University of Washington

HuskySat-2 GND Interface Control Document

ICD-GND-001

Prepared by: Systems Team
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Revision History

Revision	Date	Change	Author	Approved By	Notes
1	9/9/2025	Version 1 created	Catherine Collison	UNP	
2	10/6/2025	Subsystem ICD template	Catherine Collison	Systems Team	
3	7/15/2026	GND ICD created	Lauren Wetzel	Systems Team	
4	8/31/2026	GND Software Interfaces	Mahir Emran	Systems Team	

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Acronyms & Symbols List

Acronym	Definition
HSL	Husky Satellite Lab
HS-2	HuskySat-2
CDH	Command and Data Handling
UNP	University Nanosatellite Program
LEO	Low Earth Orbit
LOST	LOST Open-Source Star Tracker
FOUND	Found Open-Source Universal Navigational Determiner
COTS	Commercial Off-The-Shelf
ADCS	Attitude Determination and Control System
CDH	Command and Data Handling System
GCDH	Ground Command and Data Handling System
GSTAT	Ground Station
THR	Thermal control subsystem
STR	Structures subsystem
EPS	Electrical Power Subsystem
BMS	Battery management system
PDS	Power distribution system
COM	Communications Subsystem
PCB	Printed Circuit Board
GPS	Global Positioning System
NDA	Non Disclosure Agreement

Symbol	Definition

**	Number managed by the team, but unable to be provided due to NDA

Purpose and Scope

This Interface Control Document (ICD) defines the **electrical**, **mechanical**, **thermal**, and **data** interfaces required for the Ground (GND) subsystem to be successfully integrated into HuskySat-2. The GND subsystem includes all hardware to support the scientific customer of HuskySat-2. Husky Sat-2 (HS-2) is a 3U CubeSat developed by the Husky Satellite Lab (HSL) at the University of Washington in Seattle. Designed to operate in Low Earth Orbit, HS-2 aims to demonstrate the capabilities of its novel navigation technology: LOST (Lost Open-Source Star Tracker) and FOUND (FOUND Open-Source Universal Navigational Determiner). LOST and FOUND enable GPS-independent navigation for small satellites using a unique star tracker and horizon tracker package developed here at HSL. The GND subsystem includes all hardware to support the operation of LOST and FOUND.

GND

The GND subsystem has the following hardware components:

Table 1. GND Hardware

Hardware	Description	Datasheet (Public)
Ground Operations Computer	Computer used by operators to run GND software stack, including YAMCS, Grafana, mission operations scripts. The choice right now [TBR] is a Lenovo ThinkCentre M70q Gen 6 Tiny with an Intel Core Ultra 7 265T processor, 32 GB RAM, Ubuntu Server 24.04 LTS, and two 1 TB M.2 NVMe SSDs in a mirrored array. It uses wired Ethernet and UPS-backed power.	N/A
Leaf Space Ground Station	Third-party S-band ground station service used for RF uplink/downlink. Provides physical antenna, RF front end, tracking, and space-to-ground communication service	N/A
Network Equipment (Ethernet cable + Router)	Used to connect ground operations computer to the internet for ground service provider	N/A

Interface Identification and Definitions

1. Interface Overview

Electrical Interfaces: Defines the power distribution structure, including the 3.3V, 5V, and 12V voltage rails allocated by the power budget. Establishes the physical connectors, pinouts, and signal characteristics managing power and data delivery to the subsystem

Mechanical Interfaces: Captures physical dimensions, mass properties, and mounting requirements of subsystem components, as well as how they interface with each other and the spacecraft structure.

Thermal Interfaces: Specifies the heat generated by each component, establishes operational and survival temperature boundaries, and details the physical conduction paths mounting interfaces that connect the components to the structure.

Software Interfaces: Any exchange of information to, from, or inside the subsystem. Describes the data, data type, connections, and protocols.

1.0 Electrical Interfaces

The GND subsystem has no direct electrical interfaces with other HuskySat-2 subsystems. As a result, there are no electrical interface requirements applicable to the GND subsystem

2.0 Mechanical Interfaces

The GND subsystem has no direct mechanical interfaces with other HuskySat-2 subsystems. As a result, there are no mechanical interface requirements applicable to the GND subsystem

3.0 Thermal Interfaces

The GND subsystem has no direct thermal interfaces with other HuskySat-2 subsystems. As a result, there are no thermal interface requirements applicable to the GND subsystem.

