



## **BUILDING A PERMANENT HUMAN PRESENCE IN SPACE**

**GRADES 9-12**

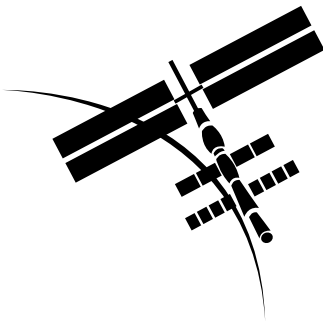
### **LESSON 2: ETHICS OF EXPLORATION**

The United States and its partners around the world are building the International Space Station (ISS), arguably the most sophisticated engineering project ever undertaken. The ISS is an orbiting laboratory where astronauts conduct research in a variety of disciplines including materials science, physiology in microgravity environments, and Earth remote sensing. The ISS provides a permanent human presence in low Earth orbit.

This lesson is one of many grade K-12 lessons developed by Challenger Center to bring the ISS experience to classrooms across the nation. It is part of Building a Permanent Human Presence in Space, one of several Education Modules developed for Challenger Center's Journey through the Universe program. This Education Module addresses the essential question "How can we build a permanent human presence in space?" Start the *Journey* at [www.challenger.org/journey](http://www.challenger.org/journey).



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## LESSON 2: ETHICS OF EXPLORATION

### LESSON AT A GLANCE

#### LESSON OVERVIEW

Space exploration currently is led by government-based agencies like the U.S. National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and others. Space exploration now is justified by the pursuit of scientific knowledge. Sooner or later, however, commercial interests will pursue space exploration to turn a profit. Once that occurs, what rules should regulate the exploitation of resources in space and celestial bodies by governments and private companies? What, if anything, can a government or private company claim to own in space? These questions are not considered explicitly in the existing treaties governing international exploration and cooperation by governments, but they will have to be considered soon. Is the pristine space environment at risk? Is that important? These are issues that students will debate in this lesson.

#### LESSON DURATION

Two 45-minute class periods



#### CORE EDUCATION STANDARDS

##### *National Science Education Standards*

Standard F6: Science and Technology in Local, National, and Global Challenges

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.



#### ESSENTIAL QUESTION

- Who has the right to explore space?



#### CONCEPTS

Students will learn the following concepts:

- With the development of new technology, new ethical issues arise.
- Research, discussion, and debate can lead to deeper understanding of an issue.
- Space exploration is dominated by governments, but some private businesses want to explore space as well.



#### OBJECTIVES

Students will be able to do the following:

- Investigate the ethical questions surrounding a space exploration through discussion and research.
- Synthesize information regarding the exploration of space into a supported opinion.

## SCIENCE OVERVIEW

Since 1957, when Sputnik 1 became the first artificial satellite launched into Earth orbit by humanity, leadership in the exploration of space has been largely the province of governments. The purpose of space exploration has been the increase of scientific knowledge for its own sake, and to proclaim the power of nations to achieve great things. The astounding costs involved, and the relative lack of immediate monetary value in scientific data, has kept private interests out of the business of trail-blazing.

Even so, private industry has claimed a place in space since the early days, first as contractors to build the equipment needed for government-operated expeditions, then as customers for government launch services, launching the vehicles constructed by private companies. Telecommunications satellites are owned by private companies, making a profit by selling international and transoceanic communications channels for earthly purposes. More recently, satellite systems have provided services directly for sale to individual private citizens in the provision of telephone services and in television and radio programming.

Private industry has, until recently, concentrated on transferring data from one place on Earth to another, earning a fee for providing the conduit. In the last decade or so, a new role has emerged. Private satellites in Earth orbit (e.g., SPOT, Landsat) produce photographs of targets on Earth, providing traditional aerial photography services, agricultural information, and geographic mapping data at a price. Private industry has entered the business of collecting new data in the space environment. Private-sector corporations now have taken on the roles of spacecraft construction, space launch, flight operation, and data collection, paid for by private funds and using private facilities in order to earn profit. The majority of space launch activities continues to be the responsibility of governments, but government no longer holds a monopoly as launch provider or launch customer.

Seats already have been sold for the occasional (exceedingly wealthy) tourist to fly to the International Space Station aboard Russian government-operated spacecraft. The first private-sector manned spacecraft already have been demonstrated at sub-orbital altitude. Manned private orbital launch vehicles, capable of reaching Earth orbit and operating in that environment, are a predictable development. It only is a question of "when" and "if"—"when" will it happen "if" there is

enough money to be made for it to pay for itself. If manned private space flight turns out to be unprofitable, unmanned private space flight already is here and will continue its advancement.

