

CougSat-1 System Requirements V1.0.1

This sheet lists all of the requirements of the satellite

Reference Number	Description	Reasoning	Priority Level
REQ-000	CougSat-1 and CougsInSpace's ground station shall comply with all requirements listed below	Requirements are required	Non-negotiable
REQ-001	CougSat-1 shall adhere to all requirements for the NASA CubeSat Launch Initiative	Contract with NASA	Non-negotiable
REQ-002	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 2: P-Pod Interface	REQ-001	Non-negotiable
REQ-003	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 3.1: General	REQ-001	Non-negotiable
REQ-004	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 3.2: Mechanical	REQ-001	Non-negotiable
REQ-005	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 3.3: Electrical	REQ-001	Non-negotiable
REQ-006	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 3.4: Operational	REQ-001	Non-negotiable
REQ-007	CougSat-1 shall comply with CubeSat Specifications Rev 13 section 4: Testing	REQ-001	Non-negotiable
REQ-008	CougSat-1's bus shall be reused on future CougSats	Mission Objective 1	Desired
REQ-009	CougSat-1 shall have a reliable and robust bus	Mission Objective 1	Non-negotiable
REQ-010	CougSat-1 may have a plant germination experiment payload for up to 30 days	Mission Objective 2	Desired
REQ-011	CougSat-1 shall transfer, to ground, all data from all payloads	Payloads need to be analyzed on the ground	Desired
REQ-012	CougSat-1 shall have at least one WSU Cougar logo	Mission Objective 3 & Go Cougs!	Non-negotiable
REQ-013	CougSat-1 may transmit "Go Cougs!" over voice around the world	Go Cougs!	Cosmetic
REQ-014	CougSat-1 may not have continuous contact with the ground	Only a single ground station is planned in Pullman	Non-negotiable
REQ-015	CougSat-1 shall operate without contact from the ground for up to 10 days	REQ-014	Non-negotiable
REQ-016	CougSat-1 shall communicate at least with a CougsInSpace's ground station	Only a single ground station is planned in Pullman	Non-negotiable
REQ-017	CougSat-1 may reprogram any of its programmable processors	Mission Objective 4	Desired
REQ-018	CougsInSpace's ground station may be developed and operated by individuals or groups outside of CougsInSpace	Must be easily reproduced and used	Non-negotiable
REQ-019	CougsInSpace's remote ground stations may send all received data to CougsInSpace	A single repository shall hold all data from CougSat-1	Desired
REQ-020	Only CougsInSpace's ground stations operated by CougsInSpace shall have transmit capabilities	Security	Non-negotiable
REQ-021	CougSat-1 shall transfer, to ground, telemetry	Mission Objective 1	Non-negotiable
REQ-022	CougSat-1 shall keep all components within prescribed operational temperature ranges beginning after ejection from the P-Pod for the mission duration	All components fail when exposed to extreme temperatures	Non-negotiable
REQ-023	CougSat-1 shall slew	Need to change attitude for payload and health reasons	Non-negotiable
REQ-024	CougSat-1 shall have at least one electrical subsystem powered beginning after ejection from the P-Pod for the mission duration	Without power, the satellite cannot function	Non-negotiable
REQ-025	CougSat-1 shall be single fault tolerant	CougSat-1 should be functional for the entire mission duration	Desired
REQ-026	CougSat-1 will buffer data until successful reception from the ground	We don't want to transmit all data every time, and we don't want to lose data	Non-negotiable
REQ-027	CougsInSpace shall have a single archive for all data with at least a backup	Losing the data negates all progress	Non-negotiable
REQ-028	CougSat-1 shall have testing procedures created	In order to validate REQ-009	Non-negotiable
REQ-029	CougSat-1 shall pass all CougSat-1 test procedures	REQ-028	Non-negotiable
REQ-030	CougSat-1 may have a camera capable of photographing the earth in the visible spectrum	Photos can help promote the club and its mission	Desired

