Class Project: Martian Network

Due Date: 13 December 2005 (Tuesday)

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

1 Introduction

Over the next 20 years, NASA expects to have a host of landers, rovers, aerobots (self-controlled airplanes), and even astronauts on the surface, or in the tenuous atmosphere, of the planet Mars. Your engineering firm is to design a system allowing uninterrupted inter-communications between all of the Mars-based assets (landers, astronauts, aerobots, etc.), as well as communication between all Mars-based assets with NASA facilities on earth. Since the Martian day is about 24.5 hours long (similar to Earth), ground-based landers and astronauts will not be in the line-of-sight to earth for periods of over 12 hours, so relay satellites will be required. Since the ground-based terminals will be at all locations on the Martian surface, 100% surface coverage must be provided.

2 Design Details

You may assume there will be up to 50 terminals on the Martian surface, and they must be reasonably compact so as to be transportable to Mars (i.e. no aperture sizes larger than 1 meter diameter on the surface). Relay spacecraft may be much larger, determined by the practical limits of launcher size (e.g. the space shuttle payload bay). Each ground terminal must be able to uplink data at rates up to 1.5 Mbps and have it received both at Earth or by any other terminal on Mars. Each ground terminal must be able to receive its own targeted data stream from the Earth at 1.5 Mbps, and one additional 1.5 Mbps data stream from one of the other Martian surface assets, which should be fully selectable from the other 49 data streams being transmitted. Since frequency allocations on the surface of Mars are not (yet) a big problem, you may select any frequencies you like for communication between the surface terminals and the relay spacecraft (except 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.) However, communication with the earth will be conducted by communicating with stations of the NASA Deep Space Network (DSN, http://deepspace.jpl.nasa.gov) which can communicate in the following bands: Earth-to-Mars: 7190-7250 MHz and 34.2-34.7 GHz, Mars-to-Earth: 8400-8460 MHz and 31.8-32.3 GHz.

In addition to your design of the overall system (spacecraft orbits, transponder designs, modulation type, multiple access, etc.) you must design the terminals to be used on the Martian surface and the orbiting relay satellites (block diagrams and appropriate solar power system). You may assume the NASA DSN Stations are already built and available for use. 34-meter diameter parabolic antennas are used at the DSN, with $T_{SYS} = 20$ K, and aperture efficiency equalling 0.94. The DSN transmitters are capable of transmitting up to 500,000 watts and at least one station is always able to view Mars. The bit error rates on the overall links from the Mars stations back to earth and the earth to Mars must not exceed 10^{-6}.

Show that your design is most cost-effective (total cost, including spacecraft and Mars surface terminals) by justifying all cost estimates or assumptions. You may estimate the cost of Mars orbiters as being $200 M (including launch) plus 1$ M per transmitted watt of power (not EIRP).

3 Deliverables

You must prepare a technical report detailing the communication network system design. 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

The idea for the this project was graciously lent by Prof. Paul Steffes.

[1] e-mail submissions must be ZIPped and are only recommended for files less than 2 MB total