What can private operators do with independent access to space? Treaties cover some of the responsibilities of nations as explorers. Treaties require nations to be responsible for policing the actions of private explorers. The practicalities of space operations in Earth orbit also limit the sorts of actions that private concerns might take. The farther that operations proceed from Earth, however, the more vague the situation becomes, as entirely new modes of space exploration, and space exploitation, come into play that never were envisioned when the existing treaties were signed. Asteroid mining, for example, was an impractical concept when the Outer Space Treaty was signed. Now, a Near Earth Asteroid Prospector (NEAP) is a serious proposal as a private exploration (not mining) mission.

Humanity has a long and well-documented history of abandoning treaties when their high-minded ideals become inconvenient. Numerous treaties with indigenous peoples have been unilaterally set aside or violated, not just by the United States but by nations worldwide. In space, there are no indigenous peoples to contend with and no known indigenous life forms. The only other parties to treaties over space exploration are fellow nations on Earth. Will ethical arguments hold any more sway in unpopulated space than they have on Earth? Will space become an arena for armed competition between nations and corporations (the Wild West), or will it be an arena of peaceful economic development (Wall Street)? The debates should happen now, while there still is no established stake in profitable space assets that stretch or break the limits of existing treaty law.

#### THE OUTER SPACE TREATY

As of 2004, 125 governments (including the United States) had signed or acceded to the United Nations "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and other Celestial Bodies," which first went into force in October 1967. This treaty is commonly called "the Outer Space Treaty." A number of other agreements and conventions have come into effect since 1967, clarifying various points and emphasizing the applicability of the Outer Space Treaty's principles to particular situations and particular celestial bodies. The Moon achieves special importance and is the subject of an agreement all its own that entered into force in July 1984, due to its special status in the heritage of all the cultures of Earth. However, not all nations have signed the treaty.

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The Outer Space Treaty and the Moon Treaty cover a number of important points (see references). The Moon Treaty devotes more space to non-governmental entities—e.g., private-sector corporations, non-profit corporations—than does the original Outer Space Treaty, presumably because even the wildest speculations of 1967 held no serious prospect for space exploration by anyone other than governments. The Moon Treaty declares a number of essential principles that are consistent with fair and equal allocation of lunar and space resources for all of humanity. In particular, the treaty declares that no nation or non-governmental entity can own any part of the Moon, not by claim, not by construction on it, not by construction under it. Nations (and non-governmental agencies) are permitted to establish manned or unmanned facilities on the Moon, with free access to that portion of the lunar environment necessary to fulfill the station's mission of exploration. Any facility on the Moon is to be freely accessible by representatives of other nations, with suitable warning of a visit. However, in an emergency, all space explorers are legally required to come to the aid of the crew of a damaged vehicle, similar to peacetime maritime laws. The lunar environment is to be maintained in its pristine condition as much as possible.

These principles pose interesting issues. Will they really stand up as useful guides to police the behavior of private-sector explorers, or government-sanctioned and funded explorers, for that matter? What about explorers from nations that have not signed the treaties? At the present time, technology does not permit the significant exploitation of resources in the lunar environment, so these principles are not put to the test. What will happen if practical technologies become available? Extraterrestrial mining could be practical on low-gravity worlds like the Moon or any asteroid. Ore or refined metal could be launched on trajectories that end on Earth as man-made meteorites. Is it possible to conduct these sorts of resource recovery missions under the principles of the current Outer Space Treaty and its successor agreements? If it is not possible, private interests may attempt to find a way around the UN treaties, rather than obey them. If it is possible, what consequences will there be for failure to abide by the Treaty principles, and what consequences can be imposed for violating them?

Private companies generally keep proprietary information on the details of their profit-making strategies. Will exploration/exploitation space facilities owned by private concerns really be available for others to inspect? Treaty principles do not permit ownership of land on the Moon or other celestial bodies, but they allow for the collection of samples. How much material constitutes a sample?

How often and how much similar material can be collected and still be called a “sample?” Once the sample is removed from the lunar surface, does it become legal property? Of whom? It is much easier to steal from a miner than to do the miner’s work—if lunar mining operations legally remove “samples” of an economically viable size without being granted ownership rights, the lack of legally enforceable ownership creates an incentive for piracy.

