

PLATFORM INTERFACE CONTROL DOCUMENT

NANOSAT PLATFORM KIT

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2.2		Update for NanoSat 12U <ul style="list-style-type: none"> • Most sections on mechanical interfaces updated with details on 12U • New section 4.5.2 added on 2U secondary structures • New section 9 added on Transportation and Storage

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1. References

1.1 Applicable documents

Ref.	Document Title	Issue and Revision
[AD-1]	NanoSoft Product Interface Application (IFS: 1018560)	4.0.0 or higher
[AD-2]	NanoCom TMTC-S RF ICD (IFS: 1047542)	3.0 or higher
[AD-3]	NanoCom Link S, X, SX User Manual (IFS: 1045187)	1.2 or higher
[AD-4]	NanoCom Link S, X, SX RF Interface (IFS: 1045318)	1.2 or higher
[AD-5]	NanoCom Link S, X, SX Control Interface (IFS: 1045207)	4.1 or higher
[AD-6]	NanoCom Link S, X, SX Data Interface (IFS: 1045208)	1.1 or higher
[AD-7]	NanoMind HP MK3 – User Space Software (IFS: 1046533)	1.1 or higher
[AD-8]	NanoMind HP MK3 – PDK User Manual (IFS: 1046532)	2.1 or higher
[AD-9]	NanoMind HP MK3 – SpaceWire Interface Manual (IFS: 1028564)	1.3.0 or higher
[AD-10]	NanoMind HP MK3 – ICD – Gateway Interface (IFS: 1046534)	1.1 or higher
[AD-11]	NanoMind HP MK3 – ICD – SpaceWire Interface (IFS: 1028565)	1.4 or higher
[AD-12]	NanoMind HP MK3 – ICD – RS-422 and RS485 Interface (IFS: 1029472)	1.4 or higher
[AD-13]	NanoMind HP MK3 Datasheet (IFS: 1036210)	2.1 or higher
[AD-14]	NanoStructure 6U Datasheet (IFS: 1060779)	1.1 or higher
[AD-15]	NanoStructure 6U User Manual (IFS: 1060787)	1.0 or higher
[AD-16]	NanoStructure 8U Datasheet (IFS: 1066042)	1.0 or higher
[AD-17]	NanoStructure 8U User Manual (IFS: 1066045)	1.0 or higher
[AD-18]	NanoStructure 12U Datasheet (IFS: 1043916)	1.0 or higher
[AD-19]	NanoStructure 12U User Manual (IFS: 1043891)	1.0 or higher

1.2 Reference documents

Ref.	Document Title	Issue and Revision
[RD-1]	NanoCom AX2150 KSAT Compliance (IFS: 1053627)	1.0 or higher
[RD-2]	CubeSat Design Specifications (CP-CDS-R14.1)	Rev 14.1

2. Glossary

2.1 Acronyms

Acronyms	Description
CAD	Computer Aided Design
CAN	Controller Area Network
CDR	Critical Design Review
COTS	Commercial Off-The-Shelf
CSP	CubeSat Space Protocol
EPS	Electric Power System
GND	Ground
GOSH	GomSpace Shell
I2C	Inter-Integrated Circuit
ICD	Interface Control Document
IOD	In Orbit Demonstration
JTAG	Joint Test Action Group
LNA	Low Noise Amplifier
LVDS	Low-Voltage Differential Signaling
NTE	Not To Exceed
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PPS	Pulse Per Second
SDR	Software Defined Radio
SW	Software
RF	Radio-Frequency
Rx	Reception
TBC	To Be Confirmed
TBD	To Be Defined
Tx	Transmission
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
VARF	VARiable Frequency (synchronization signal)
Vcc	Voltage at the Common Collector

2.2 Definition of Terms

Terms	Description
Assembly	Physically combining parts, components, equipment or segment elements to form a larger entity
CubeSat	A CubeSat is a type of spacecraft that consists of multiples of 10×10×10 cm ³ units (U)
Environment	Natural conditions and induced conditions that constrain the design definitions or operations of a product.
FlatSat	Testbed for an Electrical and Functional Representation of the spacecraft Bus
Flight Model	End product that is intended for flight.
Flight Plans	A time-tagged sequences of commands to be executed independently from a link with a ground station
Integration	Functionally combining lower-level functional entities (hardware or software) so they operate together to constitute a higher-level functional entity
Mission Designer	As Mission Designer is intended the individual, group or team responsible for adapting the generic GomSpace NanoSat CubeSat Platform to meet the Goals and Requirements of the specific mission.

Terms	Description
Nominal Operations	Planned tasks or functions performed by a spacecraft or launch vehicle orbital stage prior to its disposal.
Payload	A spacecraft payload is a set of instruments or equipment which performs the user's mission.
Project	Set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources.
ProtoFlight Model (PFM)	Flight model on which a partial or complete ProtoFlight qualification test campaign is performed before flight.
Requirement	Documented demand to be complied with.
Review	Activity undertaken to determine the suitability, adequacy and effectiveness of the subject matter to achieve established objectives.
Segment	Set of elements or combination of systems that fulfils a major, self-contained, subset of the space mission objectives.
Specification	Document stating requirements.
Subsystem	Part of a system fulfilling one or more of its functions.
Test	Measurement of product characteristics, performance or functions under representative environments.
Third Party	Person or body that is recognized as being independent of the parties involved, as concerns the issue in question.
(CubeSat) Unit	The volume available in a 1U CubeSat (~100mm x 100mm x 100mm) and/or the surface of a 1U CubeSat face (~100mm x 100mm).
Verification	Process which demonstrates through the provision of objective evidence that the product is designed and produced according to its specifications and the agreed deviations and waivers, and is free of defects.

3. Introduction

3.1 Purpose

The purpose of this document is to provide a detailed technical description of the mechanical, electrical, radio and software interfaces between GomSpace NanoSat CubeSat Platform and its Payload(s).

4. Mechanical Interfaces

4.1 Platform Layout

As a baseline, the subsystems of the NanoSat CubeSat Platform occupy a volume of roughly 3 Units:

1. Power Unit: EPS and 1x Battery Pack
2. Avionics: OBC, radios, ADCS computer and Payload computer
3. ADCS Actuators and Gyro: Reaction Wheels, Torquers and Gyro

If a Star Tracker or additional Battery Packs are added as optional, one or more additional Units are reserved to accommodate them (Star Tracker occupies 1 Unit as shown in Figure 4-1, 2x Battery Packs occupy 1 Unit, either in place of the Star Tracker or next to the Power Unit).

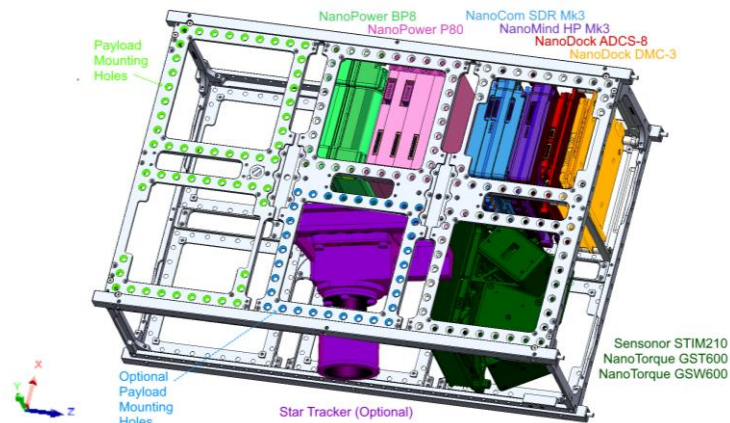


Figure 4-1: CAD of the 6U NanoSat CubeSat Platform with the platform internal subsystems

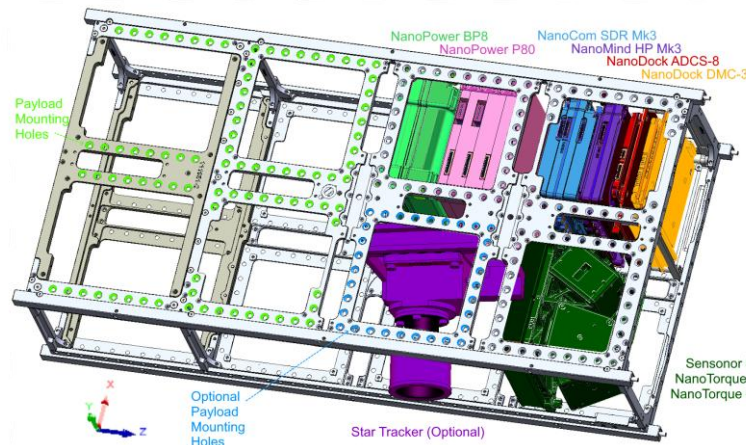


Figure 4-2: CAD of the 8U NanoSat CubeSat Platform with the platform internal subsystems

The outer frame of the 6U and 8U is made of two large frames (hereafter referred to as “Y Walls”) and four “Corner Brackets” to join the frames. Each Corner Brackets is assembled with two screws.

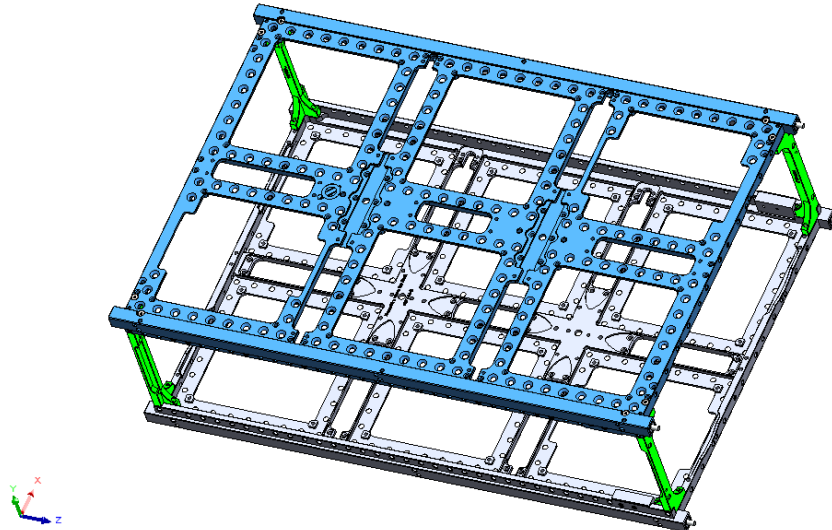


Figure 4-3: CAD of the NanoStructure 6U – “+Y Wall” highlighted in blue, “Corner Brackets” in green

For the 8U and 12U versions, there is an additional option for propulsion, occupying 1U extra. Due to the central placement, it leaves two 0.5U volumes to either side that can be used for additional hardware, e.g. extra battery packs.

