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The Application and Administration of Inducement Prizes in Technology

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Preface

The following research was done at the behest and cooperation of the following three entities:

1. The Colorado Governor's Office of Energy Management and Conservation was founded in response to the 1970's energy crisis. The Office is federally funded and headed by Rick Grice, Executive Director. The office seeks to leverage local partnerships in the energy community, support innovative and grassroots energy programs, proliferate energy technology through education, and create prosperity through energy management and conservation programs.

2. The Colorado School of Mines opened its doors in 1874 and exists presently as the oldest state-funded public institution in Colorado. The School of Mines maintains the highest admissions standards in the state of Colorado and among the highest nationally at public institutions. The esteemed engineering school has the unique mission of promoting research and study in the earth sciences, namely: energy, mineral and materials science and mineral engineering degrees.

3. Founded in 1985, the Independence Institute is a non-partisan, non-profit public policy research organization dedicated to providing timely information to concerned citizens, government officials, and public opinion leaders. Through a variety of publications and public forums, the Institute provides citizens of Colorado and the nation with specific recommendations to help resolve important issues facing our communities. The Institute addresses a broad variety of public policy issues from a free-market, pro-freedom perspective.

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1. Introduction

1.1 Research Goals

One of the eight goals outlined in the re-chartering of the Colorado Energy Research Institute is to create an "energy prize" that will stimulate technological growth and promote conservation. This report is aimed at addressing this goal and providing information on the administration and design of such a prize. A comprehensive list of questions was drafted and revised in order to identify the key areas of forming a prize. The questions were then answered through the research of previous prizes, attendance at the NASA Centennial Challenges Conference, and meetings with local energy representatives and public officials. The answers to these questions will ideally give a clearer picture of the general overlay of the procedure and timeline involved in implementing an energy prize at CERI.

One of the eight goals outlined in the re-chartering of the Colorado Energy Research Institute is to create an "energy prize" that will stimulate technological growth and promote conservation.

1.2 CERI

The Colorado Energy Research Institute (CERI) was established by the Colorado legislature in 1974 under the umbrella of the Colorado School of Mines. CERI had a contributing role in attracting the federal Solar Energy Research Institute (SERI) to Golden. SERI has since been renamed the National Renewable Energy Laboratory (NREL). After years of inactivity, CERI was rejuvenated in 2003 through the leadership of the Governor's Office of Energy Management and Conservation, the Colorado School of Mines, and the Gas Technology Institute. Dag Nummedal was appointed as the Executive Director of CERI in February 2004. The CERI charter outlines the following eight goals for the institute.

- Coordinate with other universities, state agencies, and NREL to organize a series of symposia and conferences on alternative energy, conservation, energy policy, energy security, and economic development;
- Reactivate CSM's Energy and Minerals Field Institute for federal, state, and local government officials, with a focus on both traditional and alternative energy;
- Work with Colorado universities to develop continuing and distance education programs for all Colorado residents;
- Create an "Energy Prize" to stimulate innovative technical solutions encompassing both conservation and new energy technologies;
- Participate in "support groups" (such as new trade groups) for new energy industry sectors;
- Encourage Colorado universities to develop academic courses and degree programs that will prepare students to work in emerging energy fields;
- Create an information resource base, including data, reports, and lists of experts for the use of state and local government officials to inform decision making on energy-related legislation and regulations; and
- Participate in, and coordinate, an information exchange between state and local governmental entities, industry groups, private think tanks, and universities.

1.3 Types of Prizes

Prizes have traditionally been offered as a reward or honor for an individual or team's body of work in a particular field. Prizes of this nature are called recognition prizes. Recognition prizes generally require an application process and submission of previous work(s). The applicant's accomplishment or body of work is then comparatively reviewed and weighted by a panel of selected judges. The criterion that judges use in awarding this type of prize varies greatly. Familiar examples of this genre of prizes include the Nobel Prize, The Presidential Medal of Honor, and The Department of Energy's Fermi Award.

An alternative to the traditional recognition prize is the inducement method. Inducement prizes work

backwards of recognition prizes. Instead of rewarding an entity for a past accomplishment, inducement prizes seek to reward and inspire entities to accomplish a specified objective.

Inducement prizes can be further categorized into two groups: objective-specific prizes and competition prizes. An objective-specific prize lays out a concise technological breakthrough and awards a prize only on its completion. Competition-based prizes set a specific goal and award the prize to the team that comes up with the best entry. Consequently, competition prizes leave room for subjectivity.

Historically, an inducement prize is announced to a specified or unspecified group of contestants. These contestants engage in competition with the intention of accomplishing the set goal. The prize is awarded only to a team or individual meeting the criteria set out in the initial prize offering. An appointed judging panel often oversees the adherence to the prize criteria.

2. The Prize Model and its Economics

2.1 The Technological Implications of Prizes

Both recognition and inducement prizes seek to reward an individual or team for a breakthrough in a given field. These prizes have the option of rewarding advances in traditional thinking or the development of non-traditional thinking. This freedom plays a major advantage when weighing the potential methods employed to attain a prize.

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The vast audience that a prize competition allows for increases the possibility of non-traditional ideas to be proven more effective. Specifically, inducement prizes sidestep the bureaucratic approval often necessary to gain grant and project funding. Since prizes do not discriminate against the ideas that are involved in achieving a certain technological breakthrough a new methodology is free to gain otherwise unlikely exposure. These new ideas often spark public interest and media attention creating yet another benefit of prizes.

Twenty-five percent of all Americans had personally viewed the *Spirit of St. Louis* in the year immediately following Charles Lindbergh's Trans-Atlantic flight. Given the state of personal transportation in 1927 as compared to now, this is a staggering number. Prizes in technology have shown to inspire the public much in the same way the NCAA Tournament does for college basketball. As of July 2004, the X Prize[1] had registered 3 billion print impressions of its name in newspapers, journals, and web sites.[2] This number has undoubtedly increased significantly after Burt Rutan claimed the X Prize in October. Prizes have historically been very effective at drawing public sentiment to a technology. An increase in public sentiment means a sequential increase in technology visibility and proliferation. This is evidenced by the way that the country latched on to information technology in the development of Silicon Valley.

Prizes in technology have shown to inspire the public much in the same way the NCAA Tournament does for college basketball.

2.2 The Economic Implications of Prizes

Recognition and inducement prizes both have lasting economic effects that can be attributed to the direct or indirect incentives that they supply. Often a recognition prize serves as an afterthought to a particular project or body of work, but nevertheless has some effect on the motivation of intellectuals. It is a somewhat subjective and difficult task to quantitatively measure the effects that recognition prizes have on the economy because they are an after-effect of an accomplishment.

The economic effects of inducement prizes are more clearly defined and measurable than their previously mentioned counterpart. Beyond the simple fact of a prize being won or not, the easiest way to measure prize effectiveness is by examining the financial leveraging of participation. When a prize is won,

the aggregate investment in research by contestants is an indicator of the prize leverage. Although a portion of this figure represents failed research on ideas that are did not work, often as much is learned from a mistake as a success. Regardless, many teams competing for the Ansari X Prize, win or lose, plan to extend their business ventures beyond the duration of the official competition. Similarly, many of the component systems developed by the various X Prize teams may prove to be instrumental in the unified vision of privatized space travel. While it is not possible to make these measurements now, it is possible to compare aggregate competitor investment with the prize purse offered. A chart of these results is shown in figure 1.

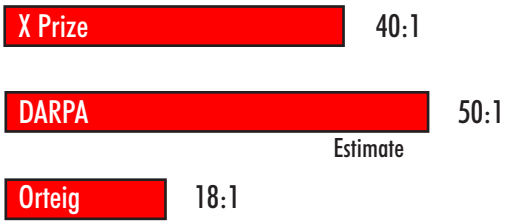

Figure 1 – Relative Prize Leveraging[3]

The figures indicate a tremendous return on investment with both the Orteig and X Prizes having documented returns of 1600 and 4000%.

The figures echo the New Growth Theory, which was made popular by Paul Romer of Stanford. The theory indicates that technology advances are not random, but rather a direct result of the money that is invested in them.[4] This philosophy is exemplified in the success of the Apollo program. At one point the program had over a 10 percent stake in the entire Federal budget.[5] While this number seems astounding, the fact that Americans put a man on the moon in such a short period must be placed in perspective. The leveraging ratios shown in Figure 1 provide an estimate of the effect that an investment in sponsoring a prize will have on an industry. If these numbers hold true, prizes prove to be a more efficient way of inspiring research than the federal funnel that existed in the Apollo program. Similarly, unlike the Apollo program prizes distribute the initial investment among an often diverse pool of competitors.

The fundamental rule of risk aversion in finance is having a diversified investment portfolio. Inducement prizes offer diversification in that the sponsor, without having to make an early judgment, automatically backs a winning solution irrespective of whether it is a traditional or nontraditional approach.

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Additionally a prize is not awarded unless a defined objective is met. This makes the risk of a prize near zero, with the only exception being administrative costs. This provides for a perfectly efficient use of capital so long as the prize value is correctly determined.

An alternative method to quantify the success of a prize is to analyze the economic growth of an industry at three points in time: before the prize was offered, during the prize competition, and after the prize competition was won. The rapid growth exhibited by the aviation industry following Charles Lindbergh's flight across the Atlantic Ocean is staggering.

The profound effect that the Orteig Prize and X Prize have had on their respective industries is easily noted. While the economic data following the completion of the X Prize will not be available for some time, the number of companies and investment that has been spawned as a result of the prize makes one take note.

