GOMSPACE

NanoGround
Datasheet

Technical Characteristics and Performance Specifications of NanoGround

DS 1065505
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API application programming interface.

CLI command-line interface.

CSMA carrier-sense multiple access.

CSP Cubesat Space Protocol.

FER frame error rate.

GOSH GomSpace Shell.

GSUFTP GomSpace Unidirectional File Transfer Protocol.

IPv4 Internet Protocol version 4.

KSAT Kongsberg Satellite Services.

REST representational state transfer.

RF radio frequency.

UDP User Datagram Protocol.

ZMQ ZeroMQ.

1 Introduction

1.1 Purpose

This document provides a technical overview and description of the GomSpace NanoGround software product.

1.2 Scope

This document is applicable within the scope of using NanoGround for ground segment integration of GomSpace satellite products and third-party ground station equipment. It does not describe the satellite products, but focuses on the technical characteristics of NanoGround. The document is intended for system integrators, software engineers/developers, and other users who need an understanding of the performance and technical aspects of NanoGround. The document does not provide detailed guidelines on usage or configuration.

1.3 Structure

The document is structured as follows:

- Section 2 provides an overview of the NanoGround system.
- Section 3 summarizes the requirements to run NanoGround.
- Section 4 describes technical details for all NanoGround components.
- Section 5 describes performance specifications for NanoGround.

1.4 Related Documents

For a general introduction to NanoGround, including an overview of all related documentation, refer to the NanoGround User Manual.

2 System Overview

NanoGround is a modular ground segment software product designed to facilitate the integration of GomSpace satellite products and third-party ground station equipment. An overview of the NanoGround system is shown in Figure 2.1.

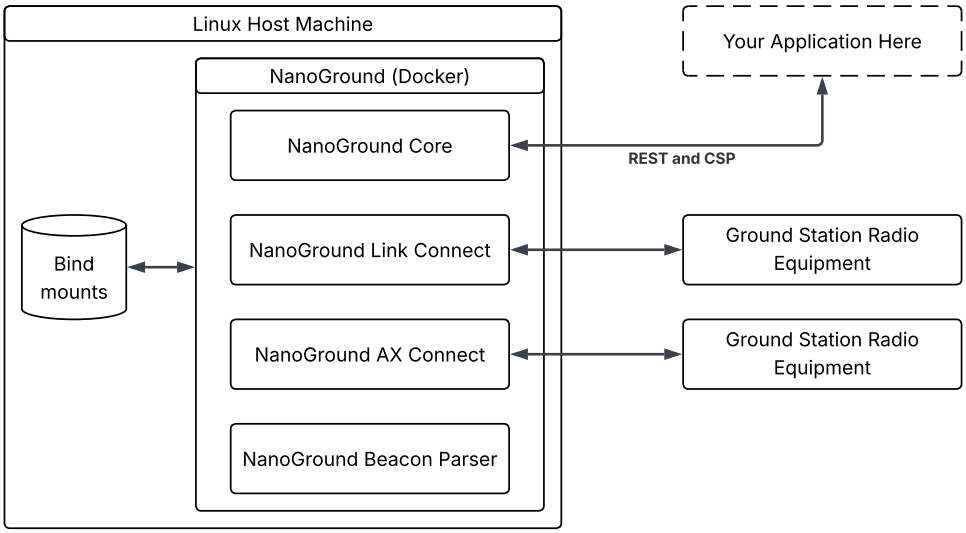

Figure 2.1: Generalized block diagram of NanoGround and its interfaces

As depicted on Figure 2.1, NanoGround is distributed as a core component with optional extensions that can be added to enhance functionality. The core component and each extension is deployed as a Docker Compose stack comprised of multiple docker containers. When installing NanoGround, the Docker images are loaded and a main directory for the NanoGround installation is created. The main directory contains subdirectories used as bind-mounts in the Docker containers. The subdirectories contain all configuration, data, and other state for NanoGround. Some configuration is provided during installation, but most configuration is done through a representational state transfer (REST) application programming interface (API) for easy programmatic interaction. The main directory contains scripts for easy start, stop, and deployment configuration of the NanoGround system.