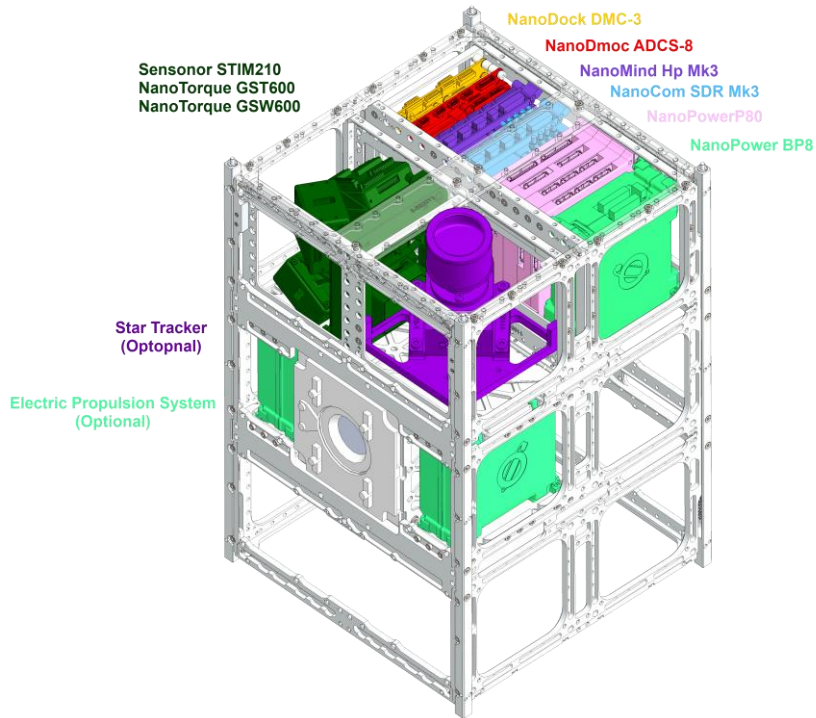


Figure 4-4: CAD of the 12U NanoSat CubeSat Platform with the platform internal subsystems

4.2 Primary Structure ICD

4.2.1 NanoStruct 6U

The 2D drawings and hole pattern definition of the NanoStruct 6U can be found in [AD-14] and [AD-15].

4.2.2 NanoStruct 8U

The 2D drawings and hole pattern definition of the NanoStruct 8U can be found in [AD-16] and [AD-17].

4.2.3 NanoStruct 12U

The 2D drawings and hole pattern definition of the NanoStruct 12U can be found in [AD-18] and [AD-19].

4.3 Internal Payload Subsystems

The figures in section 4.1 highlight in green and blue the recommended hole patterns to use to mount internal payload components into the structure. The mounting holes are designed to accommodate standard DIN M2.5 countersunk screws and are defined as shown in Figure 4-5.

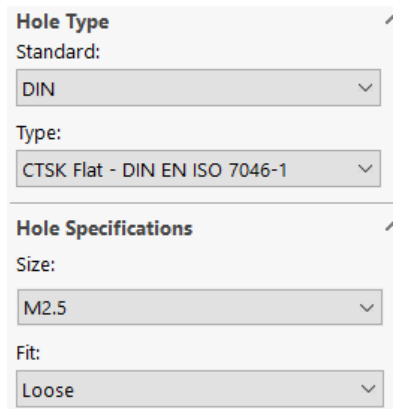


Figure 4-5: Hole definition in SolidWorks

For mounting internal components, the following screw type is recommended: M2,5x5mm Torx countersunk ISO-14581 A4 (or longer).

Refer to the NanoStructure 2D CAD for additional information about the mounting specifications and position on the satellite structure.

4.3.1 Internal Subsystems Tolerances

When an internal subassembly is interfaced with both “Y Walls” of the primary structure, it is important to control the tolerances of the subassembly in order to maintain the distance between the two Walls as per design (95mm for 6/8U) to avoid bending and twisting the primary structure when mounting the subassembly. For such subassemblies, the recommended tolerance specifications are shown in Figure 4-6. A drawing example can be seen in Figure 4-16.

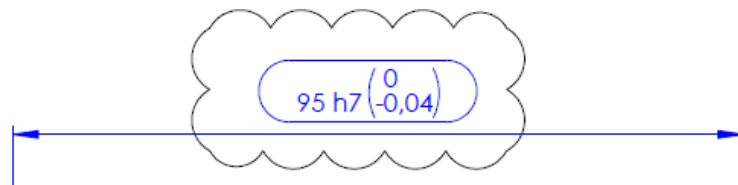


Figure 4-6: Wall to Wall Dimension and Tolerance specifications for internal subsystems

For the 12U structure, use of the secondary structure (see section 4.5.2) between Y-walls assures the correct dimensions. If a customize secondary structure is required instead, Figure 4-7 shows the recommended dimensions and tolerances for a customized secondary structure:

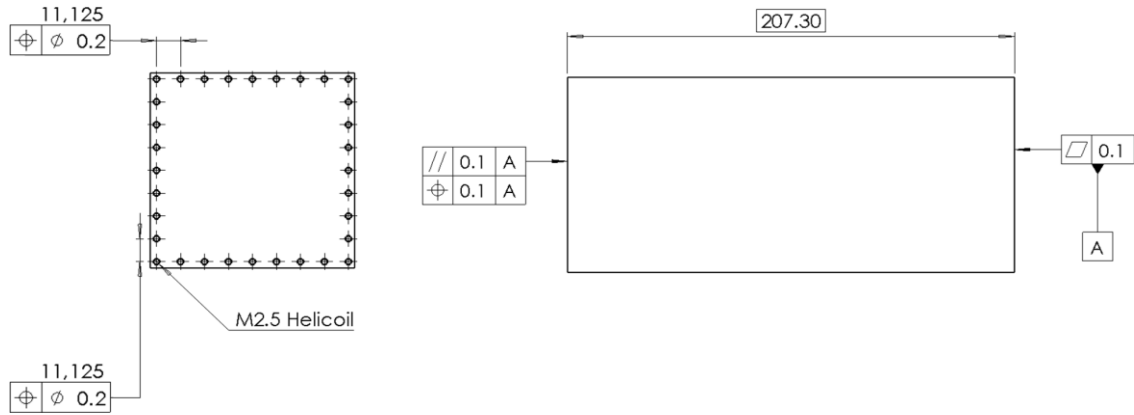


Figure 4-7: Wall to Wall Dimension and Tolerance specifications for internal secondary structures

4.4 External Payload Subsystems

Figure 4-8, Figure 4-9 and Figure 4-10 highlight the recommended possible apertures for the payload. By default, the standard platform provides small modular body mounted solar panels and aluminium cover plates to cover the unused apertures.

It is the responsibility of the Mission Designer to select which payload apertures to use for each mission and to customize/replace the cover plates if necessary. It is possible to use different apertures than the ones recommended (e.g. removing the TunaCan or a different solar panel), however in such cases, the Mission Designer is responsible for updating all relative aspects of the design of the Platform Kit and tailor it to the specific mission.

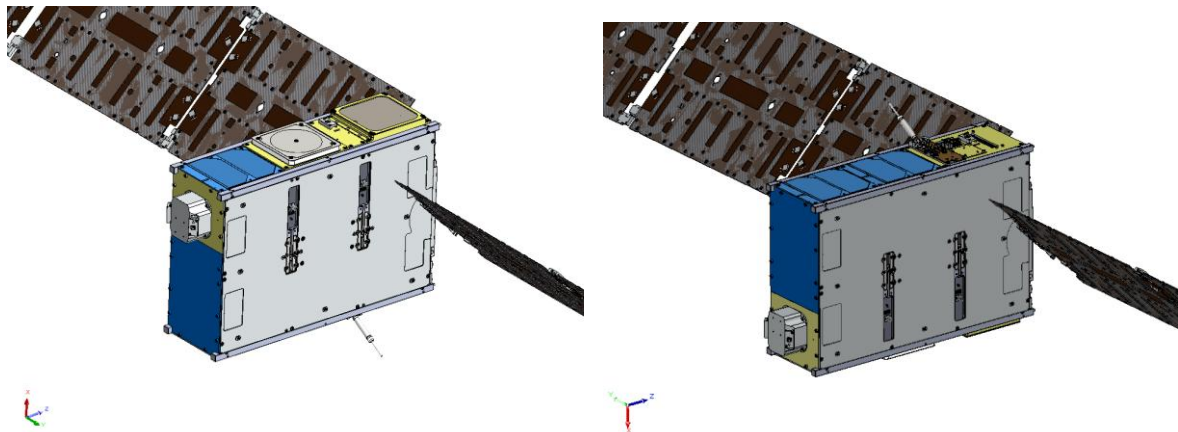


Figure 4-8: 6U Payload Apertures - Cover Plates (Left: +X and -Z faces, Right: -X and -Z faces)

