Gateway To Space

ASEN 1400 / ASTR 2500

Class #2

Colorado Space Grant Consortium
Today:

- Announcements
- Questions
- Next Time

- Spacecraft Overview Part 1
  - Really and Truly the Foundation for the Class

- One Minute Report Feedback (end)
Announcements:

- Anyone here for the first time?
- Attendance Sheet from last class
- Pictures – for those that couldn’t stay Tuesday
- HW 02 assigned today
- HW 01, HW 09, and Community Service assigned 8/26
Next Time...

Guest Lecture – Jim Paradise

- HW 01 Due
Questions?

Colorado Space Grant Consortium
Spacecraft Overview

“The Fast Version”

Class #2

Colorado Space Grant Consortium
Background image taken at 100,000 feet by a student BalloonSat

Updates

Since We Last Met (November 4, 2009)
SPACE MISSION ANALYSIS AND DESIGN
Third Edition
James R. Wertz
and Wiley J. Larson
(writer)
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
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).
Horizon Crossing Indicator
Receive Patch Antenna
Battery Box (x2)
Ball & Tube Nutation Dampers
Mass Trim System (x8)
Whip Transmit Antennas
3-axis Magnetometer
Solar Panel (x96)
Accelerometers (x6)
Subsystem Boxes (CDH, PDU)
Wind & Temperature Sensors
Stiffeners (x4)
Separation Mechanism
Torque Rods (x2)
EGSE connector
Kinematic Mounts (x4)
Lightband Adapter Brackets
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
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?

The answers to these questions make up most spacecraft systems.
Other Questions To Be Asked…

- What does he want to take pictures of, how often, and when?
- What type of orbit would it need to be in?
- How long would it take to get it to orbit?
- How long would it have to work?
- How do you know it will work when it gets there?
- How much would it cost and how much would it weigh?
- What would you have to worry about?
- What would you need?
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?
What Do You Need?

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

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

1. Mission – Thus the Mission Requirements (#11)

2. Orbit Selection

3. Launch Vehicle

4. Everything else
   - Structures, Interfaces, and Mechanisms
   - Power & Thermal
   - C&DH/Software
   - Communications
   - ADCS
   - MOPS
   - Other
Orbit Selection: (#18 & #19)

- 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: (#17)

- Then pick launch vehicle based on your orbit needs
- Weight needs
- Cost needs
- Certain launch vehicles can’t go to all orbits
Structures: (#13)
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 (#25)

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?

ADCS:
**ADCS:**

\[ D = \text{Determination} \]

- **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
Propulsion:

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 (#22)

- Project Management
- Systems Engineering
  - Comm
  - Structures
  - Thermal
  - ADCS
  - C&DH
  - Power
  - Ground Ops
  - Education
  - Prop
  - Science
  - Software
  - MOPS
**Power: (#22)**

- 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 Power Comm Thermal ADCS C&DH

Systems Engineering

Project Management

Comm Structures Thermal ADCS C&DH

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 (#7, 9, 10, x2)

- Project Management
- Systems Engineering

- Comm
- Structures
- Thermal
- ADCS
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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 (#7, 9, 10, x2)
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:

- Management (Team)
- Systems Engineering (#12)
- Budgets (Team)
- Contracts
- Planners (Team)
- Technicians, Manufacturers, Test Engineers (Team)
- 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:
Anatomy of a Satellite:
Anatomy of a Satellite:
Questions?

Colorado Space Grant Consortium
Today:
Pictures?