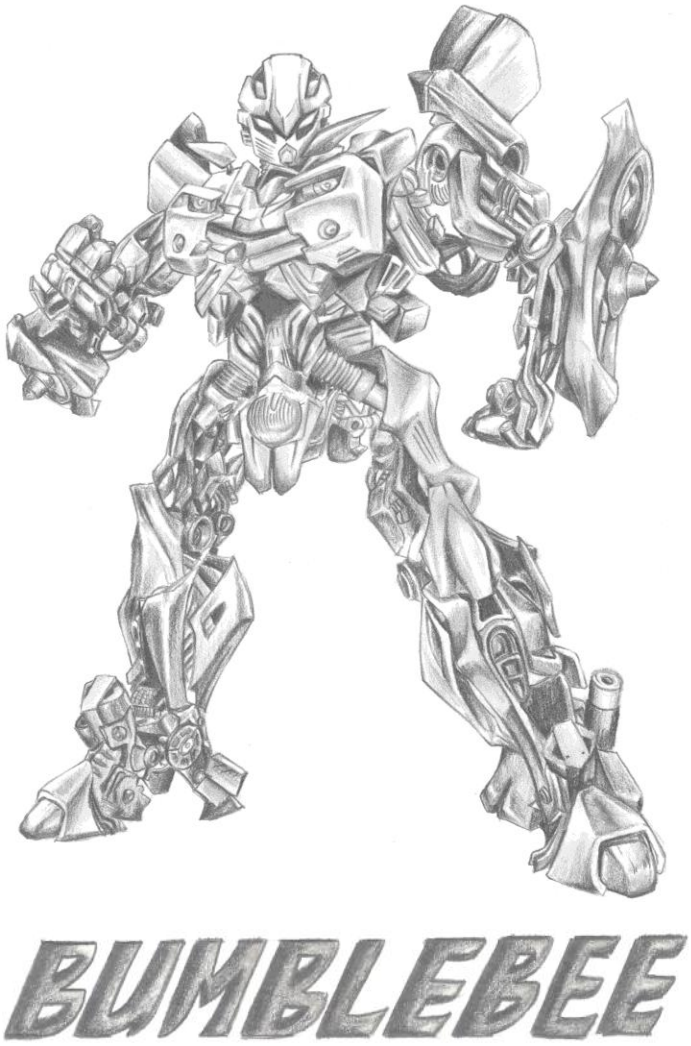


Cansat 2012

Post Flight Review

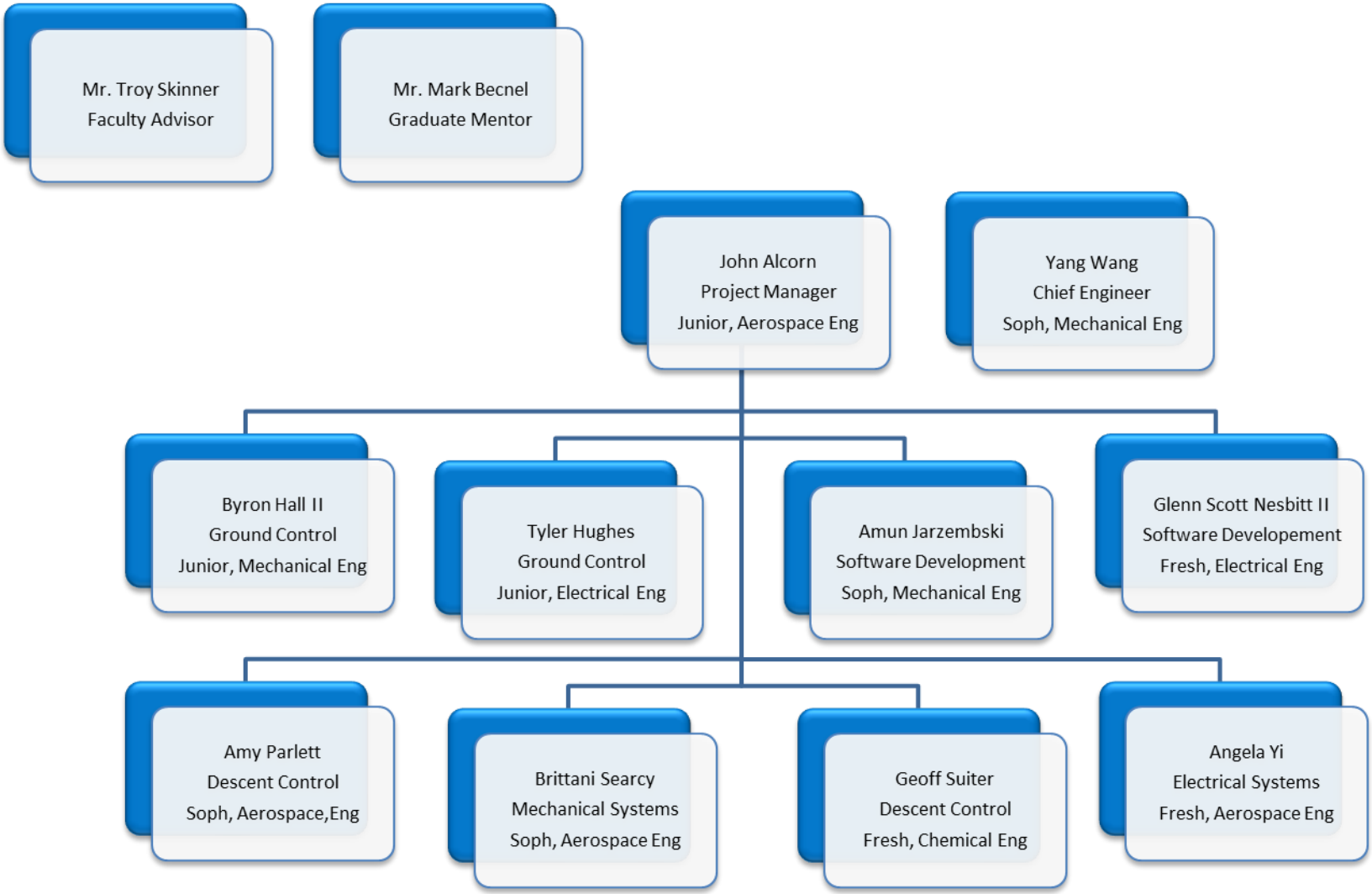
Team # 1024

" Bumblebee "

