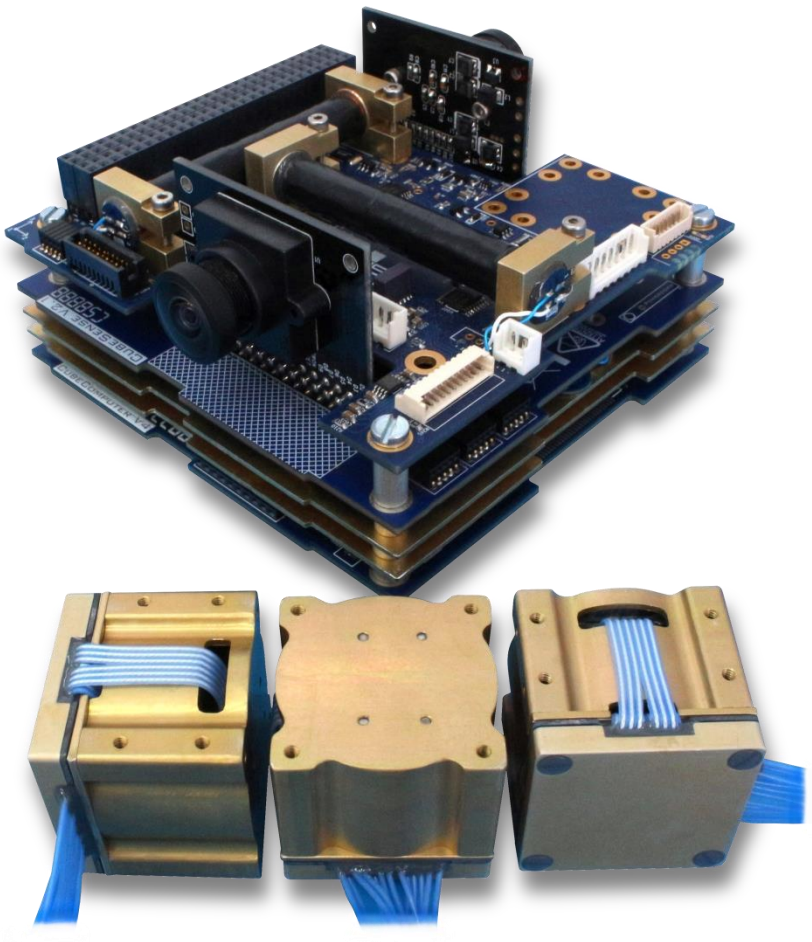
CubeADCS 3-Axis

The complete ADCS solution for 3-axis control



Option Sheet

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Table of Contents

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

1. Client Information

Company/Institution	
Physical address	
Contact person	
E-mail address	
Date	

2. Satellite Information

Name of satellite	
Size (e.g. 3U)	
Orbit	
Deployable structures	
Nominal battery voltage	

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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 3-Axis 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 3-axis control. Three reaction wheels (CubeWheels) are included in the solution and are provided on a separate interface PCB in the standard configuration. A fourth reaction wheel can be added for redundancy. CubeSpace's star tracker, CubeStar, can also be added to the solution if highly accurate attitude control is required.

Figure 1 provides a high-level system diagram of the complete CubeADCS 3-Axis solution.

