Gateway To Space

ASEN / ASTR 2500

Class # 25

Colorado Space Grant Consortium
Announcements:

- Raw data turn in

- Movies – turn in at Expo
Announcements:

- Hardware check in will be on 12-12-06

- Please make sure all hardware you have checked out from me is turned in

- Please make sure all hardware you purchased is turned in (manuals and drivers too)

- Payload must be turned in ready to fly (grade)

- FCQ’s done on 12-12-06 (volunteer)
Announcements:

- ITLL Design Expo is December 9, 2006, please sign up (I need to sign the form)

- Community service forms?

- Updated grades will be posted on web this week (Problems with grades let me know before 12-12-06)

- HW 6 assigned 12-07-06

- Final exam is 12-16-06 at 10:30 AM in a different room (Final exam review will be done on 12-12-06)
Final Presentations:

- Each team will have 15 minutes

- Allow 7 minutes for questions (grade)

- Majority of your time should focus on your results and conclusions (What worked and what didn’t and why)

- Don’t want to hear much about mass or budget

- Talk about the data and what it means (grade)
Final Presentations:

- ALL presentations are due 8:00 AM on 12-05-05

- One letter grade penalty for being late

- No changes to final presentation after 8:00 AM
Final Presentations:

12-05-06
9:30  Biohazard
9:45  Echo III
10:00 Aquila
10:15 Axiom
10:30 Justice League

12-07-06
9:30  Team 10
9:45  Hubble Jr.
10:00 Wolverines
10:15 Cutthroat
10:30 Cobras

Running over time or if I don’t get to ask my 7 minutes of questions will significantly affect your grade.
Questions?
Announcements:
Introduction to Space Communication
Introduction

- Introduction to Space Communications
- Presented by Jim Mowat
  - Communications Engineer at Ball Aerospace
Topics of Discussion

- What is Communication?
- How do you communicate from space?
- Why would you want to communicate from space?
Communication

- Let’s talk for a minute about what is communication
- Early communication
  - Animals
  - Sounds, visual
- Communication means “to convey information”
Thought question:

- Are the following “Communications”?
  - A whistle from a train?
  - The light of the moon?
Thought question:

- Are the following “Communications”?
  - A whistle from a train?
    - Yes, you know that the train is there and whether it is moving
  - The light of the moon?
    - Debatable—but there is information conveyed that the moon is there, what the surface texture and reflectivity is
How do you communicate from Space

- “In Space, no one can hear you scream”
- Therefore, we need some sort of light or “electro-magnetic wave” to send information down (and back up)
- Therefore, this class will concentrate on radio communications (RF)
  - Laser communications are also an option
Electromagnetic Spectrum

![Electromagnetic Spectrum Diagram](image-url)
Early SC-used low frequency radio
What are the Communications Parts?

Similar to radio or television, the spacecraft communication link has the following parts:

- Transmitter
- Transmit Antenna
- Receive Antenna
- Receiver

Some example links are shown:

- TDRS
- TDRSS
- WHITE SANDS STATION
  - 8.2125 GHz
  - 300 Mbps
- TLM
  - 2287.5 GHz
  - 1, 4, 16, 32 kbps (Realtime)
  - 512 kbps (Stored)
- CMD
  - 2.1064 GHz
  - 0.125 & 1 kbps
- X-Band Two Axis High Gain Antenna
- NPP
- SPACECRAFT
  - Ku Band
  - Two Axis High Gain Antenna
- S-Band Omni Antenna
- HRD
- Antenna
- S-Band Omni Antenna
- HRD Direct Downlink
- User Terminal

- NPP SPACECRAFT
- TDRSS
- WHITE SANDS STATION
- Norway SVALBARD STATION
Transmitters and Receivers

- Transmitter converts electrical information into a state where it can be transmitted long distances
  - From low frequency (voice, data) to radio
- Receiver undoes what the transmitter did
- They look about the same
Antennas

Types of Antennas

- Omni directional
  - Sends signal in all directions
  - Useful for “broadcast” and distress

- Directional (typically “high-gain”)
  - Used to send signal to one area(s)
  - Also, hide a signal from someone that you do not want to send info to
  - Ground antennas are almost always directional
Examples of directional antennas

- Ground Station High-gain antenna
- Bigger is better—Deep Space Network uses up to 70 meter diameter antennas
Examples of directional antennas

- Satellite Antenna Pattern
- Goal is to send the signal to the desired locations
Why should we communicate from Space?

