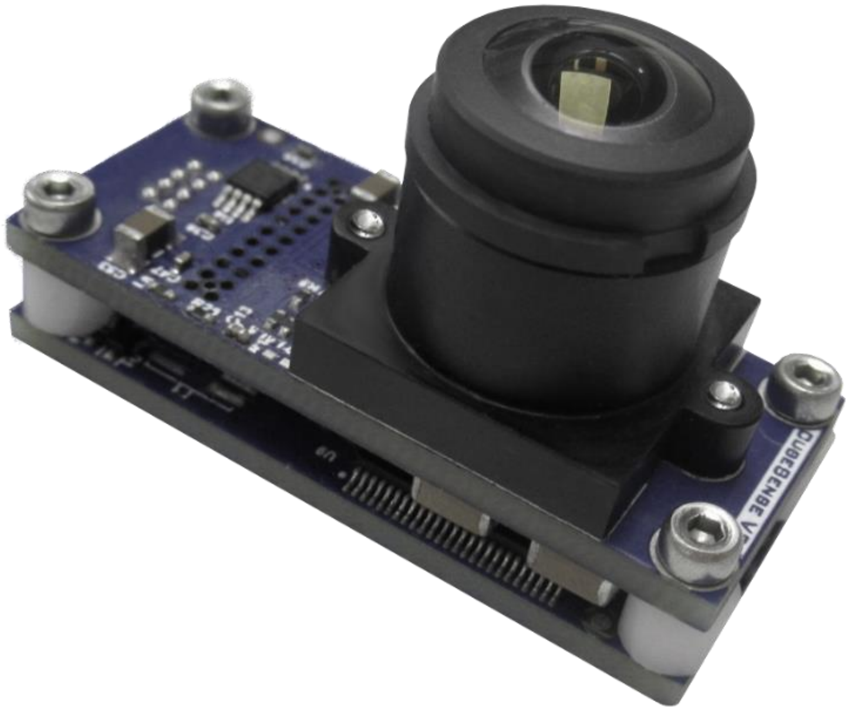
CubeSense V3

An integrated sun and nadir sensor module



Health Check

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List of Acronyms/Abbreviations

CMOS	Complementary metal-oxide semiconductor
ADCS	Attitude and Determination Control System
ESL	Electronic Systems Laboratory
FPGA	Field Programmable Gate Array
I^2C	Inter- Integrated Circuit
ICD	Interface Control Document
MCU	Microcontroller Unit
OBC	Onboard Computer
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver/Transmitter
COTS	Commercially Off-the-shelf
PCB	Printed circuit board
PSU	Power Supply Unit

List of Symbols

I_{SRAM}	SRAM Current
$I_{3\mathrm{V}3}$	3V3 Current

1. Health Check Details

CubeSense V3 serial number: CS23122

Date of health check: 18 July 2023

Name(s) of test engineer(s): **(1)** Albert Coetzee

(2)

Signature(s) of test engineer(s): **(1)**

(2)

Quality Controller Signature:

Quality Controller Name: Anele Tyesi

2. Introduction

The purpose of this document is to confirm all hardware functionality of the CubeSense module. This check is performed before shipment by the CubeSpace team and should be performed by the client immediately after reception of the component. This ensures that the client received a working unit, obtaining results similar to that measured by the CubeSpace team. The health check should also be performed at any stage to test if hardware was damaged during environmental tests.

The unit contains a variety of static sensitive devices. The appropriate electrostatic protection measures must thus be implemented. **The unit must never be handled without proper grounding.**

It is recommended that the unit be handled in a clean environment. A clean room of ISO class 8 or higher or an appropriate laminar flow workbench is recommended.

The unit should be kept **free of moisture or liquids**. Liquids and moisture could have corrosive effects on the electronics and electronic joints which may lead to degradation and loss of reliability of the circuits.

The unit must always be handled with care. **Dropping or bumping** the unit should be completely **avoided**. A mechanical shock could result in loss of performance/accuracy of the device.

The camera **lenses should be kept clean** and free of any dirt that may obstruct the images captured by the camera. If required, the lens may be cleaned using ethanol and appropriate lens cleaning equipment, but unnecessary cleaning of the lens should be avoided.

The sun and nadir optics are fitted with dust caps which should be **removed before flight.**

The position of the lens relative to the image sensor is of extreme importance for accurate detection. **Any external force on the lens or lens holder should be completely avoided.**

3. GSP Test Application

The Ground Support Program (GSP) that accompanies the CubeSense on the provided USB flash drive, allows the user to become familiarised with the functionalities available. This application will also allow the user to perform hardware tests and perform the health check that should be sent to the CubeSpace team to verify that no damage occurred during shipping.

Please follow the next steps to get started:

1. Before any connection can be made to the CubeSense, the provided CubeSupport board must be powered correctly as this is what will supply CubeSense with its regulated 3V3 input voltage. First, set the PSU to a voltage of 8 V with a current limit of 500 mA to compensate for the inrush current on device start-up.
2. After setting the PSU to the correct voltage and current limits, connect the provided DC power jack loose cables to the PSU terminals (the negative terminal should be connected to the wire indicated as ground or "GND" as labelled). The CubeSupport board has built-in backwards voltage protection, but nevertheless, care should still be taken to ensure the correct polarity of the DC jack.
3. To power the CubeSupport board, connect the DC jack male connector to the port on the board, with the power switch being in the downwards "off" position as shown in Figure 1. The DC jack can also be locked into the supply port by turning the connector clockwise to ensure a stable connection.

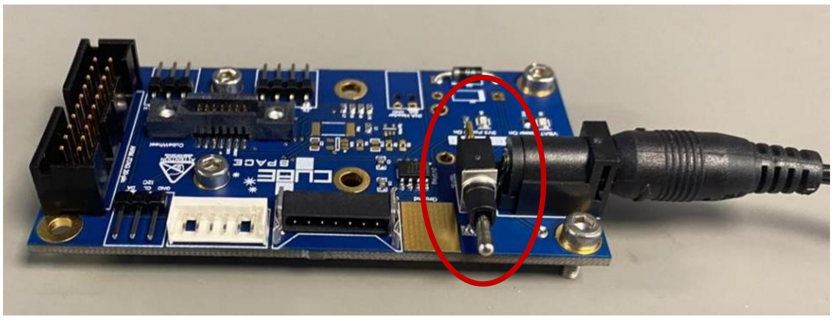


Figure 1 CubeSupport DC Jack and Power Switch

4. Next, connect the supplied CubeSense testing harness with the 7-pin Harwin connector to the CubeSense interfacing port as shown in Figure 2. With the CubeSupport power switch still in the downwards "off" position, the opposite end (*Samtec TFC-104-01-F-D*) of the CubeSense testing harness must now be inserted into the CubeSense being tested.

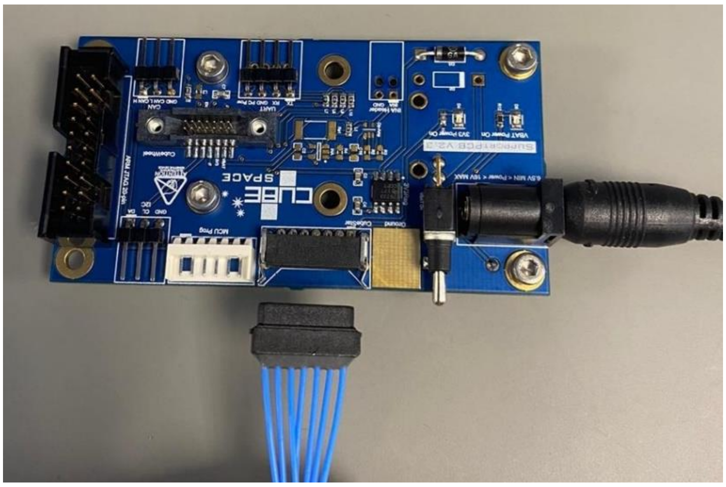


Figure 2 CubeSense Testing Harness Connection

5. Communication to and from the CubeSense during the health check, is conducted through the provided FTDI USB-to-UART 3-pin cable. Connect the cable to the CubeSupport UART pins by ensuring that the black wire is connected to the "GND" pin on the CubeSupport board as shown in Figure 3.