The **NanoGround Core** extension provides the REST API and a GomSpace Shell (GOSH) command-line interface (CLI), which can both be used to integrate and interact with NanoGround. It also provides a ZeroMQ (ZMQ) interface to a ground Cubesat Space Protocol (CSP) network and an Internet Protocol version 4 (IPv4) network interface. These network and interface comes with gateways for bridging to the CSP and IPv4 networks onboard the satellite. For more details, see Section 4.1.

The **NanoGround Link Connect** extension provides NanoCom Link connectivity via multiple different ground station equipment. In addition, it provides data parsing services for the GomSpace Unidirectional File Transfer Protocol (GSUFTP) file transfer service offered by NanoCom Link radios. For more details, see Section 4.2.

The **NanoGround AX Connect** extension provides NanoCom AX connectivity via multiple different ground station equipment. For more details, see Section 4.3.

The **NanoGround Beacon Parser** extension can be used to receive, parse, and store satellite housekeeping beacons in an easy-to-access format in a database. For more details, see Section 4.4.

3 System Requirements

The host system requirements for running NanoGround depend on the specific use case and the components being used. The general, minimum system requirements for running the NanoGround are listed in Table 3.1.

Name	Value
OS	GNU/Linux (has been verified on Ubuntu Server 22.04)
Memory	8 GiB
Disk	10 GiB
Docker	>28.3.0
Python	>=3.10

Table 3.1: NanoGround host minimum system requirements

4 Extensions

NanoGround provides the ability to extend the core functionality with additional modules called *extensions*. This section provides an overview of the various available extensions.

Extension	Optional
NanoGround Core	
NanoGround Link Connect	✓
NanoGround AX Connect	✓
NanoGround Beacon Parser	✓

Table 4.1: List of available NanoGround extensions

4.1 NanoGround Core

NanoGround Core is provided by default in all distributions of NanoGround and serves as a basis for the other extensions.

