CanSat 2016
Critical Design Review (CDR)
Outline
Version 1.0

5915

METUSAT

Presentation Outline

- Team Overview and Organization
- Systems Overview (Waheedullah Taj)
- Sensor Subsystem Design (Hasan Burhan Beytur)
- Descent Control Design (Yudum Comez)
- Mechanical Subsystem Design (Hikmat Gasimzade, Bahadir Turkyilmaz)
- Communication and Data Handling (CDH) Subsystem Design (M. Yusuf Candan)
- Electrical Power Subsystem (EPS) Design (Yelda Gungor)
- Flight Software (FSW) Design (Furkan Karakaya)
- Ground Control System (GCS) Design (Koray Cimen)
- CanSat Integration and Test (Elcin Ceren Yaldir)
- Mission Operations & Analysis (Elcin Ceren Yaldir)
- Requirements Compliance (Waheedullah Taj)
- Management (Yelda Gungor)

Team Organization

Faculty Advisor
Prof. Dr. Ozan Tekinalp

Advisor
Burak Yaglioglu

Advisor
Farid Gulmammadov

Team Leader
Waheedullah Taj

Alternate Team Leader
Hasan Burhan Beytur

Mission and Systems Engineering
- Yudum Comez (grad.)
- Yelda Gungor (4th yr.)

Communications and Ground Station
- Koray Cimen (4th yr.)
- M. Yusuf Candan (3rd yr.)

Electronic System Design (Sensors, Data Handling & Power)
- Hasan B. Beytur (3rd yr.)
- Furkan Karakaya (3rd yr.)
- Yelda Gungor (4th yr.)

Aerodynamics and Mechanical systems
- Waheedullah Taj (4th yr.)
- Yudum Comez (grad.)
- Elcin Ceren Yaldir (4th yr.)
- Hikmat Gasimzade (4th yr.)
- Bahadir Turkyilmaz (3rd yr.)

Acronyms

A:	Analysis
A/D:	Analog or Digital
ADC:	Analog Digital Converter
C:	Container
CDH:	Communication & Data Handling
CDR:	Critical Design Review
CG:	Center of Gravity
CRN:	Competition Requirement Number
D:	Demonstration
DCR :	Descent Control Requirement
E.M. :	Electro Mechanical
EPS:	Electrical Power System
FRR:	Flight Readinees Review
FSW:	Flight Software
GCS:	Ground Control System
G:	Glider
GPS :	Global Positioning System
GS:	Ground Station
HB:	Horizontal Beamwidth
HPBW:	Half Power Beamwidth
I:	Inspection
LOS:	Line of Sight

Acronyms

MR:	Mechanical Requirement
PWM:	Pulse Width Modulation
CDR:	Preliminary Design Review
PFR:	Preflight Review
RF:	Radio Frequency
SEN:	Sensor Subsystem Requirement
SR:	System Requirement
SRB:	System Requirement Bonus
T:	Test
TBC:	To be confirmed
TBD:	To be determined
VB:	Vertical Beamwidth
VM:	Verification Method

Systems Overview

Waheedullah Taj

Mission Objectives

- Simulate a sensor device travelling through a planetary atmosphere collecting atmospheric composition data during flight.
- The glider shall survive the launch conditions and separate from the rocket.
- The CanSat shall descend using a parachute and release the glider at 400 m altitude.
- The glider shall fly in the flight envelope defined by the competition requirements.
- The glider shall record atmospheric pressure, temperature and location data once per second and transmit them to the ground station.
- Measure glider speed with a pitot tube and compare it to GPS data in the ground station.
- Capture photos of the ground from the glider when a command is received and store them in the memory.
- Accomplish both of the following bonus objectives:
- 1) The camera shall be able to rotate from starboard to nadir to port and capture a photo when a command is received from the ground station.
- 2) Send the captured photos to the ground station at a rate of 1 Hz using the same Xbee radio.

External Objectives:

- Grow and popularize CanSat tradition in Middle East Technical University.

Summary of Changes Since CDR

Subject	New Design	Previous Design	Rationale
Wing type	Single Wing	Bi-plane	Lightweight, better aerodynamics
Wing airfoil	Cambered airfoil	Flat plate	Better aerodynamics
Wing materials	Balsa	Carbon fiber and cloth	Higher manufacturing precision for airfoil shape
Wing Deployment mechanism	Wings fold downwards and open with elastic band and spring	Wings fold back and open with elastic band	Solid wings can’t be bent like in the previous design.
Tail Arm	Longer tail arm	Shorter tail arm	Insufficient tail moment
Tail Deployment	Tail arm is extended from fuselage with elastic bands	Fixed tail arm	Insufficient volume inside the container

Summary of Changes Since CDR

Subject	New Design	Previous Design	Rationale
Fuselage Size	Smaller diameter, greater length	Larger diameter, smaller length	Better aerodynamics
Fuselage construction and materials	Mostly Hand-made Carbon Fiber Composite	3D printed plastic	Lightweight
Battery	Two batteries	One Battery	The power of one battery was not enough

System Requirement Summary

ID	CRN	Requirement	Children	A	I	T	D
SR1	1	Total mass of the CanSat (Container and glider) shall be 500 grams ± 10.	MR1	X			X
SR2	2, 3	The glider shall be wholly in the container and the container shall fit in a 125mm x 310 mm envelope including tolerances.	MR2,MR3	X	X		X
SR3	3	The container shall have a passive control system.	DCR1	X	X	X	X
SR4	5	The container shall not get stuck in the rocket.	MR4		X		
SR5	6, 36	The CanSat shall use a florescent color and carry team contact information for easy recovery.	MR5		X		X
SR6	7, 8	The rocket airframe shall not be used to stop deployable parts or to fulfill any operations.			X		
SR7	10	The glider shall be released from the container at 400m ± 10 m.	SEN1,DCR4, FSW1, FSW3	X		X	
SR8	11, 46	The glider shall fly for 2 minutes in a circular pattern with a diameter of no more than 1000 m.	DCR2, DCR5,DCR6	X		X	
SR9	12,13, 15,16, 17,18	The CanSat (Glider and the Container) shall be structurally robust. (resistant to acceleration and shock.)	DCR3,DCR7	X	X	X	

System Requirement Summary

ID	CRN	Requirement	Children	A	I	T	D
SR10	14, 20	All electrical and electronic components with the exception of the sensors shall be sealed from the outside environment.			X		X
SR11	19, 38	Pyrotechnics, chemical or lasers shall not be used in the CanSat.			X		X
SR12	21, 22, 23, 44	The glider shall collect, record and transmit mission time(one second or better resolution), GPS data, speed (pitot tube), temperature, pressure, photo capture command count, time of the last command, battery voltage and camera angle at 1 Hz rate starting from the launch.	SEN2,SEN6,CDH1, CDH2,CDH3,CDH4, CDH5, CDH6, CDH13, CDH14, EPS2, FSW2, FSW4, FSW5,			X	X
SR13	24, 25, 26	The glider shall use XBEE radios. The radios shall not use broadcast mode and their SETID/PANID shall be set to team number.	CDH8,CDH9,CDH10		X		X
SR14	11, 49	The glider shall use a fixed wing and only passive control surfaces.			X		
SR15	27, 28, 43	The glider shall have a color camera with a minimum resolution of 640x480 px pointing downwards. The camera is activated by a tele-command to capture and store the photos.	SEN4, CDH11, CDH12, FSW8, FSW9, GCS9		X		X
SR16	29	Total cost of the CanSat shall be no more than 1000$, excluding analysis tools and ground station.		X	X		
SR17	30, 31, 32, 33, 35	A portable ground station capable of displaying and plotting telemetry in real time in engineering units shall be developed.	GCS1,GCS2,GCS3, GCS4,GCS6		X	X	X

