

# Satellite Communications Class Project: Martian Positioning System (MPS)

ECE 6390 – Fall 2008

## Synopsis:

The *National Aeronautics and Space Administration* (NASA) recently awarded your up-start company a Phase I *small-business innovative research* (SBIR) grant to design a Martian Positioning System. The field of applicants for this next round of funding is competitive, with 5 other private companies also competing for a lucrative, multi-year Phase II contract. See the solicitation attached to this problem statement.

## Team-Member Assignments:

I will assign 6 teams with (approximately) 5 members each to constitute a “company”. Once formed, the teams must elect a team-leader, choose a company name, and submit an 80 x 80 pixel icon for their web link. I expect everyone to contribute to the final proposal and will solicit internal rankings of team-member efforts.

## System Components:

Due to the multiplicity of talents within each group and the “systems”-nature of the class, *all* aspects of the mission design should be explored in the final proposal. Communication/location systems should receive the most design focus, but the final project should address all of the following systems:

- Communication Systems – antennas, RF hardware, modulation, spectral usage, peak data output, etc.
- Location System – location estimate accuracy, error sources, RX antenna *measurement*
- Power Systems – power source, peak power output, estimated lifetime, etc.
- Propulsion Systems – rocket type and weight, fuel estimates, etc.
- Orbital Mechanics – path to the Mars, travel duration, launch site, satellite attitude controls, trajectory sensing and correction, etc.
- Budget and Timeline – total mission cost broken into materials, equipment, supplies, people costs, space resources, and other miscellaneous costs; include a small-company “overhead” of 40% for all personnel costs; include milestones listed on a Gantt chart; project an amortized cost of servicing an maintaining your MPS design.

This list is not necessarily exhaustive. The level of detail for each system is left up to the groups. However, increased descriptions will enhance the competitiveness of your design. *Verbose* descriptions will degrade the competitiveness of your design.

## Deliverables:

You must prepare a concise, well-written technical report detailing your team's mission design. The report should be in html-format with all files submitted in-class on a CD or through e-mail (e-mail submissions are strongly preferred; they must be ZIPped and are only possible for files less than 10 MB total). Projects must be submitted by noon on 9 December 2008. Late projects will not be accepted.

## Grading:

Your final proposal will be *competitively* graded on cost, functionality, and feasibility – as if I were making the Phase II funding decisions for this SBIR program. The proposals from the class teams will be ranked against one another and assigned a base score of  $100\% - 3(n-1)$  where  $n$  is the integer ranking. Thus, first place will receive a base score of 100%, second place will receive 96%, third place will receive 92%, and so on. Deductions from these base scores will then be made based on the following areas: Completeness, Technical Writing, Professional Content, Research/References, and Conciseness. Groups may also barter points with one another for use of an antenna design (should the prototype turn out to be a dud).

Each team member may also receive a small, variable downward adjustment to their individual project scores based on internal rankings of contribution and effort. I will also offer +5% bonus points to superlative proposals in the following categories:

- 1) Best Technical Writing
- 2) Creative Use of the Web
- 3) Most Novel Engineering Design or Concept

Late projects will not be accepted. All projects will be posted on the web, unless the team members collectively object and notify me.

NASA083-007

TITLE: Martian Positioning System (MPS)

TECHNOLOGY AREAS: Satellite Systems, Radiolocation, Antennas, RF engineering

OBJECTIVE: Design an innovative satellite system for providing planet-wide positioning capability on Mars to support future NASA exploration and colonization platforms.

DESCRIPTION: In several decades, NASA anticipates having numerous robotic and manned missions operating simultaneously across the entire surface of Mars, with the possibility of several small manned outposts or science colonies. Positioning in this alien world will be of extraordinary importance, both for scientific and safety purposes. This project is meant to jump-start the design of a future MPS so that NASA will be ready for that day.

The system technical description must include (a) the RF components and modulation for the MPS downlink (satellite to Martian surface), (b) low-data rate radio links between satellites to share time synchronization and status information with one another, and (c) a two-way 1 Mbit/sec (minimum) radio link between the system and Earth for the exchange of digital telemetry, control, sensor, and synchronization data.

The location system must operate somewhere between 1-3 GHz and not include any of the current radio-astronomy bands. The system must allow a user on the surface of Mars positioning accuracy within +/-5 meters everywhere (including the poles). An estimate of system cost must be included in the design, which will depend heavily on the number of satellites used to provide ubiquitous coverage. Each RF link budget in the system (satellite-to-Mars, satellite-to-Earth, Earth-to-satellite, or satellite-to-satellite) must be thoroughly analyzed and presented. You may assume Earth Station statistics comparable to NASA's Deep Space Network (DSN) are available for communicating with the Martian satellites.

PHASE I: Deliverables include (a) a technical report summarizing the design, (b) measured prototype of an electrically small antenna that a Martian terminal can use to receive your proposed MPS waveform. Link budget and location performance statistics in your technical report must be based on this measured prototype antenna. Competitive rankings will consider 1) cost, 2) practicality, and 3) functionality in equal proportions.

#### REFERENCES:

1. T. Pratt, C. Bostian, T. Allnut, *Satellite Communications*, 2<sup>nd</sup> edition, Wiley, 2002.

TPOC: Greg Durgin  
Phone: 404-894-2951  
Fax: 404-894-5395  
Email: durgin @ gatech.edu