

**3<sup>rd</sup> International  
CanSat Competition  
LEEM-UPM**



**26<sup>th</sup> to 28<sup>th</sup> July, 2012**



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## Acronyms List

CDR	Critical Design Review
CONOPS	Concept Of Operations
LCO	Launch Control Officer
LEEM	Laboratorio Para Experimentación en Espacio y Microgravedad
MSDS	Material Safety Data Sheet
PDR	Preliminary Design Review
RSO	Range Security Officer
UPM	Universidad Politécnica de Madrid



## 1. Introduction

A CanSat is an autonomous device capable of performing a certain mission, implemented inside a soft drink can. All basic functions of a satellite (communications, powering, etc) are implemented within a 330 ml can, which results in a great learning platform for all students interested in designing, manufacturing and analyzing satellite operations.

This initiative intends to offer students the first contact with a real project and all its typical phases, like mission design, PDR, CDR, certification, launch campaign, results analysis, etc. The objective is to motivate students giving them a real sight of their future career.

From LEEM, it is considered that approaching a high quality project, along with Space industry specifications, is a personal and professional challenge for University students. Through this opportunity, students can learn really useful skills for their future professional career, understanding the feasibility of a project, learning teamwork aptitudes and getting a global sight of all the parameters that lead to a successful project culmination.

Participants Registration is open until April 15th, 2012 at the dedicated website. All teams will then undergo a Preliminary Design Review (PDR) on May 10th in order to ensure the Competition Guidelines have been correctly understood. After this review, LEEM will consider if the team and its Cansat will be able to take part in the Competition. The Critical Design Review (CDR) will take place the 24th of June; all teams must submit their final documentation by this date. Finally, from 26th to 28th July; the “3rd International CanSat Competition LEEM-UPM” will be celebrated in Madrid.

The Contest is open to all high school and university students from any country.

## 2. Categories

The 2012 Competition covers the following categories:

1. **ComeBack:** The CanSat must navigate by its own means until stopping as near as possible of a target located on the launch field ground. The main parameter of evaluation will be the closeness to the target, but it will be also assessed the device originality, subsystem design and navigation algorithm.
2. **Rocket Subsystem:** This category is used to select the team who will develop the relevant subsystem for LEEM Sounding Rockets families. During this first CanSat Competition it is proposed the Communication and Telemetry subsystem. The CanSat should send, in real time to a ground station, data of barometric altitude, temperature, acceleration, GPS location and events (ejection of the CanSat from the cargo bay, opening of the parachute, etc). It will be assessed the device originality, the accuracy for achieving the objectives as well as the telemetry and whole subsystem design.
3. **Scientific Experimentation:** This category is open for those teams who want to test a certain subsystem, aiming at the design of a future CanSat, or performing a scientific experiment of diverse nature. For all the CanSats in this free category it is assessed the success in achieving the objectives, originality, design and scientific relevance of the measurements made. LEEM suggests the design of a planetary probe (the CanSat should perform relevant missions considered by the team in order to explore a new



planet: measuring of temperature and pressure, modules separation, take pictures, etc.)

The jury will assess the performance of each CanSat in the Launch Field. The points related to originality and design of the CanSat will be decided based on the documentation submitted by teams in the CDR.

The rate of success in achieving the objectives each team has undertaken (as declared in the CDR documentation), will be assessed in the presentation of the results, the day after the flights.

The jury will take into account the background level of the team members, the external help received and work hours spent while building the CanSat, as well as the economical budget, with the aim of issuing the verdict that values the real efforts of the students.

## **3. Competition Rules**

1. All the participant teams must send before the Sunday 13th of May of 2012 the required documentation for the Preliminary Design Revision (PDR).
2. All the participant teams must send before the Sunday 17th of June of 2012 the required documentation for the Critical Design Review, and prepare a small presentation of the project (Briefing) with a length of 10 slides (15 minutes) at most, that will be presented before the launch campaign.
3. All the participant teams must make a presentation with a length of 15 slides (20 minutes) at most, after the launch campaign (Debriefing).
4. All the documentation (PDR, CDR, presentations) must have been written and exposed in English. No other language will be accepted under any circumstances

### **3.1 Teams**

The teams shall be composed of a minimum of 3 members and a maximum of 6. A participant cannot be member of more than one team at a time. The teams must submit an application to the Competition pointing out the team leader who will be the only contact point with the Competition Organization. A picture of the team shall be also attached to the application form.

