This is the high-level flowchart for the ADCS. The next pages will breakdown the high-level flowchart into its constituents.
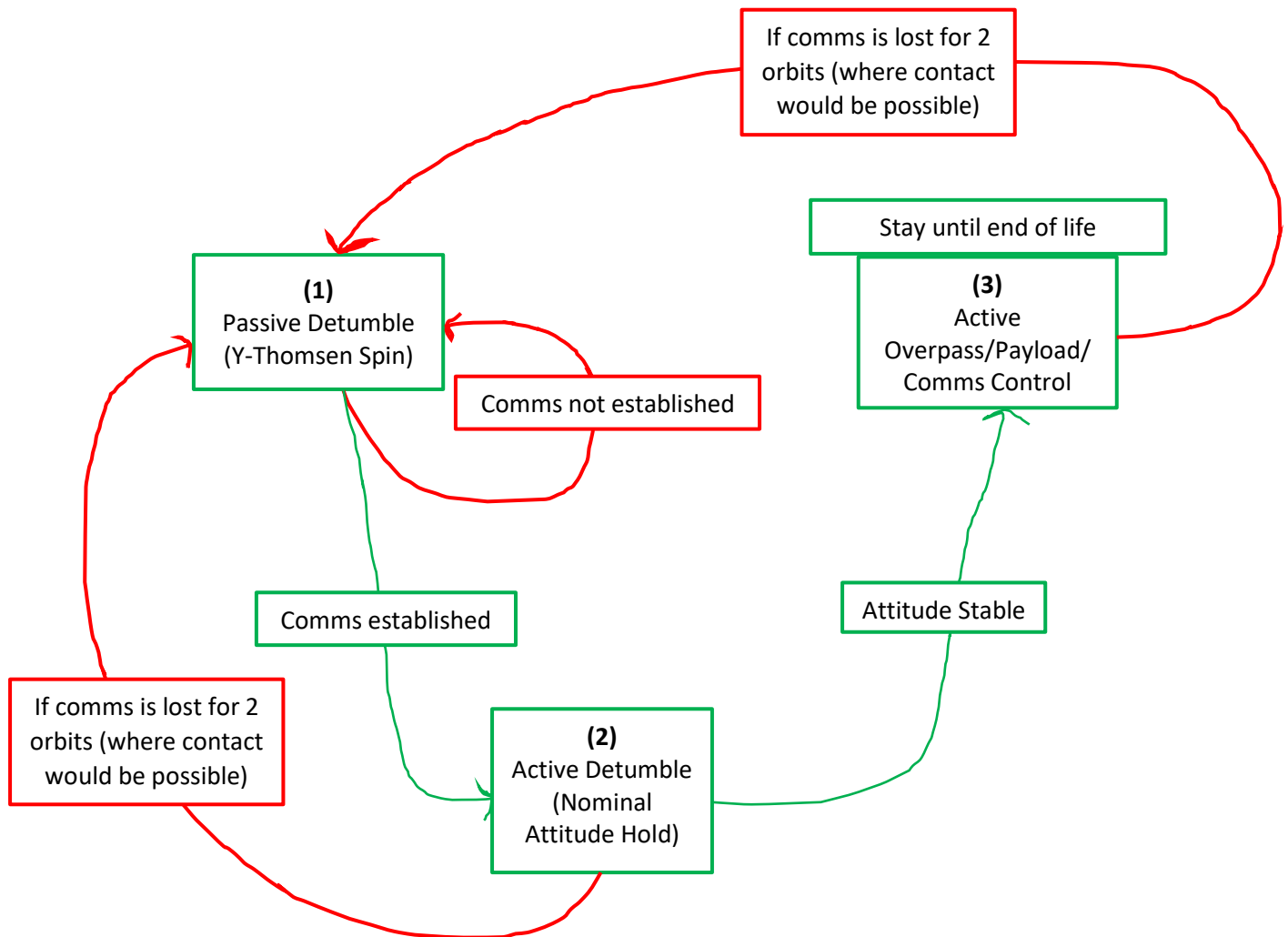
This flowchart for the detumbling procedure is pulled directly from the Commissioning Manual provided by CubeSpace. The relevant section begins on page 16.