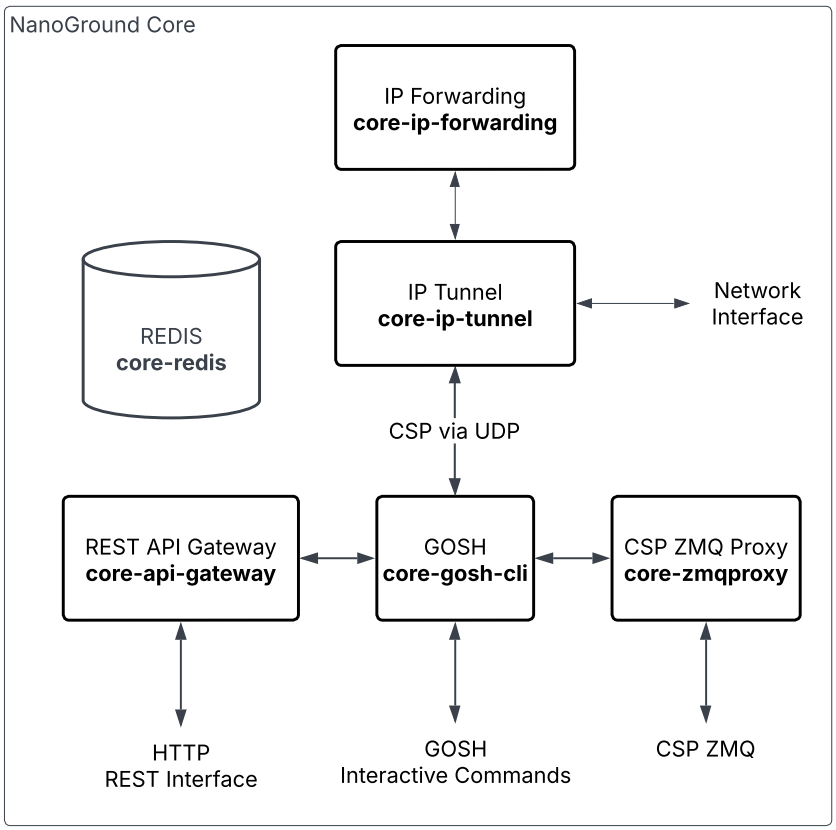

Figure 4.1: Block diagram of NanoGround Core and its interfaces

NanoGround Core provides containers that are essential for the operation of the system. An overview of NanoGround Core is shown in Figure 4.1. Each service in the overview corresponds to a Docker container when NanoGround is deployed. These containers are described in Table 4.2.

Container	Description
core-api-gateway	REST API for easy GOSH interaction and configuration/status parameter management.
core-gosh-cli	GOSH container with most GomSpace clients registered and connects NanoGround with other CSP nodes available on the network.
core-redis	An internally used redis container that holds configuration, status, and other data necessary for NanoGround to function.
core-zmqproxy	ZMQ proxy that provides a virtual CSP communications bus.
core-ip-tunnel	IPv4 network interface that acts as main gateway for all communication with ground station equipment and GomSpace radios.
core-ip-forwarding	IPv4 forwarding service that handles multiple active connections with different ground station equipment.

Table 4.2: NanoGround Core containers and their responsibilities

4.2 NanoGround Link Connect

The NanoGround Link Connect extension provides connectivity with GomSpace NanoCom Link radios via various ground station equipment. It supports a range of equipment out of the box and can be extended to support custom equipment through a custom connector.

The extension enables interaction with your NanoCom Link radio via IP-tunnelling. You can use standard Linux tools, such as rsync, to synchronize, download, and upload files to/from your satellite. Additionally, the NanoGround Link Connect extension provides a GSUFTP reception service used for fast download of large files over unidirectional radio links. An overview of NanoGround Link Connect is shown in Figure 4.2. Each service in the overview corresponds to a Docker container when NanoGround Link Connect is deployed. These containers are described in Table 4.3.