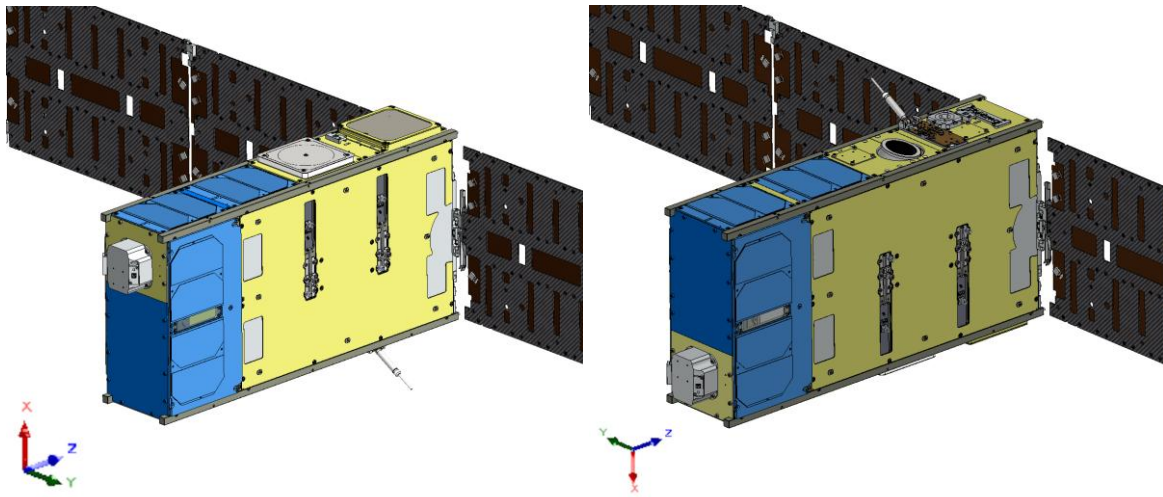


Figure 4-9: 8U Payload Apertures - Cover Plates (Left: +X and -Z faces, Right: -X and -Z faces)

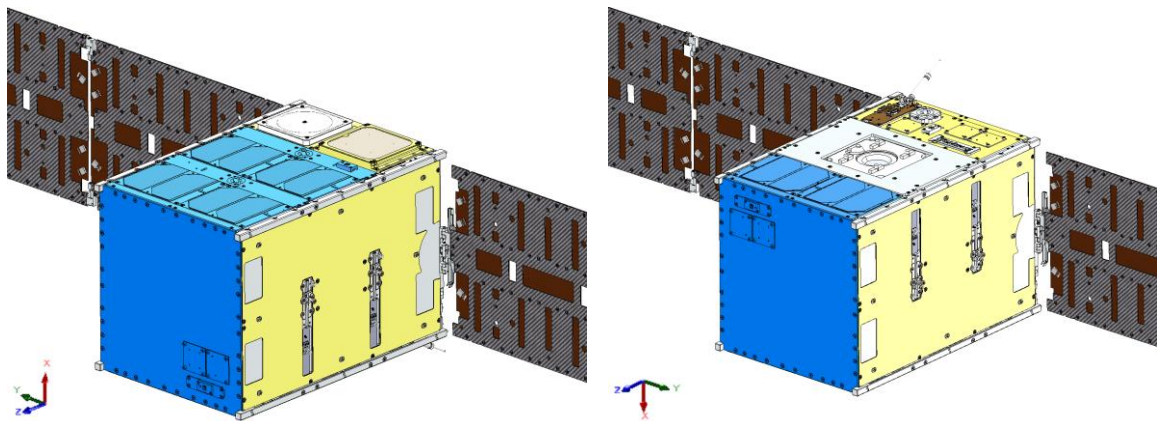


Figure 4-10: 12U Payload Apertures - Cover Plates (Left: +X and +Z faces, Right: -X and +Z faces)

Figure 4-11 highlights the hole pattern for mounting external payload components which can be accessed by removing the relative cover plates and/or solar panels from Figure 4-8 (e.g. cover plates, payload antennas, etc.).

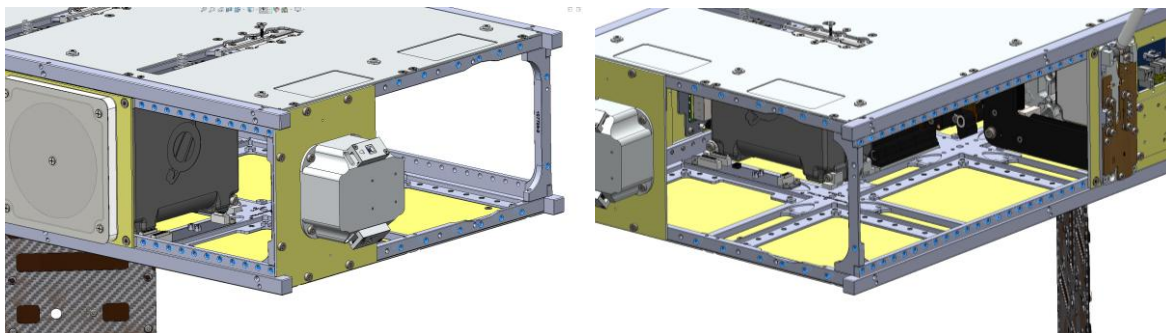


Figure 4-11: 6U External Payload Aperture - Hole pattern (Left: +X and -Z faces, Right: -X and -Z faces)

For mounting external components, on the X faces the screw holes are implemented with M2.5 ScrewLock Helicoil with insert = 1.0 * Dia.

For mounting external components, on the Z face the screw holes are implemented with M2.5 ScrewLock Helicoil with insert = 1.5 * Dia.

Refer to the NanoStructure 2D CAD for additional information about the mounting holes specifications and position on the satellite structure for the structure relevant to your mission.

4.5 Mechanical Integration Examples

4.5.1 Ring Assemblies

As a Mechanical Interface example, GomSpace developed the so-called GomSpace Rings that allow to easily integrate one or more electronic boards compliant with the PC/104 form factor. The electronic boards are first mounted in an assembly with one or more Rings as shown in Figure 4-12, depending on the number and mass of the boards.

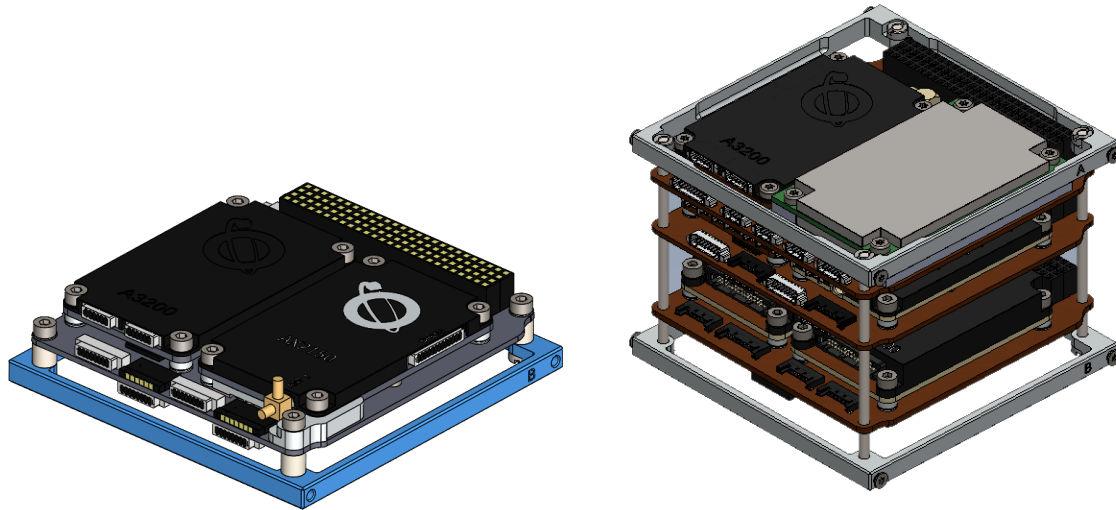


Figure 4-12: GomSpace Ring Assemblies Examples – Left: Single Ring, Right: Dual Ring

The electronic boards are mounted with either standard DIN M3 screws or M3 threaded rods cut to length, depending on the required height of the assembly and M3 spacers and washers to separate the boards from each other. A slotted nut is used to secure the assembly, fitting in the ring indentation as shown in Figure 4-13 (two types of Rings exists, A and B, with indentations for the slotted nut on the opposite side of the Ring – see Figure 4-12, Right for an example of an assembly using both Ring types).

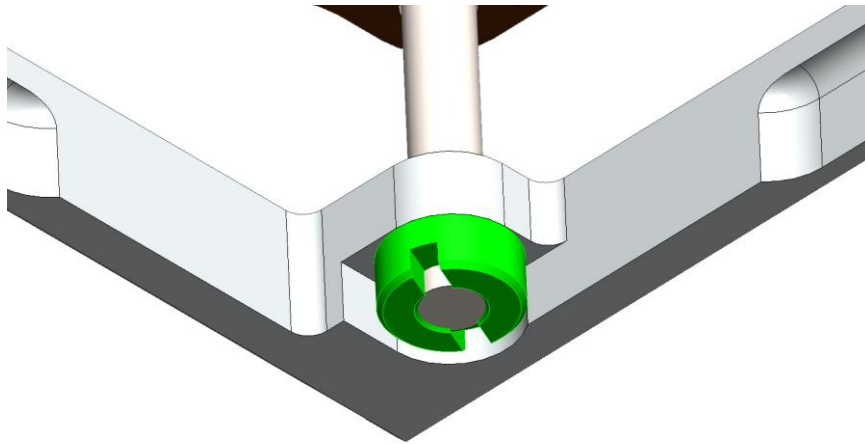


Figure 4-13: GomSpace Ring Assemblies Detail – Slotted Nut

The subassembly is then integrated directly into the main structure using 4x M2,5x5mm Torx countersunk ISO-14581 A4 for each Ring, as shown in Figure 4-14.

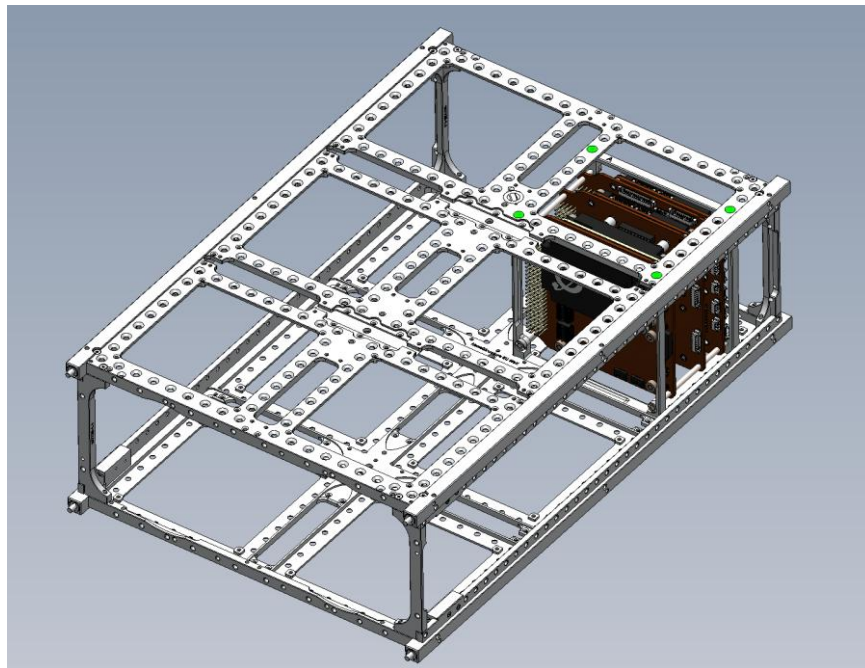


Figure 4-14: GomSpace Ring Assemblies Examples – Integration into the Main Structure

A Ring A and/or Ring B assembly can be mounted perpendicular to either the X or Z axis of the platform. A variant of the Ring A and Ring B exist to allow the integration of boards perpendicular to the Y axis as well as shown in Figure 4-15.