The reference manual will provide information such as offset (bits), length (bits) and data type of the necessary parameters. It will also demonstrate how to encode the message via I2C.

Commissioning Steps

Part	Order #	Step	Page
Passive Detumble (1)	**1**	Determine initial angular rates	3
Passive Detumble (1)	**2**	Initial detumbling	4
Passive Detumble (1)	**3**	Continued detumbling to Y-Thomson	5
Active Detumble (2)	**4**	Magnetometer deployment	6
Active Detumble (2)	**5**	Magnetometer calibration	7
Active Detumble (2)	**6**	Angular rate and pitch angle estimation	8
Active Detumble (2)	**7**	Y-wheel ramp-up test	9
Active Detumble (2)	**8**	Initial Y-momentum activation	10-11
Active Detumble (2)	**9**	Continued Y-momentum activation and magnetometer EKF	11
Active Detumble (2)	**~**	Adjusting settings to increase Y-momentum performance	12
Active Detumble (2)	**10**	CubeSense sun/nadir commissioning	13
Active Detumble (2)	**11**	EKF activation with sun and nadir measurements included	13
Active Detumble (2)	**~**	Adjusting settings to troubleshoot sun/nadir sensor parameters	14
Active Detumble (2)	**~**	Image capturing, saving, and downloading of CubeSense image	14
Active Overpass/Payload/Comms Control (3)	**12**	Adjust pitching angle for payload data and/or better communication	15
Active Overpass/Payload/Comms Control (3)	**13**	Updating satellite data and monitoring errors	16

Initial Rate Estimation

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1),
all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter (2)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

NO

Rate Sensor Rates (TLM 155)
0.1 Hz

Magnetometer Measurement (TLM 151)
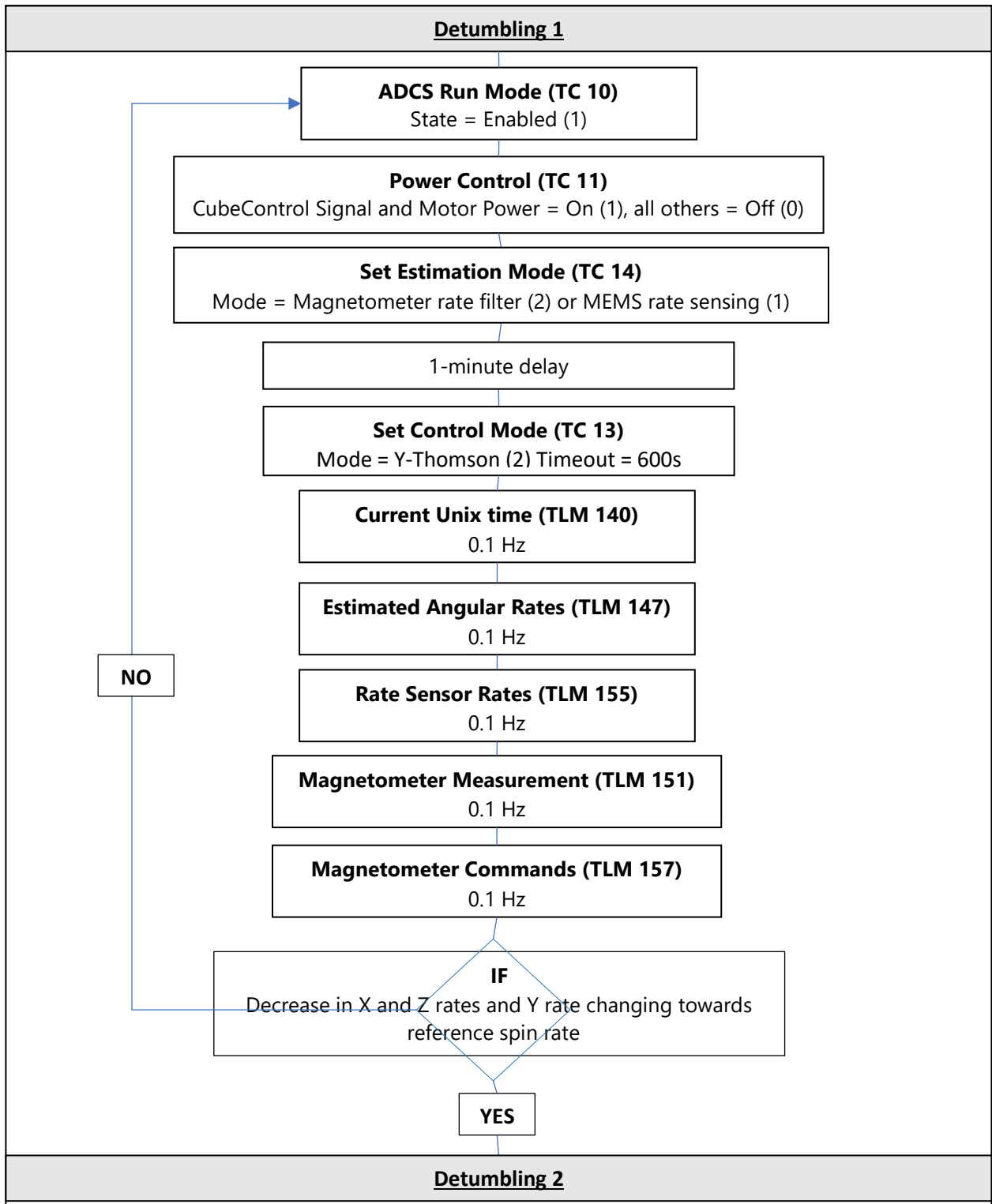0.1 Hz