The University of Alabama in Huntsville

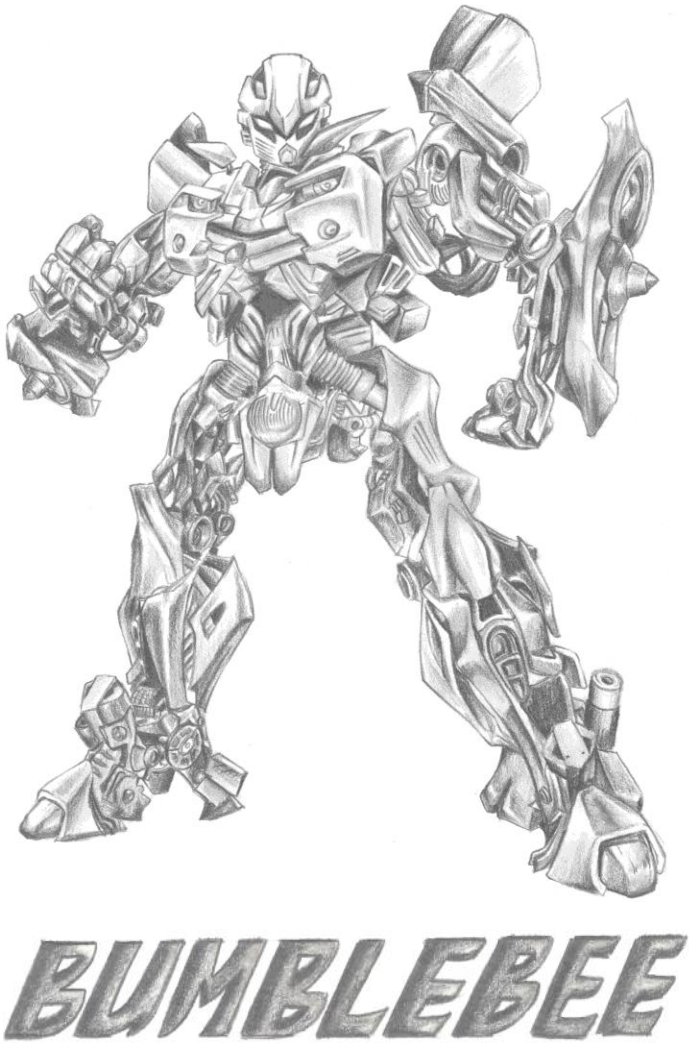
Presentation Outline

Team Organization



Acronyms

A	Analysis
ADC	Analog to Digital Converter
BMR	Base Mission Requirement
CD	Coefficient of Drag
CDH	Communications and Data Handling
CDR	Critical Desgin Review
CONOP	Concept of Operations
CRR	Carrier Requirement
D	Demonstration
DCS	Descent Control System
GCS	Ground Control System
GPS	Global Positioning System
GUI	Graphical User Interface
HW	Hardware
HWR	Hardware Review
I	Inspection
LCO	Launch Control Officer
LDR	Lander Requirement
LiPo	Lithium Polymer
MAE	Mechanical and Aerospace Engineering
MCU	Microcontroller Unit
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PFB	Pre Flight Briefing
PFR	Post Flight Review
RPSMA	Reverse Polarity SubMiniature Version A
RSO	Range Safety Officer
SF	Safety Factor
SOE	Sequence of Events
SOR	Selectable Objective Requirement
SPI	Serial Peripheral Interface Bus
T	Testing
UAH	University of Alabama Huntsville
USART	Universal Asynchronous Receiver/Transmitter
UTC	Universal Time Constant
VM	Verification Method



Systems Overview

Brittani Searcy

Junior, Aerospace Engineering

Mission Summary

- **Cansat**
  - A mock-satellite engineering demonstration carried by a rocket to an altitude of 600 meters and ejected. The Cansat is made of two systems, the Carrier and the Lander. The Carrier is the primary unit, which deploys the Lander during descent.
- **The Carrier unit**
  - Deploy secondary decent control at 200 meters altitude
  - Separate from the Lander at 91 meters altitude
  - Capture video of the Lander separation (selectable)
  - Transmit and record telemetry at 0.5 Hz
  - Beacon audible signal upon landing
- **The Lander unit**
  - Carry an egg safely to the ground
  - Separate from the Carrier at 91 meters
  - Store sensor data onboard
  - Beacon audible signal upon landing

CanSat Overview

- **Mechanical**
  - Side by side configuration
  - Machined from polycarbonate and acrylic plastic
  - Circuit boards mounted using all-thread
- **Decent Control**
  - Streamer/Parasheet/Parasheet configuration
- **Electrical**
  - External ADC
  - All components mounted on board
    - Exceptions: Camera and Buzzer
  - PCB fabrication

CanSat Overview

- **Software**
  - Commands based on pressure
  - Transmission of telemetry and memory storage to a text file for later analysis
  - Switch case structure
  - Motion video activation for CanSat separation
- **Ground Control**
  - Sends a particular string to the CanSat to begin telemetry with the press of a button
  - Displays telemetry in real time
  - Ends telemetry transmission by pressing the “Stop” button

Component Summary

Mechanical

- Structure
- Release mechanism

Decent Control

- Parasheets
- Streamer

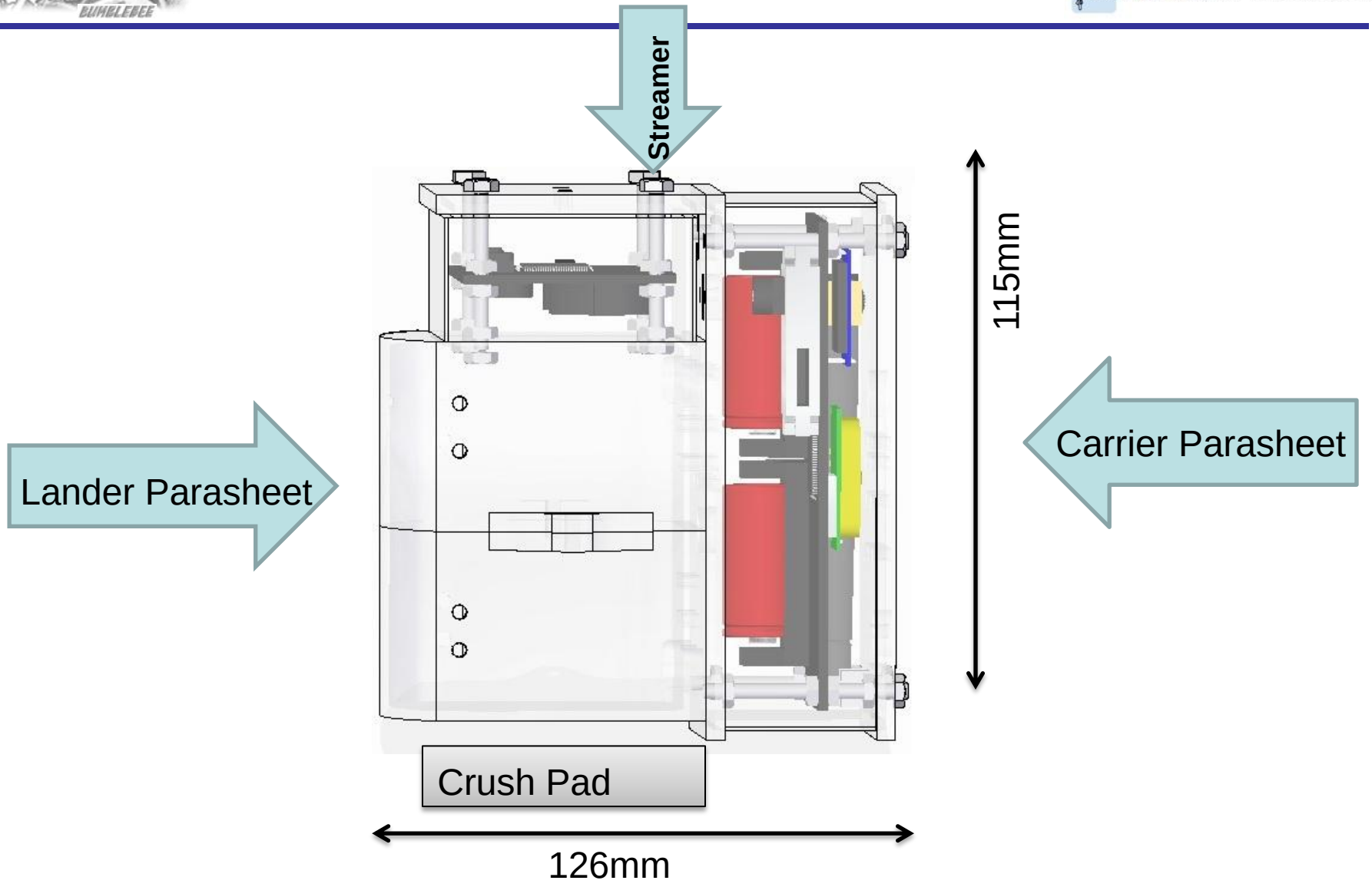
Electrical

- Carrier
  - Microcontroller, external ADC pressure sensor, thermistor, radio, GPS, video camera, microSD chip, FTDI chip, audible beacon, hotwires, MOSFETs
- Lander
  - Microcontroller, external ADC pressure sensor, thermistor, microSD chip, FTDI chip, audible beacon, MOSFETs

