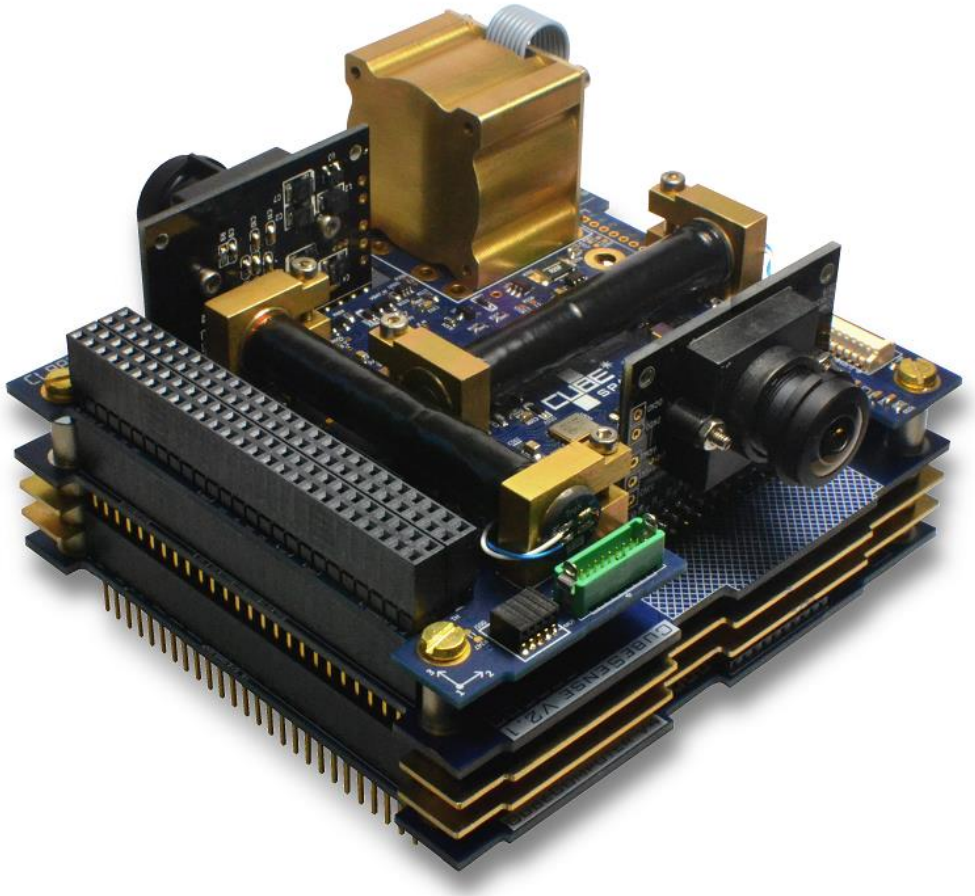
CubeADCS Y-Momentum

The complete ADCS solution for Y-Momentum control



Option Sheet

Electronic Systems Laboratory

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	Signature: 

Document Version History

Version	Responsible person(s)	Pages	Date	Description of change
3.00	MK	ALL	20/04/2017	V3 First draft
3.01	JG	ALL	20/04/2017	From option sheet V1.6 and V3.00 Added Battery voltage option Uncertain options condition added Removed standard CubeSense Cam selection Added CubeWheel grounding
3.02	MK	19/20	01/06/2017	Removed T&Cs

List of Acronyms/Abbreviations

ACP	ADCS Control Program
ADCS	Attitude Determination and Control System
CSS	Coarse Sun Sensor
ESD	Electrostatic Discharge
I^2C	Inter-Integrated Circuit
MCU	Microcontroller Unit
OBC	Onboard Computer
PCB	Printed Circuit Board
RTC	Real-Time Clock
SPI	Serial Peripheral Interface
TC	Telecommand
TLM	Telemetry
UART	Universal Asynchronous Receiver/Transmitter

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1. Client Information

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2. Satellite Information

Name of satellite	CySat-1
Size (e.g. 3U)	3U
Orbit	ISS-Deployed LEO
Deployable structures	None
Nominal battery voltage	7.4 V

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3. Introduction

CubeSpace aims to simplify the complicated task of integrating an ADCS into your satellite design. Our systems are therefore highly configurable and this document allows you to customise your CubeADCS unit to meet your requirements. If additional customisation is required, please indicate your requirements in the Additional Notes section on page 18 of this document or contact CubeSpace directly at info@cubespace.co.za.

