Gateway To Space

ASEN 1400

Class #2

Colorado Space Grant Consortium
Today:

- Announcements
- One Minute Report Feedback
- Spacecraft Overview
- Really and Truly the Foundation for the Class
- Really and Truly FAST
Announcements:

- Anyone here for the **first time**?

- **Pictures** – for those that couldn’t stay Tuesday

- Email password is Audrey, Lindsay, Amanda

- **HW 02** assigned today

- **HW 01, HW 09, and Community Service** assigned last class

- **Spatial Visualization** due Tuesday 09/05 by 12 PM
**Announcements:**

- Some Syllabus changes

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
<th>Additional Information</th>
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<tr>
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<td>08-31-17</td>
<td>R</td>
<td>72</td>
<td>Spacecraft Overview – (Compressed)</td>
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<td>3</td>
<td>09-05-17</td>
<td>T</td>
<td>67</td>
<td>BalloonSat Overview + Request for Proposals: <em>Functional Block Diagrams, Design Documents</em></td>
<td>HW 01 &amp; Spatial Vis. DUE HW 03 Assigned (Q2s 1 - 2)</td>
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<td>HANDS-ON: Team Forming + Team Activity</td>
<td>HW 02 DUE HW 03 Assigned (Q2s 3 - 11)</td>
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<td>09-12-17</td>
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<td>OPERATION: Soldering 101 (Build and Blink)</td>
<td>HW 03 DUE HW 04 &amp; 05 Assigned</td>
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<td></td>
<td>9:20 Start</td>
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<td>&lt;Arduino’s distributed to teams today for HW 04&gt;</td>
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<td>5</td>
<td>09-14-17</td>
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<td>HANDS-ON: In-Class Team Time – Work on your CoDR and Proposals</td>
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<td></td>
<td>9:20 Start</td>
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<td><em>REVIEWS: Conceptual Design Review (CoDR)</em></td>
<td>Presentations DUE 7:00 AM</td>
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<td>09-19-17</td>
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<td><em>5 minute presentations &amp; 5 minutes of Q/A</em></td>
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<td>X1</td>
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<td>HANDS-ON: Arduino Deep Dive (Sensors/SD Card): <em>All team members present for first 75 minutes</em></td>
<td>HW 04 &amp; 05 DUE HW 06 Assigned</td>
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<td>6 – 9 PM</td>
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<td>HANDS-ON: Team Inclusive Activity</td>
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<td>X2</td>
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<td>PROPOSALS DUE 5:00 PM</td>
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</table>
One Minute Report Questions:

GoatsLive

YouTube

GoatsLive
One Minute Report Questions:
Next Time...

BalloonSat Overview

HW 01 DUE
Going to try something completely new…

- Want to make this more interactive
- You are all now in start ups

- Mockheed-Lartin
- Small Aerospace
- Southrup-Brumen
- Space-Y
- Orange Origin
- Porbital-ATK
- Slurrey Aerospace
- Serious Nevada Corp
- Slaytheon

- You will answer 4 questions satellites
- You will report to me
- Keep score on how I think you did
Question #1

Your start-up is considering satellites as a product line but your creative team wants to determine what you can from other satellites by looking at pictures on Google. Identify as many spacecraft subsystems in the picture as possible.
Horizon Crossing Indicator
Receive Patch Antenna
Battery Box (x2)
Ball & Tube Nutation Detector
Mass Trim System (x8)
Whip Transmit Antenna
3-axis Magnetometer
Solar Panel (x96)
Accelerometers (x6)
Subsystem Boxes (CDH, EHS)
Wind & Temperature Sensors
Stiffeners (x4)
Separation Mechanism
Torque Rods (x2)
EGSE connector
Kinematic Mounts (x4)
Lightband Adapter Brackets
von Braun:
Your start up is going to build satellites, what do you need to worry about while designing, building, testing, launching, and operating a satellite in space? Please list as many as your creative team can think of below.
Other Items to Worry About…Why?

- Radiation
- Temperature Extremes
- Vacuum of Space
- Atmospheric Drag
- Cleanliness
- Launch Loads
- Shock
- Power
- Mission Life
- Autonomy
- Cash
- Pointing
- Schedule
- Weight
- Getting There (Launch Vehicle)
- When? Time to get there…
Question #3

Your start-up has received its first paying customer. They want to launch this camera into space to take pictures of Boulder, Colorado every day at 10:30 AM and 10:30 PM. Before you sign the contract, your creative team must come up with all the things you might need and what satellite subsystem you will need to complete this mission. Please list those here and a bullet statement as to what that system will address in the satellite. For example, you will need a power system – to power the camera.
<table>
<thead>
<tr>
<th>What Do You Need?</th>
<th>Schedule</th>
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</thead>
<tbody>
<tr>
<td>Temperature Control System</td>
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<tr>
<td>Communication System</td>
<td>Budget</td>
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<tr>
<td>Command and Data System</td>
<td>Plan</td>
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<tr>
<td>Structure and Mechanisms</td>
<td>Testing</td>
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<tr>
<td>Power System</td>
<td>Reliability</td>
</tr>
<tr>
<td>Attitude System</td>
<td>Operators</td>
</tr>
<tr>
<td>Software</td>
<td>People, People, People</td>
</tr>
<tr>
<td>Propulsion System</td>
<td>Organization</td>
</tr>
<tr>
<td>Launch Vehicle</td>
<td>Cash</td>
</tr>
</tbody>
</table>
How...

