TRAINING GRADUATE STUDENTS FOR FUTURE MARS MISSIONS. P. J. Mouginis-Mark, Hawaii Space Grant College, HIGP/SOEST, Univ. Hawaii, Honolulu, Hawaii, 96822.

INTRODUCTION:
With the loss of Mars Observer in 1993, the planetary community not only lost the new influx of scientific data from the various instruments (1), but also enthusiasm was lost by graduate students in the Planetary Geology & Geophysics Program for Martian research. As a result, the long-term (10 - 20 year) health of Mars exploration was unavoidably placed “at risk” because fewer of the next generation of planetary scientists were finding Mars an interesting topic. With 18 year old Viking data, graduate courses in the Geology of Mars at the University of Hawaii (UH) were becoming less motivating as most of the significant geologic research is now 5 - 10 years old. At UH, the Geology of Mars is taught as a 3-credit graduate course every 3 years, most recently in the Fall 1995 semester. Instead of relying on one of several fine standard Mars texts (e.g., 2, 3), this time a new approach was attempted to not only sustain interest in Mars, but also to prepare senior students for participation in Mars Pathfinder-type missions. The course was also designed to give the students experience in peer-review and debate of key mission objectives. The framework for this course is described here in the hope that other university faculty may find some of the ideas of value to their own Mars courses.

COURSE OUTLINE:
Eight students took the course. Their backgrounds ranged from never having taken a planetary geology class before to students who will graduate within two years with a Ph.D. in planetary science. After several weeks of introductory material on the geology of Mars (including impact cratering, volcanism, polar features and fluvial processes), discussions of specific Mars quadrangles were focused on what could be determined by future missions (e.g., Mars Pathfinder and Global Surveyor) and how instruments and missions are keyed to answer specific science questions. Options for new experiments, and conceptualizing what surface conditions on Mars are like based on remote sensing data (radar, thermal inertia, spectra) were reviewed. After 5 weeks of the 16 week semester, the concept of mission planning was introduced, allowing mission planning and hardware for Mars exploration to be discussed.

MISSION CONSTRAINTS:
A key aspect of the course was to set “reasonable” mission constraints for the students to define their own payloads and mission objectives. Three choices of spacecraft were provided: (A) Rovers: either one with a 500 km range or three that each had a 100 km range; (B) Balloons: which could either travel 10,000 km without landing, or 2,000 km and land at night; (C) Penetrators: 12 penetrators deployed in one region of Mars.

Payload options were one of the most contentious issues. Students wanted to do everything, and had novel engineering ideas for making a wide variety of observations. While creativity was encouraged, to provide consistency for all missions a series of options were provided based on an approximation of instrument size and capability. The concept of “Mass Units” was introduced so that students could select different payload options but were forced to make trade-offs in total payload based on science goals. Balloons that did not land were allowed 6 mass units, balloons that landed were allowed 4 units, long-range rovers could carry 5 units, and each short-range rover 2 units. Penetrators could each carry 2 mass units.

The range of instruments that were allowed for rovers and balloons was as follows: a) Mars Pathfinder-type Alpha Proton X-ray spectrometer (APX) — 1 mass unit; b) Multi-spectral stereo imager (50 channels 0.4 - 2.4 μm) — 1 mass unit; c) Multi-spectral thermal IR instrument (40 channels 8.0 - 20.0 μm) for lithologic mapping, thermal inertia studies, or detection of temperature anomalies — 1 mass unit; d) Gravimeter — 1 mass unit; e) Laser ranger (best for balloon altitude) — 1 mass unit; f) High-res. B/W imager (0.01 cm resolution at 10 cm range) — 1 mass unit.
For the penetrator experiments, the following were possible: a) Multi-spectral stereo imager operating at ground level (10 channels 0.4 - 2.4 \( \mu \)m) — 1 mass unit; b) Seismometer — 1 mass unit; c) Weather station for measurement of temperature, pressure, wind speed — 1 mass unit; d) APX — 1 mass unit.

CANDIDATE MISSIONS:
Students selected their mission sites from one of eight 1:2M-scale USGS photomosaics. These sites were picked by the instructor so that there was a diversity of possible science objectives. In addition multiple images were available for mapping and research exercises at each site, and each area has a large body of literature available for background references. The eight selected missions and sites were as follows:
1) Geophysics study by balloon of the hemispheric dichotomy and Utopia Planitia.
2) A series of 12 penetrators to Olympus Mons, studying the internal structure of the volcano, the aureole, and the meteorology on the flanks of the volcano.
3) A balloon-borne geophysics study of Schiaparelli Basin to better understand large-impacts in the southern highland. Landing the short-range balloon at night would permit APX measurements to be made of different crustal units.
4) A long-range rover traverse across the South Polar cap, sampling the stratigraphy of the ice and dust layers.
5) Three short-range rovers landing around Hadriaca Patera. The style of eruption of the volcano, and the volcano-ground ice interactions would be studied here.
6) A long-range balloon flight over western Elysium Planitia, to image the young lava flows and study the distribution of features associated with volcano-ground ice interactions.
7) Three short-range rovers would explore the styles of volcanism at Alba Patera, where both explosive and effusive activity has been identified.
8) The canyons of Valles Marineris would be explored using three short-range rovers that would study the wall stratigraphy and the layered deposits on the canyon floor.

Each student presented his/her mission concept in class, at which time they were quizzed by their colleagues on the details of their experiments. Identifying science or engineering problems with other missions was made almost as important as defining their own mission so that the students would participate in critical reviews of each mission. After these presentations, a vote was taken to select the two missions for further research and discussion. In our course, the geophysics of the highland dichotomy and the rover mission to Hadriaca Patera were the most popular and were selected for a month of more detailed studies. During this time, the students worked in two teams of four, carrying out further mapping of these sites, evaluating landing hazards, investigating further options for science experiments, and searching the literature for more background information.

CONCLUSIONS:
Compared to earlier Mars courses, much more class interaction took place under this "Mission Concept" approach. Students worked better as teams and more readily shared their different expertise and knowledge. Time constraints were a big problem, since the 16-week semester did not provide adequate time for extensive background classes on general Mars geology, remote sensing methods, or the techniques of photogeologic mapping. Significantly, many students found the inclusion of payload design and rover trafficability to be interesting topics that they had not previously experienced in geology classes. With luck, some of these skills will be put to the test as they move into real positions on NASA missions to Mars!

REFERENCES: