In the name of Allah

Aerospace Research Institute
Ministry of Science Research and Technology

Guidelines for Scientific-Exploration Class of The 10th International Iran CanSat Competition 2024

Author:
Organizing Committee of the Iran CanSat Competition

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1 INTRODUCTION

The 10^nd International Iran CanSat Competition contains two classes:

1. Remote Sensing-Communication
2. Scientific-Exploration

Iran CanSat competition provides teams from all over the world with an opportunity to design, build, and complete the flight mission of CanSat (a small satellite integrated within the volume of a drink can). Teams can participate in one or both classes.

1-1 Mission Description

In the Scientific-Exploration class, the CanSat mission aims to simulate an automated space system capable of landing on a hypothetical planet.

In this mission, following the CanSat's release from the designated altitude (exceeding 300 meters above the ground), it must autonomously employ control mechanisms without receiving ground commands. During the mission, the CanSat will execute flight maneuvers, including stabilization, glide to the target range's upper position, and spiral maneuvers, before landing within a designated circular area with a diameter of 5 meters. Note that for this class, the CanSat must utilize a fixed retractable wing for its flight.

Throughout the flight, the CanSat will gather and store pressure, temperature, altitude, and position data on an onboard memory card. Simultaneously, it will transmit real-time images and sensor data to the ground station for online monitoring. This comprehensive data acquisition and transmission capability enables real-time monitoring of the CanSat's performance and environmental conditions.

Note: If the CanSat can autonomously navigate towards the ground target using its camera and machine vision capabilities, it will be awarded additional points.

Note 2: Presenting a flight simulation report that accurately captures the CanSat's flight trajectory from launch to landing, modeled using a flight dynamics model, will earn additional points.

Note 3: Demonstrating a strong correlation between the flight simulation results and the actual flight test results will earn additional points.

1-2 Mission Scenario

Note that the critical and preliminary design must be compatible with the CanSat competition scenario as follows:

1. CanSat is turned on and placed in the launcher's container. The launcher system for ascending and releasing CanSats is designed by competition organizers.
2. The ascending CanSat collects mission data (such as temperature, pressure, etc.) and simultaneously transmits them to the Ground Station.

   Note 2: Each team should develop and have its own Ground Station.

3. CanSat is released after reaching the specified predefined altitude of the competition. CanSat must also collect and transmit data during the release phase.
4. The CanSat must utilize its onboard camera to capture images of the designated target area on the ground. These captured images must be transmitted to the ground station either during the flight or post-flight.
5. Upon release, the CanSat must autonomously navigate towards the designated target location using its control mechanisms. Once it reaches the target area, it must execute a spiral maneuver (spiral flight) to achieve a controlled landing within the designated target circle (Fig.1).
   Note: The precise coordinates of the ground target, including latitude and longitude, will be disclosed to teams on the day of the competition. However, teams are encouraged to employ additional methods, such as image processing, to identify the target and refine their navigation approach.
   Note 1: Due to high-altitude release, wind conditions will inevitably be present. Participating teams should consider wind as an external disturbance factor and incorporate it into their control algorithm.
6. Arriving at a targeted location, the CanSat stops and announces its presence so that it can be traced. The speed of the glider should be measured during the mission by using a mechanism independent of GPS. Then, it should be compared with the speed calculated by GPS.
7. After finding CanSat, it is turned off and the mission is over.
8. The final scores for the competition will be determined through a combination of ground observations conducted by the referees' committee and an assessment of the teams' image processing mission performance. Specifically, the referees will

measure the distance between the landing point and the designated target location to evaluate the accuracy of the CanSat's navigation capabilities.

Fig. 1 Cansat Mission Scenario

The following figure shows the schedule of the competition day.