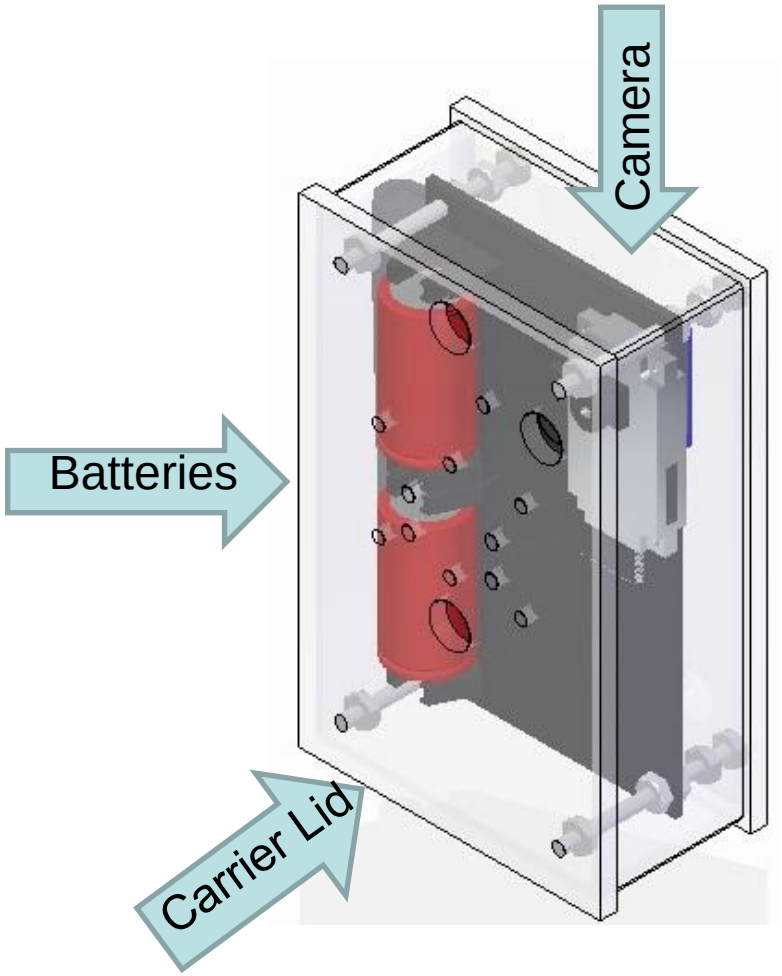
Ground Station

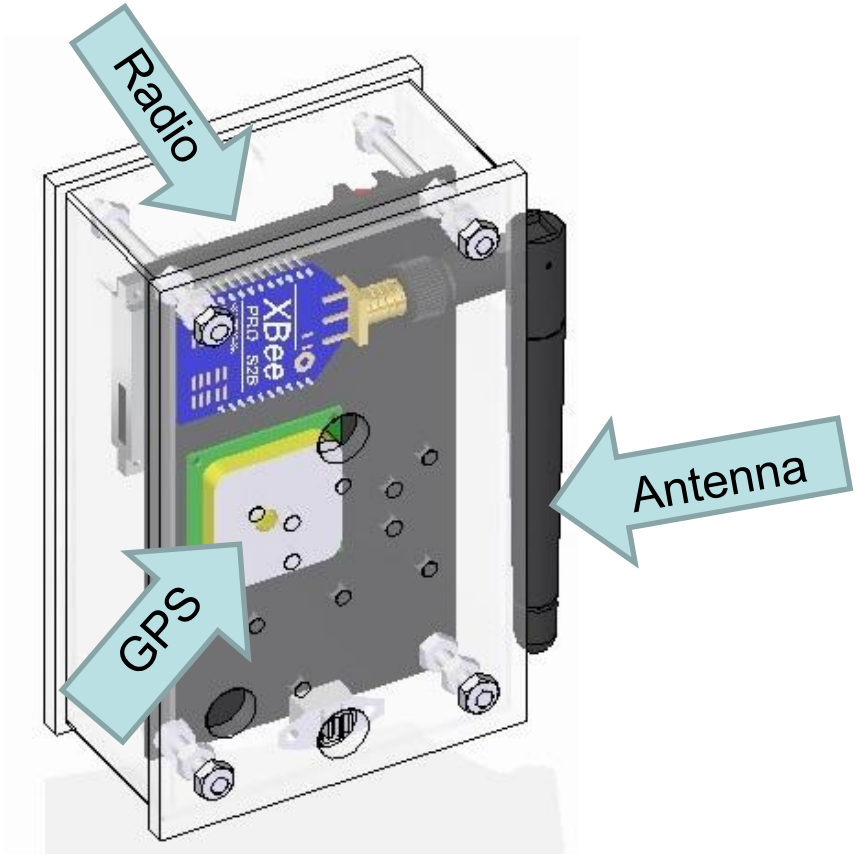
- Tower, USB cable, rope, stakes, PC

Physical Layout

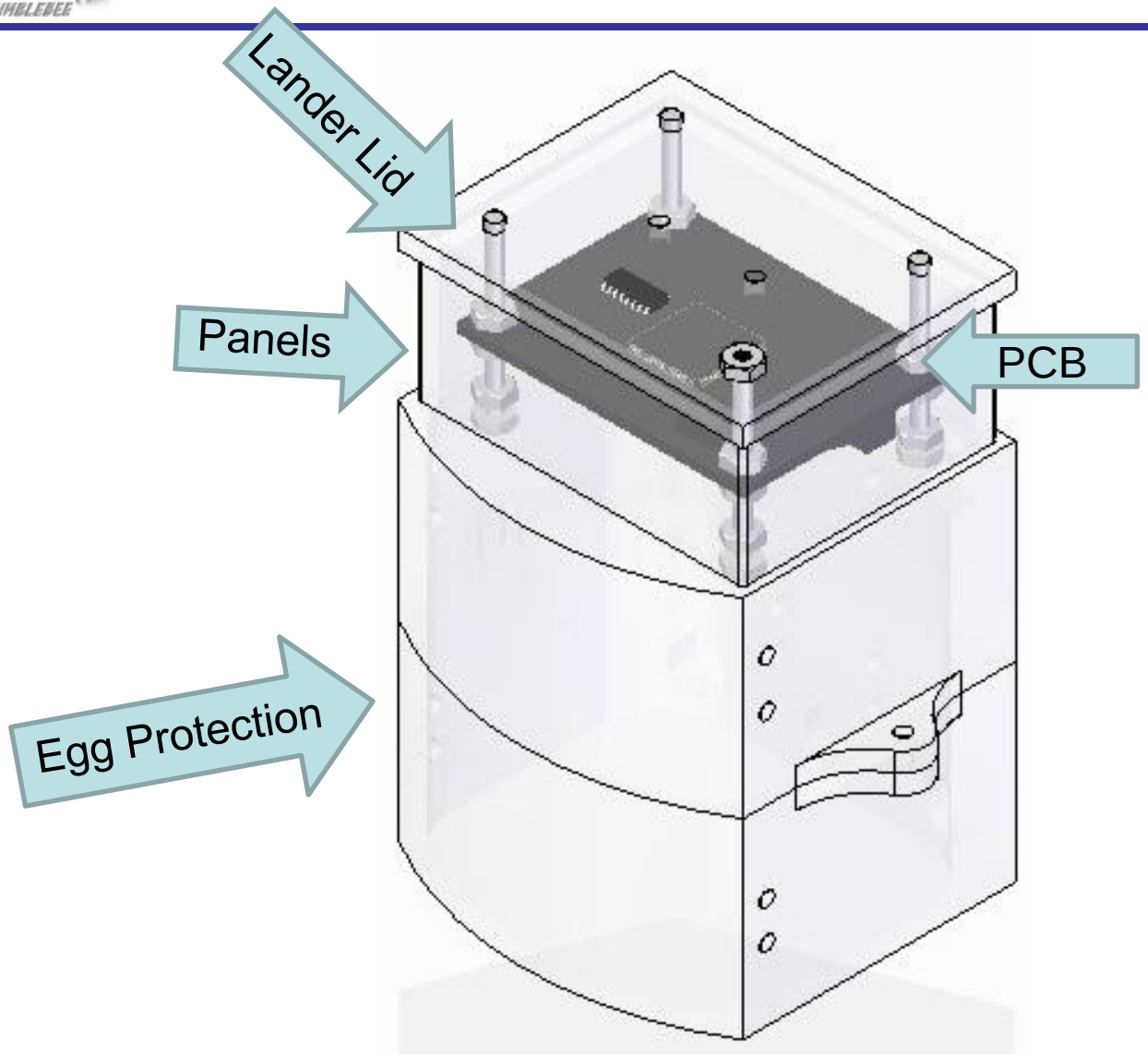


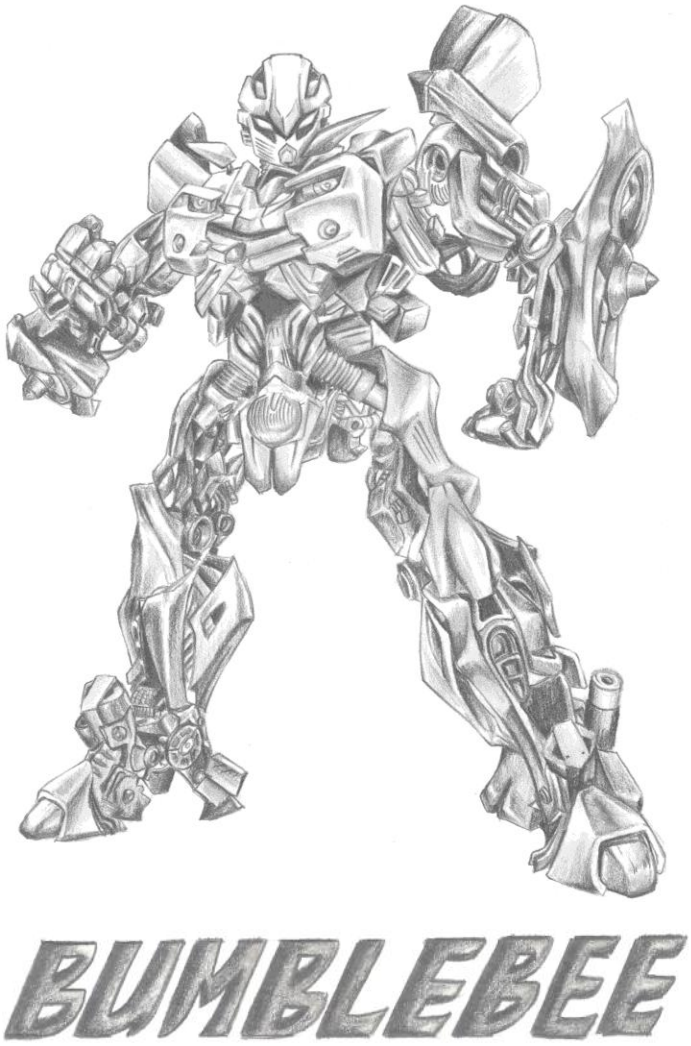
Carrier


Camera
Batteries
Carrier Lid


Radio
XBee
PRO S2B
Antenna
GPS

Lander





CONOPS and SOE

Angela Yi

Freshman, Aerospace Engineering

Concept of Operations – Planned vs. Actual

2012 Texas Annual CanSat Competition

Planned

- **Pre-launch Activities**
  - Power up test
  - GCS - Activation of telemetry
- **Launch Operations and Descent Operations**
  - Basic launch operations
  - Successful descent stages
  - Video footage of separation
- **Post-launch recovery and data reduction**
  - Safely protected egg
  - Successfully stored data

Actual

- **Pre-launch Activities**
  - Power up test