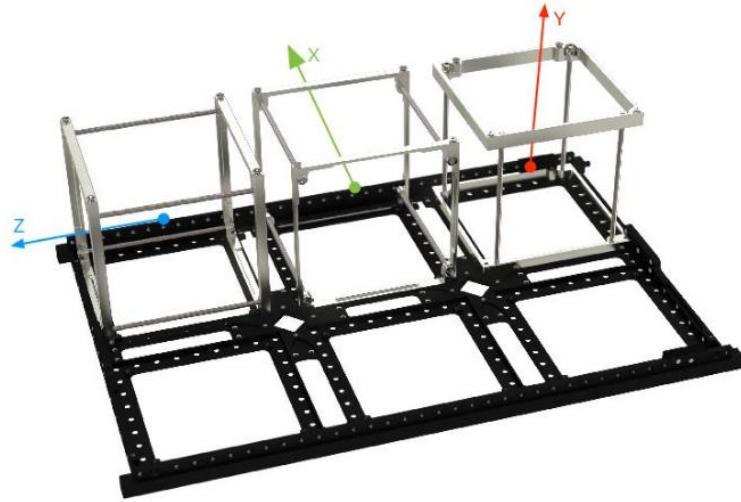


Figure 4-15: GomSpace Ring Assemblies Examples – Different Integration options

The 2D drawing of a Ring B are shown in Figure 4-16 as an example of adapter interface for internal subsystems.

Upon request, GomSpace Rings can be purchased and procured directly from GomSpace.

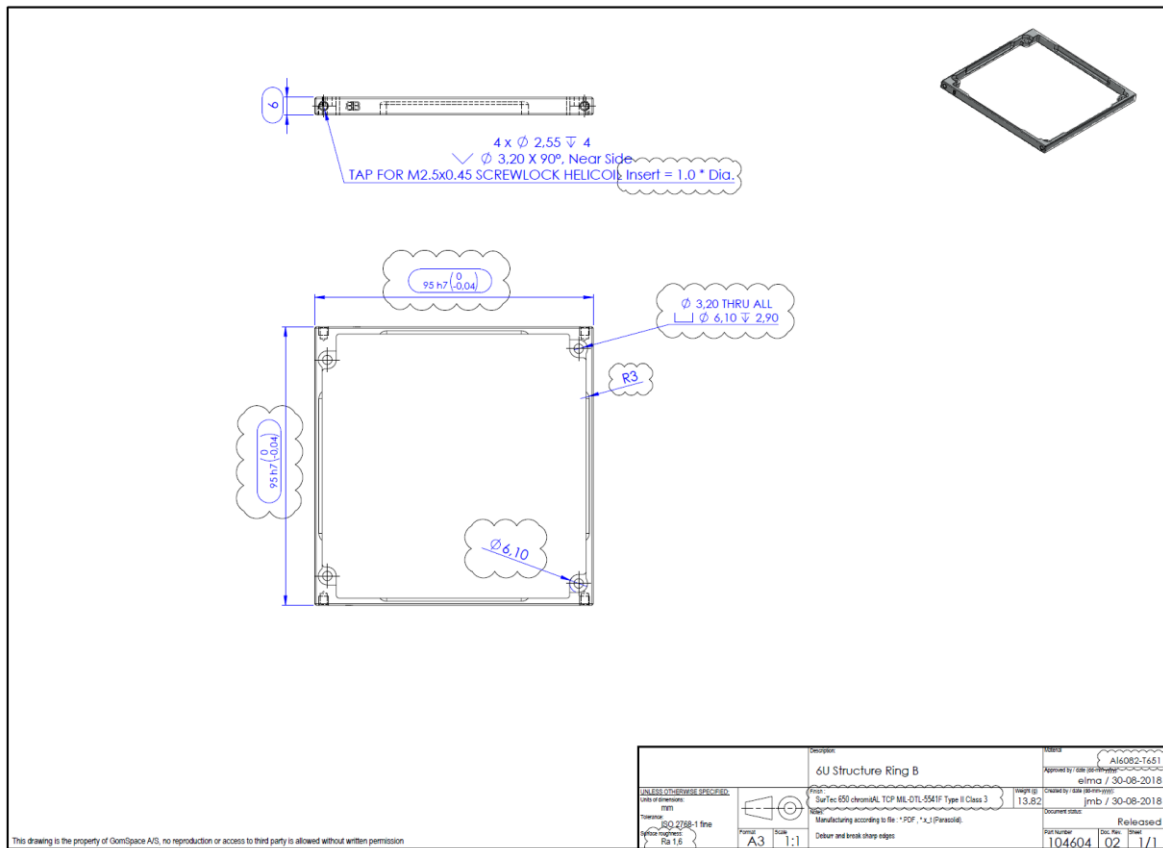


Figure 4-16: GomSpace Ring Assemblies Examples – Production Drawing and Recommended Tolerances

4.5.2 2U Secondary Structures – Towers

For GomSpace 12U and 16U satellites, an intermediate secondary structure commonly referred to as “Towers” are frequently used. The ring assemblies described in section 4.5.1 can be mounted within these towers, along with other GomSpace modules. Figure 4-14 and Figure 4-15 show how these towers are assembled and mounted.

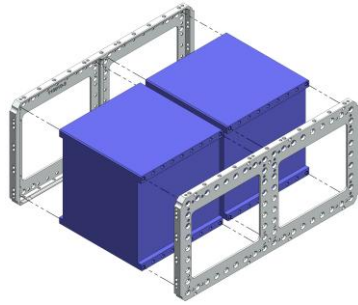


Figure 4-18: GomSpace 2U Secondary Structure

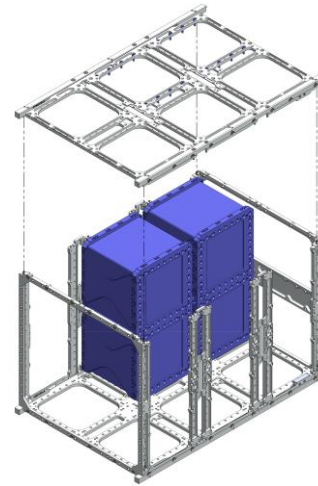


Figure 4-18: GomSpace 2U Secondary Structure Mounted in Main Structure

5. Platform to Payload Electrical and Data Interfaces

This chapter describes the different electrical and data interfaces between the Platform and its Payload(s).

5.1 Power

The NanoPower P80 system is the main module of the spacecraft EPS system, and it is responsible for supplying power to all its subsystems. The NanoPower P80 system is configured with two Power Distribution Units (PDU) on the NanoSat CubeSat Platform which are in charge of regulating, distributing and controlling all power channels for each spacecraft subsystem.

One PDU (PDU1) is dedicated for the power distribution to all Platform subsystems, while a second PDU (PDU2) is dedicated to providing power to the satellite Payload(s).

5.1.1 Power Channels

Each PDU provides up to 24 independent power outputs. The power outputs are divided in 3 different types:

- 8x Vbat channels can only provide an unregulated battery voltage output
- 4x High Voltage channels can provide either an unregulated battery voltage output or they can be connected to regulator 3 to provide a regulated voltage output selectable between:
 - 12V
 - 18V
- 12x Low Voltage channels can be connected to any of the 4 regulators and provide a regulated voltage among:
 - 3.3V
 - 5V
 - 12V

Note: If Regulator 3 is set to 18V output, it cannot be connected to any Low Voltage channels.

Table 5-1: PDU Power Outputs

Channel	Type	Regulators	Voltage	Current	Combined Channel
Ch0	Vbat	N/A	Vbat	2A	Ch0 (4A)
Ch1	Vbat	N/A	Vbat	2A	
Ch2	Vbat	N/A	Vbat	2A	-
Ch3	Vbat	N/A	Vbat	2A	-
Ch4	Vbat	N/A	Vbat	2A	Ch4 (4A)
Ch5	Vbat	N/A	Vbat	2A	
Ch6	Vbat	N/A	Vbat	2A	-
Ch7	Vbat	N/A	Vbat	2A	-
Ch8	Vbat / HV reg	3	Vbat, 12 V or 18V	2A	Ch8 (4A)
Ch9	Vbat / HV reg	3	Vbat, 12 V or 18V	2A	
Ch10	Vbat / HV reg	3	Vbat, 12 V or 18V	2A	-
Ch11	Vbat / HV reg	3	Vbat, 12 V or 18V	2A	-

Channel	Type	Regulators	Voltage	Current	Combined Channel
Ch12	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	Ch12 (4A)
Ch13	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	
Ch14	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-
Ch15	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-
Ch16	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	Ch16 (4A)
Ch17	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	
Ch18	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-
Ch19	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-
Ch20	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	Ch21 (4A)
Ch21	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	
Ch22	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-
Ch23	LV reg	0 1 2 3	3.3, 5 or 12 V	2A	-

The power channels of the Platform PDU (PDU1) are reserved for the satellite Platform. The Mission Designer can select the voltage output of the 4 regulators for the Payload PDU (PDU2), as well as the configuration matrix that connects each power output to either Vbat or a regulator output. The desired configuration needs to be selected when ordering the NanoPower P80 for the NanoSat CubeSat Platform and it is implemented with a hardware configuration at the end of the production process of the Payload PDU. The configuration is selected through an Option Sheet

If no Option Sheet is provided, PDU2 default configuration is designed to provide a wide range of voltage outputs for the Payload(s), as shown in Table 5-2