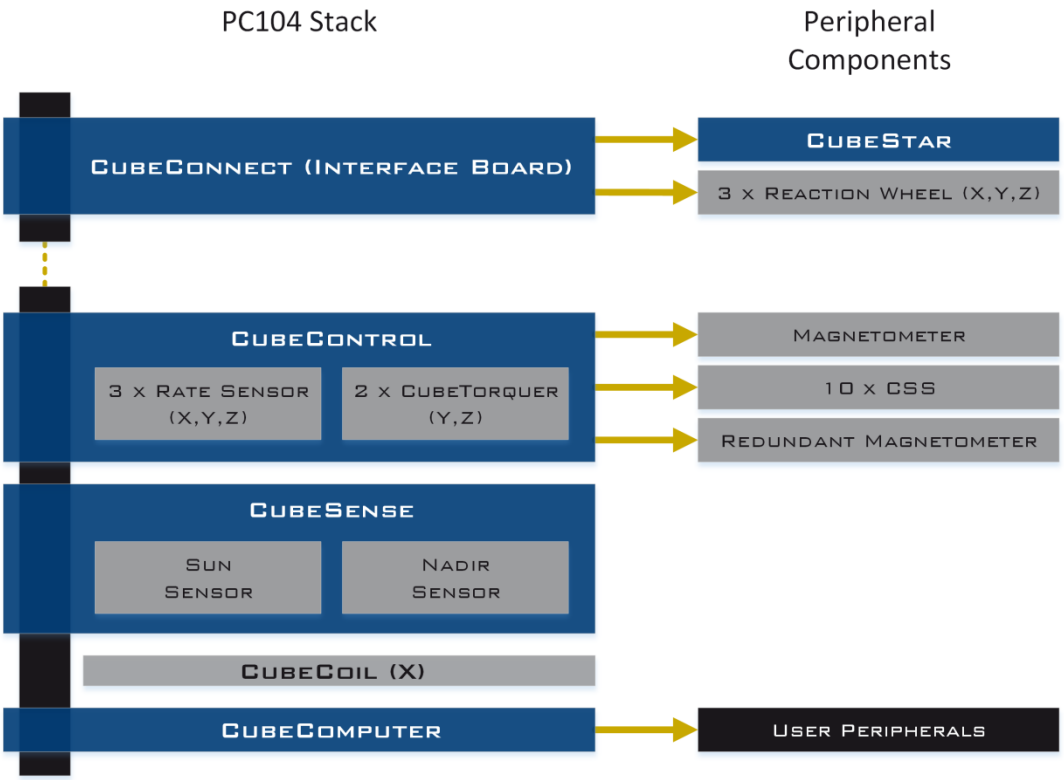

Figure 1 – System diagram of CubeADCS 3-Axis solution

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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 3-Axis 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 backup power	*option*
Internal ADCS pins					
	H1	2, 4, 6, 8	ENABLE	Enable lines for CubeADCS modules	*standard option*
	H2	17, 18, 19, 20	ENABLE	Enable lines for CubeADCS modules	*option*
	H1	5, 7, 9, 11	GPIO / ENABLE	Enable lines for Cubewheels / GPIO	*standard option*
	H1	13, 14, 15, 16	GPIO / ENABLE	Enable lines for Cubewheels / GPIO / ADC	*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 11). Please select the 3.3 V and 5 V supplies for the ADCS bundle and CubeWheels 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 MCU of a CubeWheel unit are 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		

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 CubeWheel enable lines

The CubeWheel reaction wheels require one pin each on the PC104 header for internal use. These lines are used to enable/disable the power to the CubeWheels. Although the standard configuration of the CubeADCS 3-Axis only includes 3 CubeWheels, a fourth CubeWheel can be added for redundancy. Please select the configuration for the enable lines for all the relevant reaction wheels. *(Standard option: H1-5,7,9,11)*

Option 7 – Reaction wheel enable pins location

	H1-5	H1-13
RW 1 enable pin		
	H1-7	**H1-14**
RW 2 enable pin		
	H1-9	**H1-15**
RW 3 enable pin		
	H1-11	**H1-16**
RW 4 enable pin (if applicable)		

If the suggested PC104 pins in Option 7 are not available, please indicate the available pins in the Additional Notes section on page 18 of this document.

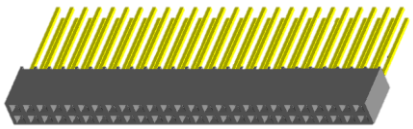
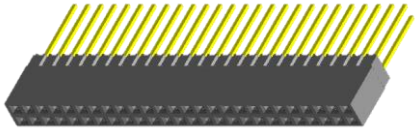
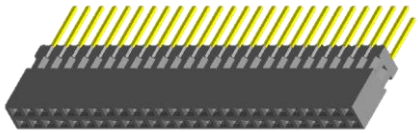
Client signature: _____

4.2 Mechanical configuration

4.2.1 Headers

The PC104 headers at the top and the bottom of the CubeADCS unit can be configured. Please select the height of the PC104 header at the **top** of the bundle. *(Standard option: 13.6 mm)*

Option 8 – Top PC104 header

Height above PCB (mm)	Image	Choice
8.5		
11.1		
13.6		

Please select the length of the PC104 pins at the **bottom** of the bundle. *(Standard option: 8.4 mm)*

Option 9 – Bottom PC104 pin length

	1.0 mm	5.7 mm	8.4 mm
Pin length below bottom PCB			

4.2.2 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 10 – Grounding of mounting holes

	Not connected	Grounded
Mounting holes		

Client signature: _____

4.3 CubeComputer configuration

4.3.1 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 11 – CubeComputer power supply

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

4.3.2 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 12 – Backup power domain power supply

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

4.3.3 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 13 – System I²C bus side pull-up resistors

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

4.3.4 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 14 – CAN bus on CubeComputer

	Yes	No
CAN controller and transceiver		

4.3.5 SPI

Section 4.3.5 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 15 – 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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4.4 CubeSense configuration

4.4.1 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). *(Standard option: Camera 1 = Nadir, Camera 2 = Sun)*

