CanSat Competition Guide 2019

Mission: Auto-Gyro Probe

Rev 1.1b
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Revisions

Date	Changes
2/26/2018	Initial guide
7/21/2018	Requirements; Environment test additions
12/14/18	Requirement #7 has been relaxed to 1 Pa.
12/18/2018	Updated document to add passive helicopter recovery with auto-gyro. Added a couple links to show examples of helicopter recovery. Added text to bonus to make requirements more clear.

1. Introduction

The CanSat competition is a design-build-fly competition that provides teams with an opportunity to experience the design life-cycle of an aerospace system. The CanSat competition is designed to reflect a typical aerospace program on a small scale and includes all aspects of an aerospace program from the preliminary design review to post mission review. The mission and its requirements are designed to reflect various aspects of real world missions including telemetry requirements, communications, and autonomous operations. Each team is scored throughout the competition on real-world deliverables such as schedules, design review presentations, and demonstration flights.

1.1 Competition Description

To control the size of the competition, only three teams per school are allowed to apply to the competition. It is recommended that schools hold internal design competitions to determine the three teams to apply. If more than three teams from one school apply, the first three applications received will be accepted.

The competition is in five phases.

Phase one in is the application phase. Teams must submit an application and a $100 competition fee that is non-refundable. The fee is used to offset the cost of rocket motors and other materials. Applications must be submitted by November 30, 2018. Payments will be requested in early December and must be paid by the given due date.

Phase two is the preliminary design. Teams are to develop designs, prototype, test concepts and generate a preliminary design review (PDR) slide package using the provided template. Teams will submit PDR slides in only PDF format at the designated due date. Teams that do not meet the due date or do not submit in the proper PDF format will be dropped from the competition. A schedule will be made available on when to present a subset of the slides. Teams will have a half hour to discuss a subset of the PDR slides via telecon.

After PDR, a total of 40 teams will be invited to the competition. The 40 teams invited include the 37 best overall teams plus the best three teams from countries that have not participated in the post-PDR phases of previous competitions.

Phase three is the critical design. Teams will finalize their design and start ordering components, manufacturing parts, test subsystems and start developing the flight unit. Teams will generate a critical design review (CDR) slide package using the provided template. Teams will submit CDR slides in only PDF format at the designated due date. Teams that do not meet the due date or do not submit in the proper PDF format will be dropped from the competition. A schedule will be made available on when to present a subset of the slides. Teams will have a half hour to discuss a subset of the CDR slides via telecon.

Phase four is the launch weekend. Friday, teams will be scheduled to present their completed CanSat for flight readiness review which must be completed in 30 minutes. The CanSat must be ready to launch at this time. It must be completely assembled and operational. Each team will be scored during the flight readiness review. Teams can only present once at the flight readiness review at their designated time. Teams late for the review will lose points. CanSats must pass the drop test, fit check, and battery verification in order to fly. Multiple attempts at the drop test are allowed.

Saturday is the launch day where teams will perform final preparations and turn in CanSats by 12:00 hours local time. Launch will start at 13:00 hours local time and continue until all launches are completed. There will be no second flights unless the fault is of the launch provider and there are spare rockets and rocket motors.

Phase five is the Post Flight Review (PFR). Post Flight Review is a 15 minute presentation of the flight results and 5 minutes for questions. Awards will be presented at the end of the post Flight Reviews.

For teams to receive certificates of accomplishment and be considered for awards, they must complete all phases of the competition.

Late submissions will not be accepted for any phase and the team will be dropped from the competition. Internet issues, file issues, email issues, and any other issues will not be considered. **Submit the documents early to be safe.**

All scoring and judging results are final. Scoring is set up to be quantitative with little qualitative scoring to minimize any biases.

The competition is operated by a dedicated group of volunteers who spend their own time supporting various phases of the competition. Some volunteers spend their own funds to attend and support the competition while others are graciously supported by their employers. The competition is designed to provide teams a great educational experience and to minimize the time of the volunteers. Strict due dates, file templates, and file name formats are required to minimize the times of the volunteers who have little time to spare. Please follow all due dates and all submission requirements to help the volunteers.

2. Mission Overview

The 2019 mission will explore the use of auto-gyro/ passive helicopter recovry descent control of a science payload when released from the launch vehicle. The CanSat shall consist of two parts, the science payload and the container to protect the science payload as it is deployed from the rocket.

The Cansat shall be launched to an altitude ranging 670 meters to 725 meters above the launch site and deployed near apogee (peak altitude). Orientation of deployment is not controlled and is most definitely violent. The CanSat container must protect the science

payload from damage during the launch and deployment.

Once the CanSat is deployed from the rocket, the CanSat shall descend using a parachute at a descent rate of 20 m/s. At 450 meters, the container shall release the science payload. The descent rate shall be 10 to 15 m/s. As the science payload descends under auto-gryo/ passive helicopter recovery control, the payload shall transmit telemetry which shall include sensors to track altitude using air pressure, external temperature, battery voltage, GPS position, pitch and roll and auto-gyro/ passive helicopter recovery blade spin rate. When the science payload lands, all telemetry transmission shall stop and a located audio beacon shall activate.