Table 5-2: Default PDU2 Power Outputs (Payload PDU)

Channel	Type	Regulators	Voltage	Current	Combined Channel
Ch0	Vbat	N/A	Vbat	4A	Ch0 (4A)
NA					
Ch2	Vbat	N/A	Vbat	2A	-
Ch3	Vbat	N/A	Vbat	2A	-
Ch4	Vbat	N/A	Vbat	4A	Ch4 (4A)
NA					
Ch6	Vbat	N/A	Vbat	2A	-
Ch7	Vbat	N/A	Vbat	2A	-
Ch8	HV reg	3	18V	4A	Ch8 (4A)
NA					
Ch10	HV reg	3	18V	2A	-
Ch11	HV reg	3	18V	2A	-
Ch12	LV reg	0	3.3V	4A	Ch12 (4A)
NA					

Channel	Type	Regulators	Voltage	Current	Combined Channel
Ch14	LV reg	1	5V	2A	-
Ch15	LV reg	2	12V	2A	-
Ch16	LV reg	1	5V	4A	Ch16 (4A)
NA					
Ch18	LV reg	0	3.3V	2A	-
Ch19	LV reg	2	12V	2A	-
NA					Ch21 (4A)
Ch21	LV reg	2	12V	4A	
Ch22	LV reg	0	3.3V	2A	-
Ch23	LV reg	1	5V	2A	-

5.1.2 Current Limits

The NanoPower P80 system maximum power handling capabilities are limited by the current rating of its different modules. The system is protected against short-circuits, latch-ups and overcurrent events. Drawing more current than what the system is rated for will result in a power cycle of the affected channel (including a full power cycle of the spacecraft if the overall current limit of the NanoPower P80 system is exceeded – current limit PM1 in Figure 5-1).

Figure 5-1 shows a simplified diagram of the Power Subsystem of NanoSat CubeSat Platform, highlighting the location the different power monitors which ensure that the system is operated within its rated current limits.

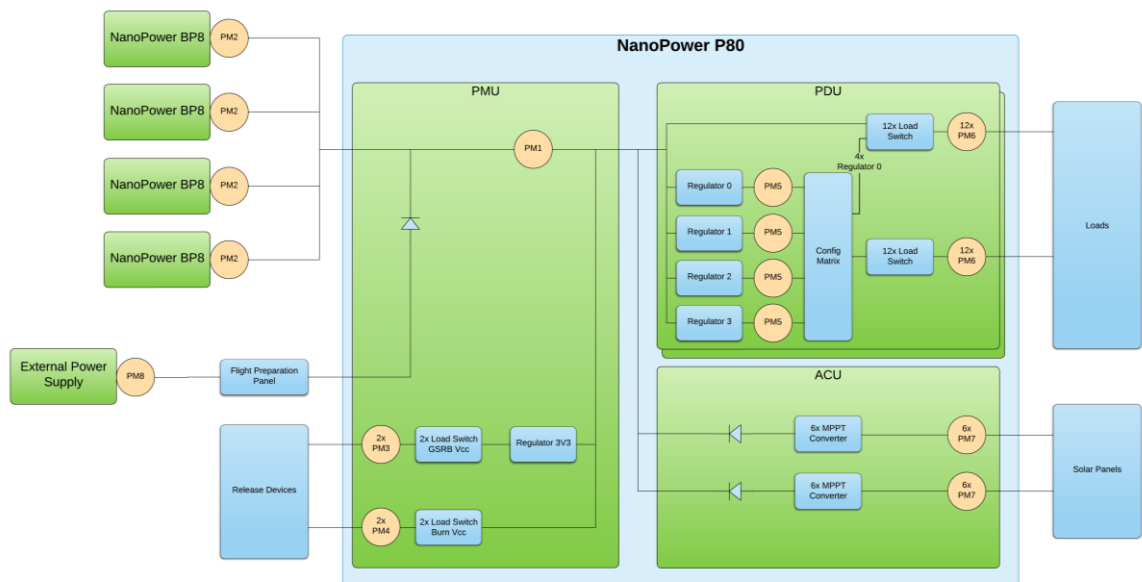


Figure 5-1: NanoPower P80 Power Monitors

With respect to Figure 5-1, an explanation of the different power monitors is provided hereafter:

- PM1 = 12A.** PM1 represents the maximum current that the NanoPower P80 can handle. Exceeding this limit will cause the entire satellite to reboot.

- **PM2 = 4A.** PM2 represents the maximum current that each NanoPower BP8 can handle. As it can be seen, **if the system is equipped with less than 3 battery packs, the current limit of the battery becomes the limiting factor of the maximum satellite power output.**

Exceeding this limit will likely cause the entire satellite to reboot due to a cascade effect triggering all PM2 monitors.

- **PM3 = 2x0.5A.** PM3 represents the maximum design current for the logic side of the release devices attached to the NanoPower P80. It is possible to configure this value to a lower limit in the software parameters of the NanoPower P80 system. For example, this can be done to protect the connected devices against a latch-up.

Exceeding this limit will cause the 3V3 line for the GomSpace Release Bus (GSRB) to power cycle. This will interrupt any ongoing release command and reboot the release devices MCUs.

- **PM4 = 2x0.5A.** PM4 represents the maximum design current for the burn resistors of the release devices attached to the NanoPower P80. It is possible to configure this value to a lower limit in the software parameters of the NanoPower P80 system.

Exceeding this limit will cause the VBAT line for the GomSpace Release Bus (GSRB) to power cycle. This will interrupt any ongoing release command without rebooting the release devices MCUs.

- **PM5 = 4A.** PM5 represents the maximum current that each regulator of each PDU can handle.

Exceeding this limit will cause a power cycle for the affected regulator as well as all loads connected through the configuration matrix.

- **PM6 = 24x2A or 4A.** PM6 represents the maximum current that each power output of each PDU can handle. As shown in section 5.1.1, six couples of output channels on each PDU can be merged in pairs to provide a single 4A power output. This allows each connected output to deliver more power, however for each pair that is merged one less channel is available.

Exceeding this limit will cause a power cycle for the affected power output.

- **PM7 = 12x1.1A.** PM7 represents the maximum current that each power input of each ACU can handle.

The ACU MPPT algorithm limits the maximum current of the power inputs of the solar arrays.

- **PM8 = 2A.** PM8 represents the maximum current that the Flight Preparation Panel can handle. The current shall be limited by the external power supply used to recharge the spacecraft batteries on ground.

Exceeding this limit for a prolonged period of time can cause damages to the Flight Preparation Panel due to the heat dissipated on the Flight Preparation Panel (the NanoPower P80 is designed to handle up to 10A input from this channel).

As it can be clearly seen in Figure 5-1, it is possible to connect a combination of loads that, if powered on at the same time, can exceed the power handling capabilities of the spacecraft either at PM1, PM2 or PM5 (e.g. if channels 0 to 11 are all set to Vbat and draw 2A simultaneously, they would draw 24A, well in excess of the thresholds of PM1 and PM2). It is responsibility of the Mission Designer to ensure that the mission design prevents this from happening. This can be achieved by either:

- designing the system so that the maximum power required cannot exceed any of the limits from PM1, PM2 and PM3 or
- designing the in orbit operational procedure to prevent powering on at the same time loads that would lead to a combined power consumption exceeding the Platform capabilities.

5.1.3 Harness and Connectors

The 24 power outputs of the Payload PDU are exposed in groups of four over 6x Harwin Gecko G125-MH11605L1R connectors on the side of the PDU. Figure 5-2 shows one side view of the NanoPower P80, where 3 out of the 6 connectors from each PDU are visible (PDU2 is the Payload PDU).

Each connector has 16 pins: two voltage outputs and two return pins for each power channel (four voltage outputs and four return pins for each combined 4A power channel).

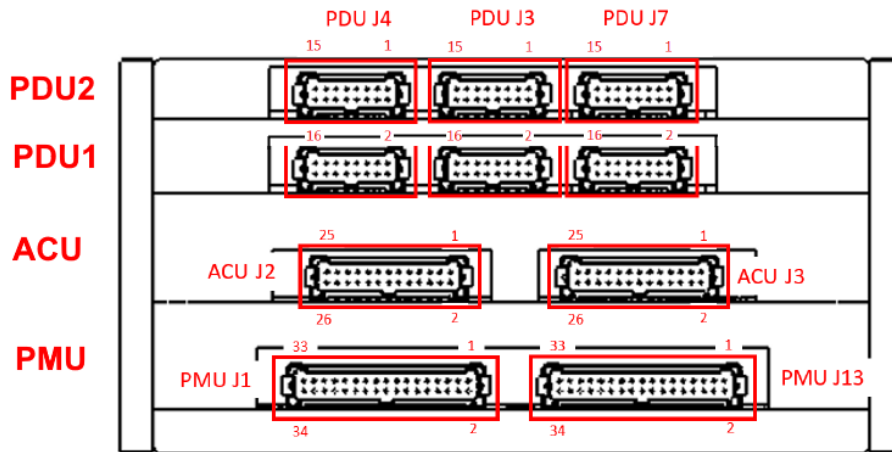


Figure 5-2: NanoPower P80 - Side View

Upon request, the NanoSat CubeSat Platform can be delivered with 6x 60cm long harness assembly for PDU2. The wires used for the cable are AVG26 with PTFE jacket (LEVITON MFG - SPC00442A002, colour-coded with red wire for power output and black wires for return lines). On one side, the cables are crimped and assembled in a mating connector for PDU2 (Harwin Gecko G125-2041696L0), while on the other side there are flying leads. Wires are twisted in pairs to minimize EMI from the cable, which are kept together with a heat shrink close to the flying leads (this can be removed when the flying leads are crimped and fixed to a connector). Wires can also be cut to length before crimping.

The harness diagram in Figure 5-3 shows the detailed design of the cable. Alternatively, GomSpace Customers can design their own tailored payload power harness taking inspiration from the diagram in Figure 5-3.

