Centennial Challenges

2004 CENTENNIAL CHALLENGES WORKSHOP REPORT

NASA Centennial Challenges
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DOCUMENT CHANGE HISTORY

REPORT DATE	CHANGE FROM PREVIOUS VERSION
13 July 2004	Original report release.
15 July 2004	Spelling corrections implemented.
16 July 2004	Additional Content in CB4: Earth Observation and RD15: Aircraft Engine sections. Page number changes in Table of Contents and Index of Session Names. Two-page document format added. Addition of Document Change History table.
28 July 2004	Additional attendee names added.
27 August 2004	Additional attendee names added. Formatting changes to RD07: Quantum Computer section.
21 September 2004	Updated attendance number for Solar Sail Race Rules Definition session. Updated photos to reduce report file size.
26 October 2004	Deleted alphabetic remnant section notations (e.g. “A.”, “B.”) as needed.

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EXECUTIVE SUMMARY

The 2004 Centennial Challenges workshop was held on Tuesday and Wednesday, 15 and 16 June 2004 at the Hilton Washington hotel. In attendance were representatives from big and small industry, aerospace and non-aerospace, universities, government, and interested individuals.

Over two hundred attendees and 30 session moderators discussed generated ideas for future Challenges in the areas of Aeronautics, Exploration Systems, Planetary Systems, Earth Observation, Bioastronautics, and Astrophysics. Attendees and moderators also discussed potential rules and other details for over 30 Challenge concepts that were generated by attendees or internally by NASA.

Three guest speakers, including Senator Sam Brownback (Chair of the Commerce Subcommittee on Science, Technology, and Space), Dr. John Marburger (Director of the White House's Office of Space and Technology Policy), and Mr. Elon Musk (Founder and CEO of Space Exploration Technologies Corp.), discussed the importance of prize competitions in fulfilling the Vision for Space Exploration and NASA's ongoing missions. They also provided unique perspectives on the role of government and private industry in space technology development.

Three discussion panels were also conducted to provide workshop attendees with multiple viewpoints of the subject areas pertinent to technology development.

The Launch Vehicle panel featured leaders of the nascent reusable launch vehicle industry, including representatives from SpaceDev (makers of the hybrid rocket engines of Burt Rutan's SpaceShipOne), Kistler Aerospace, Space Exploration Technologies Corp., Rocketplane Ltd., and Vanguard Aerospace.

The Past, Present, and Future of Prize Competitions panel included brief presentations by Erik Lindbergh (Charles Lindbergh's grandson), Dr. Peter Diamandis (Founder of the X PRIZE Foundation and Zero-G Corp.), and Col. Jose Negron (Program Manager for the DARPA Grand Challenge).

The Fund Raising panel featured descriptions of the sponsorship, venture capital, angel, and state subsidy communities.

This report includes a collection of the results of each Challenge Brainstorming and Rules Definition session held at the workshop. These results represent the raw inputs of the session attendees and moderators, unmodified by Centennial Challenges management. Centennial Challenges will use these inputs in the weeks and months following the workshop to determine what Challenges the program will pursue in 2004 and 2005 as well as the structure, rules, and other details of those Challenges.

CHALLENGE BRAINSTORMING SESSIONS

On the morning of the first day of the workshop, attendees participated in six Challenge Brainstorming (CB) sessions to identify ideas and concepts for future Challenges. These session summaries give a list of the ideas for potential challenges that were identified during each session as well as the top ideas that were considered for further discussion during the subsequent Rules Definition sessions.

The topics selected for the CB sessions followed the NASA vision: To Improve Life Here (CB1: Aeronautics and CB4: Earth Observation), To Extend Life to There (CB2: Exploration Systems and CB5: Bioastronautics), and To Find Life Beyond (CB3: Planetary Systems and CB6: Astrophysics).

Moderators of the CB sessions were tasked with collecting challenge ideas for their session topic and then to prioritize the ideas for more detailed consideration in the Rules Definition sessions that had been reserved for workshop-generated challenge ideas. Along with all the challenge ideas generated in the CB session, the top challenge ideas that were identified for more detailed consideration are also given.

CB1: AERONAUTICS

MODERATORS

- Cobleigh, Brent - NASA Dryden Flight Research Center
- Moore, Mark - NASA Langley Research Center

NUMBER OF SESSION ATTENDEES: 20

IDENTIFIED CANDIDATE PRIZES: 20

- New class of craft that flies Concorde type route but going into space. Suborbital NY-London Metric Speed. Half time of Concorde. Have to deal with airfoil infrastructure.
- Low risk of reentry using aero lift. Bleed off at high altitude.
- Point to point transportation speeds.
- Alternative Energy Flight - no emissions, alternate engine, solar cells, fuel cells, manned aircraft
- Advanced Transponder - New transponder system that can attach to plane and network with other aircraft.
- Sonic Boom Reduction - Sonic boom attenuation 50K, no boom on ground.
- Reduce GA Airport Encroachment - GA airports encroachment reduce required approach, take-off and landing steep approach, better performance, can be retrofittable.
- Automated Collision Avoidance System - TCAT, TCAS, has human component, auto system
- Black Box Improvements - including Video and Other
- Light, Green, Low-Cost Propulsion - Exoskeleton Engine composite Engine. Lower weight, cost, noise, including combined cycle.
- Passive system, see through clouds, millimeter wavelength. Semi conductor based sensor for ice detection, fog emissions, and enhanced vision in clouds.
- Architecture for manufacturing airspace system with ground system, for transportation.
- Drastically reduce jet noise using different flow paths.
- Efficiency of aircraft, low tech prizes on fuel efficiency, noise, alternative power, State-of-the-art vs. future, slightly beyond that.
- Efficient Small (Car) Engine -with the performance of car engines.

- Light, efficient anti-ice for PAV and rotorcraft.
- TPS Prize (High Temperature Reusable) - thermal protection, leading edge, no maintenance, robust.
- Cargo Blimp -
- Blimp Load Transfer -
- 100K Flier - A 100k ft altitude, 100kg payload, propeller driven UAV demonstration covering 100 nmi in 100 minutes or less. Competitors can launch or recover however they want.

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 3

- 30-Day UAV- RD TBD slot #14 was allotted to this topic.
- Cargo UAV - RD TBD slot #18 was allotted to this topic.
- Light, Green, Low-Cost Propulsion - RD TBD slot #15 was allotted to this topic.

CB2: EXPLORATION SYSTEMS

MODERATORS

- Mankins, John - NASA Headquarters, Code T
- Woodward, Neil - NASA Johnson Space Center

NUMBER OF SESSION ATTENDEES: 97

IDENTIFIED CANDIDATE PRIZES: 33

- Materials (Nuclear (Shielding, Fuels, etc.), Life Support, Structural (e.g. “factor of 4”))
- Aeroassisted Orbital Plane Change Maneuver (E.g., some “change of plane” test, w/ various benefits (e.g., servicing)
- High-Resolution Mapping of Specific Lunar Sites (Various types (e.g. radar, imaging, etc.), First to show up with data wins…)
- Sensors Development - Based on open standards, Various applications
- High Power/Propulsion - 100s MW to GWs, High Thrust and Isp, Low Mass, Need scoring metrics, like the Longitude Prize.
- Low-Cost Space Suits- might start as “pressure suits for suborbital”, might apply to terrestrial applications
- Continuous-Staging Solid Rocket Booster (concept) - 13,000 lbf payload goal with low cost launch, multiple technical challenges
- Aerocapture Demo - large delta-V in a single atmospheric pass, could be very visible, broad applications
- Asteroid - transponder/lander prize for 1st, X PRIZE to/from/to with robotics, “Nemesis Prize”, Turino scale based, bigger prize for bigger threat, Movers (e.g. Paint it…)
- Moon NOT Our Own - 1st landing
- First Demo of Single Stage to Orbit
- Demo of Reusable 1st Stage - e.g. Capable of staging at Mach 5, Multiple cycles (e.g. >5-10 times), prescribed trajectory, demo staging event
- Mars Blimp Demo (on Earth) - Very high altitude or vacuum chamber, validate in “relevant” conditions including deployment
- Precision Package Delivery to the Moon - e.g. 200kg w/proof' via transponder
- “Ventless” Long Duration Fluids Storage (cryo) - In space and on Earth's Surface, specific “not greater than” boil-off rate
- Data Exploration Prizes - Based on very large data sets waiting to be explored (e.g. by kids…)
- First Person to Climb a High Mountain Wearing a Pressure Suit

- “Grazing Incidence Braking” on Airless Bodies - e.g. the Moon, test with “gun” systems
- Heavy Lift Launch Vehicle - 1,000 kg for $1M, scalable to 100,000 kg
- Mars Atmosphere Based Propellant Rocket Demo
- Long-Distance Traverse Prizes - E.g. w/EVA systems, abrasion-resistant suit materials
- ISRU Prizes - Demo in Relevant environments of ISPP for Mars, flight weight
- The Glenn Reflight Prize
- RTG - 25% current plutonium
- Advanced Nanotech Applications - radiation shielding, structural
- Cost-Effective Production and Storage of Anti-Materials - e.g. Anti-Hydrogen
- Space Weather Forecasting Prizes
- “Pressure Vessel” Prize - lightest at known pressure, at least 50% lighter
- Autonomous Construction Prizes - robotic, drop and it builds
- Space Elevator - supported tether, 5 in T 1 mT p6
- Remote/Autonomous Navigation for Planetary Applications - a la GPS
- UISAAC - vehicles for exploration
- “Cornucopia” Prizes - series leading to “terraforming”?

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 2

- Aerocapture Demo - RD TBD slot #17 was allotted to this topic.
- “Ventless” Long Duration Fluids Storage - RD TBD slot #13 was allotted to this topic.

SUPPORTING CONCEPTS

- Offer the launch as part of the prize, perhaps at a fixed time
- Guarantee data purchase(s) with certain constraints
- Don't limit times to win prizes

CB3: PLANETARY SYSTEMS

MODERATORS

- Garvin, Jim - NASA Headquarters, Code S
- Varsi, Giulio - NASA Headquarters, Code S

NUMBER OF SESSION ATTENDEES: 33

IDENTIFIED CANDIDATE PRIZES: 17

- “Start big” science prize: involve industry, K-12
- Quantum -- new power source
- Planetary Drill Systems - autonomous, low power
- In-situ: water, propellant extraction (e.g. Martian)
- Quantum sensors: e.g gravity gradiometer, gyroscope
- Mars/asteroid Sample Return
- University competition: altitude-launched aircraft
- Alloy for use in space, from lunar materials
- Comparative planetology: e.g. vertical profile
- First new propulsion system, like geostorm

- Space elevator: robotic climbers, tethers, power beaming
- In-situ life detector
- Autonomous airships
- Find life through robot experiment
- First image of extrasolar M planet
- Measurements for Comparative Planetology
- Focus on missions, not technology

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 4

- Planetary Drill Systems - (RD25 was already scheduled to take a closer look at this topic so it didn't get one of the TBD RD session slots).
- In-Situ Life Detector - (RD27 was already scheduled to take a closer look at this topic so it didn't get one of the TBD RD session slots).
- Mars/Asteroid Sample Return - (RD24 was already scheduled to take a closer look at this topic so it didn't get one of the TBD RD session slots).
- Autonomous Earth Analog Sample Return - RD TBD slot #12 was allotted to this topic.