IF
XYZ-rate measurement and estimated XYZ-rate is equal
(to within 1 deg/s)
AND
Magnetometer measurements change with period
corresponding to estimated rate.

YES

Detumbling 1

Detumbling 1

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1), all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter (2) or MEMS rate sensing (1)

1-minute delay

Set Control Mode (TC 13)
Mode = Y-Thomson (2) Timeout = 600s

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Magnetometer Measurement (TLM 151)
0.1 Hz

Magnetometer Commands (TLM 157)
0.1 Hz

IF
Decrease in X and Z rates and Y rate changing towards reference spin rate

NO

YES

Detumbling 2

Detumbling 2

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1), all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter (2) or MEMS rate sensing (1)

1-minute delay

Set Control Mode (TC 13)
Mode = Y-Thomson (2) Timeout = 0s

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

NO

Rate Sensor Rates (TLM 155)
0.1 Hz

Magnetometer Measurement (TLM 151)
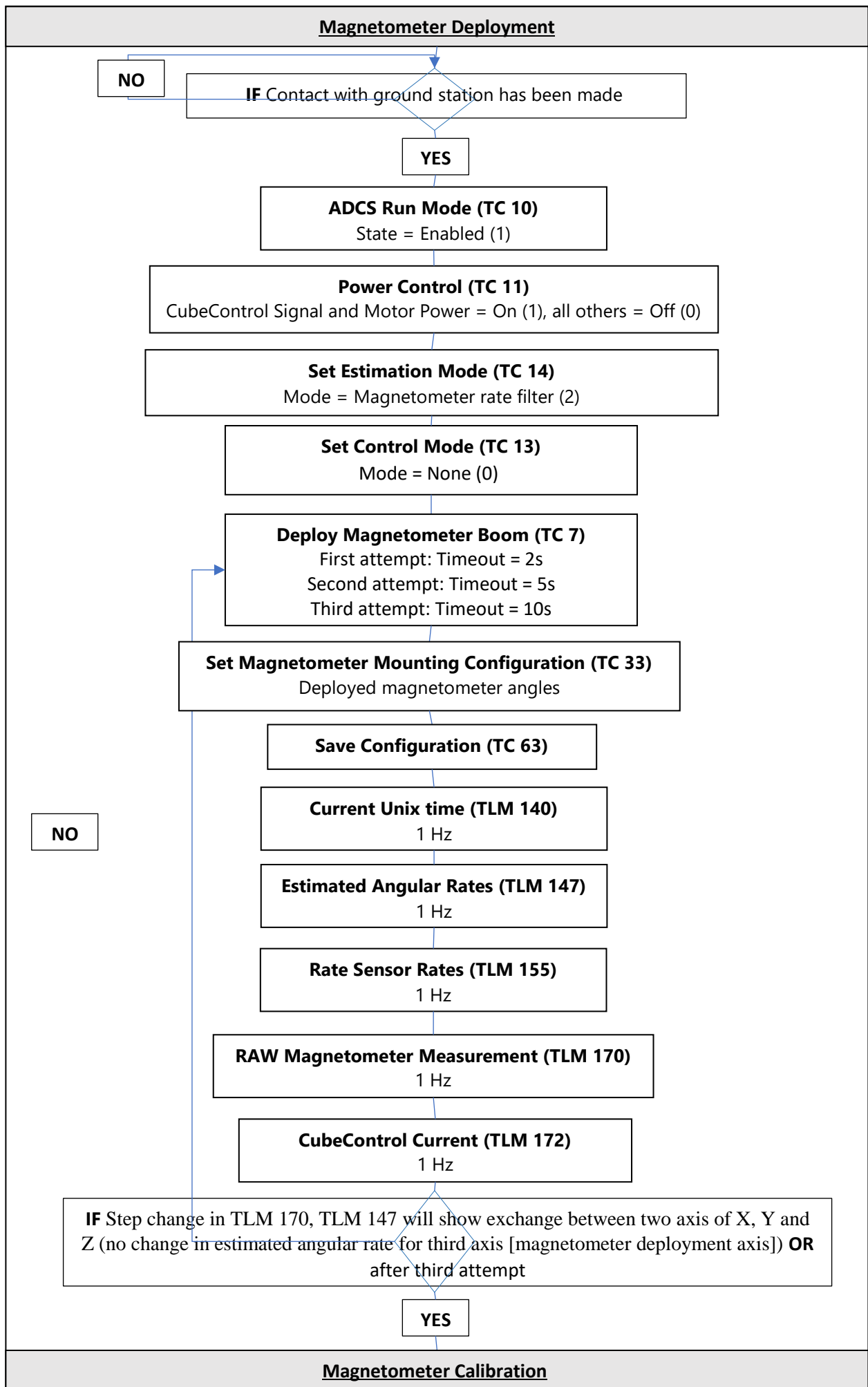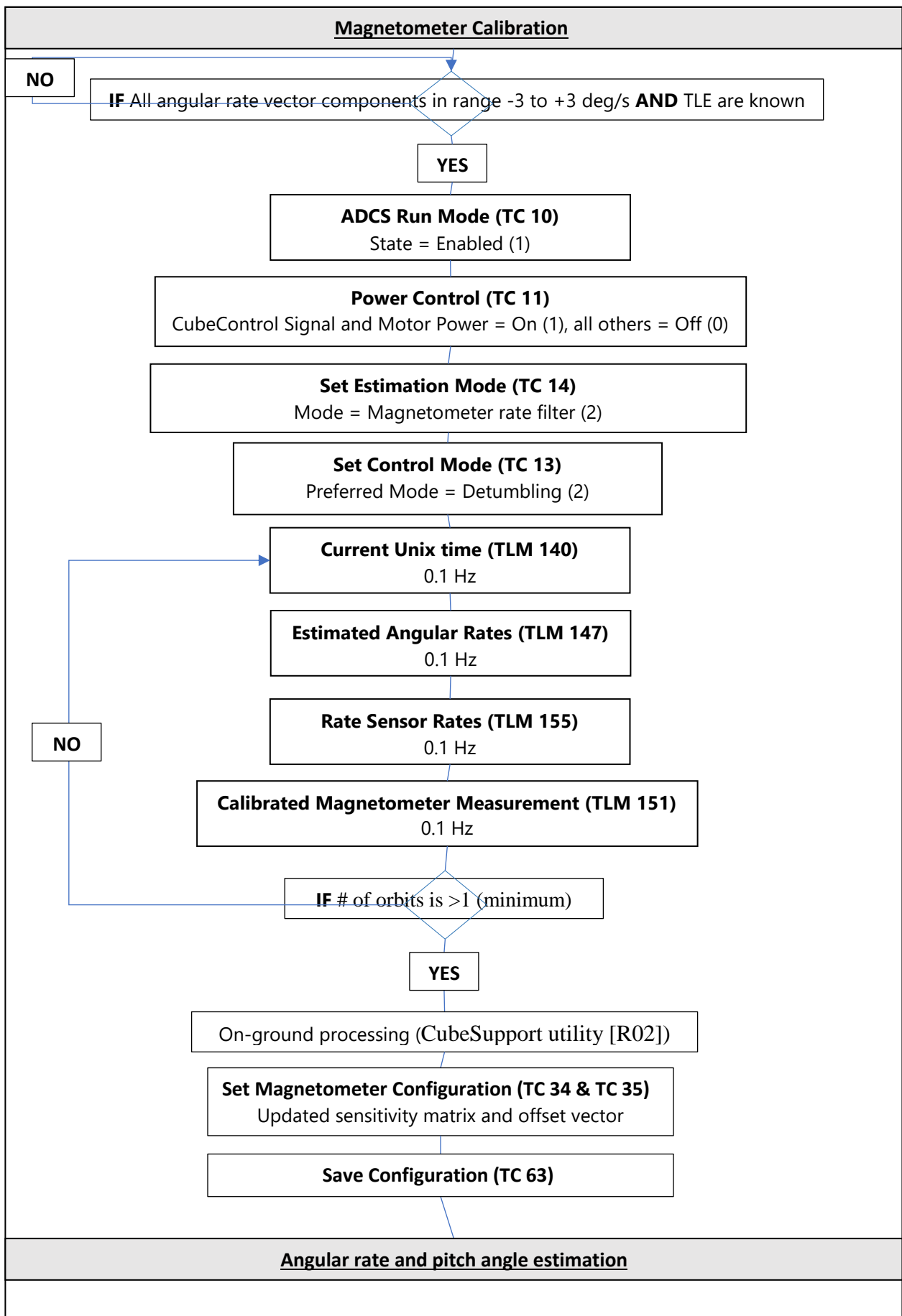0.1 Hz