  - Delayed GCS - Activation of telemetry
- **Launch Operations and Descent Operations**
  - Basic launch operations
  - No passive descent control out of rocket
  - Video footage of separation
- **Post-launch recovery and data reduction**
  - Safely protected egg
  - Successfully stored data

Mission Sequence of Events – Planned vs. Actual

2012 Texas Annual CanSat Competition

Planned

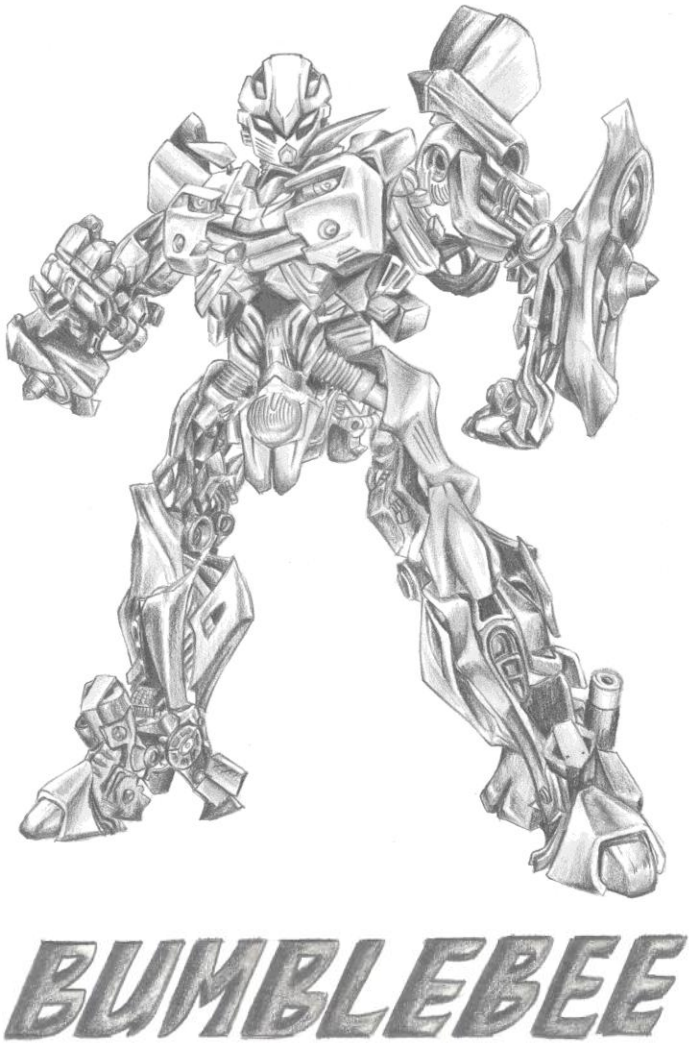
- **Pre-Launch**
  - Arrive to competition site
  - Set up the ground control station
  - Perform communications test
- **Launch Preparation**
  - Measure and record system mass
  - Prep carrier and lander units, assembly
  - Complete safety check
  - Receive approval for launch
  - Power up and load into launch vehicle
  - Initiate data transmission by GCS
- **Recovery**
  - As a team, search for CanSat
  - Check egg, video, and other data