System Requirement Summary

ID	CRN	Requirement	Children	A	I	T	D
SR18	34	The ground station shall consist of one laptop with a 2 hr power supply, an XBEE radio and a hand held antenna.	GCS5		X		
SR19	39	The CanSat shall have an easily accessible power switch.	EPS3		X		
SR20	40, 41, 42	The CanSat shall have a well secured Alkaline, lithium ion or Ni-MH battery.	EPS1,		X		
SR21	45	The pitot tube speed measurement shall be compared to GPS data.	SEN3,FSW10			X	X
SR22	47	The CanSat shall be capable of releasing the glider with a ground command.			X	X	
SR23	48	A buzzer in the glider shall be activated upon landing.	SEN5,FSW11		X	X	
SR24	11, 49	The glider shall use a fixed wing and only passive control surfaces.	DCR2		X		
SR25	23	Mission time shall start when the glider is powered on.				X	X
SR26	23	Mission time shall be maintained in the event of processor reset.	CDH7,FSW7			X	

System Requirement Summary

ID	CRN	Requirement	Children	A	I	T	D
SR27	Bonus 1	The camera shall point at any angle from starboard to port direction through nadir. An image shall be taken in the requested direction.	FSW12, FSW13, GCS10			X	X
SR28	Bonus 2	The image shall be transmitted right after it has been taken. The telemtry transmission shall not be interrupted during image transmission using the same XBEE radio	FSW14, FSW15, GCS11			X	X

System Concept of Operations

Launch Campaign
- Setting up Ground Station
- System Check (Mechanical and Electrical)
- Launch of the CanSat

Rise
- Deploy from the Rocket

Separation
- Container: Parachute Deployment
- Container: Passive attitude stabilization
- Separation of the glider from the container

Descent
- Container: Descent with a parachute
- Glider: glide in a circular path.
- Glider: Transmit Telemetries, Take photos

Landing
- Stop Data Transmission, Activate buzzer
- Post launch recovery
- Mission Data Analysis

All Phases
- Glider: Protect internal components
- Ground Station: Real Time Telemetry Collection and Plotting

System Concept of Operations

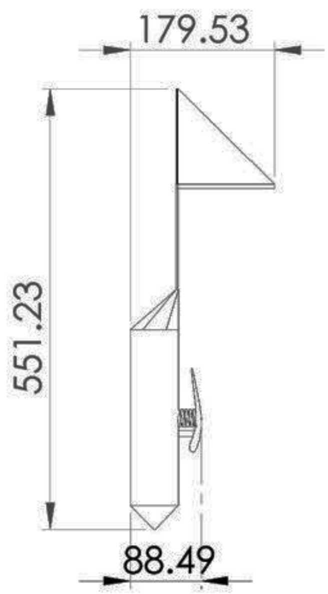
Pre-Launch	Launch	Post Launch

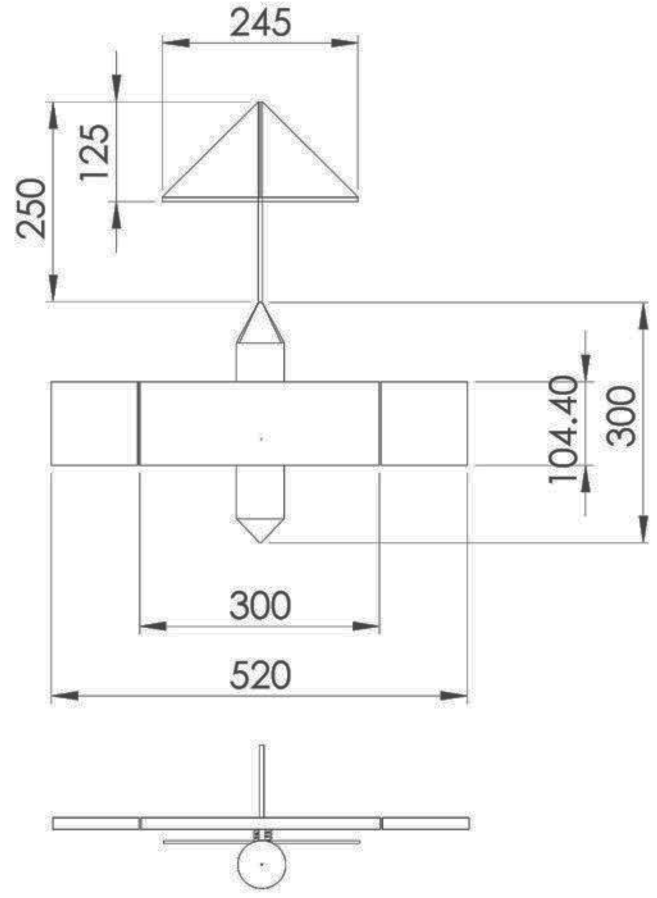
• Preflight Briefing
• Last Checks
  • Mechanics
  • Electronics
• Arrive at the competition area
	• Preflight Operations
	• Set up the ground station
	• Integrate CanSat into rocket glider
	• Launch, Rise, Separation, Descent, Landing(*)
	• Locate and retrieve Container and glider
		• Analyze Recieved Data
		• Prepare PFR
		• Presentation of PFR

* See previous slide.