Example of helicopter recovery:

https://www.apogeerockets.com/Rocket-Kits/Helicopter-Rockets

https://rocketry.wordpress.com/copter-recovery-guide/

3. Requirements

3.1 Base Requirements

Requirement Number	Requirement
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.
4	The container shall be a fluorescent color; pink, red or orange.
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.
6	The rocket airframe shall not be used as part of the CanSat operations.
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.
9	The container shall release the payload at 450 meters +/- 10 meters.
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.
12	All descent control device attachment components shall survive 30 Gs of shock.
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
14	All structures shall be built to survive 15 Gs of launch acceleration.
15	All structures shall be built to survive 30 Gs of shock.
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
17	All mechanisms shall be capable of maintaining their configuration or states

	under all forces.
18	Mechanisms shall not use pyrotechnics or chemicals.
19	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.
20	The science payload shall measure altitude using an air pressure sensor.
21	The science payload shall provide position using GPS.
22	The science payload shall measure its battery voltage.
23	The science payload shall measure outside temperature.
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.
25	The science payload shall measure pitch and roll.
26	The probe shall transmit all sensor data in the telemetry
27	The Parachute shall be fluorescent Pink or Orange
28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.
30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.
32	XBEE radios shall have their NETID/PANID set to their team number.
33	XBEE radios shall not use broadcast mode.
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
35	Each team shall develop their own ground station.
36	All telemetry shall be displayed in real time during descent.
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
38	Teams shall plot each telemetry data field in real time during flight.
39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.

40	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.
41	Both the container and probe shall be labeled with team contact information including email address.
42	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.
44	No lasers allowed.
45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.
46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.
47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.
49	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.
50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.
51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.
52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.
53	The GPS receiver must use the NMEA 0183 GGA message format.
54	The CANSAT must operate during the environmental tests laid out in Section 3.5.
55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.

3.2 Selectable Bonus Objective

A video camera shall be integrated into the science payload to record the descent after being released from the container. The camera shall point downward 45 degrees from

nadir of the science payload. It shall point in one direction relative to the earth's magnetic field with a stability of +/- 10 degrees in all directions during descent. Direction does not matter as long as it is in one direction. The payload can pick the direction. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The direction the camera is pointed relative to earth's magnetic north shall be included in the telemetry.

3.3 Telemetry Requirements

Upon powering up, the CanSat probe shall collect the required telemetry at a 1 Hz sample rate. The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return in the following format:

<TEAM ID>,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>, <PRESSURE>, <TEMP>,<VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>,<PITCH>,<ROLL>,<BLADE SPIN RATE>,<SOFTWARE STATE>,<BONUS DIRECTION>

1. **The received probe telemetry for the entire mission shall be saved on the ground station computer as a comma separated value (.csv) file that will be examined by the competition judges in Excel. Teams will provide the file to the judges immediately after the launch operations via USB drive. The csv file shall include headers specifying each field of data.**
2. The telemetry data file shall be named as follows:

   Flight_<TEAM_ID>.csv

   where the team_id is the four digit team id number. It is recommended the ground software produce this file, with the correct name, easily from the ground system user interface.
3. <TEAM ID> is the assigned team identification.
4. <MISSION TIME> is the time since initial power up in seconds.
5. <PACKET COUNT> is the count of transmitted packets, which is to be maintained through processor reset.
6. <ALTITUDE> is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.
7. <PRESSURE> is the measurement of atmospheric pressure in units of pascals. The resolution must be 1 pascals.
8. <TEMP> is the sensed temperature in degrees C with one tenth of a degree resolution.
9. <VOLTAGE> is the voltage of the CanSat power bus. The resolution must be 0.01 volts.
10. <GPS TIME> is the time generated by the GPS receiver. The time must be reported in

UTC and have a resolution of a second.

11. <GPS LATITUDE> is the latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.
12. <GPS LONGITUDE> is the longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.
13. <GPS ALTITUDE> is the altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters.
14. <GPS SATS> is the number of GPS satellites being tracked by the GPS receiver. This must be an integer number.
15. <PITCH> is the tilt angle in the pitch axis in degrees. The resolution must be 1 degree.
16. <ROLL> is the tilt angle of the roll axis in degrees. The resolution must be 1 degree.
17. <BLADE SPIN RATE> is the rate the auto-gyro blades spin relative to the science payload. The units must be in revolutions per minute (rpm). The resolution must be 1 rpm.
18. <SOFTWARE STATE> is the operating state of the software. (boot, idle, launch detect, deploy, etc.)
19. <BONUS DIRECTION> is the direction the camera is pointed relative to earth's magnetic north specified in degrees.
20. Additional data fields may be appended after the required fields as determined necessary by the team's design

It is suggested that teams make use of onboard data storage. Only the transmitted telemetry is graded, however, the backup data can be used when completing the Post Flight Review.

3.4 Banned Materials and components

1. No foam based beads or other similar bits of foam material that can be dropped and lost on the ground. This material is dangerous to the livestock that occupy this area.
2. No lithium polymer batteries. The battery is relatively easy to damage and a fire hazard. We want to avoid setting any parts of the field on fire.