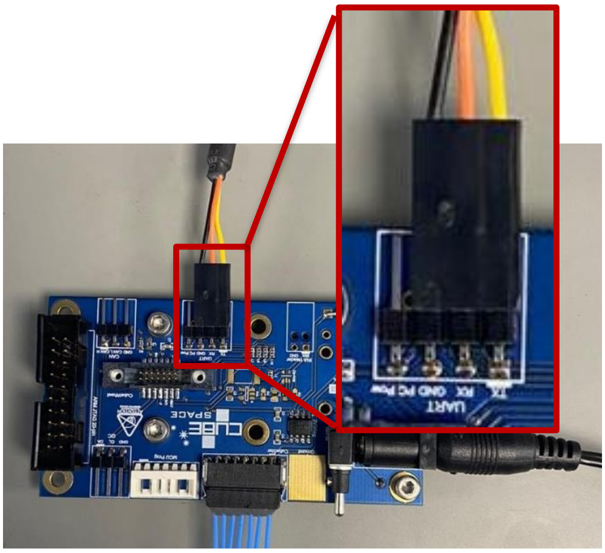


Figure 3 USB-to-UART Connection on CubeSupport

6. Connect the USB-to-UART cable to a PC running Windows 7 or later.
    a. Ensure that the FTDI driver for the cable is installed. This is supplied with CubeSense on the accompanying USB flash drive.
    b. Check the COM port assigned to the cable by browsing to *Device Manager* and noting the number shown under *Ports (COM & LPT)* for *USB Serial Port (COM **x**)*. The number given by ***x*** will be used to connect to CubeSense.

7. Switch on the power to CubeSense by flicking the power switch on the CubeSupport board to the upwards "on" position. Both the "VBAT" and "3V3" power indicating LEDs should be illuminated if the board is being correctly powered by the PSU as seen in Figure 4.

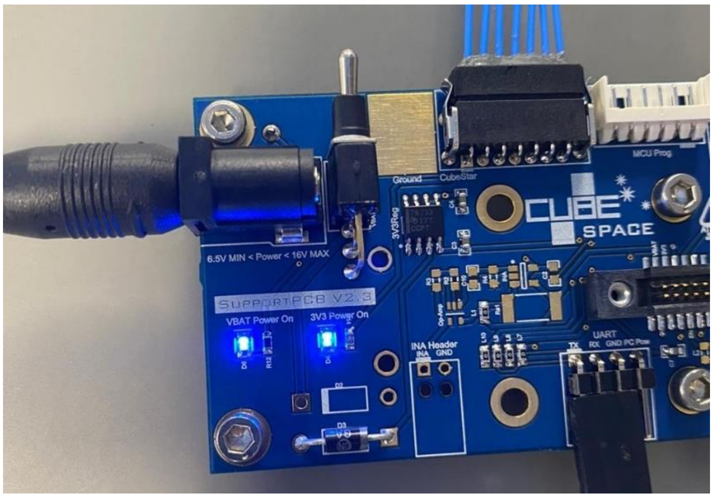
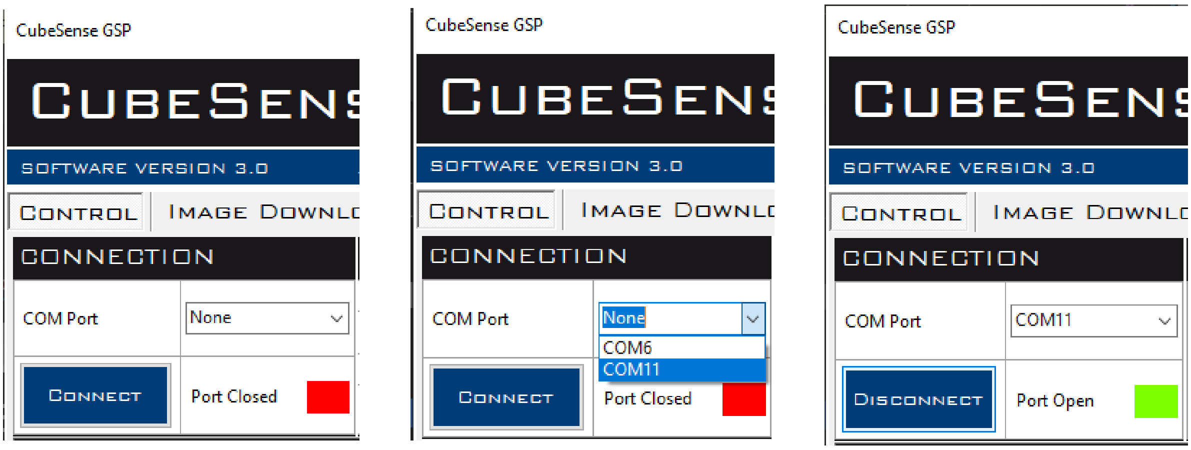


