ET-Sat™

Student Payload REV. A Board

DRAFT

Interface Control Document (ICD)

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This document describes the functional, physical, and electrical characteristics of the ThinSat and payload. This interface control document is intended to provide the payload integrator with the necessary technical information to integrate the Payload board.

Operational Description

Two types of data packets are sent from the Payload: Serial data and Beacon data. Beacon data is a set of digital and analog inputs that are sent at a set interval for health and safety information. From the ThinSat Payload, there are six Analog and two Digital inputs available for automatic transmissions of payload data to the NSL Bus. Serial data is created and commanded by the Payload. It can be sent whenever the transmitter is not Beaconing to the NSL Bus.

Document Classification	
X	NSL Proprietary

Freedom and Constraints: Within the keep-out zone space it is up to you (the Payload) to do as you like (see Figure 5). You do not have to make a student PCB as shown in Figure 4. For example, you can use electronic modules, MEDO parts, Spark Fun Parts, mechanical mechanisms, and others as long as you use the established mounting screw holes. You have 5 Sensor Ports to assess space outside and you may be able to drill other openings in the frame with approval. It is strongly suggested that you include a payload Diagnostic port for checking your payload when it is in the launch tube or on a FlatSat (you could use the dedicated Payload Diagnostic Port, or Sensor Port 1 location). All electronic interconnects and power are available through the NSL 20-pin connector for EyeStar Radio transmit. You have 7 mounting supports as shown in Figure 4.

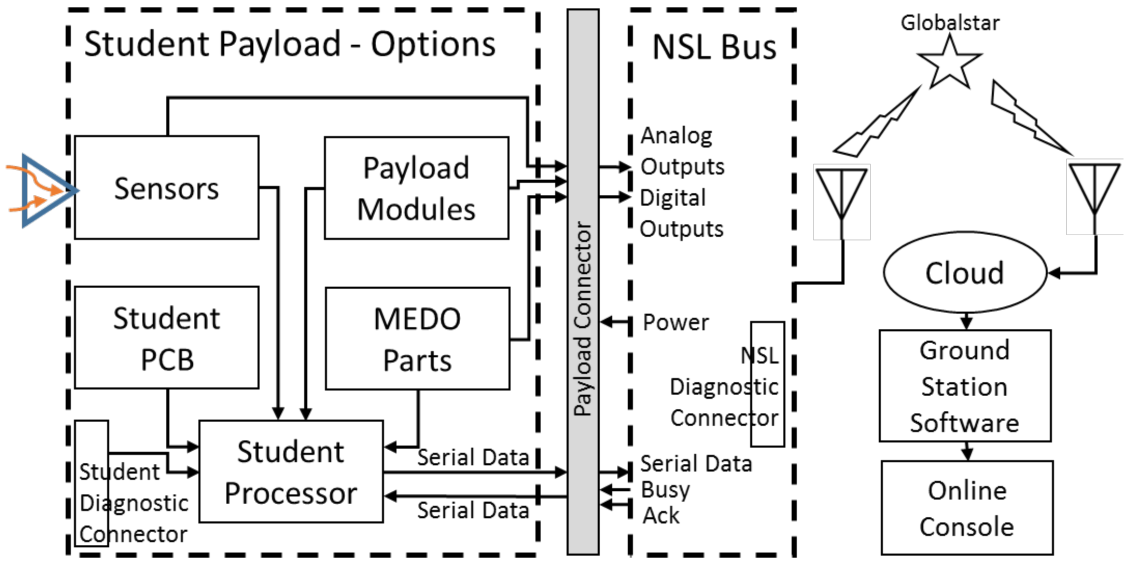


Figure 1 Payload Block Diagram

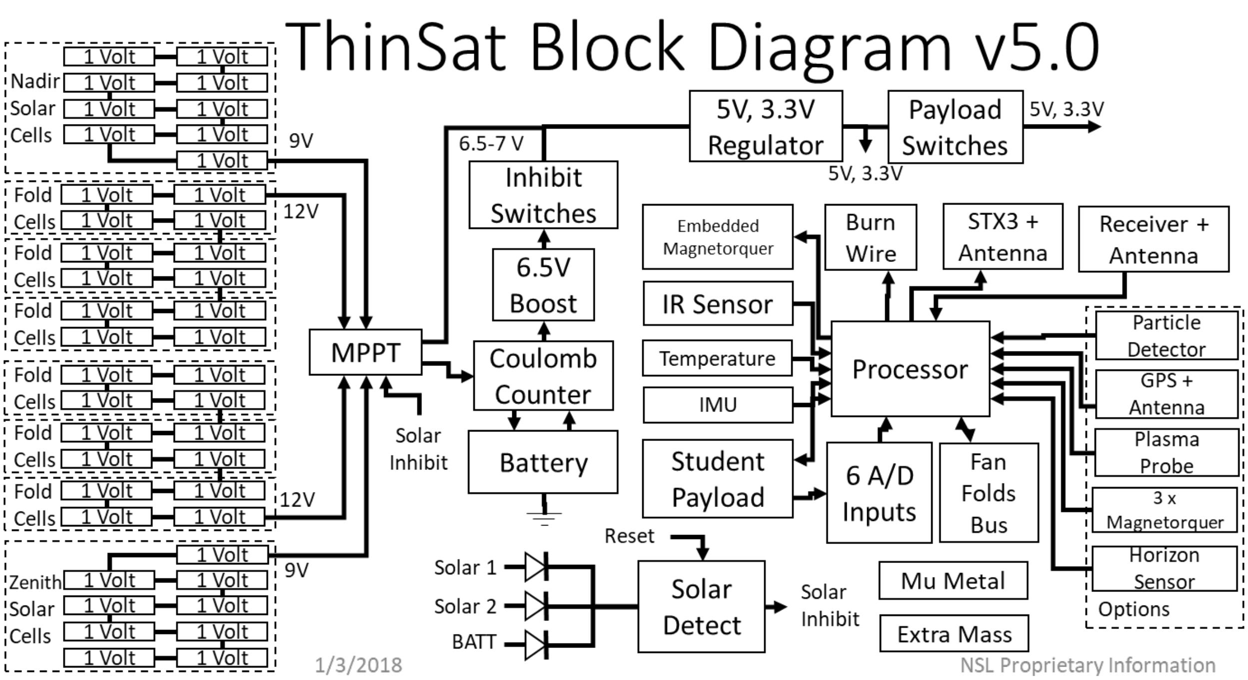
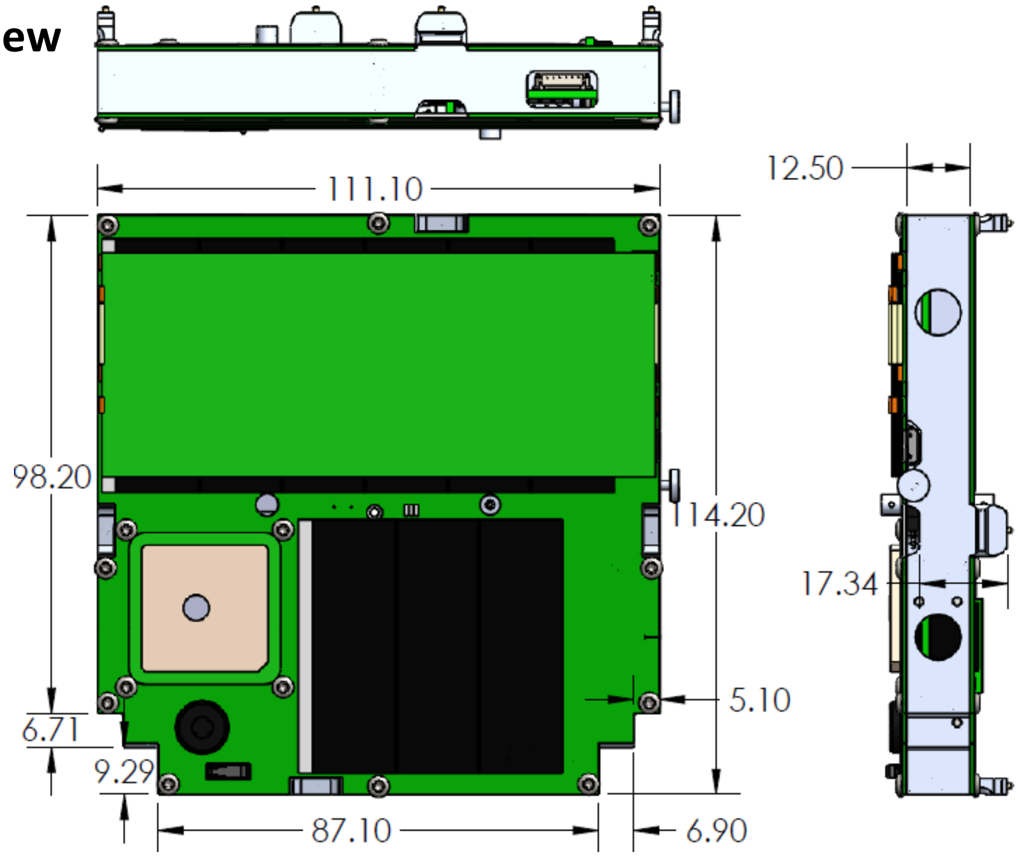
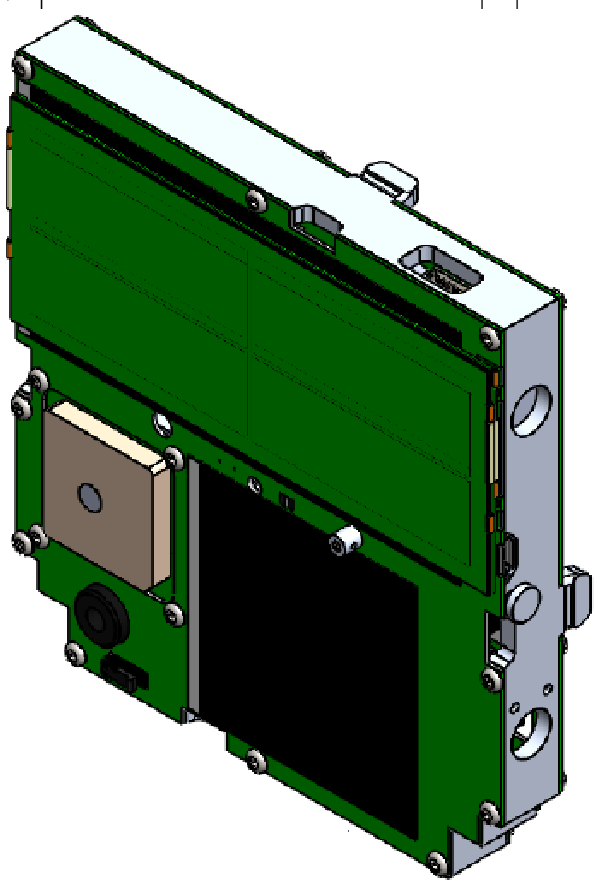