ADCS Design Requirements

This sheet lists all of the design requirements of the satellite's ADCS

Reference Number	Description	Reasoning	Derived From System Requirement(s)
ADCS-000	The ADCS shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-011, REQ-013, REQ-014, REQ-015, REQ-016, REQ-017, REQ-021, REQ-022, REQ-023, REQ-025, REQ-026, REQ-028, REQ-029, REQ-030
ADCS-001	The ADCS shall detumble CougSat-1 within 1 orbit following ejection from the P-POD	Ejection from the P-Pod often induces random motion that needs to be arrested before continuing normal ADCS operations	REQ-009
ADCS-002	The ADCS shall have a pointing accuracy within 1°	1° is about 10km on Earth and small enough for the camera and antenna's field of view	REQ-023, REQ-30
ADCS-003	The ADCS shall have current information about CougSat-1's attitude at least every 1 seconds following ejection from the P-Pod	The attitude will be updated at a rate fast enough to hold the pointing accuracy requirement	REQ-023
ADCS-004	The ADCS shall have current information about CougSat-1's location at least every 100 seconds following ejection from the P-Pod	The location will be updated roughly 50 times per orbit, the Keplerian elements of the orbit can help to interpolate if desired	REQ-023
ADCS-005	The ADCS shall have current information about CougSat-1's orbit at least every 50 hours	Two line element data gives good information about the Keplerian elements of the orbit. Orbits don't change much so the ADCS doesn't need this updated too often	REQ-023
ADCS-006	The ADCS shall have redundant non-volatile memory	The ADCS needs to store the last known information about attitude, location, and orbit to improve start up time after a reboot	REQ-009, REQ-025
ADCS-007	The ADCS shall slew up to 1°s ⁻¹	The ADCS can slew between any attitude in less than 3 minutes	REQ-023
ADCS-008	The ADCS shall accelerate its slew up to 5°s ⁻²	Faster acceleration puts harder requirements on the ADCS actuators and the deployables' rigidity	REQ-023
ADCS-009	The ADCS shall orient features of CougSat-1 at desired points of interest	CougSat-1 will want to take a picture of something specific, aim its antenna at a ground station, maximize solar power, regulate temperature, etc.	REQ-011, REQ-021, REQ-30
ADCS-010	The ADCS shall communicate to the IHU	The ADCS needs to receive commands from the IHU and transfer data back	REQ-009
ADCS-011	The ADCS shall send telemetry to the IHU upon request	The IHU logs the data and sends it to the ground for analysis	REQ-009

C&DH Design Requirements

This sheet lists all of the design requirements of the satellite's C&DH

Reference Number	Description	Reasoning	Derived From System Requirement(s)
CDH-000	The C&DH shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-011, REQ-014, REQ-015, REQ-016, REQ-017, REQ-021, REQ-025, REQ-026, REQ-028, REQ-029, REQ-030
CDH-001	The C&DH shall have a single IHU	More than one processor increase complexity and may reduce reliability at the cost of increased redundancy	REQ-009, REQ-025
CDH-002	The C&DH may manage all forms of data on the satellite	The satellite need a single subsystem responsible for organizing all subsystems into a collective	REQ-009
CDH-003	The C&DH shall execute all commands ordered by the ground	The satellite need a single subsystem responsible for organizing all subsystems into a collective	REQ-016
CDH-004	The C&DH shall prepare all packets to send to the ground	The satellite need a single subsystem responsible for organizing all subsystems into a collective	REQ-011, REQ-016, REQ-021
CDH-005	The C&DH shall interpret all packets received from the ground	The satellite need a single subsystem responsible for organizing all subsystems into a collective	REQ-016
CDH-006	The C&DH shall collect and process information about all subsystems and payloads	The satellite need a single subsystem responsible for organizing all subsystems into a collective	REQ-009, REQ-011, REQ-016, REQ-021
CDH-007	The C&DH shall keep and distribute the satellite's time with less or equal to one second resolution	Synchronized time between all subsystems is required for time dependent operations	REQ-009
CDH-008	The C&DH shall have redundant non-volatile memory	Data needs to be buffered until it is used and not corrupted in the meanwhile	REQ-014, REQ-015, REQ-026
CDH-009	The C&DH may decide and enforce current operation and mode	Different operations and modes need to affect all subsystems synchronously	REQ-009
CDH-010	The C&DH shall perform periodic inquiries on the status of all subsystems	The subsystems may encounter a fault or be in critical health which requires the aid of other subsystems	REQ-009, REQ-025