Actual

- **Pre-Launch**
  - Completed planned pre-launch
  - Had to make extra adjustments
- **Launch Preparation**
  - Completed planned launch preparations
  - Made GCS adjustments for telemetry activation
- **Recovery**
  - Performed successful recovery operations

Flight Software Requirements

- **Data acquisition**
  - Pressure, battery voltage, temperature, GPS
  - SPI communication with external ADC (increased resolution)
- **Telemetry and memory storage**
  - Data and video stored onboard
  - Ground station communication (0.5 Hz) – Telemetry activation and termination
- **Command execution**
  - Decent control stages and video (MOSFETs)
  - Buzzer activation
- **Integration with electrical**
  - Compatibility of software with MCU and other electrical devices



Flight Data Analysis

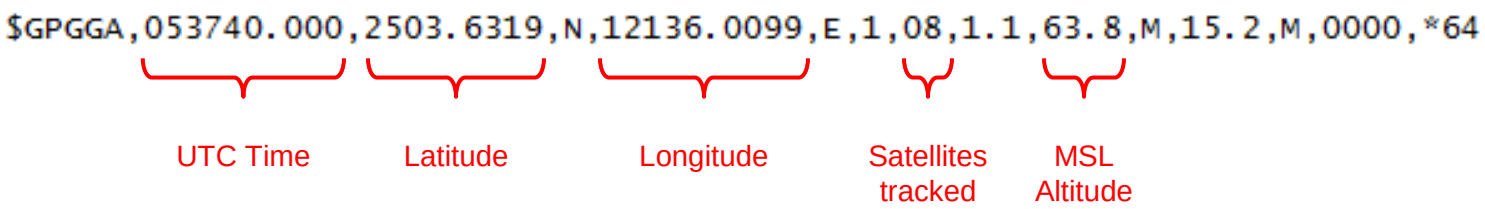
Amun Jarzembski
Junior, Mechanical Engineering

Tyler Hughes
Junior, Information Systems

Flight Data Analysis – Carrier GPS

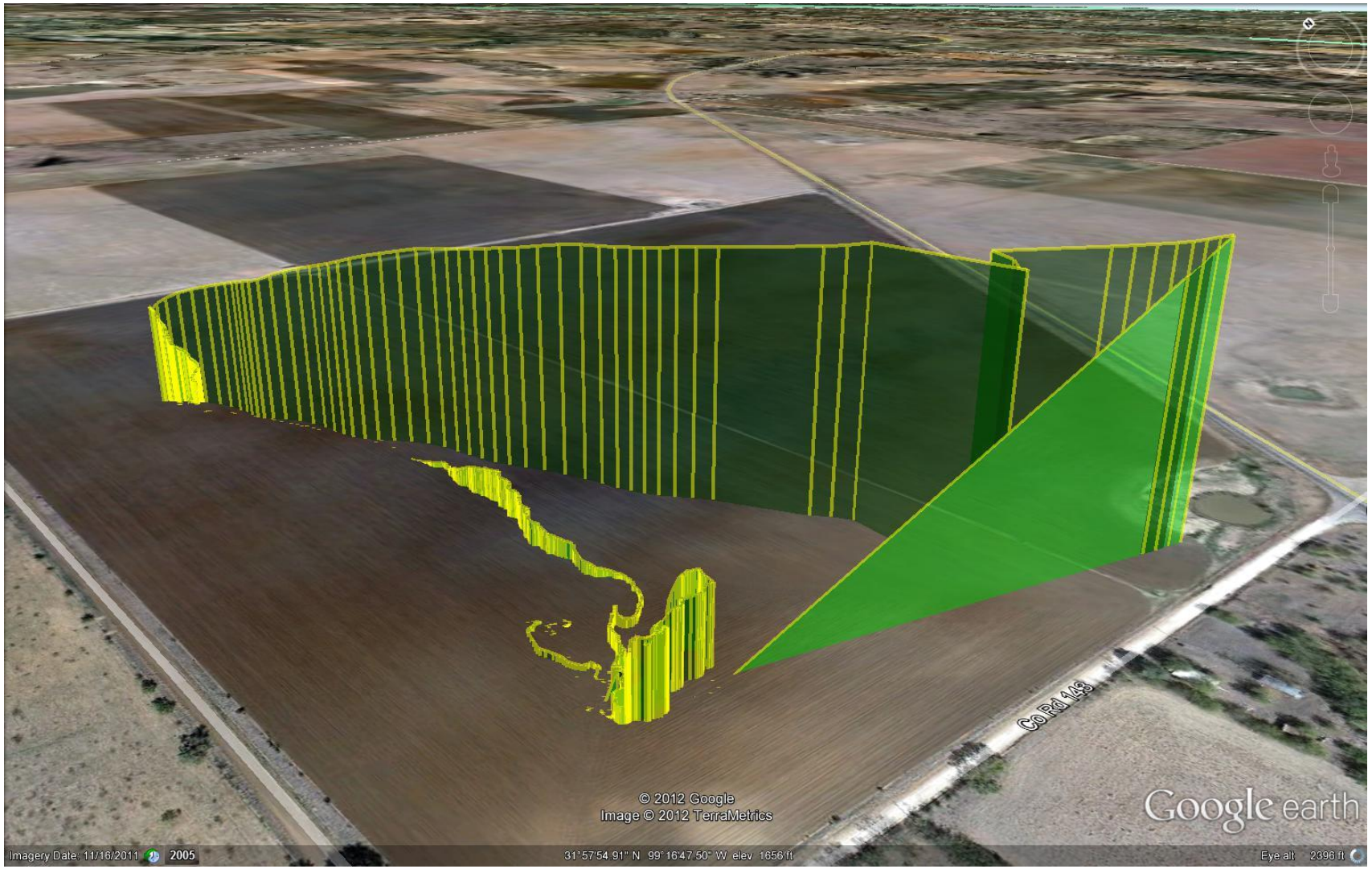
- Carrier GPS telemetry is sent via radio in the form of a GPGGA string.

