Development of Open-Class CanSat "i CAN fly" using a coordinate-controlled parafoil system

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Contents

- Introduction
- “i CAN fly” development
  - Overview of the CanSat
  - Tests
- ARLISS
- Conclusions

Introduction

- CanSat as introduction to satellite development
  - Includes electronics, control theory, fluid dynamics, and etc.
  - Learn how to run a project with others
- CanSat “ComeBack” Competition is held
  - Travel autonomously toward the predefined target as close as possible
  - Compete on the distance to the target

Survey -Which data do you use?-

CanSat (type)	Device	Data
Rocks (rover)	GPS	Coord.
SNUT (flyback)	GPS	Coord. V-vector Alt.
samurai (rover)	GPS	Coord. V-vector Alt.
C-boys (flyback)	GPS	Coord.
i CAN fly (flyback)	GPS	Coord. V-Vector Alt.

CBC-03 (flyback)	GPS	Coord. Alt.
Da vinci (flyback)	GPS	Coord.
Spopovic (flyback)	GPS	Coord.
Cool-Running (flyback)	GPS	Coord. Alt.
MICAN (flyback)	GPS	Coord. Alt.

Abbreviations: Coord. = Coordinate, Alt. = Altitude, V-vector = Velocity vector

Surveyed ARLISS 2006 ComeBack competition participants from Japan by E-mail.

i CAN fly

- Mission
  - Autonomous “flyback”
- Components
  - GPS Receiver
  - Digital Compass
  - Transceiver (for transmission, 70cm amateur band)
  - Servo
  - PIC Microcontrollers
  - EEPROM

Transition of Components

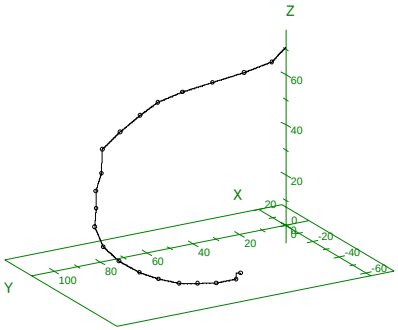
Components	Tests (8/13&15)	Noshiro Space Event (8/19)	ARLISS (9/20-22)
GPS Receiver	Garmin GPS18LVC	→	→
Digital Compass	Hitachi HM55B	→	→
Transceiver	Not used	Alinco DJ-C7	→
Servo	HS-85MG	→	→
PIC	PIC16F876 PIC16F84A	→	→
EEPROM	24LC256	→	24C1024

Flight tests in Japan

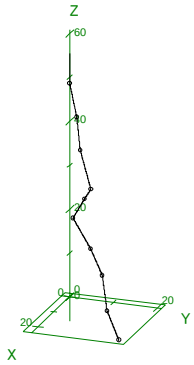
- With cooperation of Nakasuka Lab, Univ. of Tokyo
  - Yokosuka, Kanagawa (Aug. 13, 2006)
  - Univ. of Tokyo Campus (Aug. 15, 2006)
- UNISEC Event
  - Noshiro Space Event (Aug. 19, 2006)

Test at Yokosuka (Aug. 13, 2006)

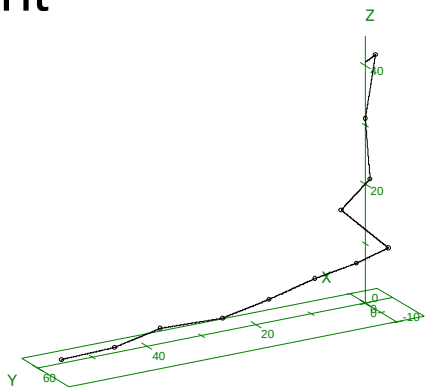
- Planned construction site
- Used Nakasuka Lab's Helium baloon (altitude ~200m)
- 4 flights to discover gliding characteristics
  - Obtained approximate glide ratio – around 4
  - Failed to record flight history of 4th flight



1st flight



2nd flight

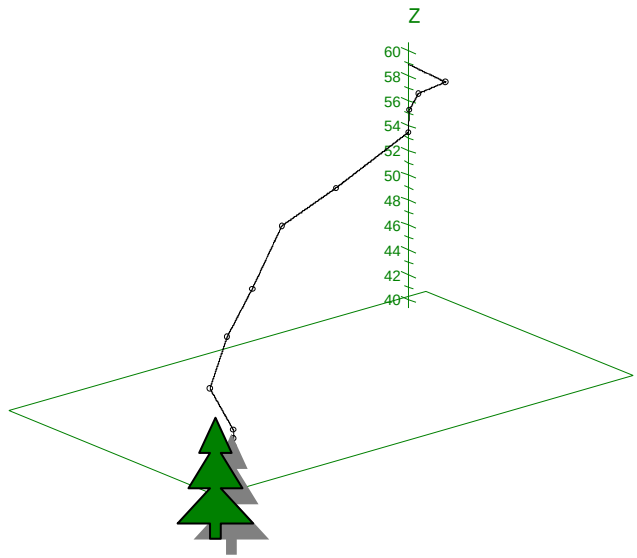


3rd flight

All graphs are isotropic.