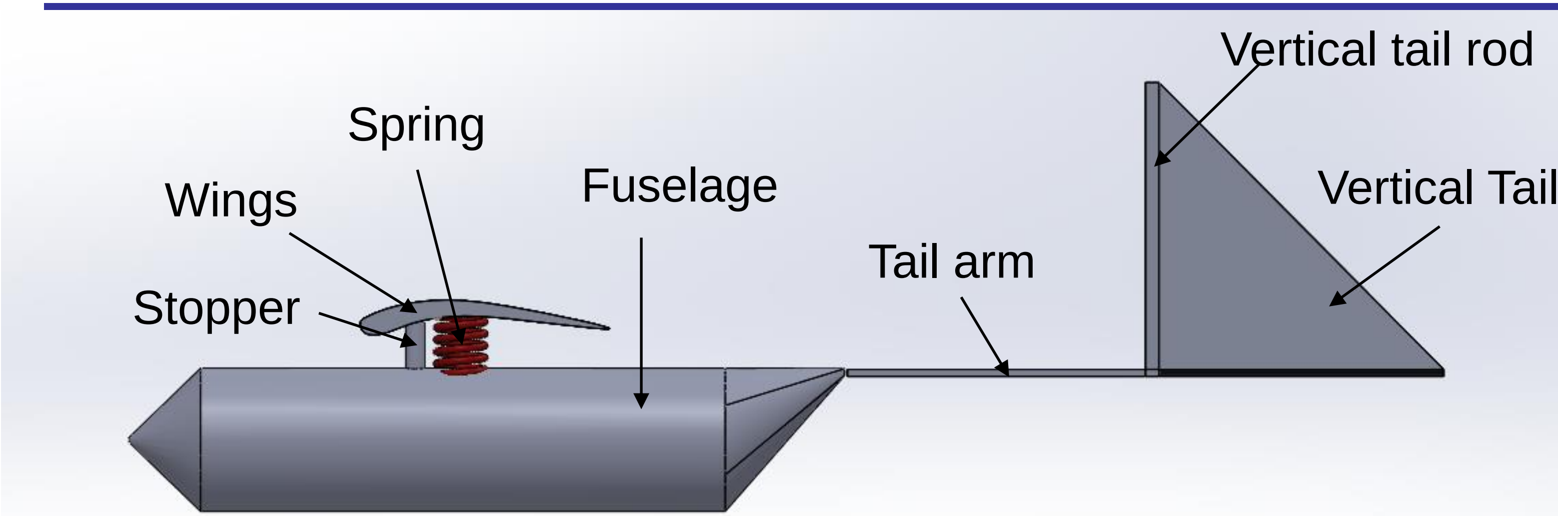
Physical Layout: Deployed glider

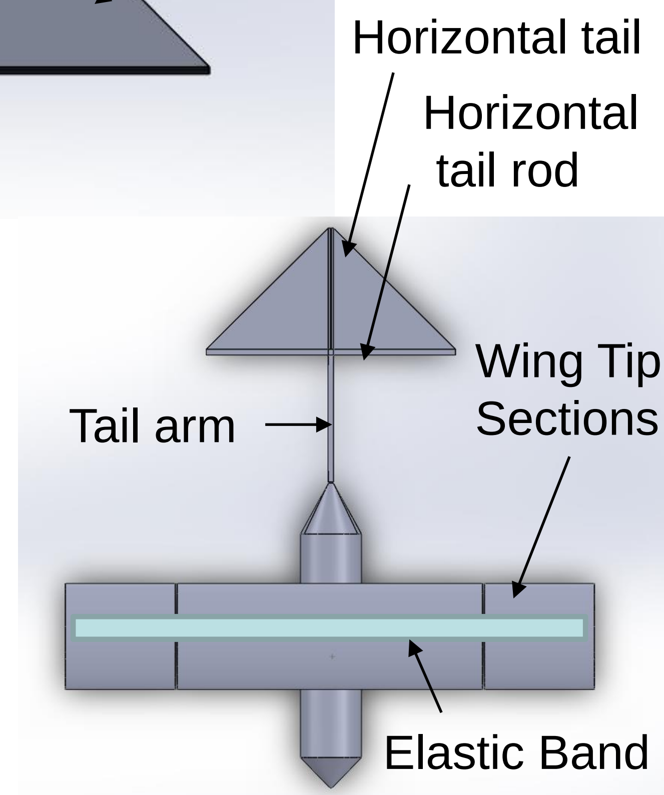
- **All dimensions in mm**





Physical Layout: Deployed glider

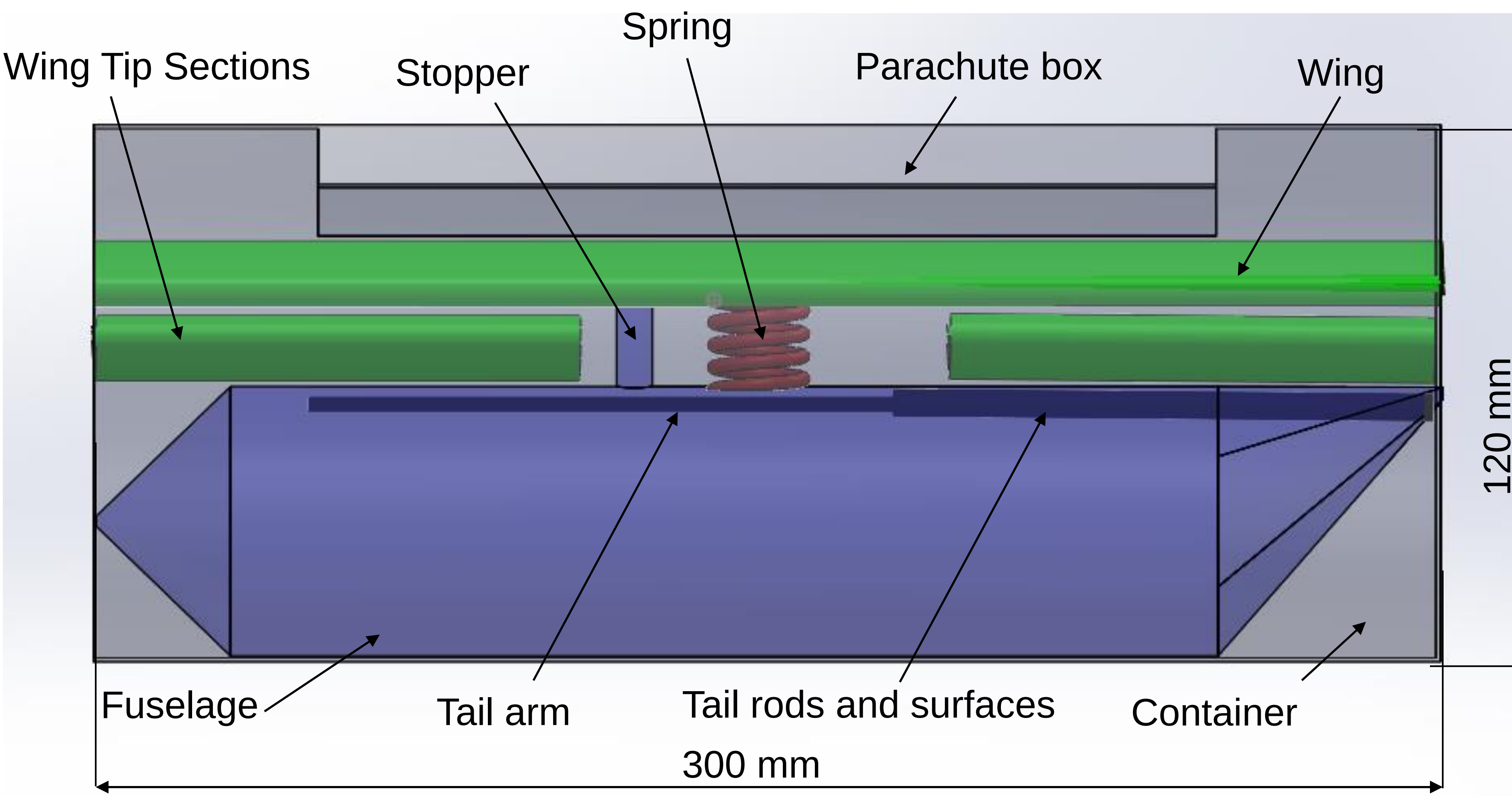




Explanations:

- Spring rotates the wing until they are perpendicular to the fuselage axis.
- Stopper stops the wing from rotating further.
- Elastic band opens the foldable wing tip sections.
- Vertical and Horizontal tails are made from cloth.
- Tail rods and arm are made from carbon fiber composite.
- Initially tails are folded and pushed into the fuselage. An elastic band inside the fuselage pushes the tail out when the fuselage is deployed.

