addr: 10.1.12.12 Mask: 255.255.255.0 Gateway:10.1.255.1	Addr: 10.1.255.12 Mask: 255.255.255.0	Same as above	Same as above
Cygnus 405 Remote 11	Addr: 10.1.13.13 Mask: 255.255.255.0 Gateway:10.1.255.1	Addr: 10.1.255.13 Mask: 255.255.255.0	Same as above	Same as above

C.3.2.5 Ringbuffers

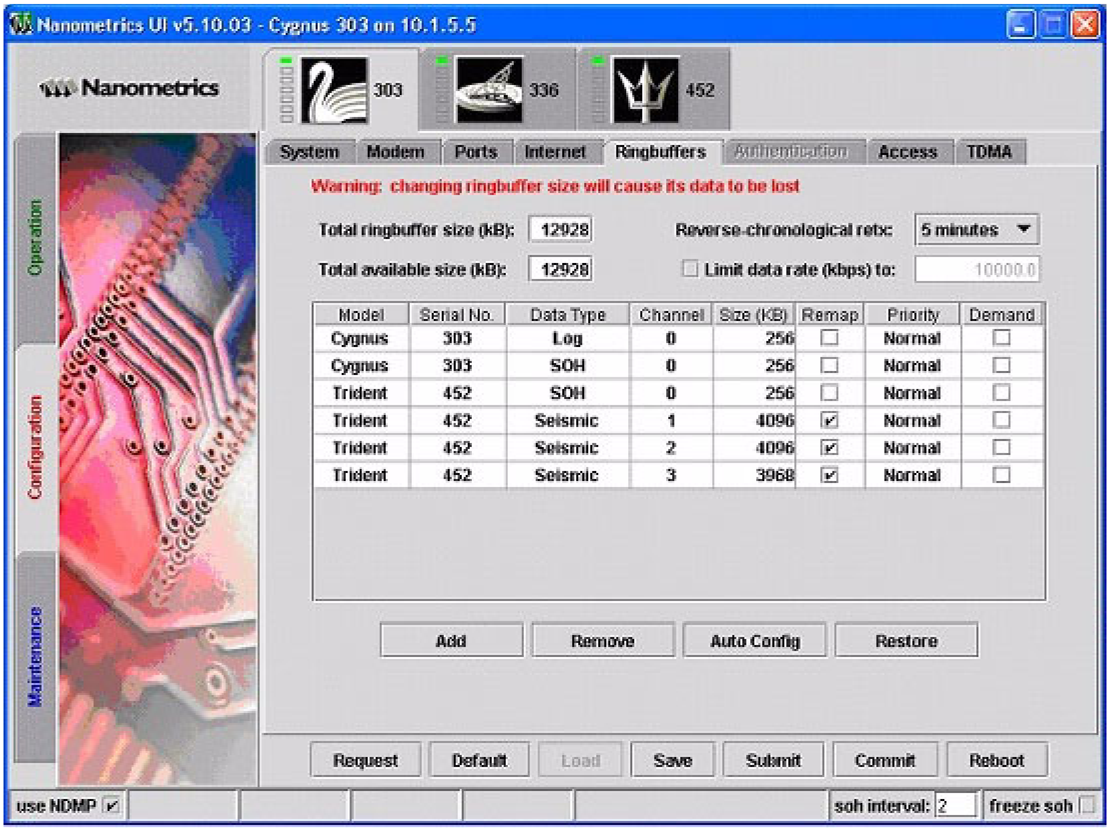
To configure new ringbuffers for the Cygnus and connected Trident digitiser (Figure C-13):

Note The initial two ringbuffers (Cygnus Log and Cygnus SOH) cannot be deleted.

1. Delete all existing ringbuffers: For each ringbuffer, click in the Serial number field, then click Remove.
2. Click Submit, then click Commit.
3. Click Auto Config.
4. Confirm that 6 ringbuffers are created:
   a) Cygnus Log
   b) Cygnus SOH
   c) Trident SOH
   d) Trident seismic channel 1 (with Remap enabled)
   e) Trident seismic channel 2 (with Remap enabled)
   f) Trident seismic channel 3 (with Remap enabled)
5. Click Submit, then click Commit.

Note You can also have the ringbuffer page set up to have the Trident ringbuffers without Remap. If you set up the remote ringbuffers without Remap, ensure that the Trident is included in your Naqs station file under the correct station heading (see the NaqsServer manual).

