X PRIZE FOUNDATION

NASA PRIZE STUDY
TOP PRIZE CONCEPTS
BY CATEGORY

November 6, 2003

Methodology Overview

More than 125 prize concepts were solicited via in person and telephone interviews at NASA Headquarters and Centers. Several individuals from Universities and industry (proposed by NASA personnel) were also interviewed.

A series of 4 prize categories (defined by prize value and time expectations) were developed in discussion between NASA and the X PRIZE Foundation. Each prize concept was then evaluated in terms of sponsorship potential, commercial potential and media interest value.

This document lists the top-ranked prize concepts in each category.

NOTICE OF PUBLIC RELEASE

From: maryniak@aol.com [mailto:maryniak@aol.com]
Sent: Friday, July 27, 2007 12:38 PM Central Standard Time
To: Davidian, Kenneth (HQ-BC000)
Subject: Re: Release of Space Architect's Report

Dear Ken,

The X PRIZE Foundation has no objection to NASA releasing the attached report at will. However, we make no warranty as to the copyright status of illustrations contained therin.

Sincerely,

Gregg Maryniak
Executive Vice President
X PRIZE Foundation

SUMMARY

NASA PRIZE Categories

Category	Prize Amount	Win Expectation
1	< $250,000	< 2 years
2	$500K - $1 million	< 3 years
3	$2 - 5 million	< 5 years
4	>$10 million	3 - 10 years

Category 1:

Amount of Prize: $25,000 -- $250,000 ***Time-Frame of Win: 1 - 2 years***

1. **Laser Launch Competition** **$100K**
2. **Rover Survivor** **$150K**
3. **Asteroid Bounty** **$250K**
4. **Lunar Processing Demonstration** **$250K**

Category 2:

Amount of Prize: $500,000 - $1 million ***Time-Frame of Win: 2 - 3 years***

5. **Micro Reentry Vehicles** **$1million**
6. **Nanotube Tether** **$1million**
7. **Precision Lander** **$1million**
8. **Life Detection** **$1million**
9. **Robotic Insects** **$1million**
10. **Gridlock Escaping Vehicle** **$1million**

Category 3:

Amount of Prize: $2M -- $5 million ***Time-Frame of Win: 2 - 5 years***

11. **Telerobotic Construction Race** **$2 million**
12. **Robotic Triathlon** **$2 million**
13. **CLSS Isolation** **$2.5 million**
14. **Variable Gravity Biosatellite** **$5 million**
15. **Robotic Antarctic Traverse** **$5 million**

Category 4:

Amount of Prize: $10 million - $30 million ***Time-Frame of Win: 3 - 10 years***

16. **Suspended Animation** **$10 million**
17. **Solar Sail Race** **$15 million**
18. **Lunar Lander** **$20 million**
19. **South Polar Lunar Lander** **$20 million**
20. **Asteroid Sample Return** **$30 million**

LASER LAUNCH COMPETITION

Short Name: LASER LAUNCH COMPETITION Prize Concept # 21

Purse Size: **$100,000 total prize pool**

Estimated Winning of Prize: **1 year**

Prize Task and Competition Description:

A series of first, second and third prizes totaling $100,000 is offered to the teams whose vehicles achieve the highest flight altitudes using energy supplied by a laser system such as the PAVE 10 kW pulsed laser at White Sands.

Goals of Prize:

- To encourage the development of laser propulsion systems
- To increase the number of individuals and institutions experimenting with such systems
- To provide US researchers with access to suitable laser facilities to test their designs
- To demonstrate the technical feasibility of laser propulsion systems

Participation Limits:

- US Citizens
- US University Teams

Practically, it will be necessary to limit launch site participants to individuals approved by the site operator. (in the case of the White Sands PAVE laser, that operator is the US Army)

Participation Expectation:

- University Teams
- Aerospace Companies (including small scale organizations)

Based on discussions with Professor Leik Myrabo of RPI, he expects that an initial competition (held within a year or so of the present) would attract at least three initial teams from universities.

Origin of this prize idea: Marc Millis of NASA Glenn Research Center with additional information supplied by Professor Leik Myrabo of RPI

Evaluation and Judging

Simple optical altitude tracking techniques similar to that used by the model rocket community (by this we mean the small hobbyist "Estes" type rockets as opposed to High Power model rockets) can be employed for initial competitions where altitudes of under 1000 feet are expected.

Issues:

University support by Federal or state governments (recommendation is to not disqualify university teams based on acceptance of government funding

Aircraft and spacecraft safety over the competition site is potentially an issue. However, this issue has been successfully dealt with in previous White Sands flight tests and is manageable.

Any such competition will be weather dependent. Therefore backup competition flight dates with facilities and airspace clearance will be required. The budget for one half day operations has been approximately $15,000 at White Sands including radar tracking of aircraft and coordination with NORAD regarding satellites (to prevent accidental illumination of spacecraft). Therefore the cost of providing the facility for the prime competition day plus two weather backup times is expected to be of the order of $50,000.

Narrative:

Providing energy external to the reaction mass of a rocket has long been considered (for example by Arthur Kantrowitz and Freeman Dyson during the 1970's among others.) More recently, Myrabo of RPI has demonstrated small models that utilize laser-heated atmosphere as reaction mass.