Physical Layout: Packed in Container



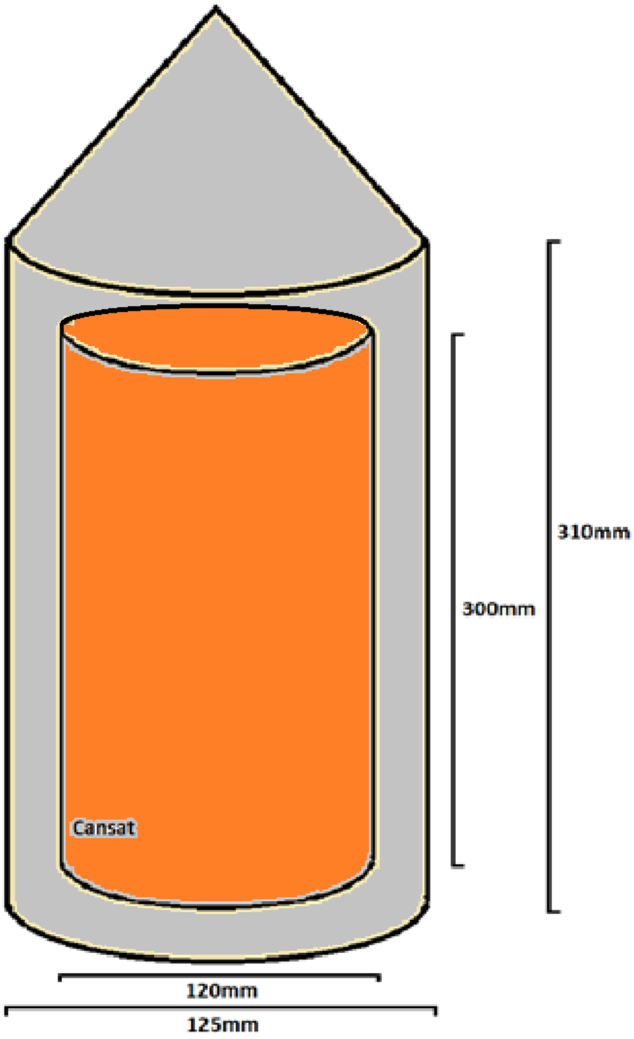
Launch Vehicle Compatibility

Diameter of CanSat: **120mm**
Height of CanSat: **300mm**

As seen from the dimensions, the CanSat will easily fit into rocket glider according to given envelope dimensions (SR2, **125mm x 310mm**)

There is a 1cm of vertical offset and 0.5cm of horizontal offset. The offsets are large enough for easy deployment and small enough to prevent internal impacts during launch.

Descent control mechanisms are included in CanSat dimensions. With no change in design, it is compatible with the rocket glider section. A cardboard tube (same diameter and thickness with the rocket) can be used for testing prior to the launch day.



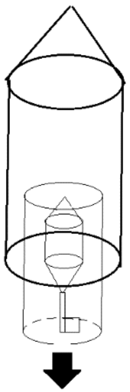
Descent Control Design

Yudum Comez

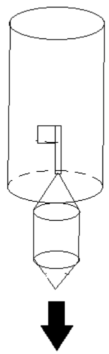
Elcin Ceren Yaldir

Descent Control Overview

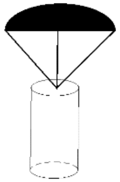
- The Descent Control System consists of a parachute for the container and wings for the glider. Descent regime is described in figures below:



Event: Separation from rocket.
Altitude: >>400 m
Parachute Deployment method: Use ambient air flow to push the parachute out



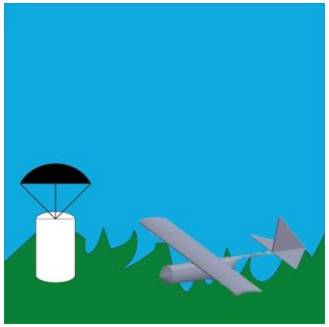
Event: Separation from container.
Altitude: 400 m
Deployment method: Wire holding the glider is cut using a thermal wire cutter. Wings are deployed with elastic strings.



Container descends with a parachute.

glider glides with wings.
Glide Duration: 2 min
Glide Path: Circular

Event: Landing
Altitude: 0 m



- **High wing configuration is chosen for the glider because:**
  - To increase the stability.
- **Commercial tail configuration is chosen for the glider because:**
  - Production is easier.
- **Parachute is chosen for the container because:**
  - Simple, low weight, no active control
  - The parachute has spill holes in the corners to reduce swaying.

Descent Control Changes Since PDR

- List changes since the PDR are given inside the table including their rationale as follows:

Subject	Old	New	Rationale
Wing Airfoil	• Flat plate airfoil	• Cambered teardrop airfoil	• Greater lift force was needed.
Wing Type	• Bi-plane	• Single wing with folding tips	• Fuselage interfered with lift generation.
Wing Opening Mechanism	• Wing leading edge rods folded back.	• Wings fold downwards and open with elastic band and spring	• Solid wings cannot be folded as in the previous case.
Fuselage	• Big diameter D = 70 mm	• Small diameter D = 60 mm	• The previous fuselage was too bulky to be aerodynamically efficient.
Tail	• T-tail	• Conventional Tail	• Production is easier with a conventional tail.