2.3 Traditional Research Methods

In 2002, the federal government financed approximately 28% of all R&D done in the United States making it the single largest sponsor of the industry.[6] The federal government also provides close to 59% of all University R&D funding. In 1999,

the National Economic Council requested that the National Academy of Engineering study the potential effectiveness of implementing inducement prizes as part of the federal research program. The Academy of Engineering concluded that inducement prizes are not, on their own, a replacement for the traditional research methods that are currently employed. Inducement prizes would complement existing R&D financing systems by providing a different means of addressing problems or challenges. Currently, the most common method of securing federal research grants is through the peer-review process and agency-issued procurement contracts.

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The peer-review process has evolved into several different methods since its inception. The heart of the process consists of an author's submission of a work or proposal in order to receive publication or funding. The submission is then reviewed by what is commonly referred to as a "referee". The referee is chosen by the sponsoring agency and is often widely considered an expert in the particular field of interest. The referees serve as intermediary advisors and do not make any binding decisions or recommendations. Typically several referees will typically review a proposal or paper in order to get a consensus and variety of opinion. The board of referees make their recommendations on an individual basis, not in a "trial by jury" sense. Traditionally, the identities of the referees have been kept anonymous, but this practice is slowly changing in some fields.

Thus, the peer-review process has adapted new methods of soliciting referees and revealing identities in order to obtain a more unbiased opinion. In a single-blind review, the reviewer has knowledge of the author's identity, but the author is unaware of the reviewer's credentials. A double-blind review consists of both parties remaining anonymous to one another.

This process of peer-review has been around for over a hundred years and has been employed in the publication of some of the most influential papers. Interestingly, two of the most important scientific works of the century managed to bypass peer-review. The 1951 paper of Watson and Crick on DNA structure and five of Einstein's papers that introduced his theories of relativity and the photo-electric effect both went straight to press.[7]

Federal procurement contracts are awarded in a variety of ways and mainly negotiated on an individual basis between government and industry agencies. The process of distributing these contracts differs between agencies, but often incorporates an executive review process similar to the peer review method described above.

2.4 Advantages and Disadvantages of Inducement Prizes with Traditional Research Methods

While the peer review process and procurement contracts have been the standard of securing research funding and publishing for some time there are still fundamental flaws in the system. The most common complaint with peer-review is that it is a slow process. It can often take several months for a paper to make it to print. The abrupt change of pace can be frustrating to any scholar that has spent the past several months working at a rigorous pace.

The bureaucratic process involved in securing grants and publishing privileges is susceptible to inefficiencies in evaluating ideas.

Procurement contracts and peer-review also lend themselves to partiality. The bureaucratic process involved in securing grants and publishing privileges is susceptible to inefficiencies in evaluating ideas. Some sociologists argue that the peer-review system allows the "elitist referees" control over the progress and direction of industry.[8] Generally, these experts have an established perception of what technology will work and what will not. The methods of single and double blind judging seek to narrow these biases, but often fail due to a prior knowledge of a

certain party's work.

Inducement prizes offer solutions to both problems listed above. If an inducement prize's goal is properly defined a winner will identify itself while being subject to little review; this will in turn speed up the process of creating visibility for an idea. More noteworthy is the theory that inducement prizes encourage non-traditional ideas that may be weeded out in either the peer-review or procurement contract process.

If an inducement prize's goal is properly defined a winner will identify itself while being subject to little review; this will in turn speed up the process of creating visibility for an idea.

Going back to the point about risk-aversion, a prize-sponsoring body does not have to worry about a "far-fetched" idea costing them money because they only have to fund the winner. Consequently, a prize competitor may snag on to an idea that would be tossed out of a boardroom or government agency.

A case in point is the Longitude Prize that was won by John Harrison in the 18th century. Harrison was an English peasant who was underestimated by many London academics. The majority of the academics supported using astronomical references to determine longitude at sea, while Harrison favored using time and distance calculations with a clock. At the time, clocks were relatively unrefined and inaccurate causing many "experts" to write off his efforts. What John Harrison ended up with was a clock that did not only win the prize, but was also the most accurate timepiece to exist for a number of years afterwards. In the midst of Harrison's clock construction he pioneered some now common practices in fields such as solid-state physics and material science.

Inducement prizes do not come without several potential disadvantages and modes for failure. The most notable disadvantage to both prize-sponsoring agencies and competitors is the lack of an initial cash flow. Research grants and contracts generally provide resources and funding to help get a program off of the ground. However, prizes do allow competitors to pool assets into a startup venture; this can be seen in the funding of Scaled Composites in the X Prize. In the same way, a prize-sponsoring agency may be funded through a grant program.

Another problem for prize-sponsoring agencies may be the control of overhead costs required to administer the prize. DARPA has spent nearly $11 million in organizing all of the details involved in its 142-mile Grand Challenge Race.[9] In defense of DARPA, most of the expenses were due to safety concerns and are only applicable due to the nature of the prize.

The last problem encountered is intrinsically woven into a benefit of prizes. Duplication of work efforts has long been debated as wasteful.[10] The same advantage of producing several competing teams may also duplicate the work done and make funding redundant. Prize competition can turn into what one expert calls a "patent race."[11] The effects of the duplication of work will have to be judged with respect to the value of the work done as compared to the prize. Given the extremely high leveraging ratios of the X Prize, it is hard to imagine that the work done by teams is redundant by a factor of forty.

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Given these key differences, it can be concluded that prizes offer distinct advantages that are not present in traditional research funding mechanisms. At the same time, prizes alone may not, as a 1999 National Academy of Engineers report suggests, be sufficient to replace completely these methods. Prizes do offer potential to increase the marketplace of a technology as well as test demand. Inducement prizes have historically reduced the amount of capital required to establish a technology and also foster non-traditional innovation such as those of John Harrison.

3. The History of Prizes

3.1 The Widespread Application of Prizes

Modern chemists may not be aware of it, but the foundation of their modern industry was laid in part

by a prize offered over 200 years ago. The French Academy offered 100,000 francs to the individual that could produce a soda alkali from sea salt. The prize was of course won and shined light down a new hallway in chemistry.

In the 21st century, prizes are still in abundance, either in the traditional form or as an evolved version. Prizes have dominated the topics of television shows ranging from Star Search in the 1980's to the wildly popular American Idol today. American Idol has used some of the most basic advantages of prizes to produce a media powerhouse. Contestants apply to the contest through an audition. The contestants that pass the audition compete on national television for a recording contract. The Fox Television Network wins in two ways: the ratings for American Idol dominate primetime television and the winner has, without an exception yet, produced at least a platinum album. Meanwhile, many of the runners-up have used the exposure given by Fox to advance their careers; one runner-up secured a recording contract and has already sold over 2 million albums.

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Prizes have also existed in the more traditional sense and led to some significant breakthroughs in the past several hundred years; some of these prizes are described in the following sections in greater detail.

3.2 The Longitude Prize

The British Parliament offered, through a legislative act in 1714, 20,000 pounds to the creator of a device or invention that determined geographical longitude.[12] One difficulty was that the device "shall have been tried and found practicable and useful at Sea."[13] The creation of the prize was in response to the recent rash of casualties suffered by shipwrecks that were the result of inaccurate longitude measurement.

Word of the prize soon spread across Europe and reached as far as the colonies of America. The prize brought forth the efforts of the world's leading astronomers. These men were all engaged in a competition for the handsome reward and recognition that would go to the winner. The feat of determining longitude was commonly seen as an analog to creating a perpetual motion machine. Isaac Newton is quoted as saying that the longitude problem is "the only problem that ever made my head ache."[14] While astronomers were working away at optical devices to determine relative star positions, John Harrison was toiling way in rural England to create a clock that would turn these traditional thinkers on their heads.

His final invention went against the popular belief, backed by Edmund Halley and Newton among others, that longitude could only be accurately determined through astronomical measurement. Clocks were seen as inaccurate in keeping time and adversely affected by the rough conditions imposed by sea travel. John Harrison's H-4 timepiece defied all logic when presented to the Board of Longitude. A clock had never before been created of such small size and stunning accuracy. The clock passed the requirements set forth by the Board of Longitude with flying colors. This is not to say that Harrison's invention was immediately heralded.

John Harrison was not awarded the full Longitude Prize until 1773 after a long battle with the Board of Longitude.

John Harrison was not awarded the full Longitude Prize until 1773 after a long battle with the Board of Longitude. Politics and public stature played a key role in the hesitation to award John Harrison the entire prize. He gave little heed to the popular opinion of respected scientists and was treated much in the same manner. Harrison was a peasant and noted by some as a man of short temper. The Longitude Board went as far as changing the rules during the competition to make it harder for Harrison to prove his device. The Board also required Harrison to personally tend to the clock on its dangerous trip west across the Atlantic. John Harrison complied with all of these changes, cementing his reputation as a determined man; he

was not interested in the money, but rather fought for the respect that he had worked at getting for so long.[15]

3.3 Aviation Prizes in the Early 20th Century

The advent of the Wright Flyer at the turn of the 20th century led to a great increase of experimentation in aviation. The government was slow to catch on to the trend and did not join the effort until World War I. As a result many of the early advances in aviation were made through the aggressive use of prizes offered by the private sector. These prizes were already being used in Europe to make great strides in the aviation industry. The U.S. was quickly falling behind the Europeans in research. The growing gap in aviation sparked the head of the Smithsonian aeronautical laboratory to take note. Advisory committees were assembled to assess the state of aviation in the United States. These committees determined that prizes were essential in keeping pace with Europe.

The feats of the prizes offered may seem trivial by today's standards, but were considered daunting and nearly impossible in the early days of human flight.