3.5 Environmental Tests

Three tests are to be conducted to test the recovery system of the container, the release mechanism for releasing the CanSat from the container, Construction quality and material performance. To verify test results, teams should provide: 1) csv file with data transmitted by

the CanSat throughout the test; 2) a picture of the CanSat in the test environment, with either the team number written on an object in the picture, or the team leader in the picture.

1. Drop Test - This test is designed to verify that the container parachute and attachment point will survive the deployment from the rocket payload section which can be very violent. The release mechanism will also be tested to verify it can hold the science vehicle in the container. Component mounts and battery mount will also be tested. The drop test generates about 30 Gs of shock to the system.
    a. Drop Test Description - This test requires a 61 cm non-stretching cord. The test was developed with a 1/8 thick kevlar cord. One end is secured to an eyebolt attached to fixed point, such as ceiling or rigid structure with enough clearance to accommodate the cord, CANSAT, and free space so the cansat does not hit the ground. The other end is tied to the parachute. A floor mat or pillow may be placed under the CanSat for the drop test.. The structure must not flex during the drop test.
    b. Drop Test Procedure -
        i. Power on CanSat.
        ii. Verify telemetry is being received.
        iii. Raise CanSat by the attached cord, so that the attachment points of the cord, on the eye bolt and the parachute, are at the same height.
        iv. Release the CanSat.
        v. Verify the CanSat did not lose power.
        vi. Inspect for any damage, or detached parts.
        vii. Verify telemetry is still being received.
2. Thermal Test - This test is to verify the CanSat and container can operate in a hot environment. When the CanSat is integrated into the rocket and sitting on the launch pad, the sun can heat up the payload section of the rocket to temperatures up to the mid to upper 30C. This test will determine if any materials warp, weaken, change characteristics, or fail to function at temperatures up to 35C.
    a. Thermal Test Description - This test requires a method to heat the CanSat to 60C for a period of 2 hours. This will allow the components to rise to heat, and verify that they continue to function. One way to heat the CanSat is a thermal chamber; there are a few ways to build a thermal chamber.
        i. The simplest is to acquire an insulating cooler, one or more hair dryers and a thermometer, preferably a remote thermometer such as a thermocouple or thermistor. Place the CanSat, hair dryer(s) and thermometer in the cooler. Try to seal any openings. Make sure the hair dryer does not blow directly on the CanSat. The hair dryer will circulate and heat the air in the cooler.

ii. Another method is to build a thermal chamber with foam insulation sheets. Select the sheets that have one side with a foil layer. Build a box and have one side be a lid. Seal all edges with duct tape. You can make a hole in the side to run cords and thermocouple through.
iii. It is highly suggested the thermistor or thermocouple be attached to the CanSat. The purpose is to make sure the CanSat does reach the peak temperature. The air will reach the peak temperature long before the CanSat does.

b. Thermal Test Procedure -
i. Place CanSat into thermal chamber.
ii. Turn on the CanSat.
iii. Close and seal the thermal chamber.
iv. Turn on the heat source.
v. Monitor the temperature and turn off the heat source when the internal temperature reaches 60C and turn on the heat source when the temperature drops to 55C.
vi. Maintain the test conditions for two hours.
vii. Turn off the heat source and perform visual inspection and any functional tests to verify the CanSat survived the thermal exposure and can operate as expected.
viii. With the CanSat still hot, test any mechanisms and structures to make sure the integrity has not been compromised. Take precautions to avoid injury.
ix. Verify epoxy joints and composite materials still maintain their strengths.

3. Vibration Test - This test is designed to verify the mounting integrity of all components, mounting connections, structural integrity, and battery connections.
a. Vibration Test Description - The test uses an orbit sander. The sander is a hand held power tool where the sanding head moves in a circular pattern. Some of the more expensive sanders can do random patterns. That is not necessary. Orbit sanders operate at a fixed orbits per minute (opm) ranging from 12,000 to 14,000 opm. That translates to 200 to 233 Hz. This test takes advantage of the power up and power down phases of the sander. The sander does not instantly turn on at 14,000 opm, it takes at most a second to get up to speed. That transition time can hit some resonances of the CanSat. This test requires the sander to be cycled regularly over a one minute duration exposing the CanSat to vibrations from 0 Hz to 233 Hz. The amount of shaking generated by the sander is around 20 to 29 Gs.
i. One setup for test is to secure the sander, upside down, via a bench vise; the CanSat should be secured where the sand-paper is installed.

b. Vibration Test Procedure -
    i. Power on the CanSat.
    ii. Verify accelerometer data is being collected.
    iii. Power up the sander.
    iv. Once the sander is up to full speed, wait 5 seconds.
    v. Power down the sander to a full stop.
    vi. Repeat steps iii to v four more times.
    vii. Inspect the CanSat for damage and functionality.
    viii. Verify accelerometer data is still being collected.
    ix. Power down CanSat.

4. Team Composition

Students currently enrolled in undergraduate degree programs, or students having graduated from such programs since the start of the current competition cycle, are counted as undergraduate students.

Students currently enrolled in post-graduate degree programs (MS, PhD), or students having entered such programs since the start of the current competition cycle, are counted as graduate students.