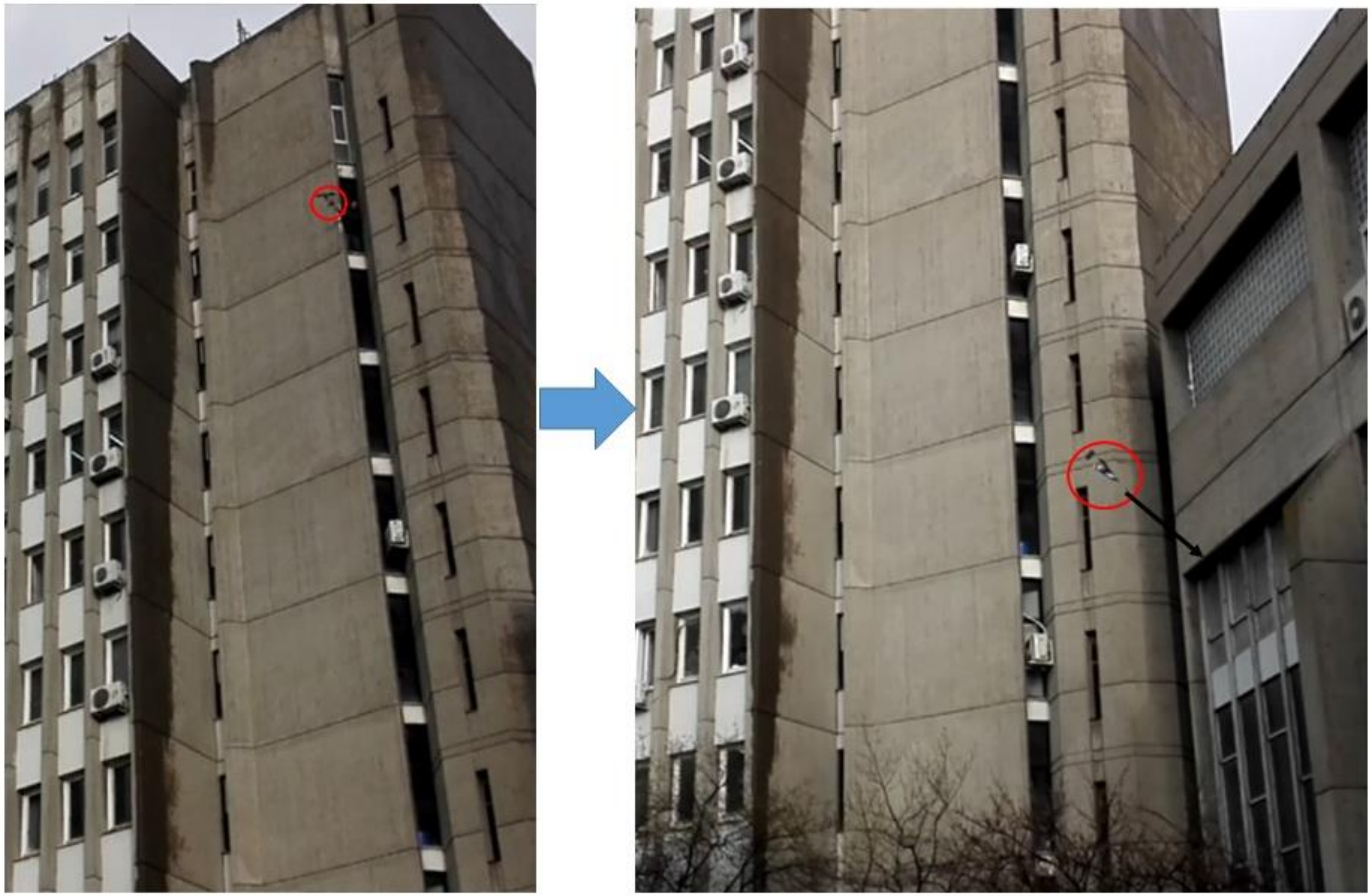
Descent Control Changes Since PDR

- **List changes since the PDR are given inside the table including their rationale as follows:**

Subject	Old	New	Rationale
Tail Deployment	Tail arm is extended from fuselage with elastic bands	Fixed tail arm	Insufficient volume inside the container
Tail Arm	Longer tail arm	Shorter tail arm	Insufficient tail moment

Prototype Testing

- A prototype of the glider was manufactured and tested. The test included throwing the glider from a tall building. The results are seen below and show that the glider starts to successfully glide after a distance of about 15 m.

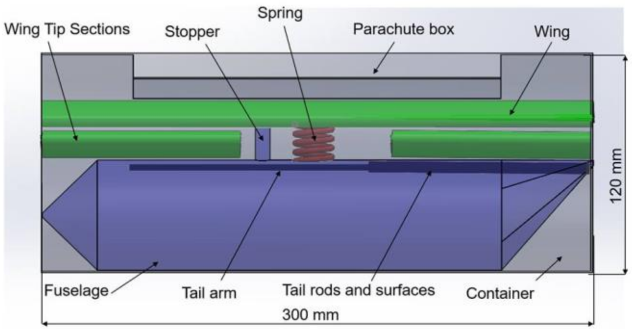


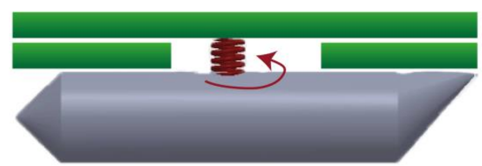
Descent Control Changes Since PDR: Wing Deployment

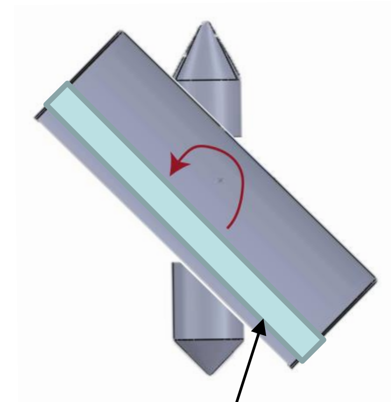
- Activation: The wing is held by an elastic band and its deployment is triggered passively when the glider comes out of the container.

Glider takes place in the container as shown below figure.

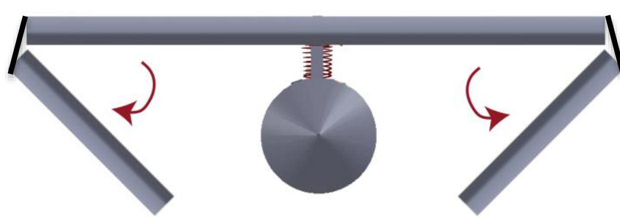
After release, torsional spring will rotate the whole wing up to 90^{o}. Stopper will stop more rotation.







Foldable wing tip sections are opened by the elastic band.

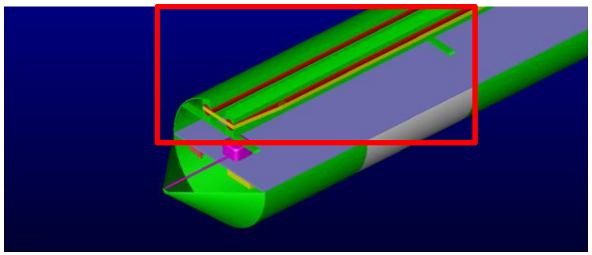


Elastic band

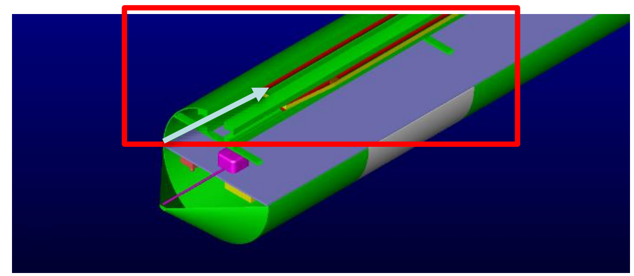
Descent Control Changes Since PDR: Tail Deployment

- Trigger: Passively trigger system applied to the tail opening system by using elastic bands.