Magnetometer Commands (TLM 157)
0.1 Hz

IF
Steady-state Y-Thomson has been reached (X and Z rates around 0 deg/s, Y-rate at reference value of -1 deg/s)

YES

Magnetometer Deployment

Magnetometer Deployment

IF Contact with ground station has been made

NO

YES

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1), all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter (2)

Set Control Mode (TC 13)
Mode = None (0)

Deploy Magnetometer Boom (TC 7)
First attempt: Timeout = 2s
Second attempt: Timeout = 5s
Third attempt: Timeout = 10s

Set Magnetometer Mounting Configuration (TC 33)
Deployed magnetometer angles

Save Configuration (TC 63)

Current Unix time (TLM 140)
1 Hz

Estimated Angular Rates (TLM 147)
1 Hz

Rate Sensor Rates (TLM 155)
1 Hz

RAW Magnetometer Measurement (TLM 170)
1 Hz

CubeControl Current (TLM 172)
1 Hz

NO

IF Step change in TLM 170, TLM 147 will show exchange between two axis of X, Y and Z (no change in estimated angular rate for third axis [magnetometer deployment axis]) **OR** after third attempt

YES

Magnetometer Calibration

Magnetometer Calibration

NO

IF All angular rate vector components in range -3 to +3 deg/s **AND** TLE are known

YES

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1), all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter (2)

Set Control Mode (TC 13)
Preferred Mode = Detumbling (2)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