Figure 4 CubeSupport Power Indicating LEDs

8. Open the GSP Test Application by running *CubeSenseGSPV3.exe*.
9. Select the previously determined COM port and click *Connect* as shown in Figure 5.



COM Port None
Port Closed 🟥

COM Port None
Port Closed 🟥

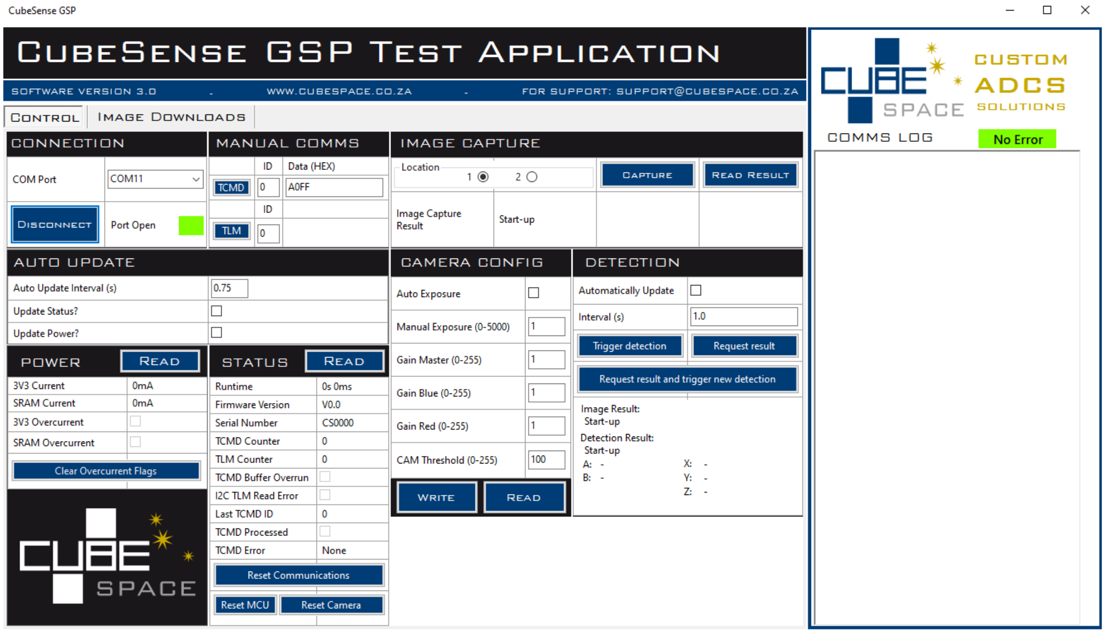
COM Port COM11
Port Open 🟩

Figure 5 Selecting a COM port

10. Begin the functional health check in the next section.
11. After testing is done, disconnect the COM port and remove power from CubeSense. The USB-to-UART cable can now be disconnected

4. Functional Tests

The interface for the GSP is shown in Figure 6. The results that are read from the application should be noted as is.