Figure 2 ThinSat System Block Diagram

External View





Student Payload Space

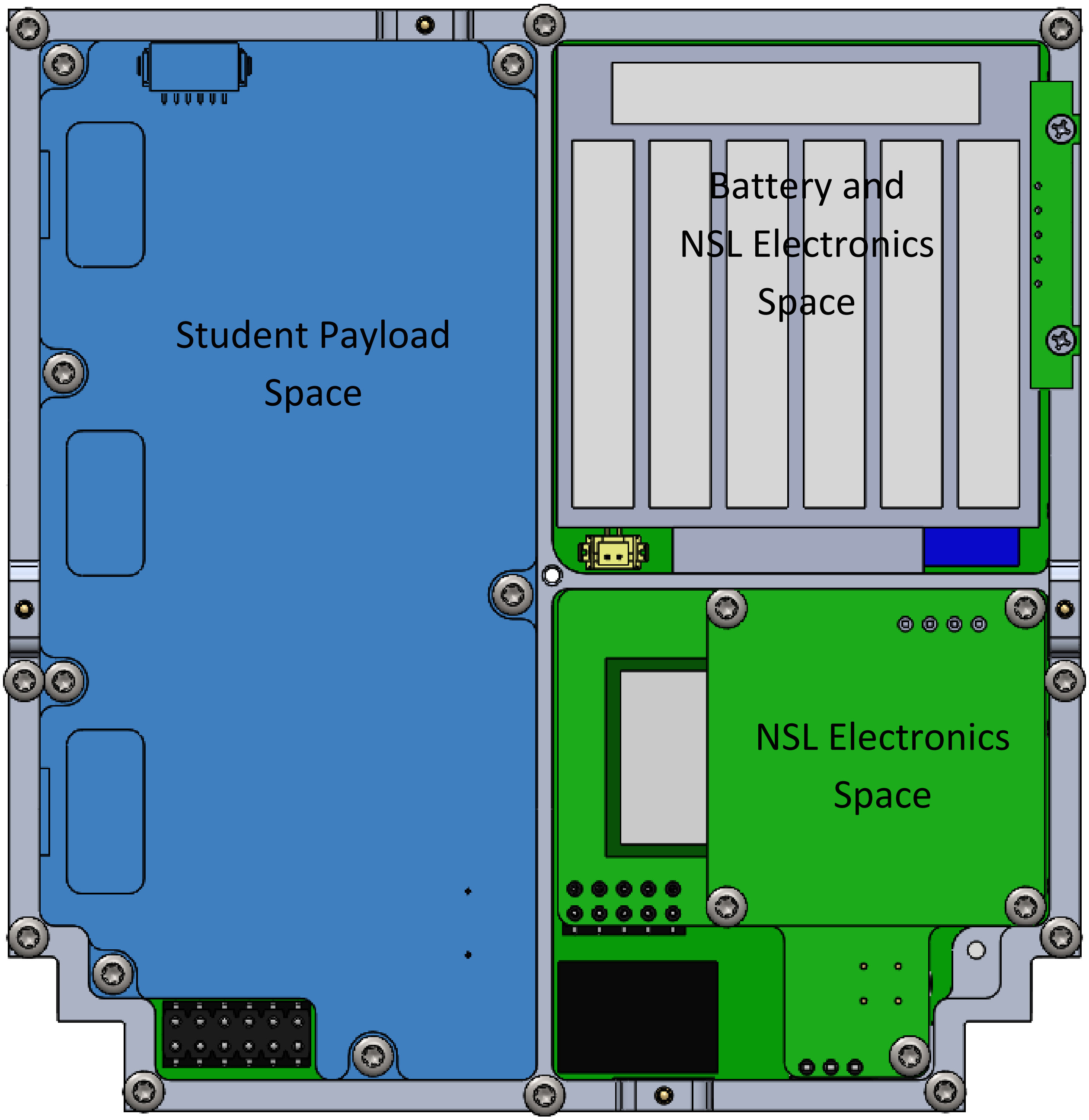


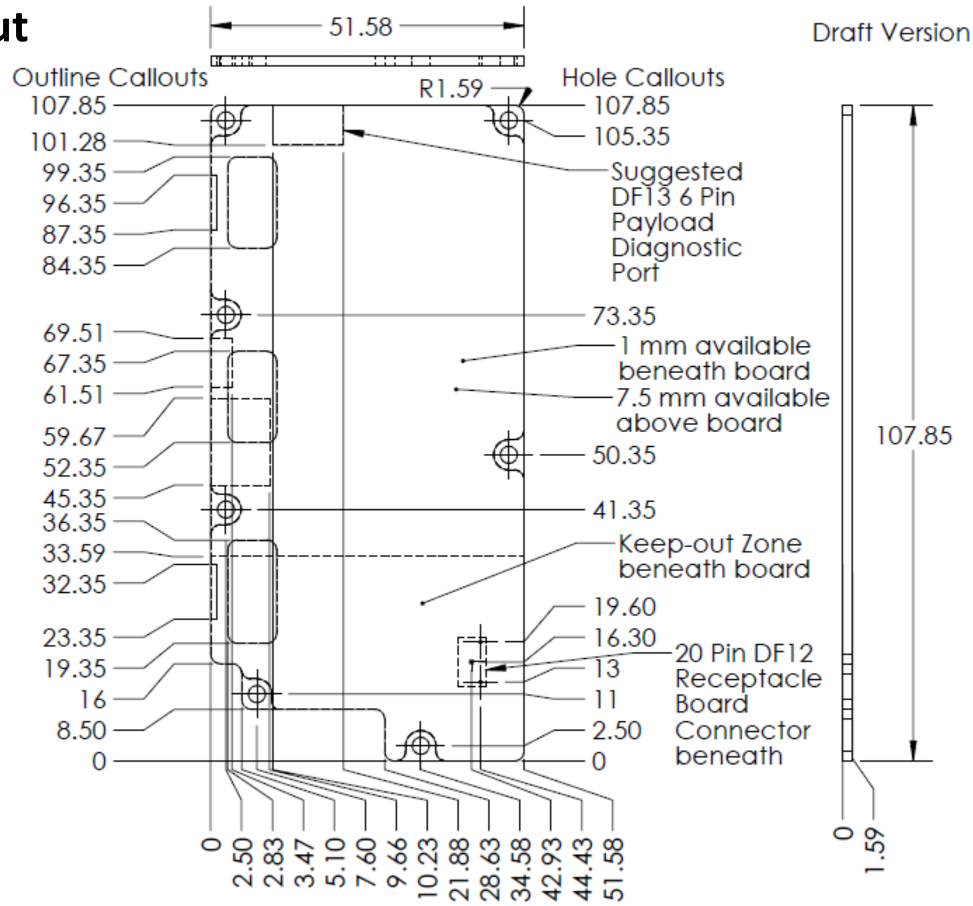
Figure 3 Blue portion is assigned Student Payload Space

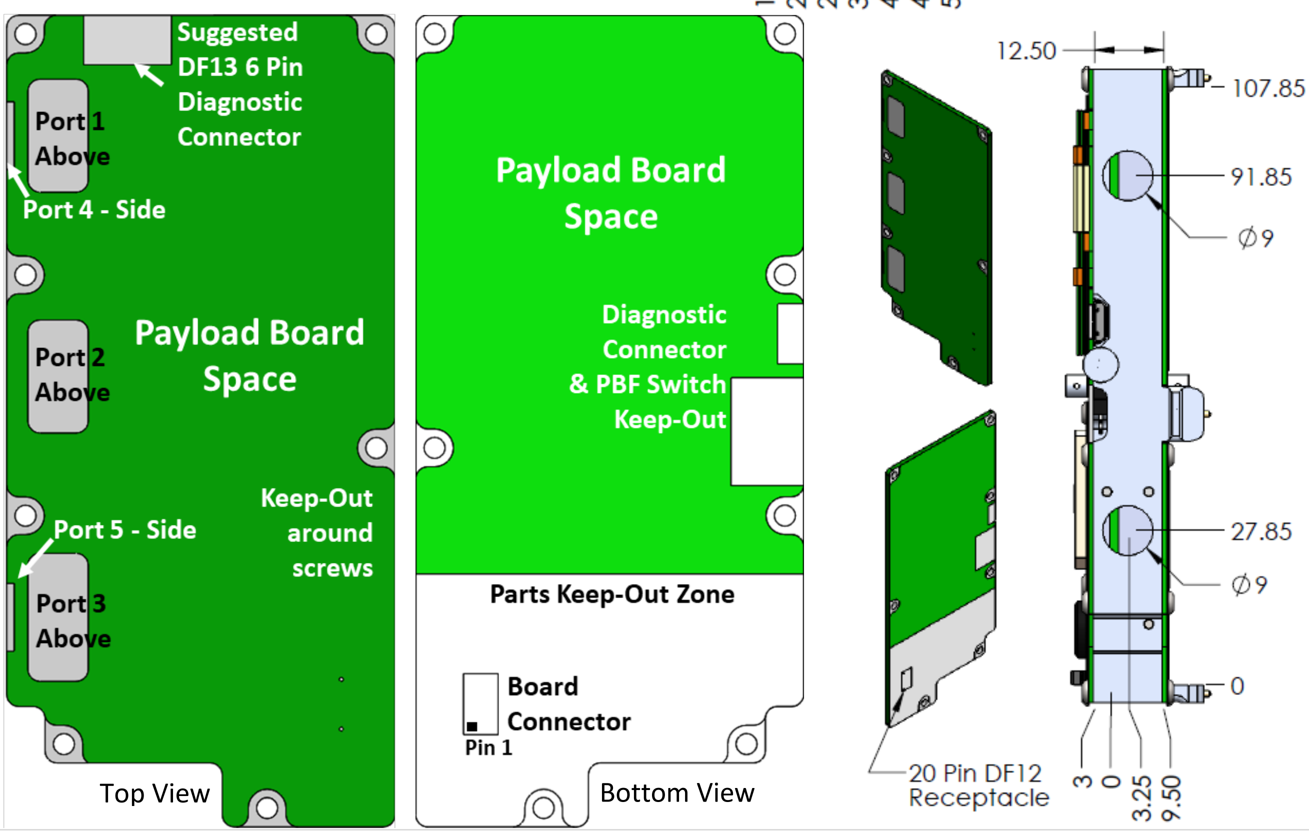
Mechanical Layout

Figure 4 Layout of Student Payload Board Space

Note #2 clearance holes 1.78 mm Diameter (0.07 in)

Note: Board dimensions are max envelope. Include 0.25 mm of tolerance on board outer dimensions to ensure a fit.