NO

Rate Sensor Rates (TLM 155)
0.1 Hz

Calibrated Magnetometer Measurement (TLM 151)
0.1 Hz

IF # of orbits is >1 (minimum)

YES

On-ground processing (CubeSupport utility [R02])

Set Magnetometer Configuration (TC 34 & TC 35)
Updated sensitivity matrix and offset vector

Save Configuration (TC 63)

Angular rate and pitch angle estimation

Angular rate and pitch angle estimation

NO

Y-Thomson spin state, held for at least 1 orbit

YES

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal and Motor Power = On (1), all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter with pitch estimation (3)

Set Control Mode (TC 13)
Mode = Detumbling (2)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

NO

Rate Sensor Rates (TLM 155)
0.1 Hz

Magnetometer Measurement (TLM 151)
0.1 Hz

IF # of orbits is >1 (minimum) **AND** pitch angle observed to change at reference spin rate

YES

Y-wheel ramp-up test

Y-wheel ramp-up test

NO

Recent TLE are known

YES

ADCS Run Mode (TC 10)
State = Enabled (1)

Power Control (TC 11)
CubeControl Signal, Motor Power, and CubeWheel-i = On (1) {where, i = 1/2/3 i.e. the Y-Wheel}, all others = Off (0)

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter with pitch estimation (3)

Set Control Mode (TC 13)
Mode = None (0)

Wheel speed command (TC 17)
Commanded Y Speed = $\omega_{wheeltest}$ [RPM]

Where, $\omega_{wheeltest}$ [RPM] = Iyy [kg*m^2] * ωy_{-ref} [deg/s] * 83333

2-minute delay

Wheel speed command (TC 17)
Commanded Y Speed = 0 RPM

Set Control Mode (TC 13)
Mode = Detumbling (2)

NO

Current Unix time (TLM 140)
1 Hz

Estimated Angular Rates (TLM 147)
1 Hz

Estimated Attitude Angles (TLM 146)
1 Hz

Rate Sensor Rates (TLM 155)
1 Hz

Measured wheel speed (TLM 156)
1 Hz

Magnetometer Measurement (TLM 151)
1 Hz

IF TLM 156 matches TC 17 **AND** TLM 147 (Y-rate) = 0 when the wheel ramps up and goes back to reference spin rate when wheel is stopped **AND** TLM 146 change is near-constant (or slowly varying) when wheel is spinning **OR** >1 pass

YES

Y-momentum mode commissioning 1

Y-momentum mode commissioning 1

ADCS Run Mode (TC 10)
State = Enabled (1)

Set Unix time (TC 2)
Current Unix time

Set Orbit Parameters (TC 45)
Current TLEs

Save Orbit Parameters (TC 64)
Save to Flash memory

Set Estimation Parameters 2 (TC 44)
Mask Sun sensor = 0 (false) ; Mask Nadir sensor = 0 (false) ; Mask CSS = 0 (false) ; All others = defaults

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter with pitch estimation (3)

Set Control Mode (TC 13)
Mode = Y-momentum (3) ; First activation: Timeout = 20mins

Estimated Attitude Angles (TLM 146)
1 Hz

NO

Pitch angle is between -10 to +10 deg

YES

Set Estimation Mode (TC 14)
Mode = Full State EKF (5)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Measured wheel speed (TLM 156)
0.1 Hz