Teams are invited to submit their own team logo design. This logo will be painted on the rocket that will be used for launching the team's CanSat. The Team logo will remain on the rocket for future editions of the Competition.

All teams must be composed by students or young professionals who have graduated during the three months prior to the date of the Competition. All the teams/persons that do not fulfil this requirement are invited to launch their CanSat on the Launch Day but not to participate in the Competition.

If a Team is developing its CanSat under a teacher or senior professional supervision, this condition must be indicated in the application form. The supervisor is welcomed to attend the competition events and the launch day.



## 3.2 CanSat

All the teams must develop a CanSat according to the following specifications:

1. All the components must be integrated in a structure like an European standard soft drink can (115 mm-height and 66 mm-diameter)
2. The maximum mass of the CanSat is limited to 350 grams.
3. The attachment of the recovery system must withstand 20 Gs in the moment of its deployment. This attachment must be fixed directly to the primary structure.
4. The antennas, transducers and other devices of the CanSat cannot oversize the can diameter until it leaves the rocket cargo bay.
5. The deployable subsystems and recovery system can exceed the length of the primary structure, up to a maximum length of 230 mm.
6. Explosives, detonators, pyrotechnics, flammable or dangerous materials and biological payloads are strictly forbidden. All materials used must be safe for personnel, equipments and environment. MSDS will be requested in case of doubt.
7. The CanSat will have to detect autonomously the separation from the rocket. For this reason, the use of timers or photoelectric sensors for this aim, are strictly forbidden. The organisation recommends the use of mechanical devices, such as pressure sensors or "Kill-switch"
8. The Power Supply of the CanSat must supply the systems during 1 hour at least.
9. The total cost of the CanSat cannot exceed 1000 Euros.

## 3.3 Openclass

It is necessary more than 4 teams inscribed in this category in order to provide a helium balloon to release "OpenClass" CanSats, although in the present edition this type of CanSat will not enter the Competition. The "OpenClass" requirements remain the same as for a standard CanSat, except for these requirements:

1. Overall dimensions: 240 mm-length and 146 mm-diameter.
2. Maximum mass: 1050 grams.

OpenClass CanSats will be released at an altitude of 50 meters above ground level.

## 3.4 Categories

### 3.4.1 Comeback

The navigation of CanSats within the Comeback category must be autonomous. Teams are authorized to download the telemetry but it is strictly forbidden to send navigation data from the ground station.

The target that should be approached by Comeback CanSats will be marked by means of a red cone with reflecting tape. Teams can get to the target before assembling the CanSat into the



rocket to get their own measurements of the target coordinates and/or upload them in the CanSat. The organization won't announce the target coordinates.

Teams willing to use an optical approach system are allowed to locate some type of indication in the target area. In any case, it remains forbidden the use of any type of active device that sends signals to the CanSat.

#### **3.4.2 Rocket Subsystem Category: Telemetry**

In this category (Telecommunications and Telemetry edition), the CanSat should send, in real time to the ground station, the following minimum data:

1. Barometric altitude
2. External Temperature
3. Acceleration (at least along the longitudinal axis of the CanSat)
4. GPS location
5. Sensing of two events:
  - Parachute deployment
  - Opening of a hatch in the CanSat

#### **3.4.3 Scientific Experimentation**

This category has been created with no restrictions, for those teams that want to test certain subsystems for the design of a future CanSat or to carry out any kind of scientific/ technological experiments. The success of the CanSat mission, in its aims, will be valued. Also the originality, the design and the scientific relevance of the measurements will be valued. To be able to launch, they will have to carry out at least the 80% of the declared design objectives in the CDR. The organisation will value the relevance of the scientific experiment or the originality of the technological system to be tested.