Payload Available Space and Keep-Out Zones

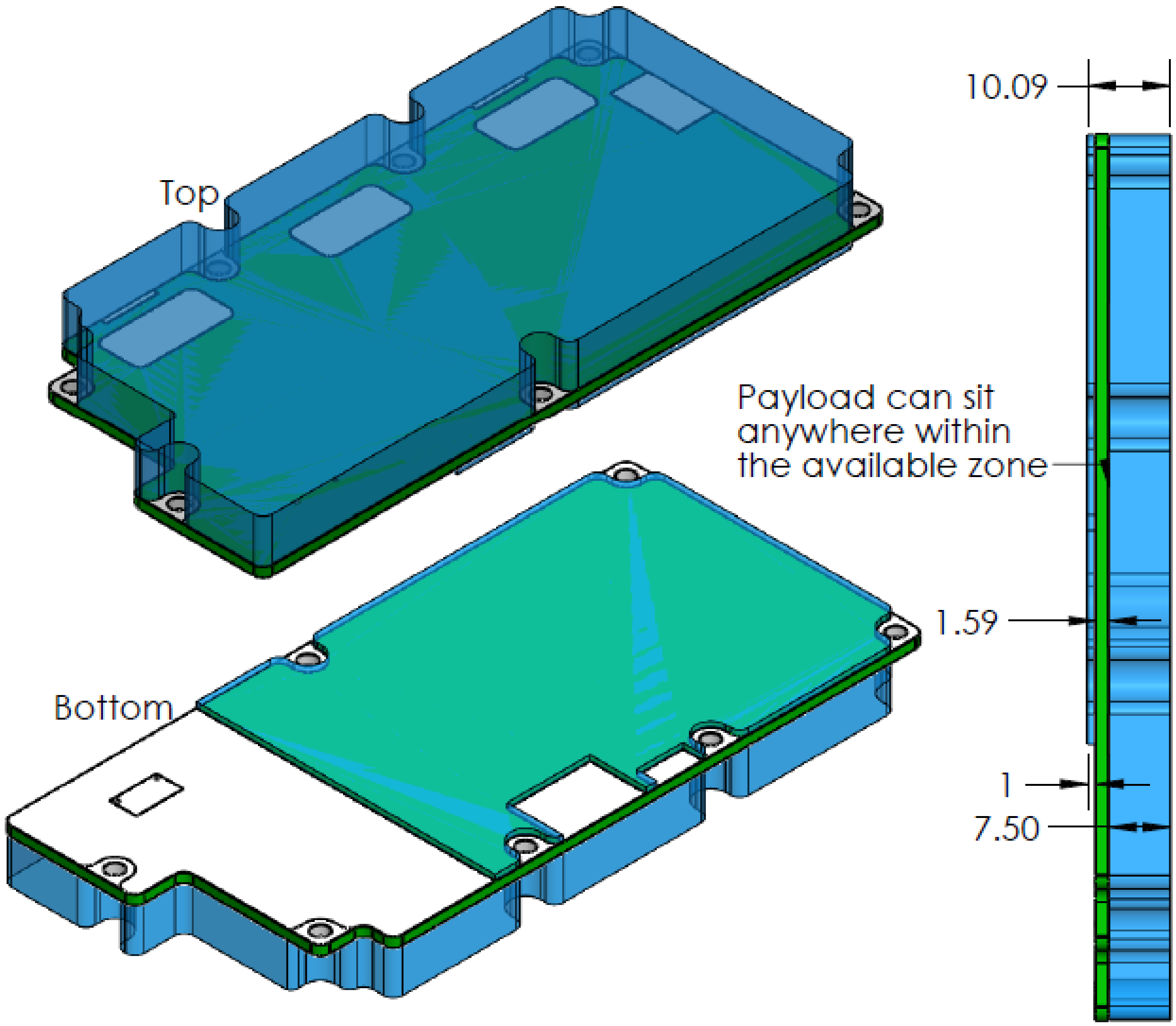


Figure 5 Keep-Out Zones and allowable space (Blue and green) for Student Payload. PCB boards can be placed anywhere within the allowable region.

Payload Interface Connector

Payload Board	Connector	NSL Board
	PWR	
	JP6.1	Analog Input 1 (0-5Vdc)
	JP6.2	Analog Input 2 (0-5Vdc)
	JP6.3	Analog Input 3 (0-5Vdc)
	JP6.4	Analog Input 4 (0-5Vdc)
	JP6.5	Analog Input 5 (0-5Vdc)
	JP6.6	Analog Input 6 (0-5Vdc)
	JP6.7	Digital Input 1 (TTL)
	JP6.8	Digital Input 2 (TTL)
<<< MEDO RX Input (LVTTL)	JP6.9	<<< MEDO TX Output (LVTTL)
>>> MEDO TX Output (LVTTL)	JP6.10	>>> MEDO RX Input (LVTTL)
>>> Serial TX Output (TTL)	JP6.11	>>> NSL Serial RX Input (TTL)
<<< Serial RX Input (TTL)	JP6.12	<<< NSL Serial TX Output (TTL)
<<< Serial BUSY	JP6.13	<<< NSL Serial BUSY Output (TTL)
	JP6.14	<<< 1 Hz Pulse output (5V TTL)
	JP6.15	<<< Standby (+5VDC@10mA)
	JP6.16	1 wire serial (NSL Use only)
	JP6.17	Switched +5.0VDC (100mA MAX)
	JP6.18	Switched +3.3VDC (100mA MAX)
	JP6.19	Ground
	JP6.20	Ground

Pinout Orientation

JP6	
20	19
18	17
16	15
14	13
12	11
10	9
8	7
6	5
4	3
2	1

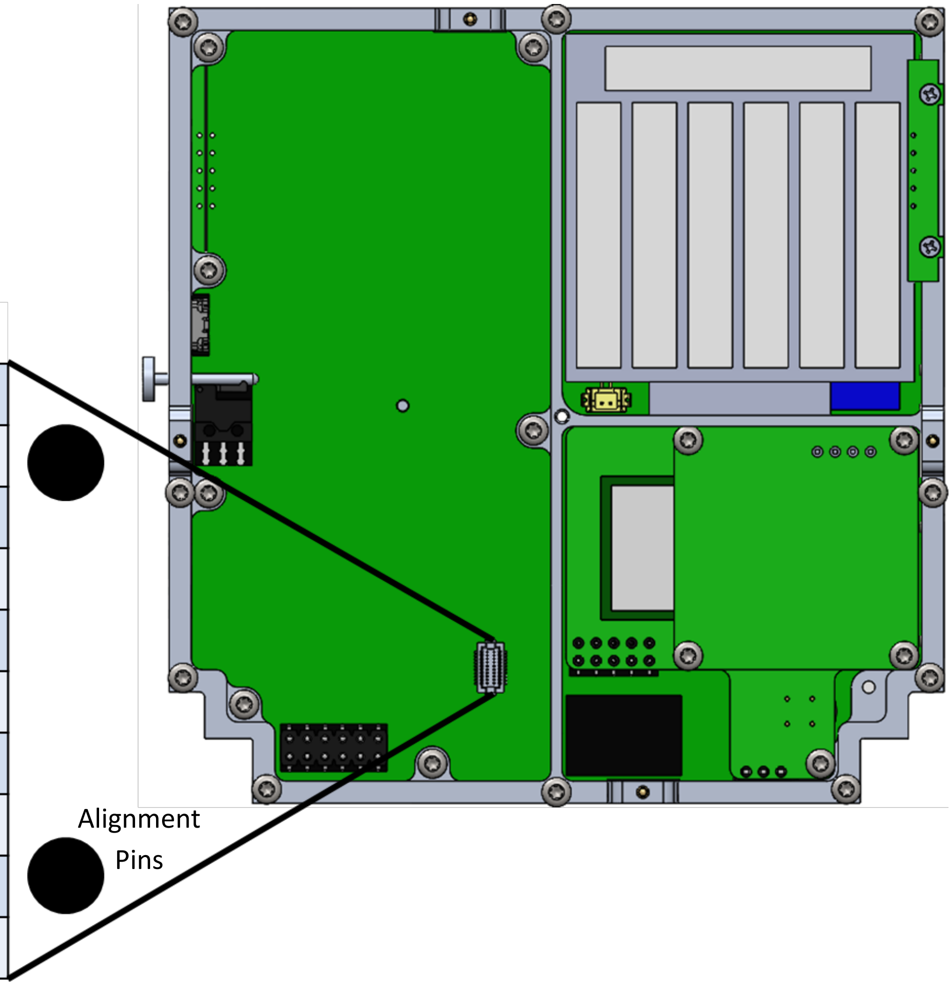


Figure 6 DF12 JP6 Layout on ThinSat, viewed looking down on main PCB. Note that the payload connector must match this, plugging down into it.

