CanSat 2019
Post Flight Review (PFR)
Version 1.0

#6203
APIS ARGE TEAM
# Presentation Outline

<table>
<thead>
<tr>
<th>Section</th>
<th>Presenter</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>İsmail ÖZCAN</td>
<td>2-3</td>
</tr>
<tr>
<td>Systems Overview</td>
<td>İsmail ÖZCAN</td>
<td>4-13</td>
</tr>
<tr>
<td>CONOPS &amp; SOE</td>
<td>Aykut ÜÇTEPE</td>
<td>14-19</td>
</tr>
<tr>
<td>Flight Data Analysis</td>
<td>Altuğ ERTAN-Resul DAGDANOV</td>
<td>20-36</td>
</tr>
<tr>
<td>Failure Analysis</td>
<td>İsmail ÖZCAN</td>
<td>37-38</td>
</tr>
<tr>
<td>Lessons Learned</td>
<td>Aykut ÜÇTEPE</td>
<td>39-41</td>
</tr>
</tbody>
</table>
Team Organization

Prof. Dr. Alim Rüstem Aslan
Faculty Advisor

Aykut Üçtepe
Senior, B.S. Aeronautical Eng.
Team Leader

Altuğ Ertan
Sophomore, B.S. Astronautical Eng.
Leader of Electronics and Programming

İsmail Özcan
Junior, B.S. Aeronautical Eng.
Leader of Mechanics

İldefon Kaper
Sophomore, B.S. Astronautical Eng.
Design

Resul Dagdanov
Sophomore, B.S. Astronautical Eng.
Flight Software-Ground Station

Buse Cop
Sophomore, B.S. Astronautical Eng.
Electronics

Elif Acar
Sophomore, B.S. Astronautical Eng.
Communication

Özen Haliç
Junior, B.S. Aeronautical Eng.
Aerodynamics

Muhammed Kara
Sophomore, B.S. Astronautical Eng.
Mechanics

Zelal Karaca
Sophomore, B.S. Astronautical Eng.
Organization

Sercan Saldamli
Freshman, B.S. Metallurgical Eng.
Mechanics
System Overview
PAYLOAD Design Overview (1/6)

- Blade
- Shaft
- XBee
- Radio Antenna
- Switch
- GPS Antenna
- Stepper Motor Layer
- Servo Motors
- Connector
- Spring
- RPM Sensor
- Rod
- Pcb
- Battery
- Camera Stabilizer
- Plexiglass Covering Structure
- Pcb
Payload Design Overview (2/6)

Real Prototype
Payload Design Overview (3/6)

Auto-gyro Mechanism

- Shaft
- Fixing Element
- Hinge
- Bearing
- Connector
- Spring
- Bolts
- Latexes
Camera Stabilizer Mechanism

- Servo Motors
- Plexiglass Cover
- Camera
Payload Design Overview (5/6)

Top View (Blades Opened)
- 255 mm
- 3 mm thick layers

Top View (Blades Closed)
- 260 mm
- 545 mm
- 105 mm
- 72 mm
- 45 mm
- 95 mm
- 228 mm
- 50 mm
CANSAT

Launch Configuration

Deployed Configuration
CONTAINER Design Overview (1/2)

- Nichrome Wire
- Battery
- Intermediate Layer
- Top Layer
- Pcb
- Fishing Line
- Container Main Body
Container Design Overview (2/2)

- 310mm
- 18mm
- 40 mm
- 120 mm
- 3 mm thick intermediate layer
- 2 mm thick top layer
Safety Precautions of Release Mechanism

- It is shown that the effect of heat, produced by nichrome wire, to environment.
- Aluminium silicate cover the nichrome wire to minimize the heat transfer between container and release mechanism.
CONOPS (Concept of Operations) & SOE (Sequence of Events)
Comparison of planned and actual CONOPS

**Planned CONOPS**

### Pre-Launch
- Competition area arrival.
- Team briefing.
- Electronic and mechanic integrity checks.
- GCS and antenna set up.
- Damage control before the flight by CanSat Crew.
- Double check for final CanSat integrity configuration and release mechanism by Inspection Crew.
- Making sure mass is between 490 g and 510 g

### Launch
- Placement of Cansat into rocket payload section by Cansat Crew.
- Launch, and events of CONOPS (given in previous slide).
- Telemetry data obtaining and .csv file creation via GCS software.