However, the complexities of finding suitable laser systems has limited experimentation and development. By offering a prize and providing a competition site with suitable laser equipment, the number of participants in this field can be increased.

It is believed that some work along these lines may have been accomplished in the former Soviet Union. Ultimately expanding the competition to international participants may stimulate disclosure of useful technologies and research.

ROVER SURVIVOR

Short Name: ROVER SURVIVOR **Prize Concept # 115**

Purse Size: **$150,000 total prize pool; (i) $100,000 1st Prize; (ii) $ 50,000 2nd Prize**

Estimated Winning of Prize: **2 (min) – 4 (max) years**

Prize Task and Competition Description: Teams are invited to build and deliver to a deserted location a Robotic Surface Explorer. The Robot explorer must be autonomous, solar powered, and required to conduct a sequence of daily (TBD) activities. The Explorer relays images and data on a regular basis via a satellite uplink to a mission control. The robot able to last for 6 months (minimum) or the longest, wins the competition. The location of the robot competition is a deserted region (desert or island) without human contact. Robots must explore, avoid disasters, and return data. There is a total mass and volume restriction. Cooperative (hive) robots are allowed.

Goals of Prize:

- To demonstrate the challenges of building a robust planetary robotic explorer.
- To improve the state of art of building long-endurance, robust, autonomous robotic explorers.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Robotic companies

Origin of this prize idea: JPL -- Interview with Dr. Andrea Donnellan, PhD, Deputy Division Manager, Earth & Space Sciences Division, JPL

Evaluation and Judging: Judging is objective depending on data being returned to a central mission control.

Issues: No specific Issues; Rules need to be specifically defined.

Narrative: Robot wars have been very successful in the reality TV world. The state of practice for novice robot builders has increased considerably. This is an opportunity to flow novel practices being developed by individuals and universities into NASA related mission objectives.

BOUNTY FOR ASTEROID DISOVERY

Short Name: ASTEROID BOUNTY **Prize Concept # 3**

Purse Size: **$250,000 total prize pool**

Estimated Winning of Prize: **1 year or less for first recipients**

Prize Task and Competition Description::

A bounty of ($1000 to 5000 is paid for each new (previously unidentified) Earth-Crossing Asteroid discovered by a U.S. Citizen whose orbital elements are published in the Minor Planet Circulars. The bounty is raised to $25,000 for any object whose trajectory comes within 1 lunar radius of the Earth. Prizes are paid until pool of prize funds has been expended.

Gene and Carolyn Shoemaker at Mt. Palomar

Goals of Prize:

- To increase the discovery rate of and Earth Crossing Asteroids
- To encourage a broader base of astronomers to search for and report such objects
- To encourage the development of tools and techniques for the automated search of asteroids.

Participation Limits:

US Citizens (in the interest of reducing complexity in initial offering)

Federal Government-Funded searches specifically excluded. (See *Issues* below for argument in favor of permitting some federal supported researchers to be included in this activity.)

Participation Expectation:

- Amateur astronomers
- Students with access to appropriate telescopes and related equipment
-

Origin of this prize idea:

Code M, John Mankins, NASA Headquarters and other interviewees

Evaluation and Judging:

The most important part of the decision-making process in this prize concept is made externally by the publishers of the Minor Planet Circulars. The remaining judging task

will be to determine that the bounty applicant fits the participation criteria. An application form should be designed for submission / registration purposes.

Issues:
Will require rules analysis regarding whether researchers using equipment funded with federal grant money are excluded.) Arguably, unpaid researchers (graduate students?) using such equipment would be motivated to seek these objects if they were able to be rewarded with a bounty.

From a public policy standpoint, the finding of additional solar system objects is of sufficient value that providing a modest bounty over and above other government support should not pose a problem.

Narrative:

Over the past 20 years, the scientific community and the general public have begun to appreciate the potential threat posed to the Earth by asteroids. Meetings and conferences on detecting such asteroids and mitigating the threat that they may pose have observed that a handful of observers account for a significant fraction of the known objects found to date. (It has been suggested that the total number of astronomers in the world concerned with the search for Earth-approaching objects is less than the normal crew complement of a typical fast-food restaurant.) The purpose of this prize is to increase the number of observers and spur the development of automated search techniques and equipment.

LUNAR PROCESSING DEMONSTRATION

Short Name: LUNAR PROCESSING DEMONSTRATION Prize Concept #49

Purse Size: **$250,000**

Estimated Winning of Prize: 2-3 years

Prize Task and Competition Description:

A prize of $250,000 is provided to the first team to demonstrate a bench scale system capable of processing oxygen from a standard lunar stimulant while meeting specified performance criteria. Alternatively a time limit for entries can be specified with prizes awarded to the demonstrated systems that give the best performance against specified criteria.

Goals of Prize:

- To encourage the development of tools and techniques for In-Situ Resources Utilization (ISRU).
- To reduce the risk of selecting ISRU for future space missions
- To increase the number of researchers in the space resources community

Participation Limits:

US Citizens, organizations and companies

Participation Expectation:

- **Small companies**
- **University teams**
- **Small teams of researchers**

Origin of this prize idea: Code M, John Mankins, NASA Headquarters

Evaluation and Judging:

See *Issues*

Issues:

Concise criteria for system operation need to be specified. These could include some or all of the following:

- Power usage per mass of feedstock or product produced.
- Specific system mass per product produced
- Mass of consumed “imported” materials such as sacrificial electrodes, reagents lost to the output streams etc.