Connector Numbers:

- Connector on NSL's board: DF12(3.0)-20DP-0.5V(86) Header
- Required mating connector on payload board: **DF12(3.0)-20DS-0.5V(86)** Receptacle
  - Mounting plane is in line with payload mounts, which rise 3 mm off of the NSL main PCB.

Figure 8 NSL's DF12(3.0)-20DP-0.5V(86)

Figure 7 Payload's DF12(3.0)-20DS-0.5V(86)

NSL Bus Beacon Communication Packet Format

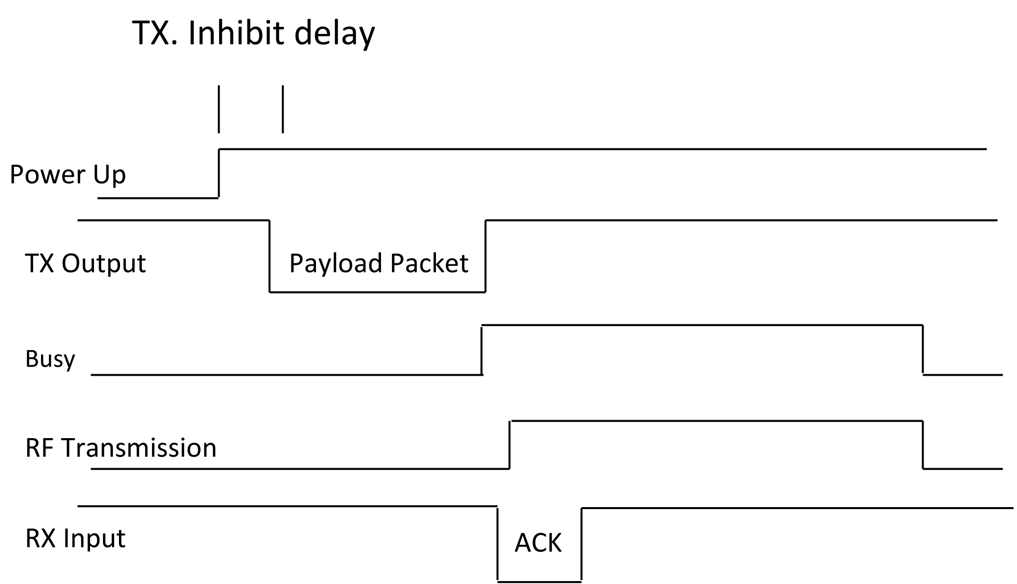
The Simplex radio will Beacon at a set Beacon Rate (see Specifications), a time interval. This Beacon will send out an 18 byte packet of the health and safety of the satellite, as well as IR/Mag packets, Particle data packets, and possibly Plasma data packets. Some of this data will be accessible to schools for data analysis after the mission.

Payload Analog/Digital Inputs Mode

If students do not wish to transmit the payload data serially, they may use the analog and digital inputs. 6 Analog inputs (A1 – A6), with 2 bytes each, and 1 byte total for the 2 Digital Inputs (P1DI) are available to be sampled on this payload connector. The radio will read each of these inputs at a set interval before it Beacons, and fill up the packet with your data before transmitting it.

Payload Serial Mode

If you would like more data sent than simply what is available in the Beacon packet, you can command the Simplex to transmit serially at any point that the radio is not Beaconing, and power is supplied to the Payload.



Payload Serial Communication Packet Format

Payload sends data to the modem when the BUSY signal is LOW. Once data is sent to the modem, the modem will return an ACK (Acknowledge) from RX Input to acknowledge the packet, or a NAK (No Acknowledge) if there is a problem with the packet. If the packet is good, the modem will set the BUSY line HI and send the data to the GlobalStar network. Once finished sending, the BUSY line is set back to LOW and the module waits to receive the next packet from the payload.

Serial Port

A half-duplex LVTTL / TTL / RS232 asynchronous serial port (UART) is the primary interface to payload. The serial port operates with the serial parameters of 38,400bps, 8 data bits, no parity, 1 stop bit. The Tx, Rx, and BUSY lines are 5V TTL.

Each data packet to the modem is sent in serial. Upon receiving the packet, the modem answers with an ACK if the packet is correct, and Transmits the packet. If the packet is incorrect, it will send a NAK back to the payload.

Payload packet format (Function A1)

Total packet size: 38 bytes	
Preamble: 3 bytes	Payload Data: 35 byte
Fixed pattern (hex 50 50 50)	35 bytes Data

Payload Send Data

Header	Payload
50 50 50	35 Bytes

Modem ACK Response

AA 05 00

Modem NAK Response

AA 05 FF

Re-entry Mode

Re-entry physics study is a topic of interest to this program. When the ThinSat begins re-entry, we want to collect as much data as possible during that time. During that phase, once it heats up under 110 km, the ThinSat will begin transmitting every 15 seconds until it burns up or depletes the battery.

Potential Use of Data Budget (DRAFT FOR TSL TO BE UPDATED)

12/21/2017				**Table: Data rates for one ET-Sat**			
	Change yellow column			**10 min on, 50 min off**			
Packet name	Measurements	Bytes/ Packet	Packets / orbit	Packets /hr	Bytes /day	Bytes/ 5 days	Cost 5 days 0.7 c/byte
	BUSS and MOTHERSHIP						
Health 1: Health and Safety	Bus Voltage, Solar cell Voltage, Charge, Temperaturs	36	1.5	1	864	4320	$ 30
IR: Infared	IR for spin rate burst, MShip	36	0.375	0.25	216	1080	$ 8
Particles: PIN	burst of particles, Mship	36	0.375	0.25	216	1080	$ 8
Plasma: Density	Burst of Plasma density, Mship	36	0.375	0.25	216	1080	$ 8
ADC: Mag	Burst Mag, IMU, 3-Axis, rates	36	1.5	1	864	4320	$ 30
GPS; Position	UT time, alt, lat, long,	72	1.5	1	864	4320	$ 30
	Student Payload						
Student:	Temp, UV, Light, MEDO, E-Field,…	36	28.5	19	16416	82080	$ 575
	96 by 128 resolution, Packets						
Camera:	170.7	36	15	10	8640	43200	$ 302
1.4	Number of images/day/ThinSat						
88.9	Images/day with 8 cameras						
1.5	or color VGA images/day						
			49.125	32.75	28296	141480	$ 990
	or about $1,000 per ThinSat						
Note A: 63 ET-Sats at 0.7 cent/byte							**$ 62,393**
Note B: If students could raise matching funds of $1000 then we would get twice the anount of data/Thin							
Note C: String Motherships use the Student Data alocation for GPS, Plasma, IR, Mag, Attitude, & health							
Note D: Baseline image is 96 by 128 pixels. VGA color is 48 times more data/image (480 by 752 pixels)							

Specifications

Power	Symbol	Minimum	Normal	Maximum	Units
Input voltage	JP6.17		5.0		V
	JP6.18		3.3		V
Current (per switch)		0		100	mA
Time power on/hour			10		min
Serial Communication Port					
Protocol			Serial N81		TTL
Bus voltage		3.0		5.2	V
Data rate			38.4		Kbits
Beacon Mode					
Beacon Rate		0.25		60	Minute
Analog inputs					
Six	10 bit	0		5	VDC
Source impedance			2.5K		Ohm
Digital inputs					
Two	TTL	0	-	5	VDC
Physical					
Mass	Total			280	g
	NSL Bus		208		g
	Payload	0		72	g
Operating Temperature		-30		60	C

Design Notes

- Ensure that at 0.25 mm tolerance is used when designing parts to fit within the satellite.
- Each project should have a diagnostic port built in to the payload and accessible through one of the view ports. We recommend using the dedicated student diagnostic port, built to use either a MEDO connector, or a 6 pin DF13 SMD right angle header mounted to either a 1/32” or 1/16” PCB. You may use any other connector type that you wish, as long as it fits in the Diagnostic Port in the frame.
- You may draw 100 mA from both power switches (3.3 V and 5 V) for a total of 200 mA. However, we recommend keeping the max current draw to around 100 mA total to keep from draining the battery.
- If the battery voltage drops beneath a certain level, the ThinSat will enter Power Save Mode and decrease the transmission rate.
- Students may choose to fly the NSL options of a particle detector, horizon sensor, and plasma probe. The plasma probe is located on the NSL side, and so takes no payload space. The particle detector and horizon sensor would take up the space of one, two-layers, MEDO section (about ¼ of the payload space).