CB4: EARTH OBSERVATION

MODERATORS

- Johnston, Gordon - NASA Headquarters, Code Y
- Cobleigh, Brent - NASA Dryden Flight Research Center

NUMBER OF SESSION ATTENDEES: 21

IDENTIFIED CANDIDATE PRIZES: 28

- Earth System Measurements - with enough resolution, small repeat times, near real time, vertical temp, H2O, pollutants, high spectral, repeat times. Possibly link with innovative orbits.
- Glide-Back Balloon Payload Support Package - precision recovery.
- Small Super-Pressure Balloon - Long Duration. Target progressive demonstrations of payload size/mass, flight duration, and payload return capability. Suggest initial demonstration sized below FAA thresholds.
- Extreme Weather Challenge - detect a tornado 10 miles away using passive sensors only.
- Data Mining Technology.
- Possibly link data and information demonstrations into an integrated demonstration target (from sensor to comm. link to model/information mining to display for user).
- First Images of Earth Core.
- “World Online” - Real-Time images of Earth anywhere, anytime, internet based.
- Aerial Quantum Gravity Gradiometer for High Resolution Sub-Surface Imaging.
- Subsurface imaging systems -- see through sand, ice, etc.
- Autonomous Marine Transects.
- Precision Payload Drop.
- Novel Gas Sensors - Ground Truth - For UAVs (small power, volume, and mass), potential commercial link for factory/power plant emission compliance validation.
- Low Cost Spectrum Sensor, - specify key parameters such as spectrum, resolution, array size/coverage, calibration accuracy, target low cost, possible balloon demonstration.
- Data Compression Prize -- complement commercial market incentives for imaging and voice compression with prizes for compression of spectral data, interferograms, radar data, etc.

- Intelligent on-board analysis -- possibly couple with data compression and/or data mining.
- High rate data (e.g., Laser communications) -- possibly couple with data compression to set prize for integrated data communications solution. Possibly target balloon to balloon or balloon to ground demonstration.
- System to Find Aquifers.
- UAV for Earth Observation, extendable to Mars, other planets with atmospheres?
- Ocean Sensing buoys (akin to UAVs, but for surface & underwater operations).
- Deployable Community Balloon System to Continuously Show Fire Location.
- Sensor for Thin Clouds - they have large impact on Earth cooling.
- Innovative Orbits - pole sitters, eccentric Earth orbits, periodic Earth/Moon interactions, etc.
- “Flying Saucer” -- single platform for observations from air and space.
- LEO Observation - Multi-spectral, rapid analysis, rapid revisit (hours), for disaster analysis.
- Education of User Community of Remote Sensing.
- Track Multiple Atmospheric Devices -- possibly include surface, air, and space devices, akin to airspace transponders, tie to national grid.
- Earth Science Challenge - Pose an important science question.

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 1

- Precision Payload Drop - - (a similar topic, RD01 Precision Lander, was already scheduled to take a closer look at this topic so it didn't get one of the TBD RD session slots).

CB5: BIOASTRONAUTICS

MODERATORS

- Davison, Stephen - NASA Headquarters, Code U
- Diamandis, Peter - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: 30

IDENTIFIED CANDIDATE PRIZES: 32

- $250K - 1 yr - Methods to determine flight safety to mitigate risk
- Planetary protection - Find way (energy efficient) to sterilize system that doesn't harm components -- $$-- TT -- 2
- Life detection -- given volume & time limit, sample 100 boxes of stimulant; 1 m^2, in less than 5 min. $1M; 3 years - 19
- Develop a whole body modeling (all systems) for microgravity effects; $1M; 10 yrs; 8
- Probabilistic multi objective technique; 1 yr; $250K; 1
- Create a Multifunctional material to absorb radiation and noise; 2 yrs; $200K; 10
- Develop a process/product/method to reduce the # of people who have Space Motion Sickness to 1 in 100; $1M; 10 yrs; 5
- Human Radiation shielding - take ISS shielding to double protection and half the weight; 10 yrs; $1M; 11
- Long term space travel- multifunctional treatment modality -- $1M - 5 yrs; 3
- Astronaut Food Drive - Facility to demonstrate continuous food production for one person - 3yrs -- $250K; 1
- Bone Loss- develop and demonstrate a process that reduces BL by X% over existing processes -- $10M - 5 yr; 6
- Prize to Astronaut who make their medical records public - $10K - ongoing; 3
- 95% closed loop system for Water recycling, sustainable - 5yrs - $250K - $1M; 8

- $10M; 10 yrs; first person to spend 1000 days in space (with data made available);
- $1M; 3yrs; micro sat artificial gravity demonstrator; 8
- $250K; 2 yrs; Self cleaning tool for clean sample acquisition of dirty platform;3
- 2 yrs; $250K; for light source to grow hydrop. Plant growth; TBD specified spectrum and energy efficiency; 3
- Closed Loop Greenhouse system that mimics conditions on Mars; $-- Yrs; 5
- 5 yrs; $500K; how deep to find life in the Earth; 1
- $2M; 5 yrs; place a life form on lunar surface for 90 days; 5
- Low cost spacesuit - $250K - $500K; fit any 4 people within 2 months; 2 yrs; 6
- Human-Machine Interface; 2 yrs; $500K; recognize 100% 120 WPM; 1
- Human-Interface; $1M; 5 yrs; Input a document into the “brain” without using sound, sight or touch; 5
- Solve the biochemistry of the Interstellar media; 2 yrs; $250K;
- 1st person to detect non-terrestrial life off the Earth; 10 yrs; $10M; 3
- Medical approach to radiation protection; 5
- 6-people; 6 months; in mars habitat; survive; 5yrs; 2
- Automatic detection of fossilized extinct life on EARTH; $500K; 1 yr; 4
- $5M; 5 yr; 1st person to walk at the bottom of the M. Trench.; 1
- Micro satellite based free-flying for bio-research; 2 yrs; $1M; 4
- Telecom for sensors; transmit info with limited bandwidth; within timelimit. Real-time medical; continuous; 3-5 yrs; 1
- Terrestrial spacesuit race; $250K - $1M; 3yrs; 6

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 2

- Life Detection (RD27 was already scheduled to take a closer look at this topic so it didn't get one of the TBD RD session slots).
- Human Radiation Shielding - RD TBD slot #19 was allotted to this topic.

CB6: ASTROPHYSICS

MODERATORS

- Smith, Eric - NASA Headquarters, Code S
- Varsi, Giulio - NASA Headquarters, Code S

NUMBER OF SESSION ATTENDEES: 25

IDENTIFIED CANDIDATE PRIZES: 15

- Inflatable telescope, real-time shape characterization
- Telescope without mirrors or refraction
- List of questions that need answers outside community
- Robotic servicing demonstration
- Increase communications rates, bandwidth
- For students: rocket to 100 km, w/ 3 ways to verify apogee, min impulse
- Detect ET life
- Bounty for earth-crossing asteroids
- Synchronized suborbital launches
- Methods for deflecting or stopping asteroids (nonrotating and tumbling)
- Sample return, open market
- Calculation of cosmological constant
- Theoretical astrophysics: dark energy, etc.
- Infrastructure to enable South Pole astrophysics
- Low cost space-based optical interferometry

TOP PRIZE IDEAS SELECTED FOR FURTHER DISCUSSION: 1

- Inflatable telescope (later renamed to Deployable Telescope) - RD TBD slot #16 was allotted to this topic.

ANONYMOUS CHALLENGE IDEA SUBMISSIONS

The following 31 prize ideas were submitted during the workshop but outside the structure of the six CB sessions.

• Beamed Power Drag Race/Tractor Pull	• Personal Jetpack
• Cryogenic Propellant Source in LEO/Orbit	• Plug and Play Networking for Space
• Everest (EVA Suit) Summit Climb	• Pressure Suit Durability
• Exo-Skeletal Planetary Surface Structures	• Rapid Design/Develop/Demo
• Innovative Earth-Moon Architectures	• Reusable Second Stage Liquid Rocket
• Interactive Toy	• Suborbital Payloads
• Micro-Reentry	• The Prize Prize
• On-Orbit Cryogen Storage	• Ventless Storage Systems
• 30 Day UAV	• Extreme Environment Computers
• Reusable First Stage Liquid Rocket	• Cosmic Positioning System
• Power and Propulsion Breakthrough	• Multi-Factor Probabilistic Model
• Robotic Triathlon	• L4 Spacecraft
• Spaceport Financing Innovation	• Ram Jet Improvements
• Cryogenic Propellant Transfer in Space	• Radiation Protection
• Double Radiation Protection in Space	• High School Science Fair
• Lunar Lithobraking	

RULES DEFINITION SESSIONS

Rules Definition (RD) sessions were scheduled during the workshop to define in more detail the characteristics of the challenge ideas that were generated during the Challenge Brainstorming (CB) sessions.

The topics selected for the Rules Definition (RD) sessions were mixed between challenge ideas that were internally generated by NASA and ideas that were generated by workshop attendees in the CB sessions. Special RD sessions with no prespecified subject were placed in the schedule specifically for these latter challenge ideas.

Moderators of the RD sessions were asked to facilitate discussion of the group in attendance and generate details about the challenge rules, definitions, judging methodology, purse amount, time limit, intellectual property rights, the challenge name, and other considerations. The RD session summaries for each challenge topic give the results of the session in a standard format. Where attendees and moderators did not have time to address a particular topic in their session, it is omitted from the report.

RD01: PRECISION LANDER

MODERATORS

- Cobleigh, Brent - NASA Dryden Flight Research Center
- Hamill, Doris - NASA Langley Research Center

NUMBER OF SESSION ATTENDEES: 22

RULES

- Competitors have known information
- 25-cm resolution image of target landing area and surrounding
- Entry position +/- some error
- Target position relative to the entry position
- Wind maximums (representative of Mars, Titan, ….TBD)
- Competitors must prevent excessive landing shock to payload
- Suggested that they carry an egg. Perhaps there is something better (but still simple) for this task.
- Volume, mass, and power limits are defined based on a reasonable interplanetary mission (TBD)
- Use of GPS not allowed
- Competitors must meet safety requirements defined by event host (TBD)
- May not allow pyros such as rockets or explosive bolts
- Some discussion on having unknown obstacles to avoid but most people thought this was complicating the task.