- This satellite lost its ability to communicate
- It might as well not be there
Analog and Digital, what’s the difference?

- Data can be sent analog or digital
- Analog is where the data (voice, temperature etc) is sent directly
- Digital first has the step of quantizing the analog information to make it easier to handle
  - Quantized information bundles are called “bits”
- Almost all modern communications are digital
- For digital data, the received data can be compared with the sent data to create a measure of quality called bit error rate
Thought question:

- What kind of communication links do you use in everyday situations?
- And do you have the same problems with these types of communications that a Space-Comm engineer might have?
Thought question:

- What kind of communication links do you use in everyday situations?
  - Conversations
  - Traffic lights
  - Listening to the radio
  - Honk your horn
  - Facial expressions
  - Email
  - Putting a poster on your wall
Communication Concepts:

- **Signal to Noise**
  - How much useable signal is there relative to the noise?

- **Bit Error Rate**
  - How distortion-free is the information?

- **Latency**
  - How “fresh” is the data?
What does a signal look like?

- The more a signal varies in a way that can be interpreted by a receiver, the more information can be conveyed.

Signal example:
- High voltage might represent a “1”:
- Low voltage might represent a “0”
What does a signal look like?

- Here is the far end-big changes show low signal-to-noise
Bit Error Rate

- BER is Bit Error Rate - a measure of how perfect the data is on the far end of the pipe
  - BER is used to measure the quality of the link
  - Measured in Bit errors per total bits
- Some applications like voice, do not need a very good BER (1 in $10^4$)
- Some like compressed images, need better than 1 error in $10^{11}$ bits
- Analog data has similar characteristics, but this is harder to explain
  - Analogous to a conversation becoming harder to make out the further away the listener is
  - Analog errors are known as distortion
Bit Errors

- Bit errors are caused by the signal becoming too low relative to the noise level—
  - “Conversation” is too far away or in a noisy room
- Bits may be coded in order to allow for some correction on the receive side
  - Simple example: They can be sent twice
- Errors happen in the communications that occur everyday
Latency

- Some data is required immediately
  - Conversations
- Some data can wait for a few minutes or hours
  - Weather data
- Some data can wait for years
  - View of other galaxies is millions of years old
Types of Spacecraft

- Communication
  - TV, Data, intelligence, phone, radio, etc
- Scientific
  - Earth viewing and space viewing
- Global positioning
- Picture
- Military
- Exploration—Space shuttle, Space Station, Mars rovers
SC Examples - Exploration

- International Space Station

Launch of the International Space Station:
- Zarya and Unity
Example from Scientific SC

“Picture” of the sun taken by the SOHO spacecraft
This satellite is called QuikSCAT.
It is being flown by the Laboratory for Atmospheric & Space Physics here at CU.
The satellite measures surface winds by bouncing radar off of the ocean.
Very effective weather tool.
Example from picture SC

This picture was taken by the Quickbird spacecraft owned by Digital Globe of Longmont CO.

Takes imagery with approximately 0.6 meter resolution.
What does space communication mean to me?

- The Space-Comm engineer tries to create a system that can send as much low-error data between SC and the ground as is required without impacting the rest of the spacecraft, other spacecraft or other people on the ground.
SpaceComm Summary

- Communication is a specialized area of electronics and mathematics.
- Space Communication requirements are increasing as more spacecraft are launched and more data are available from each spacecraft.
- Questions: Jim Mowat jmowat@ball.com