At this time, aviation was still a dangerous field, dominated by "fliers willing to risk their lives in such crazy, but crowd-pleasing, stunts."[16] As a result, prizes were used, most likely, to shift the inherent risk of flying away from the aeronautical companies. The feats of the prizes offered may seem trivial by today's standards, but were considered daunting and nearly impossible in the early days of human flight. Prizes soon became abundant, as did the amount of money available to daring pilots and airplane manufacturers.[17] It is estimated that $1,000,000 was offered through prizes in 1911.[18] These prizes were, for the most part, sponsored by aeronautical societies, newspapers, mail companies, and interested individuals. The prizes addressed everything from speed trials, distance competitions, and technological advances. The capstone of these prizes was the Orteig Prize issued for a Trans-Atlantic flight.

3.4 The Orteig Prize

Raymond Orteig immigrated to the United States in 1912 and began at the bottom in hotels. Orteig quickly moved through the ranks and became a businessman by acquiring several hotels in New York City. In 1919, Orteig reasoned that if there was a way to utilize aviation for international tourism, New York hotels would benefit. He approached the National Aeronautic Association (NAA) with a check for $25,000. The check was to be awarded to any team that could successfully complete a non-stop flight between New York City and Paris; Orteig specified an expiration of the prize in five years, the rest of the administrative details were left to the NAA.

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The prize hung in limbo for the first five years and Orteig decided to extend his offer for another five. Still, little progress was made until the 1926 invention of the Wright radial engine. Soon after, aviation big shots and daredevils lined up at the prospect of the challenge. The popular approach among pilots was to utilize a three-engine aircraft with multiple crewmembers. This was thought of as a way to circumvent the doom of an engine failure or pilot fatigue. The first attempt was made using a Sikorsky S-35 plane. The plane had a crew of four and was piloted by esteemed WWI ace, Rene Fonck. The plane was put together hastily and had part of its landing gear detach on takeoff. The disaster cause two deaths and minor injuries to Fonck and another crewmember. Despite the failure, several other teams pursued the prize with the same aircraft configuration.

As an air mail carrier and part-time flying daredevil, Charles Lindbergh had a different plan to get to Paris. He wanted a single-engine plane that would be stripped down to only the essentials in order to maximize fuel capacity. Lindbergh's credentials were frequently swiped at and most people wrote him off from the start.

Shortly after the construction of Lindbergh's

plane was completed, one competing French team departed successfully from Paris for New York City. Despite the disheartening news, Lindbergh headed from San Diego to St. Louis in an unprecedented non-stop test flight; only then did Lindbergh gain the notoriety that he deserved. Lindbergh sat patiently in New York City awaiting good weather and word of the French pilots' location. Meanwhile the competing teams that gathered in New York City rallied around each other's efforts by sharing information. Lindbergh set off for Paris on May 20, 1927, in his single-engine *Spirit of St. Louis*. The French pilots had reportedly been spotted at Newfoundland, but never were seen again.

Lindbergh landed in Paris on May 21 to an enormous audience which was there to congratulate him on his record-breaking feat. Lindbergh navigated the flight with no radio, minimal army food rations, no jacket, and emergency equipment consisting of little more than a flare and an inflatable raft. A sealed barograph that showed a positive altitude throughout Lindbergh's flight validated that his flight was non-stop. The accomplishment was signed off on by both the National Aeronautic Association and the Procès-verbal and Lindbergh was given the world record for a non-stop flight of 5,809 kilometers.

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Possibly the most amazing part of Lindbergh's accomplishment was the effect that it had on the aviation industry; this period is known as the Lindbergh Boom. As Lindbergh appropriately commented, "It was like a match lighting a bonfire."[19]

- The *Spirit of St. Louis* was personally viewed by a quarter of all Americans within a year of Lindbergh's 1927 flight;
- The number of U.S. airline passengers increased nearly from 5,782 in 1926 to 173,405 in 1929;
- US air cargo flown went from 45,859 lbs. in 1927 to 257,000 lbs. in 1929
- US Air Mail increased form 97,000 lbs. in April to 146,000 lbs. in September of 1927;
- There was a 300 percent increase in applications for pilot's licenses in US in 1927;
- An increase of more than 400 percent in the number of licensed aircraft in America in 1927;
- The number of airports in the United Sates doubled within three years of Lindbergh's flight;[20]

The impetus of this movement in the aviation industry may have been even more staggering had it not been for the onset of The Great Depression. It is hard to evaluate the exact implications that Lindbergh's flight had on the current state of aviation, given the wide variety of applications that Lindbergh's flight ended up serving. International flight is now an integral part of the tourism industry, mail service, and business travel.

3.5 The CATS Prize

In cooperation with the International Non-governmental Development of Space (FINDS), the Space Frontier Foundation announced the CATS Prize in November of 1997. These two groups sought to demonstrate that space is not solely the realm of the government. A prize of $250,000 was offered to the first team/individual that can design a spacecraft to propel a 2kg (4.41 lbs) payload to an altitude greater than or equal to 200 km (124.3 mi.). A secondary prize of $50,000 was offered to the team/individual that can launch the same payload 120 km (74.6 mi.) into space. A deadline of November 8, 2000, was set for the prize. The spacecraft did not need to be reusable or recoverable so long as it could be sufficiently proven that the goals of the prize were reached. The payload, which could also be non-recoverable, was provided by the judging committee in the shape of a right cylinder with a minimum 100mm diameter and 200mm length. The deadline approached

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before any of the many teams competing were able to claim the prize. Their efforts "added to the advancement of private space enterprise" and can be thought of as "free" R&D. [21]

3.6 The Ansari X Prize

The X Prize was established May 18, 1996, in St. Louis by a group of investors/space enthusiasts. The goal set out by the X Prize founders was to "promote the development and flight of spaceships able to provide low-cost commercial transport of humans into space." Ten million dollars was offered to the team that constructed a reusable spacecraft to carry three passengers to an altitude of 100 km (62.5 mi.), return safely, and repeat the endeavor within two weeks. The prize shows promise of reducing the cost of sending humans into space; it is estimated that prices may fall to $100,000 by 2020.[22] Currently NASA shells out approximately $60 million for each astronaut who is sent into space.[23]

The goal set out by the X Prize founders was to "promote the development and flight of spaceships able to provide low-cost commercial transport of humans into space."

The idea was founded on the idea of reestablishing St. Louis as a center for aviation activities. Charles Lindbergh's Atlantic Crossing had built up St. Louis's reputation previously, but the city's foothold had slipped away. Several space enthusiasts and Lindbergh family members formed the X Prize Foundation as a result. The movement gained momentum among St. Louis businessmen and resulted in the framing of the X Prize.

The X Prize was announced and established with the support of an influential group of supporters. The respective heads of the FAA and NASA, seventeen astronauts, and members of Charles Lindbergh's family were all present at the press conference announcing the prize's inception. The prize is endorsed and partly administered by the New Spirit of St. Louis Foundation. The competition was renamed the Ansari X Prize after the Ansari family made a large contribution to the X Prize Foundation. As a protection against a quick-win success before the $10 million purse was fully funded, it was backed with a "hole-in-one" insurance policy until January 5, 2005.

The X Prize has led to the creation or proliferation of more than twenty-four private companies in the space industry. These companies are all in pursuit of the mission set out by the X Prize and many have similar side projects that branch off of their core X Prize concepts. It is estimated that these companies have collectively spent close to $400 million in pursuit of the $10 million X Prize.

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Burt Rutan, who has designed more aircraft than Lockheed and Boeing combined, and Microsoft's Larry Allen have teamed up to head the effort of Scaled Composites.[24] On June 21, 2004, Scaled Composite's Spaceship One reached the altitude requirement set forth by the X Prize with a single passenger. The company announced its intentions to launch its first flight for the formal X Prize bid with three passengers at the end of September. On August 5, 2004, Canada's DaVinci Project announced plans to launch its rocket in competition for the X Prize October 2.

The formal X Prize competition is just a springboard for the general movement occurring in privatized space access. The X Prize Foundation recently announced a $9 million deal with the state of New Mexico to host the X Prize Cup. The X Prize Cup will be a more traditional competition than the X Prize because teams will be competing at the same site. The Cup offers cash prizes for each of the following five categories:

1. Fastest turn-around time between launches
2. Maximum number of passengers in one flight
3. Total passengers carried during the X Prize Cup
4. Maximum altitude
5. Fastest flight between take-off and landing.

These categories are awarded individually and also combined into an aggregate score that will determine the overall winner of the X Prize Cup.

Further rumored plans by the X Prize foundation include Dr. Diamandis' expressed interest in creating a space race from New York to Sydney. This event would have a more comparable framework to the original Orteig Prize and also likely draw a huge interest from shipping companies looking to implement global same-day delivery.

Further rumored plans by the X Prize foundation include Dr. Diamandis' expressed interest in creating a space race from New York to Sydney.

The X Prize has been successful from many standpoints. The prize leveraging is confidently estimated at ranging from 35 to 40 times the amount of the actual prize. [25] This figure is made up of a number of companies that were formed for or have the direct goal of competing for the X Prize's mission. Beyond that, the X Prize has laid a foundation for the privatized space industry to grow in the X Prize Cup. The success of the X Prize has been publicly and federally lauded[26]. Members of the X Prize Foundation have been called upon several times to give testimony before both Congress and NASA[27].

Beyond the scope of the X Prize foundation a follow-on prize has already been offered by a Las Vegas billionaire offering $50 million to the team that can successfully send five humans into orbit. The X Prize has also caught the eye of mogul Richard Branson. Branson unfurled his plans to enter his Virgin Airlines into the space tourism business. He has contracted with Rutan's Scaled Composites in the amount of $100 million to build five replicas of SpaceShipOne, each carrying seven passengers starting in 2007. The price per flight is expected to be in the $200,000 range and will take passengers to an altitude of 70 miles. Early estimates are that the first five years of the venture will attract 3,000 people and generate $600 million. Indeed, the X Prize ripples are just beginning their change of the world.