Engineering Unit (Phase 2)

- Comes with a cable and software to plug into the NSL diagnostic port to view and download data from the ThinSat.
- Does not include battery, EyeStar-S3 radio, sensors (except for temperature), receiver, antennas, solar cells, mu metal, 1 Hz pulse, standby power, and is in a 3D printed frame instead of 7075 aluminum.
- You may cut the sensor ports 1, 2, and 3 above the payload in the plastic cover board, in order to give a bettery field of view for your sensors during the balloon launch. It is recommended to not make any cuts if you are building your own payload, but make cuts in the cover if you are using the white MEDO chips for Phase 2.

ET-Sat System Layout

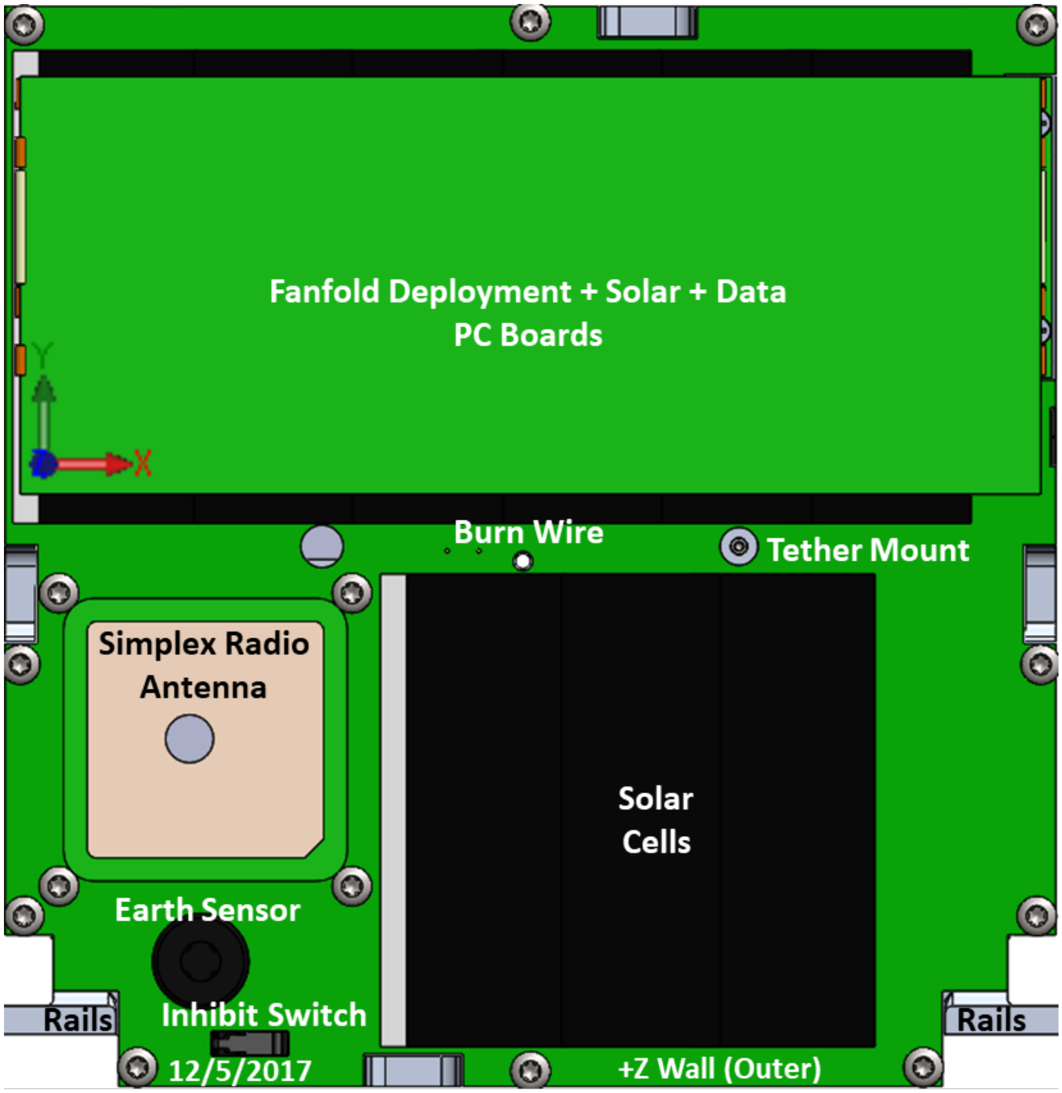


Figure 9 System layout of Outer +Z Wall of ET-Sat. This diagram is shown on the distributed Demo Units.