JUDGING METHODOLOGY

- 1-day Contest
- Competitors dropped from helicopter (8000 ft altitude, TBD) at “entry position” with some error that is within the specified tolerance. All competitors are dropped from this “dispersed” position. Team that is closest to target point and stays below the max shock requirement and is within a minimum success criterion (e.g. 100m, TBD).

PURSE AMOUNT

- $250k

TIME LIMITS

- One time event. Conducted just prior to school year start (last week in July, first week in August). Recommend giving 1 to 1.5 years total time before event.

OTHER CONSIDERATIONS & OPTIONS

- A good challenge to attract university participation. In order to win, the competitors will most likely need to use the image of the landing site to find and track itself to a landing. This technology may have uses in other exploration applications.

RD02: Astronaut Glove

MODERATORS

- Woodward, Neil - NASA Johnson Space Center

NUMBER OF SESSION ATTENDEES: 19

RULES

- Vacuum Box
  - Fatigue testing- Vacuum box
  - Standardized NASA vacuum box
  - Competition vacuum box will be provided
  - Discussed using existing NASA / USAF assets. Maybe Space Act agreements would give competitors access to NASA vacuum boxes and other hardware such as “busy boxes”.
- Pressure Differential
  - 4.3. psi differential between external and internal environment
  - Problem should definitely involve the pressure differential. Discussed the feasibility of providing plans to all for a vacuum box, which may be practical (~$300 cost, estimated by participants). Some worry about some (amateur) participant injuring selves through faulty vacuum boxes.
  - Some discussion about the exact pressure differential. Currently we use 4.3 psi (verify?), but some competitors suggested higher. My cut: need to talk to advanced suit guys to see if future designs will have higher differentials which may require a more stringent challenge.
- Tasked based challenge
- Preliminary tests: Tear resistance, weight,
- Provide participants with standardized task kits- sent from center to participant
- Design gloves for tasks unknown to participants in order to test the gloves ability and not the hand within the glove
- Assume the task will be defined by “the glove”
- Allow for variations on the formal definition of glove- can be flexible
- Best score wins- ability to complete the task in the fastest, yet must meet requirements of the glove system- tear, leak, mobility, psi testing, fatigue

DEFINITIONS

- Need to come up with a glove or system that is tear resistant, vacuum resistant, that improves fatigue, mobility of current glove
- Head to head competition- not who come up with the glove first
- Somebody asked if we had to use a “glove” - were we open to using more unusual configurations, such as robotics? I said I don't care, as long as the solution did not interfere with the use of the hands for translation, etc., but this needs further refinement. To me, flexibility (and radical ideas) is good.

JUDGING METHODOLOGY

- Much discussion about whether it is necessary to have the same astronaut or judge test the glove to be more "fair" or whether each contestant would wield their own gloves in the task. Consensus was that we should have the contestant compete with his own glove. Reasons were that there may be training issues, and there would be no time to train an astronaut or neutral party the peculiarities of each glove. As to whether it was "fair" for one team to have a more natural EVA player wielding the glove, the group felt that "fairness", in this context, was overrated. Let the best design, used by somebody comfortable with that design, win.
- Some discussion of using something like the Cooper-Harper scale, but to met this is problematic because this means that the evaluator of the glove must be unrelated to the contestant. This would preclude the use of technologies that would require user training (such as powered exoskeletons, etc.) for reasons discussed above.
- Score based on different psi ratings
- Rated against current glove- time dimensions, certain tasks,
- Standardized testing for all possible participants- screw and nut found at home depot
- Judging will be done at approved location with vacuum specifications
- Transparently fair- can't level playing field completely
- Generally, the competitors seemed to like "task based" vice "requirements based" judging, although this was by no means unanimous. My suggestion that tear resistance and insulation should be "qualifying" characteristics (all gloves had to demonstrate a threshold level of tear resistance, etc.) seemed to be accepted, although this would make the competition more difficult. Also, need to define the "tear resistance" and "insulation", etc., in ways such that anybody could verify compliance in their garage.
- As opposed to "head to head" competitions, participants seemed to like a "first past the post" competition - something like "first team that can demonstrate [your task here] in less than [x] seconds" wins.
- Judging will be done at approved location (NASA center with vacuum box) with vacuum specifications, etc., verified.
- The task may involve some sort of "busy box". If so, contestants may have to be able to "check one out" from a NASA center, or at least be told how to construct one. However, some tasks, such as screwing successively smaller nuts onto bolts, have the advantage of simplicity.
- Competition should be transparent but not necessarily "fair"- can't level playing field completely.
- Be careful that our rules don't result in a winning "single point" design.

PURSE AMOUNT

- Allow winners and/or participants to take part in NASA's technology located at NASA centers in order to create appeal and personal/ group pride
- Use the phrase "developed by NASA"
- 250k
- $250 may not be enough, certainly not by "rational" standards. This Challenge has the disadvantage that there is no obvious commercial market, so the prize money itself (and the possibility of a NASA contract) is the only incentive. Although many were interested in the technology, it wouldn't be as "sexy" as task as some of, say, the moon landing tasks, so there will be less incentive there also. Due to added risk, a "head to head" competition would require a larger purse.
- Allow winners and/or participants to take part in NASA's technology located at NASA centers in order to create appeal and personal/ group pride. Kind of like a "semi-final" round, although this has less applicability to a "first past the line" type competition.

INTELLECTUAL PROPERTY RIGHTS

- No special concerns for this contest.

OTHER CONSIDERATIONS & OPTIONS

- Advanced suit- contingent on changing space suit
- How difficult is it to build a vacuum box? How safe is it?
- Need to define level of maturity-?
- Need to define what the competition will test- glove ability, adaptability, fatigue, ability to perform tasks (vacuum box), all of the above? Do we split these out into individual contests? Do we go with one big omnibus contest?
- Increase purse size if the competition will be head to head
- Some participants wanted to "break up" the Challenge into individual parts - just tactile feel first, say, or zero volume change with movement, etc. Some discussion of making this too hard for a guy in a garage, but not enough $ to interest a company. The closer that you are to doing this for a living, the more $$is required, especially with the minimal commercial markets. Although, it looks like there is a definite lack of good pressure suits out there so there may be a nascent commercial market. But can we demonstrate this such that people would actually participate?
- How do we account for the insulation and puncture resistant cover? Does NASA supply the material, or do we specify what they should be made of, or what? Maybe NASA can give the specs, then slip the cover over the glove just before the competition…
- Could NASA provide participants with current gloves, as a means to "jump start" the competition? It would reduce the material costs for the competitors greatly, but I don't know how many extra gloves we have floating around.

RD03: MOBILE POWER BREAKTHROUGH

MODERATORS

- Lyons, Valerie - NASA Glenn Research Center

NUMBER OF SESSION ATTENDEES: 17

RULES

- Create a device which can store energy in a way that it can be easily converted to useful power for a defined application (could be Mars rover, remote instrumentation station, etc.)
- Requirements: temperature ranges (specify for Mars, Moon, orbit, etc.); desired amps and volts; g loads; output required; desired number of cycles - charge/discharge; scalability; reliability; weight/volume; trade offs= power density, reliability, temperature, cycles, etc.
- Bonus - terrestrial/commercial value - dual use for space and earth-bound markets.

DEFINITION

- The device can be a power generation and storage device combined - e.g. Fuel cells. Or, it can be purely a storage system - e.g. Batteries.

JUDGING METHODOLOGY

- Candidates must provide data resulting from a demo at normal "earth conditions" in a candidate application - e.g. Laptop, phone, electric car, etc.
- Pre-screen candidates based on panel's examination of the concept's ability to withstand space-qualification tests and minimum goals (these goals can be higher as the years pass) regarding their energy storage capabilities- these candidates will then pass to the next round of competition.
- Pick a date, place (maybe every 2 years) for all the candidates to show their capabilities - could pick an application they all need to power- e.g. Some "showy" electric

vehicle or robot; Could run them through a "torture" test in a public contest where they must survive a launch environment, then run for a period of time, exposed to harsh temperatures and g-loads.
- Winner gets a "free" vacuum facility test and moves to final round.
- Ultimate prize winner must survive vacuum/temperature/vibe tests and life tests - meeting all the goals listed in the "requirements".

PURSE AMOUNT

- Graduated prizes: First round winners (chosen every 2 years) win a "free" series of tests in a relevant space environment, provided by the government - rough estimated value of $250-$500K. The best candidate that survives this space environmental testing and provides the best energy storage device for this second round (could be chosen every 4-6 years from the first round winners), gets $1M.

TIME LIMITS

- These first and second rounds could be continued until the Challenge is declared over- could go on indefinitely as more novel energy storage devices are discovered.

INTELLECTUAL PROPERTY RIGHTS

- Remains with the inventor/company but NASA can have use of the device for its missions.

OTHER CONSIDERATIONS & OPTIONS

- The device must pass a safety test before being allowed in the government facilities for space environmental testing.

NAME

- "Thunderbolt Prize"

RD04: MICRO REENTRY VEHICLE

MODERATORS

- Kreykenbohm, Barbara - NASA Headquarters, Code U
- Rasky, Dan - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 27

RULES

- Two prize categories recommended:
- Suborbital Demonstration:
  - Contestants develop return capsule and provide the launch to a minimum altitude (100 km) carrying a mock or test payload with characteristics defined by the judges (volume, mass, temperature, etc.)
  - Throughout the test the payload must be maintained under certain conditions (temperature, pressure, g-load, etc.) set by judges.
  - Payload must be returned in usable condition. Contestants can provide data proving that the required conditions were maintained or the judges can examine the payload to determine if it is usable.
- Two possible ways to determine winner of Suborbital Demonstration:
  - Contestant who comes closest to a set recovery point (at a set minimum distance from the launch site), with usable payload intact, wins. All contestants launch at the same place and time.

  - First person to demonstrate that a payload has been launched and returned in usable condition wins. Each contestant launches when ready from a site of his choice with at least one judge present.
- Orbital Demonstration:
  - NASA arranges for appropriate piggy back launch opportunity
  - Contestants provide their own separation, deorbit & re-entry system with an official payload as above.
  - Contestant who recovers and returns the official payload, in usable condition, to the contest judges in the shortest period of time from entry interface (100 km) wins.