The CubeADCS Y-Momentum bundle is an integrated collection of CubeSpace ADCS components which provides the necessary actuators and sensors for a nanosatellite to achieve a stabilised attitude with Y-axis control. A momentum wheel (in various sizes) is included in the solution and can be mounted either on the bundle or separately from the bundle, depending on the size of the wheel. CubeSpace's fine sun and nadir sensor module, CubeSense, can also be added to the solution if more accurate attitude control is required.

Figure 1 provides a high-level system diagram of the complete CubeADCS Y-Momentum solution.

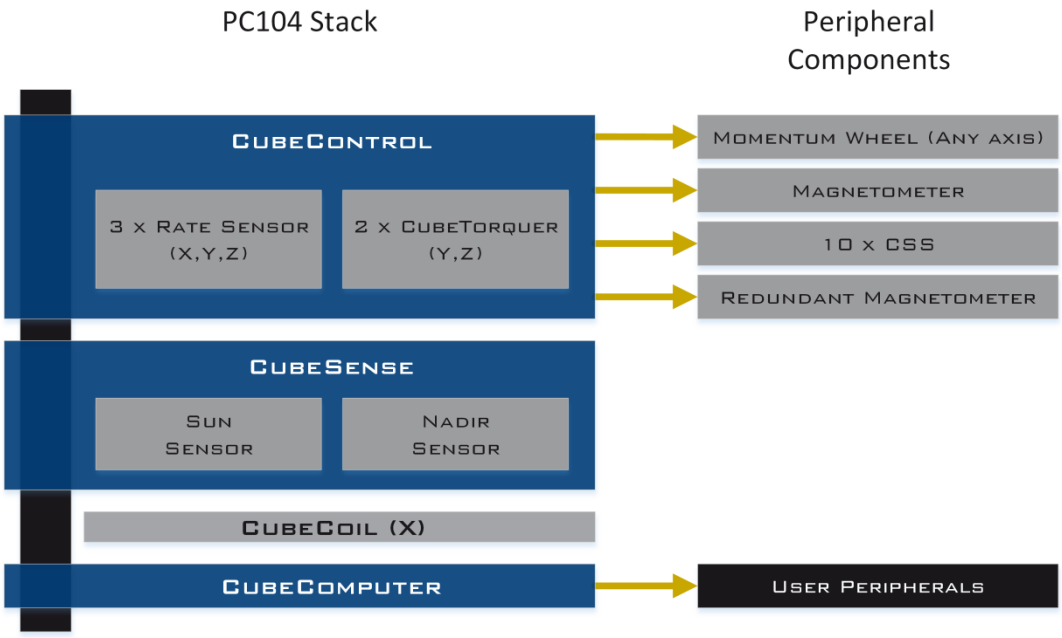

Figure 1 – System diagram of CubeADCS Y-Momentum solution

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4. Hardware Configuration

Please complete all the relevant sections below to configure the CubeADCS unit. Additional customisation must be indicated in the Additional Notes section on page 18 of this document.

4.1 PC104 bus configuration

The options in this section will determine the pin configuration of the main PC104 bus. The pin description of the PC104 bus (as used by the CubeADCS Y-Momentum unit) is shown in Figure 2.

H2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51
H1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51

PC104 interface pins					
Communication					
	H1	1	CANL	CAN bus low	*option*
	H1	3	CANH	CAN bus high	*option*
	H1	21	I2C_SCL_ADCS	Internal I2C clock for all ADCS modules	required
	H1	23	I2C_SDA_ADCS	Internal I2C data for all ADCS modules	required
	H1	41	I2C_SDA_SYS	System I2C data for CubeComputer	required
	H1	43	I2C_SCL_SYS	System I2C clock for CubeComputer	required
	H1	17, 18, 19, 20	UART_1	Usable pins for UART_1 (RX or TX)	*option*
	H2	21, 22	UART_1	Usable pins for UART_1 (RX or TX)	*option*
	H1	33, 35, 39, 40	UART_2	Usable pins for UART_2 (RX or TX)	*option*
	H1	29	SPI_CLK	SPI Clock	*option*
	H1	30, 31	SPI_MOSI / MISO	SPI MOSI or MISO	*option*
	H1	32	SPI_CS	SPI Chip Select	*option*
Power					
	H2	29, 30, 32	GND	Ground connection for all modules	required
	H2	45, 46	V_Bat	Battery voltage bus	required
	H2	25, 26	5V_Main	Main 5 V supply	*standard option*
	H2	27, 28	3V3_Main	Main 3.3 V supply	*standard option*
	H1	47, 49, 51	5V_S	Switched 5 V supply options	*option*
	H1	48, 50, 52	3V3_S	Switched 3.3 V supply options	*option*
	H1	42	BUVIN	CubeComputer optional backup power supply	*option*
Internal ADCS pins					
	H1	2, 4, 6, 8	ENABLE	Enable lines for CubeADCS modules position 1	*standard option*
	H2	17, 18, 19, 20	ENABLE	Enable lines for CubeADCS modules position 2	*option*