4.0 - Software Interfaces

The GND subsystem breaks down into two sections:

- GCDH (Ground Command and Data Handling)-- handles our data/telemetry processing and interface for sending commands
- GSTAT (Ground Station)-- handles direct communication to and from the satellite, sending and receiving data from GCDH. We use Leaf Space for this component.

4.1 - GCDH

The software being used by the GCDH is:

- YAMCS, for uplinking commands and interfacing with the GSTAT to receive telemetry/logs
- Grafana, for visualizing the telemetry/logs that YAMCS receives from the GSTAT

4.1.1 - Communication Protocol

For HS-2, the communications protocol used for downlinked packets is the CCSDS TM Space Data Link Protocol (based on the CCSDS TM specification (CCSDS 132.0-B-3)). For uplinked packets, the communication protocol to be used is the CCSDS TC Space Data Link Protocol

(based on the CCSDS TC specification (CCSDS 232.0-B-4)). YAMCS provides framing capabilities for deframing downlinked telemetry and framing uplinked packets. Encryption occurs after TM/TC frames are applied using SDLS, with the protocol being AES256.

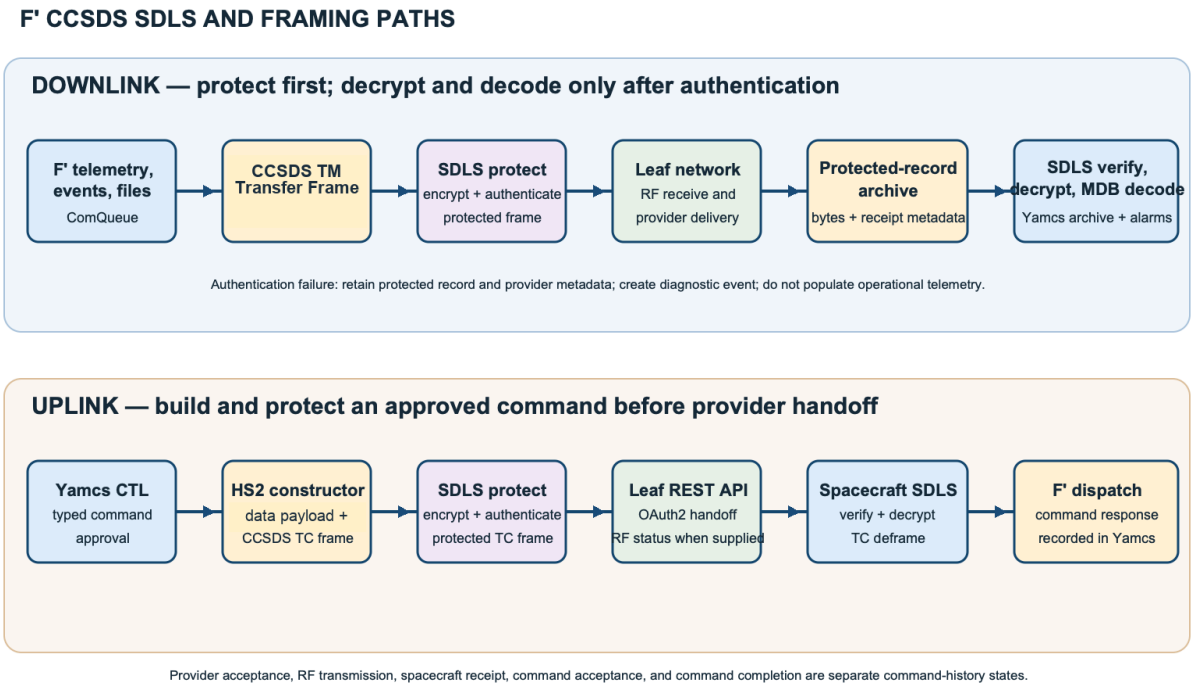


Figure 1: The pipeline of how our data gets packaged for both downlinked data and uplinked commands

4.1.2 - Uplinked Commands

All commands sent follow the F' CmdDispatcher format, meaning in addition to our own parameters, we add 4 bytes representing the command type, 4 bytes representing the command ID, 4 bytes representing the sequence number, and 12 bytes for framing. Parameters listed below do not include this 24 [TBR] bytes of overhead, but it is accounted for in the 'Size (Bytes)' column. We use YAMCS as our command interface, which handles this packet formatting + framing, and sends the data to the Leaf Space server (refer to 4.1.3). Refer to the Command and Telemetry List (CTL) for the list of commands that GND can send. Note that many of the commands for individual hardware components on the satellite are for error correction purposes and not meant for nominal usage.