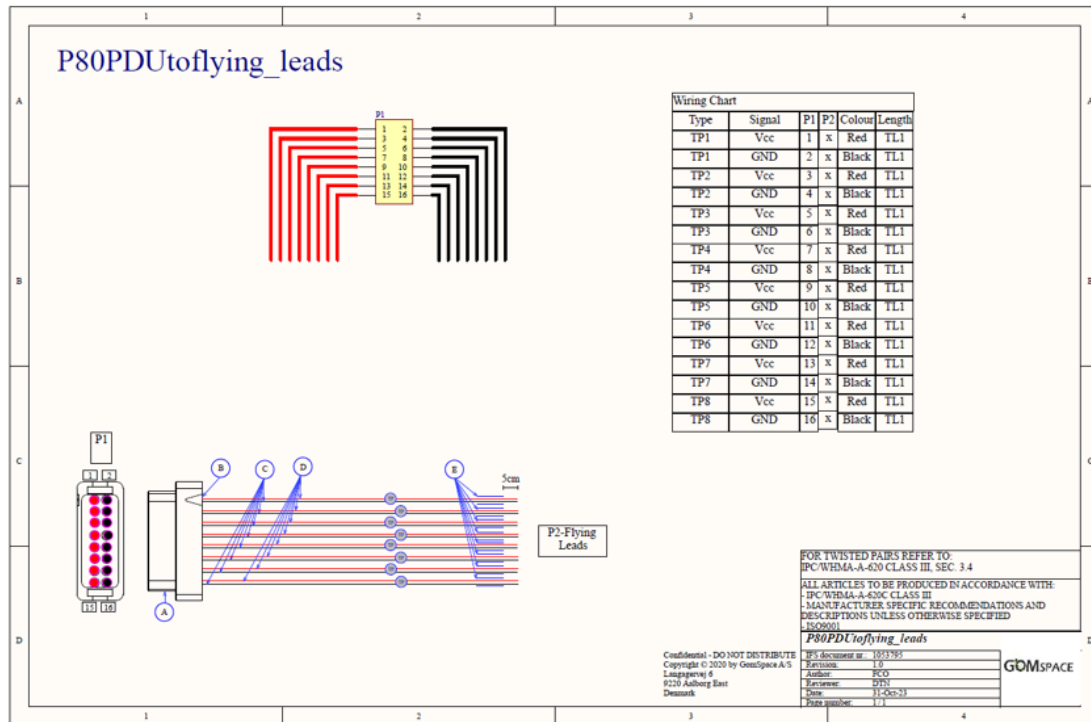


Figure 5-3: Payload PDU Flying Leads Harness

5.2 Data

By default, all data interfaces between Platform and Payload are handled by a single node, the NanoMind HP MK3 acting as Payload Gateway.

This architecture is designed to decouple the Platform from the Payload, thus enabling a generic platform to be more easily compatible with a wide range of different payloads.

In this section, a brief overview of the recommended interfaces is provided, while the Reader can refer to the NanoMind HP MK3 documentation for additional information and the full range of available data interfaces (see [AD-7], [AD-8], [AD-9], [AD-10], [AD-11] and [AD-12]).

5.2.1 Command and Telemetry

The primary command and telemetry interface of the NanoMind HP MK3 is represented by two independent CAN data busses.

The first CAN bus (CAN1) is used to interface the NanoMind HP MK3 with the rest of the subsystems of the GomSpace platform and enables the computer to interact with the rest of the spacecraft. This CAN network is reserved for the Platform and it is not recommended to be used to connect a Payload.

The second CAN bus (CAN2) of the NanoMind HP MK3 is dedicated to interface one or more Payloads to the GomSpace NanoSat Platform and it represents the recommended primary command and telemetry interface for the Payload(s).

CAN2 is accessible through the NanoMind HP MK3 Mainbus connectors (J5 and J6) as seen a screenshot from the NanoMind HP MK3 datasheet in Figure 5-4.

9.2 CAN and RS422 - COMM 1-2 (J5-J6)

NanoMind HP MK3 is equipped with two Harwin Gecko G125-MH12005L1R 1.25mm pitch high-reliability connectors, with latches, for access to its main communication interface. The individual pins of the two connectors are interconnected, which allow the Nanomind to use with in different bus topologies. The secondary connector can be used for interconnecting with other devices in multidrop bus configuration or for bus terminations if it is the last node in the system.

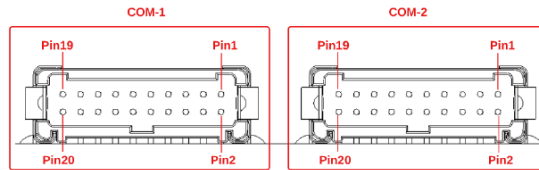


Figure 9.3: COM-1 and COM-2 pinout

Pin	Signal	Description
1	I2C-SDA	I2C serial data line ¹
2	CAN1_H	CAN1 High ²
3	GND	Ground
4	CAN1_L	CAN1 Low ²
5	I2C-SCL	I2C serial clock line ¹
6	CAN2_H	CAN2 High ²
7	GND	Ground
8	CAN2_L	CAN2 Low ²
9	PPS-P	Pulse Per Second LVDS positive input line ³
10	CLK-P	External reference clock LVDS positive input line
11	PPS-N	Pulse Per Second LVDS negative input line ³
12	CLK-N	External reference clock LVDS negative input line
13	NC	Not connected
14	RS422-TX-P	RS422 Noninverting driver output for payload data interface
15	GND	Ground
16	RS422-TX-N	RS422 Inverting driver output for payload data interface
17	NC	Not connected
18	RS422-RX-P	RS422 Noninverting receiver input for payload data interface ⁴
19	GND	Ground
20	RS422-RX-N	RS422 Inverting receiver input for payload data interface ⁴

Table 9.2: COM-1 and COM-2 pin allocation

Figure 5-4: NanoMind HP MK3 - MainBus connectors¹

As the MainBus connectors are also used to connect the NanoMind HP MK3 to the rest of the platform, by default the NanoSat platform is shipped with harness connected to the NanoMind HP MK3 COM-1 port that exposes the payload connections to the MainBus connectors with flying leads, as shown in Figure 5-5. Through the same port, the NanoMind HP MK3 also exposes two synchronizations signals for the payload (PPS – Pulse Per Second and VARF – VARIable Frequency signal). The synchronization signals are generated by the satellite GNSS receiver and provided to the payload through the NanoMind HP MK3.

The wires used for the cable are AVG26 with PTFE jacket (LEVITON MFG - SPC00442A002, with colour-coded twisted pairs as shown in Figure 5-5). On the platform side, the cables are crimped and assembled in mating connectors for the NanoMind HP MK3 and the subsequent module in the platform MainBus chain (Harwin Gecko G125-MH12005L1R), while on the payload side there are flying leads. Flying leads are ~500mm long and can be cut to length according to the specific mission requirements. The Mission Designer shall define how to connectorize or otherwise connect the flying leads to the specific payloads of the mission.

¹ This is an extract from the NanoMind HP Mk3 datasheet. In case of discrepancy, the latest version of the NanoMind HP Mk3 datasheet shall prevail: [https://gomspace.com/shop/subsystems/command-and-data-handling/nanomind-hp-mk3-\(1\).aspx](https://gomspace.com/shop/subsystems/command-and-data-handling/nanomind-hp-mk3-(1).aspx)

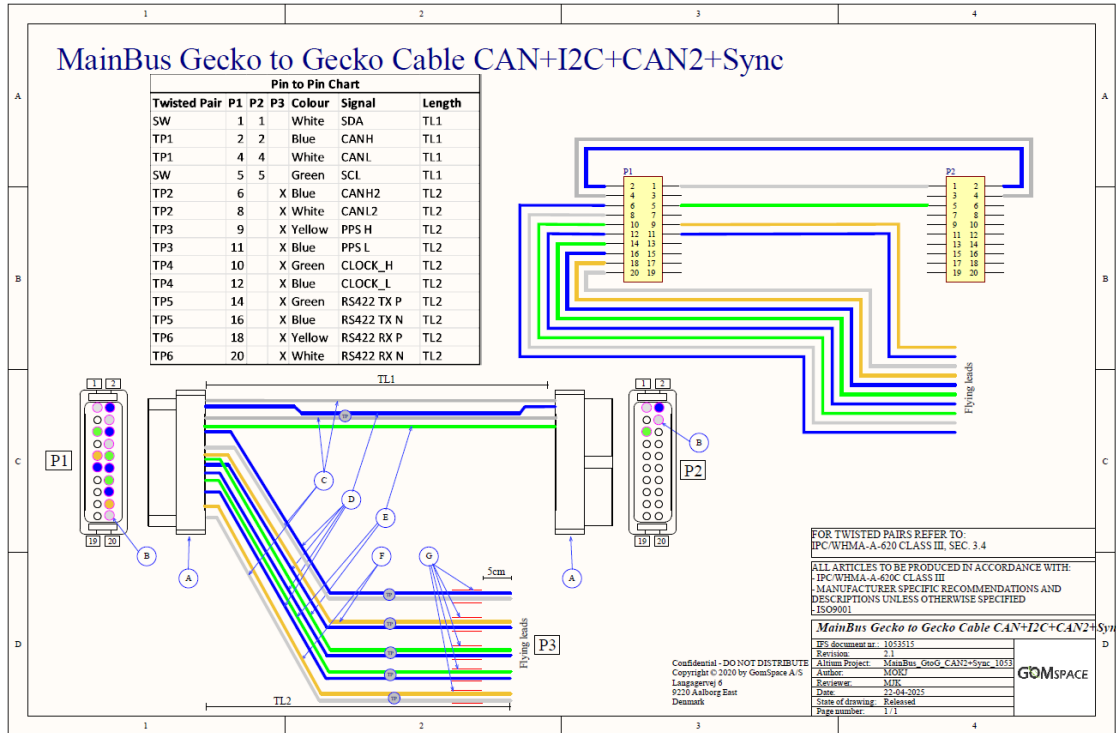


Figure 5-5: NanoMind HP MK3 - MainBus Payload Harness

5.2.2 Payload Data

For fast data rate transfer, up to 2x dedicated SpaceWire interfaces are provided from the NanoMind HP MK3 for its Payload(s), while the third SpaceWire interface (SPW1) is reserved to connect the NanoMind HP MK3 to the NanoCom Link SX on the Platform side (see Figure 5-6). The interface is described further in detail in [AD-9] and [AD-11].