As the realm of the possible becomes the practical, space treaties will have to be modified or replaced to accommodate the realities of what private interests and governments have the power and the motivation to do.

#### WEALTH IN SPACE

What is the value of private space exploration? Why would a private individual or corporation spend massive amounts of money to go out to explore space? To make more money, of course. The most easily obtained space asset is visual remote-sensing data. No landing is immediately required, no samples need be collected and safely returned to Earth, no *in situ* analysis need be performed. Simple (high-quality) photography suffices. The continued support of nations for space exploration, and rapt attention to the results of manned and robotic exploration, shows the deep interest that people have for simply knowing what there is to know about space and other worlds. A first wave of profits no doubt can be made from sharing the experience of being there.

Any ethical issues raised by private space exploration for the collection and distribution of remotely-sensed data—TV imagery, for example—are not particularly troubling, no more so than exploration by governmental agencies. If something truly astounding or dangerous were discovered and held secret until money changed hands, that would be a different matter, of course. However, private acquisition of remote-sensing data is accessing an essentially infinite resource. So long as the region observed is left undisturbed and pristine (consistent with treaty responsibilities), it always is available in principle for the next interested party to make the same observations.

The stakes become higher as remotely-sensed data loses its novelty and value and *in situ* exploration becomes the new reality. A lander or rover unavoidably alters its environment to some extent. On a world with an atmosphere, such as Mars, a flying vehicle can be envisioned that might significantly alter only the point of the vehicle’s final resting place when it inevitably ceases to function. The Moon, or an asteroid

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or other airless body, will require a vehicle in nearly constant direct physical contact in order to perform sample collection or sample studies from the surface. Even then, the damage to the formerly pristine environment, faithfully recording the history of that world, will be limited only to the region directly contacted by the probe. The damage in this sort of exploration is small and generally acceptable.

The last vista is the exploitation of material resources. In a word, mining. The effects of mining are not small. The availability of certain light metals is greater in the Moon's surface rock and soil than on Earth, so that less ore needs to be processed for the same amount of refined metal. The Moon has advantages for ore smelting and processing. Aluminum refining is much easier in a natural vacuum, as aluminum burns in air at a lower temperature than it melts. Solar or nuclear power might make it cost-effective to seek metals from the Moon rather than Earth, refining the ore in place and shipping the finished product to the Earth.

How would a prospector stake a claim? On Earth, the only land that is not under territorial control of one nation or another is Antarctica. In any other case, prospectors make a deal with the sovereign government or the owner of a plot of land in order to acquire the right to mine it. On the Moon, there is no single governing body to make a ruling on who owns a plot, or how big the plot may be. There are no natural boundaries such as rivers on the Moon. Even now, there are companies that claim to sell plots of land on the Moon to private individuals. Current treaty law does not even permit the ownership of any portion of the Moon's surface or subsurface, by private interests or otherwise. However, when it becomes a practical reality for a miner to identify a mineral resource and actually be capable of exploiting it, there will have to be some sort of law to govern what happens.

What about asteroids? The Moon has been claimed as a birthright to all nations of Earth, and therefore a sacrosanct international preserve off-limits to any form of non-scientific, non-exploratory use. There are thousands of asteroids, however, most of them far too small to be seen from Earth except by extraordinary measures. Many asteroids are expected to be composed of essentially pure metals, requiring practically no smelting, only the effort needed to saw off a piece—or, for a small asteroid, perhaps the whole object might be an exploitable resource all at once. Could a mining company make a claim for an asteroid? What rights would the company have to shift the asteroid's orbit to be more convenient? What rights would a company have to carve pieces off an asteroid? What about the largest asteroids, that actually can be seen

by people on Earth using modest telescopes? Is private ownership of these asteroids acceptable, or not? Private ownership of even a piece of them? In what way does the size of the body affect its suitability for private exploitation?

The United States has taken on the mission of returning humans to the Moon, to a possibly permanent base, in the spirit of exploration and scientific inquiry. Other nations more than likely will join, with money, materials, and expertise, to be part of the great exploration. We—meaning all of humanity—will, sooner or later, claim a larger place in the Solar System. Government will fund or motivate the development of technologies necessary to get there.

It seems certain now that private profit-making interests will follow the first explorers out into space, just as trappers and miners and farmers and ranchers followed the Lewis and Clark expedition out into the profitable lands of the American West. Settlers changed the face of the West, arguably improving the general lot of mankind, but unquestionably damaging the lot of the indigenous peoples who occupied those lands beforehand. Can we only hope for a better showing in the next great round of human expansion? Or can we ensure a better showing, by laying our plans now to constrain and police behavior in this new arena? People will go. Investments will be made. Shareholders will demand a profit. Hiding our eyes and willing otherwise will not prevent a private entrance into space. The ethical debates had better begin now.

