Class Project: Lunar Radio Telescope

Due Date: 12 December 2006 (Tuesday)

ECE 6390: Satellite Communications and Navigation Systems
Georgia Institute of Technology

1 Introduction

Because visible light only accounts for a tiny portion of electromagnetic spectrum, *radio* astronomy is an extremely important research enterprize that allows scientists to see new, invisible parts of the universe. In a similar vein, radio astronomy likely provides the only pathway for discerning the existence of extra-terrestrial intelligence in our universe. There is a growing problem with earthbound radio astronomy observatories, however. The phenomenal growth of wireless communications and noise-generating devices has polluted the radio spectrum with increasing amounts of man-made interference. Even in frequency bands that have been traditionally reserved for radio astronomers, man-made noise is creeping into the spectrum and making it impossible to resolve the faint signatures of distant radio-emitting bodies. Soon there will be no place on or around the earth that is possible to study this beautiful and invisible part of outer space.

There is one last chance for the radio astronomers, however. Earth has the incredible fortune of having its one and only natural satellite, the unnaturally large *moon*, locked in synchronous rotation. That is, the moon completes one rotation and one revolution about the earth at precisely equal periods. Thus, there is one side of the moon (the inappropriately named "dark side of the moon") that is perpetually facing away from the earth, shielded from manmade noise. One idea for greatly enhancing the prospects of radio astronomers is to build an astronomy on this far side of the moon and relay the collected radio data back to earth-based laboratories.

NASA has contracted your private space consulting firm to design the radio frequency (RF) and communication system that will collect the radio astronomy data and relay it back to earth-based researchers. Your final design, to be unveiled to the world on Tuesday, 12 December 2006, will be judged against designs from competing firms that will try to make the most reliable, low-cost, and functional radio observatory.

2 Design Details

The goal is to build a radio observatory that makes continuous measurements of the spectrum between 1.000-4.000 GHz. This data must be relayed back to earth without loss through one or more satellites in a communication network. The moon-based dish will have a diameter of 300m, an aperture efficiency of 0.90, and a receiver with $T_{SYS} = 20$ K. It will be constructed in the crater Daedalus and will operate in a manner similar to the earth-based radio astronomical observatory at Arecibo in Puerto Rico.

You may choose the operating frequencies of the return data link to earth (avoid 1.40-1.43 GHz, 4.9-5.0 GHz, 10.6-10.7 GHz, and 15.3-15.4 GHz, which would interfere with radio telescopes on the Earth.) In addition to your design of the overall system (spacecraft orbits, transponder designs, modulation type, multiple access, etc.), you must demonstrate the technical feasibility of

your design by finding specifications on analog-to-digital converters, RF oscillators, and any other specialty electronics that would limit your implementation.

Show that your design is cost-effective (total cost, including spacecraft) by justifying all cost estimates or assumptions. You may estimate the cost of putting satellites into high-earth orbits as being \$150 M (including launch) plus 1\$ M per transmitted watt of power (not EIRP). For each communication link, there should be a chart in your report that lists transmit power, RF bandwidth, pulse shape/modulation scheme, symbol rate, bit rate, antenna gains, carrier frequency, estimated CNR, and any other technical specifications important for understanding your design.

3 Deliverables

You must prepare a concise, well-written technical report detailing your design for the RF front end of the radio astronomy station on the moon as well as the relay network for sending the data back to earth. The report should be in html-format with all files submitted in-class on a CD or through e-mail[1]. Your report will be graded on the following:

- Completeness
- **Technical Writing**
- Technical Correctness
- Professional Content
- Research (cite all references)
- Conciseness

I will offer +5% bonus points to superlative reports in the following categories:

- Best Technical Writing
- Most Thorough Technical Research
- Creative Use of Web Presentation

Late projects will not be accepted. I will likely post some of the unique solutions and high-quality projects to the web, unless the author requests otherwise.

4 Credits

Thanks to Prof. Paul Steffes for help with the formulation of this project.

[1] e-mail submissions are strongly preferred; they **must** be ZIPped and are only possible for files less than 10 MB total