Magnetometer Measurement (TLM 151)
0.1 Hz

Satellite position (LLH) (TLM 150)
0.1 Hz

NO

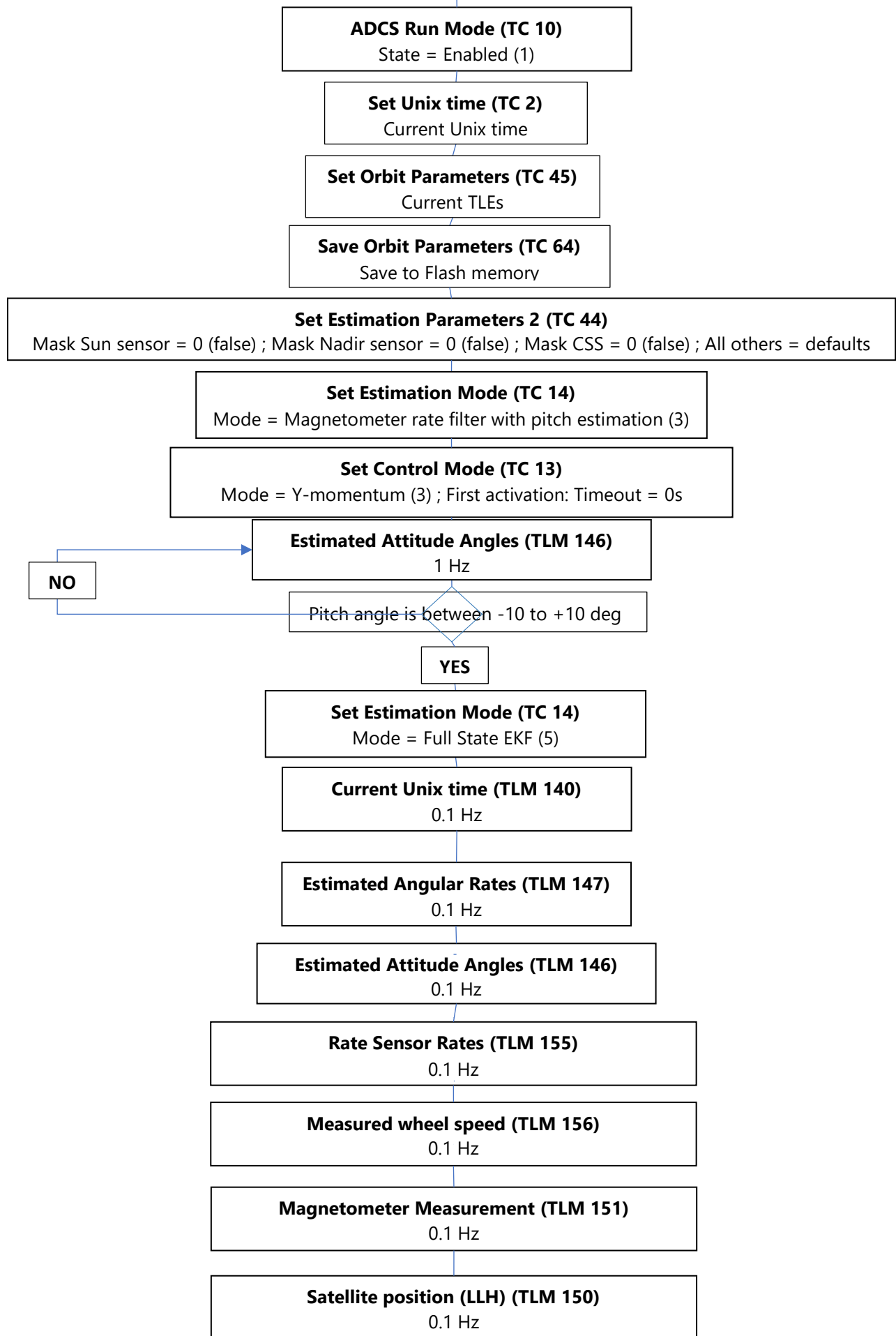**IF** Pitch angle is controlled to zero **AND** angular rates are controlled to zero
AND wheel momentum stays around reference value **OR** >20 minutes

YES

Y-momentum mode commissioning 2

Y-momentum mode commissioning 2

ADCS Run Mode (TC 10)
State = Enabled (1)

Set Unix time (TC 2)
Current Unix time

Set Orbit Parameters (TC 45)
Current TLEs

Save Orbit Parameters (TC 64)
Save to Flash memory

Set Estimation Parameters 2 (TC 44)
Mask Sun sensor = 0 (false) ; Mask Nadir sensor = 0 (false) ; Mask CSS = 0 (false) ; All others = defaults