CubeSense GSP

CubeSense GSP Test Application

Software version 3.0 - www.cubespace.co.za - For support: support@cubespace.co.za

Control | Image Downloads

Connection
COM Port: COM11
Port Open 🟩

Manual Comms
TCMD ID: 0 Data (HEX): A0FF
TLM ID: 0

Image Capture
Location: 1 ● 2 ○
Image Capture Result: Start-up

Auto Update
Auto Update Interval (s): 0.75
Update Status? □
Update Power? □

Camera Config
Auto Exposure □
Manual Exposure (0-5000): 1
Gain Master (0-255): 1
Gain Blue (0-255): 1
Gain Red (0-255): 1
CAM Threshold (0-255): 100

Detection
Automatically Update □
Interval (s): 1.0
Image Result:
Start-up
Detection Result:
Start-up
A: -
B: -
X: -
Y: -
Z: -

Power
3V3 Current: 0mA
SRAM Current: 0mA
3V3 Overcurrent □
SRAM Overcurrent □

Status
Runtime: 0s 0ms
Firmware Version: V0.0
Serial Number: CS0000
TCMD Counter: 0
TLM Counter: 0
TCMD Buffer Overrun □
I2C TLM Read Error □
Last TCMD ID: 0
TCMD Processed □
TCMD Error: None

Comms Log: No Error

Figure 6 CubeSense GSP Test Application

4.1 Status

Press the *Read* button once (located at the top of the *Status* block) and confirm the results in the table below.

Test / Task	Expected Result	CubeSpace Result	Client Result
Firmware version	**V3.2**	V3.2	
Serial number	**CSXXXXX**	CS23122	
TCMD Counter	**0**	0	
TLM Counter	**2**	2	
TCMD Buffer Overrun	**False (Unchecked)**	False	
I2C TLM Read Error	**False (Unchecked)**	False	
Last TCMD ID	**0**	0	
TCMD Processed	**True (Checked)**	True	
TCMD Error	**No Error**	No Error	

Verify that the *Runtime* increases with each press of the *Read* button and that *TLM Counter* increments with 4.

Expected Result	CubeSpace Result	Client Result
True	True	

Press the *Reset MCU* button, followed by the *Read* button and verify that *Runtime* and *TLM Counter* have reset.

Expected Result	CubeSpace Result	Client Result
True	True	

Press the *Reset Camera* button, followed by the *Read* button and verify that *TCMD Counter* has incremented.

Expected Result	CubeSpace Result	Client Result
True	True	

Press the *Reset Communications* button, followed by the *Read* button and verify that *TCMD Counter* (reads a value of 0) and *TLM Counter* has reset (reads a value of 2), but not *Runtime*.

Expected Result	CubeSpace Result	Client Result
True	True	

4.2 Power

Press the *Read* button located at the top of the *Power* block.

Test / Task	Expected Result	CubeSpace Result	Client Result
3V3 Current	**15.5 mA** $\leq I_{3V3} \leq$ **22 mA**	17.9 mA	
SRAM Current	**0.1 mA** $\leq I_{SRAM} \leq$ **5.5 mA**	2.1 mA	
3V3 Overcurrent	**False (Unchecked)**	False	
SRAM Overcurrent	**False (Unchecked)**	False	

4.3 Camera Configuration

Press the *Read* button located at the bottom of the *Camera Config* block.