3.7 DARPA Grand Challenge

The Defense Advanced Research Projects Agency (DARPA) blazed the trail in creating a government-funded prize with its Grand Challenge. The Challenge was sparked by DARPA's interest in developing ground vehicles that will operate autonomously in a combat environment.

The DARPA Grand Challenge requires entrants to build an autonomous vehicle that can successfully navigate a course of obstacles and varying terrain in less than ten hours. In addition to constructing the vehicle, each team must turn in a technical paper prior to entry detailing the method that will be employed in the competition. An initial prize of $1 million was offered to the team that could complete such a vehicle[28].

The DARPA Grand Challenge requires entrants to build an autonomous vehicle that can successfully navigate a course of obstacles and varying terrain in less than ten hours.

The first DARPA Grand Challenge was held March 13, 2004, and stretched a course from California to Nevada. Teams were unsuccessful in completing the course and no prize was awarded.

DARPA has already begun a continuation of the first Challenge by announcing a $2 million follow-up contest to be conducted in the fall of 2005. The program as a whole is authorized by Congress to run until September 30, 2007.

DARPA was left to define many rules and regulations on its own. Entrants were limited to U.S. citizens, but with some loose stipulations. A team's nationality is defined only by its leader, meaning that in theory an international team could be organized under a U.S. team leader. Federal employees were allowed to enter the competition provided that they competed "on their own time" and used "only non-Federal equipment and supplies."[29] Federally Funded Research and Development Centers (FFRDC) were allowed participation as long as "no

Federal funding is specifically used to prepare for or participate in the Challenge."[30]

Another noteworthy tactic employed by DARPA in its rules definition disqualifies entries "that cannot demonstrate intelligent autonomous behavior," leaving the qualification of teams somewhat open to subjectivity. At the same time, this saves DARPA from allowing frivolous or embarrassing entries into the competition. A chief judge whose decisions are final and binding makes all of these rulings.
The chief judge is responsible for clarifying existing rules, defining new rules, and has a broad scope of authority in otherwise modifying the Challenge. Entrants are encouraged to communicate ideas with DARPA since the winning team is required to prove rules compliance to the U.S. Government before the prize is awarded.

3.8 Federal and Professional Recognition of Prizes

In 1999, the National Economic Council asked the National Academy of Engineering (NAE) to "asses the potential value of federally sponsored prizes and contests in advancing science and technology in the public interest."[31] Forty-one members of government agencies, academic institutions, and industry gathered to deduce the potential for prizes; the end result of this conference produced the paper, "Concerning Federally Sponsored Inducement Prizes in Engineering and Science." The report was presented to Congress concluding that the federal government should experiment with the use of inducement prizes to complement the existing peer-review and procurement contract system, (A full summary of the conclusions reached in the report is included in the appendix.)

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The 1999 NAE report has served as a roadmap for much of the research done in this project and also validated opinions on prizes through the expertise of those directly affected by such a program. The NAE Report also often has served as a point of reference for future government discussions and arguments regarding the organization of a program of federal inducement prizes. One such report that was inspired by the 1999 study is the 2004 Aldridge Report. The President's Commission on Implementation of United States Space Exploration Policy delivers the Aldridge Report annually to the President. The 2004 Report dedicated several pages to encourage the use of prizes to build a more "robust" space industry. The Report cited given testimony by various parties including organizers of the X Prize to deduce the value that prizes have in commercializing the industry. The Commission suggested future prizes of various values up to a proposed $1 billion program to the company that can send humans to the moon and sustain their inhabitance for a set period of time. Funding for such an effort was assumed to be a joint venture between NASA and Congress.
On a more immediately relevant note, the Commission "strongly supports the NASA Centennial Challenges Program" and encourages an expansion of the realm of the developing program to "encourage entrepreneurs and risk-takers to undertake major space missions."[32]

3.9 NASA Centennial Challenges

As an indirect result of the NAE recommendations and the success that the X Prize was having, NASA, through the leadership of Brant Sponberg, sought to create a program that would offer and administer prizes addressing various NASA objectives. The 1999 NAE paper along with a 2003 Space Architect Study led to the development of the Centennial Challenges Program. The program was established in the NASA Office of Exploration Systems. This being said, the goals of the program address the "NASA vision with an emphasis on exploration." [33]

...NASA, through the leadership of Brant Sponberg, sought to create a program that would offer and administer prizes addressing various NASA objectives.

Congress initially authorized Centennial Challenges to cap prize values at $250,000 for the 2004 fiscal

year. Subsequent prizes would include larger purses that must be approved by the NASA Administrator. The program was established with loose prize objectives to be more clearly defined at an annual workshop (first held June 15-16, 2004) and a collection of prize suggestions submitted via the Centennial Challenges website.

The first workshop was held in downtown Washington D.C, at the Hilton hotel. Attendees included an array of NASA officials and scientists as well as representatives from the X Prize and aeronautical/astronautical organizations. The conference featured keynote speeches from the government and private sectors, followed by brainstorming and rules definition sessions. NASA has previously divided the topics of prizes into six categories, which served as the topics of the brainstorming sessions:

- Astronautics
- Astrophysics
- Bioastronautics
- Earth Observation
- Exploration systems
- Planetary Systems

In these sessions, potential topics for prizes were discussed in order to determine the state of the art in each area and determine a useful threshold for the advance required by the prize. Ideas from the brainstorming sessions were then reviewed by NASA and incorporated into rules definition sessions along with pre-established NASA ideas for prizes. The rules-definition sessions included defining a particular prize goal, establishing a judging metric, projecting potential rules discrepancies, and suggesting an appropriate prize purse. NASA will again review these suggestions with selected entries expected to be implemented by January 2005.

Ideas from the brainstorming sessions were then reviewed by NASA and incorporated into rules definition sessions along with pre-established NASA ideas for prizes.

As a general policy, NASA does not intend to require possession of the intellectual property rights for technology developed by the Centennial Challenges Program. In some situations, NASA will give the winning team/individual free reign with intellectual property. In most cases, however, the rules will require the issuance of a license for NASA to utilize the technology.

Participation in Centennial Challenges competitions is currently open to U.S. citizens who are not federal employees (unless particularly specified in specific prize rules) with some potential to expand to international participation. Judging will mostly be done by NASA, but may be opened up to include outside members of academia and industry.

4. The Components of Administering a Prize

4.1 The Scope of Prizes

Traditionally, prizes have not specified the exact technology involved in achieving a goal. Prize administrators have been careful not to narrow the scope of the technology allowed in prize competitions in order to avoid trumping the inherent advantage of encouraging non-traditional ideas. Given the nature of the energy field, determining the scope of a prize may not be as cut and dry as it would be in an area like space exploration. The X Prize can specify relatively little regarding the technology employed and still be efficient, so long as three people reach sub-orbital altitude.

Traditionally, prizes have not specified the exact technology involved in achieving a goal.

The same cannot necessarily be said of the energy industry, due to existing infrastructure and investment. A challenge issued to create a low energy home is a prime example of a potentially ineffective situation. An energy-efficient home supported mainly by solar panels can be built in Colorado to take advantage of the abundant sunlight. These panels will hardly be efficient if the same home were to be constructed in Seattle.

When possible, it is advantageous to maximize the scope of technological methods that can be

employed in a prize competition. This allows for technologies to compete against each other and reduces the possibility of a redundant technological breakthrough. Restated, a more general prize scope helps to create multiple alternatives for the marketplace. Many companies involved in the Ansari X Prize competition had their own patented method to reach sub-orbital altitude. Just because one team is more likely to win does not mean that their method will prove to be more marketable or cost-efficient. For the X Prize, Scaled Composites has spent an estimated $25 million in R&D, while the da Vinci team that planned on launching only a few days later has only spent $5 million. Scaled Composites may win the X Prize, but da Vinci may end up with the edge in the market.

...a more general prize scope helps to create multiple alternatives for the marketplace.

Discrepancies, such as the house efficiency scenario described above, will require an in-depth analysis to determine the approach that is most efficient in providing a prize and the scope of its corresponding solution.

4.2 Prize Objectives

Prize objectives need to be determined simultaneously with the scope of the prize; one is likely to limit the other.

The National Academy of Engineers suggested, in its 1999 report, the following four subgroups of inducement prize objectives:

1. New or Best Invention
2. New Application
3. Performance Improvement
4. Technology Diffusion

These four categories of development are fairly encompassing and should give the framers of a prize a general idea of the options for setting up a prize. These four objectives are not discrete by nature and may have a tendency to overlap each other, which in theory will produce a more desirable result.

4.3 Setting a Deadline

The threat of a looming deadline has been essential in the efficient development of technology. This is no different in prize competitions. Some may argue that competition itself will keep teams on pace with each other, but this has not been previously shown. David Anderman, a previous prize administrator, gave two pieces of advice for setting up a prize. One of the two was to make sure that the money is there; the other is to make sure that the prize has a deadline. He indicated that a deadline is essential in forcing teams complacent with their work to switch into a higher, sometimes necessary, gear. The NAE study performed in 1999 reached the same conclusion that Anderman did by stating that a deadline must be set for a prize competition to be effective. Many teams in the X Prize competition are currently rushing to get their vehicles to launch before the January 2005 insurance policy expiration date. The certainty that prize funding is in place serves to accelerate the competitive pace. If the accelerated rate could be quantified, future prize efforts could weigh the value of exercising insurance as a supplemental tool.

Deadlines must also be set with care and in a reasonable manner. A short deadline may discourage a team from entering a competition altogether. A premature deadline in the case of a high-risk prize may also lead to safety concerns by prompting a team to compete without completing safety tests. Risk is unavoidable due to the nature of a competition with teams vying to reach the same goal first. Several pilots met their fate during the rush to send a plane across the Atlantic Ocean.

It is accordingly essential to set a prize deadline that is in step with the changing cost of the technology required and allowing for the necessary safety precautions.