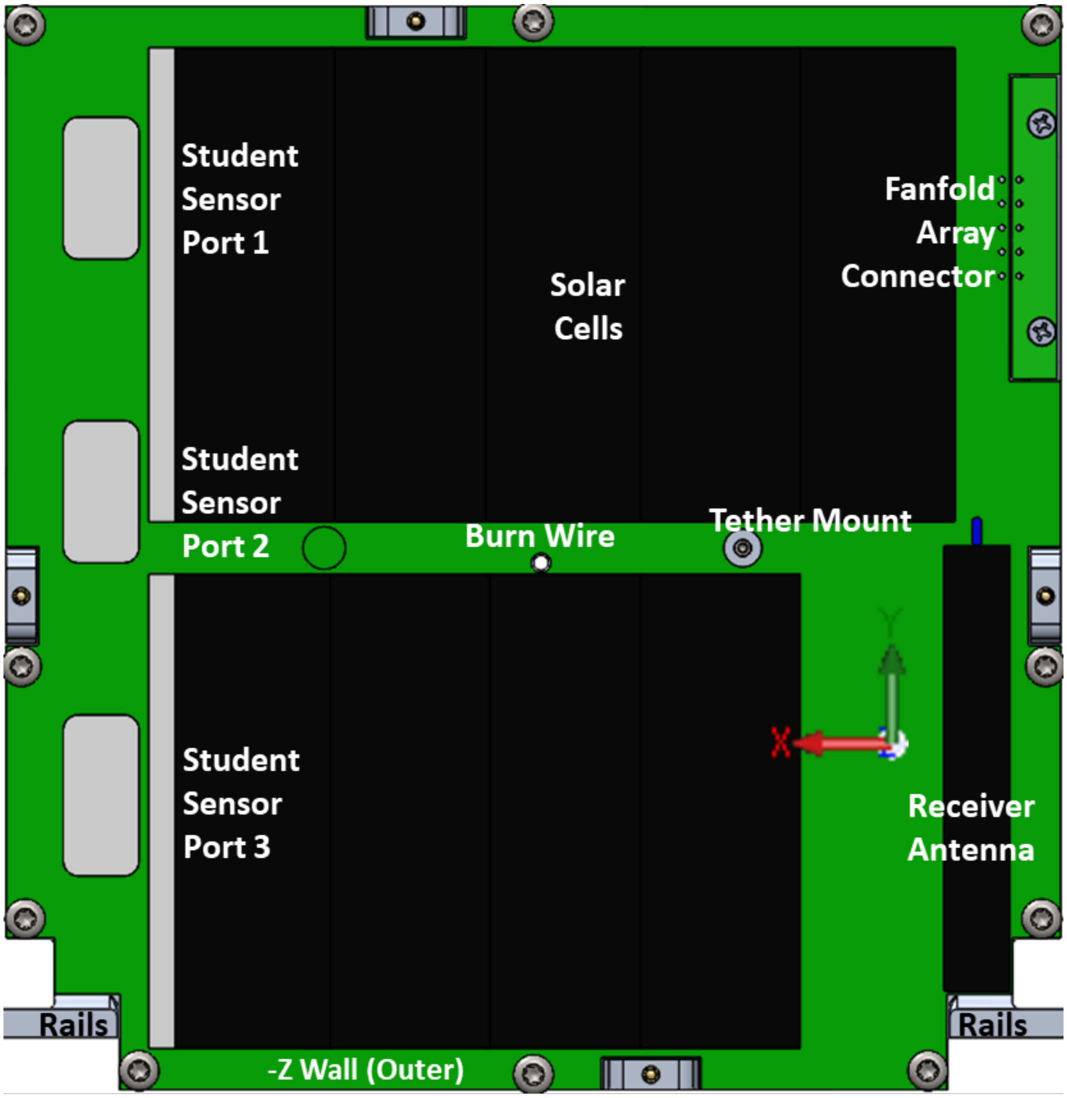


Figure 10 System layout of Outer -Z Wall of ET-Sat. This diagram is shown on the distributed Demo Units.

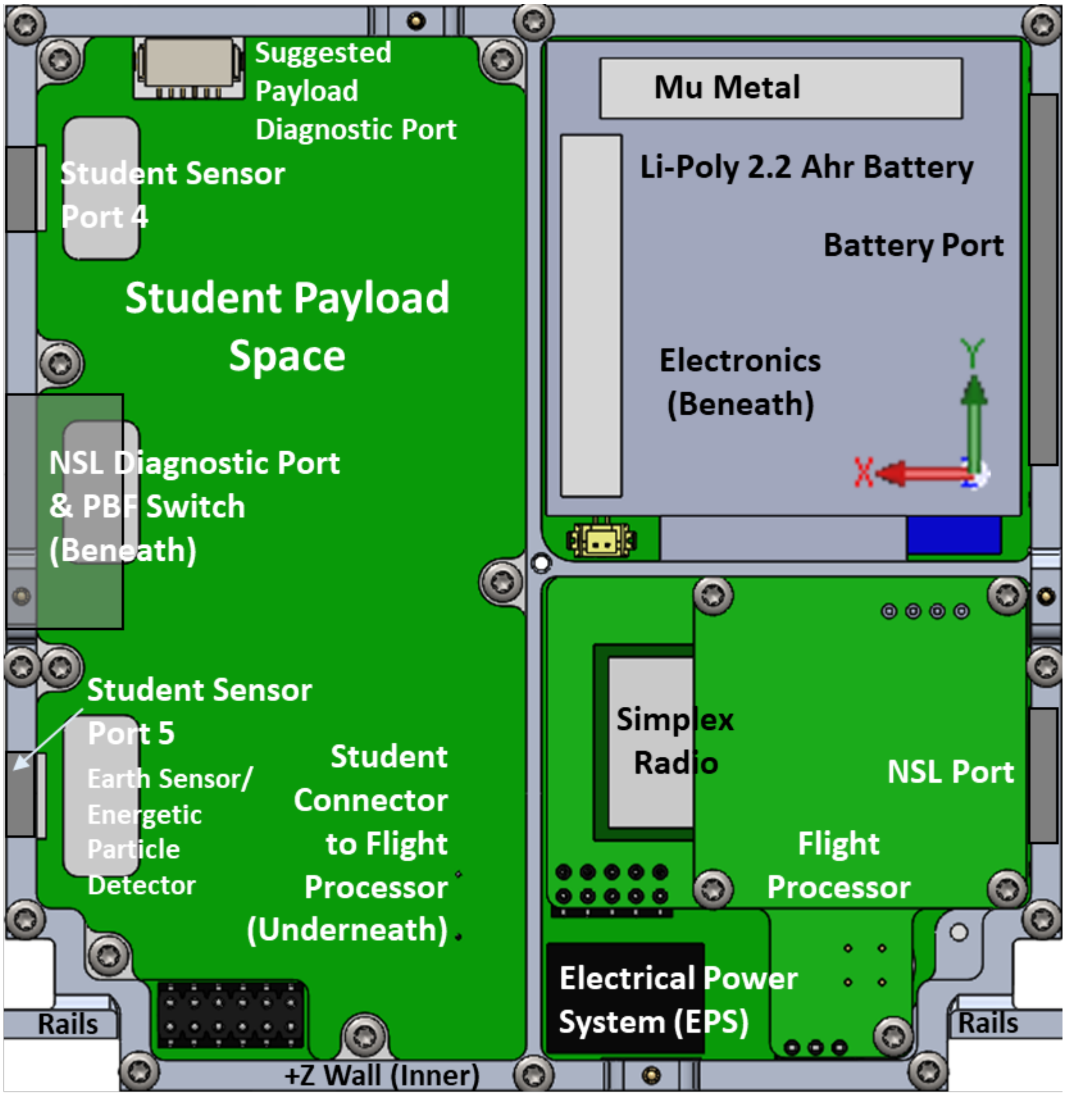


Figure 11 System layout of Inner +Z Wall of ET-Sat. This diagram is shown on the distributed Demo Units.

Figure 12 System layout of Inner -Z Wall of ET-Sat. This diagram is shown on the distributed Demo Units.