Test / Task	Expected Result	CubeSpace Result	Client Result
Auto Exposure	**False (Unchecked)**	False	
Manual Exposure (0-5000)	**35 (Nadir) / 0 (Sun)**	35	
Gain Master (0-255)	**0**	0	

Gain Blue (0-255)	**128**	128	
Gain Red (0-255)	**128**	128	
Cam Threshold (0-255)	**150 (Nadir) / 200 (Sun)**	150	

If the CubeSense is a Sun camera then set the value for the Sun camera *Manual Exposure* to 4500, otherwise set the value for the Nadir camera to 30. Press the *Write* button to transmit these changes and press the *Read* button to verify that they changed.

Expected Result	CubeSpace Result	Client Result
True	True	

4.4 Image Capture

For this test, a light source is required. If the CubeSense being tested is a Sun camera, a phone flashlight or an equivalently small light source is required. In the case that a Nadir camera is being tested, a modified lamp (shown in Figure 7) can be used, or something equivalent to mimic the bright round Earth.

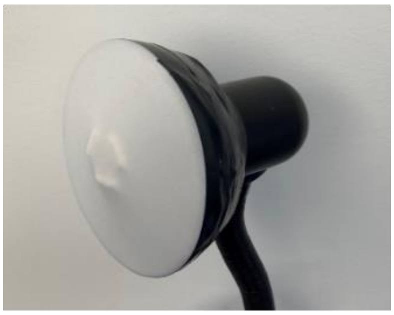


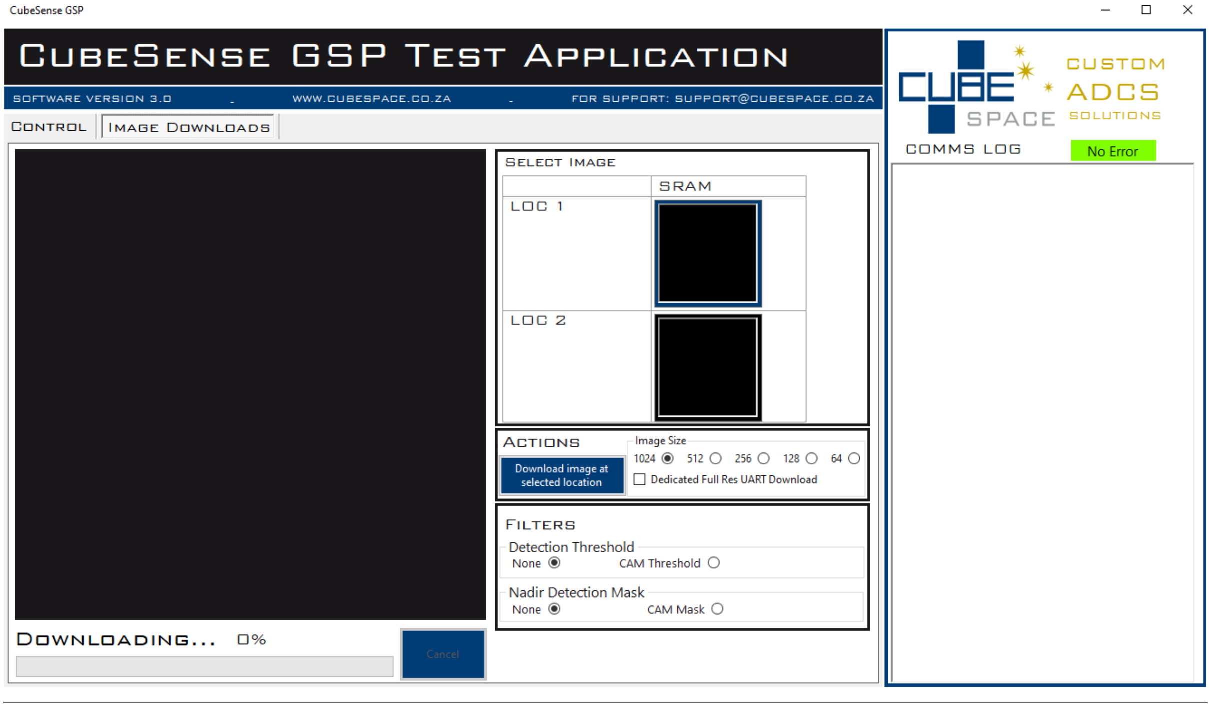
Figure 7 Example Nadir Cam Light Source

In the *Image Capture* block, ensure that the *Location* is set to 1. Hold the light source in front of the CubeSense camera (ensuring that the lens cap is removed) and press the *Capture* button followed by the *Read Result* button. The *Image Capture Result* field should show *Success*.