It is accordingly essential to set a prize deadline that is in step with the changing cost of the technology required and allowing for the necessary safety precautions. A deadline can be extended, as it was in the Orteig and CATS prizes, so long as competitors are not planning for an extension. The setting

of such a time limit of a prize has often been the responsibility of a prize's administrative body.

4.4 Prize Administrators

Historically, prizes have always had an administrator or board that has been responsible for overseeing the management of the prize. A general overview of the tasks of this administrative agency (AA) includes, but may not be limited to, the following functions:

- **Communication** – The prize AA must coordinate communication efforts between:

1. Sponsors – The AA must ensure that the prize objectives are being met and that there is a guaranteed source of funding.

2. Competitors – The AA is responsible for recruiting qualified competitors, communicating the rules, clarifying rules interpretations, determining the effectiveness of and arranging an online forum, and maintaining an image of impartiality.

3. Media – The AA must maximize media exposure, coordinate press releases, and be able to direct inquiries to the proper parties.

4. General public – The AA is responsible for captivating the general public through a multitude of mediums. The AA will be responsible for maintaining a fair and productive image of the prize program. The AA will also be responsible for the implementation of a website to increase exposure and accessibility.

- **Organization** – The prize AA must arrange for the following activities or processes:

1. Prize award ceremony – The AA must determine what kind of public recognition shall be given to the winner of a prize. This most likely will be commensurate with the value of the prize the degree of the technological advance made. This may include a trophy or plaque presentation, arranging for keynote speakers, a public or private assembly, a formal banquet, or any combination of the aforementioned.

2. Prize entry screening – The AA will be responsible for screening out frivolous entries in order to increase the credibility and efficiency of a prize program. Potential ways of accomplishing this are entry fees, auctioning entry slots, and technical paper submissions.

3. Judge selection procedure – The AA will need to ensure that qualified experts are chosen as judges and that they are able to work together. The AA must ensure that there is no partiality among the judges and that prizes are awarded on a fair basis.

4. Rules collaboration – The AA will need to determine what body will be in charge of making the rules for a prize. Possibilities include: the AA, judges, qualified experts, industry leaders, sponsoring bodies, or any combination of these. The AA will then be in charge of delegating rules clarification procedures.

5. Prize idea solicitation – The AA will be responsible for judging submitted prize suggestions as well as soliciting new ideas. Possibilities include a type of prize to reward larger prize suggestions or technical paper submissions to judge the merits of an idea.

6. Funding – The AA will be in charge of lining up and ensuring that funding is present for each particular prize purse. The AA will also be responsible for specifying how the prize will be awarded and determining the range of control allowed by sponsoring bodies.

- **Other** – The responsibilities of the AA may extend to more general aspects of the program or specific prize, potentially including:

  Legal issues – The AA may be in charge of ensuring legal compliance. This would include, but is not limited to determining intellectual property possession issues, licensing rights, competitor risk management, and competitor compliance with local, state, and federal restrictions.

4.5 Prize Financing

Dr. Peter Diamandis, the CEO of the X Prize Foundation said that arranging funding for the X Prize was the greatest obstacle his organization had to overcome. Many interested funding sources were concerned with the risk involved in placing their logo on a rocket that has the potential to explode in front of a national audience. This example pertains particularly to prizes involving volatile technology, like the X Prize, and illustrates a general apprehension in recruiting funding from private corporations. The interests of funding sources must be taken into account in order to ensure a smooth running prize program. Different entities have different considerations, all of which must be accounted for when arranging financing for a prize.

Many interested funding sources were concerned with the risk involved in placing their logo on a rocket that has the potential to explode in front of a national audience.

Most people would agree that the federal government might prove to be an abundant source for prize funding. Government funding can make sense in that the massive amount spent on research and development might more expeditiously achieve its goal by occasionally utilizing the prize notion. The federal government has already done studies involving the implementation of prizes and often has resources that are greater than those of state or private entities. NASA has already indicated a willingness to co-sponsor a prize with a non-government entity. The advantages and disadvantages of using federal funding must be critically analyzed. Problems, not the least of which is politicization of the process, may arise by using government money. Government participation may involve an added layer of bureaucracy in administering a prize. The effects of this may damper the non-discriminatory approach encouraged by inducement prizes in areas such as judging, scope of competition, and conceptual diversity. One of the most obvious restrictions may be the limit on competition entry. Since no precedent has been set with an outside agency using government money to administer a prize it is difficult to predict the flexibility in regional competition. The DARPA Grand Challenge and Centennial Challenges Program both prohibit international competition, with some room for flexibility. On the other side of the argument, a state entity that seeks to promote an industry in their state exclusively may have difficulty in limiting competitors to companies and/or residents located in the state.

Problems, not the least of which is politicization of the process, may arise by using government money.

State governments could be a potential source for prize funding. The question arises for state support of a national prize because the prize may or may not have direct benefits to the state. Thus, state decisions are likely to be on a case-by-case basis depending on the perception of benefits.

One problem inherit in government funding is risk-aversion. While prizes provide for some protection from liability and direct financial loss, they introduce a safety risk indirectly in the form of a poor public image. The Orteig Prize claimed several lives on the path to crossing the Atlantic Ocean; the X Prize on the other hand has not. The X Prize did have trouble recruiting sponsors due to safety concerns. Dr. Diamandis also pointed out at the Centennial Challenges Conference that the average Formula 1 Racing team gets over $100 million a year from sponsors. These same sponsors that declined to participation in the X Prize generally see their logo in flames or crunched up on the wall on an annual basis. One can conclude that the risk factor is based

more on the public perception of the technology and will thus be specific to each prize offered. The federal government has made its stance clear on safety issues by shelving the space program after both the Challenger and Columbia incidents.
An alternative to government funding is to seek support from either for-profit or not-for-profit organizations. The advantage to these two groups is that they do not always have a geographic constituency. A drawback, in the case of for-profit or not-for-profit corporations, is that they may be interested only in a prize that will be in tune with their goals. Not-for-profit organizations including foundations do not have drawbacks that would interfere with their potential interest in funding prizes. The main shortfall of some of these organizations would be budgetary funding limitations or non-conformance with their stated mission.

Another scenario is a joint effort between any combination of the above players. The government could offer tax incentives to contestants or sponsors of a prize. These tax benefits would be supplemented with a monetary prize award from other organizations. This model could prove very effective in promoting robust business growth in a particular technical field. Tax relief might be a means of addressing the concern about regional-specific benefits. Tax relief would also bring a new dimension to the prospect of funding the required prize purse. In theory the prize might be smaller, but the prize sponsor might otherwise benefit by cultivating new businesses within its geographic area of interest. This approach diverges from the ideal prize because it offers some financial benefit for many competitors rather than just the winner.

A unique funding alternative introduced by the X Prize is an insurance policy to pay the winner.

A unique funding alternative introduced by the X Prize is an insurance policy to pay the winner. The X Prize Foundation and an insurance company commissioned a consultant to identify the odds of a team winning the X Prize by January 2005. This number was used to set the insurance premium that the X Prize would pay in order to award the prize amount should it happen to be won before it was fully funded by sponsor donations. This mechanism of funding is only effective in the case that the prize is won before full funding is in place.

Organizers of a prize must be selective when approaching funding sources. Some sponsoring bodies are likely to request conditions that may help or may get in the way of the effective operation of the prize program.

4.6 Competitor Selection

National security concerns and funding sources may play a role in limiting competitors allowed to participate in a prize competition. The ideal model is an international prize competition without limits on either source of funding or contestants. This would attract the best minds from all over the globe and would be the most successful at motivating competition. But the universe of competitors may become relevant with regard to technologies that contain a national security risk. This is the reason that DARPA limits contestants to American citizens.

National security concerns and funding sources may play a role in limiting competitors allowed to participate in a prize competition.

With a prize, such as the X Prize, international competition makes sense because interest is nearly universal and the sponsoring body is promoting a broad agenda. However, in a situation such as the DARPA Grand Challenge, military sensitivity may exist in the technology. Funding the research of a technology that may end up in the hand of another country obviously defeats its purpose in this case. The limiting of funding sponsors and/or competitors may be used as a way to regionalize an agenda. If an entity would like to promote research and growth in the state of Colorado, it might make sense to only offer the prize to individuals or teams that reside or have interests in Colorado. Efforts to impose regional limitations will likely lead to trade-off decisions that injure the region because Coloradans do not always have the best or only solution.

In order to attract a variety of entrants, the prize contest must be construed as an equal-opportunity program. For this reason, limitations are often put on some government employee participation. The goal of many recent prizes, including the X Prize, DARPA, and Centennial Challenges is to promote private efforts in certain industries. These contests often do not allow the use of government facilities that are not "fair-use" or equally accessible to anyone. Additional stipulations indicate that government employees may participate as long as it is on their own time (not on time paid by the government) and does not use proprietary government resources.

In order to attract a variety of entrants, the prize contest must be construed as an equal-opportunity program.

4.7 Judging Procedures

It is of the utmost importance to maintain impartiality and integrity in the judging of prizes. Most competitions access recognized experts in the particular field of the prize who do not have a conflict of interest in working with other teams. Government issued prizes, e.g., the Longitude Prize, DARPA, etc., generally appoint members of government as judges. Unless government members have direct knowledge in the field as the prize, the risk of politicizing judging is elevated.

This brings to mind the question of judging by individual versus judging by committee. Most prizes have been historically judged by committee. All of the prizes detailed earlier had a committee that convenes to reach a conclusion on the validity of competitor achievements. The committee often has an appointed head that has the tie-breaking vote (the chief judge in the DARPA competition is an example).