### **3.5 Documentation**

The participating teams must submit to the Organization the documents needed for the design reviews (PDR and CDR) on time. The minimum contents of these documents are explained in an example form, available in the Competition website.

#### **3.5.1 PDR y CDR**

The aim of the PDR is to ensure that all teams have correctly understood the Competition requirements and so the CanSat design has taken into account these specifications. LEEM technicians will review the documentation and possible comments will be transmitted to the team in order to solve the issues found.

The CDR documentation will be submitted to the jury in order to assess the originality and quality in the design, economical budget and external help received by the team. The designs will be frozen in the CDR and any later modification must be announced to the Organization before the reception of the CanSats, the day before the Launch sessions.



### **3.5.1 Deadlines**

**PDR:** until 20<sup>th</sup> May, 2012

**CDR:** until 24<sup>th</sup> July, 2012

### **3.5.2 Briefing**

In the Competition briefing, that will take place the morning before the Launch day, each team will make a brief presentation of its CanSat (less than 10 slides and a maximum of 15 minutes), and show the objectives of its mission. This briefing is used to present the CanSat to other participants.

### **3.5.3 Presentation of the results**

The Debriefing of the Competition will take place the day after the Launch day. In this event, each team must present the data obtained during the flight and the Mission Analysis (15 slides and a maximum of 20 minutes). The minimum content of this presentation will be the following:

1. Description of the mission objectives.
2. CONOPS (Concept of Operations)
3. Description of the definitive design.
4. Graphics of the gross data obtained during the flight.
5. Data analysed, showing the results.
6. Success/Failure Analysis.
7. Comparison with the initial design concept.
8. Conclusions.

## **3.6 Financial Budget**

Each team must submit by the CanSat reception a detailed budget reflecting all the costs incurred in manufacturing the CanSat. The total cost of a CanSat is limited to 1.000 Euros. Other costs like the ground station, ground support equipment (GSE) or auxiliary devices are not limited, but should be included in a dedicated section of the budget.

Teams must also submit a report reflecting the work hours dedicated to the project. This report shall specify the hours dedicated to design, construction and test phases, and must point out the external help received as supervisor dedication or mechanical developments. This report will be used by the jury to appreciate the student efforts in the whole project.



## 4. Operation in the Flight Field

### 4.1 Preparation

Work benches and sockets will be provided inside the hangar to make final preparations since participants' arrival to the launch field. Half an hour before the start of each launch batch, the teams can proceed to their tent in the flight line to prepare their ground station and auxiliary equipment.

The flight line will be placed along the limit of the restricted area, providing a direct view of launches and in-flight operations.

### 4.2 Launch Schedule

Tras el lanzamiento y posterior recuperación del Cohete y CanSats, se procederá a preparar la siguiente tanda de lanzamiento, la cual tendrá lugar entre los 30 y 60 minutos posteriores, con el objetivo de que se preparen los equipos de tierra en la línea de vuelo y reacondicionamiento de los cohetes.

Due to the rockets used in this third edition will be able to launch two CanSat at the same time, each team will be assigned to a launch batch in advance, jointly with other team. 15 minutes prior to the start of a batch, the rockets will be available to integrate the CanSat on its Cargo Bay.

Five minutes before the batch starts, the two CanSats should be ready for launch, the rocket placed on the launch ramp and electronic devices switched on. The security perimeter around the launch ramps will be evacuated and access will be allowed exclusively to security personnel and Launch Control Officers (LCOs).

After the launch and recovery of the rocket and two CanSats, the next batch will be prepared to be launched between the following 30-60 minutes in order to prepare the new ground equipments in the flight line and refurbish the rockets for the following batch.

### 4.3 Delays

If any reason external to the team (meteorology, logistic issues in the Flight field, launch operations, etc) leads to a delay in the launch ramp of 45 minutes or more, the affected team will be allowed to replace the CanSat batteries, in order to launch within the same batch.

If the team is responsible for the delay, the organization can declare the batch finished. The team will have the opportunity to launch its CanSat in the last batch of the day.

In case the flight has not been successful for any reasonable issue (in opinion of the jury); the team could be allowed to repeat the launch in the last batch of the day, just one more opportunity per team. The final decision belongs to the jury.