It is recommended that a maximum system size/mass be specified.

Narrative:

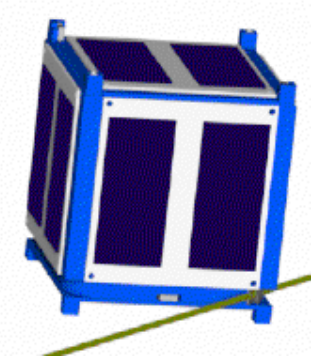
The notion of using local materials for construction, propellant, life support and other consumables for lunar, planetary and solar system exploration is well documented. A considerable body of literature exists (for example, see the Princeton Conferences on Space Manufacturing co-sponsored by the AIAA and the Space Studies Institute) but the number of practical hardware system demonstrations has been modest. Additional tests and demonstrations will be needed to reduce the programmatic risk of relying upon local resources for future space missions.

MICRO-REENTRY SYSTEM

Short Name: MICRO-REENTRY SYSTEM **Prize Concept # 117**

Purse Size: **$1 million**

Estimated Winning of Prize: **2 (min) – 4 (max) years**



Prize Task and Competition Description: Build and demonstrate a microsatellite (<2Kg total weight) able to reenter the Earths atmosphere (from orbital velocities) and safely land a fragile payload at a specific location (with an accuracy of 50 mile radius). The payload bay of the satellite will have a sensor package. Parameters for vibration, temperature, pressure and acceleration will need to remain within TBD parameters. This concept is particularly interesting for the return of science samples from space station, on a per experimenter basis. The concept is based on work done by Cubesat (www.cubesat.org).

Goals of Prize:

- To develop and demonstrate low-cost, lightweight reentry systems

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Small Sat Companies

Origin of this prize idea: AMES -- Interview with Daniel Rasky and Paul Kolodziey

Evaluation and Judging: Judging is objective depending on ability of satellite to renter with a specific accuracy and have payload environment within certain specifications.

Issues: Need to examine the regulations regarding reentry of satellites into Earth's atmosphere with the intent to land. Current FAA Regulations (FARs) have weight thresholds for unmanned kite, balloon, or rocket payloads, above which licensing and lots of added safety equipment are required. If the payload is <4 pounds, it is exempt from those requirements, but still has to meet some basic safety rules. The payload can be up to 6 pounds if its effective density is low enough, and up to 12 pounds for a string of vertically separated balloon payloads.

Rules need to be specifically developed

Narrative: This prize idea provides an interesting solution to the "download" problem for scientific payloads from ISS to the Principal Investigator. If successful it can provide a revolutionary way to get samples back in a fast and low-cost method.

CARBON NANO-TUBE TETHER

Short Name: NANOTUBE TETHER **Prize Concept # 103**

Purse Size: **$1 million**

Estimated Winning of Prize: **3 – TBD years**

Prize Task and Competition Description: Prize for the first team to construct and demonstrate a 10 meters long tether able to demonstrate a strength of 60 Giga Pascal with density less than 2.0 gm/cc.

Goals of Prize:

- To encourage the development of lightweight, high-strength tethers that can be used for such areas as Space Elevators.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Materials companies

Origin of this prize idea: Ames -- Interview with Dr Meyya Meyyappan, Center for Nanotechnology, Meyya@orbit.arc.nasa.gov

Evaluation and Judging: Judging is objective depending on data being returned to a central mission control.

Issues: No specific issues

Narrative: The area of nanotechnology offers tremendous breakthrough opportunities for the Space Community. Access to space is so weight sensitive that being able to make orders of magnitude improvements here can be revolutionary. Recently the idea of the Space Elevator, originally conceived by Sir Arthur C. Clarke has been seriously discussed in the media given expected future breakthroughs in material sciences. This prize helps to promote the creation of tethers required to enable such breakthrough ideas.

PRECISION LANDER DROP TEST

Short Name: PRECISION LANDER **Prize Concept # 32**

Purse Size: **$750,000 (1st); $250,000 (2nd) – Total Prize: $1 million**

Estimated Winning of Prize: 2 – 3 years

Prize Task and Competition Description: Prize is given for first (and 2nd place) team to build a lander dropped by Helicopter from 20,000 feet that is able descend, avoid certain obstacles, seek out a specific terrain profile and land at a TBD location with 2 meter accuracy. Lander **may not use GPS**. Data is uplinked to lander 30 minutes prior to helicopter release. Total weight, power and volume limits on lander is TBD.

Goals of Prize:

- To develop new approach and landing algorithms for future robotic explorers to the Moon, Mars and Asteroids.
- Develop technology to enable hire precision landings in the future

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Small and Large Corporate teams

Origin of this prize idea: JPL -- Interview with Dr. Charles Elachi

Evaluation and Judging: Judging is objective depending on landing accuracy.

Issues: No specific Issues; Rules need to be specifically defined.