DEFINITIONS

- Two categories: 1) Suborbital, 2) Orbital
- The intent is to demonstrate an alternate method for returning valuable samples from the International Space Station. Some temperature control of the samples will probably be required.

JUDGING METHODOLOGY

- See rules
- Panel of judges affirms viability of the payload, certifies that launch parameters and other conditions were met, and declares winner.

PURSE AMOUNT

- For suborbital - $250k (Contestant provides launch)
- For orbital - $250k (NASA provides launch)

TIME LIMITS

- 1 to 3 years for both categories

INTELLECTUAL PROPERTY RIGHTS

- Remain with contestants.

NAME

- Special Delivery Challenge

RD05: Robot Triathlon

MODERATORS

- Jacoff, Adam - NIST
- Volpe, Rich - NASA Jet Propulsion Laboratory

NUMBER OF SESSION ATTENDEES: 29

TASK

- Proposed three elements of triathlon: manipulation, mobility, and intelligence (perhaps related to onboard science data processing or other AI problem such as onboard planning).
- To involve all of the elements above, a possible task definition might be: have several tasks that require manipulation but are distributed over the surface. Mobility is required to reach the sites, and intelligence is required to optimally do the tasks in a best order.

RULES

- At least fixed mass, power, and volume.
- Possible fixed hardware system given to all contestants.
- Actual triathlon: traverse, operation, get back?

- Carry weight, traverse slopes?
- Size limits? Yes/no
- Weight limits? Yes/no
- Power limits? Yes/no/penalty
- Sub leagues? Open/kit/stock/legged/power source
- A priori knowledge: Fully auto/delayed teleoperated
- Communication w/ vehicle: Limited bandwidth, Mars time delay?

DEFINITIONS

- Relevant environment: Shake out vs. Game Day
- Stamina (distance, obstacles, slope): 1 K, 10 K a day?
- Perception: Navigation and Task oriented
- End Task: Manipulate tools/carry payload

JUDGING METHODOLOGY

- Multiple categories possible:
  - Shortest time for fixed result.
  - Best result for event not bounded by time (perhaps bounded by power).
  - Best results for fixed system with programming only.
  - Best results for system bounded by mass, power, and volume only.
- How often?
- Performance metric: Distance / overall weight
- Pass / fail: One time only?
- Performance metric: Power, time, weight, energy

PURSE AMOUNT

- $250K allows prize to start FY 04, or
- Much bigger prize amount, more revolutionary goal

OTHER CONSIDERATIONS & OPTIONS

- Safety of people, vehicles, property
- Data collection
- Instrumented, Unobtrusive test site

RD06: LUNAR PROCESSING DEMO

MODERATORS

- Lueck, Dale - NASA Kennedy Space Center
- Maryniak, Gregg - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: 20

RULES

- Standardization of processes.
- Use of lunar-like materials in order to perform tests.
- Multiple winners, prizes for second and third place.
- Cost and weight associated with energy generation to be included.

DEFINITIONS

- Two stage competition- 1) digging 2) oxygen and other element production from lunar materials.
- Possible Demonstrations:
  - Sand packing: ability to pack certain amount of sand in a set time frame.
  - Physical transformation of materials- brick making.

  - Build a physical barrier such as a wall or building.
  - Simply create a pile of materials that can be extracted.
- Figures of Merit:
  - Energy per mole of material.
  - Oxygen per metric ton.

JUDGING METHODOLOGY

- Point system includes design with built in power generation.
- Moving parts a negative due to lunar dust.
- Ability to maintain longevity of life through expelling external dust and keeping. machine parts clean- part of efficiency.
- Processing time of lunar material.
- Ability to produce useful elements out of lunar material.
- Ability to produce multiple usable elements and by-products of processing.
- Point system based on using less energy, points awarded criteria-developmental points. that are time sensitive.
- Survival through a lunar day and temperature cycle.

PURSE AMOUNT

- Phase prizes- annual prizes for development.
- Bottlenecking prizes.
- 10k prize.
- Keep lunar sample or operate machine on lunar surface.

OTHER CONSIDERATIONS & OPTIONS

- Competition should encompass vision statement- must advance Mars cause along with lunar.
- Two part competition- moveable platform, smaller project- connect into platform to perform digging.
- Not include power generation hardware, only the weight penalty associated with power generation.
- What is the non-NASA use that can be extrapolated from this competition?

RD07: QUANTUM COMPUTER

MODERATORS

- Williams, Colin, NASA Jet Propulsion Laboratory
- TR Govindan, NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 11

RULES

- Example computational problems …
  - Simulating effect of Space environment on human body
  - Combustion chemistry - large scale chemical simulations; fluid mechanics plus chemistry
  - Quantum chemistry
  - Nanotechnology
  - Cell simulation (metabolic enzymes)
  - Signal, data and image compression
  - Astrophysical applications - N body problem simulating galaxy formation. Hydro-dynamics of stars
  - Numerical weather prediction
  - Climate

  - Plant physiology simulation
  - Vision, pattern matching, face recognition
  - Planning and scheduling
- We consider 6 challenges at various levels of difficulty / purse:
  - Speed Challenge I: Invent a quantum algorithm to compute some NASA relevant computation (examples above), prove it is correct, and that its performance is at least a constant factor faster ($250K).
  - Speed Challenge II: Faster by a polynomial factor ($500 K).
  - Speed Challenge III: Exponentially faster ($1M).
  - Hardware Design Challenge I: Designing a scalable architecture for a universal quantum computer: $1M (physical qubits).
  - Hardware Design Challenge II: Designing a scalable architecture for a universal quantum computer $3M (logical qubits including quantum error correction).
  - Real Time Challenge: Build a quantum computer that can solve a complex problem (e., protein reaction, waterway network model, medical or fault diagnosis, planning or scheduling), in REAL time (i.e., here is on focus of run time of machine not complexity scaling of the algorithm). $10M.
- Consider a later prize for operating a quantum computer in the Space environment Radiation, temperature and physical stresses environment).

DEFINITIONS

- By real time we mean have computation within the critical time scales of the mission.

JUDGING METHODOLOGY

- Algorithm Challenge: compare quantum algorithm against best known results in computer science on same problem. Compare against known benchmarks.
- Hardware Challenge: Judging criteria for hardware: reproducibility of outs, correctness, reliability
- Hardware Challenge: Test hardware against benchmarks. Onus is a challenge to prove performance. Judge defines benchmark ahead of time. Show-me attitude!

PURSE AMOUNT

- Algorithm Challenge (progressive awards for increasing complexity): first prize in range $250K, $500K, $1M (for constant factor speedup, polynomial factor speedup, and exponential factor speedup respectively).
- Hardware Challenge: $10M

TIME LIMITS

- Algorithm Challenge: rely on competition to stimulate effort
- Hardware Challenge: rely on competition to stimulate effort.
- Suggest open category for time limit.

INTELLECTUAL PROPERTY RIGHTS

- Algorithm/Hardware Challenge: government/NASA? gets royalty free use but inventors retain rights. NASA is not buying anything we are trying to stimulate research. Group wants to leave IP with inventor to stimulate commercial adoption.

OTHER CONSIDERATIONS & OPTIONS

- Speed of light communication delays do not factor into the estimation of computation time. Dissenting opinion - Hendricks says speed of light delays should factor in.
- Payoff to NASA: buzz about science, inspiring science.
- Payoff to Nation: DoD applications and other agencies (e.g., NIH - cellular simulation applications).
- Recommend allowance of international collaboration. What NASA wants is the computer.

- Recommend similar prizes for quantum sensors such as quantum gravity gradiometers, gyroscopes, and gravity wave detectors. Quantum dot solar cells.

NAME

- The QUANTUM Prize. The qPRIZE. The QutE Prize.

RD08: LUNAR LANDING

MODERATORS

- Lembeck, Mike - NASA Headquarters, Code T

NUMBER OF SESSION ATTENDEES: NO ATTENDANCE DATA COLLECTED

RULES

- Precision landing to defined target zone (old Apollo sites, Saturn upper stage impacts science targets of interest)
- A race would bring a lot of international interest (might have to spec payload for race)
- Race 2010 NASA lander to the moon.
- Should definitely investigate incorporating some sort of "precision landing" capability, such as at a "Historical" Apollo site (either a landing site, or perhaps where a Saturn upper stage impacted the moon (I was unaware that this happened?).
- Also, some suggested a "race", with multiple simultaneous launches from multiple competitors towards a goal and the first to accomplish it wins.
- This would have a natural interface with some of the student prizes - maybe make the student competition one to design the payload for this vehicle, and then the winner gets flown as part of this competition.
- Some discussion of "Buy American". Precluding international (esp. Russian) launches would require additional $ to make the contest attractive.

DEFINITIONS

- What constitutes a lander? Are penetrators allowed? Rovers? Hoppers?
- Some participants discussed breaking this Challenge up into stages - e.g., first "stage" is to present NASA with data about a proposed landing site, second is to put a lander there, third to put a rover there. ML said that NASA wants to spread its prize money around, and is unlikely to dedicate much money to a "series" of related prizes, although in some circumstances it may make sense.
- Likewise, a participant suggested a "lunar landing on earth" where the Challenge was to successfully design a "simulated" lunar landing using some sort of hovering technology (made me think of the old Lunar Lander trainers at Langley and up at Ellington).
- Maybe we could involve "hopping", or demonstrating that this lander could transit across the lunar surface to be used as a transportation system or some such.

JUDGING METHODOLOGY

- Return a picture as proof of landing. Other science data
- TV / Video / PR in general should be a major concern. Perhaps the "task" should involve sending back a picture, or a video / data stream. This would have the advantage of perhaps becoming a viable cash flow source post-Challenge.
- Sponsorship will be a big player in this Challenge due to the "sexy" nature. "If there are no pictures, it didn't happen".

PURSE AMOUNT

- $10M for first landing
- OR $/capability, $/lb landed, $/MB data returned

- Some discussion about having a part of the purse be a guaranteed selection for a NASA follow-on contract. Interesting idea, but one that is a philosophical one across all Challenges.
- $10M +, without NASA-furnished launch. More if the scope is made more broad, or if they are required to use a US launcher.
- Maybe a way to work pictures or video into the prize would be to have a “menu” of prize money: a certain amount for the lander, an additional amount for a video camera, more for a still camera, still more for a rover, etc. A team would have to balance achievability with ambition.
- This Challenge involves some possibly lucrative post-Challenge markets, so participation would be less sensitive to amount of money offered.