If meteorology makes impossible to launch during the Launch Day, an indoor demonstration will be made instead. The decision of the jury will be limited to assess the documents submitted in the CDR.

## 4.4 Communications

The frequencies used for communications must be related inside the ORDEN ITC/3391/2007 of the 15 of November, for which is approved the CUADRO NACIONAL DE ATRIBUCIÓN DE FRECUENCIAS (CNAF) (National Attribution Frequencies Frame).

Source of information: <http://www.mityc.es/telecomunicaciones/Espectro/Paginas/CNAF.aspx>

For this reason, the communication devices of non-regulated use must use the bands assigned to ISM communications (Industrial, Scientific and Medical). The bands ISM defined by the UIT-R for the Region 1 (were Spain is located) are displayed in the Table 1.

The use of these frequencies bands is open to everybody without the need of a license, respecting the regulations that limit the levels of power transmitted. This fact forces that this kind of communications have a certain degree of tolerance to errors and that use protection mechanisms against interferences, like techniques of widening spectrum.

<i>Frequency Range [Hz]</i>	<i>Central Frequency [Hz]</i>
6 765 – 6 795 kHz	6 780 kHz
13 553 – 13 567 kHz	13 560 kHz
26 957 – 27 283 kHz	27 120 kHz
40,66 – 40,70 MHz	40,68 MHz
433,05 – 434,79 MHz	433,92 MHz
2 400 – 2 500 MHz	2 450 MHz
5 725 – 5 875 MHz	5 800 MHz
24 – 24,25 GHz	24,125 GHz
61 – 61,5 GHz	61,25 GHz
122 – 123 GHz	122,5 GHz
244 – 246 GHz	245 GHz

*Table 1. ICM Bands defined for the UIT-R for the Region 1 (Spain)*

To the teams that want to use the bands assigned to radio ham, the organisation will demand them the Certificate of Operator of Radioelectric Radio Ham Stations according to the legislation in use, and the station's indicative. According to the ORDEN ITC/1791/2006, of the 5th of June, for which is approved the Reglamento de Uso del Dominio Público Radioeléctrico por Aficionados (Regulations of the Use of the Radioelectric Public Domain by Amateurs), the frequency bands and technical characteristics of the application are displayed in the tables: Table 2, Table 3, Table 4 and Table 5.



<i>Bandas de Frecuencias in kHz</i>	<i>Max emission power</i>		<i>Max wideband (-6dB)</i>
	<i>carrier</i>	<i>peack</i>	
135,7 – 137,8	<i>1 w p.r.a</i>		0.3 kHz
1.830 – 1.850	50 w	200 w	3 kHz
3 500 – 3 800	250 w	1000 w	3 kHz
7 000 – 7 100			6 kHz
7 100 – 7 200			
10 100 – 10 150			
14 000 – 14 250			
14 250 – 14 350			
18 068 – 18 168			
21 000 – 21 450			
24 890 – 24 990			
28 000 – 29 700			

Table 2

<i>Frequency Bands in MHz</i>	<i>Max emission power</i>		<i>Max wideband (-6dB)</i>
	<i>carrier</i>	<i>peack</i>	
50 – 51	100 w	--	12 kHz
144 – 146	150 w	600 w	25 kHz
430 – 440	50 w	200 w	25 kHz

Table 3

<i>Frequency Bands in MHz</i>	<i>Max emission power</i>	
	<i>carrier</i>	<i>p.i.r.e.</i>
1 240 – 1 300	10 w	30 dBw
2 300 – 2 450	10 w	30 dBw
5 650 – 5 850	10 w	30 dBw

Table 4.

<i>Frequency bands in GHz</i>	<i>Max emission power (p.i.r.e)</i>
10,00 – 10,50	30 dBw
24,00 – 24,05	
24,05 – 24,25	
47,00 – 47,20	
76,00 – 77,50	
77,50 – 78,00	
78,00 – 81,00	

Table5.