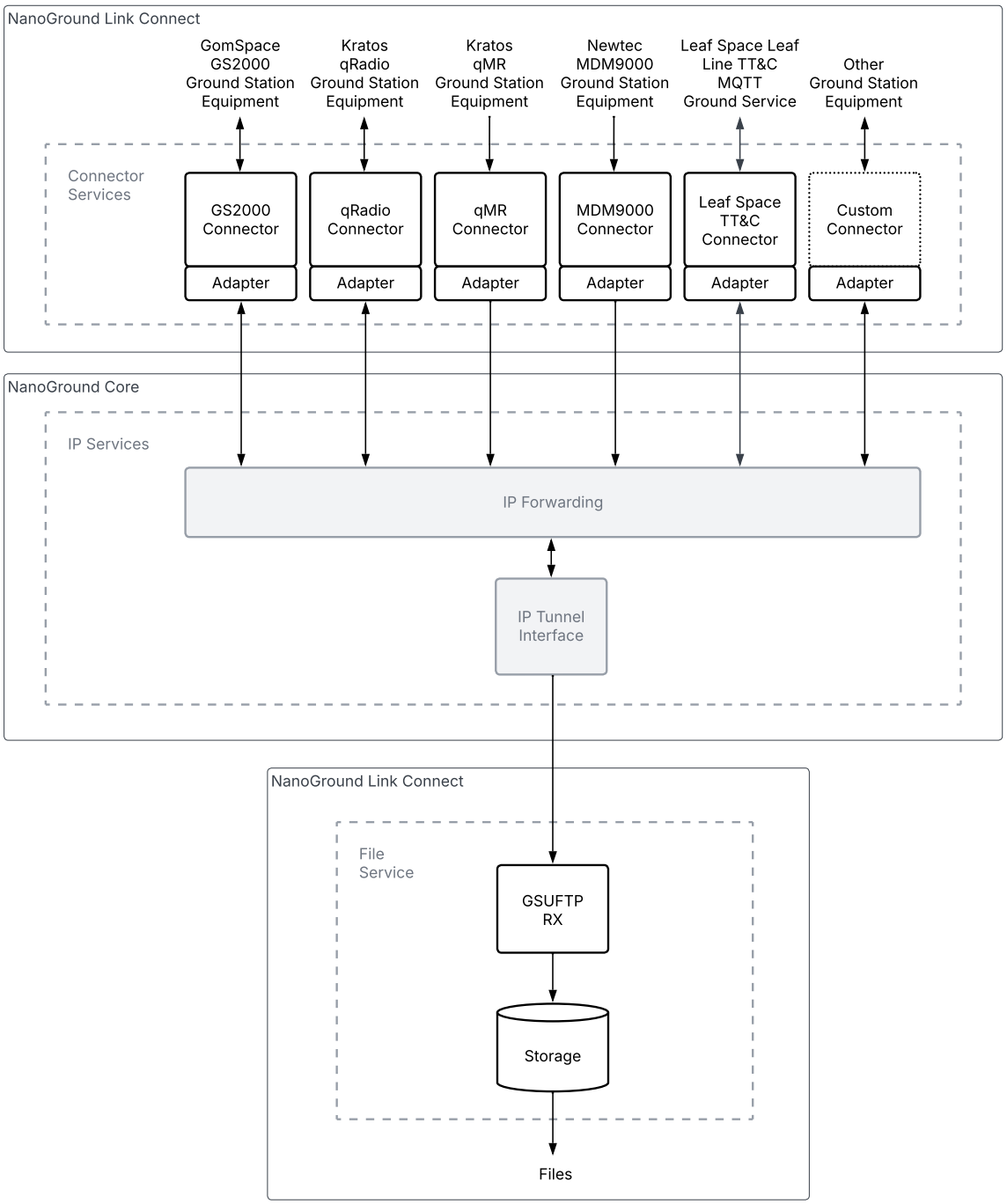

Figure 4.2: Block diagram of NanoGround Link Connect and its interfaces

Container	Description
gs2000-connector	Connector service used to integrate NanoGround with GomSpace GS2000 ground equipment.
qradio-connector	Connector service used to integrate NanoGround with Kratos qRadio ground equipment. Note this is also used for integration with KSAT lite ground station services.
qmr-connector	Connector service used to integrate NanoGround with Kratos qMR/qRX ground equipment. Note this is also used for integration with KSAT lite ground station services.
mdm9000-connector	Connector service used to integrate NanoGround with Newtec MDM9000 ground equipment.
leafspacettc-connector	Connector service used to integrate NanoGround with Leaf Space TTC ground static services.
custom-connector	This service is not provided by NanoGround Link Connect but must be provided by the user if support for custom equipment is needed.
adapter	Adapter service that handles all common data processing allowing all connectors to focus entirely on handling ground equipment protocols.
gsuftp-rx	GSUFTP reception service.

Table 4.3: NanoGround Link Connect containers and their responsibilities

4.3 NanoGround AX Connect

The NanoGround AX Connect extension provides connectivity with GomSpace NanoCom AX radios via various ground station equipment. The extension supports a range of equipment out of the box.

The extension enables interaction with your NanoCom AX radios via CSP through the NanoGround Core ZMQ Proxy. The AX radios use carrier-sense multiple access (CSMA) to access the radio channel, and transmit in bursts. For optimal performance of the link, the extension should be configured to suit the particular situation. All CSP traffic is routed through the NanoGround Core GOSH CLI, which encapsulates the CSP traffic in User Datagram Protocol (UDP) packets which are sent to equipment specific connectors. An overview of NanoGround AX Connect is shown in Figure 4.3. Each service in the overview corresponds to a Docker container when NanoGround AX Connect is deployed. These containers are described in Table 4.4.