Option 16 – Camera type

	Sun	Nadir
Camera 1		
Camera 2		

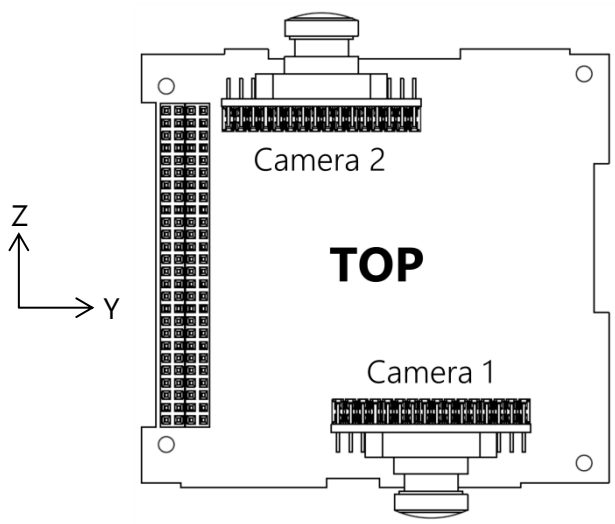

Figure 3 – CubeSense camera sensor location

4.4.2 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 17 – 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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4.5 CubeControl configuration

4.5.1 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.

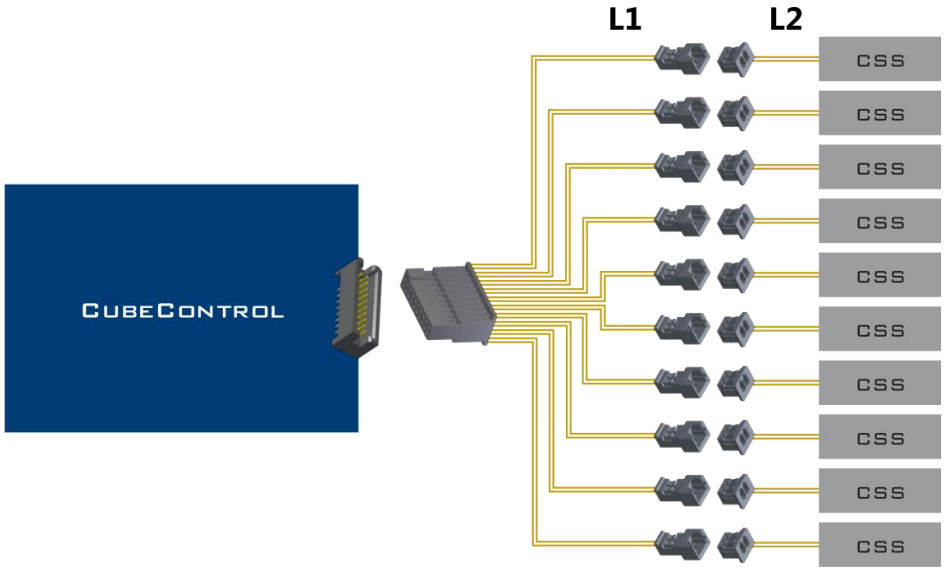

Figure 4 – Coarse sun sensor wiring diagram

The lengths of the harnesses on both sides of the in-line connectors (L1 and L2 in Figure 4) can be configured individually. The maximum length of L1 is 350 mm and the maximum length of L2 is 150 mm. Please indicate the desired CSS harness lengths. *(Standard option: L1 = 300 mm, L2 = 50 mm)*

Option 18 – Coarse sun sensor harness length

	Standard length	Other	
		L1 (mm)	L2 (mm)
CSS 1			
CSS 2			
CSS 3			
CSS 4			
CSS 5			
CSS 6			
CSS 7			
CSS 8			
CSS 9			
CSS 10			

Client signature: _____

4.5.2 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.

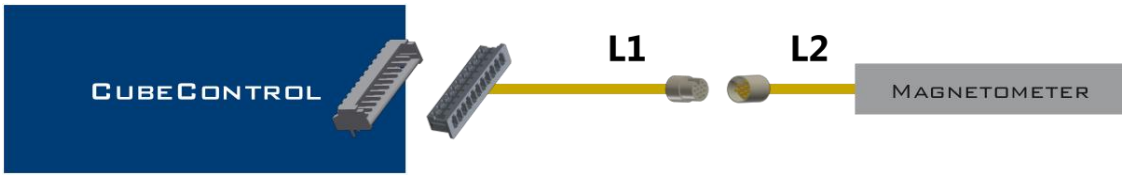

Figure 5 – Magnetometer wiring diagram

The lengths of the harnesses on both sides of the in-line connectors (L1 and L2 in Figure 5) can be configured. The maximum length of both L1 and L2 is 350 mm and the maximum length of L1 + L2 is 500 mm. Please indicate the desired magnetometer harness lengths. *(Standard option: L1 = 300 mm, L2 = 50 mm)*

Option 19 – Magnetometer harness length

	Standard length	Other	
		L1 (mm)	L2 (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 20 – Deployable magnetometer

	Deployable	Not deployable
Magnetometer configuration		

4.5.3 Redundant magnetometer

Section 4.5.3 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)*

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Option 21 – Redundant magnetometer harness length

	300 mm	Other (specify)
Redundant magnetometer harness		

4.5.4 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 22 – 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 23 – CubeTorquer mounting brackets

	Not connected	Grounded
CubeTorquer mounting brackets		

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4.6 CubeWheel configuration

Section 4.6 is only applicable if Small CubeWheels are included in the ADCS solution.