4.1.3 - Data Interface

GCDH interfaces with the GSTAT through Leaf Space's delivery servers. For the current low-rate S-band design, the real-time interface is authenticated MQTT: GCDH subscribes to the spacecraft-specific /NORAD_ID/downlink topic and publishes commands on /NORAD_ID/uplink. Leaf's ground station receives the spacecraft RF and exposes the downlink as a raw binary, containing an ISO-8601 timestamp. GCDH audits and validates the received transfer frame

before forwarding it over a local YAMCS UDP link for F′/XTCE decoding and archival. Leaf's REST API is used separately for pass status, station configuration, and tracking records. This is how data is sent to and from the GSTAT from the GCDH.

Table 2. GCDH and GSTAT Communication Interface

Wired/Wireless	Wired logical network connection over the Internet/VPN
Communications Protocol	MQTT over TCP/TLS for real-time telemetry and telecommands; HTTPS REST API for pass and station metadata
Signal Type	Digital IP network traffic
Data Format	Leaf-defined raw binary containing a timestamp, uplink format defined in 4.1.2
Protocol (if defined)	MQTT/TLS, production topics are `/<NORAD_ID>/downlink` and `/<NORAD_ID>/uplink`
Type of Data	Downlink transfer frames, uplink command payloads, delivery timestamps, monitoring/link data, and pass metadata
Software	GCDH Leaf adapter, MQTT client library, Yamcs interface, and Leaf Space/GSTAT service
Commands/Inputs	GCDH subscribes to the downlink topic, publishes validated uplink commands, and queries the Leaf REST API for passage and ground-station information

4.2 - GSTAT

The communication protocol and the data interface from the GSTAT to GCDH follows the same protocols as defined in 4.1.1 and 4.1.3. The GSTAT receives commands and configuration from GCDH through the Leaf Space delivery service and provides the spacecraft RF interface during scheduled contacts. The GSTAT is responsible for ground-station scheduling, RF transmission and reception, and delivery of telemetry and command data through the contracted Leaf Space interface.

4.2.1 - Sending Data to Spacecraft

During an authorized contact, GSTAT receives an uplink command payload from the Leaf Space service and transmits it to the spacecraft using the S-band ground-station chain. The command payload is generated and validated by GCDH/Yamcs before being handed to Leaf Space. GSTAT performs the station-side RF transmission and forward-error-correction of the data.