9.3 SpaceWire – PL DIFF 1-3 (J7-J8-J9)

NanoMind HP MK3 is equipped with three independent bi-directional, full-duplex SpaceWire interfaces for payload data transfer. It uses Gecko G125-MH11005L1R 1.25mm pitch high-reliability connectors, with latches from Harwin for each of the three interfaces:

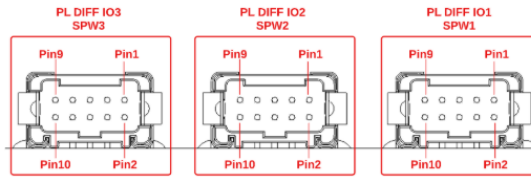


Figure 9.4: SPW1, SPW2 and SPW3 pinout

Each SpaceWire¹ interface uses two signals, data and strobe, in receive and transmit direction to send serial bit streams. The signals are based on low voltage differential signals according to the ANSI TIA/EIA-644 Standard and requires two pins for each signal. The signals are named:

Pin	Signal	Description
1	Dout-	LVDS Data output negative line
2	Sin+	LVDS Strobe input positive line ²
3	Dout+	LVDS Data output positive line
4	Sin-	LVDS Strobe input negative line ²
5	GND	Ground connection for internal cable shielding ³
6	GND	Ground connector for external cable shielding ³
7	Sout-	LVDS Strobe output negative line
8	Din+	LVDS Data input positive line ²
9	Sout+	LVDS Strobe output positive line
10	Din-	LVDS Data input negative line ²

Table 9.3: SPW-1, SPW-2 and SPW-3 pin allocation

Figure 5-6: NanoMind HP MK3 - SpaceWire connectors

Upon request, the NanoSat CubeSat Platform can be delivered with 2x 60cm long harness assembly for the NanoMind HP MK3 SpaceWire interfaces. The wires used for the cable are AVG26 with PTFE jacket (LEVITON MFG - SPC00442A002, colour-coded to identify each SpaceWire pair of differential signals). On one side, the cables are crimped and assembled in a mating connector for the NanoMind HP MK3 (Harwin Gecko G125-MH11005L1R), while on the other side there are flying leads. Wires are twisted in pairs to minimize EMI, which are kept together with a heat shrink. Flying leads can be cut to length according to the specific mission requirements. The Mission Designer shall define how to connectorize or otherwise connect the flying leads to the specific payloads of the mission.

The harness diagram in Figure 5-3 shows the detailed design of the cable. Alternatively, GomSpace Customers can design their own tailored payload power harness taking inspiration from the diagram in Figure 5-3.

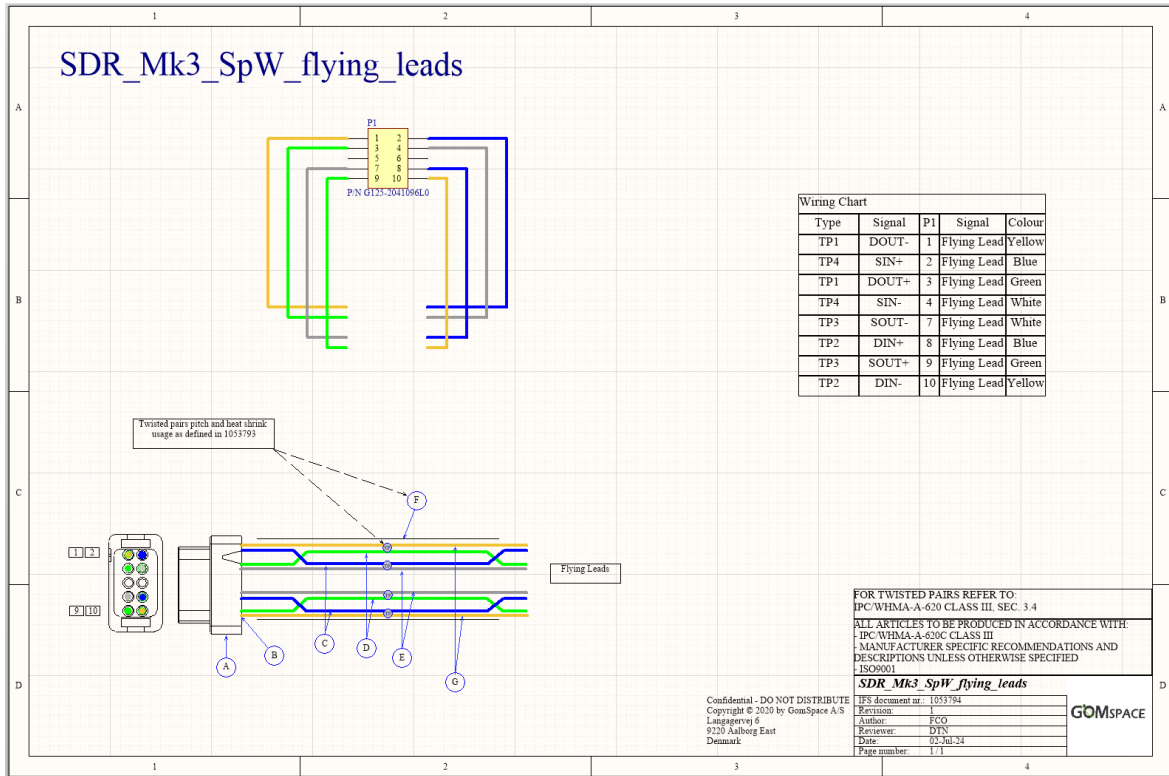


Figure 5-7: NanoMind HP MK3 - SpaceWire Flying Leads Harness

5.2.3 Alternative Data Interfaces

In addition to the data interfaces described above, the NanoSat CubeSat Platform offers additional hardware support for alternative data interfaces. Such interfaces are not described in detail here, as they are not meant to be the primary interfaces for the NanoSat CubeSat Platform and therefore not supported by default, but their availability is mentioned in case the Mission Designer decides to implement them in their design.

If needed, two additional SpaceWire interfaces can be used from the NanoCom Link SX and routed directly to a Payload. The NanoCom Link SX shares the same SpaceWire interfaces as the NanoMind HP MK3, as seen in Figure 5-6 (also in this case, SPW1 is reserved to interface the NanoCom Link SX and the NanoMind HP MK3 with each other).

The NanoMind HP MK3 further supports:

- 11x general purpose Low Voltage Differential Signaling (LVDS) pairs
- 10 x general purpose single-ended (SE) input/output
- 2x full duplex RS485 interfaces
- 1x full duplex RS422 interface (in addition to the reserved RS-422 interface in the MainBus shown in Figure 5-4)
- 3x hardware CAN interfaces

The NanoMind HP MK3 Datasheet [AD-13] further details the additional available interfaces, including additional interfaces not listed above (additional single-ended GPIO, additional multiplexed single-ended GPIO)

6. Software Interfaces

6.1 CubeSat Space Protocol (CSP)

The NanoSat CubeSat Platform and its subsystems rely on the CubeSat Space Protocol for commanding and monitoring of the platform, as well as for internal communication between the different subsystems, CSP is a light network-layer delivery protocol designed for CubeSat, based on a 32-bit header containing both network and transport layer information. Figure 6-1 shows the high-level structure of the CSP network on the NanoSat CubeSat Platform.

NanoSat CubeSat Platform

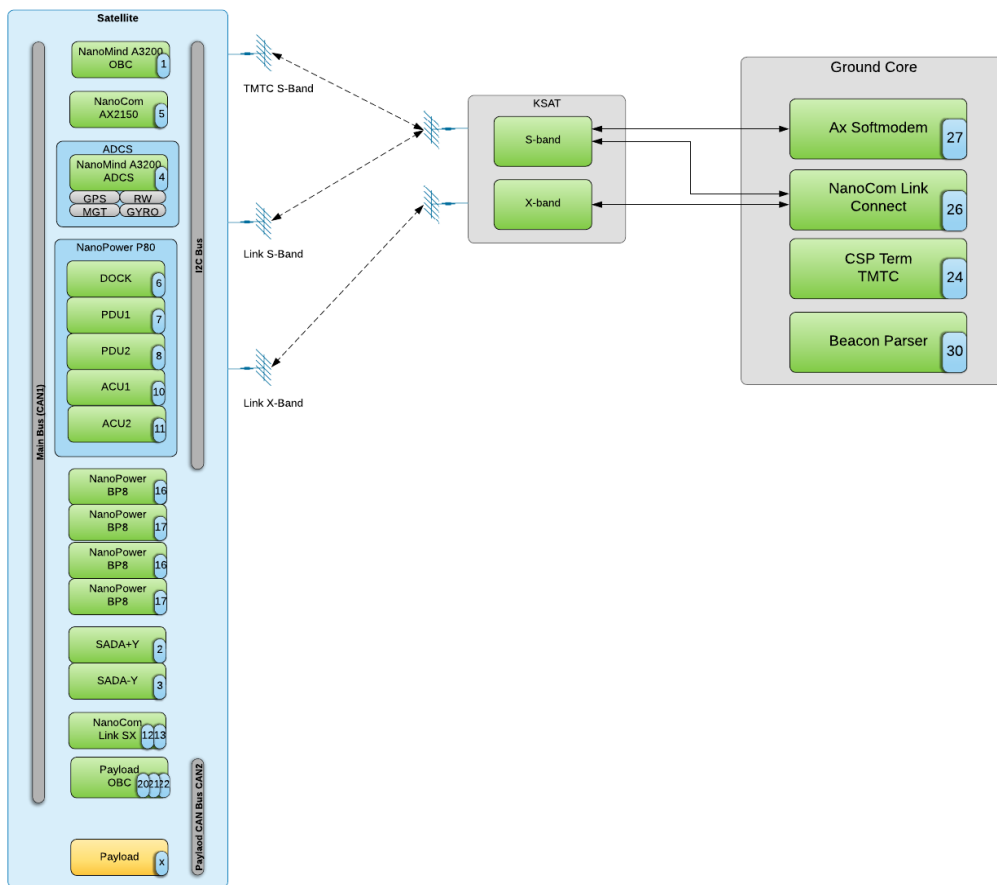


Figure 6-1: NanoSat CubeSat Platform - CSP Network and Addresses

A more in depth description of the usage of the CSP protocol can be found in [AD-1]

6.2 Payload OBC

As mentioned in section 5.2, the NanoSat CubeSat Platform is designed to decouple the Platform from the Payload through the use of the NanoMind HP MK3 as a Payload OBC. This allows the Mission Designer freedom of focusing on the tailoring the payload software to the specific needs of the Mission and of the Payload instrumentations. The Platform software is delivered by GomSpace and remains unchanged across different Missions, thus increasing the Platform software reliability through reuse and lessons learned from other Missions.