In the moment to carry out the register of the team in the competition, the team must inform about the frequency that wants to operate, this way the organization will be able to distribute the participant teams in different groups. A unique frequency will be assigned to each team to communicate with its CanSat. During the reception of the CanSats, it will be checked with each team that it only operates with a specific frequency. If a team causes interferences with other participants, it must shut off its equipment while it's not its turn of operation and launch.



The use of walkie-talkies will be allowed for the communication between the team members, never for data transfer. This communications will have to be suspended from the evacuation of the security perimeter until the landing of the rocket and the CanSat, during this interval will be used by the security and control personal of the launch area.

## 4.5 Available Information

### 4.5.1 Meteorology

A Meteorology Ground Station will be placed at the launch pad in order to provide participants the following data:

1. Temperature
2. Relative Moisture
3. Relative Pressure (hPa)
4. Direction and velocity of the wind (m/s)
5. Variation trend of the relative pressure

### 4.5.2 In flight measurements

Prior to the participants' launches, the organization will launch a CanSat in order to measure the real flight conditions and the atmosphere. This data shall serve the participants to fine tune the parameters of the CanSat in order to optimize the performances of their device. The organization shall make public plots with the following data versus the barometric altitude:

1. Temperature
2. Acceleration in 3 axis
3. Vibration levels
4. GPS deviation from the theoretical trajectory (qualitative information of wind strength versus altitude)

## 4.6 Field Safety Rules

The following Safety Rules are specified by the organization and shall be complemented with the Safety Rules pointed out by the owner of the launch field:

1. Consumption of alcohol or drugs is forbidden during the Competition events.
2. Is not allowed to use mobile phones or radios inside the restricted area.
3. Is not allowed to smoke near the rocket motors and inside the restricted area.
4. Is not allowed to catch rockets during the falling phase.
5. The audience and the participants shall keep out of the restricted area. The access to the restricted area shall be authorized by the Range Safety Officer (RSO).
6. Everyone shall be alert when the launch of a rocket is announced and shall pay attention to the launch platform. Anyone shall be alert, standing up and ready for moving if necessary.
7. Is not allowed to retrieve rockets without direct authorization of the Local Organization.



8. In case of a rocket or CanSat piece is found at the launch field, it shall be pointed out to the RSO. All the found objects shall be delivered to the RSO.
9. Children shall follow the Safety Rules and shall be under supervision in any moment.
10. Is not allowed to have pets on the launch field.
11. The violation of the safety rules shall result in expulsion from the Competition.

#### **4.7 Insurance**

During the Launch day, all the participants and audience are covered by a Civil Responsibility Insurance which shall cover all the potential damages to third parties produced by the rockets. The participants and audience shall sign a document prior to the launch date about the knowledge and understanding of the safety rules.

The Organizing Committee is not responsible for the damages in the CanSat during the competition in any of the launch phases: lift off, ejection and retrieval.

#### **5. Awards**

The award ceremony shall take place at the debriefing of the competition, the following day of the Launch Day. All participants shall get a certificate of attendance..

#### **6. Event Schedule**

The first competition day (Thursday, July 26th), the participants shall be registered and the devices shall be verified (organization specifications and requirements). Then, the Organization shall perform a briefing where all the competition issues shall be explained in detail, the rocket will be presented to the participants and each team shall present their CanSat and their mission goals.

On the afternoon, the participant teams are invited to show their CanSats at the static exhibition. For this purpose a poster board/area shall be available. On the other hand, a workshop shall be available for the participant teams willing to make final preparations on their devices.

The second day or "Launch Day" shall be celebrated at the Launch Field.

The third day (Saturday, July 28th) shall take place the competition debriefing with the presentation of the participant teams' results as well as the Award Ceremony.

This schedule is going to be updated on the competition website until a month prior to the event when a final programme shall be delivered.



