Gateway To Space

ASEN 1400

Class #2

Colorado Space Grant Consortium
Today:

- Announcements

- One Minute Report Feedback (end)

- Next Time

- 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 list password is Gabriel, Amber, or Leina

- **HW 02** assigned today

- HW 01, HW 09, and Community Service **assigned** 8/25

- **Spatial Visualization** assigned today (not ready)
What would this look like from the bottom?
Foam Core Example
Why do we like spatial visualization?

1. Most significant predictor of success in engineering
2. It’s learnable!
Purdue Spatial Visualizatıon Test: Rotations (PSVT:R)
Purdue Spatial Visualization Test: Rotations (PSVT:R)

- 30 question multiple choice in 30 minutes
- Score > 20 = passing
- Score < 20 = required to attend SV workshops
- 5% of semester grade given after passing PSVT:R

<table>
<thead>
<tr>
<th>Week</th>
<th>Block A</th>
<th>Session A</th>
<th>Session B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 1</td>
<td>9/7 – 9/11</td>
<td>Isometric Drawing</td>
</tr>
<tr>
<td></td>
<td>Week 2</td>
<td>9/14 – 9/18</td>
<td>Orthographic Views</td>
</tr>
<tr>
<td></td>
<td>Week 3</td>
<td>9/21 – 9/25</td>
<td>1D &amp; 2D Rotations</td>
</tr>
<tr>
<td></td>
<td>Week 4</td>
<td>9/28 – 10/2</td>
<td>Review + <strong>TEST</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Block B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 5</td>
<td>10/5 – 10/9</td>
<td>Modules A-C</td>
<td><strong>--</strong></td>
</tr>
<tr>
<td>Week 6</td>
<td>10/12 – 10/16</td>
<td>Modules D-F</td>
<td><strong>--</strong></td>
</tr>
<tr>
<td>Week 7</td>
<td>10/19 – 10/23</td>
<td>Modules G-I</td>
<td><strong>--</strong></td>
</tr>
<tr>
<td>Week 8</td>
<td>10/26 – 10/30</td>
<td>Review + <strong>TEST</strong></td>
<td><strong>--</strong></td>
</tr>
</tbody>
</table>

*Tuesdays, 5-7pm, ITLL 150*

*Thursdays, 5-7pm, ITLL 150*

*Block A*

*Block B*

*makeup sessions on Sundays 4-6pm in ITLL 150*
Spatial Visualization Test:

- Everyone Required to take test by 9/3 at 9:30 AM

- Pass 5%  Fail 0%

- If you fail, you will be requested by the college to attend workshops starting next week so they are looking at your results

- After workshops, you will be able to retake test and still get 5%
Spatial Visualization Test:

- I took it

- Only have 30 minutes

- It was a mind bending experience but fun

- My score was 26 out of 30

- My advice…Use your hand
Spatial Visualization Test:

- Log into learn.colorado.edu
Spatial Visualization Test:

- Log into learn.colorado.edu
Spatial Visualization Test:

- Log into learn.colorado.edu
Spatial Visualization Test:

GEEN 1400 - Spatial Visualization (Fall 2014)

Questions

0 of 30 questions saved

Page 1:

Quiz

Note: It is recommended that you save your response as you complete each question.

Information

This test consists of 30 questions designed to see how well you can visualize the rotation of three-dimensional objects. Shown in figure 1 is an example of the type of question included in this test.

Figure 1

IS ROTATED TO

AS

IS ROTATED TO

A  B  C  D  E
Spatial Visualization Test:

- You must click SAVE after each question or no credit

Question 1 (1 point)

```
is rotated to
```

```
as
```

```
is rotated to
```

Options:

- [ ] 
- [ ]
- [ ]
- [ ]
- [ ]
- [ ]

Save
Questions?
One Minute Report Questions:

“The function of education is to teach one to think intensively and to think critically. Intelligence plus character - that is the goal of true education.”

Martin Luther King, Jr.
Next Time...

BalloonSat Overview

HW 01 DUE
Questions?

Colorado Space Grant Consortium
Spacecraft Overview

“Fast Version”

Class #2

Colorado Space Grant Consortium
Updates Since We Last Met (November 4, 2009)
Spacecraft Subsystems:

- Power
- Comm
- Project Management
- Structures
- Thermal
- ADCS
- C&DH
- MOPS
- 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
Landing sites on opposite sides of Mars.
The mission was planned to last for 90 days each.
The rovers were designed to travel up to 350 feet each Martian day, or sol (approximately 24 hours, 37 minutes).

Image credit: NASA/JPL-Caltech
Say I Wanted You...

To take pictures from space with this...

- How would you do it?
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
The answers to these questions make up most spacecraft systems. How...
What Do You Need?

- Temperature Control System
- Communication System
- Command and Data System
- Structure and Mechanisms
- Power System
- Attitude System
- Software
- Propulsion System
- Launch Vehicle
- Schedule
- Budget
- Plan
- Testing
- Reliability
- Operators
- People, People, People
- Organization
- Cash
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…
The Process: (Chris’s Process)

To put this into orbit...
The Process: (Chris’s Process)

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
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
Structures: (#13)
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:

- CITIZEN EXPLORER
- ID91789-1 ADAPTER PLATE (NEW)
- ID91789-2 ADAPTER PLATE (NEW)
- ID70781-1 SIDEPLATE (EXISTING)
- ID70781-2 SIDEPLATE (EXISTING)
- ID70780-503 BACKPLATE ASSY (MODIFIED)
- I888535-501 INSTALLATION FIXTURE (EXISTING)

FLIGHT VEHICLE
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:

- Design vs. Implementation
Communications

- Project Management
- Systems Engineering
- Comm
- Structures
- Thermal
- ADCS
- C&DH
- Power
- Ground Ops
- Education
- Prop
- Science
- Software
- MOPS
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
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 (#23)

**Project Management**

**Systems Engineering**

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

- Attitude Determination and Control System

D = Determination

C = Control

- Think of driving a car...
on a mountain pass at night without headlights and no tires - D vs. C?
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 (#27)

- Project Management
- Systems Engineering

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

- Ground Ops
- Education
- Prop
- Science
- Software
- MOPS
- 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 (#17)

- 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, 7, 8, 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 (#6, 7, 8, x2)

- Project Management
- Systems Engineering

- Comm
- Structures
- Thermal
- ADCS
- C&DH
- Power
- Ground Ops
- Education
- Prop
- Science
- Software
- MOPS
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 store
    write16(adcGet16(PRESSURE)); // Convert analog value for pressure and write
```
Software:

- Software is usually last thing done

- Last minute fixes are very dangerous
Other:

- Management (Team)

- Systems Engineering (#12)

- Budgets (Team)

- Contracts

- Planners (Team)

- Technicians, Manufacturers, Test Engineers (Team)

- Mechanisms
Mechanisms

Project Management

Systems Engineering

Comm
Structures
Thermal
ADCS
C&DH
Power

Ground Ops
Education
Prop
Science
Software
MOPS
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
**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:

- Starboard strap-on booster
- Core booster
- First-stage RS-68 engines
- Second-stage RL10B-2 engine
- LO₂ tank
- LH₂ tank
- Avionics
- Interstage
- Port strap-on booster
- DemoSat and Nanosat-2 payload
  - Payload attach fitting
  - Second stage
Anatomy of a Satellite:
Anatomy of a Satellite:
Questions?

Colorado Space Grant Consortium
Today:
Pictures?