Example packet:

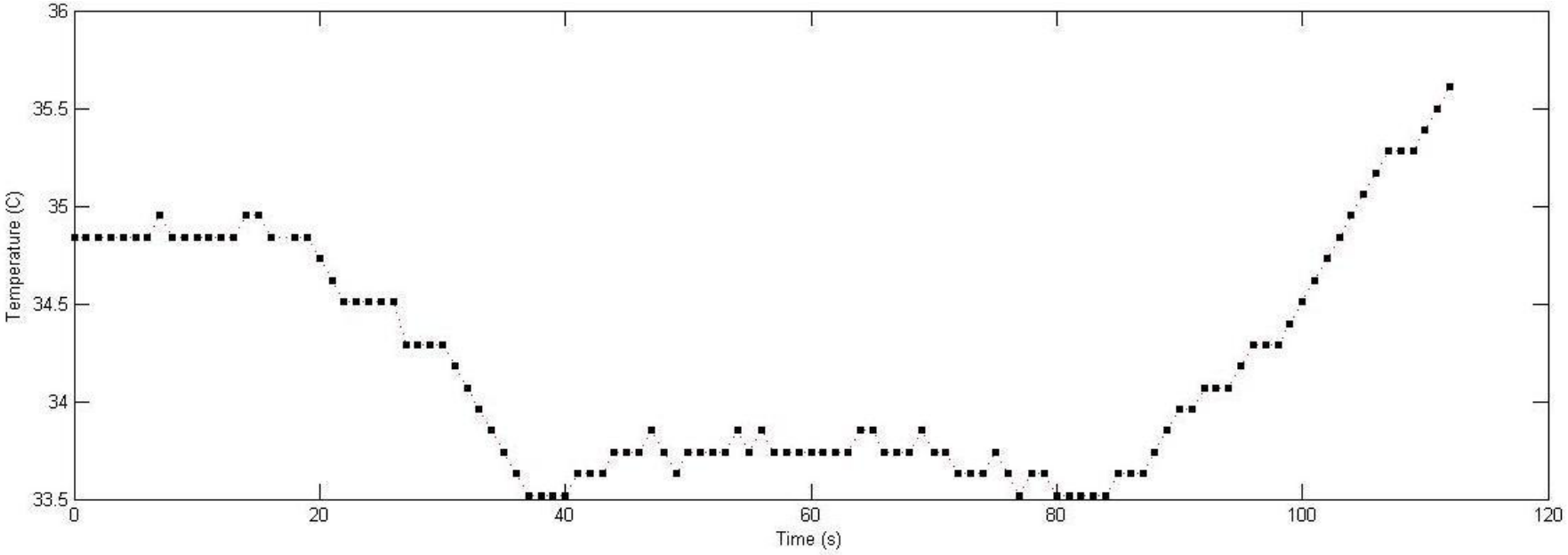


- The ground station is used to receive all telemetry from the carrier. It can also be used to:
  - Analyze GPS packets (GPGGA).
  - Plot data in KML format for later analysis of altitude.
  - It also saves the raw packets to a text file for later analysis by third party software (i.e. Microsoft Excel).

GPS Plot

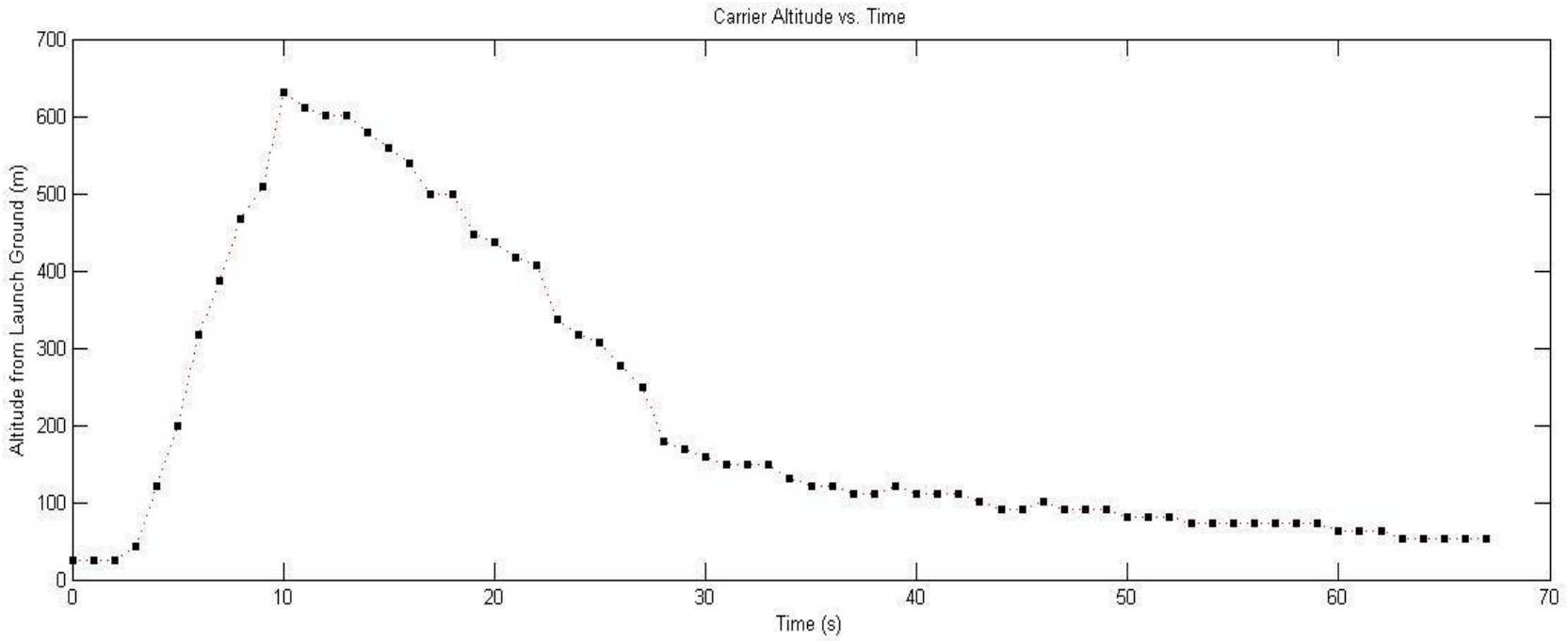

Co Rd 143
© 2012 Google
Image © 2012 TerraMetrics
Google earth
Imagery Date: 11/16/2011
2005
31°57'54.91" N 99°16'47.50" W elev 1656 ft
Eye alt 2396 ft

Carrier Temperature Data



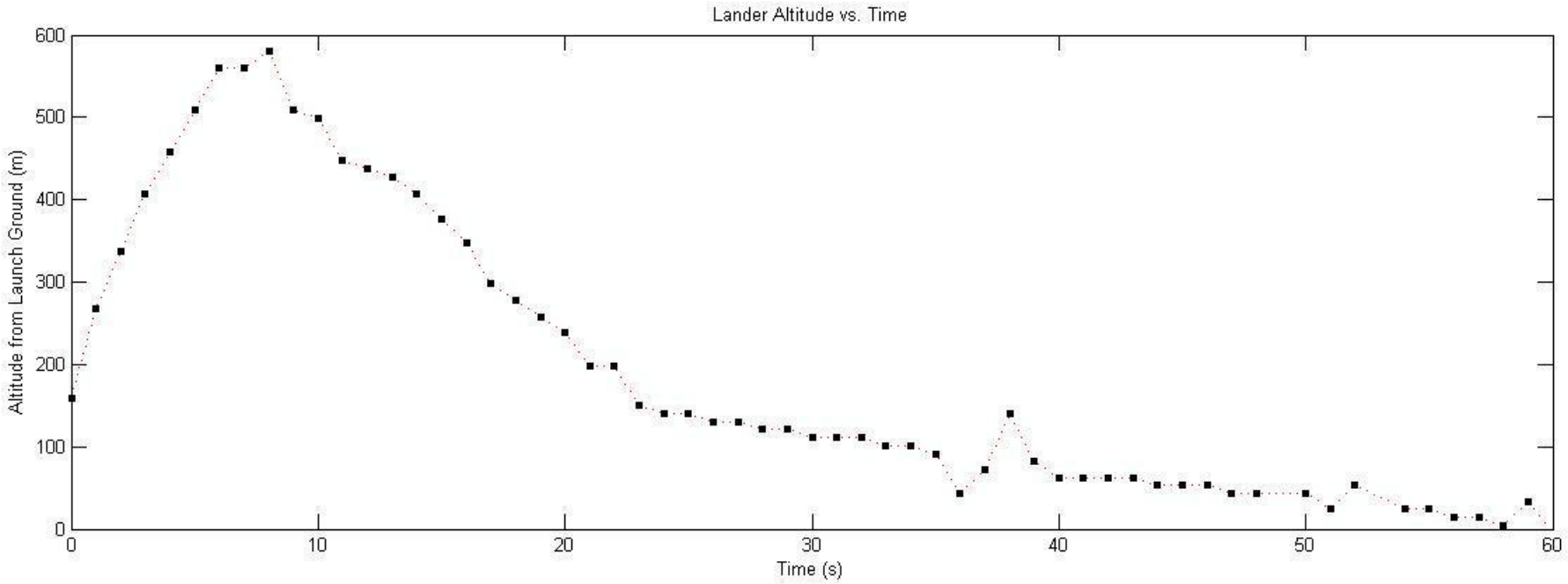
- **Minimum temperature: 33.5 °C**
- **Maximum temperature: 35.6 °C**