Narrative: Dr. Elachi proposed that new technologies and algorithms able to assist our future lunar and Martian probes land more accurately can be developed through this type of competition. The need for accurate landing capability on Mars, to get rovers near specific geological points of interest, is critical. Today landings error ellipses are very large and don't allow scientists to choose specific points of interest for exploration.

IN-SITU LIFE DETECTION

Short Name: LIFE DETECTION **Prize Concept # 115**

Purse Size: **$1 million**

Estimated Winning of Prize: **2-3 years**

Prize Task and Competition Description: In-situ Life Detection Prize: Given a weight, volume and power restriction, create a device that will examine one hundred different 10 milligram soil samples and determine which of these contain life. Each sample will look identical, but some number of these will have a small sample of life. Each will have life of different types – spores, bacterial, algae, viruses, etc. The prize will go to the device which is able to detect 100% of the current samples without providing any false positives.

Goals of Prize:

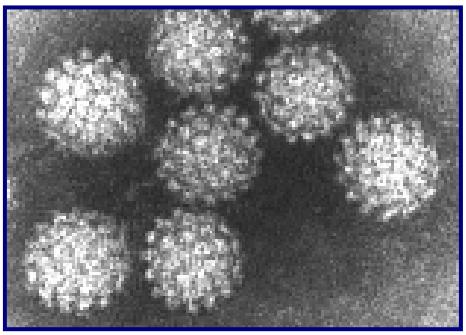
- To demonstrate the challenges of detecting life.
- To improve the state of art of autonomous life detection technology to support future Mars missions.

Participation Limits:

- US Citizens, Privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Biotech companies
- Homeland defense companies



Origin of this prize idea: AMES -- Interview with Dr. Lynn Harper, TR Govindan (govindan@nas.nasa.gov), Kathleen M. Connell (kconnell@thecwgroup.com).

Evaluation and Judging: Judging is objective depending on data.

Issues: No specific Issues; Rules need to be specifically defined. Types of life, amount of soil, amount of biomass needs to be defined.

Narrative: Detection of life is the major driver in NASA's Mars missions. Given limited mobility, limited volume and power, developing more effective in-situ life detection technologies is critical. Homeland defense will also be interested in this area given the need to detect biological agents.

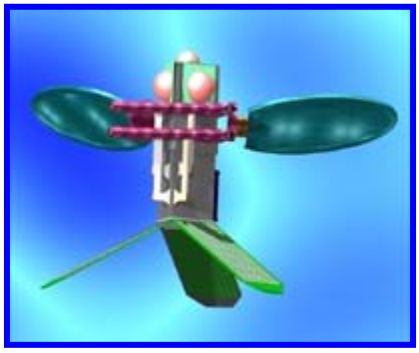
ROBOTIC MICRO-FLYING INSECTS

Short Name: ROBOTIC FLYING INSECTS Prize Concept # 104

Purse Size: **$1 million**

Estimated Winning of Prize: **2-3 years**

Prize Task and Competition Description: Construction and demonstration of a 10 cgm mechanical flying insect class sensor package able to sense and transmit two different TBD parameters and fly for 10 minutes between solar recharge.



Goals of Prize:

- To demonstrate micromechanical systems
- To develop new ideas for Mars robots.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Robotic companies

Origin of this prize idea: **Ames** -- Interview with Dr Meyya Meyyappan, Center for Nanotechnology, Meyya@orbit.arc.nasa.gov

Evaluation and Judging: Judging is objective depending on data being returned to a data recorder and measuring the time of flight.

Issues: How repeatable must the flights be in order to win?

Narrative: The low atmospheric pressure on Mars is actually more conducive to the flight of insects than airplanes or balloons. These types of micro-mechanical insects could be the idea future robotic explorers of the red planet. This prize will help provide proof of ability for this concept. This may also be of substantial benefit to homeland defense efforts

GRIDLOCK-ESCAPING COMMUTER VEHICLE

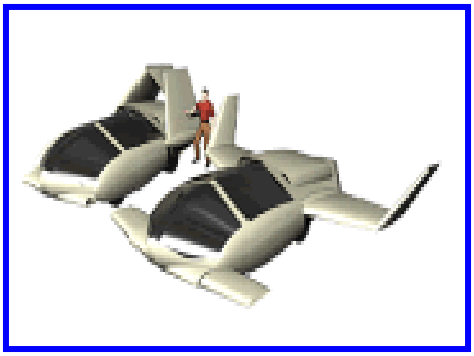
Short Name: GRIDLOCK-ESCAPING VEHICLE Prize Concept #98

Purse Size: **$1 million**

Estimated Winning of Prize: **5 to 7 years**

Prize Task and Competition Description:

A prize of $1 Million is presented to the first team to demonstrate the successful flight (including meeting TBD speed, payload, and noise requirements) of a single person capable flying vehicle that can operate within a Balanced Field Length of 250 feet and that is 'roadable' under DOT Section 500 specifications.



Goals of Prize:

- To focus attention on new classes of aircraft that could have profound impact on general aviation.
- To provide a challenging goal for university and US industry research

Participation Limits:

US Citizens, organizations and companies

Participation Expectation:

- Individuals
- University Teams
- Small business

Origin of this prize idea:

Andrew Hahn (Andrew.s.hahn@nasa.gov) and Mark Moore (m.d.moore@larc.nasa.gov)
of NASA Langley Research Center

Evaluation and Judging

Judging is based on objective performance standards.