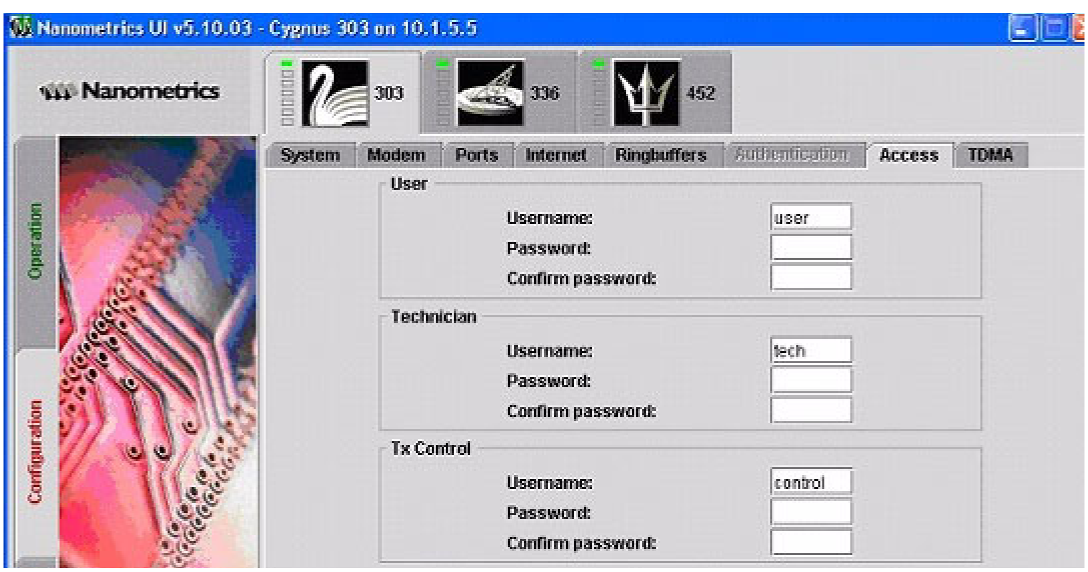
Figure C-13 Cygnus > Configuration > Ringbuffers screen



C.3.2.6 Access

Typically, no changes are required in the Cygnus > Configuration > Access screen (Figure C-14). Use this screen to change user name and password for the Cygnus.

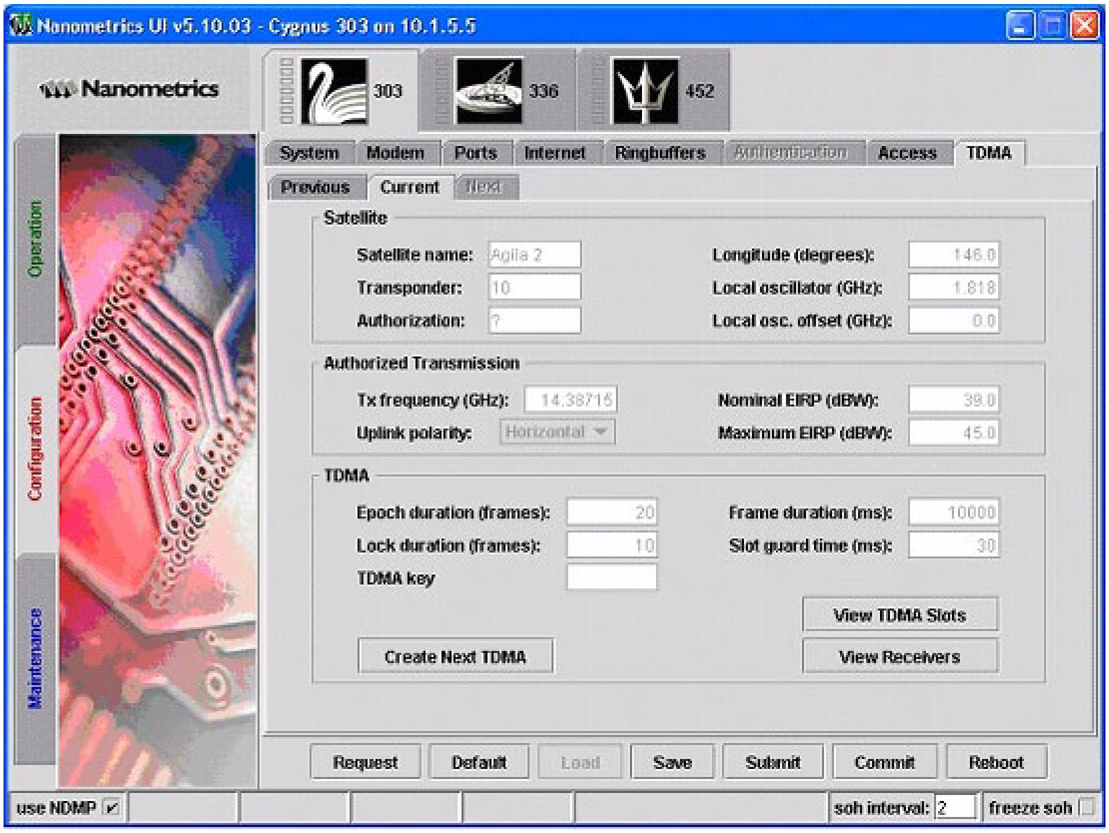
Figure C-14 Cygnus > Configuration > Access screen