Set Estimation Mode (TC 14)
Mode = Magnetometer rate filter with pitch estimation (3)

Set Control Mode (TC 13)
Mode = Y-momentum (3) ; First activation: Timeout = 0s

Estimated Attitude Angles (TLM 146)
1 Hz

NO

Pitch angle is between -10 to +10 deg

YES

Set Estimation Mode (TC 14)
Mode = Full State EKF (5)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Measured wheel speed (TLM 156)
0.1 Hz

Magnetometer Measurement (TLM 151)
0.1 Hz

Satellite position (LLH) (TLM 150)
0.1 Hz

Sun/Nadir sensor test

To improving Y-momentum performance, please refer to pages 31-32 in the CubeSpace Commissioning Manual.

Sun/Nadir sensor test

Power Control (TC ID 11)
CubeSense Power = On (1) ; All others = Default

Set Estimation Parameters 2 (TC 44)
Mask Sun sensor = 0 (false) ; Mask Nadir sensor = 0 (false) ; All others = defaults

Set Estimation Mode (TC 14)
Mode = Full State or Gyro EKF (5 or 6)

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Raw CSS measurements (TLM 168 and if needed 169)
0.1 Hz

Raw Nadir sensor measurements (TLM 166)
0.1 Hz

Raw Sun sensor measurements (TLM 167)
0.1 Hz

NO

IF # of orbits >1 **AND** Raw Nadir measurement: (X and Y angles close to zero **AND** zero or few detection errors in sunlit **AND** Invalid detection result in eclipse) **AND** Raw sun measurement : (X and Y varying to correspond with CSS measurements **AND** Zero or few detection errors in sunlit **AND** Invalid detection result in eclipse

YES

Set Estimation Parameters 2 (TC 44)
Mask Sun sensor = 1 (True) ; Mask Nadir sensor = 1 (True) ; All others = defaults

Active Payload/Comms Control

For adjustments to Sun and Nadir sensor parameters, see page 34 in the CubeSpace Commissioning Manual.

To capture, save, and download a CubeSense image, see page 34 in the CubeSpace Commissioning Manual.

Active Payload/Comms Control

NO

IF an angled payload measurement is desired **OR** having trouble with communication and want better angle

Yes

Commanded Pitch Angle (TC 15)
Offset 16 bits: [int]
(raw parameter value obtained using the formula:
raw parameter = formatted value*100
formatted value is in [deg] units

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Measured Wheel Speeds (TLM 156)
0.1 Hz

Magnetorquer Command (TLM 157)
0.1 Hz

Wheel Speed Commands (TLM 158)
0.1 Hz

Commanded Attitude Angles (TLM 199)
0.1 Hz

Overpass Actions

Overpass Actions

Set Unix time (TC ID 2)
Offset 0 bits: [UINT], Offset 32 bits: [UINT]
Time in s since 01/01/1970, 00:00. (Unit of measure is [s]), Current millisecond count. (Unit of measure is [ms])
Perform every pass

Set Orbit Parameters (TC 45)
Current TLEs
Perform only when new TLE are available

ADCS State (TLM 190); CubeSense, CubeControl, & wheel currents, ADCS & rate sensor Temperatures (TLM 171-175)
Perform every pass

Current Unix time (TLM 140)
0.1 Hz

Estimated Angular Rates (TLM 147)
0.1 Hz

Estimated Attitude Angles (TLM 146)
0.1 Hz

Magnetic Field Vector (TLM 151)
0.1 Hz

Fine Sun Vector (TLM 153)
0.1 Hz

Nadir Vector (TLM 154)
0.1 Hz

Rate Sensor Rates (TLM 155)
0.1 Hz

Measured Wheel Speeds (TLM 156)
0.1 Hz

Magnetorquer Command (TLM 157)
0.1 Hz

Wheel Speed Commands (TLM 158)
0.1 Hz

Commanded Attitude Angles (TLM 199)
0.1 Hz

NO

IF an angled payload measurement is desired **OR** having trouble with communication and want better angle

Yes

Active Payload/Comms Control (Back up to page 15)