Issues:

Pilot safety during testing is a potential issue. Potentially this might be largely addressed by requiring a safety system such as the rocket-propelled ballistic parachute systems utilized on many ultralight sport aircraft. NASA and the aviation industry have traditionally used test pilots and the risks have been deemed acceptable. If pilot safety is deemed to be a show-stopper for purposes of this specific competition, it might be possible to specify that the required demonstration flights necessary to win the prize be conducted using remote control and make-up ballast. However, realistically, it should be expected that aircraft builders will use live test pilots during aircraft development.

Narrative:

A longstanding dream of the both the general public and the aviation community has been the personal aerial commuter vehicle. Characteristics of such a vehicle would include the ability to land and take off within a relatively tiny area compared with modern day general aviation aircraft and the ability to use streets (under DOT Section 500 requirements) for a portion of the journey.

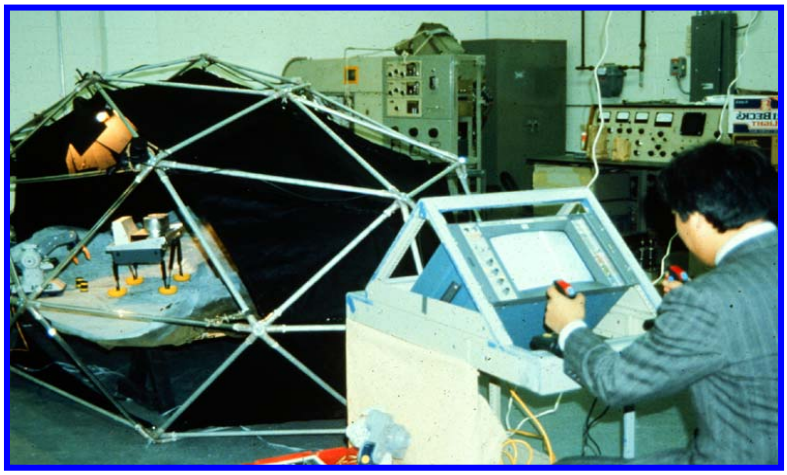
The prize would establish a target specification for such a vehicle. In the tradition of the Kremer Prize for human-powered flight and the Orteig Prize that induced Charles Lindbergh's *Spirit of St. Louis* flights, the prize would be awarded to the first team to accomplish the specified feat.

Habitat Construction Race with Teleoperated Robots

Short Name: TELEROBOTIC CONSTRUCTION RACE **Prize Concept #110**

Purse Size: **$2 million** **Estimated Winning of Prize:** **2 years**

Prize Task and Competition Description:



Teams compete to erect a specified habitat structure using teleoperated robots controlled through a time delay system simulating lunar or Martian distances. A maximum data-link capability is specified. Each team is provided with a standard cache of materials. Options (which would increase time and prize purse size) could include:

- Siteing the competition in an environmentally challenging location such as the Arctic and/or
- Including a requirement that each team must traverse a 10 km distance to get to their cache

Goals of Prize:

- To encourage the development telerobotic construction systems.
- To increase the number of individuals and institutions experimenting with such systems.
- To explore the impact of time delay on telerobotic human-machine systems

Participation Limits:

US Citizens, organizations and companies

Participation Expectation:

- **University Teams**
- **Professional Society Teams**
- **Corporate joint research institutions**
- **Corporations**
- **Individuals**

Evaluation and Judging

Judges from the construction and potentially excavation (assuming finished habitats are to covered for radiation protection and that site work is required prior to structure assembly) will inspect the work against contest rules and standards. Inspection periods will take place at predetermined phases of the construction task and for equal amounts of time per team. Although in theory it would be possible to have each contestant perform their task in sequence and compare the total construction time of each team, in practice having several teams building in parallel would be a more interesting race and therefore more likely to attract sponsorship,

Issues:

- Potential environmental impact if Arctic region selected for competition.
- Length of contest if time delays greater than a few seconds are selected.

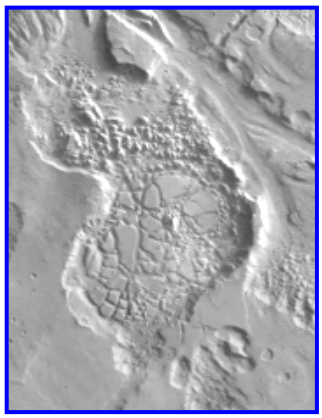
Narrative:

Telerobotic systems hold great promise for space construction tasks. These systems can range from human-dependent remote controlled machines that are essentially idle during time-delay to human-supervised robotics that perform mainly automatic functions but call for help from their human operators when required.

Experiments with students from the inaugural International Space University session at MIT in 1988 performed by the Space Studies Institute, demonstrated rapid human adaptation to operating equipment with a lunar (~3 second) time delay. Vision issues such as lighting, number of cameras, image refresh rates tended to be significant (and will be constrained by data link considerations in operational systems.) These challenges will be greatly magnified when performing actual construction and excavation tasks.