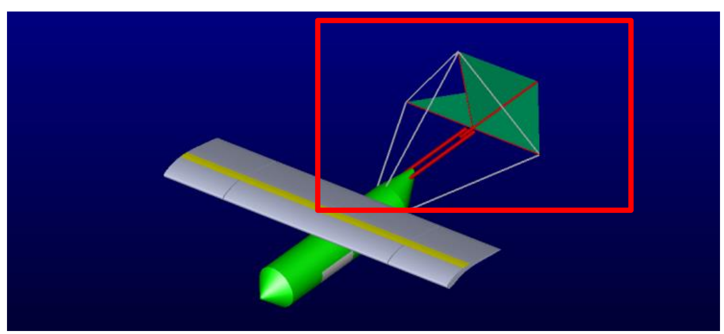
- The tail arm is held by a couple of rails inside the fusulage.



- The tail arms move on this rail and would be extracted by streching elastic bands.



- The tail moves out of the fuselage and strings erect the tail rods.

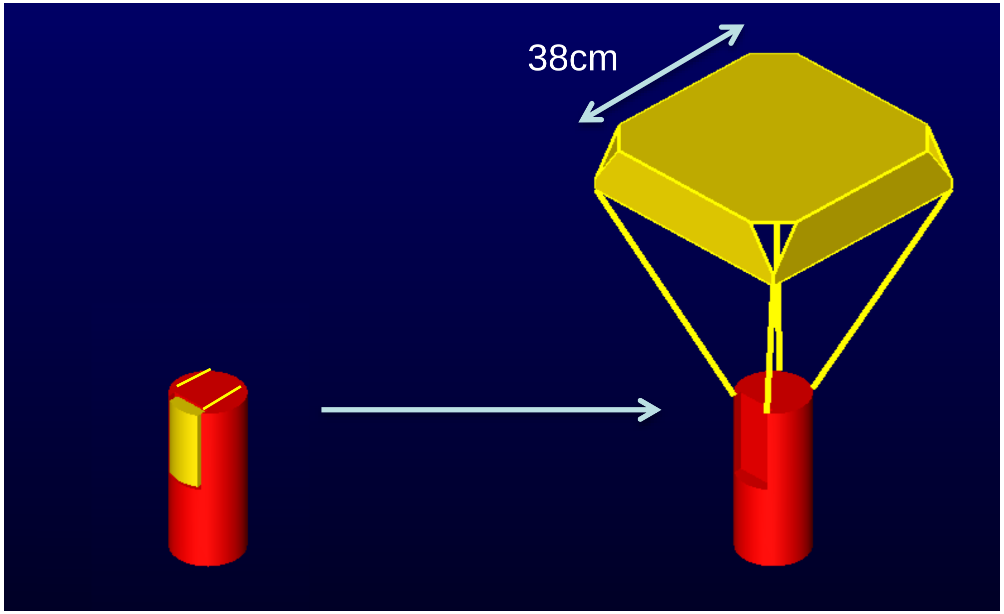


Descent Control Requirements

ID	Requirements	Rationale	Parent	A	I	T	D
DCR1	The container shall use a passive descent control system.	Competition requirement	SR3		X	X	
DCR2	The glider shall use a fixed wing.	Competition requirement	SR8		X		
DCR3	The CanSat shall be structurally robust.	Competition requirement	SR9	X		X	
DCR4	The glider shall detach from the container at an altitude of 400 +/-10 m.	Competition requirement	SR7	X		X	
DCR5	Average descent rate of the glider shall be as close to 3.3 m/s as possible.	Competition requirement (implied)	SR7	X		X	X
DCR6	The glider shall glide in a spiraling path with a diameter less than 1000 m.	Competition requirement	SR8	X		X	X

Container Descent Control Hardware Summary

- After the separation from the rocket, the CanSat descends with a parachute.
- The parachute is deployed from the side of the container with airflow.
- The parachute has four strings attached to the closed end of the container.
- No active components are used according to requirements.



Container Descent Control Hardware Summary

- A florescent orange color is chosen for the container.
- The glider shall descend from 400 m altitude in 120 s this means an average 3.3 m/s descend rate.
- Parachute will be placed at the side of the container structure. It will be deployed passively with airflow after deployment from the rocket glider section.
- Container’s covering shell will be detachable so that it allows preflight tests. The shell will be attached after the glider is placed into the container.

Payload Descent Control Hardware Summary

- A light green material is chosen for the glider for easy detection.
- The glider is connected to the container via a string that is cut at 400 m altitude with a thermal wire cutter.
- Since the wing configuration is changed the glide ratio is determined to be 3.6:1 based on a competitor study. Coupled with descent rate of **3.3 m/s** this results in a flight velocity of about 12.5 m/s.
- Glider cover will be easily detachable for easy inspection and preflight review.
- Wing dimensions are as follows:

Span: 520 mm
Surface area: 0.055 m^2
Aspect ratio: 4,98

Root chord: 104,4 mm
Tip chord: 104,4 mm
Design angle of attack: 15°

Descent Rate Estimates

Container + glider post separation (prior to deployment of the glider)

To have a stable and smooth glider separation from container the terminal velocity of cansat should be small

$$l = \mathrm{sqrt}(2.W / C_d.\rho.V^2)$$

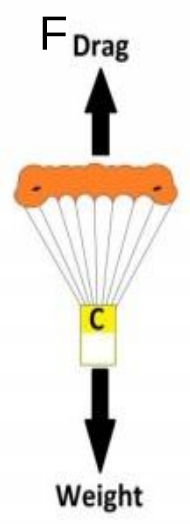
Total mass = 0.5 kg

Assume air density is constant and $\rho = 1.2 kg/m^3$

Cd = 1.0 for square parachute (restrained mode of descent)

A terminal velocity of 8 m/s is appropriate from previous knowledge, the length of one side of the parachute is calculated as

$$\mathbf{l = 0.35\ m}$$



Container following deployment of the glider

The same parachute will descend the container. Then velocity is calculated;