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## CONDUCTING THE LESSON

### WARM-UP & PRE-ASSESSMENT



#### TEACHER MATERIALS

- Images of manned and unmanned space exploration found in the back of the lesson

#### PREPARATION & PROCEDURES

1. Show students several pictures of space explorers and spacecraft. Ask students if they can identify any of them. (*Answers are located in the Teacher Answer Key section.*) Go through each image and ask students who was responsible for developing and conducting each mission. (*Desired answer: in each case the answer is NASA*) Ask students if NASA is privately funded or a government agency. (*Desired answer: government agency*) Ask students if they feel that private businesses should be allowed to conduct missions or to send spacecraft into space for a profit. Accept all opinions.

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## ACTIVITY: WHO HAS THE RIGHT TO EXPLORE SPACE?



### STUDENT MATERIALS

- *Fly My Stuff to the Moon*, an article by Robert Roy Britt located at the back of the lesson

### PREPARATION & PROCEDURES

1. Ask students: if you wanted to explore an area in your community, assuming that it is not private property, should you be able to do so or should only the government be able to survey this area? Accept all opinions. What about space; should anybody or only the government be able to explore this area? Accept all opinions. Many students will say that they should be able to explore the area in their community, but that not everyone should be able to explore space. Ask students what makes space different from land on Earth. Accept all opinions. Many students will not be sure why this is their opinion, but claim it is a feeling they have. Tell students that by learning more about the topic they will find information that will support or challenge their opinion.
2. Have students read the article entitled, *Fly My Stuff to the Moon*. Have students create a list of pros and cons of private space exploration for profit presented in the article.
3. Once the students have completed their lists, facilitate a class discussion of the pros and cons of private space missions and exploration for profit. You can ask the following questions to prompt the discussion:
  - Is the information discovered by private missions possibly valuable to further explorations?
  - Does private industry introduce competition and drive down costs of exploration?
  - Is the pristine environment of space at risk?
  - Is the Moon at risk of becoming a travel destination?
  - Do corporate sponsors who help pay for some of the costs associated with missions influence those missions' goals?
  - Do we have a responsibility to future generations to preserve the space environment?

4. After the class discussion, tell students that they will be participating in a class debate on the topic: Who has the right to explore space? Students can use information from the article *Fly My Stuff to the Moon* and the class discussion to form their arguments. Allow students additional time to research additional arguments and to organize them as a team.

#### REFLECTION & DISCUSSION

Discuss with students how the debate helped them gain a better understanding of the issue. Did their teammates or members of the other team make a point they did not previously consider? Ask students if anyone has changed their original opinions discussed in the *Warm-Up & Pre-Assessment*. Allow students to share their ideas.

#### TRANSFER OF KNOWLEDGE

One of the central issues in the class debate was the preservation of the space environment. Some scientists can envision ways of developing bacteria that could modify the soil and atmosphere on Mars or Venus, making the planet much friendlier for human habitation through the process of terraforming. Write a persuasive essay in support of, or in opposition to, pursuing the development of this technology.

#### EXTENSIONS

- Explore the ethical debate surrounding genetics. We are rapidly developing the ability to modify our own species' biology. Should we take biology into our own hands? Should we wait until we know more about what we are doing? Or should we just ignore what we have learned and let nature run its course?

#### PLACING THE ACTIVITY WITHIN THE LESSON

In this activity, students researched who has the right to explore space. Students used their research in a debate. Discuss with students how this is an excellent method for exploring complex ethical issues. Ask students to share what they learned through the debate that they did not learn from their research.

#### CURRICULUM CONNECTIONS

*Language Arts* – Review the components of a persuasive essay and structure of a debate.

#### TEACHING TIP

You can ask students to choose the side they feel most strongly about or you may choose the side for them, compelling them to see other sides of the issue.

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## ASSESSMENT CRITERIA FOR ACTIVITY

## 4 Points

- ▶ Students created a list of pros and cons based on the article, *Fly My Stuff to the Moon*, showing a deep understanding of all the issues.
- ▶ During the debate, all information was presented in a clear, accurate, and thorough way.
- ▶ During the debate, every major point was supported with facts, statistics, or examples.
- ▶ Student wrote a persuasive essay about terraforming, and supported their opinion with many relevant facts.