Figure 2 – PC104 bus pin description

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4.1.1 Power supply

The CubeADCS unit requires 3.3 V, 5 V, and the battery voltage to operate. CubeComputer can however be powered by a separate 3.3 V supply (as specified in Option 8). Please select the 3.3 V and 5 V supplies for the ADCS bundle on the PC104 header. *(Standard option: 3.3 V = H1-48 and 5 V = H1-47)*

Option 1 – 3.3 V supply

	H2-27,28	H1-48	H1-50	H1-52
3.3 V supply pin(s)		✓		

Option 2 – 5 V supply

	H2-25,26	H1-47	H1-49	H1-51
5 V supply pin(s)		✓		

The gains of the speed controller on the momentum wheel is dependent on the battery bus voltage of the satellite. Please specify the expected nominal battery voltage. *(Standard option: 8.0 V)*

Option 3 – Battery bus voltage

	8.0 V	Other (specify)
Raw battery voltage		7.4 V

4.1.2 UART

The CubeADCS bundle has two UART buses, designated UART 1 and UART 2, which can be used to interface with the bundle. Both buses are routed to the PC104 header and UART 2 is also accessible from the piggyback header on CubeComputer. Please select to which PC104 pins the UART must be connected, if any. *(Standard option: None)*

Option 4 – UART 1

	H1-17	H1-18	H1-19	H1-20	H2-21	H2-22	None
UART 1 TX	✓						
UART 1 RX		✓					

Option 5 – UART 2

	H1-33	H1-35	H1-39	H1-40	None
UART 2 TX					✓
UART 2 RX					✓

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4.1.3 CubeADCS enable lines

The CubeADCS bundle requires 4 pins on the PC104 header for internal use. These lines are used to enable/disable the individual components of the bundle. If the suggested PC104 pins are unavailable, a wire harness can be used to route the enable lines. Please select the configuration for the enable lines. *(Standard option: H2-17, 18, 19, 20)*

Option 6 – Enable pins location

	H1-2,4,6,8	H2-17,18,19,20	Wire harness
Enable pins		✓	

4.1.4 Mounting holes

The standard CubeSat mounting holes on the corners of the CubeADCS stack can be connected to ground if required. Please select whether or not to ground the mounting holes of the bundle. *(Standard option: Not connected)*

Option 7 – Grounding of mounting holes

	Not connected	Grounded
Mounting holes		✓

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4.2 CubeComputer configuration

4.2.1 Power supply (main OBC)

If CubeComputer is intended to be used as the satellite's main onboard computer (OBC), it is recommended that the main 3.3 V bus (H2-27,28) should be used to supply power to CubeComputer. It is possible to have only CubeComputer on the main 3.3 V bus and the other ADCS components on the 3.3 V supply selected in Option 1. Please select the 3.3 V supply for CubeComputer. *(Standard option: H2-27,28)*

Option 8 – CubeComputer power supply

	H2-27,28	H1-48	H1-50	H1-52
CubeComputer 3.3 V supply	✓			

4.2.2 Backup power domain

The EFM32GG280F1024 microcontroller unit (MCU) on CubeComputer contains a backup power domain which can be used along with the backup real-time clock (RTC). The backup power domain can be powered from an alternative power supply through the BUVIN pin. *For more information on the backup power domain of the MCU, please refer to Chapter 10.3.4 ("Backup power domain") in the EFM32GG Reference Manual.*