Mass of the container = 0.15kg

$$V_c = \mathrm{sqrt}(2.W / C_d.\rho.l^2)$$

The terminal velocity for the container is calculated as

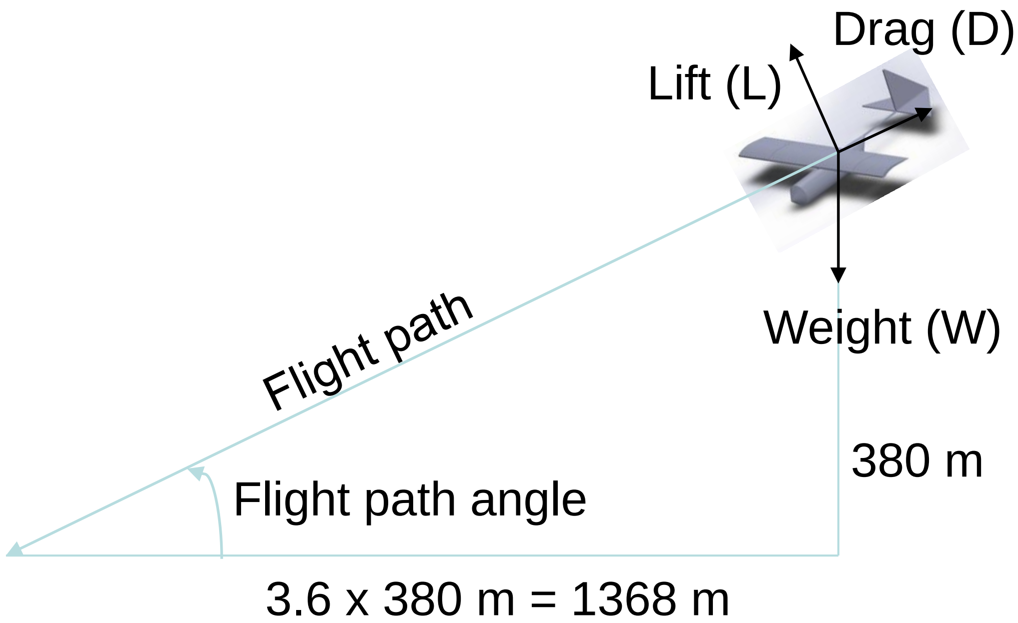
$$\mathbf{V_c = 4.3\ m/s}$$

Descent Rate Estimates

The glider is assumed to fly in two phases

- Transient phase
- Steady state phase

Our experiments show that the transient phase last 20 meters and in 2 seconds. Then steady state flight profile is shown below.



Descent Rate Estimates

By now the path, velocity, glide ratio and others are known for steady state.

Flight path angle = atan(380/1368) = **15°**
L/D_{glider} = cotan(15) = 3.6

This is after all losses including induced drag. Including aspect ratio of the wing into the calculations the $C_l/C_{d,airfoil}$
has to be 4.2.

NACA 58115 airfoil will be used. The required lift is obtained at an angle of attack of 15 degrees which is equal to fligth path angle. This means that the glider will fly in horizontal altitude.
This angle of attack C_L=1.8

Finally $L = W \times \cos(15) = 1/2 \rho V^2 S C_L$
Weight of the glider only is assumed to be 400 gr based on past experience.
Then **S = 0.055 m²**

Descent Rate Estimates: Summary

Flight parameters are summarized below

Glide Ratio	Flight Velocity	Descent Rate	Flight Path Angle	Angle of Attack	Coefficient of Lift (C_L)	$C_L/C_{D,glider}$	Airfoil
3.6	12.5	3.3	15	15	1.8	3.6	NACA 58115

CanSat Integration and Test

Elcin Ceren YALDIR

CanSat Integration and Test Overview

- **Subsystem integration**
  - Electronic components are attached to carbon fiber composite base plate using pin bolts and special adhesive.
  - The fuselage has a removable nose cone that allows for components to be inserted inside.
  - Internal components are attached to the base plate first. The base plate is then inserted into the fuselage from the front end and secured using nuts and bolts.
  - A strip of cloth will be glued to one side of the wing and wing tips. The cloth will act as a hinge that lets the tips to be folded.
  - A plane elastic band that extends from one wing tip to the other will be glued to the top of the wing tips.
  - The wing will be attached to the fuselage with a bolt.
  - The tail will be inserted to the fuselage from the front end.
  - The nose cone will then be closed.

CanSat Integration and Test Overview

- **Cansat integration and tests are performed using three models**
  - Structural Model to perform mechanical and structural tests.
  - BreadBoard Model to perform CDH tests.
  - Protoflight Model to perform system level tests after system integration to verify functionality.
- **Content of the structural and breadboard models and performed subsystem tests are summarized in the next slide.**

CanSat Integration and Test Overview

Model	Content	Performed Subsystem Tests
Structural	Prototypes of container and glider with wings and tail	Stability tests, wind tunnel aerodynamic tests, drop test from high altitude, speed tests.
Breadboard	Processors, sensors, tranceivers, power supply	Flight software, data handling, actuator and communication functionality, power regulation

- **Protoflight model will be integrated after the CDR based on the following sequence of subsystems:**
  - **Communication and Data Handling:** Sensors, Processors, Actuator, Transceivers, Flight Software
  - **Power:** Battery, Electronic Circuit Boards, Harness
  - **Mechanical:** Structural components, Interfaces, Parachute, Wings, Tails

CanSat Integration and Test Overview

Component Procurement

Mission & Requirements

Sensor Selection

Software Development & Bug Fixing

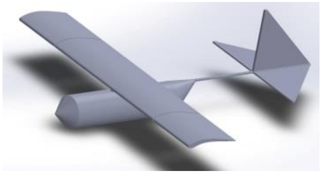
CDH

Power

Mechanical

Development and Integration

Test & Analysis



Protoflight Model

Start

Launch

Sensor Subsystem Testing Overview

- **Discuss tests being performed in order to verify the sensor subsystem.**
- **The test selection should demonstrate an understanding of what is important for testing each sensor at the subsystem and system levels.**
- **It is not necessary to go through each test in detail, but provide:**
  – What each test is to accomplish?
  – Constraints on testing (necessary operational subsystems, ground support equipment, etc.)
  – Pass/fail criteria and expected results – what are you looking for? (not just “it works” – discuss how you know it works)

Descent Control Subsystem Testing Overview

	Tests	Equipment/ Environment
Descent Control Tests	Parachute Deployment	1. By deploying the CanSat from a known altitude (e.g. Roof of a building) 2. By performing wind tunnel tests to measure drag force.
	Payload Deployment Mechanism	1. By deploying the CanSat from a known altitude (e.g. Roof of a building)
	Descent Control Mechanism	1. By deploying a glider prototype from a known altitude (e.g. Roof of a building) 2. Lift force is tested in wind tunnel
	Shock Force and Acceleration Survival	1. By dropping /throwing the CanSat from a known altitude (e.g. Roof of a building) 2. By performing structural analysis

Mechanical Subsystem Testing Overview

- **Discuss tests being performed in order to verify the Mechanical Subsystem.**
- **Demonstrate an understanding of what is important for mechanical testing at the subsystem and system levels. What each test is to accomplish?**
  - Constraints on testing (necessary operational subsystems, ground support equipment, etc.)
  - Pass/fail criteria and expected results – what are you looking for? (not just "it works" – discuss how you know it works)
  - Deployment / separation testing
  - Acceleration / shock / survivability requirement testing

CDH Subsystem Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
CDH-T1 Near Communication Test (DONE)	Communication can be done in the required packet format (CDH 4)	Arduino, XBees, GCS software Subsystems: CDH, GCS	1) Random data will be sent in the required packet format. 2) Graphs will be obtained from the data.	Successful sending and receiving of data
CDH-T2 Sensors Test (DONE)	Sensors can send data to Arduino in required format (CDH 1,2,3,5)	Sensors, Arduino Subsystems: CDH, FSW and Sensor	1) Each sensor will be connected to Arduino 2) Necessary data is requested by an Arduino code	Arduino successfully obtains sensor data