ROBOT TRIATHLON

Short Name: Robot Triathlon **Prize Concept # 121**



Purse Size: **$2 million**

Estimated Winning of Prize: **2 -3 years**

Prize Task and Competition Description: Prize awarded to the first robot able to traverse a complex, hazardous, geological site and conduct some science. This is a multi-team race with a starting gate. Teams must traverse 20 KM, climb up (or down) a 30 – 50 degree slope, sample a particular region, and take a measurement. First team to accomplish this event wins. Robots can be autonomous or teleoperated. Teleoperations are subject to data rates and delays typical of Mars.

Goals of Prize:

- To demonstrate complex operation of robots able to access unique locations on the Martian surface (e.g. rim of craters) and take samples for scientific purposes.
- To explore different approaches and methodologies towards this goal.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Robotic companies

Origin of this prize idea: AMES - Dan Clancy, Chief, Computational Science Division. dclancy@arc.nasa.gov

Evaluation and Judging: Judging is objective depending on data being returned to a central mission control.

Issues: No specific Issues; Rules need to be set difficult enough so that it is a non-trivial objective. Is there a time limit put on accomplishing the task? (e.g. 12 hours).

Narrative: Many of the most interesting geological locations on Mars are at the top of cliffs or over the edge of crater rims. Today's landing technology is insufficient to take a sensor package to an exact location. Robotic explorers will need to be able to travel a distance, traverse dangerous terrain and sample a specific location of interest. This prize is intended to develop a series of efforts to explore various approaches.

SMALL GROUP/LIFE SUPPORT COMPETITION

Short Name: CLOSED CYCLE ISOLATION Prize Concept #123

Purse Size: **$2.5 million**

Estimated Winning of Prize: **2 – 3 years**

Prize Task and Competition Description: First team to build and demonstrate a capability to provide complete closure for a group of 4 individuals for 180 day period. Teams are physically isolated for this period of time and monitored from the outside. Communications with the team is restricted to data-rates and delays similar to that of a Mars mission. Enclosure is restricted by power, volume and weight similar to that of a Earth – Mars - Earth mission. Environmental and psychological health of crew is monitored for safety. No external control of environment or resupply is allowed.

Biosphere-2, Arizona

Goals of Prize:

- To demonstrate new technologies allowing for safe full closure of a spaceship's environment (Air, Water, Waste, etc.)
- Conduct crew psychological experiments

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Environmental companies

Origin of this prize idea: **AMES & JSC --** Interview with Dr. Jeffrey R. Davis - Director, Space & Life Sciences, Dr. John A. Rummei - Dep. Director, Space & Life Sciences, and Dr. Rebekah Davis Reed - Special Assistant for Policy.

Evaluation and Judging: Judging will depend on the group remaining within the enclosure for the entire duration, and all of the environmental parameters remaining within accepted tolerances.

Issues: There may be some issues involving human subjects. There should not be any situation that ever puts a person's life in danger. Subjects can exit whenever they wish.

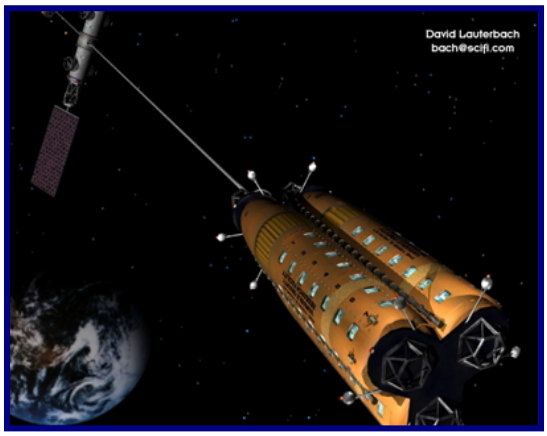
Narrative: New Closed Life Support System technology is now available, but it is difficult to give it any proven heritage. This technology dies in the TRL "valley of death". This will offer companies a chance to demonstrate their approaches.

VARIABLE GRAVITY RESEARCH BIOSAT

Short Name: VARIABLE GRAVITY BIOSAT Prize Concept # 19

Purse Size: **$5 million**

Estimated Winning of Prize: **3 – 5 years**



Prize Task and Competition Description: First team to build and launch a satellite capable of providing a group of 10 mice with variable gravity between 1/6th and 1G. Mice must then maintained at a specific G-level for 60 days and returned safely back to Earth

Goals of Prize:

- To develop a new class of hardware able to provide Variable-Gravity on orbit
- To obtain science regarding g-sensitive limits on mammalian development, reproduction and survival.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Aerospace companies

Origin of this prize idea: JSC & HQ -- Interview with Dr. Jeffrey R. Davis - Director, Space & Life Sciences, Dr. John A. Rummei - Dep. Director, Space & Life Sciences, and Dr. Rebekah Davis Reed - Special Assistant for Policy. Also supported by Code U (Guy Fogleman) and Code M (John Mankins) meetings at Headquarters.

Evaluation and Judging: A series of parameters will need to be explicitly determined regarding the biosat's ability to sustain g-levels within TBD parameters. Other parameters must be determined such as how many mice must survive reentry, and their health status.