Test at Univ. of Tokyo (Aug. 15, 2006)

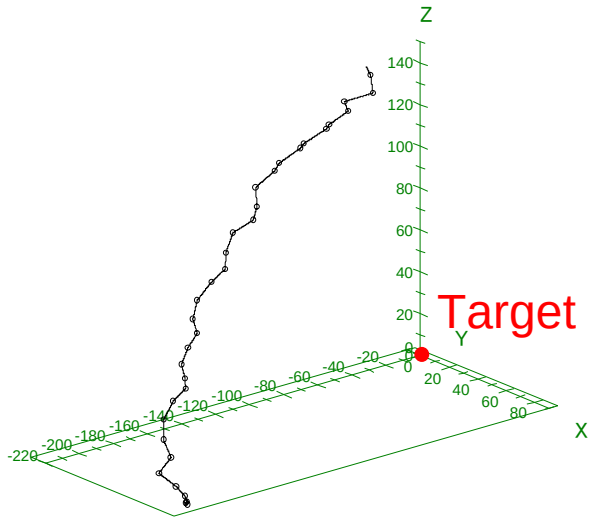
- Field of Faculty of Agriculture, Univ. of Tokyo
- Used Nakasuka Lab's Helium baloon (altitude ~50m)
- 2 flights to discover turning characteristics
  - Test failed
    (caught in a tree, parafoil deployment failure)



1st flight, caught in a tree

Noshiro Space Event (Aug. 19, 2006)

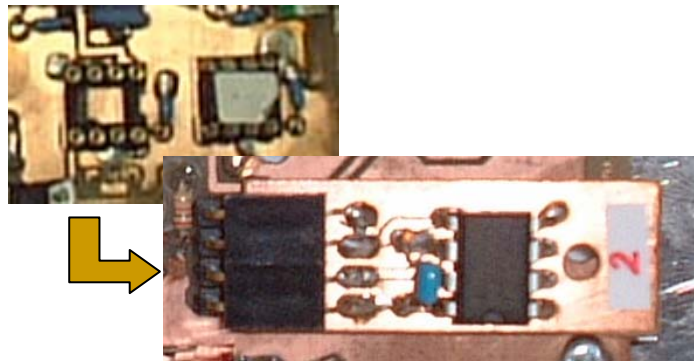
- 1st flight
  - 220m from target (with history)
  - Inconsistent flight history
  - Failed to decode beacon due to noise
- 2nd flight
  - 200m from target (w/o history)
  - Failed to decode beacon due to noise
  - Observed that the CanSat was unable to glide against wind



Flight History of 1st flight
(plotted every 2 seconds)

Results of Tests in Japan

- Serious problems became evident
  - Software (history recording failure)
  - Communication (terrible noise)
    - Metal parts were “floating” electrically
- Additional improvements for ARLISS
  - Vibration Tolerance
    - Vibration test with cooperation of Nakasuka Lab
  - EEPROM Capacity
    - Increased from 256kbit to 1Mbit
  - Easy Access to EEPROM
    - Changed from IC socket to cartridge
  - Power Distribution
    - Enabled to work more than 2 hours

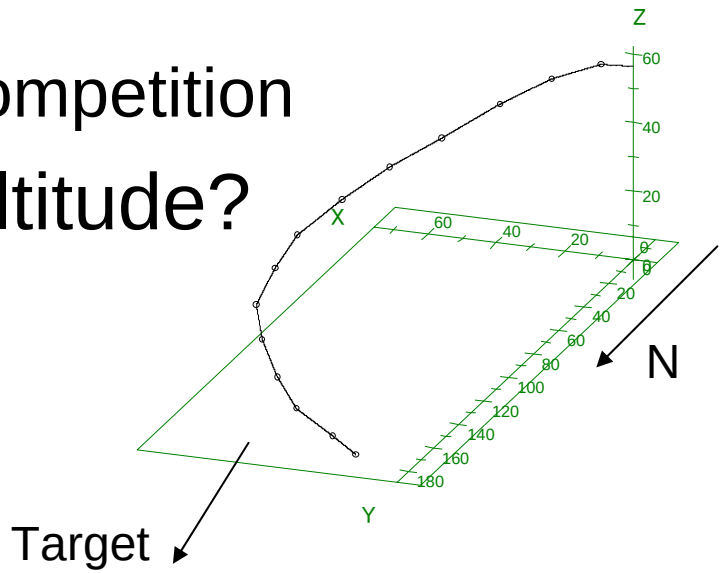


Flights at ARLISS (Sep. 20-22, 2006)

- ARLISS (A Rocket Launch for Int'l Student Satellites) was held at Black Rock desert, NV

1st flight (Sep. 20th)

- Low Altitude Deployment
- Consistent control and history
- 2250m from target
  - 3rd place of ComeBack Competition
- What if ejected at high altitude?
  - Converged or Diverged?



Flight History of 1st flight at ARLISS

2nd flight (Sep. 21)

- CanSat Deployment Succeeded
- No Beacon at Deployment
  i.e. untraceable

- 2 hours later, found beacon and decoded the position info.
- Finally found approx. 13km from target

Why failed

- Deployment detection switch stuck
  - 3 switches, connected as OR logic, didn't work.
- Why we could find it
  - Assumed that CanSat started working by detecting "deployment" by shock of landing
  - Luckily, we could decode the complete coordinate ONCE

Conclusions

- Project
  - The system worked as intended but rarely.
    - Need to raise credibility for better performance.
  - Need to obtain flight characteristics as much as possible to build reliable and precise control algorithm.
  - Parafoil might not be the best solution, especially when the wind is strong.
- People
  - Earned numerous skills
    - Electronics, Control, Running Projects, and etc.
  - Earned further motivation to set higher objectives

Thanks!

Any Questions??