4.1 Team Size

Each team shall consist of between 3 and 10 students (undergraduate teams) from an accredited college or university. Teams may consist entirely of undergraduate students (undergraduate teams), entirely of graduate students (grad teams), or a combination of the two (mixed teams). Graduate teams shall consist of no more than 5 students. Mixed teams shall consist of no more than 7 undergraduate students and 3 graduate students.

Teams from the same school must develop their designs independently and **not** copy from other teams. Bulk purchasing of materials is allowed such as batteries and raw materials for construction. Sharing tools and services are allowed. Designs must originate from within the team.

There shall be no more than three teams from any one school.

4.2 Faculty Advisor

Each team must have a faculty advisor. The role of the faculty advisor is to:

- Provide a point of contact for the team, both with the university and the competition.
- Aid teams with logistics such as arranging conference rooms, laboratory resources, etc.
- Providing general guidance throughout the competition.

The faculty advisor shall not:

- Make design decisions or direct recommendations.
- Participate in more than an oversight role during reviews.

5. Deliverable Items

Teams will be evaluated based on a series of deliverable items provided at various stages of the development. The deliverable items are selected to provide representative real-world milestones for tracking the CanSat development and ensuring team success.

5.1 Preliminary Design Review

The PDR is a “multi-disciplined technical review to ensure that the system under review can proceed into detailed design, and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints”. The CanSat PDR shall demonstrate:

- An understanding of the CanSat mission requirements
- Allocation and derivation of system and subsystem requirements
- Definition of the CanSat concept of operations
- Overview of preliminary design that meets specified requirements
- Results of, or identification of, necessary trades to support preliminary design. While it is ideal to have completed trades prior to the preliminary design, it is not necessary.
- Results of, or identification of, necessary prototyping or testing efforts necessary to support or finalize the preliminary design.
- Preliminary budget
- Detailed development schedule

Preliminary design reviews shall be conducted via teleconference coordinated by the team lead(s). The PDR presentations shall be less than 30 minutes in duration including time for questions. Presentation reviewers shall be permitted to ask questions during the presentation (i.e., questions are not held until the end of the presentation).

The PDR shall follow the presentation template posted on the CanSat Competition website.

5.2 Critical Design Review

The CDR is “a multi-disciplined technical review to ensure that the system under review can proceed into system fabrication, demonstration, and test; and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints”. The CDR shall demonstrate:

- All PDR level requirement TBDs and TBRs shall be resolved
- Refinement of the CanSat CONOP
- Results of detailed design and analysis for each subsystem
- Verification that detailed design meets system and subsystem level requirements
- Identification of subsystem and system level tests necessary for requirements verification
- Results of requirements verification tests completed to date
- Overview of mission operations
- Preliminary launch day sequence of events
- Revised budget

- Updated development schedule

Critical design reviews shall be conducted via teleconference coordinated by the team lead(s). The CDR presentations shall be less than 30 minutes in duration including time for questions. Presentation reviewers shall be permitted to ask questions during the presentation (i.e., questions are not held until the end of the presentation).

The CDR shall follow the presentation template specified in the "CanSat CDR Outline" document available on the CanSat Competition website. Extra material in the form of backup slides is permitted.

Each section of the CDR shall be scored in accordance with the values listed in the outline. The CDR shall contribute to the total evaluation of the CanSat design according to the values listed the section Evaluation and Scoring.

5.3 Post Flight Review

The PFR provides an assessment of flight operations and results of the demonstration flight. The PFR provides an assessment of successful and unsuccessful flight operations. The PFR shall provide:

- Overview of mission objectives and CanSat design
- Comparison of planned and actual CONOPS and SOE
- Raw and processed data from flight operations
- Failure analysis and assessment (for unsuccessful mission objectives)

Post Flight Reviews shall be conducted the day following the demonstration flight activities, unless flight operations are canceled due to weather. Presentations shall be limited to 20 minutes, including questions.

Each section of the PFR shall be scored in accordance with the values listed in the outline. The PFR shall contribute to the total evaluation of the CanSat design according to the values listed in the section Evaluation and Scoring.

Post Flight Review presentations shall be submitted by 8:45 AM to the judges. There will be two presentation rooms. Teams will be preassigned to the presentation room. Late submissions will lose points. Each team will be given a thumb drive. Teams are to install their PFR slides on the thumb drive and deliver the thumb drive to the designated location between 8 AM and 8:45 AM Sunday. Teams delivering after 8:45 AM will lose points. This is done to make sure all teams have the same amount of time to prepare for PFR.

5.4 Deliverable Submissions and Scheduling

All deliverable items shall be submitted to the competition email by the dates listed in Table 1.

All deliverable items shall be submitted in PDF format using the naming convention listed in Table 1 where # corresponds to the assigned team number for each team and v# is a unique revision number for the review package that can be used to track revisions. For example, a submission for Team number 1021 of version 2 of the PDR package would be named **`Cansat2019_1021_PDR_v02.pdf`**. Note that adherence to the filename and format specification is scored during the competition.

If you resubmit your presentation, you must increment the version number otherwise the previous version may be used. If so, scoring will reflect the previous version. With a large number of submissions and resubmissions, it is not possible to track correctly without using the version numbers.

Presentations will be scheduled after submission of the document. A calendar of available time slots will be sent to all teams. Each team is to send to the competition email a list of three time slots. The team will be notified of the which time slot they are assigned.

Updated presentations will not be accepted after the deadline. It is understood and expected that changes will occur between document submission and the presentation time. The scoring is based on the quality of the presentation and understanding of the competition requirements. There will be no point loss due to changes in the design between document submission time and the presentation time.

Table 1: Deliverable item due dates

Deliverable

Material Due	Required Filename Format	Due Date
PDR	Cansat2019_XXXX_PDR_vYY.pdf	02/01/19
CDR	Cansat2019_XXXX_CDR_vYY.pdf	03/29/19
Demo Flight	Flight_XXXX.csv	06/15/19
PFR	Cansat2019_XXXX_PFR_vYY.pdf	06/16/19

XXXX is the team number. YY is the revision number. **Use this file format or your team will be removed from the competition. Files are to be in PDF format. No other formats will be accepted.**

At the end of the competition, the PDR, CDR, and PFR packages may be placed on the website for reference in subsequent years.

5.5 Slide Format Guidelines

The following guidelines shall be used when developing the presentation material:

- Use the template made available. Failure to do so will result in loss of points.
- All slides shall have simple white backgrounds. This helps reduce the file sizes and makes the slides easier to read.
- All slides shall have pages numbers in the footer. This is to allow for easier referencing of material during the reviews.
- All slides shall list the presenters name in the footer. This provides all the reviewers with an identity as to who is presenting the material.
- No embedded files or movies shall be included in the presentations. Not all reviewers will be able to access or view movies during the reviews due to network security settings at the various organizations involved.
- Each line-item in the review outlines shall correspond to a dedicated slide. This may result in slides with single bullets on them, however, this makes it easier for the reviewers to follow the presentation.

5.6 Disqualification Guidelines

The following are grounds for removal from the competition.

1. Any team found to be copying a PDR/CDR document from a previous competition will be disqualified from the competition.
2. Any team not meeting the basic competition requirements by CDR will be disqualified. This means teams using requirements from previous competitions and not following the current mission guide. This is an indication of teams copying a design from a previous competition.
3. Teams not demonstrating an understanding of the requirements of the competition will be disqualified.
4. Any team copying slides, content and designs from other teams will be disqualified.
5. Teams not submitting PDR and CDR documents in the required PDF format and file name convention as stated in the competition guide will be disqualified.
6. Teams not submitting PDR and CDR documents by the due dates will be disqualified.
7. Teams not scheduling presentation times by the specified date will be disqualified.
8. Teams not attending the PDR and CDR teleconference within 15 minutes of the set time will be disqualified. Find a phone that works. It can be a landline or mobile phone.
9. Excessive arguing with judges or any staff.

6. Launch Weekend

6.1 Schedule

All times are referenced to central daylight time.

The competition starts Friday and ends Sunday evening.

Flight readiness review and safety inspection and preflight briefing will occur on Friday starting at 12 pm. The preflight briefing starts 7:30pm.

Saturday will be the launch day unless weather causes a postponement.

Sunday will be Post Flight Review presentations.

A detailed schedule will be provided at a later date. Be available Friday at noon until Sunday 8:00 pm.

6.2 Flight Readiness Review

Friday, teams are required to have their CanSats inspected for flight worthiness. Each team will be assigned a one half hour time slot to present their CanSat. This means the CanSat must be completed, built and ready to launch at the flight readiness review. A ball of wires and boards does not constitute flight ready. To emphasize, when presented at the Flight Readiness Review (FRR), it must be in a state where it can be turned on and placed into a rocket for immediate launch and be fully operational. **Flight Readiness Review will be scored once.**

6.2.1 FRR Sequence of Events

Teams must be prepared to demonstrate the ground station.

The first test will verify communications with the CanSat and demonstrate the ground station software. The ground station software operations will be scored at this time. The ground station must show data being plotted in real time.

The CanSat will be inspected for safety. The structure will be reviewed and determined if it is flight worthy. The mounting of the electronics and sensors will be reviewed. Mechanisms will be reviewed. Hazards will be identified such as heating elements exposed to the outside, etc.

The last test at the FRR will be the drop test. The CanSat must be in flight configuration and will be subjected to the drop test. If the test fails, the team must make repairs before being allowed to fly. The CanSat must pass the drop test in order to be launched.

If any CanSat is determined to not be flight ready, the team has until their flight the next day to make repairs and modifications. This is done to make sure your CanSat is completed before coming to the competition and for the safety of all people on the field.

Safety is highest priority. Any CanSat deemed not flight worthy will not be flown. The team

will lose all flight day points.

Crew assignments must be submitted at the flight readiness review in the Mission Operations Manual. The mission control officer will be given an identification so the flight coordinator and launch control officer knows who is the mission control officer. The missions operations manual will be reviewed at the FRR.

Teams must show photos and videos of all environmental tests required. These tests are described in Section 3.5

6.3 Team Member Launch Operations Crew Assignments

Crew assignments must be submitted at the flight readiness review. The mission control officer will be given an identification so the flight coordinator and launch control officer knows who is the mission control officer.

