Exploring the Solar System: Student-Designed Planetary Missions

Rob Viens, Bellevue Community College (Washington)
(rviens@bcc.ctc.edu; 425-564-3158)

Exploring the Solar System = Geology 101 + Astronomy 101 (12 credits)

Exploring the Solar System is a 12-credit interdisciplinary, lab-science class that incorporates the basic concepts of geology and astronomy. It is co-taught by a geology instructor (Rob Viens) and an astronomy instructor (Art Goss). One of the central themes of the class is to use current data from Cassini and the Mars missions to understand geology. Throughout the quarter, students complete a research project that requires them to design a robotic spacecraft mission.

The Premise of the Project

"Historically, the exploration of the solar system has been undertaken by large government agencies, with the financial support of the taxpayers. For years, spacecraft were only launched by the United States and Russia, the only countries that could really "afford" a space program. In the past decade, however, the European and Japanese space agencies have been playing a larger role in planetary exploration. Up until now, no space mission has been privately funded. That is about to change...

Recently, a wealthy benefactor from Western Washington (named Paul Smallen) decided to finance his own planetary mission. In order to facilitate that wish, Mr. Smallen has decided to award a $1 billion research and development grant to the team of scientists that can propose and carry out the most relevant and scientifically significant robotic mission to our solar system. This is an opportunity that we just can't pass up!

Your job is to form a research team, choose a target object, design a planetary mission, and convince Paul Smallen to finance your mission. Now it is your chance to explore the solar system. To make things exciting, a prize will be awarded to the team that makes the most convincing proposal."

Benefits of the Project

- Integrates many concepts from geology and astronomy
- Understand how science is done (where do data come from)
- Rewards both scientific and artistic creativity
- Enhances teamwork skills
- Creates life-long learners

Comments:

1. Proposals and Research Teams

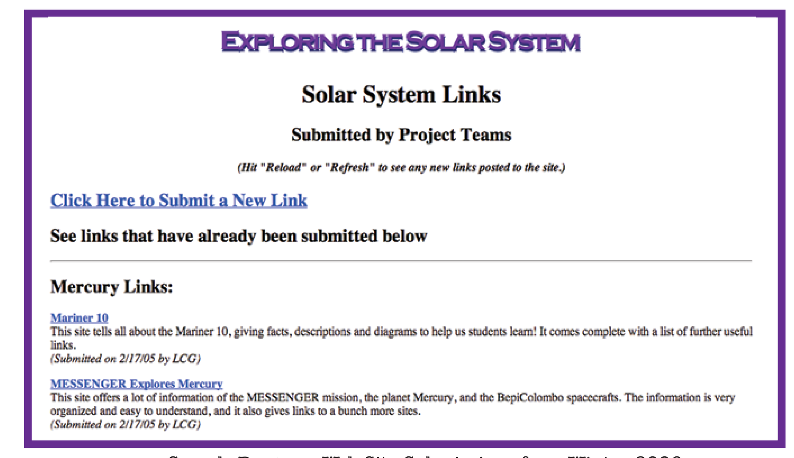
Students write a proposal describing the target they would like to explore and why. Based on these proposals, they form research teams and name their team and spacecraft mission. Some teams also design a mission logo. Students then work in these teams for the entire quarter.

Target	Team Members	Research Team Name	Mission Name
Venus	Josef, Nic, Travis, Nicole	Team Illiad	I.S.H.T.A.R. (Interlithospheric Seismic High Temperature Activity Recorder)
Mars	Brett, Jesse, Tim, Antonio	L.U.M.M. (Last Unmanned Mission to Mars)	A.R.E.S. (Area Recon Excavation Sampling)
Io	Lillian, William, Alex, Andrea, David	Project McDonald	E.I.E.I.O. (External Imaging Electromagnetic Orbiter)
Europa	Chris, Jared, Kellie, Kelsey, Melinda	Team Atlantis	Poseidon
Titan	Kenric, Laura, Kathe, Annie	Team Titan	Zeus
Uranus/Neptune	Jessica, Brianna, Cameron, BJ	Team X	KY (Kentucky)
Triton	Marc, Jeff, Kyle, Sean	Thats No Moon	Trident
Chiron	Shannon, Matt, Jordon, Morgan	Giants	Project Chiron
Comet (Temple II)	Eric, Ibrahim, Joe, Meghan, Kelly	Rocket Surgeons	Hitch Hiker

Winter 2006 Research Teams & Missions

2. Reference Web Page

One of the first tasks assigned to each team is to research online reference sites for their target. They are expected to evaluate these sites for quality and to post them to a shared class web site. This reference site is available to the whole class.



EXPLORING THE SOLAR SYSTEM

Solar System Links

Submitted by Project Teams

(Hit "Reload" or "Refresh" to see any new links posted to the site.)