Issues: There is an MIT group that has been working on this for years who might be thought to have the 'lead'... however they have not passed PDR and have been unsuccessful in raising substantial funding. Other serious teams could easily catch up. Possible concerns with animal welfare issues. Need to determine if launch is provided.

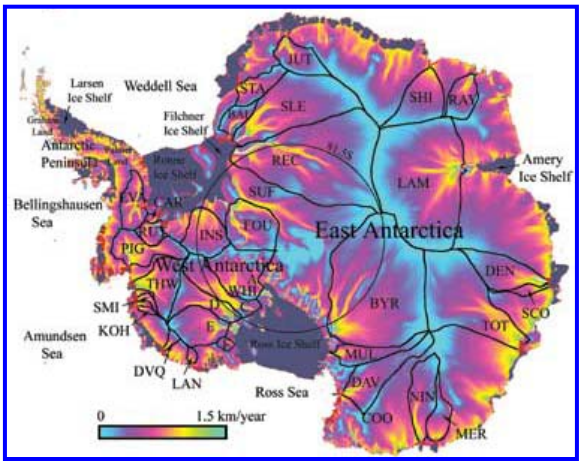
Narrative: Humanity's ability to go to Mars may well hinge on effective countermeasures for the long roundtrip time in zero gravity. Also we don't currently know if Earth-based-life can survive for long periods in 1/6th G.

ROBOTIC TRAVERSE OF ANTARCTICA

Short Name: TRAVERSE OF ANTARCTICA Prize Concept #120

Purse Size: **$5M - $10 million**

Estimated Winning of Prize: **3 – 4 years**



Prize Task and Competition Description: 2007 is the 50th Anniversary of the commissioning of Scott Base, Edmund Hillary's trek to the South Pole. $5M - $10M purse for first team to do this traverse using a 20 min timedelay (Mars) with Martian data-rates.

Goals of Prize:

- To demonstrate robotic teleoperations in hazardous environments.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Groups similar to those participating in the DARPA Grand Challenge
- Robotic companies

Origin of this prize idea: AMES - Dan Clancy, Chief, Computational Science Division. dclancy@arc.nasa.gov

Evaluation and Judging: Judging is objective, there should be a starting point and ending point (GPS).

Issues: **(1)** Best not to do this as a race because too many robots who liter the environmental footprint. If it is the first team to accomplish it will have less effect on the environment. (2) Are teams required to remove the vehicle from Antarctica? (3) Are there limits on mass and power?

Narrative: Plans are now underway for an "International Polar Year" in 2007/08 to mark the fiftieth anniversary of the International Geophysical Year (IGY) of 1957–58, the commissioning of Scott Base, and Edmund Hillary's trek to the South Pole as part of the International Trans-Antarctic Expedition.

SUSPENDED ANIMATION

Short Name: SUSPENDED ANIMATION **Prize Concept #8**

Purse Size: **$10 million**

Estimated Winning of Prize: TBD

Prize Task and Competition Description: Prize for the first team to demonstrate suspended animation for a specified period of time with a higher primate.

Goals of Prize:

- To encourage the development of techniques for hibernation or suspended animation of human space explorers

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Medical institutions

Origin of this prize idea:

Interview with John.Mankins of Code M

Evaluation and Judging: Judging is objective depending on data being returned to a central mission control.

Issues: Unknown time frame for completion, animal rights issues.

Narrative: The ability to put humans into hibernation during extended voyages would be a fundamental breakthrough that would greatly impact space exploration. A prize for such an audacious goal would be in the tradition of the Longitude Act and many of the early aviation prizes. For example a 1908 prize for a 200 mile non stop flight was lampooned by Punch Magazine as being as possible as an aeronaut flying his aeroplane to Mars and back in one week.

EARTH-MOON SOLAR SAIL RACE

Short Name: SOLAR SAIL RACE **Prize Concept #7**

Purse Size: $15 total prize pool

Estimated Winning of Prize: 3 - 7 years


Manchu

Prize Task and Competition Description:

A series of first, second prizes totaling $15 million is offered to the teams whose solar sail-propelled vehicles circumnavigate the moon and return to a specified Earth orbit.

Goals of Prize:

- To encourage the development of light sail propulsion systems
- To increase the number of individuals and institutions experimenting with such systems
- To demonstrate the technical feasibility of solar sail propulsion systems
- To reduce the technical risk of employing such systems

Participation Limits:

See *Issues* section below

Participation Expectation:

- University Teams
- Non profit organizations such as Planetary Society, AMSAT, SEDS
- Corporate Teams

See the Issues section regarding factors that would greatly affect participation.

Evaluation and Judging

Active tracking (utilization of an active transponder) will be required along with attendant ground equipment to verify position of the contestants.

Issues:

The key issues here relate to participation. If the competition is international in nature it will attract considerably more sponsorship and therefore more participation (probably

including participation by more US teams than would be the case in a US-Team-only competition.)

The concern that has been raised internally regarding international competitions is the specter of a non-US entry winning a US government sponsored prize. It can be argued that if the value provided by such a contest to US industry and the general public is commensurate with the expenditure that there is no significant issue here. It is also possible to construct a scenario where NASA challenges its international colleagues to each ante up a similar prize with the proviso that if a team from their nation wins, that the prize will be paid by that nation. In that scenario, participating countries might provide launch services to teams from their nations (see below) and might cooperatively contribute tracking, imaging, telemetry and other support for the overall competition.