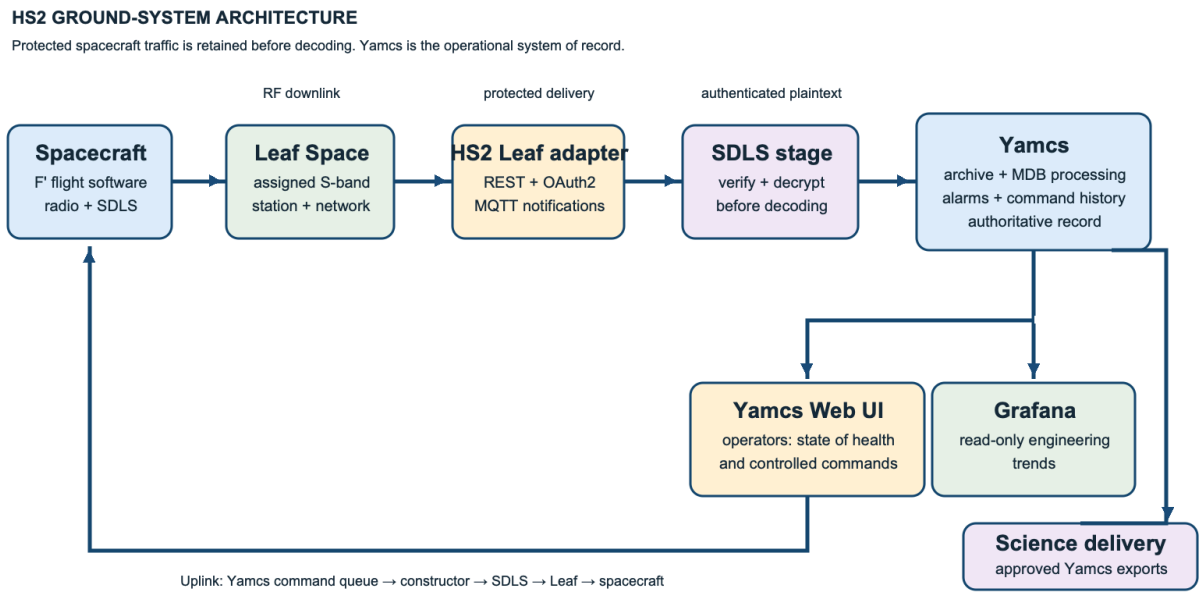


Figure 2: The pipeline of data between the ground station and spacecraft

Table 3. GSTAT and COMMS Communication Interface

Wired/Wireless	Wireless over S-band RF
Communications Protocol	CCSDS Telecommand Space Data Link Protocol for the spacecraft-facing command data
Signal Type	Digital, modulated S-band RF uplink
Data Format	F′ command packet encapsulated in a CCSDS TC Space Packet and/or TC Transfer Frame, with radio-layer processing applied by the configured ground-station chain
Protocol (if defined)	CCSDS TC frames; encryption, HDLC, scrambling, synchronization, and FEC follow the EnduroSat/Leaf Space mission configuration
Type of Data	Telecommands, command arguments, command sequence information, and required framing/error-control data
Software	Leaf Space/GSTAT ground-station software (not made in-house), GCDH Leaf adapter, YAMCS, and the F′ command postprocessor
Commands/Inputs	Validated uplink commands received from the Leaf `/NORAD_ID/uplink` service topic, contact schedule and station configuration from Leaf Space

Data rate	50 kbit/s nominal fixed S-band transceiver rate; usable command throughput is lower after framing, encryption, synchronization, and FEC overhead

4.2.2 - Downlinked Telemetry/Logs

During a scheduled contact, GSTAT receives the spacecraft's S-band downlink and forwards the resulting Leaf delivery to GCDH. The downlink contains CCSDS telemetry frames carrying F′ telemetry channels, events, logs, and files, which is encrypted through SDLS with the protocol being AES256. Leaf Space handles FEC, and GCDH handles the encryption and unraveling the packets. For the expected Narrowband service, Leaf delivers the data to GCDH through the spacecraft-specific /NORAD_ID/downlink MQTT topic as either a JSON timestamp/payload envelope or raw binary, depending on the contracted configuration. GCDH records the Leaf delivery metadata, validates the transfer frame, and forwards the frame to Yamcs for F′/XTCE decoding, event processing, and archival. Grafana reads the decoded Yamcs archive for engineering and science dashboards.

Downlinked telemetry is split into two categories: F' telemetry and F' events. F' telemetry (which is data like State of Health (SOH), modes, etc) is downlinked according to the TlmPacketizer component, which adds the following overhead on the telemetry payload: descriptor U32 (4), packet ID U16 (2), and a timestamp (11), for a total of 17 [TBR] bytes. F' events (which represent changes in states for hardware and the satellite state machine, as well as errors), are downlinked according to the EventsManager. Each event is 23 [TBR] bytes, breaking down as follows: event ID (4), time tag (11), descriptor (4), and event argument (4). Refer to the CTL for a list of telemetry (meaning both F' telemetry and F' events) that can be sent down by the satellite.

GND must directly request to downlink an image. GND can also configure the satellite's communication mode to not downlink any data, only downlink real-time data, or downlinking both real-time data and historical SOH data.

5.0 References

Leaf Space's documentation is behind their Atlassian portal which requires authentication, and documents are not approved for public release. As such, we cannot link them, but we used the following documents:

- Leaf Space Network Datasheet
- Leaf Space Ground Station ICD