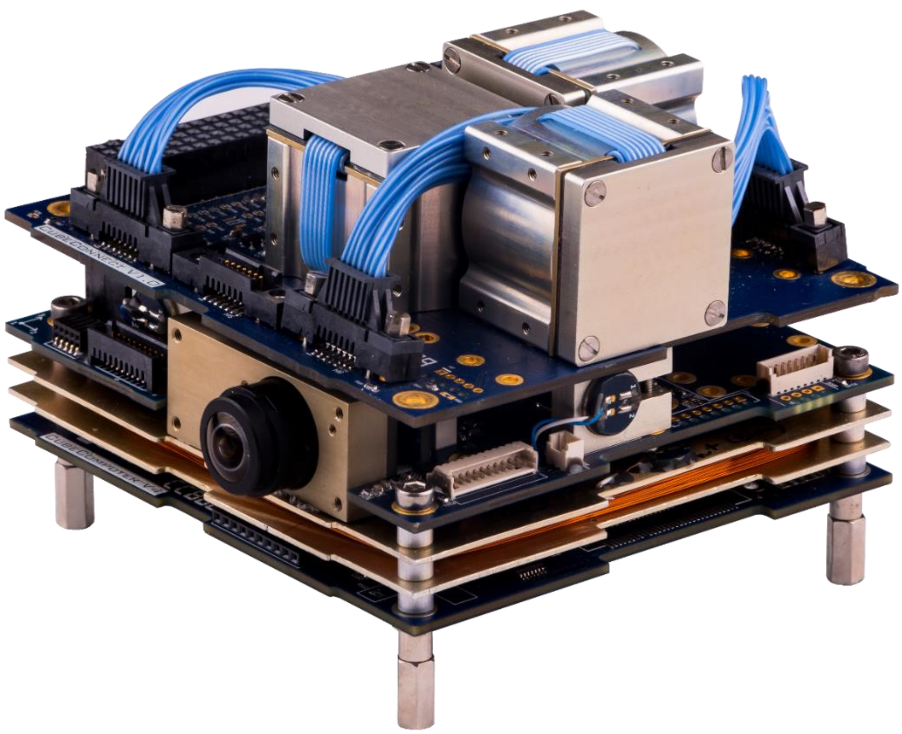
CubeADCS

The complete ADCS solution



ADCS Configuration Sheet

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Domain	Public
Date modified	2021-07-20
Approved by	Name: Gerhard Janse van Vuuren
	Signature:

Table of Contents

1. General Information

Company/Institution	Arizona State University
Contact person	Danny Jacobs
E-mail address	dcjacob2@asu.edu
Satellite name	DORA
Planned orbit	
Date	10/27/2023

2. Introduction

This form should be completed after the placement of the ADCS unit as well as the ADCS sensors and actuators inside the satellite have been defined. When completing this form, please refer to the *CubeADCS User Manual*.

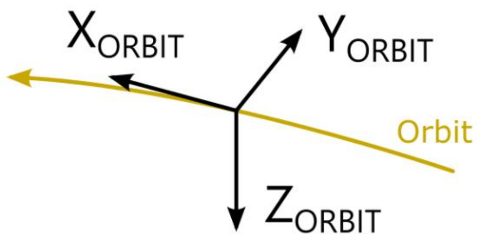
Once complete, the form should be emailed to CubeSpace at sales@cubespace.co.za. This information will then be used to create a customised ADCS configuration XML file that **must be uploaded onto the CubeADCS unit before flight** (using the CubeSupport application for example).

NOTE: If possible, please provide 3D renderings of your satellite, showing the mounting locations of the ADCS sensors and actuators. This will allow us to confirm the information you have provided in this document.