Phase 1 Data Flow

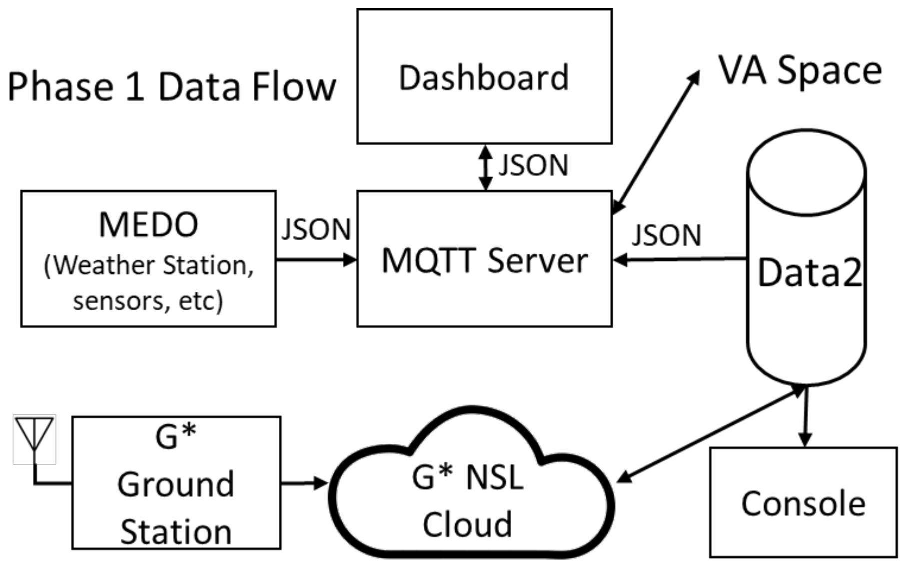


Figure 13 Phase 1 Data Flow

Phase 2 Interface Diagram and Data Flow

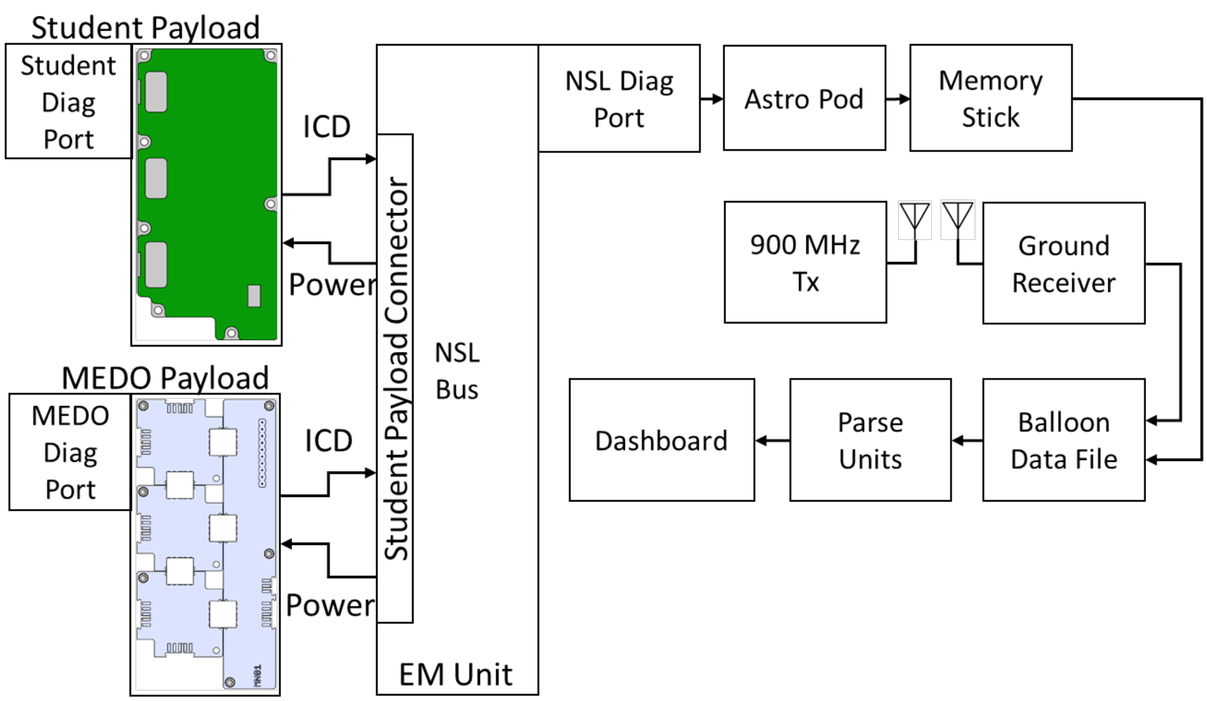


Figure 14 Phase 2 Engineering Unit Interface Diagram and Data Flow

Phase 3 Interface Diagram and Data Flow

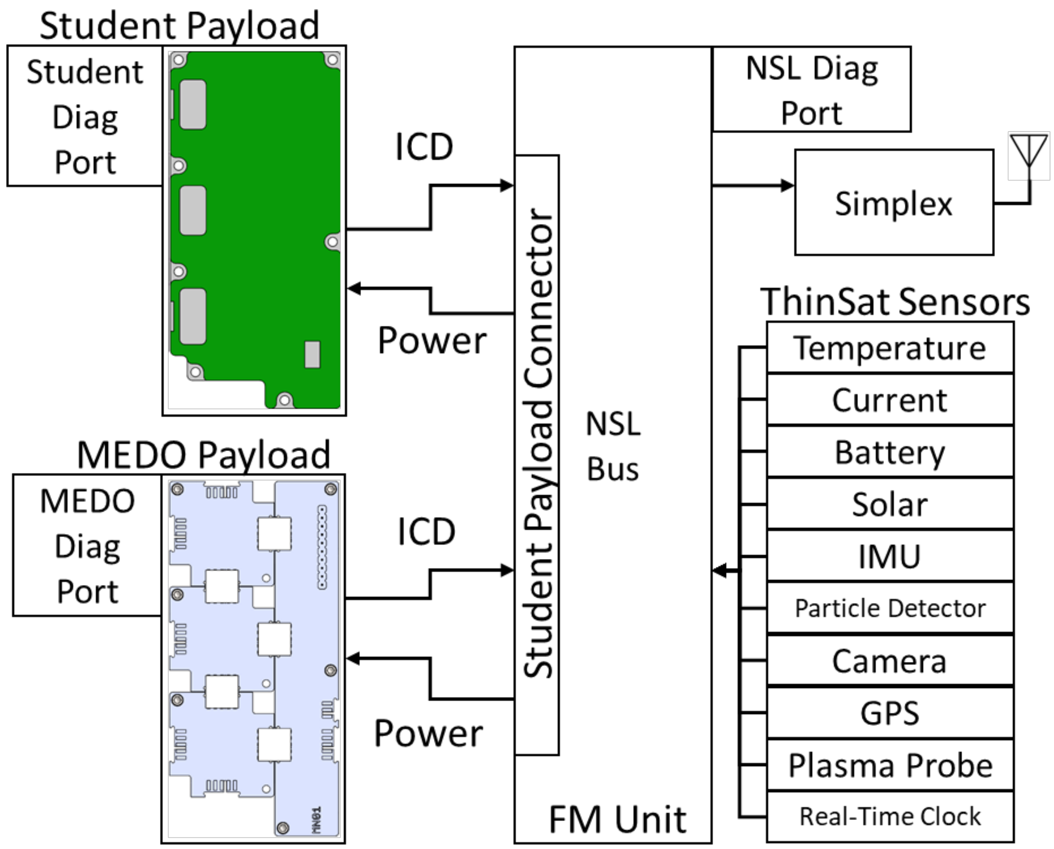


Figure 15 Phase 3 Flight Unit Interface Diagram

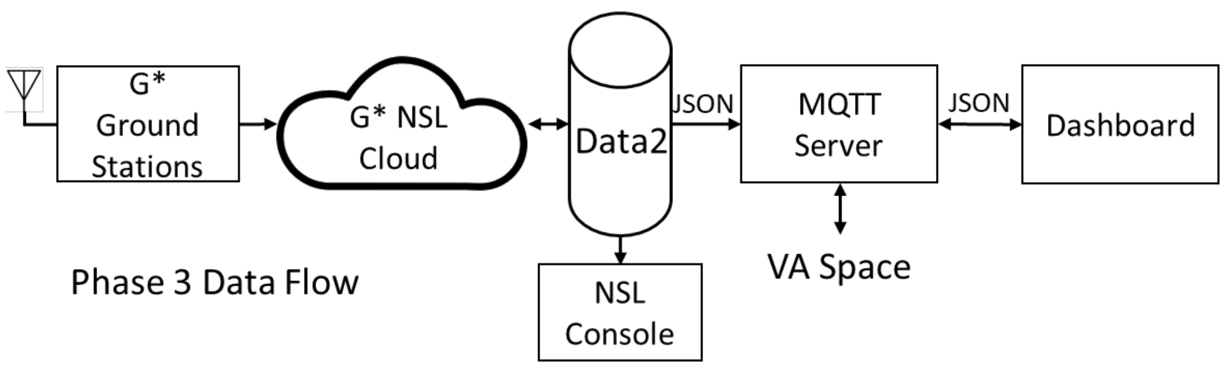


Figure 16 Phase 3 Flight Unit Data Flow