Expected Result	CubeSpace Result	Client Result
True	True	

4.5 Image Downloads

Navigate to the *Image Downloads* tab as shown in Figure 8. Select the SRAM/LOC1 option and set the *Image Size* to 64. Press the *Download image at selected location* button and wait for the download to complete. This will take about 15 seconds. Select the other SRAM/LOC2 option and download the same size image. Only the first image should show the bright spot caused by the light source. Downloaded images can be found in the same root directory as the “CubeSenseGSPV3.exe” file in the folder named “Run_YY_MM_DD_HH_mm” where the suffix of the “Run” folder is the most recent date and time at the instant of launching the application.



CubeSense GSP

CUBESENSE GSP TEST APPLICATION

SOFTWARE VERSION 3.0 - WWW.CUBESPACE.CO.ZA - FOR SUPPORT: SUPPORT@CUBESPACE.CO.ZA

CONTROL | IMAGE DOWNLOADS

SELECT IMAGE

	SRAM
LOC 1	
LOC 2	

ACTIONS

Download image at selected location

Image Size: 1024 ● 512 ○ 256 ○ 128 ○ 64 ○

□ Dedicated Full Res UART Download

FILTERS

Detection Threshold: None ● CAM Threshold ○

Nadir Detection Mask: None ● CAM Mask ○

DOWNLOADING... 0%

Cancel

COMMS LOG: No Error

Figure 8 CubeSense Image Downloads Tab

Expected Result	CubeSpace Result	Client Result
True	True	

Navigate back to the *Image Capture* block under the *Control* tab. Sequentially capture illuminated images to the second SRAM location and verify with the *Image Downloads* tab that the light source is now visible from downloads at both SRAM locations. Remember to move the light source slightly before each capture.

Expected Result	CubeSpace Result	Client Result
True	True	

Download a full-resolution (1024) image at each SRAM location under the *Image Downloads* tab and verify that the downloads complete successfully and that the images appear as expected.

Expected Result	CubeSpace Result	Client Result
True	True	

Navigate to the *Manual Comms* block under the *Control* tab. Enter telecommand=52 with data=003200640032006400 and press the *TC* button. The *Comms Log* should display: *ACK = Success*. Enter Telemetry Request=72 and verify that the *Comms Log* displays DATA = [31, 127, 50, 0, 100, 0, 50, 0, 100, 0, 0,… …, 0, 31, 255]. Navigate back to the *Image Downloads* tab and select the radio button next to *CAM Mask* under the *Filters* block. A green block should display in the top left corner of the image.

Expected Result	CubeSpace Result	Client Result
True	True	

4.6 Detection

Navigate to the *Detection* block under the *Control* tab. Select the checkbox next to *Automatically Update*. The CubeSense will attempt to detect the sun or nadir at one second intervals. To test a sun detection, use the aforementioned small light source to simulate a point light source. To test a nadir camera detection, use the modified circular diffused light source previously mentioned. The nadir light source should look like a large uniformly illuminated circle. Note that all other light sources should be eliminated from the camera field of view and the exposure and detection threshold can be adjusted to improve detections. Additionally, moving the light source closer and further away may assist with detections. Examples of typical images resulting in successful detections can be seen in Appendix A.

Refer to Appendix A to see the defined camera coordinate system. Move the appropriate light source to the approximate boresight of the camera lens and verify that the A (Azimuth) and B (Elevation) values are near zero or that the light vector X and Y coordinates are close to 0 and the Z coordinate is close to 1 and verify that the detection succeeded below.