Three configurations are available for the BUVIN pin: (1) permanently connected to H2-27, 28 (main 3.3 V bus), (2) connected to H2-42, or (3) routed to a 2-way Molex MicroLatch header (Molex part number: 53254-0270) for an external power connection. If CubeComputer is intended to be used as the satellite's main OBC, it is recommended that the BUVIN pin is connected to the main 3.3 V bus (H2-27, 28) permanently. Please select the desired backup power domain configuration. *(Standard option: H2-27, 28)*

Option 9 – Backup power domain power supply

	H2-27,28	H2-42	External supply
BUVIN pin connection	✓		

4.2.3 I^2C

CubeComputer is set to be a master on the secondary I^2C bus (H1-21,23) to communicate with the other CubeSpace ADCS modules on the bus. CubeComputer is also connected to the system I^2C bus (H1-41,43). Please indicate the desire configuration for the bus side pull-up resistors on the system I^2C. *(Standard option: None)*

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Option 10 – System I²C bus side pull-up resistors

	10 kΩ	Other (specify)	None
I2C_SYS bus side pull-up resistors			✓

4.2.4 CAN

CubeComputer contains optional CAN electronics which allows the user to interface with the CubeADCS unit via a CAN bus. If the CAN interface is not required, CubeComputer's power consumption can be reduced slightly by leaving the CAN electronics unpopulated. Please indicate whether or not the CAN bus will be required. *(Standard option: No)*

Option 11 – CAN bus on CubeComputer

	Yes	No
CAN controller and transceiver		✓

4.2.5 SPI

Section 4.2.5 is only applicable if CubeComputer is to be used as the main OBC.

If CubeComputer is intended to be used as the satellite's main OBC, an unused SPI bus can be connected to the PC104 header to interface with other subsystems. The SPI bus is also connected to CubeComputer's piggyback header. As shown in Figure 2, the SPI bus can be connected to H1-29,30,31,32. The MOSI and MISO lines can both be connected to either H1-30 or H1-31, depending on the user's requirements. Please indicate the desired SPI configuration. *(Standard option: SPI not connected)*

Option 12 – SPI configuration

	SPI not connected	SPI connected	
		MOSI on H1-30 MISO on H1-31	MOSI on H1-31 MISO on H1-30
SPI connections on PC104	✓		

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4.3 CubeSense configuration

The following options should only be completed if a CubeSense must be included in the CubeADCS Y-Momentum.

4.3.1 Camera sensor type

Each of the camera sensors on CubeSense can be configured to be either a sun sensor or a nadir sensor. Please select the type of sensor for Camera 1 and Camera 2 (refer to Figure 3 for the location of the relevant camera on CubeSense).

Option 13 – Camera type

	Sun	Nadir
Camera 1	✓	
Camera 2		✓

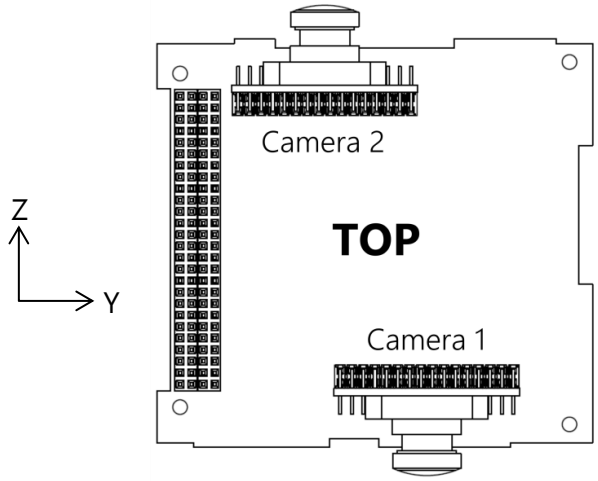

Figure 3 – CubeSense camera sensor location

4.3.2 Camera sensor mounting

Although the camera sensors are soldered into CubeSense by default, their orientations can be configured upon request (e.g. one camera in the Y-direction). The camera sensors can also be provided with harnesses to allow custom mounting by the user. Please select the mounting for Camera 1 and Camera 2. *(Standard option: On PCB)*

Option 14 – Camera mounting

	On CubeSense	Custom mounting*
Camera 1	✓	
Camera 2	✓	

*** Please specify custom mounting requirements (e.g. harness length or orientation) in the Additional Notes section on page 18 of this document.**

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4.4 CubeControl configuration

4.4.1 Coarse sun sensors

CubeControl can interface with a photodiode coarse sun sensor (CSS) array, consisting of up to 10 sensors. The 10 CSSs will each be connected to CubeControl by a Molex PicoBlade 2-way in-line connector. The ten 2-way harnesses are terminated in a single 20-way female connector. An illustration of the CSS connection can be seen in Figure 4.