The next question is the realm of judging authority. In the case of the X Prize and Longitude Prize, judges collaborated with administrators to determine the rules. This method preserves technical integrity as well as the economic and underlying goals of a prize. In the case of the X Prize, the judges were given the freedom to create rule judgments as problems arose during the contest. While this may seem unfair to some, the X Prize Foundation allowed any team to withdraw with a full refund of the entry fee after the final rules were published. The X Prize also informed competitors of the rules changes at the same time eliminating any potentially unfair advantage.

4.8 Intellectual Property

The topic of intellectual property (IP) was briefly mentioned earlier in organizing a prize. The Longitude Prize demanded that John Harrison turn over detailed drawings of his clock along with all working prototypes. The X Prize, on the other hand, has no right or say in the intellectual property of any of the technology developed by the winning team or any of the other competitors. These two prizes facilitate comparison because they offer approximately the same modern equivalent prize dollar amount. The key difference is the amount of money invested to win the two prizes. The X Prize requires an investment that is, in many teams case, around or greater than the prize itself. Scaled Composites has reportedly put nearly $25 million towards it efforts. The Longitude Prize was won with minimal investment and proved to be a labor of time and thought more than one of money. John Harrison gave up all rights to his invention, yet he received a handsome reward relative to the money that he himself invested (he funded much of his research with private and government grants). This comparison shows that intellectual property rights are a major factor when determining the amount of a prize. Harrison gave up his invention rights for a larger reward. Scaled Composites spent more money than the X Prize offers, but has the opportunity to recoup by taking their product to market. The X Prize purse served as a catalyst or pump-priming incentive for innovation, potentially offsetting a portion of the expenses in the venture.

The X Prize purse served as a catalyst or pump-priming incentive for innovation, potentially offsetting a portion of the expenses in the venture.

A second approach to intellectual property rights will be taken by NASA in its Centennial Challenges Program. NASA will leave the IP rights to the prize contestants, but will request a license to use the technology if it is aligned with one of NASA's projects. NASA has not made it clear whether it will ask for a license from only the winning team or all teams that enter the competition. The potential licensing rights could even serve as a fee for teams if NASA decides to request licenses from everyone. The advantage of requesting a license from all teams would be that NASA could utilize individual components from teams instead of the whole design.

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4.9 Safety and Liability

In any competition there is always concern for both safety and liability. Both should be carefully addressed in the prize competition's rules. Most prizes have both a disclaimer and a waiver that releases all sponsoring and administrative parties from potential liability. Prize contestants need to comply with all relevant federal, state, and local regulations. This consideration will have to be handled on a case-by-case basis as different technologies present their own share of hazards in development and testing. It is important to note that waivers and disclaimers do not absolutely guarantee immunity against lawsuits. Prize-sponsoring bodies must construct their rules with the intention of minimizing the potential for lawsuits.

The implications of safety extend beyond legal concerns. As mentioned earlier, sponsor participation in the X Prize was often refused due to safety concerns. Sponsors tend to avoid attaching their names to something that may result in public embarrassments. This is a factor in determining the best way to market prize sponsorships.

Unlike the X Prize, many competitors for early aviation prizes knowingly risked their lives. They had either an excessive confidence in their invention or blocked the inherent risks from their thinking in order to compete.

4.10 Public Relations

With over three billion press printings, the X Prize has attracted significant attention to its efforts. Dr. Diamandis stated that the public perception and knowledge of the prize is utterly important in maximizing the effectiveness of the contest. The buzz created by the X Prize has done a great deal to motivate teams, inspire the public, and create a visibility of the technology. More importantly, the X Prize has proven that there is a market for privatized space travel. Companies will produce it and people will watch and buy it. The same can be said of the Orteig Prize. Thousands of French citizens were in Paris to greet Lindbergh, and 25 percent of all Americans saw the *Spirit of St. Louis* on tour after its return. The audiences that these two prizes drew illustrate both a cultural shift in acceptance and demand for technological growth.

Each of these prizes put forth an idea that was "sexy." Americans can identify with the space program after the Apollo days in the same way that the world identified with the courage and significance of Charles Lindbergh's flight. As the X Prize has gained momentum sponsors became more willing to attach their name to the contest.

In this sense, public relations are important to any prize contest. The cultural shift in attitudes is as significant a change as the technological achievement itself. A prize is most successful when it touches a large and diverse audience. Modern prizes have used a range of media to reach the public and promote the prize. The Internet has played a large role in informing the public of the status of the prizes and also providing a central location for the media to request or view information. Other press is often gained through newspaper, journal, website, and television publicity.

A prize is most successful when it touches a large and diverse audience.

5. CERI Prize Recommendations

The following section is a result of the feedback that the author received during meetings with area energy experts, local officials, and participants in the Centennial Challenges Program. The opinions do not necessarily represent those of the author.

5.1 Scale of Operation

A key issue for CERI is the startup effort involved in garnering a solid reputation. This means deciding whether a "larger prize" with greater implications would be desirable or rather a series of "small" prizes to ramp up the reputation of CERI. The terms large and small assume that the amount of the prize offered is directly related and proportional to the technological advance.

A key issue for CERI is the startup effort involved in garnering a solid reputation. This means deciding whether a "larger prize" with greater implications would be desirable or rather a series of "small" prizes to ramp up the reputation of CERI.

Starting with a large prize may harm CERI if the prize is never won, if the prize is won after an extended period of time thus postponing CERI's growth and reputation, or if the prize is widely considered unobtainable and garners limited interest. By the same token, a large prize can have the opposite effect if it offers a significant breakthrough in a timely manner.

Smaller prizes offer less risk and increase the chances for rapid success. A small prize might not gain the notoriety of an X Prize, but may advance the agenda of CERI to the point that such a larger prize soon becomes more feasible. Small prizes could also prove to be ineffective and have a diminished appreciation for CERI's broader agenda.

Given these advantages and disadvantages, most people agreed that smaller prizes would be more appropriate in the initial stages of the program at CERI. The prizes should also approach a broad audience and promote growth in areas ranging from schools to industry.

5.2 Prize Scope

It was widely agreed that the possibilities for energy prizes may extend beyond the simple propositions such as flying across the Atlantic Ocean. Some technologies may need to be developed individually while other prizes could offer a goal such as efficiency improvement or storage capability. It is important to determine what the broader general goal of a prize is and to keep that in mind, while not permitting preconceptions to exclude out-of-the-box approaches. An easy error for the X Prize would have been to make the prize for a reusable "rocket" going into space. The "rocket" stipulation could have precluded development of Spaceship One, inadvertently delaying the breakthrough and elevating costs.

The conversation consensus is that the prize needs to be as large as possible. This would attract more entries, including more non-traditional entries into a competition increasing the probability that one may turn out to be the unconventional innovator (the John Harrison type) of the energy field.

5.3 Prize Financing

One of the conclusions reached in addressing financing of the prize is that it would be better to approach corporations and industries for funding on the basis of their self interest. Forward-thinking companies in an area touched by a prize breakthrough will be most interested in funding specific ideas. It would be best for CERI to first decide a prize scope and establish a reputation on its own in order to have more "pull" before contacting these entities.

Forward-thinking companies in an area touched by a prize breakthrough will be most interested in funding specific ideas.

The most abundant source to get a large prize funded could be the Department of Energy (DOE) of the federal government. In order to get the DOE's attention for funding it may be necessary to rally political support of several reputable entities.

Smaller prizes to get the program going could be

funded by a combination of state or local governments as well as for-profit and non-profit groups. These entities would have an interest in funding a prize, particularly if it benefited their constituencies. An interesting side-note to funding is determining the amount of a prize. There were few people that had a particular insight into determining a formula for the most efficient prize purse; most reached the conclusion that it will vary across a range. Too large of a prize purse may make funding difficult and draw in corporations that could "overpower" competition with their superior resources. Too small of a prize may not create the needed incentive or be effective to induce wide and aggressive participation. Several representatives of major aerospace companies indicated at the NASA Centennial Challenges Program that it may take prizes as large as eight figures for a company like Lockheed or Boeing to enter a prize competition. At the same conference, Jim Benson, an entrepreneur and founder of SpaceDev Corp., indicated that a prize should be approximately 1/5 of the cost that the project would require if pursued in the more traditional sense.

Too large of a prize purse may make funding difficult and draw in corporations that could "overpower" competition with their superior resources.

5.4 Prize Suggestions

The following is a preliminary list of prize suggestions that were gathered through various sources. The ideas are preliminary, giving more of a preliminary direction than a developed idea.

- Net-Zero Home – An idea brought up several times involves the construction of a home that has a "net-zero" rating for pollution and/or external energy needs. The project is already being pursued by several companies in the state and is the subject of a major Department of Energy funding. Sources indicated that the DOE may be willing to put some money up for a prize for net-zero housing. The contest is appropriate for Colorado due to its abundance of natural resource options.

- Power Storage – This is a broad category, but has many applications. Possibilities include residential units to store power that is generated onsite and can be tapped at peak times. An industrial application could involve storage units at power plants in order to decrease wasted energy and eliminate the need for off-site peak plants. Commercial applications could involve battery technology. NASA has expressed interest in this area in its Centennial challenges Program. It is possible that a single prize could be offered that would allow for an application in all areas; in this case it would just be a matter of scaling the technology.

- Alternative Energy Vehicle Challenge – An electric vehicle challenge was brought up several times to capitalize on the excitement and attention that a same-site competition brings. Possibilities include a race across Colorado utilizing a variety of non-traditional energy technologies. The contest could also draw an auto-manufacturing market to Colorado in the same way that Saturn has shifted some of the manufacturing to Tennessee.

- Wind Energy Storage – The possibility of using depleted, underground oil "pockets" to store off-peak wind-generated energy, possibly in the form of compressed air, for use during times of high demand, was mentioned as an application that would be particularly viable in Colorado. The prize would require the development of a method and mechanism to convert wind energy into a storable form and then be able to draw on it from the underground storage site. Other wind technologies mentioned include low-speed turbines that would allow for wind energy to become feasible in non-traditional regions.