The NanoMind HP MK3 is a powerful and flexible Linux-based computing platform, which allows to take advantage of the large amount of existing public software libraries and products. The Mission Designer is responsible for the creation of the necessary drivers to support the payload and for the software to handle the payload. The reader can refer to [AD-7] and [AD-8] for more in depth information about the NanoMind HP MK3 capabilities and programming.

6.2.1 Payload Software Example

For most Payload applications, the recommended approach to control the Payload is through the execution of scripts on the Payload OBC node commanded from either CAN1 (Platform CAN bus) or CAN2 (Payload CAN bus).

This allows the Platform NanoMind A3200-CDH computer to execute any script via Flight Plans, thus enabling the operator to schedule Payload tasks.

Payload outputs can be stored in the form of files in the NanoMind HP MK3 **/data** folder. For most Payload applications, the recommended approach is to create a sub-folder inside the **/data** folder (e.g. **/data/payload**) and set up the NanoCom Link SDR to continuously check such folder for new files and download them to ground.

7. Space to Ground Interfaces

The radio is equipped with two radio Gateways that enable communication with the Ground Segment. The first radio is the NanoCom AX2150, a low-power omnidirectional half-duplex S-Band radio. The second radio is the NanoCom Link SX, a high-performance directional combined full-duplex S- and X-Band radio.

The radio Gateways are used both to control the satellite and download its health status telemetry (see Command Plane, section 7.2), as well as for transmitting payload data (see Data Plane, section 7.3). The two radios have very different performance and satellite resources requirements. Therefore, the two are intended to be used for different applications.

The NanoCom AX2150 is primarily designed to minimize the resources needed to operate it, thus ensuring a very reliable communication link between the satellite and the Ground Segment. In particular, the AX2150 link does not require a specific satellite pointing (quasi-omnidirectional radiation pattern) and it can remain powered on at all times (very low power consumption).

The NanoCom Link SX is primarily designed to maximize data transfer rate, thus providing the best performance. It is therefore hereafter also referred to as HSL (High-Speed Link). It requires the satellite to point its antennas towards the target ground station, as well as consuming a considerable amount of power. It is therefore intended to be powered only when needed (e.g. when a ground station is view of the satellite) and remain otherwise powered off to save power.

Both radio Gateways rely on an S-band link with a ground station and are therefore normally considered mutually exclusive (only one of the two should be used in each Contact Window).

7.1 Radio Links Management Strategies

The characteristics of the two radio links enable two alternative management strategies:

- TMTc Radio + Payload Data Radio Strategy
- Primary and Fallback Radio Strategy

7.1.1 TMTc Radio + Payload Data Radio Strategy

The baseline strategy is to use the NanoCom AX2150 as the TMTc radio, to exchange health telemetry data, commands and Flight Plans, all of which have very low data rate requirements. The NanoCom Link is instead only used to exchange large amounts of data on demand.

This is the simplest radio link management strategy, as the NanoCom AX2150 is normally left always on and guarantees the possibility to contact the spacecraft at any time without any previous preparation. The HSL is only used when large amount of data needs to be transferred, and the satellite is instructed to use it though a Flight Plan previously uploaded through the NanoCom AX2150 in a previous contact window. This means that Flight Plans are only required to be active when an operation is scheduled.

7.1.2 Primary and Fallback Radio Strategy

The alternative strategy is to use the NanoCom Link as the Primary radio link during normal operations, while the AX2150 is used as a LEOP and Fallback radio.

This management strategy is a bit more complex to maintain, as the operator needs to ensure in each pass that the subsequent pass is always schedule in the satellite running Flight Plan, so that the HSL is available for that pass. This requires to always maintain an active and up to date Flight Plan, so that the HSL is available during contact windows.

During LEOP, the NanoCom AX2150 is used to first contact the spacecraft, transition to three-axis pointing and set up the first HSL communication window. After that, the NanoCom AX2150 can be powered off and the HSL is used to constantly update the satellite active Flight Plan, so that the satellite knows when to activate the HSL and point it towards a ground station. In case contact is lost (for example due to a mistake in one of the Flight Plans), the satellite watchdogs ensure that the satellite will reboot after the timer runs

out without contact from a ground station (normally 48 hours) and the NanoCom AX2150 comes back online. In such cases, the HSL schedule can then be re-established as during the LEOP.

Note: multiple HSL contact windows can be scheduled within the same Flight Plan, so that the Ground Segment has multiple opportunities to contact the spacecraft before the watchdog counters expire.

7.2 Command Plane

7.2.1 TeleMetry and TeleCommands (TMTC)

The NanoCom AX2150 represents the default gateway for spacecraft telemetry and telecommands, including the upload of Flight Plans (time-tagged sequences of commands to be executed independently from a link with a ground station).

The interface with the NanoCom AX2150 is described in detail in:

- NanoCom TMTC-S RF ICD [AD-2]

7.2.1.1 TMTC over NanoCom Link SX

If necessary, the NanoCom Link can be used to control the spacecraft (send commands and Flight Plans) and retrieve telemetry.

This is done by sending CSP commands over the HSL and changing the spacecraft routing to send telemetry through the HSL.

The interface with the NanoCom Link SX is described in detail in:

- NanoCom Link S, X, SX User Manual [AD-3]
- NanoCom Link S, X, SX RF Interface [AD-4]
- NanoCom Link S, X, SX Control Interface [AD-5]
- NanoCom Link S, X, SX Data Interface [AD-6]

7.3 Data Plane

Payload data are primarily routed through the high-speed NanoCom Link SX radio.

The interface with the NanoCom Link SX is described in detail in:

- NanoCom Link S, X, SX User Manual [AD-3]
- NanoCom Link S, X, SX RF Interface [AD-4]
- NanoCom Link S, X, SX Control Interface [AD-5]
- NanoCom Link S, X, SX Data Interface [AD-6]

8. Launch Interfaces

The GomSpace CubeSat Platform is designed to be compatible with a variety of commercial CubeSat Deployers and Launch Vehicles. The mechanical specifications of the platform are mostly aligned with Cal Poli's CubeSat Design Specifications.

However, the platform takes advantage of the allowed protrusions from the rail dimensions to mount the external solar panels and antennas. Such protrusions are allowed by a vast majority of commercial CubeSat Deployer. It is the responsibility of the Mission Designer to verify that the platform stowed dimensions shown in Figure 8-1 and Figure 8-2 are compatible with the constraints of the selected CubeSat Deployer for the mission.

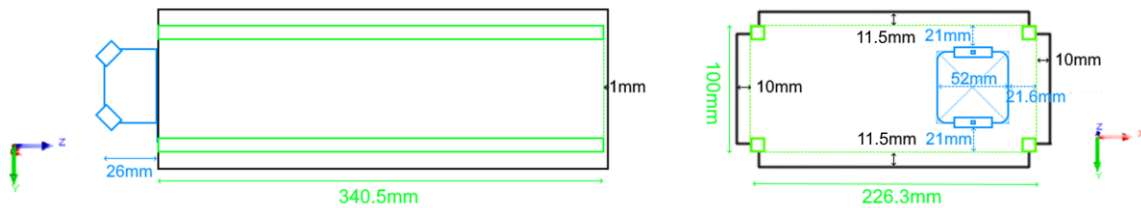


Figure 8-1: NanoSat 6U platform – Stowed Dimensions

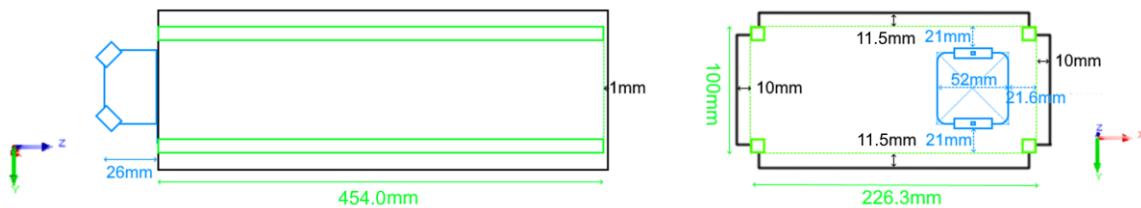


Figure 8-2: NanoSat 8U platform – Stowed Dimensions

Since the integration with the CubeSat Deployer, throughout the launch and until the deployment in orbit, the platform is designed to remain powered off. The spacecraft automatically powers on when the Kill-Switches integrated in the structure rails are released when the spacecraft leaves the CubeSat Deployer. The release of even only one of the two connected switches causes the spacecraft to boot. It is recommended to validate the correct behaviour of the Kill-Switches during the integration with the deployer (e.g. by monitoring the EPS boot count before and after integration in the deployer to ensure it did not increase of more than one. The flight preparation panel allows to force the spacecraft to power on even when the Kill Switches are pressed in order to check the boot count after integration in the deployer, which causes the boot count to increase by one when it is checked).

9. Transportation and Storage

Table 9-1 summarizes the recommended specifications for transportation and storage of the NanoSat Platform kit.

Table 9-1: Transportation and Storage specifications

Parameter	Recommended Condition
Temperature	<p>0°C to +40°C allowed for short periods of time (days to few weeks).</p> <p>0°C to +25°C for prolonged periods of storage, (preferred storage 0–10 °C when batteries installed)</p> <p>For systems equipped with Electric Propulsion system, the propulsion system (or the full integrated satellite) should be placed in an aerated environment with temperature and humidity control.</p>
Humidity	< 60% RH, non-condensing
ESD	Recommendation: ESD bag/enclosure and/or ESD-safe transport box
Shock & Vibration	Minimized; qualified hardware but avoid handling shocks
Cleanliness	Clean, dust-free environment; sealed inner packaging
Battery	<p>State of Charge 30–60% SOC for transport/storage</p> <p>Periodic battery top-off every 3 months</p>
Packaging	Rigid transport box with packaging foam and desiccant

Orientation labels and fragile handling notices should be applied.

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