3. Definitions

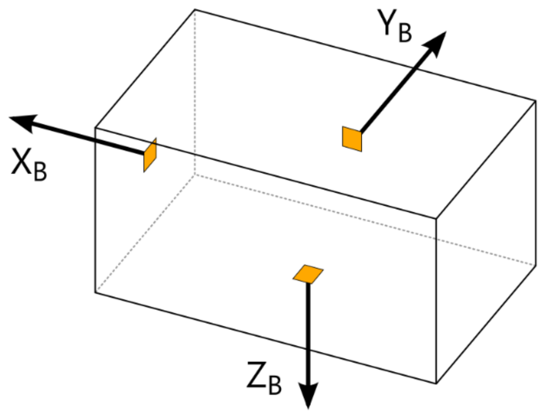
3.1 Reference Frames

The **Orbit Reference Coordinate (ORC)** frame, notated as **X_{ORBIT}**; **Y_{ORBIT}**; and **Z_{ORBIT}**, is defined throughout the CubeADCS literature as:



X_{ORBIT}	Flight direction
Y_{ORBIT}	Orbit anti-normal direction
Z_{ORBIT}	Nadir direction

The **Spacecraft Body Coordinates (SBC)** frame is notated as **X_B**, **Y_B**, and **Z_B**.

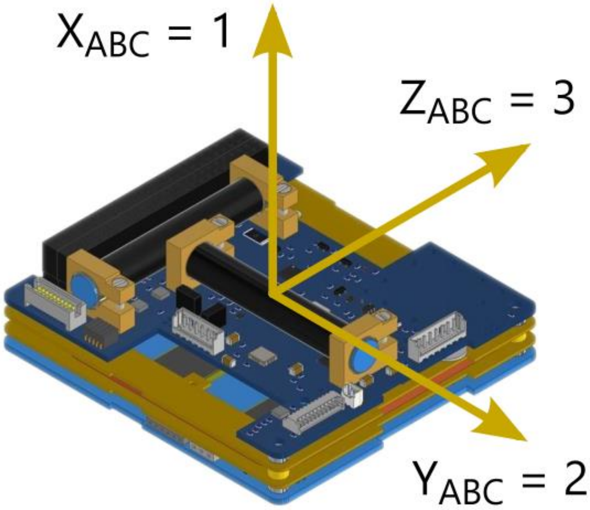


PLEASE NOTE:

The SBC frame is **NOT** related to any customer-defined frame, such as a mechanical or CAD frame. The SBC is defined in such a way that in nominal flight, the SBC and ORC frames will be aligned for zero roll, pitch, and yaw angles. For this reason, the ADCS must be configured so that the mounting of all the actuators and sensors of the ADCS are defined relative to the SBC. Also note that in some cases (outside of the scope of this document), the SBC is also referred to as the ADCS body frame.

3.2 Component Frames

The **ADCS Bundle Coordinates (ABC)** frame is notated as $\mathbf{X_{ABC}}$, $\mathbf{Y_{ABC}}$, and $\mathbf{Z_{ABC}}$ and is defined as in the image below. The torquer rods, rate sensors, and (potentially) reaction wheels are mounted on the CubeADCS unit such that sensor/actuator 1/2/3 is aligned with $X/Y/Z_{ABC}$.



The sensors and actuators in the CubeADCS unit are either classed as **single-axis** or **multiple-axis**. **Single-axis components** are sensors or actuators where the alignment of only one axis is relevant, such as a wheel or single-axis rate sensor. In this case, the axis about which rotation or sensing takes place, is important, but the mounting angle about the rotation/sensing axis is irrelevant.

Multiple-axis components are sensors or actuators for which the alignment of all three principal axes are relevant.

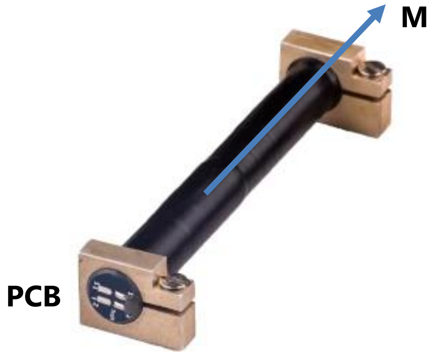
The mounting of the sensors and actuators of the CubeADCS must be defined by:

- **For single-axis components -** specifying the SBC axis to which the component is aligned.
- **For multiple-axis components -** specifying mounting transform angles to rotate the component's coordinate system to match the SBC.

4. Single-Axis Components

The single-axis CubeADCS components include the Coarse Sun sensors (CSS), MEMS rate sensors, torquer rods, and reaction/momentum wheels.