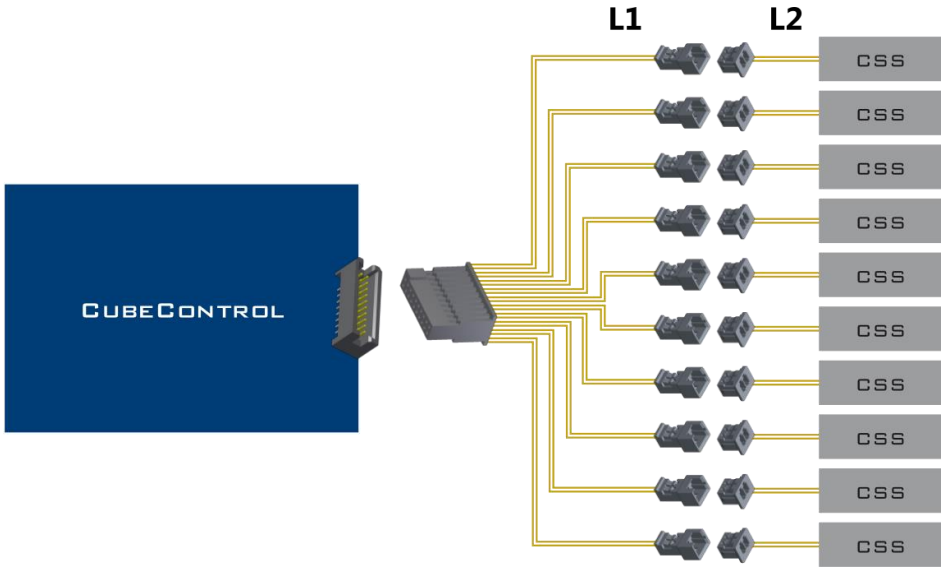

Figure 4 – Coarse sun sensor wiring diagram

The length of the harness on CubeControl's side of the in-line connectors (L1 in Figure 4) can be configured. The maximum length of L1 is 350 mm. The length of L2 is 50 mm. Please indicate the desired CSS harness length. *(Standard option: L1 = 300 mm)*

Option 15 – Coarse sun sensor harness length

	Standard length	Other L1 (mm)
CSS 1		
CSS 2		
CSS 3		
CSS 4		
CSS 5		
CSS 6		
CSS 7		
CSS 8		
CSS 9		
CSS 10		

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4.4.2 Primary magnetometer

CubeControl interfaces with the external magnetometer using an Omnetics Nano Circular 11-way in-line connector set. The harness is terminated in an 11-way Molex PicoBlade female connector. An illustration of the magnetometer connection can be seen in Figure 5.

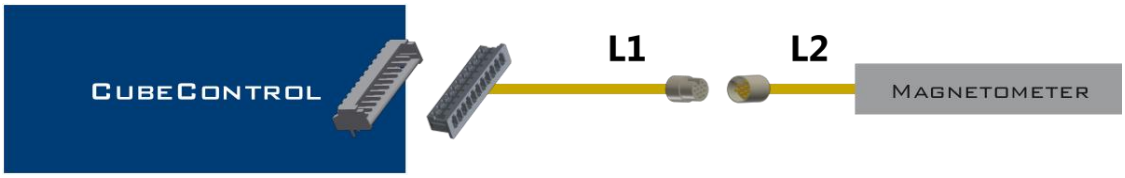

Figure 5 – Magnetometer wiring diagram

The length of the harness on CubeControl's side of the in-line connector (L1 in Figure 5) can be configured. The maximum length of L1 is 350 mm. The length of L2 is 50 mm. Please indicate the desired magnetometer harness length. *(Standard option: L1 = 300 mm)*

Option 16 – Magnetometer harness length

	Standard length	Other L1 (mm)
Magnetometer harness length		

The primary magnetometer can be attached to a small boom which is deployed via a telecommand. The boom separates the magnetometer 8 cm from the satellite body, limiting the effect of electromagnetic interference and lowering the measurement noise. **It is strongly recommended that the magnetometer should be deployable.** Please select whether or not the magnetometer should be deployable. *(Standard option: Deployable)*

Option 17 – Deployable magnetometer

	Deployable	Not deployable
Magnetometer configuration	✓	

4.4.3 Redundant magnetometer

Section 4.4.3 is only applicable if an optional redundant magnetometer is included in the ADCS solution.