## 3 Points

- ▶ Students created a list of pros and cons based on the article, *Fly My Stuff to the Moon*, showing a deep understanding of the major issues.
- ▶ During the debate, most information was presented in a clear, accurate, and thorough way.
- ▶ During the debate, most major points were supported with facts, statistics, or examples.
- ▶ Student wrote a persuasive essay about terraforming, and supported their opinion with several facts.

## 2 Points

- ▶ Students created a list of pros and cons based on the article, *Fly My Stuff to the Moon*, showing a limited understanding of the major issues.
- ▶ During the debate, some information was presented in a clear, accurate, and thorough way.
- ▶ Student wrote a persuasive essay about terraforming, and supported their opinion with a few relevant facts.

## 1 Point

- ▶ Students created a list of pros and cons based on the article, *Fly My Stuff to the Moon*, showing little understanding of the major issues.
- ▶ During the debate, little information was presented in a clear, accurate, and thorough way.
- ▶ Student wrote a persuasive essay about terraforming, but did not support their opinion with relevant facts.

## 0 Points

- ▶ No work was completed.

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## **LESSON WRAP-UP**

### **LESSON CLOSURE**

Discuss how the development of technology affects the things we can imagine doing with it. The question we need to ask as a society is: just because we can do something, should we? New issues and problems will continue to arise that will spark ethical debate and consideration. Discuss how being able to research these topics and discuss them is the first step to finding a solution.

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## RESOURCES

### INTERNET RESOURCES & REFERENCES

#### *Student-Friendly Web Sites:*

How Terraforming Mars Will Work

<http://science.howstuffworks.com/terraforming.htm>

Tier One private manned space program

<http://www.scaled.com/projects/tierone/>

NASA Space Commercialization

<http://commercial.nasa.gov/>

TransOrbital

<http://www.transorbital.net/>

*Fly My Stuff to the Moon* by Robert Roy Britt

[http://www.space.com/businesstechnology/technology/transorbital\\_040129.html](http://www.space.com/businesstechnology/technology/transorbital_040129.html)

*SpaceDev to Build Piloted Spaceship* by Tariq Malik

[http://www.space.com/businesstechnology/spacedev\\_dreamchaser\\_040920.html](http://www.space.com/businesstechnology/spacedev_dreamchaser_040920.html)

SpaceDev

<http://www.spacedev.com/>

#### *Teacher-Oriented Web Sites:*

International Space Law

<http://www.oosa.unvienna.org/SpaceLaw/treaties.html>

Terraforming

<http://www.users.globalnet.co.uk/~mfogg/>

The Space Review: Property Rights and Space Commercialization

<http://www.thespacereview.com/article/141/1>

Challenger Center

<http://www.challenger.org>

*Journey through the Universe*

<http://www.challenger.org/journey>

### ACKNOWLEDGEMENTS

The article *Fly My Stuff to the Moon*, by Robert Roy Britt, is used with permission from SPACE.com and the author, and is copyright 2004 by Imaginova Corp.

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*Internet Resources  
& References*





**FLY MY STUFF TO THE MOON:  
PRIVATE MISSION SLATED FOR FALL LAUNCH**



By Robert Roy Britt

Senior Science Writer, *SPACE.com*

January 29, 2004

[http://www.space.com/business/technology/technology/transorbital\\_040129.html](http://www.space.com/business/technology/technology/transorbital_040129.html)

While President Bush's new out-of-this-world vision has generated worldwide debate over whether private industry should play a bigger role in space exploration, one company is poised to answer the question with an enthusiastic thud later this year.

Thousands of people have paid to have messages, business cards, art or ashes of loved ones sent to the Moon on the Trailblazer robotic probe, which if successful will slam into the lunar surface and squash any doubt about the looming commercialization of space.

The mission is a private venture of California-based TransOrbital Inc., which is also drawing on corporate sponsorships and advertising to fund the effort.

After years of delay, launch is now slated for this fall, company President Dennis Laurie said in a telephone interview yesterday.

Individuals can book items for the flight at the company's web site, [transorbital.net](http://transorbital.net). Sending a business card to the Moon costs \$2,500. Other relics or mementos can fly for \$2,500 per gram. A text message costs \$17.

#### **Creative financing**

Trailblazer will orbit the Moon for about three months, sending back high-quality and potentially saleable photos of Apollo landing sites, plus HDTV-quality video that might be sold for advertising use. Data will be collected to create a new, high-resolution lunar map, also potentially saleable.