The MEMS rate sensors are mounted on the CubeADCS system, and the rate sensor 1/2/3 aligns with the X/Y/Z axes of the ABC. In most cases, this is also true for the magnetorquers, although larger satellites often require larger magnetorquers that must be mounted separately from the CubeADCS unit. For those cases, the positive direction of the magnetorquers are defined as:



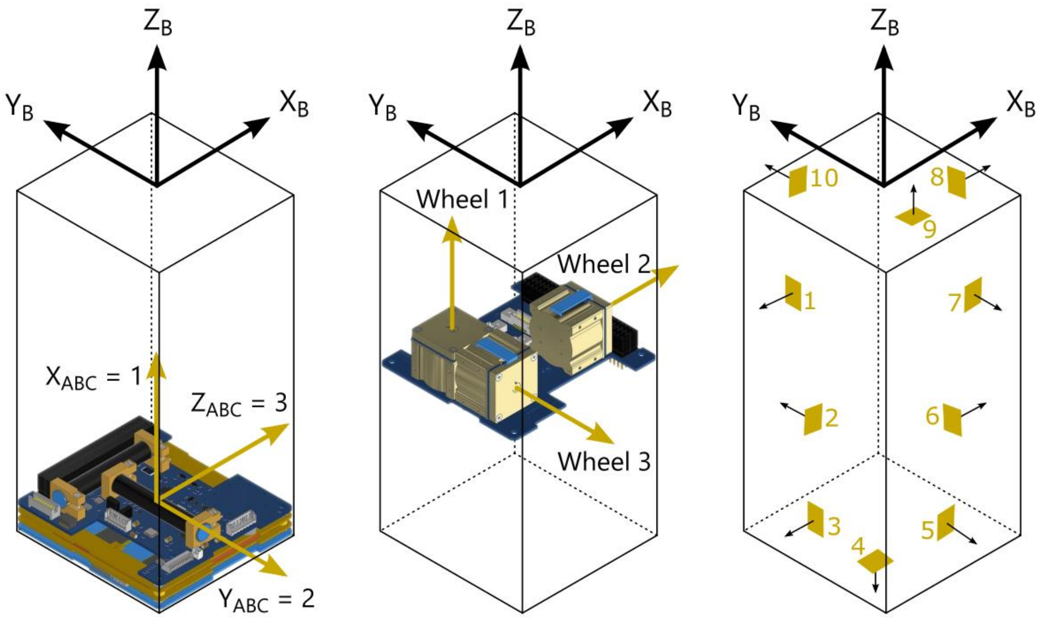
The reaction wheels are either mounted on a board as part of the CubeADCS stack or mounted separately by the client. In either case, the reaction/momentum wheel positive direction is defined as:

If the wheels are mounted on the CubeADCS unit, wheel 1/2/3 will align with X/Y/Z_{ADCS}. Otherwise, if the user mounts the wheels, care must be taken to determine the mounting direction of the wheel according to the definition above.

CSS photodiodes are mounted by the user on whichever facet they prefer.

4.1 Example Case

An example case for the mounting of the single axis sensors and actuators is shown below:



The mounting of actuators relative to the SBC would be:

	SBC Axis
MTQ 1 (typically X_{ABC})	$+Z_B$
MTQ 2 (typically Y_{ABC})	$-Y_B$
MTQ 3 (typically Z_{ABC})	$+X_B$
MEMS 1 (always X_{ABC})	$+Z_B$
MEMS 2 (always Y_{ABC})	$-Y_B$
MEMS 3 (always Z_{ABC})	$+X_B$
RW 1	$+Z_B$
RW 2	$+X_B$
RW 3	$-Y_B$
RW 4	Not Used
CSS 1	$-X_B$
CSS 2	$+Y_B$
CSS 3	$-X_B$
CSS 4	$-Z_B$
CSS 5	$-Y_B$
CSS 6	$+X_B$
CSS 7	$-Y_B$
CSS 8	$+X_B$
CSS 9	$+Z_B$
CSS 10	$+Y_B$