Click Here to Submit a New Link

See links that have already been submitted below

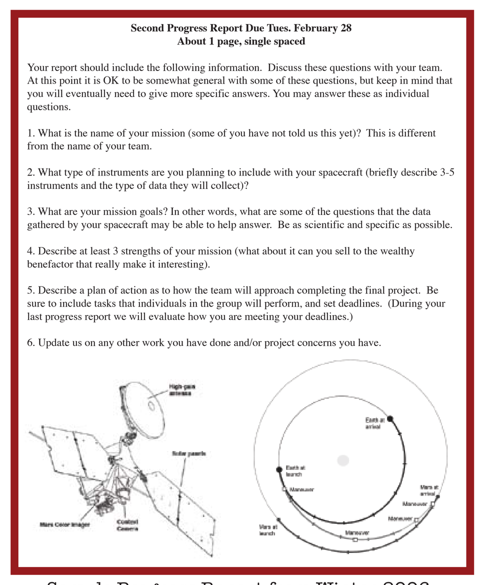
Mercury Links:

Mariner 10
This site tells all about the Mariner 10, giving facts, descriptions and diagrams to help us students learn! It comes complete with a list of further useful links.
(Submitted on 2/17/05 by LCG)

MESSENGER Explores Mercury
This site offers a lot of information of the MESSENGER mission, the planet Mercury, and the BepiColombo spacecrafts. The information is very organized and easy to understand, and it also gives links to a bunch more sites.
(Submitted on 2/17/05 by LCG)

Sample Progress Web Site Submissions from Winter 2006

3. Background Research Assignments & Progess Reports



Second Progress Report Due Tues. February 28
About 1 page, single spaced

Your report should include the following information. Discuss these questions with your team. At this point it is OK to be somewhat general with some of these questions, but keep in mind that you will eventually need to give more specific answers. You may answer these as individual questions.

1. What is the name of your mission (some of you have not told us this yet)? This is different from the name of your team.

2. What type of instruments are you planning to include with your spacecraft (briefly describe 3-5 instruments and the type of data they will collect)?

3. What are your mission goals? In other words, what are some of the questions that the data gathered by your spacecraft may be able to help answer. Be as scientific and specific as possible.

4. Describe at least 3 strengths of your mission (what about it can you sell to the wealthy benefactor that really make it interesting).

5. Describe a plan of action as to how the team will approach completing the final project. Be sure to include tasks that individuals in the group will perform, and set deadlines. (During your last progress report we will evaluate how you are meeting your deadlines.)

6. Update us on any other work you have done and/or project concerns you have.

Sample Progress Report from Winter 2006

Throughout the quarter, students complete several assignments. One assignment, called "Seeing Through Robotic Eyes" requires that they research instruments on other spacecraft and how they collect different types of data. In addition, they research the naming convention for their target and summarize previous missions. Each project team submits regular progress reports to ensure that they stay on task.

4. Mission Design

The core of the project involves designing a robotic scientific mission to another object in the solar system. As a part of this project, students are expected to design the science of the mission as well as plan the design of the spacecraft itself and the mission logistics.

4A. Mission Science

The science of the research project focuses on understanding what is known about the target object, what questions still remain to be answered, and how to go about answering those questions. To do this the students must understand the scientific method, the basic principles of geology and astronomy, and the methods that astrogeologists employ, to study places where no human observer has ever been.

Once the students have decided on questions they would like to address, they must then figure out what instruments they require to collect their data and how to get those instruments to the target object.

Cost analysis
Teams calculate the weight of their spacecraft and then use existing NASA web sites to determine the cost of spacecraft development and construction. In addition they include the cost of the launch vehicle and "Mission Operations and Data Analysis" costs.

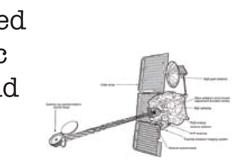
4B. Spacecraft Design and Logistics

Students "engineer" the spacecraft (in simple terms) and plan the mission logistics. This includes:

A. Mission type: Orbiter, flyby, lander, etc.
Teams must take into account science mission goals.

B. Propulsion system & energy supply
This is largely determined by where they are going and their weight restrictions.

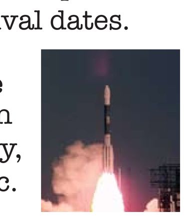
C. Onboard instruments
Chosen based on scientific mission (and justified).