- Take a picture?
- Power the camera?
- Record the images?
- Get the image?
- Save the image?
- Take an image of what?
- Frequency of pictures?
- Get pictures from space?
- Point the camera?
- I know it will work?
- Keep it cool?
- Cost?

- C&DH/Software
- EPS
- C&DH/Software
- COMM
- C&DH/Software
- Orbit/ADCS
- Orbit
- Launch vehicle
- Structures/Mechanisms
- Integration/Test
- Thermal
- Management
Spacecraft Subsystems:

- Project Management
- Systems Engineering
  - Comm
  - Structures
  - Thermal
  - ADCS
  - C&DH
  - Power
    - Ground Ops
    - Education
    - Prop
    - Science
    - Software
    - MOPS

Teamwork
Spacecraft Subsystems:

- Project Management
- Systems Engineering
- Comm
- Structures
- Thermal
- ADCS
- C&DH
- Power
- Ground Ops
- Education
- Prop
- Science
- Software
- MOPS

Systems YOU will have on your BalloonSat
1. Mission – Thus the Mission Requirements (#10)

2. Orbit Selection

3. Launch Vehicle

4. Everything else
   - Structures, Interfaces, and Mechanisms
   - Power & Thermal
   - C&DH/Software
   - Communications
   - ADCS
   - MOPS
   - Other
Orbit Selection: (#17)

- Do you want to take picture of Boulder every day?
- At the same time?
- As many times as possible per day?

- Pick orbit right up front

Different Types of Orbits
- Polar Orbits
- LEO
- GEO
- Different altitudes and inclinations
- Sun Synchronous Orbits

- STK (Satellite Tool Kit)
Launch Vehicle: (#16)

- Then pick launch vehicle based on your orbit needs
- Weight needs
- Cost needs
- Certain launch vehicles can’t go to all orbits
Your start-up is going to the Satellite Depot this weekend to pick up some of the hardware you need. Please report to the front of the “store” when called to pick up your necessary hardware.
Structures (#13)

Project Management

Systems Engineering

Comm  Structures  Thermal  ADCS  C&DH  Power

Ground Ops  Education  Prop  Science  Software  MOPS
Structures:
Structures:

- Your launch vehicle helps direct your structure design
- Volume, CG, and weight constraints
- Launch loads and shock issues associated with LV
- Interface constraints
- Vibration constraints
Structures:
Structures:

- The whole purpose of the structure is to support the payload
- Then the other systems
  - Composites
    - Honeycomb
  - Aluminum
    - Plate
    - Isogrid
  - Titanium
  - Stainless Steel
Structures:
Structures:

- Design vs. Implementation
Communication:

- Think of it as an internet connection

- Data rates are similar but
- Can only connect for 10 minutes (pass time)
  - This can vary based on orbit
Communication:

- Transmitter (TX)
- Receiver (RX)
- Antennas (TX, RX, and Ground)
- Sometimes modems and TNC
- TX are big power hogs but usually not on all the time

- Signal to noise ratio

- Cell phone technology
- IP technology
- Satellite to satellite
Communication/Ground Ops:
Communication/Ground Ops:
Mission Operations (MOPS)/Ground Ops:

- “Houston, we have a problem”

- MOPS is the command center of the satellite
Mission Operations (MOPS)/Ground Ops:

- All human interaction occurs through this team
- Much coordination is required to properly operate satellite
- Failure modes determined FMEA
- Data storage and analysis
- All communication is done through MOPS
- Usually staffed 24/7
Mission Operations (MOPS)/Ground Ops:

- Some teams will have ground ops this semester if you...
  - Have a communication system
  - Have a sensor(s) that need ground data to compare to flight data
  - Have a mission that requires ground data
Mission Operations (MOPS)/Ground Ops:
ADCS:

- Attitude Determination and Control System

D = Determination

C = Control

- Think of driving a car...
ADCS:

on a mountain pass at night without headlights and no tires
- D vs. C?
**ADCS:**

D = Determination

- Determination Systems
  - Star Trackers, Magnetometer, Sun Sensors
  - Horizon/Limb Sensors
ADCS:

- C = Control Systems
  - Torque Rods, Momentum/Reaction Wheels, Control Motion Gyros, Thrusters, gyros, booms
  - A lot of software and control laws
Functions of Spacecraft Propulsion:
- Attitude Control
- Station Keeping or stay in orbit (Atmospheric drag)
- Delta V burns (orbit maneuvers)

- Different types
  - Mono-propellant
  - Bi-propellant
  - Cold Gas
  - Ion
Power:

- Miniature power plant

- Most spacecraft use less power than a 300 W light bulb

- Very complicated system

- There is high likelihood of power being the reason a satellite fails

- Batteries
Power:

- Solar cells
- Charging circuits
- Distribution system
- Control system
- Conversion system
Thermal (#19)

- Project Management
- Systems Engineering
  - Comm
  - Structures
  - Thermal
  - ADCS
  - C&DH
  - Power
  - Ground Ops
  - Education
  - Prop
  - Science
  - Software
  - MOPS
Thermal:

- Can make or break a system literally

- Three types of thermal control: Active, Passive, Do Nothing

- Active
  - Heaters, heat pipes, thermostats, cryogenics

- Passive
  - Radiators, insulation, surface finishes, conductive materials

- Do Nothing

- Usually a combination of first two
Thermal:

- Thermal Modeling
Thermal:
Thermal:
C&DH (#6, 8, 9, x2)

- Project Management
- Systems Engineering

- Comm
- Structures
- Thermal
- ADCS
- C&DH
- Power

- Ground Ops
- Education
- Prop
- Science
- Software
- MOPS
C&DH:

- Command and Data Handling (Computer)

- Basically a home computer but much smaller and less of a power hog

- The brain of a satellite

- Is pretty dumb without software

- Very difficult system, many unknowns and bugs
C&DH:
Software:

- Programmers are worth weight in gold
- Days of Voyager spacecraft are over
- Today, satellites are very complex and so is the software

```c
#include "inc.h" // Include Library Files
#define MEMSIZE 0x200000L

void sample(void)
{
    /* Use this function to perform the following tasks:
       1) Sample each of the payload's sensors
       2) Sample the Geiger counter
       3) Write these values to memory
       4) Clear the Geiger counter
    */

    write(adcGetChar(ACCEL_X_LOW)); // Convert analog value for x low accel and
    write(adcGetChar(ACCEL_Y_LOW)); // Convert analog value for y low accel and
    write(adcGetChar(ACCEL_Z_LOW)); // Convert analog value for z low accel and
    write16(adcGet16(ACCEL_X_HIGH)); // Convert analog value for x high accel and
    write16(adcGet16(ACCEL_Y_HIGH)); // Convert analog value for y high accel and
    write16(adcGet16(ACCEL_Z_HIGH)); // Convert analog value for z high accel and
    write16(adcGet16(TEMP)); // Convert analog value for temp and write to storage
    write16(adcGet16(PRESSURE)); // Convert analog value for pressure and write
```
Software:

- Software is usually last thing done

- Last minute fixes are very dangerous
Other

- Project Management
  - Systems Engineering
    - Comm
    - Structures
    - Thermal
    - ADCS
    - C&DH
    - Power
    - Ground Ops
    - Education
    - Prop
    - Science
    - Software
    - MOPS
Other:

- Management (Team)
- Systems Engineering (#112)
- Budgets (Team)
- Contracts
- Planners (Team)
- Technicians, Manufacturers, Test Engineers (Team)
- Mechanisms
**Mechanisms:**

- In addition to structure you have mechanisms
- People are afraid of mechanisms
- Two types, deployment and payload support
- They usually are single point failures
- Hard to test on ground as they are used in space
  - Mast example (Special Programs, Balloon)
  - KC-135 Boom Video
WELCOME REDUCED GRAVITY
EDUCATION FLIGHT PROGRAM 2011

JOHNSON SPACE CENTER
Mechanisms:

- Deployment failures usually are mission ending
- Spacecraft design try to minimize mechanisms
- Deployment mechanisms are the biggest concern
- Pointing mechanisms are less of an issue
KEEP CALM AND WRAP IT UP
Say I Wanted You...

To take pictures from space with this...

- How would you do it?
Anatomy of a Satellite:
Anatomy of a Satellite:
Anatomy of a Satellite:
Anatomy of a Satellite:
Anatomy of a Satellite:
Anatomy of a Satellite:
Anatomy of a Satellite:
Questions?

Colorado Space Grant Consortium
Today:

1. Sun Shade
2. #2
3. CCD Radiator
4. #4
5. Spacecraft Avionics
6. #5
7. Photometer
8. Photometer Electronics
9. Solid State Recorder
10. Omni-antenna (1 of 2)
Pictures?