4.6.1 CubeWheel mounting

If Small CubeWheels are included in the CubeADCS solution, the mounting of the wheels can be configured to suit the user's need. The Small CubeWheels can be (1) integrated within the bundle, (2) mounted on a separate PC104 PCB module (CubeConnect, see Figure 1), or (3) provided loose for mounting by the client. If the Small CubeWheels are provided loose, a CubeConnect interface board will also be supplied. Each wheel's harness is terminated in a screw-down female connector, of which the male counterpart is populated on CubeConnect. In this case the harness length must be specified (up to a maximum of 300 mm). Please select the desired Small CubeWheel mounting. *(Standard option: Integrated in bundle)*

Option 24 – Small CubeWheel mounting

	Integrated in bundle	Separate PC104 PCB module	Loose (user mounts CubeWheels)
Small CubeWheel mounting			
If wheels are supplied loose			**Length (mm)**
Harness length			

4.6.2 CubeWheel housings

Section 4.6.2 is only applicable if the Small CubeWheels are NOT supplied loose (as selected in Option 24).

The aluminium housings of the Small CubeWheels can be connected to ground if required, but only if Option 24 specifies that the wheels are not supplied loose. Please select whether or not the housings should be grounded. *(Standard option: Not connected)*

Option 25 – Small CubeWheel housings

	Not connected	Grounded
CubeWheel housings		

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4.7 CubeStar configuration

Section 4.7 is only applicable if CubeStar is included in the ADCS solution.

CubeStar connects to CubeComputer via the CubeConnect interface board (see Figure 1). A 7-way harness connects CubeStar to CubeConnect via a HARWIN M80-8760722 L-Tek SIL connector set. **The user is responsible for mounting CubeStar.** The user must send the mounting transformation matrix relative to the satellite body coordinate frame (SBC) to CubeSpace one month prior to the delivery date. Please indicate the desired CubeStar harness length. *(Standard option: 150 mm)*

Option 26 – CubeStar harness length

	150 mm	Other (specify)
CubeStar harness length		

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5. Additional Notes

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6. Terms & Conditions

The following terms and conditions are imposed on this document:

1. The "Contact Person" (listed in Section 1 of this document) must be a legal representative of the "Company/Institution" (listed in Section 1 of this document). The "Contact Person" and the "Company/Institution" will hereafter collectively be referred to as **the client**.
2. The selections made in this document will only be valid and binding after the following process has been completed:
    a. **The client** will receive an empty Option Sheet from **CubeSpace**.
    b. **The client** must send the filled and signed Option Sheet back to **CubeSpace**.
    c. After all the selected configuration options have been validated, **the client** will receive an Option Sheet Summary from **CubeSpace**, which also serves as an acknowledgement of receipt of the filled and signed Option Sheet.
    d. **The client** will receive an official quotation from **CubeSpace**.
    e. **The client** must accept the quotation received from **CubeSpace**.
    f. **The client** will receive an invoice from **CubeSpace** for the required deposit (50% of the total quotation amount).
    g. **The client** must forward the proof of payment of the required deposit to **CubeSpace**.
3. **The client** may request free-of-charge changes to certain selections made in this document within 7 (seven) days of receiving the Option Sheet Summary from **CubeSpace**.
4. Changes to the selections made in this document that are requested after 7 (seven) days of receiving the Option Sheet Summary from **CubeSpace** may result in additional costs and/or delays in delivery time.
5. Production of components will only commence once proof of payment of the required deposit has been forwarded to **CubeSpace**.
6. The standard delivery time of standalone CubeSpace components is 3 (three) months from the day on which the proof of payment of the required deposit is received by **CubeSpace**. The standard delivery time of CubeADCS bundles is 4 (four) months from the day on which the proof of payment of the required deposit is received by **CubeSpace**.
7. The aforementioned delivery time may be subject to component availability on rare occasion. **CubeSpace** retains the right to extend the delivery time by a maximum of 1 (one) month in the event of unplanned manufacturing delays. **CubeSpace** must, however, notify **the client** as soon as possible if an extension of the delivery time is expected.

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7. Declaration

I, _____, hereby declare that I am a legal representative of _____. I also declare that I have read, understand, and accept the Terms & Conditions of this document (see Section 6).

Signature	Date