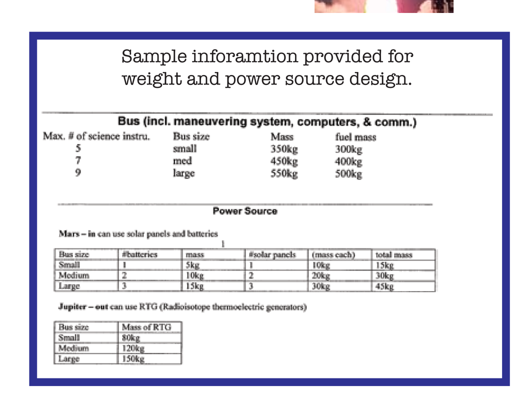


D. Launch and arrival dates
Students use "The Sky" software, Excel spreadsheets, and weight and thrust measurements to calculate optimal launch and arrival dates.

E. Trajectory & necessary slingshot calculations
Using "The Sky" software and simple geometry, students map out their flight path. In addition, they calculate the gain in speed they can get by "slingshotting" along the way (thereby saving on fuel costs).

F. Launch vehicle
Chosen based on payload capacity, success rate, etc.





Sample inforamtion provided for weight and power source design.

Bus (incl. maneuvering system, computers, & comm.)

Max. # of science instru.	Bus size	Mass	fuel mass
5	small	350kg	300kg
7	med	450kg	400kg
9	large	550kg	500kg

Power Source

Mars – in can use solar panels and batteries

Bus size	#batteries	mass	#solar panels	(mass each)	total mass
Small	1	5kg	1	10kg	15kg
Medium	2	10kg	2	20kg	30kg
Large	3	15kg	3	30kg	45kg

Jupiter – out can use RTG (Radioisotope thermoelectric generators)

Bus size	Mass of RTG
Small	80kg
Medium	120kg
Large	150kg

6. Written Grant Proposal & Oral Presentation

The Final Project Consists of the following "deliverables":

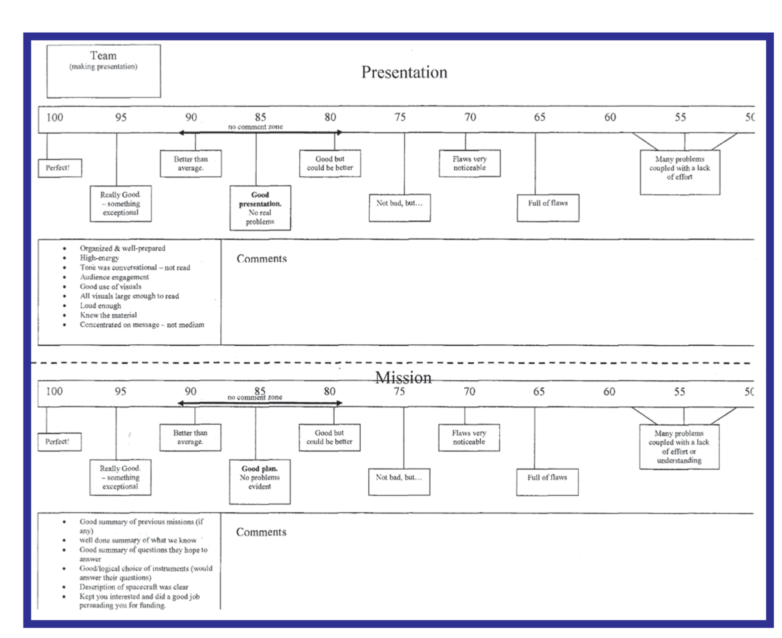
Oral Presentations - "The Pitch"
Each team makes a 15-20 minute PowerPoint presentation to the class on their target object. This presentation includes a history of the target object, as well as the team's proposal for exploring the object (science and spacecraft design/logistics). Everyone on the team is required to participate in the presentation.

Written Grant Proposal
The grant proposal includes the following sections:
Introduction
Exploration History
What We Know about the Target Object
Mission Goals (What We Don't Know)
Spacecraft Design/Logistics
Mission Cost
Significance of the Mission
References

Highlights/Press Release
This one-page summary includes the highlights of the mission statement and a pitch for why it should be funded. This is generally written as a press release that addresses the question, "What would make the general public excited about your mission?"

7. Evaluation

Each team's presentation and written grant proposal is evaluated by the instructors and other teams (peer review). In addition, the contributions of each team member are evaluated by the rest of their team via an anonymous online evaluation form. Students' grades are based on a combination of all of these evaluations. In addition, the team that made the strongest proposal, based on the feedback of the instructors and the feedback from the class, is "awarded the grant". (In our case we usually purchase a prize for those team members. This year the top team members each received a copy of "A Traveler's Guide to Mars" and the top three teams all received small meteorite samples.)



Form students use to evaluate team presentations.

Thanks to BCC astronomy instructor Art Goss for contributing to the design of this assignment.

Course Web Site: http://www.scidiv.bcc.ctc.edu/rv/solarsystem/