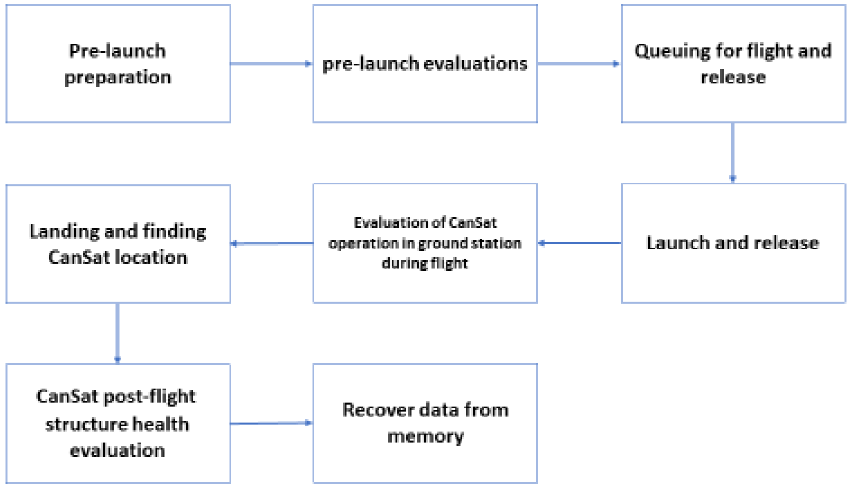

Figure 2: Schedule of the competition day

2 OPERATIONAL AND FUNCTIONAL REQUIREMENTS

1. Operation after being released from an altitude of 300-350 meters above the ground
2. Stabilization of the cansat and Target detection
3. Navigate towards the designated target location using its control mechanisms
4. Executing a spiral maneuver (spiral flight) to achieve a controlled landing within the designated target circle measuring and reporting the vertical velocity, independent of the positioning system
5. End of operation in the predefined area from the target point
6. End of operation within a prescribed time (maximum 5 minutes from releasing)
7. Maintenance of the structure and subsystems and their operation during safe landing
8. Quality of the search signals after stop (messages/signals must start 5 seconds after stop and last for 60 seconds in the form of light/ sound/radio signal)
9. Measuring parameters include:

   Mandatory:

   -air pressure

   -geographical location

   -vertical velocity

   -ambient temperature

   -image

   -height

   Optional (with extra scores):

   - humidity

   - Linear and rotational velocity

   - Horizontal velocity independent of the location system

   - Or any other parameters approved by the referees' committee

10. Capturing images/videos from the target area during landing
11. Accurate and on-time measurement of parameters
12. Sending measured parameters to the ground station

13. Valid and reliable telecommunication between Ground Station and CanSat without interference
14. Updating data rate at least every second
15. Recovering/Retrieving recorded data from memory after operation
16. Appropriate graphical display of received and analyzed data immediately in Ground Station
17. Quality and resolution of transmitted and stored images:
    - Images should be completely transmitted in digital format
    - At least three images should be transmitted at the time of descent
    - The images must be compressed while transmitting to the ground station

19. CanSat glider must glide in a circular pattern with a diameter of about 300 meters. Use of control mechanisms without receiving commands from the ground is allowed

2-1 Dimension and Mass Requirements

1- The maximum diameter of CanSat should be 150 mm
2- The maximum height of CanSat should be 250 mm
3- The maximum mass of CanSat should be 1000 gr

*Disobeying the above-mentioned rules will result in score penalties or prohibition from the competition.

2-2 Table of Technical Requirements

Technical requirements and their approval methods in the conceptual and preliminary design phase of CanSat are categorized in the following table as an example:

code	**requirement**	**source**	**Physical specification**	**priority**	**Approval method**			
					Design review	**test**	**analysis**	**control**
1	The mass of CanSat must be less than 1000 gr	competition	structure	high				✓
2	In professional	competition	structure	hight				✓

	class, CanSat dimension must be (250 mm height and 150 mm diameter)							
2	CanSat must be compatible with the ascending system (during ascending, acceleration changes in design must be considered)	competition	Structure, recovery	high				✓
3	CanSat must land safely to the ground(conditions of descend, acceleration changes, and landing, … must be considered in design)	mission	recovery	medium		✓		
5	The use of toxic and flammable materials is not allowed in the design of CanSat	competition	structure	medium		✓		
6	CanSat must obey the radio frequency rules	competition	Telecommunication	high	✓		✓	
7	CanSat must measure	mission	payload	high		✓		

	cinematic parameters							
8	CanSat must collect data related to atmospheric sensor or data in payload such as temperature or payload image	mission	Data management and command	high	✓			
9	CanSat must transmit GPS data, sensors data, and cansat health status information	mission	Transmission/telecommu nication	mediu m	✓	✓		
10	CanSat must be in operational status for 90 minutes	Operatio n concept	power	low		✓	✓	
11	CanSat must be resistant to operation load (launching phase, phase of releasing before releasing of controlling mechanism, releasing using controlling mechanism, and landing)	Operatio n concept	structure	mediu m		✓	✓	
12	Each CanSat must be equipped with a beacon system to declare its	mission	payload	high			✓	

	presence at the location							

3 COMPETITION RULES

1- CanSat teams consists of 3 to 5 people and a supervisor can be introduced separately in the registration form.

2- The representative of each team for correspondence is the head of the team and all correspondence is done through the supervisor.

3- The change of team members is done at the request of the team leader, and this change can be made before the final teams are announced (declaration of the results of the detailed design and construction report).

4- All opening parts and connections must satisfy the dimension of CanSat class before release. Exceptions are as follows:
Competition organizers are responsible for providing the means for the launch and release of the CanSat which satisfy the dimensional requirement.

5- CanSat will be released at an altitude of 300-350 m according to weather conditions.

6- CanSat shall conform to dimensional constraints of their categories and fit in the release system without causing any interference to the performance of the release system.

7- The teams must comply with the radio frequency regulations in their design and development.

8- The final product shall be in conformance with the Critical design and manufacturing report (CDR). Any difference between these two may lead to score penalties. Significant dissimilarity of the CanSat by the CDR report will lead to disqualification and elimination from the competition.