### Post-Launch
- Recovery of payload with indicators fluorescent color, GPS telemetry and audio beacon.
- Recovery of container with indicators fluorescent color.
- Recovered CanSat is brought to GCS.
- Analysis of sampled data.
- Preparation of PFR.
- PFR presentation to jury.

---

**Inspection Crew**

- **Mechanics:** İsmail - Özen
- **Electronics:** Altuğ - Resul

**Cansat Crew**

- İsmail - Sercan
## Comparison of planned and actual CONOPS

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td><strong>Placement</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power on the Cansat.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check the communication between payload and GCS.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Placement to rocket payload section.</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong></td>
<td><strong>Launch</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rocket takes off.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parachute opens at apogee. Cansat starts to descent with parachute until 450m.</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>Separation</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 450m, the separation mechanism is activated and payload is released.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At same altitude, camera starts to capturing the descent.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>During descend, CanSat continues to collect: air pressure, temperature, voltage, GPS data, tilting, software state, RPM until the landing.</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td><strong>Recovery</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Payload lands with auto-gyro mechanism.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The payload finishes descent, stops telemetry and initiates audio beacon.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Container lands with parachute.</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td><strong>Data Analysis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analyzing the data retrieved from descent control devices.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivering requested data to jury.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Getting ready for PFR.</td>
<td></td>
</tr>
</tbody>
</table>

**Mission Control Officer:** Aykut

**GCS Officer:** Resul

**Recovery Crew**

- **Payload:** Özen - Altuğ
- **Container:** İsmail - Buse
- **PFR:** İsmail - Altuğ - Resul - Aykut
Comparison of planned and actual CONOPS

Planned CONOPS are same with the real CONOPS.

Pre-Launch
- Competition area arrival.
- Team briefing.
- Electronic and mechanic integrity checks.
- GCS and antenna set up.
- Damage control before the flight by CanSat Crew.
- Double check for final CanSat integrity configuration and release mechanism by Inspection Crew.
- Making sure mass is between 490 g and 510 g

Launch
- Placement of Cansat into rocket payload section by Cansat Crew.
- Launch, and events of CONOPS (given in previous slide).
- Telemetry data obtaining and .csv file creation via GCS software.

Post-Launch
- Recovery of payload with indicators fluorescent color, GPS telemetry and audio beacon.
- Recovery of container with indicators fluorescent color.
- Recovered CanSat is brought to GCS.
- Analysis of sampled data.
- Preparation of PFR.
- PFR presentation to jury.

Inspection Crew
Mechanics: İsmail - Özen
Electronics: Altuğ - Resul

Cansat Crew
İsmail - Sercan
## Comparison of planned and actual CONOPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
<th>Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Placement</td>
<td><strong>Mission Control Officer:</strong> Aykut</td>
</tr>
<tr>
<td></td>
<td>- Power on the Cansat.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Check the communication between payload and GCS.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Placement to rocket payload section.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Launch</td>
<td><strong>GCS Officer:</strong> Resul</td>
</tr>
<tr>
<td></td>
<td>- Rocket takes off.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Parachute opens at apogee. Cansat starts to descent with parachute until 450m.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Seperation</td>
<td><strong>Recovery Crew</strong></td>
</tr>
<tr>
<td></td>
<td>- At 450m, the separation mechanism is activated and payload is released.</td>
<td><strong>Payload:</strong> Özen - Altuğ</td>
</tr>
<tr>
<td></td>
<td>- At same altitude, camera starts to capturing the descent.</td>
<td><strong>Container:</strong> İsmail - Buse</td>
</tr>
<tr>
<td></td>
<td>- During descend, CanSat continues to collect: air pressure, temperature, voltage, GPS data, tilting, software state, RPM until the landing.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Recovery</td>
<td><strong>PFR:</strong> İsmail - Altuğ - Resul - Aykut</td>
</tr>
<tr>
<td></td>
<td>- The Payload lands with auto-gyro mechanism.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The payload finishes descent, stops telemetry and initiates audio beacon.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The Container lands with parachute.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Data Analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Analyzing the data retrieved from descent control devices.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Delivering requested data to jury.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Getting ready for PFR.</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of planned and actual SOE