Carrier Altitude Data



- **Descent stage 1 (apogee to 200m)**
  - Average speed: 23.3 meters per second
- **Descent stage 2 (200 to 91m)**
  - Average speed: 4.3 meters per second

Lander Altitude Data

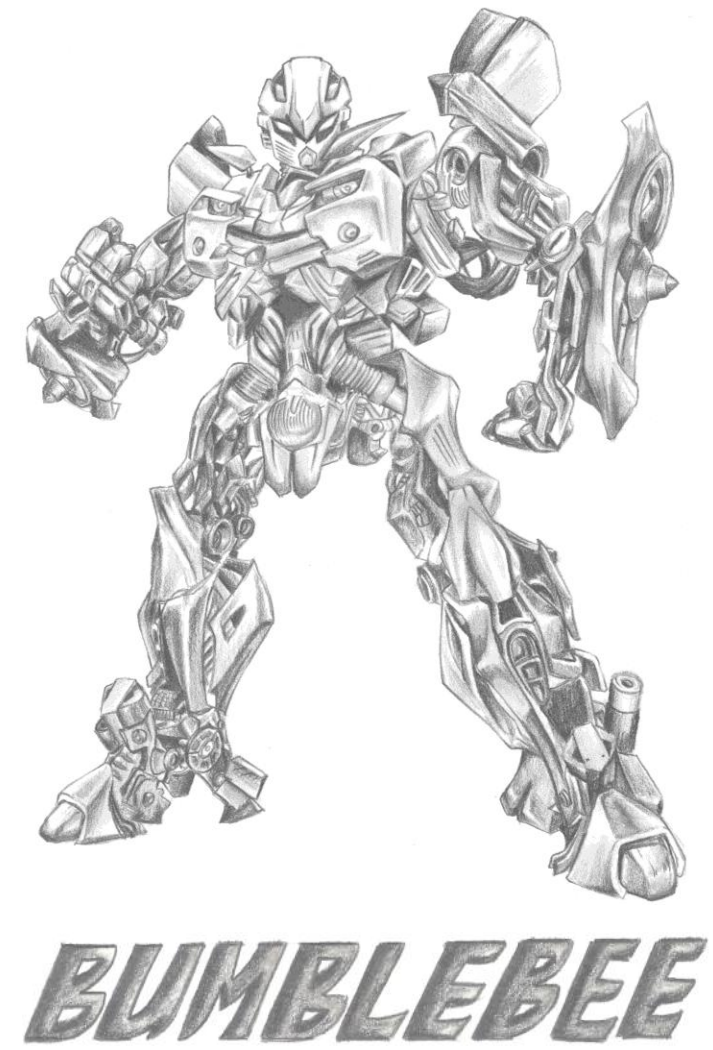


- **Separation (91m to ground)**
  - Average speed: 3.66 meters per second

Data Analysis Procedure

- **Excel to compile data**
  - From .csv text files
  - Trendline application on graphs
  - Isolate decent stages to find average speeds
- **Statistics methods**
  - Chauvenet's Criterion – based on number of samples
  - Identify and eliminate outliers

Video footage



Failure Analysis

John Alcorn
Junior, Aerospace Engineering

Failure Analysis - Streamer

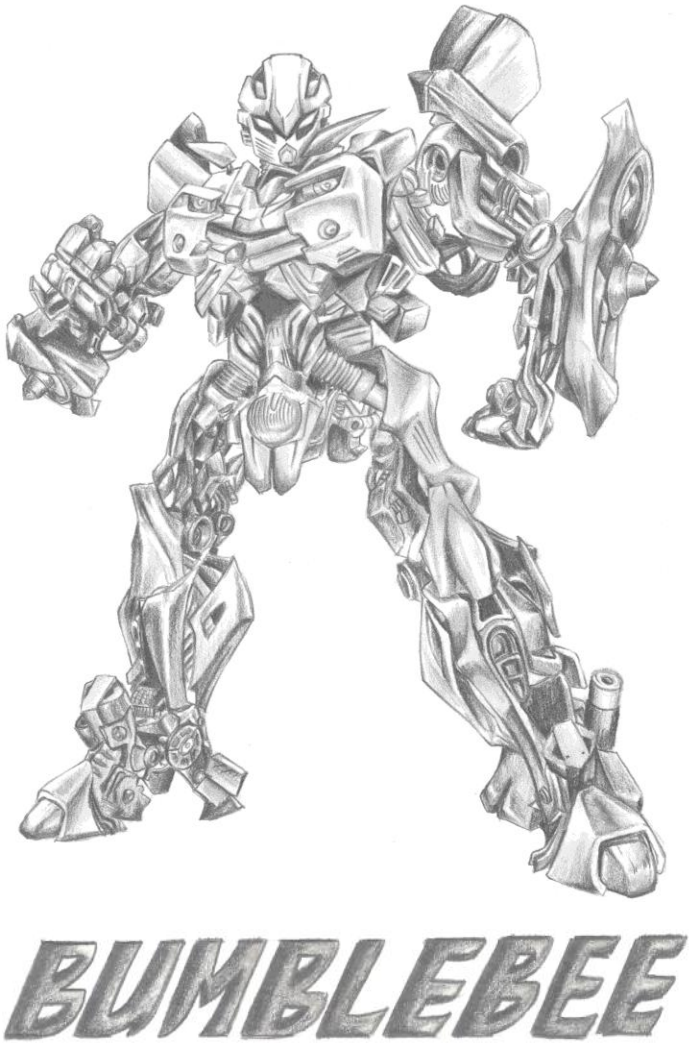
- **Failure**
  - Streamer material ripped upon separation from rocket
  - Determined by inspection of system and line of sight view during descent
- **Cause**
  - Angled ascent of rocket caused high apogee velocity; separation from rocket was followed by large shock force which ripped material
- **Result**
  - Cansat descended uncontrolled from apogee to 200 meters
- **Possible resolution**
  - Avoid use of material which could fail under shock force

Failure Analysis – COMMS activation

- **Failure**
  - COMMS activation from GCS failed during first launch attempt
- **Cause**
  - Serial buffer on Cansat was constantly full
- **Result**
  - Cancelled first launch attempt
- **Resolution**
  - Insert line of code that flushes serial port
  - Allowed us to activate telemetry for second launch