A generic issue regarding space mission competitions is that the cost of access to space provides an enormous energy barrier to participation. One method of reducing the total risk and cost would be to provide the first ***N*** teams to submit flight-ready hardware (where flight readiness includes objective safety checks) with launch and delivery to the starting position. Providing DSN time or other command and telemetry link services would also reduce the cost and risk of competing. Shifting these costs and risks from the teams word permit them to focus on the still considerable technical issues that relate to the specific propulsion task rather than spending most of their time and energy soliciting funding or in-kind launch services support.

Secondary issues include providing sufficiently interesting means of depicting the real-time status of the vehicles so that the competition is suitably exciting. Ideally some means of providing actual visuals of the vehicles with sails deployed at the start of the race would enhance the sponsorship opportunities and public relations and education value of the endeavor.

Narrative:

The notion of a solar sail regatta dates back at least to 1964 when Arthur C. Clarke's short story *The Sunjammer* (later retitled *The Wind from the Sun* to avoid confusion with a similarly-named science fiction story) was first published. Guy Pignolet of CNES, Klaus Heiss in the United States and others have championed similar solar sail race ideas. At present, at least one commercial organization (Encounter) is planning a solar sail. The Planetary Society's non-profit solar sail attempt failed to be delivered by its launch vehicle and a second project is now underway.

This idea also would lend itself to other contests using low-thrust, high efficiency propulsion systems such as solar thermal propulsion and ion drive systems.

LUNAR LANDER/ROVER

Short Name: LUNAR LANDER/ROVER **Prize Concept #23**

Purse Size: **$20 million**

Estimated Winning of Prize: **3 – 5 years**

Prize Task and Competition Description: Competition for the first team able to land a Robotic Rover on the lunar surface able to transmit back to Earth a 2 Mb video signal and traverse 10 Km.

Goals of Prize:

- To demonstrate the ability to build and fly low-cost lunar rover exploring robots.
- Get back to the moon in the near term
- Encourage innovative design approaches for lunar robots.

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Universities
- Entrepreneurial companies
- Robotic companies

Origin of this prize idea: Headquarters – Discussion with Gary Martin and Steve Isokowitz. Concept is based on the Blastoff concept put forward by idealab! of Pasadena, CA.

Evaluation and Judging: Judging is objective depending on data being returned to a central mission control.

Issues: This competition would yield substantially better results if it were allowed to be international in scope, with U.S., European and Asian teams.

Narrative: It is hard to believe that it has been over 30 years since we last conducted exploration on the surface of the moon. In early 2000 an idealab! company called BlastOff was created to place a robotic explorer on the moon. The effort budgeted at $40M - $50M proceeded past PDR but was closed down for lack of funds during the dot.com financial implosion. The technology to accomplish this mission is publicly available and could result in a new class of low-cost lunar and asteroid explorers. A prize such as this would significantly enable companies to raise the funds (through sponsorships & media sales) that will be required to build and fly the mission.

SOUTH POLAR LUNAR LANDER

Short Name: POLAR LUNAR LANDER Prize Concept # 11

Purse Size: **$20 million**

Estimated Winning of Prize: **3 - 7 years**

Prize Task and Competition Description:

Land and return video and surface composition data near the South Lunar Pole

Goals of Prize:

- To provide information on the features and composition of unexplored portions of the lunar surface

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.
- See *Issues* below

Participation Expectation:

- Universities
- Aerospace Companies (traditional)
- Small aerospace companies created to meet this challenge

Origin of this prize idea: John Mankins, Code M, NASA Headquarters

Evaluation and Judging: Judging is based on data returned to Earth

Issues:
International competition would be likely to enhance the number of participants willing to compete. Alternatively the first N safety-qualified landers within specified mass and volume constraints could be offered Trans Lunar Injection of their craft plus a smaller cash prize.

Narrative: Lunar Prospector and Clementine have returned tantalizing information on the permanently shadowed regions at the moon's poles that suggest the possibility of trapped water and other volatiles. Data about these regions is of significant value to the planning of all future human space exploration. Even if this prize were to be won by a non-US team the information would be of sufficient value to merit such an expenditure.

ASTERIOD SAMPLE RETURN

Short Name: Asteroid Sample Return **Prize Concept # 6**

Purse Size: **$30 million**

Estimated Winning of Prize: 4 – 10 years

Prize Task and Competition Description: To return 10 grams of top surface materials from an Asteroid to Low Earth Orbit reachable by the Space Shuttle.

Goals of Prize:

- To sample an asteroid
- To encourage a new, low-cost approach to asteroid missions

Participation Limits:

- Efforts majority lead by US Citizens and corporations, and privately funded
- Federal Government-Funded teams specifically excluded.

Participation Expectation:

- Aerospace companies

Origin of this prize idea: JPL -- Interview with Dr. Charles Elachi

Evaluation and Judging: Judging is objective.

Issues: No specific Issues; Rules need to be specifically defined. NASA will need to arrange for the sample to be picked up and returned to Earth from LEO.

Narrative: This prize allows NASA to conduct "fixed price science" by paying only on successful delivery of a sample back to Earth.