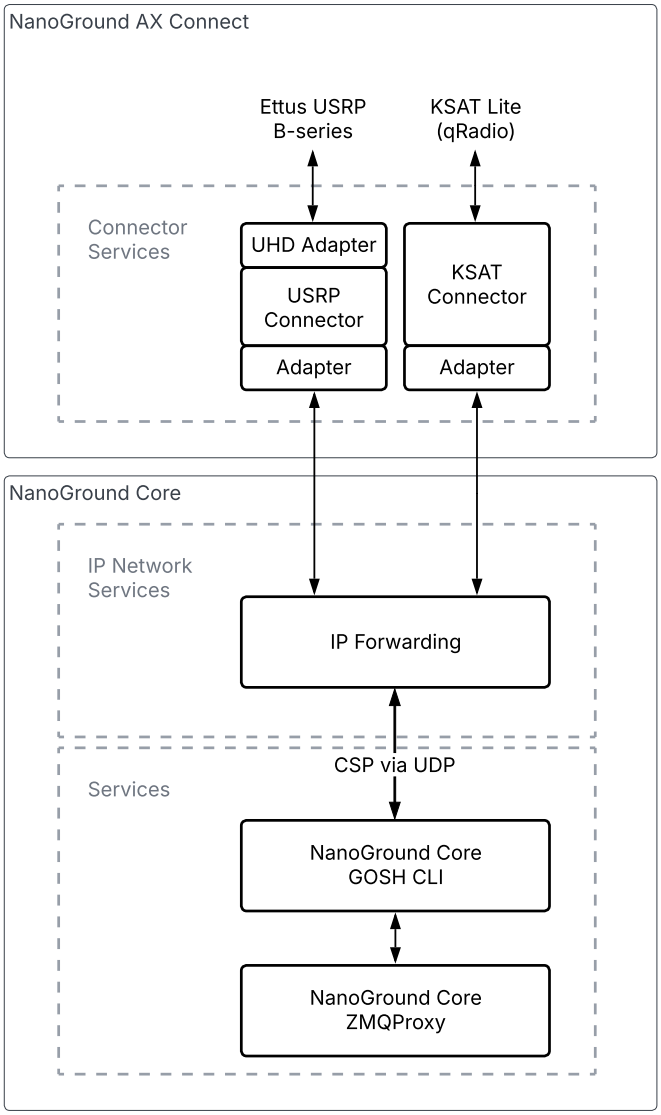

Figure 4.3: Block diagram of NanoGround AX Connect and its interfaces

Container	Description
`ksat-connector`	Connector service used to integrate NanoGround with Kongsberg Satellite Services (KSAT) ground station service (using Kratos qRadio).
`usrp-connector`	Connector service used to integrate NanoGround with Ettus USRP ground equipment.
`adapter`	Adapter service that handles all common data processing allowing all connectors to focus entirely on handling ground equipment protocols.

Table 4.4: NanoGround AX Connect containers and their responsibilities

4.4 NanoGround Beacon Parser

The NanoGround Beacon Parser extension provides the ability to receive, parse, and store beacons generated by a GomSpace housekeeping system. It provides two services which are described in Table 4.5.

Container	Description
`beacon-parser`	Parser service used to receive and parse beacons.
`beacon-timescale-db`	TimescaleDB service used to store beacon data.

Table 4.5: NanoGround Beacon Parser containers and their responsibilities

5 Performance

NanoGround performance has been tested on individual test setups against NanoCom Link SX and NanoCom AX2150 radios. During these tests, the radios were configured for their maximum bandwidth performance. Note that, during these tests the radio frequency (RF) connections were realized via coaxial cables rather than real radio frequency antennae. The specifications for the host machine used during testing are shown in Table 5.1.

Name	Value
CPU	Intel(R) Core(TM) i7-7700 CPU @ 3.6 GHz
Memory	32 GiB
OS	Ubuntu 22.04
Docker	28.3.0
Python	3.10.12

Table 5.1: GomSpace NanoGround performance test machine specifications

5.1 NanoCom Link SX

The NanoGround IPv4 bandwidth performance when connected with a NanoCom Link SX has been tested with the results shown in Table 5.2.