4.2 User Case

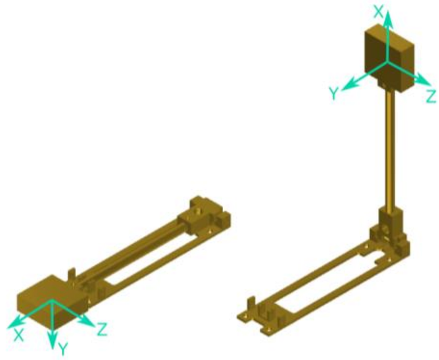
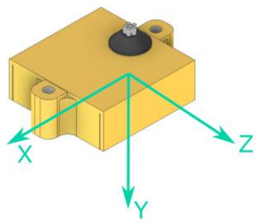
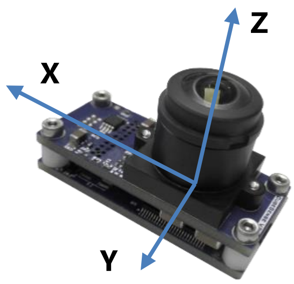
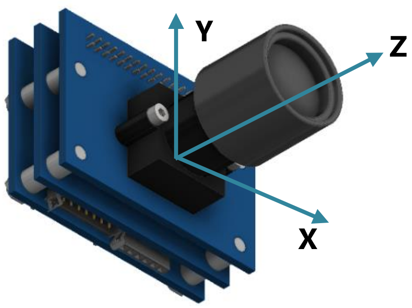
Please provide the mounting information for the single-axis components in your satellite (as illustrated by the previous example).

	SBC Axis
MTQ 1 (typically X_{ABC})	$-X_B$
MTQ 2 (typically Y_{ABC})	$+Z_B$
MTQ 3 (typically Z_{ABC})	$+Y_B$
MEMS 1 (always X_{ABC})	$-X_B$
MEMS 2 (always Y_{ABC})	$+Z_B$
MEMS 3 (always Z_{ABC})	$+Y_B$
RW 1	$-X_B$
RW 2	$-Y_B$
RW 3	$-Z_B$
RW 4	Not used
CSS 1	$-Y_B$
CSS 2	$-Y_B$
CSS 3	$-Z_B$
CSS 4	$-Z_B$
CSS 5	$+Y_B$
CSS 6	$-X_B$
CSS 7	$+Z_B$
CSS 8	$+Z_B$
CSS 9	$+Y_B$
CSS 10	$+Y_B$