Comms Design Requirements

This sheet lists all of the design requirements of the satellite's Comms

Reference Number	Description	Reasoning	Derived From System Requirement(s)
COMMS-000	The Comms shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-011, REQ-013, REQ-014, REQ-015, REQ-016, REQ-017, REQ-021, REQ-022, REQ-023, REQ-025, REQ-026, REQ-028, REQ-029, REQ-030
COMMS-001	The Comms shall have a CW beacon during SAFE mode and only after the specified radio inhibit timeout	CW is the most spectrum efficient, can get through the weakest link, and lowest power consumption transmission	REQ-009, REQ-014, REQ-016
COMMS-002	The Comms shall have a telemetry containing beacon during STANDBY and SCIENCE mode and only after the specified radio inhibit timeout	The beacon will be used for tracking and will send telemetry to any ground station	REQ-009, REQ-014, REQ-016, REQ-021
COMMS-003	The Comms may have a high speed downlink during TRANSMIT mode and only after the specified radio inhibit timeout capable of at least 500kbps goodput	This will be used to transfer large files (payload images). A single photo will take 80s at this rate which is up to 30 images a day	REQ-011, REQ-014, REQ-016, REQ-017, REQ-021
COMMS-004	The Comms shall have sufficient preamble for receiver synchronization	A preamble allows the receiver to wake up and recover the clock from the signal	REQ-009, REQ-014
COMMS-005	The Comms shall have a receiver continuously on and only after the specified radio inhibit timeout	Communication from the ground may occur at any time	REQ-009, REQ-014, REQ-020
COMMS-006	The Comms may have a voice message audible during the telemetry beacon	Listener can be informed of our website which will have instructions for decoding the telemetry encoded in the transmission	REQ-013
COMMS-007	The Comms shall have at least a low gain antenna	If the Comms malfunctions, data still needs to be capable of transferring to the ground (low gain is low directionality)	REQ-009, REQ-014
COMMS-008	The Comms shall communicate to the IHU	The Comms needs to receive commands from the IHU and transfer data back	REQ-009
COMMS-009	The Comms shall send telemetry to the IHU upon request	The IHU logs the data and sends it to the ground for analysis	REQ-009

ECS Design Requirements

This sheet lists all of the design requirements of the satellite's ECS

Reference Number	Description	Reasoning	Derived From System Requirement(s)
ECS-000	The ECS shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-022, REQ-025, REQ-028, REQ-029
ECS-001	The ECS shall keep all components within storage temperature bounds	Over and under temperature can stress components to failure	REQ-009, REQ-022
ECS-002	The ECS shall keep all components within operating temperature bounds beginning after ejection from the P-Pod for the mission duration	Over and under temperature can stress components to failure	REQ-009, REQ-022
ECS-003	The ECS may protect against damaging levels of ionizing radiation	Ionizing radiation may result in damage to components	REQ-009