The missions operations manual will be reviewed at the flight readiness review.
Team Member Launch Operations Crew Assignments

In order to have a successful launch, teams need to coordinate among themselves and with the flight coordinator. Team members need to be assigned to specific tasks and develop a checklist for a successful flight. The following task assignments must be delegated:

Mission Control Officer - This is a single person who is responsible for informing the FLight Coordinator when the team and their CanSat is ready to be launched.

Ground Station Crew - This is one or more persons who is responsible for monitoring the ground station for telemetry reception and issuing commands to the CanSat.

Recovery Crew - This is one or more persons responsible for tracking the CanSat and going out into the field for recovery and interacting with the field judges. This crew is responsible for making sure all field scores are filled in or loss of points will occur.

CanSat Crew - This is one or more persons responsible for preparing the CanSat ,integrating it into the rocket, and verifying its status.

Team members can take on multiple roles except for the Mission Control Officer. The Mission Control Officer should be coordinating all efforts and interacting with the flight coordinator as needed. It is highly recommended that a checklist be developed that steps the crews through the preparation, integration, and flight operations.

Crew assignments must be submitted at the flight readiness review.

6.4 Mission Operations Manual

Each team is required to assemble a mission operations manual. The mission operations manual includes five checklists/operations procedures to be created by the team. The checklists are for configuring the ground station, preparing the CanSat, and integrating the CanSat into the rocket. The launch preparation procedures, launch procedure, and removal procedure are provided. Additional steps can be added by the team. The document is available for download and modification. Each section of the mission operations manual must start on its own page. Pages should be numbered and a table of contents is to be included.

The team must have the mission operations manual assembled into a three ring binder. The mission control officer must use the manual during launch. The mission control operator shall go to the microphone at the launch site and announce their team and go through their launch procedure which will include the count down to the launch.

6.5 Launch Schedule

The launch will start at 1pm. All CanSats are to be submitted at noon. The time period of 8am to 12pm is available for launch preparations and check in. This is the time to set up antennas, ground stations, and final CanSat tests and preparations.

CanSats must be submitted at the check-in by noon. Only one or two team members must be in line with the completed cansat by noon. Teams who submit CanSats after the noon deadline will lose 100 points from launch day points. CanSats must be in flight ready condition in order to be in line. Teams cannot be in line while working on the CanSat. The CanSat must be in the stowed configuration and off when submitted. Teams will be kicked out of the check-in line if they are seen working on their CanSat or their CanSat is not fully assembled in the stowed configuration.

The launch will start at 1pm and will be done in groups of five. Each team will be assigned a round which will be scheduled in one half hour increments. 15 minutes before the launch round, the teams assigned to the round shall retrieve their CanSat, turn it on and insert it into the rocket payload. CanSats shall not be disassembled at this stage. The CanSat must be flight ready and the only thing that can be done to the CanSat is to turn on the CanSat with the power switch. Any team that does not launch in their scheduled launch round will lose an additional 50 points. Any team that requires to unload their CanSat from the rocket after the rocket is mounted on the launch pad will lose an additional 50 points. Any team that requires to disassemble their CanSat will lose an additional 100 points.

Each team will be given a thumb drive to upload their ground station data after they perform their flight operation. The thumb drive must be submitted to the judging table before leaving the field.

6.6 Competition Operations and Sequence of Events

Details of flight day operations shall be provided at the Pre-Flight Brief. An overview of the flight day operations include the following activities:

1. Arrive at launch site
2. Prepare CanSat for turn in. Make it flight ready and perform any tests.
3. Turn in CanSat at the check-in table by noon. It will be weighed and fit checked and stored in the stowed configuration and off state until rocket preparation time.
4. Upon the team round, the team will collect their CanSat and load it into a rocket.
5. Verify the CanSat is communicating with the ground station.
6. Take the rocket with the ground station to the assigned launch pad. A staff member will install the rocket on the launch pad.
7. When it is time to launch, a judge will come by the ground station to monitor the ground station operation.
8. The team mission control officer will go to the launch control table and execute the launch procedures with the flight coordinator providing oversight.
9. Ground station crew will perform all required flight operations.
10. After all CanSats have launched for the current half hour round, team recovery personnel can head out to recover.
11. Ground station crew must clear out of the ground station area to allow the next round ground stations to set up.
12. Ground station crew must turn in the thumb drive with any ground station data to the ground station judge.
13. Recovery crew must return to the check-in for any final judging requirements is required.

Teams shall not touch the CanSat until the field judge verifies all necessary scoring information.

6.7 Second Flight Rules

Second flights are rare but do occasionally happen. The following conditions will qualify for a second flight.

1. If the rocket has a catastrophic failure. This includes the motor failing causing the rocket to crash or rocket parachute fails to deploy and crashes with the CanSat still inside. This event will require the team to have a working spare CanSat that can be prepared and made operational within an hour.
2. If the nose cone does not release keeping the CanSat from deploying and the CanSat has passed the fit check. Containers wider than 125mm and still flown will not get a second flight.

All are contingent on enough spare motors being available.

A team whose CanSat is destroyed due to a rocket failure will receive all launch day points only if they passed the drop test, the fit check, and the FRR tests and inspections otherwise no points will be received for the launch day.