TIME LIMITS

- 5 years
- 3-5 years, maybe more, depending on scope.
- An interesting idea: the goal is to “Beat NASA” to the moon - the prize would be awarded if the Challenge lander can take a picture / video of the NASA lander as it is landing. This could be motivating to both the competitors, and the NASA workforce, if the competition were kept friendly. There were some that felt that if some of the larger aerospace companies stood to lose money if the competitors “beat NASA”, they would be tempted to prevent this from happening by using extra-competitive means.

INTELLECTUAL PROPERTY RIGHTS

- NASA could enter into sole source contract with winner for future package deliveries to moon base
- None specific to this Challenge. SBIR standards?

OTHER CONSIDERATIONS & OPTIONS

- International participation could expand excitement factor and improve chances for selling world-wide media rights for funding program
- Educational opportunities?
- Restrict foreign content if limited to US teams, precludes use of cheap Russian hardware
- If no cheap launchers available, NASA might have to provide, allow Russian launchers, or up prize money. Some good discussion of the timing of this Challenge. There is an obvious commercial follow-on in NASA's requirements for Constellation - for example, the winner here could compete for the opportunity to fulfill (or fulfill outright) the lunar landing requirements. However, this means that the Challenge would have to be completed early enough that the winner could then compete for the Constellation contract. If we already were building the lander, the participants considered it likely that they would be frozen out of these follow-on opportunities. Excellent point.
- Some discussion of a “Private Global Space Race” where each existing space agency - NASA, ESA, JAXA, RSA (what's the new acronym?) - offers an individual prize to their own nationals for accomplishing this goal. Kind of a globalization of the Challenges.

RD09: TELEROBOTIC RACE

MODERATORS

- Ambrose, Robert - NASA Johnson Space Center
- Woodward, Neil - NASA Johnson Space Center

NUMBER OF SESSION ATTENDEES: 20

OBJECTIVE

- Construction field either terrestrial or in space/planetary surface
- Assemble inflatable structure
- Assemble, maintain telescope
- Assemble, disassemble, reconfigure components
- Build radiation shield/wall
- Build pressure vessel
- Bulldoze a site
- Dig trench
- Melt water, refreeze into igloo
- Place/connect cables or piping
- Build 2x4 wall and tilt up
- Cover structure with regolith
- Combine: trench, build hab, cover
- Laying out thermal/solar shielding
- Sliding instrument module into rack
- Inspecting a structure for damage
- Collecting distributed modules

RULES

- Trades:
  - Set up site for all contestants vs. multiple sites
  - Use in-situ resources vs. prepared items
  - Provide kits vs. specify design of kits
  - Pick one task for all years vs. evolving tasks
  - Specify time delay / bandwidth for teleoperators
  - No humans as on-site construction team members
  - Number of humans at remote site?
  - Nature of environment: temperature, light, dust

DEFINITIONS

- Defining success: use standardized kits

JUDGING METHODOLOGY

- Judges have already built item
- Customizing the kit
- How to win:
  - First to accomplish?
  - Weight and volume vs. creativity of open field
- Starting state of contest?

PURSE AMOUNT

- $250K vs. millions

OTHER CONSIDERATIONS & OPTIONS

- IP Rights: NASA would take non-exclusive first use

RD10: GENERAL AVIATION

MODERATORS

- Cobleigh, Brent - NASA Dryden Flight Research Center
- Moore, Mark - NASA Langley Research Center

NUMBER OF SESSION ATTENDEES: 15

RULES

- Initial Prize Concept: NASA/EAA Door to Door Travel Challenge
- Objective: Encourage creative solutions to satisfying the need for faster door to door travel vehicle options, while developing individual technology breakthroughs in the quality of travel that demonstrates future General Aviation as a viable personal travel choice.
- Prize Challenge: A single day event rally/race that approximates the challenge of achieving fast door to door travel. The rally/race circuit would include 3 airfields at Oshkosh; the main runway, the ultralight field, and the helicopter field. The challenge would be for contestants to pickup 3 flags, with 1 flag located at each airfield and the requirement of flying out to a 25 mile marker and back (150 mile total travel distance). Since 1 flag is at each airfield, the challenge is to balance the vehicle speed versus the takeoff/landing field performance to achieve a vehicle that can achieve the best door to door block speed. This allows the opportunity for advocates of higher speed GA to compete with ultralights, to helicopters, even to the fringe of roadable aircraft (since there is a ground leg required to reach flags if the vehicle is not VTOL capable). While this challenge could be performed in many different ways, the intent is to reward vehicle designs that achieve the best overall door to door equivalent travel time. While the grand prize would go to the fastest competitor, additional technology prizes would be awarded to the contestants who achieved the best 'quality' of travel. This quality of travel would be measured by a yearly rotating technology category which repeats after 5 years.
- 1st Year: Noise - Community noise and cabin noise
- 2nd Year: Comfort - Ride quality and cabin volume
- 3rd Year: Environmental - Fuel efficiency and exhaust emissions
- 4th Year: Safety - Engine out glide distance w/o adverse yaw, crosswind landing capability 5th Year: Vehicle cost (only open to existing production kits and certified aircraft)

JUDGING METHODOLOGY

- Our current thinking is that a panel would be put together to for a prize committee; including such potential member representation from EAA, NASA, CAFE, PADA, and the FAA.

PURSE AMOUNT

- Prize Amounts: NASA prizes are limited to an authority of $250,000 this year, but approval is being pursued for greater prizes in subsequent years. Initially it is thought that a $100,000 Grand prize for the fastest time, and $50,000 prizes for the 2 technology prizes (in the first year this would be a community noise category and a cabin noise category) with $25,000 2nd place prizes in each category - for a total of $250,000 in prizes. However, to win the technology prizes, the contestants would still need to place in the top 10 for the door to door speed (thus providing the incentive to reach higher speeds while improving the quality of travel). Perhaps a Grand Champion prize could be added later that provides a $1 million prize for the contestant who can win all technology prizes with the same vehicle across many years.

NAME

- Possibly: General Aviation Innovation (GAIN) Prize

RD11: 3-DIMENSIONAL DETECTOR

MODERATORS

- Hill, Bob - Science Systems and Applications Inc.

NUMBER OF SESSION ATTENDEES: 10

RULES

- Prize for multifunctional /multilayer material; range of frequencies and resolution defined by the individual layers; need to define sensitivity as a function of resolution; prototype would be ~20x20 pixels
- Sensor could be scanned or could store incident energy
- Ultimate sensitivity goal should be to detect individual photons; for current competition, need to be able to detect source of? intensity at S/N of 10.
- Resolution goals can be graded; layers could start with 10 and then increasing to 1000s
- Inventor should mate detector with optical system to demonstrate capability of detecting point sources.

JUDGING METHODOLOGY

- Prototype demonstration

PURSE AMOUNT

- $1M for 20x20 array with 10 layers (9 layers of sensors), spatial resolution elements ~1mm (IR)
- Another prize for visible with spatial resolution ~100um.
- Note that other prizes should be available for different wavelength ranges (requirements TBD)

TIME LIMITS

- 3 years

INTELLECTUAL PROPERTY RIGHTS

- NASA should have access to prototypes (data and testing); inventor retains IP rights.

OTHER CONSIDERATIONS & OPTIONS

- Mixed opinions regarding international participation

RD12: AUTONOMOUS EARTH ANALOG SAMPLE RETURN

MODERATORS

- Varsi, Giulio - NASA Headquarters, Code S

NUMBER OF SESSION ATTENDEES: 23

RULES

- Demonstrate on Earth key features of a sample return
- Autonomous technology (for collection only)
- What is sample: extant or extinct life
- Pick one or some:
  - Sample acquisition
  - Avoiding contamination, temp/press control
  - Control of sample / back contamination (quarantine)

  - Launch of sample, landing from space
  - Security of sample
- Sample locations: Vostok, Mid-ocean Ridge, Yellowstone, Atacama Desert, Columbia Plateau, sedimentary basins, 6 miles down, Death Valley
- How much pre-contest mapping is allowed?

DEFINITIONS

- Proposal:
  - Pick surface site of biological interest
  - Surveying provided by NASA two days before
- All contestant vehicles placed at same starting place
- Collect specified extremophile sample autonomously
  - Transport sample, preserve sample
  - NASA verification of sample

JUDGING METHODOLOGY

- Minimum mass of the contestants who succeed?

PURSE AMOUNT

- $1 million, or $500k

TIME LIMITS

- Three days contest
- Three years until competition

OTHER CONSIDERATIONS & OPTIONS

- Future prizes would have more stringent requirements
- Zero forward contamination

RD13: LONG-DURATION CRYOGENIC PROPELLANT STORAGE TANK

MODERATORS

- Notardonato, William - NASA Kennedy Space Center

NUMBER OF SESSION ATTENDEES: 19

RULES

- To create a low mass, high efficiency liquid Hydrogen Storage system

DEFINITIONS

- Determine the amount to be stored.
- Length of time to store hydrogen
- Retrieval of hydrogen -% of loss from starting weight
- Any Power supply necessary to operate system must factor into total mass.

JUDGING METHODOLOGY

- X kg of hydrogen available after X weeks (Months) with availability at x Kg/s with total system including hydrogen mass under X kg demonstrated X times.
- Losses include chilldown mass
- Loss criteria (55?) - Any boil off loss must factor in the mass required to produce and liquefy hydrogen.
- System mass cost for input (xkg system/kg hydrogen? In a relevant environment

- Vacuum thermal solar irradiance. NASA hazard assessment. FMEA, Safert (?) Screening.

PURSE AMOUNT

- First prize - 250K
- Second Prize - 50K

TIME LIMITS

- 2 years

INTELLECTUAL PROPERTY RIGHTS

- Belong to developer with NASA rights to use. May want to refer to DARPA rules.

NAME

- Last to Burst - Liquid Hydrogen Tank.

RD14: Perpetual (30-Day) UAV

MODERATORS

- Cobleigh, Brent - NASA Dryden Flight Research Center
- Dittmar, Mary Lynne - Dittmar Associates

NUMBER OF SESSION ATTENDEES: 16

RULES

- Must remain in-flight for 30 days.
- Must include many days of station keeping for station observation purposes.
- No tethering.
- Any altitude- must discuss further. Dependant upon regulations.
- Minimum payload- 50 kilos.
- Must deploy and recover payload in a safe manner.
- The method of getting vehicle up and returning safely not restricted.
- Must stay within a cylindrical area defined by a radius of 10km- contingent on altitude height and requirements.
- Allowed to refuel in-flight.
- Autonomous or ground controlled is acceptable.

DEFINITIONS

- GOALS: application is in earth science and national security-surveillance systems

JUDGING METHODOLOGY

- 1st to demonstrate

PURSE AMOUNT

- $1 million

TIME LIMITS

- No time limits

INTELLECTUAL PROPERTY RIGHTS

- Not discussed.
- Off-the-record suggestion that NASA work IP issues with commercial entities and develop a policy for Centennial Challenges as part of larger IP policy.