C.3.2.7 TDMA

You must edit the TDMA at each remote station so the station can receive authorization from the hub (Figure C-15).

Figure C-15 Cygnus > Configuration > TDMA screen



Note If you are doing this procedure prior to passing the cross-pol test, ensure that you have disconnected the transmit cable from the SSPB. Power down the Cygnus before disconnecting or connecting the Tx or Rx cable.

See your satellite lease for the correct values for the parameters in the Satellite and Authorized Transmission panels.

1. Confirm that the Cygnus is in Normal mode (Configuration > Modem > Operating > VSat Mode: Normal).
2. In the Configuration > TDMA screen, click the Create Next TDMA button.
3. In the Authorized Transmission panel, edit the transmit frequency to the appropriate value.
   For example, **Tx Frequency (GHz): 14.38715**

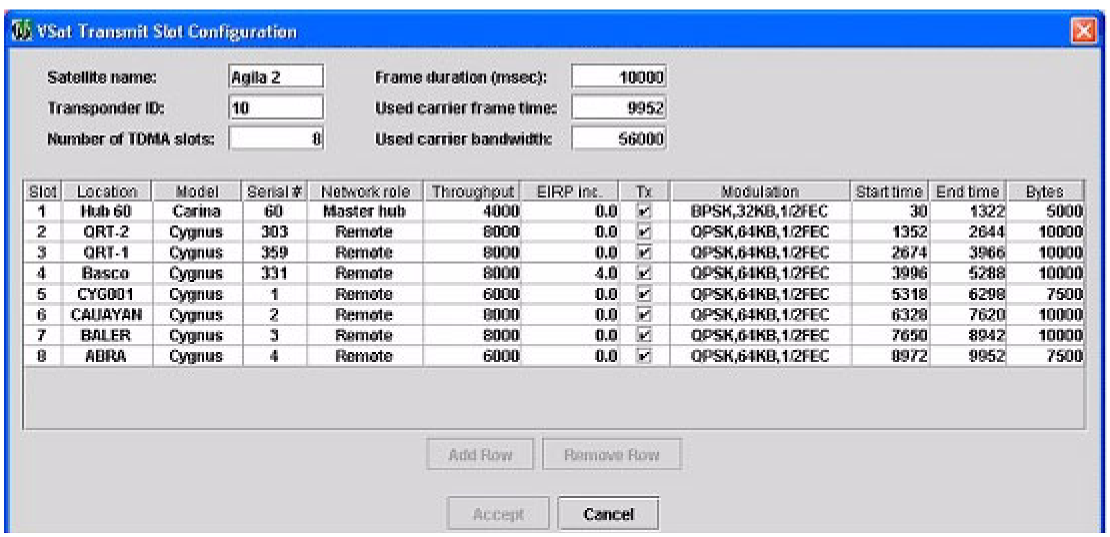
Note East is positive and West is negative in the Nanometrics UI. For example:

146°E = 146

146°W = –146

4. Edit the satellite longitude to the appropriate value.
   For example, **Longitude (degrees): 146 degrees**
5. Edit the satellite Local Oscillator frequency.
   For example, **Local Oscillator (GHz): 1.818**
6. Configure the TDMA slots:
   a) Click the Configure TDMA Slots button.
   b) In the VSAT Transmit Slot Configuration window (Figure C-16), select the correct Carina and enter the appropriate configuration values.
   For example
   1, Hub 60, Carina, 60, Master hub, 4000, 0, ☑, BPSK,32KB,1/2FEC
   (Start time, End time, and Bytes are calculated values)
   c) Click Accept to close the VSAT Transmit Slot Configuration window with the new configuration values.
7. Enter 1 in the TDMA Key field.
8. Click Submit to send this configuration to the Cygnus.
   - If you see the message "… please wait XX seconds" or "… busy sweeping", wait a few seconds and then try again. Eventually it will confirm when it accepts the configuration.