6.8 Weather Delays

If weather conditions require the Saturday launch to be postponed to Sunday, the post flight

reviews will be cancelled. Scores from PDR, CDR and the launch day will be used to determine the final rankings. Awards will be held Sunday evening.

If both Saturday and Sunday do not allow for launches, the final rankings will be based on PDR, CDR and flight readiness reviews.

Appendix A Field Safety Rules

1. Consumption of alcohol is not allowed.
2. Smoking is only allowed at designated areas. If anyone is caught smoking where it is not allowed, the landowner can throw you off the field.
3. Do no catch rockets or CanSats out of the air.
4. Stay behind the designated range line unless the range safety officer (RSO) or launch control officer (LCO) or flight coordinator has given permission to put your rocket on a pad.
5. Pay attention at all times. Every launch is potentially hazardous.
6. If a “heads up” launch is announced, you must be standing and facing the launch pad.
7. Do not retrieve a rocket from the range unless the LCO had given you permission.
8. Everyone must be alert when a “heads up!” is called and be ready to move.
9. Do not litter. Do not throw trash on the ground anywhere on the field. We have been invited to use the land owner's field and should treat it with respect. Any team caught throwing trash on the ground anywhere will be disqualified from the competition and the school will be notified of the disqualification. The landowner can order the team to leave the property and enforce the order.

Appendix B Presentation Recommendations

The following recommendations for presentation content and layout are being provided based on past experiences of the judges. These recommendations are not required to be followed but make it easier for the judges to review the material presented.

1. Use a consistent table format throughout the various subsystems when presenting requirements, component trades, and changes since previous reviews. Using a standard table format makes it easier for the judges to find the information in the table quickly since all tables are formatted the same.
2. During the CDR, the Changes Since PDR slides should use a table that contains a discussion of what the state of the design was at PDR, what it is at CDR, and what the rationale of the change was. Details of the change can be discussed in subsequent slides so an in-depth discussion is not always necessary.
3. Include the class year (freshman, sophomore, etc.) and major of each team member for reference. This doesn't play into the scoring of the team, however, it is often nice for the reviewer to know the status of the team members.
4. Be sure to follow the PDR and CDR outlines very carefully. Provide at least one chart for each scored item in the outline; this makes it easier for the judges to follow the presentation and confirm the required information is provided. In the presentation, be sure to address the questions and topics listed in the "description" column of the presentation outline -- those are the key points the judges are looking for.
5. Be clear which optional requirements, if any, are to be included in the design.
6. Be detailed in test descriptions. Identify specific tests, what is going to be done, and the pass/fail criteria.

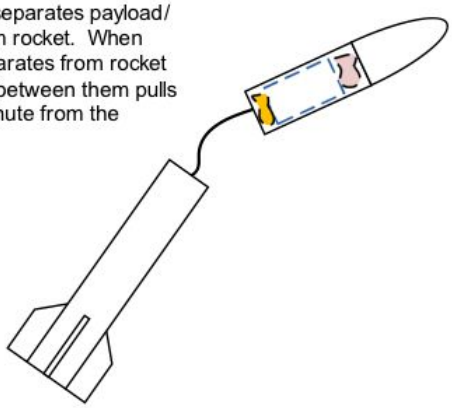
Appendix C Payload Deployment Description

The figure illustrates a typical launch and separation sequence. Due to this nominal

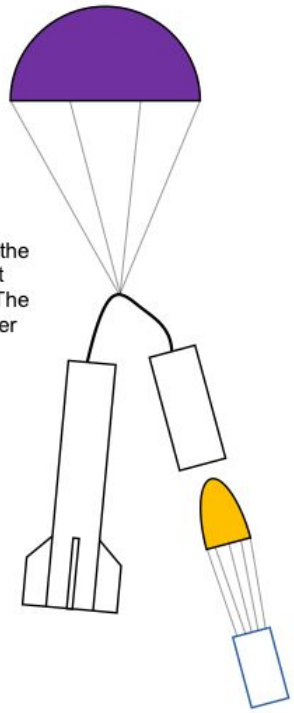
deployment sequence, it is recommended that CanSat be integrated with the payload section “upside down” such that the folded CanSat parachute rests on the payload section bulk plate. The CanSat then rests on the parachute and the folded nose cone parachute rests on the CanSat. Once the ejection charge burn is completed, the payload section and nose cone separate from the rocket and tip over. The nose cone slides out of the top of the payload section and the CanSat then falls out of the payload section due to gravity.

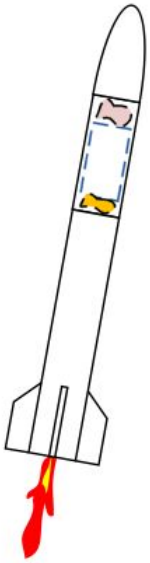
If a mission does not require a parachute at deployment from the rocket, the nadir pointing end of the cansat shall be facing toward the nose cone.

Ejection charge separates payload/ nose section from rocket. When front section separates from rocket the shock chord between them pulls the rocket parachute from the rocket.