Metric	Value
Uplink Speed (S-band)	6.4 Mbit/s
Downlink Speed (S-band)	6.4 Mbit/s
Downlink Speed (X-band using gsuftp)	210.6 Mbit/s

Table 5.2: NanoCom Link SX bandwidth performance results

5.2 NanoGround AX Connect

The NanoGround CSP bandwidth performance when connected with a NanoCom AX2150 has been tested with the results shown in Table 5.3. These results are very use-case dependent and can vary significantly based on the configuration, packet sizes and flow of the data. The results are only to be used as indications of the expected performance of the system. The results are not guaranteed and may vary based on the specific setup and environment.

Metric	Value
Simplex Uplink Speed	14 864 bit/s
Simplex Downlink Speed	8315 bit/s
Half-duplex Uplink Speed	8542 bit/s
Half-duplex Downlink Speed	4530 bit/s

Table 5.3: NanoCom AX2150 bandwidth performance results

5.3 NanoGround AX Connect Modem

The NanoGround AX Connect extension provides a modem implementation for the USRP connector. The frame error rate (FER) performance of the NanoGround AX Connect modem is shown in Figure 5.1.

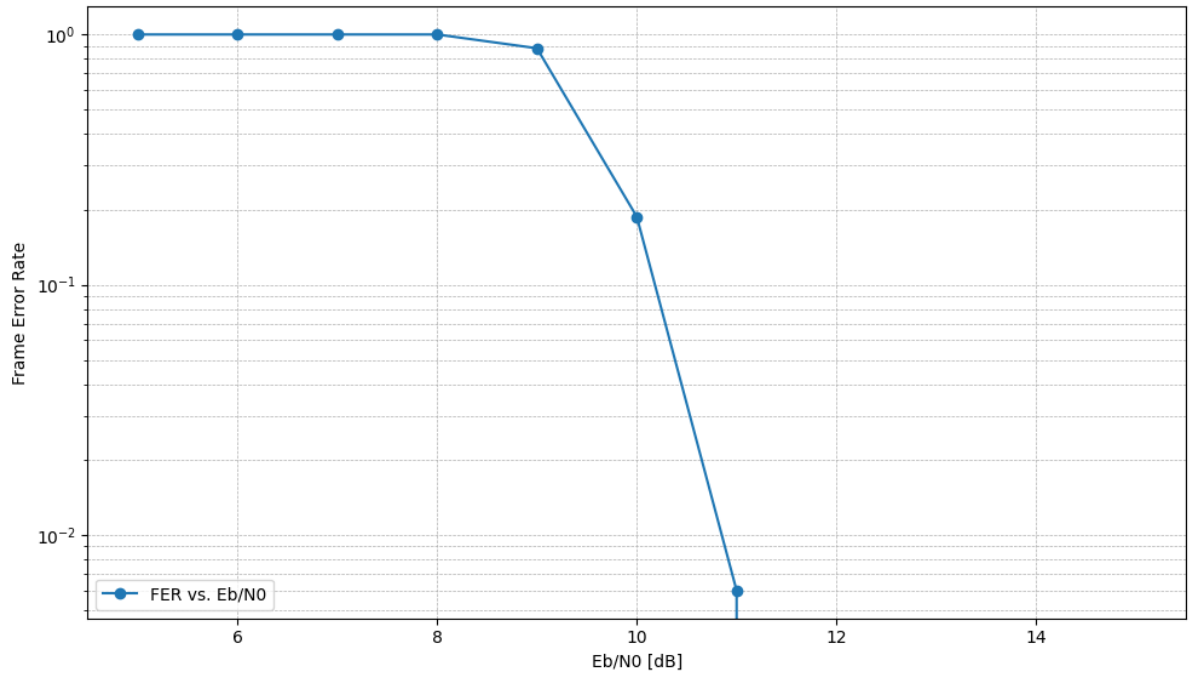

Figure 5.1: Frame error rate performance of the AX Connect softmodem