EPS Design Requirements

This sheet lists all of the design requirements of the satellite's EPS

Reference Number	Description	Reasoning	Derived From System Requirement(s)
EPS-000	The EPS shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-011, REQ-015, REQ-016, REQ-017, REQ-021, REQ-022, REQ-023, REQ-024, REQ-025, REQ-026, REQ-028, REQ-029, REQ-030
EPS-001	The EPS shall have at least two voltage outputs	Different components require different voltages	REQ-008
EPS-002	The EPS shall keep enabled regulated rails' average voltage within 5%	Components expect a voltage and should be given that voltage	REQ-009
EPS-003	The EPS shall keep enabled regulated rails' voltage noise to less than 1%	Smooth voltage rails reduces stress on components	REQ-009
EPS-004	The EPS shall keep enabled regulated rails' voltage ripple to less than 0.5%	Smooth voltage rails reduces stress on components	REQ-009
EPS-005	The EPS shall be capable of providing 2W continuously to loads including during periods of eclipse from the earth	An energy budget shows an average use of 1.6W	REQ-009
EPS-006	The EPS shall be capable of providing 10W of peak power to loads for 10 minutes each orbit	An energy budget shows an peak use of 8.5W	REQ-009
EPS-007	The EPS shall have an efficiency of at least 90% during average continuous load	Wasted power is unusable and undesirably raises the temperature of the satellite	REQ-009
EPS-008	The EPS shall have two independent power chains with capabilities to route inputs and/or outputs to either chain	Independent power chains increases redundancy. Routing inputs/outputs allow load balancing and avoiding faulty components	REQ-009, REQ-025
EPS-009	The EPS shall have energy storage devices	Need to operate while in the shade (eclipsed by the earth)	REQ-009, REQ-024
EPS-010	The EPS shall use photovoltaics to capture energy from the sun	The sun outputs a lot of easily obtained and reliable power	REQ-009
EPS-011	The EPS shall monitor the current consumption of each load	Overcurrent consumption needs to be halted	REQ-009
EPS-012	The EPS shall be capable of disabling each load	Low power states needs to controlled	REQ-009
EPS-013	The EPS shall have an regulated rail for the PMIC that is always on beginning after ejection from the P-Pod for the mission duration	If the PMIC turns off, it may not be able to turn back on	REQ-009, REQ-024, REQ-0025
EPS-014	The EPS shall be capable of entering safe mode where only critical subsystems are enabled	When the stored energy is nearing being exhausted, it needs to be prioritized for preserving the health of the satellite	REQ-009, REQ-024, REQ-025
EPS-015	The EPS shall monitor the power production from each solar cell	Power level can be used to aid the ADCS in aiming the solar cells	REQ-009, REQ-021
EPS-016	The EPS shall monitor the energy level in its energy storage devices	The EPS needs to know when to enter safe mode	REQ-009, REQ-021
EPS-017	The EPS shall monitor the temperature of each component in the power chain	The EPS needs to know when to enter safe mode. The ADCS needs to know when to aid in temperature regulation	REQ-009, REQ-021
EPS-018	The EPS shall communicate to the IHU	The EPS needs to receive commands from the IHU and alert it when entering safe mode	REQ-009
EPS-019	The EPS shall send telemetry to the IHU upon request	The IHU logs the data and sends it to the ground for analysis	REQ-009
EPS-020	The EPS shall have a RBF pin and deployment switches that disconnect all loads from the power chain	When in the P-POD, the entire satellite needs to be off	REQ-005
EPS-021	The EPS shall be capable of using power from the umbilical during testing	Need to operate the entire satellite without requiring an artificial Sun	REQ-009

EPS-022	The EPS shall have a single PMIC whose role is to monitor the EPS, control the EPS, and communicate with the IHU	More than one processor increase complexity and may reduce reliability at the cost of increased redundancy	REQ-009, REQ-025
EPS-023	The EPS shall activate deployables release mechanisms	Deployables release mechanism are high power devices requiring direct connection and control from the EPS	REQ-006

Ground Design Requirements

This sheet lists all of the design requirements of the Cougs in Space Ground Station

Reference Number	Description	Reasoning	Derived From System Requirement(s)
GND-000	The Ground shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-008, REQ-009, REQ-011, REQ-014, REQ-015, REQ-016, REQ-018, REQ-019, REQ-020, REQ-021, REQ-026, REQ-027, REQ-028, REQ-029
GND-001	The Ground shall receive all forms of transmission from the Comms	The Ground is the other side of the communication system	REQ-016
GND-002	The Ground shall transmit commands up to the Comms	The Ground is the other side of the communication system	REQ-016
GND-003	The Ground shall be capable of autonomous reception for up to 10 days	Having the Ground with an operator for every pass is too much time and effort	REQ-014
GND-004	The Ground may use cross-platform software	Minimum is it must operate on Windows 10	REQ-018
GND-005	The Ground shall transmit received data to a common repository	This archive will have all of the data of all of the satellites	REQ-019, REQ-027
GND-006	The Ground may have a website with the latest telemetry	Websites are an easy way to show the current status of the satellite to the general public	REQ-027
GND-007	The Ground shall have a RX only and a TX/RX version	Only ground stations authorized by Cougs in Space will have TX capabilities for security	REQ-020

IFJR Design Requirements

This sheet lists all of the design requirements of the satellite's IFJR

Reference Number	Description	Reasoning	Derived From System Requirement(s)
IFJR-000	The IFJR shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-014, REQ-015, REQ-016, REQ-017, REQ-021, REQ-025, REQ-026, REQ-028, REQ-029
IFJR-001	The IFJR shall have a single processor	More than one processor increase complexity and may reduce reliability at the cost of increased redundancy	REQ-009, REQ-025
IFJR-002	The IFJR may program any subsystem processor using JTAG	JTAG programming is widely used and is not complex to implement	REQ-009, REQ-017
IFJR-003	The IFJR shall alert a subsytem before performing programming operations	Sudden programming can interrupt a CMT	REQ-009, REQ-025
IFJR-004	The IFJR shall have redundant non-volatile memory	Processor binaries needs to be buffered until it is used and not corrupted in the meanwhile	REQ-014, REQ-015
IFJR-005	The IFJR shall communicate to the IHU	The IFJR needs to receive commands from the IHU and transfer data back	REQ-009
IFJR-006	The IFJR shall send telemetry to the IHU upon request	The IHU logs the data and sends it to the ground for analysis	REQ-009