9- Considering the goals of the competition, each team should put their effort into gaining knowledge and experience in the design and development of a system. Therefore, the use of any commercial off-the-shelf (COTS) modules/equipment as a CanSat total subsystem is not allowed. COTS modules can be used as constructive parts of subsystems.

10- The use of toxic and flammable materials is not allowed in the design of CanSat, and on the competition day. In case of incorporating any hot/hazardous parts in CanSat design, the organizer team must be informed and their confirmation must be obtained well ahead of the competition time

11- CanSat shall operate autonomously and no command from Ground Station is allowed to be sent during the operation scenario (telecommand is not allowed)

12- Cansat must execute flight maneuvers, including stabilization, glide to the target range's upper position, and spiral maneuvers, before landing within a designated circular area.
13- After landing, the apparent structure of CanSat, the integrity of systems (mechanically and electrically), and fulfillment of these conditions will be evaluated.
14- The electrical power supply subsystem of the Cansat must provide the required power for the entire operation time, including the time required for gliding flight and recovering after landing and at least 60 minutes before the operation.
15- The team name shall be printed on the CanSat to help with the identification of the CanSats. Also, a colored ribbon, which is visible from far away, must be applied axially to the surface of CanSat.
16- Each team shall design its own Ground Station. As ground station design significantly affects the presentation of CanSat functionality, teams should pay enough attention to the design of the Ground Station.
17- Considering the tight schedule on the operations day, each CanSat will only have one release chance, and the results and operation during the release will be used for evaluation.
18- After landing and recovery, each CanSat will be evaluated by the referees, data will be recovered, and CanSat will be given back to the team representative.

3-1 Radio Frequency Regulation

The communication frequency of the CanSat with the ground station should be in the range of amateur radio frequencies of: 430-440 MHz or 2400 to 2450 MHz. Transmitted power shall be less than 20 dBm (or 100 mW). Teams shall report their utilized operating frequency and transmitted power in their CDR. Teams must be ready to apply slight changes in their operating frequency in case of interference with other teams or the launching system occurs. After the CDR report and confirmation of the frequencies, affected teams would be notified of these necessary changes in the frequency band. Also, if using any network-supported communications module, each team should choose a unique random NETID/PANID code. The network settings including NETID/PANID code must be reported in CDR.

3-2 Data Format

Data packages should have the following formats respectively (read from left to right), and delivered to the referees on flash memory or CD. The comma (,) should be used to separate data pieces. File extension should be .CSV or .TXT. This order of data storing is known as alpha recovery.

The order of storing data (alpha recovery) is (read from left to right):

<Abbreviation of team name with at least three letters>, <Mission time since release>, <Data packet count>, <Longitude>, <Latitude>, <Altitude>, <Temperature>, <Pressure>, <Humidity>, <UV indicator>, <Other optional data>, <CR>

Example:

ARI, 3.37, 153, 35.423, 52.487, 121.2, 25, …

4 REPORTS

Each team should provide three technical reports. Reports shall be following a predefined format and schedule explained in the following list:

4-1 Preliminary Design Review (PDR)

Objective:

Understanding design requirements and constraints

Understanding essential subsystems

Understanding communication subsystems

Understanding of system stability

Connection between the control system and modification of the flight trajectory

Understanding the design process

Planning financial, time, and human resources

Content:

Explaining design requirements

Defining and explaining subsystems to address the design requirements

Preparing scenario and operational concepts

Team introduction

Presenting configuration and layout

Presenting subsystems' specifications

Presenting architecture and relation between system and subsystem's components

Fundamentals of theoretical and scientific design

Test design and product standardization

Studying and statistical matching

Product development schedule (Gantt Chart)

Financial and human resources budget

4-2 Critical Design and Manufacturing Report (CDR)

Objective:

Presenting design with details of components, modules, subsystems, and systems

Presenting relation between designed subsystems

Presenting functional quality test results for components and subsystems

Presenting product features based on the design specification and test results

Presenting flight simulator output (if available)

Providing details and capabilities of the Ground Station

Providing an operational checklist from the beginning of the launching moment to the end mission

Providing financial, time, and human resources budget

Content:

Providing concept of operation (CONOPS), operational requirements, and aging profile.

Providing details of critical design of subsystems, providing changes and improvements of preliminary design

Proving coverage of design requirements by designed subsystems

Presenting test results and verifying operational/functional quality test

Presenting the designer's prediction of system operational capability by providing measurable statistics and data

Presenting the architecture and configuration of the system and relationships between the subsystems

Details of the design and setup of the ground equipment

Providing details of the overall operation phases

a preliminary plan of pre-launch operation

updating human resources and financial budget

Updating the initial scheduling (Gantt Chart)

4-3 Post Operation Report

Objective:

Evaluation of system performance compared with design objectives

Estimating operation success

Analyzing function of Components and Systems

Content:

An overview of the operational objectives of the plan

Comparison of operating scenarios with the operations performed

Providing raw data as well as the results of analyzing these data

Introducing the strengths and weaknesses of the design and providing solutions for improvement