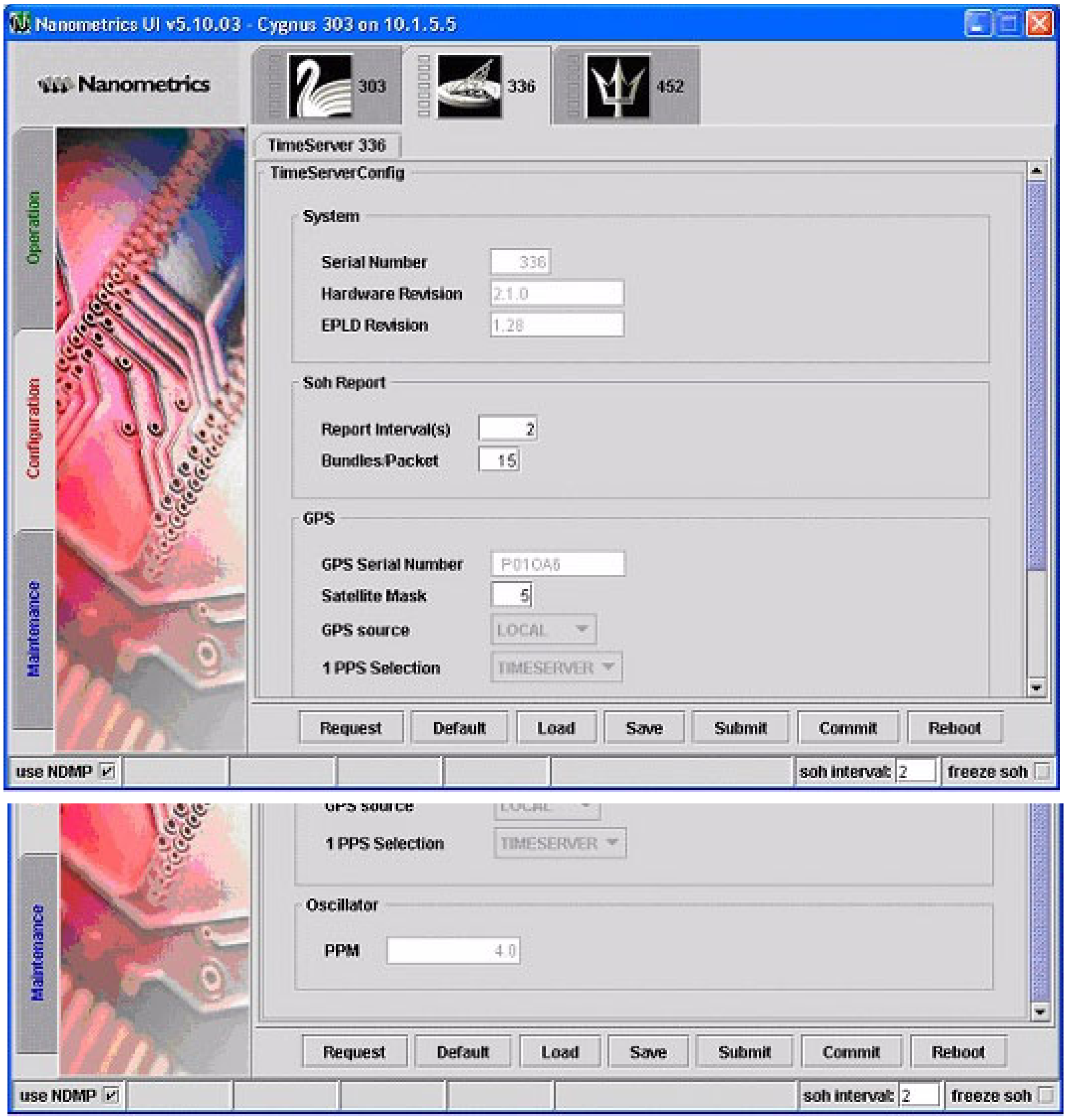
Figure C-16 VSAT Transmit Slot Configuration window



C.3.3 TimeServer configuration

The TimeServer configuration typically does not require modification.

Figure C-17 TimeServer > Configuration screen



C.3.4 Trident configuration

Confirm that you have the correct settings for the digitiser (Figure C-18). For example:

- If you set DC removal to enabled, use the appropriate cut-off frequency.
- Ensure that the seismometer control lines are set up correctly for your sensor. For example, the Trillium settings are:
  - High Voltage Level:High Z
  - Calibration Mode: Voltage (active low)
  - Line 1 Level: Low
  - Line 2 Level: High
  - Line 3 Level: High

Figure C-18 Trident > Configuration screen