- E-85 Proliferation – One source estimated that one-third of all new cars are (manufac-

tures are motivated by tax-breaks) retrofitted for compatibility with E-85 fuel (85% ethanol and 15% petroleum). This change is due to a Congressionally-issued tax incentive to auto-manufacturers to produce such vehicles. The problem is that gas stations lack the incentive to install equipment for distribution of E-85. A prize could be issued for the design of inexpensive, retrofitting equipment to make the market more attractive for these companies. A possible source of funding for such a prize could come from farmers and farmer unions.

- Truck Idling Energy Reduction – This technology would reduce the energy waste and pollution caused by semi-trucks when they are parked. In order to operate the air-conditioning and other amenities in the cabs of trucks, drivers leave the engine idling overnight. A prize could be offered to come up with an alternative, possibly renewable, way of powering such a system. One study found that the average truck spends $2,200 per year in such practices. The Department of Energy has currently funding a $500,000 to study of ways to reduce truck idling.

- Solar Cell Advance – Currently, commercially ready solar cells are only about 15% efficient. One of the key factors in their inefficiency is that they are not able to convert the full spectrum of light. A potential prize could be offered either to increase the spectral conversion range or to otherwise advance their overall efficiency by a specified percentage. This prize is attractive in that results are easily measurable. The input and output of a solar cell can be measured by current methods.

6. Conclusions

1. Historically prizes have brought non-traditional technology into the mainstream.

   John Harrison and his clock, Lindbergh and his single-engine plane, and Rutan and Spaceship One are just several examples of how the unthinkable has become a reality. Prizes solicit an audience that is not reached by traditional methods of grants and contracting.

2. Prizes have economic benefits that exceed those of traditional grants and contracts.

   Prizes have had a documented success at leveraging the initial investment by as much as 40 times. The New Growth Theory of economics relates a higher investment to a higher pace of technological advance. Whether on subscribes to this theory or not, most individuals would jump at the chance to have as much as 40 times the work done as the amount personally invested.

   Besides leveraging advantages, prizes are perfectly efficient minus overhead costs. A prize is not awarded unless a competitor can prove that the goal that was set out has been achieved.

3. Due to inexperience in prizes, consideration must be given to all administrative details associated with their implementation.

   The CATS Prize is an example of efforts that have for the most part faded into obscurity. Few at the NASA Centennial Challenges Conference had even heard of the prize, much less given serious thought to competing. This can largely be attributed to administrative fumbling. Prizes must be administered with great consideration for all of the aspects that such a competition encompasses. Much of this research has shown that there is a strong relationship between prize variables that must be maximized in order to achieve efficiency

and avoid potentially costly complications. The success of the X Prize makes it an ideal model to use a guideline for developing a modern prize.

4. The use of high visibility prize competitions is increasing and gaining public recognition.

The X Prize has done a lot to bring the prospect of prizes back into public light. Since the prize's inception, the federal government has done extensive several studies to determine the effectiveness of such prizes. DARPA was the first government agency to implement such a system, and one is currently being constructed at NASA through the Centennial Challenges Program. These programs, with the addition of the Aldridge Report recommendations, cite prizes as an effective way to create a more robust market for their particular technology and encourage their implementation.

7. References

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- Villard, H.S., *Contact! The Story of the Early Birds*. Thomas Crowell. New York, 1968.

- Information regarding the Orteig Prize, Ansari X Prize, DARPA Grand Challenge, and NASA Centennial Challenges Program was in part gathered, respectively, at the following websites:

  http://www.charleslindbergh.com

  http:// www.xprize.org

  http://www.darpa.mil/grandchallenge

  http://centennialchallenges.nasa.gov

Appendix

A.1 National Academy of Engineers 1999 Report Recommendations

1. The steering committee recommends limited experiments in the use of federally sponsored inducement prize contests to stimulate private-sector research, innovation, and technology deployment in service of agency and societal goals.

   Specifically, the committee recommends that Congress encourage federal agencies to study further the feasibility of inducement prize contests as a potential complement to their existing portfolio of science and technology policy instruments. In addition, Congress should consider providing explicit statutory authority and, where appropriate, credible funding mechanisms for agencies to sponsor and/or fund such contests.

   It is important to note that the purpose of these experiments would be to test the effectiveness of prizes and contests as complements to—not replacements for—traditional R&D grants and procurement contracts.
2. Both Congress and federal agencies are

encouraged to take a flexible approach to the design and administration of inducement prize contests.

Prize contests can be agency funded and administered; agency administered and privately funded; agency initiated and privately funded and administered; or joint agency-private sector funded and administered. Prize contest rules must be seen as transparent, simple, fair, and unbiased. Prize rewards must be commensurate with the effort required and goals sought. Moreover, prize contest designs should include mechanisms for appropriating prize money, for flexibly distributing intellectual property rights, and for reducing political influence.

3. Given its experimental nature, the use of prizes and contests should be accompanied by a mechanism for evaluation and a time limit.

   The use of inducement prize contests should be evaluated at specified intervals by the agencies involved to determine their effectiveness and impact.

A.2 Aldridge Report Recommendations

- Congress increase the potential for commercial opportunities related to the national space exploration vision by providing incentives for entrepreneurial investment in space, by creating significant monetary prizes for the accomplishment of space missions and/or technology developments and by assuring appropriate property rights for those who seek to develop space resources and infrastructure.

  For example, we are persuaded that the award of significant monetary "prizes" tied directly to the vision plan will spark entrepreneurial investment globally and accelerate the development of technologies and systems that enable travel to the Moon and Mars. In our hearings, the Commission also heard from state governments that are prepared to invest in America's space infrastructure, if those investments can be appropriately tied to their own economic growth.

- The Commission heard testimony from a variety of sources commenting on the value of prizes for the achievement of technology breakthroughs. Examples of the success of such an approach include the Orteig Prize, collected by Charles Lindbergh for his solo flight to Europe, and the current X-Prize for human suborbital flight. It is estimated that over $400 million has been invested in developing technology by the X-Prize competitors that will vie for a $10 million prize – a 40-to-1 payoff for technology.

- The Commission strongly supports the Centennial Challenge program recently established by NASA. This program provides up to $50 million in any given fiscal year for the payment of cash prizes for advancement of space or aeronautical technologies, with no single prize in excess of $10 million without the approval of the NASA Administrator. The focus of cash prizes should be on maturing the enabling technologies associated with the vision. NASA should expand its Centennial prize program to encourage entrepreneurs and risk-takers to undertake major space missions.

  Given the complexity and challenges of the new vision, the Commission suggests that a more substantial prize might be appropriate to accelerate the development of enabling technologies. As an example of a particularly challenging prize concept, $100 million to $1 billion could be offered to the first organization to place humans on the Moon and sustain them for a fixed period before they return to Earth. The Commission sug-

gests that more substantial prize programs be considered and, if found appropriate, NASA should work with the Congress to develop how the funding for such a prize would be provided.

- The Commission recommends that Congress increase the potential for commercial opportunities related to the national space exploration vision by providing incentives for entrepreneurial investment in space, by creating significant monetary prizes for the accomplishment of space missions and/or technology developments and by assuring appropriate property rights for those who seek to develop space resources and infrastructure.

A.3 Additional Prize Descriptions taken from the 1999 National Academy of Engineers Report

FCC Pioneer's Preference Program
In 1991, the U.S. Federal Communications Commission (FCC) offered what amounted to a technology prize. It offered guaranteed slices of the telecommunications spectrum to companies that committed to developing and implementing innovative communications services and technologies—particularly in the areas of wireless personal communications services (PCS) and low-earth-orbit (LEO) communications. In October 1992, the FCC tentatively granted pioneer's preferences to three companies.

The program made a certain sense in an era when spectrum allocations were based on either administrative decisions or lotteries. The FCC recognized that companies would not develop expensive new technologies unless they had some assurance that they would receive licenses and thus be able to recoup their investments. The pioneer's preference program sought to give those assured licenses in return for credible commitments to develop and deploy the innovative technologies.

However, in 1993 Congress sought new sources of government revenue and authorized the FCC to hold auctions of telecommunications frequencies. A market quickly developed for those parts of the spectrum subject to auctions. That market, in turn, raised serious questions for the preference program. Was it still necessary or fair to give preferences in an era when other companies, including innovative companies, would pay for their licenses? Even before the auctions, companies denied pioneer's preferences complained that the program gave unfair economic advantage to a few. Those complaints grew after the auctions began. The FCC planned to terminate the program in September 1998, but a new act of Congress led to its termination in September 1997.

Energy-efficient Appliances
In 1992, 24 major American utility firms created a new nonprofit corporation, the Super Efficient Refrigerator Program (SERP). The utilities pooled together $30 million as a reward to the manufacturer that could develop and successfully market a refrigerator which used at least 25 percent less energy than required by existing regulations. An interesting feature of this contest was the stipulation that part of the prize money would be awarded for each refrigerator sold—an inducement not only to develop but also to market the new product. Whirlpool Corporation won the contest and did indeed manufacture and market a super-efficient refrigerator. However, as energy prices fell during the 1990s, no large market developed for this product. Whirlpool eventually discontinued the refrigerator—although it continues to market products with moderate energy efficiency. This case illustrates three points: (1) a sizable prize can indeed induce innovation, (2) tying prize money to sales can encourage the production of an innovative product, and (3) even the most well-designed program will encounter problems if the marketplace changes and demand for a product falls.