## 6.1 Preliminary Programme

The preliminary event programme for the three days of the Competition should be the following:

### Day 1: July 26th

#### 9:00 Participant reception and register (UPM)

- Badge, Abstract book and Welcome Kit Collection
- CanSat reception: Mass, Measures and Frequencies check
- Poster display. Loading of Presentations

#### 11:00 Competition Briefing

- UPM Welcome Speech
- LEEM Welcome Speech
  - Introduction to the Association
  - Competition Description
  - Rocket Description
  - Future perspectives
  - Acknowledges
- Participants Presentations (15 minutes each)

#### 12:55 Group Picture/1

#### 13:00 Welcome Cocktail

#### 15:00 Static exhibition of CanSats and Rocket

- Possible Demonstration
- Workshop available for CanSat reparation
- Visit to University Facilities

#### 19:00 End of events day 1: Free time

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### Day 2: July 27th

#### 8:30 Bus leaving from Competition Base (Cardenal Cisneros Square)

#### 9:00 Bus Leaving Hotel

#### 10:30 Participants' arrival to the Launch Field

- Teams distribution on the workbenches
- Programme announcement - Music Animation
- Rocket preparations

#### 11:30 VIPs and Press reception (Hangar)

#### 12:00 CanSat Launches

- 3 Rockets series - 30-60 minutes break between two series
- Micro rockets demonstration by high school students

#### 14:55 End of Launches; Group Picture/2

#### 15:00 Lunch at the Launch Field

## **3<sup>rd</sup> International Cansat Competition LEEM-UPM**



**16:00 Participants' Busses leaving the field**

**17:30 Participants' Busses arrival to the Hotel**

**18:00 Participants' Busses arrival to the Competition Base (Cardinal Cisneros Square)**

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### **Day 3: July 28th**

**11:30 Competition Debriefing**

- Introduction by the Organization
- Teams present their results (20 minutes each)

**12:45 Coffee Break. Jury meeting**

**13:00 Award Ceremony (UPM Representative)**

**13:15 Competition Conclusions (Organization)**

**13:30 Closing Ceremony. Bus to the closing lunch**

**14:00 Closing lunch**

**Free time**

**22:30 International Space Party**



## 6.2 Competition Logistics

Each Team must make their own arrangements for accommodation and transport from and to the Competition Base. The Local Organizing Committee shall make reservations in a semi sponsored accommodation for the participant teams.

In the Launch Day, a bus will pick up the participants at the Competition base and the sponsored accommodation in order to move them to the Launch field. At the end of the day, another bus will retrieve the participants to the Competition base and the sponsored accommodation. A map will be provided by the Local Organization for those teams willing to reach the Launch Field by their own means of transportation.

Work benches and electricity shall be available the days of the briefing and launch in order to perform last minute tasks on the CanSats. The organization shall not provide components or tools to the teams.

During the Launch day, the teams will have available a tent with benches in order to install their Ground Support Equipment. This place shall have direct view to the Launch Pad and Flight field. This day, the organization shall provide meals to the participant teams.

## 7. Last Minute Information

Any modification in the schedule or location shall be announced by the competition web site: <http://cansat.leem.es>

## 8. Contact

For more information, do not hesitate to contact the Local Organization Committee  
[cansat@leem.es](mailto:cansat@leem.es)

## 9. Sponsors and Partners





## 10. ANEXO I: System of Evaluation of the Projects

While the evaluation of the technical complexity of the devices will be left in the hands of the members of the jury, from the Organization is especially valuable the Exchange of opinions and personal experiences between the students and professionals of the industry and the following points will be evaluated positively or negatively:

- **Positive evaluations**
  - Global educative experience and learned lessons (to explain during the results display)
  - Previous computer simulations (Fluent, Fortan, Catia...).
  - Parachute design with its own simulations.
  - Development of inboard electronics (not based in integral commercial solutions like Arduino)
  - Use of improvement systems of GPS: SBAS o GBAS. It will be particularly valued the use of EGNOS.
  - Use of manually manufactured systems (example: antennas).
  - Originality of the technique solutions that contribute to the realization of the Project..
  - Getting the economic support of a company, university, institution
  - Having accomplished that the effort is used as an academic project in the University of Origin (end of career project, practices...)
  - Good presentation of the PDR and the CDR
- **Negative evaluations**
  - The use of commercial solutions like: *CanSat Kit*, *Kit Aeromodellismo radio-control*, *Arduino*, etc.