The craft will then de-orbit and disintegrate upon impact. Some 22 pounds (10 kilograms) of personal effects will remain intact, housed in a protective capsule that will tunnel 13-16 feet (4-5 meters) into the lunar surface.

TransOrbital initially had planned a July 2001 launch. Trailblazer was later expected to go up early this year. But a new deal struck with Hewlett Packard last summer, which will allow anyone with a properly equipped handheld computer to communicate with the lunar orbiter, forced additional engineering, Laurie said.

"We'd like to have as many people either send things to the Moon or access the satellite while it's in orbit around the Moon as possible," he said. Terrestrial communicators would get a confirmation message that the craft had received a signal.

Despite delays, the 242-pound (110-kilogram) orbiter is under construction, the launch vehicle is in place at a Russian facility, and it looks like liftoff will occur "in October or November of this year," Laurie said. He added that he's 80 to 90 percent confident in that forecast.

#### **Good model for NASA**

Proponents of expanded space exploration and the commercialization of space are eager for a private mission like this.

Brian Chase, executive director of the National Space Society, said TransOrbital's concept is sound.

In fact he said NASA could learn a thing or two from the approach.



Chase thinks the space agency should provide incentives for the private sector by buying data, rather than just doling out contracts for spacecraft construction. The current way of doing business leaves the space agency, in many cases, in charge of overseeing construction, running flight operations and doing the scientific observations, “a lot of details that probably NASA doesn’t need to worry about.”

Given Bush’s call to put humans back on the Moon, Chase told SPACE.com, “Now is a great time” for a mission like TransOrbital’s to succeed.

“I think it bolsters the case that there is a role for the private sector in space exploration,” he said, adding that unlike some advocates of privatization he sees the government continuing to play a dominant role.

TransOrbital appears to have little immediate competition.

Nearly four years ago another company, LunaCorp, got \$1 million in backing from Radio Shack to design a robotic craft that would be assembled on the International Space Station and launch from there to the Moon. Like TransOrbital’s probe, it would generate high-resolution pictures and video and involve public participation.

LunaCorp President David Gump said yesterday the mission awaits further funding before construction could begin.

“Our prospects obviously improved with the President’s declaration,” Gump said, adding that LunaCorp’s mission would be one way to repurpose the space station toward lunar exploration. Bush had said research on the station should be refocused to support his grand vision of putting people on the Moon and Mars.

### **On the verge**

Meanwhile, TransOrbital appears to be the only company on the verge of launching a privately funded spacecraft beyond Earth orbit. Yet because the company is private, it is not known with certainty whether it is financially prepared for liftoff.

In a test in 2002 from the Baikonur Cosmodrome in Kazakhstan, TransOrbital put a dummy craft into Earth orbit using a Russian Dnepr rocket. The same setup will be used for the Moon launch.

Laurie said the Baikonur success should convince potential supporters that the company has the finances, engineering and planning resources to make the lunar trip a reality. “You just go that one step farther,” he said.

TransOrbital plans to make money off this and future planned missions to the Moon by selling advertisements and sponsorships in addition to the revenue it collects on its web site.

Laurie would not divulge sales figures but said “thousands of messages and products” have been booked for the flight. The cards and other personal items, “will contribute significantly” to the revenue of the project, he said.

Additional revenue could come from Trailblazer’s lunar map, which will be the highest resolution ever and could help NASA and other private firms plan future lunar forays, he said.

The mission is expected to cost less than \$20 million.

Critics of the project have expressed worry about littering the Moon. Most of the critics, Laurie said, are environmentalists “who would like to make sure the Moon won’t suffer some of the ungracious treatment the Earth has experienced.”

TransOrbital has been addressing the environmental concerns from the outset, he said, and the Trailblazer mission is the only private, beyond-Earth-orbit space-flight plan presently approved by State Department. The agency required TransOrbital show that the impact “wouldn’t disturb the normal environment in any untoward way,” he said.

**MANNED AND UNMANNED SPACE EXPLORATION**



*Credit: NASA Headquarters - Greatest Images of NASA (NASA-HQ-GRIN)*



*Image downloaded from <http://spaceflight.nasa.gov/gallery/images/mercury/mercury6/ndxpage2.html>*



*Credit: NASA Kennedy Space Center (NASA-KSC)*



*Credit: NASA Jet Propulsion Laboratory (NASA-JPL)*