OTHER CONSIDERATIONS & OPTIONS

- NASA provide a range for testing? NASA host Cost?
- Some people thought having to find your own test site would limit the number of entries (too hard for the little guy)
- Others thought that people could find a place to do it and that they would want to be near there home site, especially if you have to keep the aircraft up for a month.
- Altitude is a serious question
- Should it be higher altitude?
- Staying within specified area is another big problem.

RD15: AIRCRAFT ENGINE

MODERATORS

- Blankson, Isaiah - NASA Glenn Research Center

NUMBER OF SESSION ATTENDEES: 15

RULES

- Double the range on an existing certified airframe
- Decrease noise by 20 dB
- Substantial weight reduction?
- Decrease emissions

JUDGING METHODOLOGY

- Must double the range

RULES

- The engine would be integrated into an existing certified airframe so that it is aerodynamically balanced, and safe to fly.
- The certified airframe may be a personal aircraft.
- No airspace restrictions.
- Engine size, power limits, not restricted.
- Engine must be reusable at least 4 times.
- Minimum payload is pilot.

JUDGING METHODOLOGY

- 1 - time event at competitors disposal. First to demonstrate wins.
- Contestant vehicles must fly the same distance irrespective of starting point.
- Distance flown is TBD, could be across continental US and back.

PURSE AMOUNT

- $1.0M strictly for engine.
- Contestant must provide own airframe.

OTHER CONSIDERATIONS & OPTIONS

The audience felt that the aircraft engine companies would not be interested in this prize and that they should be excluded from competing. It was felt, however, that competitors should be free to consult with engine manufacturers or actually be able to buy from them components that enabled an engine breakthrough (such as a high-performance power system or alternate fuels).

NAME

- LAETC (The “Little Airplane Engine That Could”) engine.

RD16: DEPLOYABLE TELESCOPES

MODERATORS

- Grimm, Charles - Reed Technical

NUMBER OF SESSION ATTENDEES: 20

OBJECTIVE

- Produce light-weight, small-package-volume telescope
- Scalable, just need proof of concept
- Possibilities:
  - Resolve 1-4 kilometers from L1
  - Resolve newspaper headline from X km away (less than 4)
  - Resolve X mountain or crater on moon

RULES

- Constraints:
  - initial volume 1 cubic foot, total weight 10 kg
  - Visible light (390-760 nm) telescope
  - Weight of computer (for offboard processing?), external stuff not included in limit
  - (Support and pointing mechanism not included in size or weight limit)
  - (Unresolved question: should deployment mechanism be included in
  - package size and weight, i.e., gas generation, foam, etc.?)
  - Equivalent to 1 meter diffraction limited mirror in performance after correction
- Telescope must be deployed on site within 5 min by 1 person
  - (I think 15 min. would be better- CG.)
  - (Additional 1 hour for active/passive optics setup?)
- Telescope works on Earth
- Possible methods:
  - Annual "see-off"
  - First to meet objective

JUDGING METHODOLOGY

- Use current telescope quality tests
- Smallest letters on eye chart?
- Contestant images compared on screen

PURSE AMOUNT

- 1 meter - $50K / $10K (second)

TIME LIMITS

- Annual competition

INTELLECTUAL PROPERTY RIGHTS

- Must be willing to license to NASA
- Standard SBIR / DARPA Challenge approach

OTHER CONSIDERATIONS & OPTIONS

- AFRL working on it, haven't checked patents
- Hand off judging and administration to organization
- (Sky and Telescope, Astronomy org., or other?)

RD17: AEROCAPTURE

MODERATORS

- Svitek, Tomas - Stellar Exploration, Inc.
- Rasky, Dan - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 24

RULES

- Aero assist includes 3 items:
  - Braking - Multi-passes of a planet during inter Planetary travel.
  - Capture - use of the atmosphere
  - Maneuvering - Accomplishing a plane change

DEFINITION

- Be the first to capture a specific target.
- Be the first to do a plane change.

JUDGING METHODOLOGY

- Single pass
- Minimum Specs
- Min pre-pass apogee 30,000KM
- Min & Max post pass - 300 to 600 KM apogee
- Safe disposal
- Max Propulsion 10% Mass/Fraction Pre pass
- Vehicle mass class?

PURSE AMOUNT

- $5,000,000. ($5M)

TIME LIMITS

- 5 Years

INTELLECTUAL PROPERTY RIGHTS

- Belongs to developer with NASA having the rights to use it.

NOTE

Please see Challenge Identification form from Dr. David Young entitled “The Lunar Cup”.

RD18: AUTONOMOUS UAV CARGO HAULER

MODERATORS

- Cobleigh, Brent - NASA Dryden Flight Research Center
- Moore, Mark - NASA Langley Research Center

NUMBER OF SESSION ATTENDEES: 16

RULES

- Autonomous UAV (aircraft, helicopter, blimp, OK)
- Cargo has to survive take off and landing
- Landing: designated area where there are no electronic landing aids

- Return trip- repeatable process
- Cargo: 100 pounds
- Range: 100 miles
- 100 ft by 1000 foot runways
- Negotiate traffic and obstacles
- The winner is determined by the fastest time to drop off cargo on a runway and return to departure area with another payload with the ability to navigate obstacles.
- Low altitude in order to create good PR- below 1000 feet.

DEFINITIONS

- UAV moving point to point without the influence of man
- Near term prize with a focus on autonomy
- Want it to be based on a race format- exact format can be determined in a later time.

JUDGING METHODOLOGY

- Competition- race format
- Point to point race where you must drop off cargo as well as return with specified cargo with judging based on time in transit to move payloads. Cargo will have to be placed in designated area using precision drop off and retrieval systems.
- Time is not based on drop off and pick off time- allowed for human interaction for payload loading and unloading
- Landing areas are clear
- Air space will not be open, there will be obstacles such as virtual, physical barriers and no fly zones.
- No free-for-all
- Barriers or tracking device used to determine flight pattern so there is no cheating

PURSE AMOUNT

- 250k

TIME LIMITS

- Demonstrate the same processes within a two week period with the same vehicle

OTHER CONSIDERATIONS & OPTIONS

- AUVSI: student competition, similar to proposed NASA challenge
- White Sands possible partnership for competition
- Discovery channel
- Reality TV sponsorship?

RD19: Human Radiation Shielding

MODERATORS

- Dittmar, Mary Lynne - Dittmar Associates

NUMBER OF SESSION ATTENDEES: 16

RULES

- Shielding system that meets or exceeds the NASA requirement for safe radiation protection for humans in a spacecraft for a flight of two years duration outside the magnetosphere
- 50% or more reduction of a standard benchmark material weight
- Volume to be shielded equivalent to ISS module

DEFINITIONS

- Radiation type, dosage. Need scientific/medical input.

JUDGING METHODOLOGY

- Ground test in existing facility.
- Minimum weight is one criterion.
- Expert judging panel to define testing criteria.

PURSE AMOUNT

- $1M

TIME LIMITS

- 3 years

INTELLECTUAL PROPERTY RIGHTS

- First use license for NASA (similar to DARPA approaches). IP remains with the inventor(s).

RD20: SOLAR SAIL RACE

MODERATORS

- Lembeck, Mike - NASA Headquarters, Code T
- Mulligan, Patricia - National Oceanographic and Atmospheric Admin.

NUMBER OF SESSION ATTENDEES: 13

VALUE

- A Solar Sail Could Support Observational Requirements
  - Along sun-earth line close to sun that gives warnings for solar storms
  - North or south of ecliptic pole sitters, climate observations
- Mission limited to optical solar sail propulsion techniques
- Solar sail may scale down better than solar electric, force mass minimizing
- Start in LEO for public awareness
- Different prize formats:
  - 1st to complete mission with delta V provided
  - Possible data purchase often get to destination and be stolen to win prize

RULES

- Deployment of solar sail in LEO with some maneuverability demo
- Deployment of solar sail anywhere and achievement of some level of DV
- Race around the moon or to point in space
- TRACKING, TELEMETRY ETC.
- NASA provides launches for all comers, then race A.
- Delay times for long mission may reduce interest
- Where is the finish line?
  - Race to moon or moon orbit
  - Specific point in space
  - LEO deployment for max public visibility
- 30-40 meter sails are hard to test but very visible from Earth backyards.

DEFINITIONS

- Minimum size sail of 30m-40m would provide good deployment test and be visible from ground

JUDGING METHODOLOGY

- First sail to achieve goal wins
- 1st to complete mission with delta V provided

PURSE AMOUNT

- $6-10 million seems like reasonable size for prize
- Where is the finish line?

TIME LIMITS

- 5 years

INTELLECTUAL PROPERTY RIGHTS

- Follow-on data buy contract (NOAA) could be given to first sail to achieve observational point out in front of L1 and relay data from GFE package

OTHER CONSIDERATIONS & OPTIONS

- Largest problem to overcome is deployment of solar sail
- Limited payload capability, few applications for exploration
- Deployment in LEO would be visible from ground for enhanced public awareness
- Delay times for longer missions to reach a level of DV could take a long time with an attendant reduction in interest
- Possible data purchase after get to destination

RD21: ROVER SURVIVOR

MODERATORS

- Jacoff, Adam - NIST
- Lavery, Dave - NASA Headquarters, Code S

NUMBER OF SESSION ATTENDEES: 13

RULES

- Lunar Conditions.
- Must survive lunar Conditions - temperature extremes
  - Sunlight/darkness cycles
  - Thermal cycles
  - environmental i.e. sand & dirt
- Long Duration. Productivity. Performance matrix =Time/distance
- Goals of rover - getting around from place to place. Deployment of tools.
- Autonomous - little or no human intervention.
- No GPS
- Multi tasks on multi days.
- Distance +work performed + time accomplished.
- Renewable power source.