CDH Subsystem Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
CDH-T3 XBee Communication Range Test (NOT COMPLETED)	(CDH 4,16)	XBee Modules Arduino External Antenna Subsystems: GCS and CDH	1) One XBee will be connected to external antenna, and computer 2) The other will be connected to Arduino 3) The one with Arduino connection moves away	Successful communication without lost packets until 1.5 km distance
CDH-T4 RTC of GPS (Reset tolerance) (NOT COMPLETED)	(CDH 5,7)	Arduino GPS Subsystems: FSW and CDH	1) Real Time Clock of GPS is started with Arduino 2) Arduino will be reseted and error in time will be checked	Timekeeping continues with less than a second of error in reset

EPS Testing Overview

- **Discuss the test being performed to verify the EPS**
- **Demonstrate an understanding of what is important for testing each component at the subsystem and system levels**
- **It is not necessary to go through each test in detail, but provide:**
  - What each test is to accomplish?
  - Constraints on testing (necessary operational subsystems, ground support equipment, etc.)
  - Voltage sensor testing
  - Pass/fail criteria and expected results – what are you looking for? (not just “it works” – discuss how you know it works)

FSW Testing Overview

- **Discuss tests being performed in order to verify the flight software**
- **Test selection should demonstrate an understanding of what is important for software at subsystem and system levels**
- **It is not necessary to go through each test in detail, but provide:**
  - What each test is to accomplish?
  - Constraints on testing (necessary operational subsystems, ground support equipment, etc.)
  - Pass/fail criteria and expected results – what are you looking for? (not just “it works” – discuss how you know it works)
  - Simulation test beds / ground system checkout tests

GCS Testing Overview

Test ID	Verified Requirements	Equipment	Test Description	Pass/Fail Criteria
GCS-T1 Software Test **(COMPLETED)**	GCS can plot data in engineering units correctly. (GCS3)	Laptop, GCS Software	• Random data have been produced and graphs have been obtained from those data.	**PASS** (Graphs have been obtained successfully)
GCS-T2 Near Distance Communication Test **(COMPLETED)**	Communication can be done in required packet format.	GCS Software, Arduino, Xbee(x2)	• Predefined string data were produced and sent in required packet format. • Received packet has been displayed.	**PASS** (Packet has been displayed correctly)
GCS-T3 Image Transmission Test **(COMPLETED)**	GCS Software can obtain the image while receiving telemetry with 1Hz(GCS10)	GCS Software, Arduino, SD Card, Xbee(x2)	• A JPEG image in SD card has been sent via Xbee and displayed in MATLAB.	**PASS** (20 KB Image has been sent in 25 seconds and displayed in MATLAB)
GCS-T4 Far Distance Communication Test **(NOT STARTED)**	Link budget shall be satisfied.(GCS7)	Arduino, Xbee(x2), Antenna, GCS Software	• Xbee radios will be communicated from approximately 1.5km distance.	Successfull reception of data packets and correct plotting from 1.5km distance and + - 30 degrees

Mission Operations & Analysis

Elcin Ceren Yaldir

Overview of Mission Sequence of Events

Ground Support Equipment Preparation
- Prepare electrical ground support equipment (check antennas, etc.)
- Connect electrical ground support equipment to the ground station computer
- Start up ground station software and wait for listening mode

CanSat Preparation
- Assemble final CanSat configuration
- Check structural integrity
- Check electrical connections
- Check software version and install software
- Power ON and check telemetry collection
- Confirm that the checklist is complete (connections, tests, etc.)

CanSat Integration to the Launcher
- Place CanSat in the payload section
- Check allowance and structural integrity
- Rocket Launch

Rise Phase
- Ground Station: Receive and monitor telemetry
- Container: Store & Transmit Altitude and Mission Time Data
- Release from Rocket (670-700m)

Separation Phase
- Container Parachute Deployment
- Ground Station: Receive and monitor telemetry
- Container: Store & Transmit Altitude and Mission Time Data
- Separation of Payload and Container (500m)

Descent Phase
- Payload: Passive Descent Control Mechanism
- Container: Store & Transmit Altitude and Mission Time Data
- Payload: Store & Transmit Data (Pressure, Temp, Voltage, Mission Time, +Bonus)
- Touchdown

Landing
- Stop Data Transmission
- Save mission data
- Locate CanSat
- Recover Container and Payload
- Check for egg
- Delivery of telemetry data file to judge

- **Mission and Systems Engineering:** Coordination of launch campaign and operations
- **Electronic System Design Group:** CanSat, software and electrical ground support equipment preparation
- **Communication and Ground Station Group:** CanSat, software and electrical ground support equipment preparation
- **Mechanical System Group:** CanSat, structure and mechanical ground support equipment preparation

Overview of Mission Sequence of Events

Mission and Systems Engineering

- Coordination of Launch Campaign and Mission Operations

Electronic Systems Group

- Electronic System Inspection and Check
- Software and Electrical Ground Support Equipment Preparation
- CanSat Preparation
- CanSat Operations & Recovery

Communication and Ground Station Group

- Software and Electrical Ground Support Equipment Preparation
- Communication System Inspection and Check
- CanSat Preparation
- CanSat Operations
- Delivery of CSV file and received image files to judges

Mechanical Systems Group

- Mechanical Ground Support Equipment Preparation
- Structural Inspection and Equipment Check
- CanSat Preparation
- CanSat Recovery
- Retrieval of on-board logged data

Field Safety Rules Compliance

- **The Mission Operations Manual will include**
  - A set of checklist for the Ground Station and CanSat (Container + Science Vehicle) assembly and pre-flight functional tests
  - A set of checklist for the attachment of CanSat to the rocket.
  - Timelines of events, parameters to be monitored and commands throughout all mission phases from launch till landing.
  - Troubleshooting procedures based on the final electrical configuration and software functionalities.
- **Outline of the Mission Operations Manual has been prepared and it will be finalized after system level tests based on the final system configuration.**
- **Two copies of the Mission Operations Manual will be ready at the Flight Readiness Review by the day before launch.**

- **Container and Glider Recovery**
  - The last GPS coordinates telemetry will be used as a primary lead.
  - The buzzer will start beeping as soon as it touches the ground and this will help to recover our CanSat
  - Visible colours for the parachute and the glider will be selected in order to aid team for locating them.
  - A label with contact information will also be placed on both container and science vehicle.

Mission Rehearsal Activities

- **Ground system radio link check procedures**
  - Prepare electrical ground support equipment (ground station computer, antenna, RF modules, mast etc.) and connect the antenna
  - Configure the communication link
  - Check the telemetry
- **Powering on/off the CanSat**
  - Check for the electrical connections
  - Power the Science Vehicle via umbilical power source
  - Check for the electrical power availability / connection stability

Mission Rehearsal Activities

- **Launch configuration preparations (performed with structural model)**
  - Assemble CanSat configuration
  - Check for the structural integrity
  - Check for final mass and dimensions

- **Telemetry processing, archiving, and analysis**
  - Install the final version of the software
  - Check for the telemetry collection, storage and monitoring in the ground station

- **Loading the CanSat in the launch vehicle (performed with structural model)**
  - Check for the final dimensions and rocket compatibility
- **Recovery**
  - Check for Buzzer functionality
  - Locate CanSat using observations, Buzzer noise and received data