Payload Design Requirements

This sheet lists all of the design requirements of the satellite's Payload

Reference Number	Description	Reasoning	Derived From System Requirement(s)
PAYLOAD-000	The Payload shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-011, REQ-014, REQ-015, REQ-016, REQ-022, REQ-023, REQ-025, REQ-026, REQ-028, REQ-029, REQ-030
PAYLOAD-001	The Payload shall maintain a pressurized germination chamber at 0.8 to 1.0 atm until the completion germination experiment	Environment needs to be similar to Earth's for the germination experiment	REQ-010
PAYLOAD-002	The Payload shall have a controllable mechanism to initiate the germination experiment	The time from sealing the chamber to ejection from the P-Pod can be between several weeks and many months. A time based initiation mechanism is difficult for this wide range	REQ-010
PAYLOAD-003	The Payload shall have a suite of sensors to measure the germination experiment until the completion of the germination experiment	The germination experiment needs data to determine the life cycle of the seeds. This may include a CO ₂ sensor, an O ₂ sensor, and/or a visible light color camera	REQ-010
PAYLOAD-004	The Payload shall have lighting with output power and spectrum defined by the germination experiment	Cameras need light to image and confirm seed germination	REQ-010
PAYLOAD-005	The Payload shall keep the germination experiment within 20 to 35°C until the completion of the germination experiment	The seeds are biological and cannot die before the germination experiment completes	REQ-010
PAYLOAD-006	The Payload shall have a visible light color camera with a field of view of at least 160° that points outward from CougSat-1	A wide angle camera is easy to aim and focus	REQ-030
PAYLOAD-007	The Payload may have a visible light camera with a field of view of no more than 30° that points outward from CougSat-1	A telephoto camera is harder to aim and focus but can resolve smaller details	REQ-030
PAYLOAD-008	The Payload shall have a suite of sensors to measure the health and environment of CougSat-1	This data can be used to determine the success of CougSat-1's bus. This may include temperature sensors, an ionizing radiation sensor, and light intensity sensor	REQ-008, REQ-009
PAYLOAD-009	The Payload shall communicate to the IHU	The Payload needs to receive commands from the IHU and transfer data back	REQ-009
PAYLOAD-010	The Payload shall send telemetry to the IHU upon request	The IHU logs the data and sends it to the ground for analysis	REQ-009

Structure Design Requirements

This sheet lists all of the design requirements of the satellite's Structure

Reference Number	Description	Reasoning	Derived From System Requirement(s)
STRUCT-000	The Structure shall comply with all requirements listed below and all applicable system requirements	Requirements are required	REQ-001, REQ-002, REQ-003, REQ-004, REQ-005, REQ-006, REQ-007, REQ-008, REQ-009, REQ-010, REQ-012, REQ-022, REQ-023, REQ-025, REQ-028, REQ-029
STRUCT-001	The Structure shall mechanically support all subsystems	The subsystems cannot be ejected from the P-POD without being attached to rails	REQ-004, REQ-009
STRUCT-002	The Structure may maximize the use of commercial off-the-shelf parts	More things we can order, the less needs to be designed, fabricated, and tested	REQ-008
STRUCT-003	The Structure may limit the unique fasteners whenever the design allows	Using the same fastener is easier to design, fabricate, and assemble	REQ-009
STRUCT-004	The Structure may be used as a heatsink and radiation for the ECS	Heat may need to be absorbed or radiated by the structure to regulate subsystems' temperatures	REQ-022
STRUCT-005	The Structure shall store deployables from before P-POD integration until controlled release from the EPS	The deployables need to fit within the P-POD until the specified timeout after P-POD ejection	REQ-006
STRUCT-006	The Structure shall keep deployed deployables supported during slewing	The deployables cannot retractable and need to handle the dynamics induced from slewing	REQ-009, REQ-023