RD22: PLANETARY SURFACE POWER TRANSMISSION

MODERATORS

- Lyons, Valerie - NASA Glenn Research Center
- Maryniak, Gregg - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES

- 20

RULES

- Standard solar powered vehicle
- 10 kilo-watt power source for each team
- Standardized vehicle and drive-train system from Radio shack (possible funding partner)
- FIRST-like competition

JUDGING METHODOLOGY

- Battery efficiency test
- Race format based on power efficiency rated by duration, speed,
- Race format based on ski race-race against hypothetical clock
- Closed circuit race track
- Power transmission form tower in center
- Best time- first won wins format

PURSE AMOUNT

- 25,000 to 1 million.
- Purse amount will incorporate second and third place money purses

TIME LIMITS

- Annual event

OTHER CONSIDERATIONS & OPTIONS

- Find a project that creates frenzy yet meets application goals
- Line of sight vs. non line of sight
- Steady power flow vs. surge
- Race track dynamics

NAME

- Beamer derby
- Beam-stalk

RD23: EXTREME ENVIRONMENT COMPUTER

MODERATORS

- Arnold, James - NASA Ames Research Center
- Partridge, Harry - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 12

RULES

- No active or passive cooling on the chip
- Operational duration (8 hours?)
- Architecture and hardware open
- In-put data sets provided in an electronic form
- Out-put in an electronic form

JUDGING METHODOLOGY

- Must work in a NASA GFE temperature, xenon bath at 1 atm. for 8 hours and execute 2 code error- free and performance must equal wall-clock time for MER (room temperature and pressure.)

- Expose a second computer to radiation environment. Then temperature trials.

PURSE AMOUNT

- $500K to pass temperature test in xenon bath
- $2M to pass radiation and temperature test

TIME LIMITS

- First one over the line
- Second one gets 30% of purses within 1 year after the first winner

INTELLECTUAL PROPERTY RIGHTS

- NASA has first licensing rights (use DARPA model)

NAME

- The Hadean Prize

RD24: MARS COMM/NAV MICROMISSION

MODERATORS

- Lembeck, Mike - NASA Headquarters, Code T

NUMBER OF SESSION ATTENDEES: 13

OBJECTIVES

- Micro satellite application at a distance.
- Possible “challenge”:
  - Simply get there and transmit one image
  - Impact/land on Phobos
  - Sample return from Phobos
  - Communications or bandwidth
  - Relay in Mars stationary orbit
  - Relay transmission from Mars surface
- Store and forward systems, provide diversity of comm. resources at mars
- Low orbit or geostationary
- GPS/chirper beacons for nav
- Mars radiation environment characterization

RULES

- How to deal with government technology or expertise?
  - Companies with existing small production lines
- Challenge can provide three different functions: 1.) utility functions, 2.) science data products, or 3.) media activation

JUDGING METHODOLOGY

- First data returned

PURSE AMOUNT

- $20M for first relay of data

TIME LIMITS

- 5 years from start of challenge, but not until after this stage is reached

INTELLECTUAL PROPERTY RIGHTS

- Do companies with existing small sat production lines funded by government contracts have an unfair advantage

OTHER CONSIDERATIONS & OPTIONS

- Offer Mars prize after Moon prize, capitalize on winners of the first prize.
- Combine prize with data contract.
- Use of Deep Space Network; how does NASA give time.
- Need for DSN to support could be barrier to entry
- Very little interest in this session, considered a follow-on challenge after similar challenges are met in LEO or lunar vicinity
- Need for precision clocks at mars
- Cumulative radiation dosage is much higher for Mars than moon

RD25: AUTONOMOUS DRILL

MODERATORS

- Essmiller, John - NASA Jet Propulsion Laboratory

NUMBER OF SESSION ATTENDEES: 12

RULES

- Mass limited
- No fluid or air can be used
- Limit power at a given time (50W / 7 days / 8 hours/day)
- Must be autonomous
- Different options:
- Recover a 50 gm sample at 10m and know what depth it came from.
- Multiple holes
- Directional drilling (no GPS)
- Volume 0.5 cubic meter
- Achieve a drilling depth of 50 to 100 meters (prize related to depth?)
- Test environment to be provided by Judging Committee.
  - Possible use of an environment more engaging to Public (e.g., urban search and rescue (USAR) setting).
- Competition is structured such that a percentage of the total purse is allocated to the first team to achieve a base set of criteria and additional small awards would be provided to any teams that are first to demonstrate additional capabilities (e.g., greater depths, additional holes, largest core collected, etc.) regardless of whether that team was first to meet base criteria.

DEFINITIONS

- Autonomous Drill: No human interaction after drill is placed in starting location

PURSE AMOUNT

- $2M Total

TIME LIMITS

- 3 years

INTELLECTUAL PROPERTY RIGHTS

- belongs to developer with NASA having rights to use.

RD26: NANOTUBE TETHER

MODERATORS

- Arnold, James - NASA Ames Research Center
- Partridge, Harry - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 14

RULES

- Strength > 100 GPA
- Minimum GPA
- Mass < 100g/KM
- Length > 1Km
- Can be rolled and deployed
- Operating temperature range 200-400K
- Taper requirement
- No single strand of carbon nano-tube
- Strongest material wins, period.

DEFINITIONS

- Make sure that the product is applicable to space objectives
- Strength vs. weight test
- How can we make the strength test attractive to public and media?
- Weight restrictions? Or best ratio of strength to weight
- Open to foreign competition

JUDGING METHODOLOGY

- Annual challenge- strongest tube wins-
- Strength test
- Stress test- similar to bridge testing
- Space qualification necessary

PURSE AMOUNT

- Annual award
- Point system for strength
- Dollar amounts starts at 50k. After initial year, the next winner will be given an increased in prize purse only if GPA level is increased y 10%

TIME LIMITS

- Yearly event

OTHER CONSIDERATIONS & OPTIONS

- Conductivity- it is an issue
- Density may need to reviewed for possible restriction and/ or rules decisions
- Vertical and horizontal stress test will need to be evaluated for best applicability

NAME

- Tether award

NOTE BY DORIS HAMMILL

This does not in the least reflect my recollection of the conclusion of the meeting. We pretty much decided that there would be a weight limit on all entrants (perhaps 100g) for a 1km tether. The contest was to show how much weight a tether could hold, suspended vertically from a high structure like a bridge. The one that holds the most weight wins. The competition was an annual event, but the winner has to exceed the previous year's event by at least 10% or no prize awarded. There was no issue of space qualification, conductivity, etc.

RD27: In-Situ Life Detector

MODERATORS

- Meyer, Mike - NASA Headquarters, Code S

NUMBER OF SESSION ATTENDEES: 14

RULES

- Detect extant life in situ in an oligotrophic environment
- An instrument less than 50 kg
- 50 watt-hours
- Concentration 1000/cc
- Technique must work on extra-terrestrial life

DEFINITIONS

- Microbes from each of the 3 kingdoms

JUDGING METHODOLOGY

- Panel will determine if life has been detected in an oligotrophic environment

PURSE AMOUNT

- $1M each for up to 3 independent approaches

TIME LIMITS

- 5 years

INTELLECTUAL PROPERTY RIGHTS

- DARPA model

NAME

- ET Assay

RD28: Asteroid Mission

MODERATORS

- Hamill, Doris - NASA Langley Research Center
- Lembeck, Mike - NASA Headquarters, Code T
- Rasky, Dan - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 14

OBJECTIVE

- Land on NEAR and bring back sample to Earth

RULES

- Stipulations for preservation of sample
- 10 gram sample (?)
- Return sample from piece of asteroid
- Could offer bounty for EVERY sample returned within time period

- Land a beacon on asteroid

DEFINITIONS

- Many levels of difficulty: getting there, getting back, etc.
- May require specification of return environment for useful science to be returned

JUDGING METHODOLOGY

- In-situ characterization of sample site
- Photographic evidence of sample site

PURSE AMOUNT

- Bounty for material from asteroid, for first X asteroids
- Fund successive purses at later date
- Sliding scale for follow-on samples
- Minimum of $20 million for first sample
- Drop by increments of $5m
- $10M- 20M for first sample, maybe less for follow-on samples returned with-in time period

TIME LIMITS

- Five years / ten years (subsequent)
- 5 years for first return
- Pay bounties for up to 10 years from start of challenge

INTELLECTUAL PROPERTY RIGHTS

- Sample be own prize and large percentage could be retained by competitor

OTHER CONSIDERATIONS & OPTIONS

- For sample returns, should competitor be able to keep part of sample? All but one gram? To sell on ebay
- Outer space property rights
- Regulatory approval for re-entry
- Bounty for every sample could allow characterization of a number of asteroids/NEOs
- International participation could improve on number of asteroids visited
- Requires re-entry vehicle from other challenge?
- Only first mission has media activation appeal, larger bounties may be required after that

NAME

- Nemesis prize?

RD29: MINIATURE ROBOTIC FLYER

MODERATORS

- Lohn, Jason - NASA Ames Research Center

NUMBER OF SESSION ATTENDEES: 9

RULES

- Must fit in a box 4cm on each side
- No rules on type of propulsion
- Two options:
- Must takeoff in the end zone of a football field, traverse the field without touching the ground and land in the opposite end zone. Must return within 30min (TBD).

- Longest distance covered in a given time period. (each “hop” must cover at least 100 ft (TBD)
- Must send transmit data (e.g. temp or pressure) at some interval (e.g. 1 second).
- Must be fully autonomous from takeoff to landing

JUDGING METHODOLOGY

- Do annually till it's won
- Contest or 1st to demonstrate

PURSE AMOUNT

- $1M (seems too high)

OTHER CONSIDERATIONS & OPTIONS

- Allowable winds?
- Potential application to terrestrial search and rescue

RD30:HUMAN SPACE FLIGHT - ORBITER TECHNOLOGY

MODERATORS

- Diamandis, Peter - X PRIZE Foundation
- Maryniak, Gregg - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: NO ATTENDANCE DATA COLLECTED

RULES

- 3 people
- Cannot use existing rocket technology
- 48 hours in space
- ISS-like orbit
- Two weeks after landing, must make a successful return mission
- People involved have to return in good health

DEFINITIONS

- Two part challenge:
  - 3 man crew using a percent reusable vehicle
  - 12 man crew using a percent reusable vehicle

PURSE AMOUNT

- Staggered purse based on reusability:
  - 30%- 30-40 million
  - 60%- 30-40 million
  - 90%- 30-40 million
  - 90% is highest prize because winner will receive purse for smaller percent reusable vehicle challenge

NAME

- Earth orbit:

RD30:HUMAN SPACE FLIGHT - SUBORBITAL FLIGHT

MODERATORS

- Diamandis, Peter - X PRIZE Foundation

- Maryniak, Gregg - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: NO ATTENDANCE DATA COLLECTED

RULES

- 6-8 k nautical miles
- 6 plus crew- 8 people
- Reusable vehicle- round trip requirements
- Complete 8,000 miles in 2-3 hours
- Person returns in good health

PURSE AMOUNT

- 80 million

OTHER CONSIDERATIONS & OPTIONS

- NASA find partnership for prize funding

RD30: HUMAN SPACE FLIGHT - PVT APOLLO 8

MODERATORS

- Diamandis, Peter - X PRIZE Foundation
- Maryniak, Gregg - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: NO ATTENDANCE DATA COLLECTED

RULES

- People have to be involved
- Person must be in good health after flight

RD31: EDUCATION

MODERATORS

- Freeman, Jason - NASA Headquarters

NUMBER OF SESSION ATTENDEES: 14

K-12 EDUCATION

- Take lessons learned from previous programs, such as Get Away Special (GAS) Cans that accompanied the Space Shuttle. Erika Vick from Code N was in attendance and discussed current education flight projects, including student launch opportunities on NASA vehicles, sounding rockets, etc.