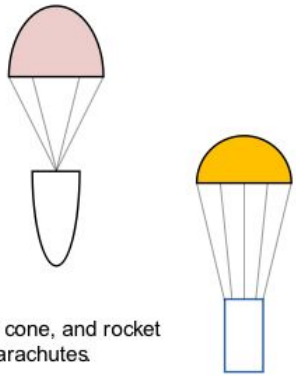


When the front section tips over, the nose cone falls off and the cansat falls out of the payload section. The cansat parachute now inflates over the cansat.





Cansat rests on its parachute.
The nose cone parachute rests on the bottom of the cansat.



The cansat, nose cone, and rocket descend under parachutes.

Appendix D Acronyms

A	Analysis
CDR	Critical Design Review
CONOP	Concept of Operations
D	Demonstration
DCS	Descent Control System
FRR	Flight Readiness Review
GCS	Ground Control Station
HW	Hardware
HWR	Hardware Review
I	Inspection
LCO	Launch Control Officer
PDR	Preliminary Design Review
PFB	Pre Flight Briefing
PFR	Post Flight Review
RPM	Revolutions Per Minute
RSO	Range Safety Officer
SOE	Sequence of Events
T	Test
TBD	To Be Determined
TBR	To Be Resolved
VM	Verification method

Appendix E Definitions

Analysis	Verification method that utilizes evaluation of data generated by accepted analytical techniques or simulations under defined conditions to show the item will meet the specified requirements.
CDR	A multi-disciplined technical review to ensure that the system under review can proceed into system fabrication, demonstration, and test; and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints.
CONOP	Describes what the system will do and the way the system works from the operator's perspective. The CONOP is a high level description that should include a top-level block diagram.
Demonstration	Verification method that utilizes a qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation.
Inspection	Verification method that utilizes an examination of the item against applicable documentation to confirm compliance with requirements.
Need Date	Latest date a component or element (software, etc.) must be received or completed in order to not impact the end completion date.
PDR	A multi-disciplined technical review to ensure that the system under review can proceed into detailed design, and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints.
Shall	Verb used to indicate a requirement is binding. All shall statements require verification.
Should	Verb used to define a goal or non-mandatory provision.
Test	Verification method utilizing operation of all or part of the item under controlled conditions, either real or simulated, to determine that the quantitative design or performance requirements have been met.
To Be Determined	An item or parameter that has not been specified at the time of document release.
To Be Resolved	An item or parameter that is preliminary or uncertain at the time of document release and for which a final value is to be specified at a later time.
Validation	Confirms that the system, as built (or as it will be built), satisfies the user's needs. Confirmation you built the right thing.
Verification	Confirms that the system, its elements, its interfaces, and incremental work products satisfy their requirements. Confirmation you built the

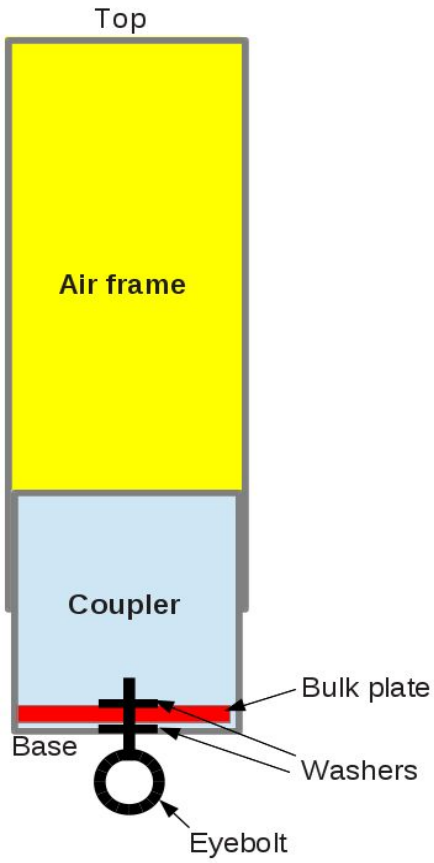
	system right.
Will	Verb used to reference a binding or hard requirement elsewhere in the document text.

Appendix F – Payload Section

This information is provided to allow teams to build a test rocket payload section.

The payload section consists of a 20 inch long cardboard airframe tube, a coupler that slides into the air frame, a bulk plate and an eyebolt.

The top of the payload section is the open end where the cansat is inserted and the nose cone is inserted. The base of the payload section is the opposite end where the coupler is secured and the bulk plate is secured with the eyebolt.



Assembly sequence:

10. Epoxy the bulk plate to one end of the coupler tube.
11. Secure the eyebolt to the bulk plate. Place the washers on both sides of the bulk plate when securing the eyebolt.
12. Epoxy the coupler into the air frame with only half the coupler inserted in the airframe. Make sure no epoxy drips onto the exposed end of the coupler tube. It has to be clean and smooth for it to fit into the rocket.

Alternative to epoxying the coupler into the airframe is to use four screws or click-lock shank rivets.

Link to the payload kit:

https://www.locprecision.com/product/payload-bays/

Select the 5.38x20 inch payload

Link to the rocket kit:

https://www.locprecision.com/product/minie-mag/

The rocket motor used will either be a Cesaroni I303 or Aerotech J425.