<table>
<thead>
<tr>
<th>PLANNED</th>
<th>ACTUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put the CanSat inside the rocket properly.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Starting telemetry before launch.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Send calibration command from ground station to Payload.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Deployment from rocket.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Parachute open after deployment from the rocket.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Payload separation and blades deployment at 450 meters.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Continuous telemetry transfer during flight.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Capturing the descent after Payload Separation.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Buzzers worked when payload and container landed in order to ensure easier recovery.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Recovery.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Protecting the integrity of payload and container after landing.</td>
<td>Accomplished</td>
</tr>
<tr>
<td>Descent rates of container and payload meet mission req.</td>
<td>Partial</td>
</tr>
</tbody>
</table>
Flight Data Analysis
Container Separation Altitude Plot

![Container Altitude - Time Plot]

- **Apogee**
- **Separation**
- **Lift-off**
Payload Pressure Sensor Data Plot
Payload Altitude Plot

Altitude - Time

- **Lift-off**
- **Apogee**
- **Separation**
Column D shown the "Altitude".
Column R shown the "Software State".
At software state 5 - Separation - the release mechanism is activated.
At the altitude **455.3** meters, the separation occurs and the auto-gyro mechanism starts to operate.
• Before the flight the calibration command from the ground control station is send to the payload.
• Calibration command calibrated payload to the true the magnetic north direction. (*Column “S”*)
• Altitude data of the payload is calibrated to 0 meters. (*Column “D”*)
• Roll and Pitch data are calibrated with respect to the payload. (*Roll: Column “O”; Pitch: Column “P”*)
Payload Temperature Sensor Plot
Software States

Change of Software States

Altitude (meters)

Time (seconds)
Payload 2D GPS Plot

Latitude - Longitude

Launchpad

Landing Location
Payload 3D GPS Plot

3D GPS Position

Launchpad

Landing
Payload Battery Power Plot
Tilt Sensor Plot (1/2)
Auto-gyro Blade Spin Rate Plot
Video Link:
https://youtu.be/dA2NRpcGzOY
Ground Station Real Time Plots

Video Link: https://youtu.be/sswmalKrpN0
Recovery

Latitude: 32.2486
Longitude: -98.1999

Latitude: 32.2409
Longitude: -98.2000

13 Farm to Market 8

9 min
0.4 mile
Failure Analysis
**Minor Failures:**

➔ Descent rate of the container and payload is slightly different than the mission requirements.

  - Descent rate of the payload is 7.44 m/s. (Mission Req. is 10-20 m/s)
  - Descent rate of the container+payload is 11.48 m/s.

(Mission Req. is 15-25 m/s)

**Correction Methods:**

➔ Weather conditions should be considered more.
➔ Certain mass measurement should be done earlier to produce more convenient descent systems.
Lessons Learned
## Discussions of what worked and what didn’t

<table>
<thead>
<tr>
<th>WORKED</th>
<th>DIDN’T WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Data Lost</td>
<td></td>
</tr>
<tr>
<td>Separation Mechanism</td>
<td></td>
</tr>
<tr>
<td>Auto-gyro Mechanism</td>
<td></td>
</tr>
<tr>
<td>Camera</td>
<td></td>
</tr>
<tr>
<td>Buzzer</td>
<td></td>
</tr>
<tr>
<td>Parachute</td>
<td></td>
</tr>
<tr>
<td>Deployment of Rotor Blades</td>
<td></td>
</tr>
<tr>
<td>Calibration Command</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Considering the previous table, the mission was a major success.
• Most of the components are specifically designed according to competition purposes and withstand extreme forces of lift-off. Therefore, components worked very well.
• Electronic and mechanical requirements analyzed carefully, and the space is used efficiently with reliable and sturdy mechanism while providing flight, we managed to design and manufacture a CanSat matching all 50 requirements.