UNIVERSITY-LEVEL

- Discussion seemed to focus on involvement of university students. Attendees recommended university-level challenges to engage these students directly (instead of assuming that they would participate in regular challenges).
- These challenges could help NASA grab the “low-hanging fruit” that would not attract the attention of major competitors but could benefit NASA and support other challenges. One example was the need for a super pressure balloon.
- Prizes could include internships, gadgets, honors, up through a $10K - $50K prize for the hardest of these challenges. A representative from XRocket recommended that NASA purchase rides into space as prizes.

NASA'S ROLES WOULD BE

- Engaging faculty to promote these contests. Schools may include these in curriculum. They may even encourage cross-disciplinary cooperation (engineering, science, business, etc.)
- Reaching students directly.

SAFETY

- NASA should provide specific guidance to ensure safety in these competitions. This could include submission of a safety plan with an NOI. NASA may provide a kit or specific requirement for inclusion of kill switches or similar safety measures.
- Among specific programs presented:
  - Gabriel Elkaim, UC-Santa Cruz, offered a presentation on a student drop-land-launch challenge.
  - Greg Peebles, JAMSTARS, discussed his program that assists university students in building rockets and launching payloads.
  - Additional discussion included payload competitions (such as picosats, cubesats, etc.)

RD32: SUBORBITAL FLIGHTS FOR SCIENTIFIC PAYLOADS

MODERATORS

- Diamandis, Peter - X PRIZE Foundation

NUMBER OF SESSION ATTENDEES: 17

RULES

- Reach an Altitude of 100nm (or approximately 200km)
- Payload mass of 100 kg
- Flight frequency 10 flights in 10 days
- Acceleration limits not to exceed 5 Gs during any phase of the mission

JUDGING METHODOLOGY

- First to accomplish wins.

PURSE AMOUNT

- 1st Place: $1,000,000 (one million dollars) plus a guarantee for 10 additional paid launches in the form of vouchers given to NASA funded researchers
- 2nd Place: Some number of vouchers
- 3rd Place: Some number of vouchers

INTELLECTUAL PROPERTY RIGHTS

- IPR to developers.
- NASA has right to purchase flights.

OTHER CONSIDERATIONS & OPTIONS

- Reusability
- Volume
- Soft-Ride
- Prize Classes include a) Time and Quality of micro-G, and b) Exo-atmosphere and view.

LIST OF ATTENDEES

This section includes a listing of the names of many of the over 200 individuals who attended the 2004 Centennial Challenges Workshop. These individuals gave their expressed written permission for their names to be included here.

1. Able, Charley - Individual
2. Alexander, Iwan - National Center for Microgravity Research
3. Anderson, Bob - Boeing
4. Anderson, Eric - Space Adventures Ltd.
5. Anstine, Nick - Bechtel National, Inc.
6. Arnold, James - NASA Ames Research Center
7. Ashley, Kevin - Bechtel Corporation
8. Askins, Janine - Individual
9. Austin, James - Rutgers University
10. Avnet, Mark - GW Space Policy Institute
11. Bae, Young - Bae Institute
12. Barber, Andrew - Aerospace Industries Association
13. Barton, Andrew - Australian Space Research Institute
14. Benson, Jim - SpaceDev, Inc.
15. Blankson, Isaiah - NASA Glenn Research Center
16. Bowen, Brent - NASA Space Grant
17. Burton, Rod - Univ. of Illinois
18. Cabrera, Sergio - University of Texas El Paso
19. Carr, Christopher - MIT
20. Carrillo, Jaime - Inventor
21. Carroll, Joseph - Tether Applications, Inc.
22. Charania, A.C. - SpaceWorks Engineering, Inc. (SEI)
23. Claflin, Scott - Boeing - Rocketdyne
24. Claybaugh, William -
25. Cobleigh, Brent - NASA Headquarters - Code T - CC
26. Cromelin, Caroline - National Space Society
27. Dahlstrom, Eric - InternationalSpace.com
28. Davidian, Ken - NASA Headquarters - Code T
29. Deel, Monty - GST Protocol Services
30. Diamandis, Peter - X PRIZE Foundation
31. DiBello, Frank - Florida Aerospace Finance Corporation
32. Diebler, Corey - NASA Dryden Flight Research Center
33. Diedrich, Benjamin - NOAA
34. Dittberner, Gerald - NOAA / NESDIS
35. Dittmar, Mary Lynne - Dittmar Associates
36. Divine, Charles - Space Pioneers
37. Dolgin, Benjamin - UTD Incorporated
38. Dunstan, Jim - Garvey Schubert Barer
39. Eckert, Paul - Boeing Space Exploration Systems Office
40. Edwards, Jake - NASA Headquarters - Code T
41. Elkaim, Gabriel - UC Santa Cruz
42. Essmiller, John - NASA Jet Propulsion Laboratory
43. Faktor Lepore, Debra - Kistler Aerospace Corporation
44. Falk, Harry - Trek Aerospace, Inc.
45. Farry, Kristin - Excalibur Technical Services
46. Foust, Jeff - Futron Corporation
47. Freeman, Jason - NASA Headquarters - Code N
48. Freid, Sheldon - Bechtel Nevada

49. Garbe, Gregory - NASA Marshall Space Flight Center
50. Garver, Lori - The Planetary Society
51. Floyd, Brian - Floyd Research
52. Govindan, T.R. - NASA Ames Research Center
53. Greason, Jeff - XCOR Aerospace
54. Grimm, Charles - Reed Technical
55. Guerrero, Jose - Swales Aerospace
56. Gump, David - LunaCorp
57. Hamill, Doris - NASA Langley Research Center
58. Hasebe, R. Sergio - CSC
59. Hendricks, Robert - NASA Glenn Research Center
60. Henry, Richard Conn - National Space Grant Foundation, Inc.
61. Hill, Bob - Science Systems and Applications Inc.
62. Hill, Tom - The Aerospace Corporation
63. Hillhouse, James - nWerx
64. Hirschmann, Franz G - Boeing Phantom Works
65. Hogie, Keith - Computer Sciences Corp.
66. Holt, Milton - Technology Commercialization Center
67. Hudiburg, John - NASA Kennedy Space Center
68. Hughes, C. Gary - RTI International
69. Isakowitz, Matthew - Individual
70. Jameson, Austin - USAF/FAA
71. Jarvis, Celeste - Global Science & Technology (GST)
72. Karanian, Linda - Lockheed Martin
73. Kestner, Richard - White Sands Missile Range
74. Kim, Tony - NASA Headquarters - Code T
75. Kostiuk, Peter - LMI Government Consulting
76. Kreykenbohm, Barbara - NASA Headquarters - Code U
77. Krezel, Jonathan - NASA Jet Propulsion Laboratory
78. Laine, Michael - LiftPort Group Inc.
79. Lauer, Chuck - Rocketplane, Ltd.
80. Lauzon, Pierre - Boeing
81. Lavery, Dave - NASA Headquarters - Code S
82. Legge, Jeff - Sensis Corporation
83. Lembeck, Mike - NASA Headquarters - Code T
84. Liberatore, Vincenzo - Case Western Reserve University
85. Lindbergh, Erik - XPRIZE Foundation
86. Lohr Jr., William C. - Lohr Technologies, LLC
87. Lueck, Dale - NASA Kennedy Space Center
88. Lyons, Valerie - NASA Glenn Research Center
89. Mankins, John - NASA Headquarters - Code T
90. Maryniak, Gregg - X PRIZE Foundation
91. McGrath, Steven - Vanguard Spacecraft
92. McLaughlin, Jeremy - Radford University
93. Meyer, Mike - NASA Headquarters - Code S
94. Miley, Steven - NASA Headquarters
95. Morring, Frank - Aviation Week & Space Technology
96. Mulligan, Patricia - NOAA
97. Negron, Jose - DARPA - Grand Challenge
98. Notardonado, Bill - NASA Kennedy Space Center
99. O'Donnell, Patricia - Hamilton Sundstrand
100. Owens, Dawn Brooke - X PRIZE Foundation
101. Palumbo, Nathan - NASA Dryden Flight Research Center
102. Pawley, Andrea - NASA Headquarters

103. Pedersen, Liam - QSS Group, Inc
104. Peebles III, H Greg - Jamstars
105. Penney, Yvonne - X PRIZE Foundation
106. Pittman, Bruce - Profit Engineering Technologies
107. Platt, Don - Micro Aerospace Solutions, Inc
108. Rasky, Dan - NASA Ames Research Center
109. Reichhardt, Tony - Air & Space Magazine
110. Renno, Nilton - University of Michigan
111. Roberts, Brian - Space Systems Laboratory
112. Rubin, Marco - Exoventure Associates
113. Ruff, Arthur - ATI
114. Ruth, Ed - The Aerospace Corporation
115. Sammons, Chuck - Space Adventures Ltd.
116. Santos, Orlando - NASA Ames Research Center
117. Shea, Karen - Independent Consultant
118. Shelef, Ben - Gizmonics, Inc.
119. Shenhar, Joram - UTD Incorporated
120. Simmons, Anne - The Tauri Group
121. Sordjan, Simeon - Unidirectional Centrifugal Force
122. Sponberg, Brant - NASA Headquarters - Code T - CC
123. Springs, Tony - Northrop Grumman
124. Svitek, Tomas - Stellar Exploration, Inc.
125. Taylor, Tom - Lunar Transportation Systems, Inc.
126. Thompson, Warren W. - Space Enthusiast
127. Van Sant, Tim - NASA Goddard Space Flight Center
128. Varsi, Giulio - NASA Headquarters - Code S
129. Veal, Gordon - L'Garde Inc.
130. Volpe, Rich - NASA Jet Propulsion Laboratory
131. Webber, Derek - Spaceport Associates
132. Williams, Colin - NASA Jet Propulsion Laboratory
133. Wise, Jeff - Popular Science
134. Wood, Barbara - ISU / AIAA / WIA
135. Wood, Peter - ISU
136. Woodward, Neil - NASA Johnson Space Center
137. Wooster, Paul - MIT
138. Wright, Edward - X-Rocket, LLC
139. Young, David - Young Aerospace Company
140. Zeller, Mary - NASA Glenn Research Center

INDEX OF SESSION NAMES