Expected Result	CubeSpace Result	Client Result
True	True	

When facing the camera, the A and X value should increase when moving the light towards the right side and should decrease when moving the light towards the left. When the light is moved upwards, the B or Y value should increase and should decrease when moving it downwards.

Expected Result	CubeSpace Result	Client Result
True	True	

4.7 I2C Functionality

The GSP Test Application does not have the ability to interface to the CubeSense via I2C. This functionality was tested by CubeSpace, where the user is additionally free to design their own I2C test to confirm the functionality if desired. To test the I2C functionality, please refer to the CubeSense ICD to find out how to communicate to the device.

5. Observations

Please indicate any observations that were made that should be addressed by the CubeSpace team.

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Appendix A

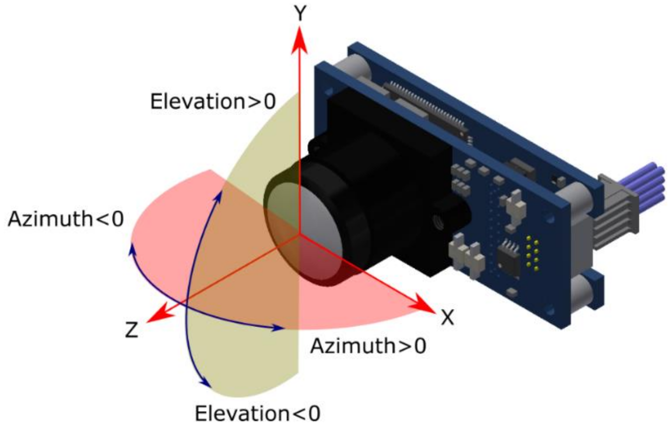

Figure 9 CubeSense Axes

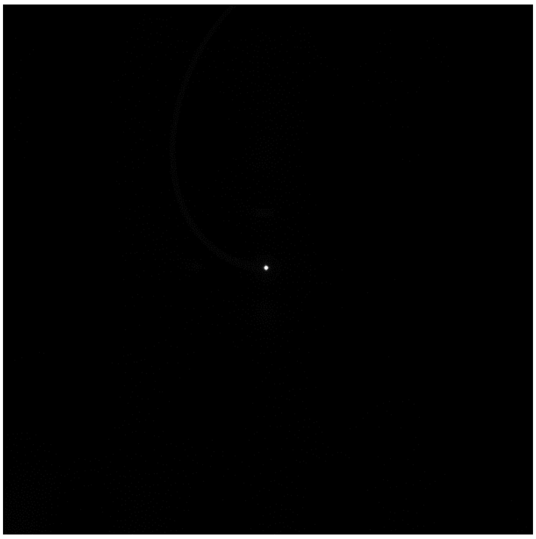

Figure 10 Typical Successful Sun Detection

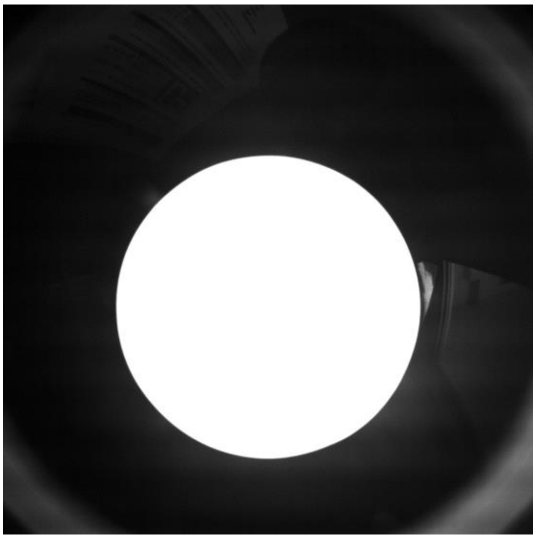

Figure 11 Typical Successful Nadir Detection