CubeControl has the ability to interface with a second (redundant), non-deployable magnetometer. The redundant magnetometer, which is not supplied with the CubeADCS bundle by default, is connected to CubeControl by a 6-way wire harness. The maximum

harness length is 400 mm. Please indicate the desired redundant magnetometer harness length. *(Standard configuration: 300 mm)*

Option 18 – Redundant magnetometer harness length

	300 mm	Other (specify)
Redundant magnetometer harness		

4.4.4 Magnetic torquers

CubeControl can interface with three magnetic torquers, two of which are CubeTorquer rods mounted on CubeControl. The third magnetic torquer can either be an air-core CubeCoil located between CubeComputer and CubeSense or a loose CubeTorquer rod. The loose rod connects to CubeControl with a 2-way wire harness and Molex PicoBlade connector set. The maximum harness length is 300 mm. Please select the desired configuration for the third magnetic torquer. *(Standard option: CubeCoil)*

Option 19 – Third magnetic torquer

	CubeCoil	CubeTorquer rod (specify harness length)
Third magnetic torquer	✓	

The aluminium mounting brackets of the CubeTorquers on CubeControl can be connected to ground if required. Please select whether or not the mounting brackets should be grounded. *(Standard option: Not connected)*

Option 20 – CubeTorquer mounting brackets

	Not connected	Grounded
CubeTorquer mounting brackets		✓

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4.4.5 CubeWheel

Section 4.4.5 is only applicable if a Small CubeWheel is selected as the momentum wheel of the ADCS solution.

The standard momentum wheel (Small CubeWheel) that is supplied with the CubeADCS Y-Momentum bundle is mounted on CubeControl and can be orientated to provide angular momentum along any of the three ADCS axes. The CubeADCS coordinate frame can be seen in Figure 6, where the momentum wheel is mounted in the Y-axis.

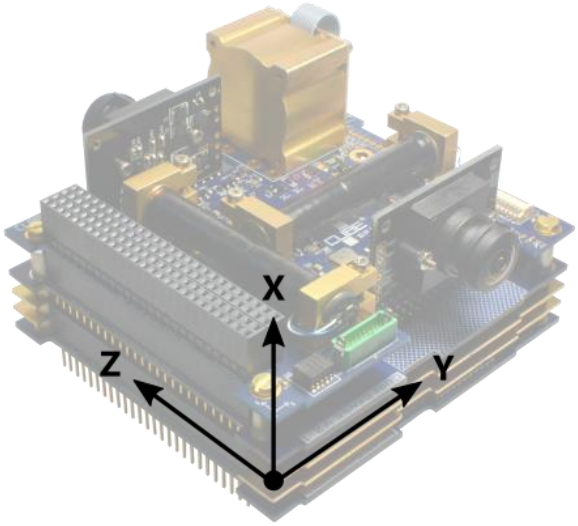

Figure 6 – CubeADCS coordinate frame

Please select the desired mounting orientation for the Small CubeWheel momentum wheel. *(Standard option: Y)*

Option 21 – Mounting of Small CubeWheel momentum wheel

	X	Y	Z
Momentum wheel mounting axis		✓	

4.4.6 CubeWheel housings

The aluminium housing of the Small CubeWheel can be connected to ground if required. Please select whether or not the housing should be grounded. *(Standard option: Not connected)*

Option 22 – Small CubeWheel housing

	Not connected	Grounded
CubeWheel housing		✓

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5. Additional Notes

Our EPS supplies 3.3 and 5, and 12 V, so reaction wheel could run on any of these as well.
We would like only 6 CSSs since we have no deployables
We would also like to mount the CSSs directly to our external PCBs with the leads incorporated into our custom PCBs. So if this is doable we would like the sensors supplied not attached to anything, and we will mount them ourselves and hook up the ports on the ADCS to our PCB. (Length TBD)
We are still deciding if we can afford the redundant magnetometer, will keep you updated

Client signature: Tomas Gonzalez-Torres

6. Declaration

I, Tomas Gonzalez-Torres, hereby declare that I am a legal representative of CySat and Iowa State University.

Signature	Date
Tomas	

Client signature: Tomas Gonzalez-Torres