Failure Analysis – Battery voltage

- **Failure**
  - Unable to measure battery voltage during flight
- **Cause**
  - Analog pin dedicated to measuring battery voltage bridged over to other pin
- **Result**
  - No meaningful data
- **Resolution**
  - Use extra caution when soldering, shield system from environment



Management

John Alcorn

Junior, Aerospace Engineering

CanSat Budget – Hardware

Device	Manufacturer Model #	Vendor Part #	Trade	Vendor	Quantity	Price Each	Subtotal
Antenna	A24-HASM-450-ND	A24-HASM-450-ND	Digi	Digi-Key	1	$ 5.00	$ 5.00
Audible Beacon	CST-931AP	102-1458-ND	CUI Inc	Digi-Key	2	$ 1.57	$ 3.14
Battery	SF12-BB	SF12-BB	Surfire	Batteries Plus	4	$ 3.50	$ 14.00
Camera	VCC-004-ATOM-MUVI	VCC-004-ATOM-MUVI	Veho	Veho	1	$ 44.95	$ 44.95
Frame/Housing			INTERNAL FABRICATION			$ -	$ -
GPS	LS20031	#1249	Locosys	Pololu	1	$ 59.95	$ 59.95
Memory	SDSDQ-004G	SDSDQ-004G	Sandisk	eTech	2	$ 5.39	$ 10.78
Microcontroller	ATMega2560-16AU-ND	ATMega2560-16AU-ND	Atmel	Digi-Key	2	$ 12.86	$ 25.72
Miscellaneous						$ 64.44	$ 64.44
PCB			ExpressPCB	ExpressPCB	1	$ 84.85	$ 84.85
Pressure Sensor	MP3H6115A6U	MP3H6115A6U-ND	Freescale Semiconductor	Digi-Key	2	$ 27.27	$ 54.54
Radio	XBP24BZ7SIT-004	602-1180-ND	Digi	Digi	1	$ 29.00	$ 29.00
Ripstop Nylon			Joann Fabrics	Joann Fabrics	1.5	$ 5.98	$ 8.97
SD card holder	DM3BT-DSF-PEJS	HR1942CT-ND	Mouser	Mouser	2	$ 1.09	$ 2.18
Temperature Sensor	NTCLE100E3103JB0	BC2301-ND	Vishay	Digi-Key	2	$ 0.11	$ 0.22
Voltage Regulator	NCP502SQ33T2G	NCP502SQ33T2GOSDKR-ND	ON Semiconductor	Digi-Key	2	$ 0.39	$ 0.78
						TOTAL	**$ 407.52**

Total system cost: $407.52

CanSat Budget – Other Costs

Testing

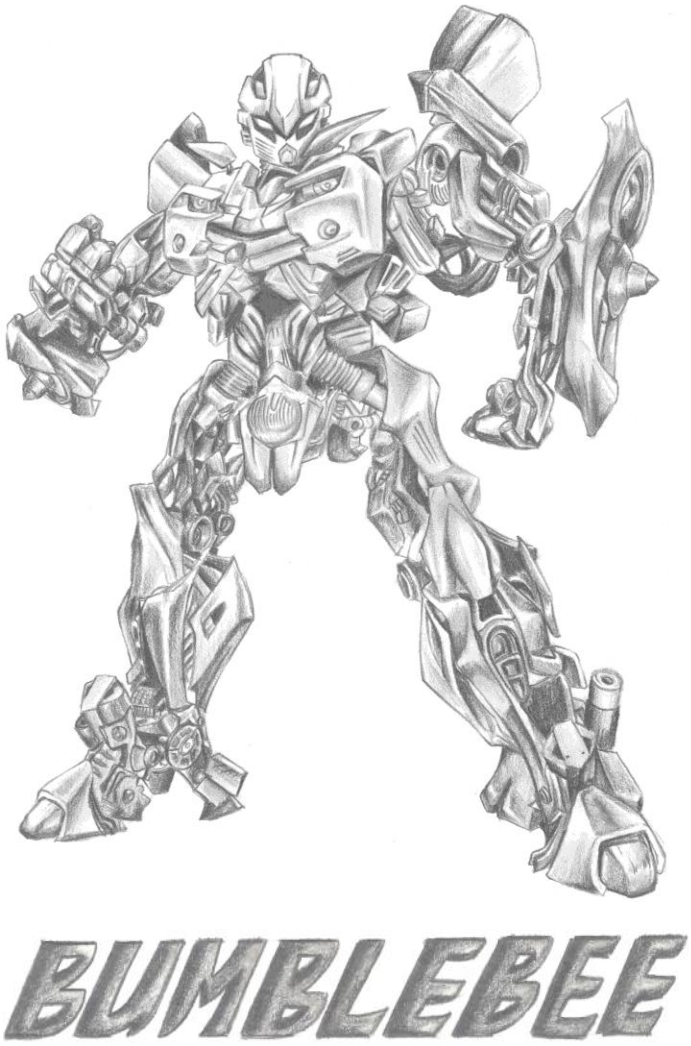
Item	Description	Trade	Quantity	Price	Cost
Rocket tubing	Rocket airframe	Rocketry Warehouse	2	$ 168.00	$ 336.00
Launch fees	High power rocket launch	ON SITE PURCHASE	1	$ 50.00	$ 50.00
Rocket motors	High power rocket motor	ON SITE PURCHASE	3	$ 50.00	$ 150.00
Helicopter services		UNIVERSITY PROPERTY	-	$ -	$ -
High altitude balloon		INTERNAL FABRICATION	-	$ -	$ -
				TOTAL:	**$ 536.00**

Prototyping

Item	Quantity	Price	Total
Rapid Prototyping	1 Canister	$ 360.00	$ 360.00
		TOTAL:	**$ 360.00**

Travel

Item	Description	Quantity	Rate	Duration	Total Costs
Hotel expenses	Lodging in Abilene	4 rooms	$99.00	4 nights	$ 1,584.00
Food expenses	Dining	10 Students + 2 Advisors	$40.00	5 days	$ 2,400.00
Vehicle	University vehicle usage	1800 miles	$0.40		$ 720.00
				TOTAL:	**$4,704.00**



Conclusions

Yang Wang

Yang Wang, Mechanical Engineering

What Worked / What Didn't

- **Successes**
  - Parasheets
  - Mechanical structure, component grouping, egg protection
  - Software (flight progression, data acquisition)
  - Electrical (sensors, hotwires, radio, buzzers, batteries)
  - GCS (antenna and tower, telemetry reception)
  - Camera
- **Failures**
  - Streamer
  - Analog pin bridging on Carrier
- **Design decisions that paid off the most**
  - Grouping components on circuit boards
  - Side-to-side Carrier/Lander configuration

Lessons Learned

- **Lesson learned from in-flight performance**
  - Make descent control material and attachment points stronger
  - Test descent control with rocket
  - Perform more extensive testing between GCS and Cansat
- **Next year…**
  - Focus on software and electrical design troubleshooting
  - Perform “dress rehearsal” system level test with rocket
  - Stick to Gantt chart, avoid letting deadlines slide

Conclusions

- **Project was mostly successful**
  - Hardware performed well; very few component failures
  - All subsystems achieved main objectives
- **Competition has been an excellent learning experience for the team**
  - Have gained great experience through development and flight
  - The team intends to improve next year by resolving the issues met

Questions?