Name of person responsible:	Ben Weber
Signature:	Ben

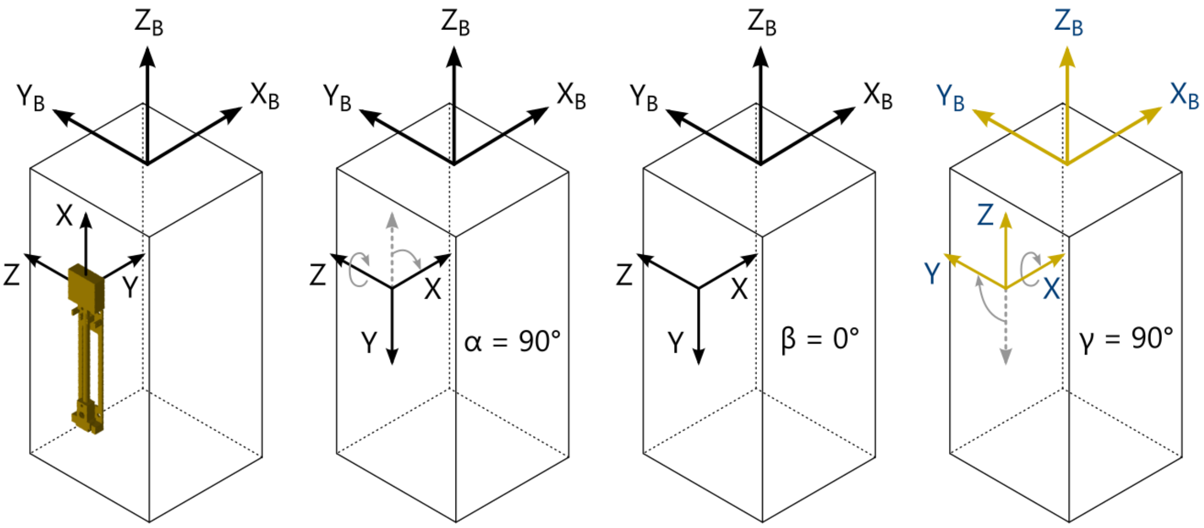
5. Multi-Axis Components

Multi-axes sensors include the deployable magnetometer (deployed and undeployed state), redundant magnetometer, fine Sun sensor, fine nadir sensor and star tracker. The mounting of each of these sensors is specified by a set of three angles **alpha (α), beta (β), and gamma (γ).** These three angles correspond to the angles in a Euler 3-2-1 rotation to rotate the sensor's coordinate frame to the SBC. The sensor coordinate frames for the various sensors are defined as follows:

Magnetometer stowed vs deployed	
Redundant magnetometer	
Fine sun and nadir sensors	
Star tracker	

5.1 Example Case

The rotations α, β, and γ are around the sensor's Z, Y, and X axes, respectively. The example below shows the steps of such a rotation. Consider the stowed magnetometer below. The rotations that must be done to align the sensor's axes with the SBC are as follows:



The following mounting transform angles therefor apply for this sensor:

α	*90°*
β	*0°*
γ	*90°*

NOTE: There may be more than one combination of α, β, and γ angles that result in the same transformation. Any of these combinations are acceptable

5.2 User Case

The procedure illustrated by the example case can be followed for each of the multi-axis sensors. Please complete the table below for the mounting of the multi-axis sensors in your satellite.

	α	β	γ	
Magnetometer stowed	0	-90°	-90°	
Magnetometer deployed	0	-90°	180°	
Redundant magnetometer	0	0	90°	
CubeSense 1 (fine sun/nadir sensor)	-90°	0	180°	Sun
CubeSense 2 (fine sun/nadir sensor)	-90°	0	0	Nadir
Star tracker				

Name of person responsible: Ben Weber	
Signature: [signature]	

6. Satellite Parameters

6.1 MOI and POI

Please provide the satellite's inertia moments and products, taken at the centre of mass with respect to the SBC frame defined in this document.

Moments of Inertia

I_{xx} (kg.m^2)	
I_{yy} (kg.m^2)	
I_{zz} (kg.m^2)	

Products of Inertia

I_{xy} (kg.m^2)	
I_{xz} (kg.m^2)	
I_{yz} (kg.m^2)	

Name of person responsible:	
Signature:	

6.2 Sun Pointing Facet

Please provide the satellite axis or facet (**in SBC frame**) to be used for sun-pointing modes, if applicable. Facet options are:

- On-axis: $+X_B$, $-X_B$, $+Y_B$, $-Y_B$, or $-Z_B$ (i.e. $+Z_B$ cannot be used)
- Off-axis: $+X_B/+Y_B$ (45° between the two facets)

Sun-pointing facet selection	$-Z_B$

Document Version History

Version	Responsible person(s)	Pages	Date	Description of change
3.0	MK	ALL	20/03/2017	V3 First draft
3.01	MK	9	26/07/2017	Fixed MM axis definition
3.02	WHS	ALL	18/12/2017	Add MOI, Orbit elements, Start UNIX
3.03	MK	ALL	22/01/2018	-Magnetometer axis fix in example -Formatting
3.04	CCH	ALL	24/05/18	General language editing
3.05	CJG	9	13/02/2019	Updated/Fixed CubeStar Body Reference frame
3.06	WHS HW	ALL	23/09/2019	Updated 4th RW, Clarify axes definitions Updated front page
7.1	GJVV		30/06/2020	New version numbering scheme (v7.x to match ACP interface v7) Move doc history to back Major doc formatting updates Add CubeSense V3 Add torquer rod polarity Remove TLE and Unix time section
7.2	JG	10	24/07/2020	Added harness to redundant mag axis definition image
7.3	GJVV	5, 6, 8, 13	20/07/2021	Updated images Added note about SBC Added tracking/pointing facets