Malcolm Baldrige Quality Awards
Congress established the Baldrige Awards program in 1987 to recognize U.S. companies for their achievements in quality and business performance

and to raise awareness about the importance of quality and performance excellence as a competitive edge. There is no cash prize, but there is prestige. While this is a primarily a recognition prize, it also serves as an inducement for firms to adopt the techniques of total quality management. Many companies have upgraded their quality programs in the hope of being considered for the awards. The program is a public-private partnership: applicant fees and a privately funded foundation pay for the reviews, but the Commerce Department is involved in the final judgments and the President traditionally makes the awards. The Baldrige program shows that monetary awards are not necessary to have a successful contest, provided that the awards are prestigious and make good economic sense for the applicants.

International Computer Go Championship
This prize offers 40,000,000 Taiwanese dollars (about $1.6 million in U.S. currency) for any computer program that can beat a professional player at the oriental game of Go. The sponsors are the computer company Acer and the Ing Chang-Ki Wei-Ch'i Education Foundation of Taipei. They also sponsor annual contests that award NT$200,000 (about U.S. $8,000) for the best computer program for Go entered that year.

Loebner Prize
In 1990 Dr. Hugh Loebner pledged a grand prize of $100,000 and a gold medal for the first computer whose responses were indistinguishable from a human's. Every year an annual prize of $2,000 and a bronze medal are awarded to the "most human" computer. The winner of the annual contest is the best entry relative to other entries that year, regardless of how good it is in an absolute sense. The contest was inspired by mathematician Alan Turing, who asked, "Can a machine think?" Turing's suggestion was this: If the responses from a computer were indistinguishable from those of a human, then the computer could be said to be thinking. No one has won the grand prize to date.

EFF Cooperative Computing Challenge
On March 31, 1999, the Electronic Frontier Foundation (EFF) announced prizes up to $250,000 for the discovery of large new prime numbers. According to EFF's press release:
The first million-digit prime found will be worth $50,000; a ten-million-digit prime will claim $100,000; a hundred-million-digit prime garners $150,000; and the finder of the first billion-digit prime will receive $250,000. The largest known prime number has 909,526 digits.

The prizes are designed to encourage cooperative computing. No single supercomputer is likely to solve this problem soon, but large numbers of personal computers linked through the Internet could tackle the problem. "In the process," according to the EFF press release, "EFF hopes to inspire experts to apply collaborative computing to large problems, and thereby foster new technologies and opportunities for everyone."

Feynman Prizes
The Foresight Institute, a nonprofit educational foundation in Palo Alto, California, offers a set of prizes named for the late physicist Richard Feynman. These prizes encourage and reward scientific and technical progress in the field of nanotechnology, which the Institute defines as "the coming ability to build materials and products with atomic precision."

The grand prize will be at least $250,000 and will be awarded for the demonstration of a 50-nanometer 8-bit adder and a 100-nanometer robot arm. Starting in 1997, the Institute awards two $5,000 prizes each year—one for the best work published in recent years on experimental aspects of nanotechnology, and one for the best theoretical work of recent years. The Institute will award annual prizes until someone wins the grand prize, at which point the series of annual prizes will end.

EU Information Technology Prize
The annual European Information Society Technology (IST) Prize is organized jointly by the IST program of the European Commission 's DG

XIII and Euro-CASE, the European Council of Applied Sciences and Engineering. The contest is open to companies, laboratories, universities, and others in Europe and Israel. Each year, three grand prizes are awarded (200,000 euros and a trophy) and 25 winner prizes are awarded (5,000 euros and a certificate). Unlike most of the contests described above, this one does not have a precise technical objective. The prize's Web page states that awards "are made for outstanding contributions to generating and converting innovative ideas and R&D results into marketable products. "

The IST Prize can be labeled a combination inducement/recognition award. Along with the recognition of past efforts, this contest also encourages European researchers to develop new technologies. The program then tries to help winning researchers refine and market their products by publicizing the results and providing what the Web page calls a "blue-chip reference for all stakeholders, whether upstream financiers or downstream customers."

Wolfskehl Prize for Proving Fermat's Last Theorem
Inducement prizes can be offered to encourage advances in science and mathematics as well as technology. The prize was created in 1908 to reward whomsoever could prove Fermat's Last Theorem. The 17th century French mathematician Pierre de Fermat argued, in what became known as his Last Theorem, that the equation xn+ yn=zn has no whole number solutions for n greater than 2. Paul Wolfskehl, a German industrialist, had an interest in mathematics, and upon his death in 1908 his will bequeathed a large portion of his fortune for the prize.[14]

Initially, the prize attracted few ideas from serious mathematicians, since the problem has longed seemed difficult, even a lost cause. However, the prize did attract a whole new audience of eager amateurs, none of whom succeeded. In the early 1990s, British-born Princeton professor Andrew Wiles began an eight-year intensive effort to prove the theorem. He finally succeeded, and on June 17, 1997, Wiles collected the Wolfskehl Prize, worth $50,000.

A.4 Prize Organization Considerations

Prize Concept

1. What is the success rate of prizes?
2. Who has been involved in prize competitions before?
3. Are prizes more successful in certain fields?
4. Are there any precedents in the energy field to derive a model from?
5. Is there active competition amongst prizes offered by different conglomerates?
6. Should there be a deadline?
7. Would the prize still be offered after the deadline in a lesser amount?
8. Should there be incremental prizes for accomplishing different steps involved in the main prize?
9. Who should the prize target?
   - University faculty
   - Field researchers
   - Hobbyists
   - General public
10. Is the prize announced before or after funding has been raised?
11. Are the final rules announced before or after funding has been raised?
12. Will the prize be annual or a one-shot deal?
13. Does CERI want to offer one prize at a time or have several going on simultaneously?
14. Who will hold on to the intellectual property rights of the designs?
    - 2% agreement?
15. Will interested competitors be required to pay an entry fee?
    - How much?
    - Possibly screen out the less serious applicants to maximize efficiency of materials/ funds?
16. Is it possible to implement prize with another already established prize?
17. Who solicits prize ideas?
18. Who determines what prize ideas are acceptable?

- CERI?
- Sponsors?
- Colorado School of Mines?
- Appointed Board?

19. Could there be much smaller prizes for prize suggestions?
    - e.g, modestly reward those with innovative prize ideas
20. What additional legal issues are involved beyond liability and IP rights?

Financing of the Prize

1. Where does the money for the governing program come from?
2. Is the amount of a prize commensurate with technological innovation?
3. How does the value of a prize compare with administrative fees?
4. Who retains tax responsibility for the prize?
5. Are competitors able to use industrial bonds in financing their projects? (see X-Prize)
6. Will a certain business sector be targeted in raising funding?
7. Will the state or federal government be allowed or willing to provide funding?
8. Is the prize system comparable to the lottery system in financing?
9. Will the prize be paid as a lump sum?
10. How will the prize money be retained?
    - Invested? Who gets interest/return?
    - Sponsor makes payout?

Judging

1. Who composes the judging committee?
2. Will the judges be constant or selected for each prize?
3. What are the qualifications of the judges?
4. Is the judges committee ruling subject to appeal?
5. Does the judging committee also dictate the rules for competition?
6. How active are the judges in the design/idea process?
7. What are the limitations of contact between judges and competitors?
8. If judges interact with competitors will they be required to sign a confidentiality agreement?
9. Must competitors be informed of the judges identity and qualifications?
10. How will judges be compensated for their work and efforts?

Competitors

1. Do competitors generally suffer a capital loss in financing the project?
2. How do competitors raise funding for their efforts?
3. Is the public sector generally supportive of such efforts?
4. How effective is a web board in communicating ideas?
    - Should there be password protection?
    - Should there be a separate forum for the media and the public?
5. What motivates competitors to seek prize?
6. What is the liability of the competitors?
    - Is there a way to get group coverage for all competitors?
    - Whose responsibility is that?
7. What are the requirements for competitors to register?
8. Will the competition be international or domestic?
9. What are the limitations on the usage of government-funded ideas, products, designs, etc.?
10. How will government designs be restricted and monitored from being a part of the competition?
11. How do competitors register for the prize competition?
12. Will there need to be notification prior to final testing?
13. Are progress reports required from the competitors?
    - How will this be monitored?

Public Relations

1. Should CERI hold workshops as a forum for competitors?

2. What is the involvement of the media?
   • What form of media is the most efficient?
   • What form of media is the most advantageous?
3. How do you get the public excited about energy development?
4. What is the role of public attention in accomplishing the goal of the prize?
5. Is there a way to place volunteers/enthusiasts with the competitors?
6. Merchandising or no?
7. What should the role of a CERI website be?
8. Will logo be required on prototypes?
9. Will promotions seek to boost CERI or the prize being offered?
10. Will the public be able to witness any testing of designs?
11. Will the prize program seek endorsements from outside agencies?
12. How will the importance of the prize be portrayed?
13. Possibility for celebrity endorsements?
14. Seek developmental program in schools to promote prize (see X-Prize EGGS competition)?
15. Is there a possibility for a public competition such as the X-Prize Cup?
16. Should there be an awards banquet for the prize?
17. Should there be a trophy or plaque for the prize?

Endnotes

[1] The X Prize is defined in Section 3.6 on p. 10.
[2]Diamandis, Peter. Centennial Challenges Conference, Washington D.C., June 2004.
[3] The figure for DARPA's leveraging ratio was estimated using the DARPA's statement that $5 million is needed to develop the technology to win the challenge. The figure was reduced to $2 million for estimation purposes with the knowledge that more of the 25 teams had spent under this amount.
[4] Robinson, Peter, "Romer's Radical Approach to Economics," 70.
[5] Diamandis, Peter. Centennial Challenges Conference, Washington D.C., June 2004.
[6]http://www.nsf.gov/sbe/srs/seind04/c4/c4s1.htm#c4s1l2
[7] http://en.wikipedia.org/wiki/Peer_review
[8] http://en.wikipedia.org/wiki/Peer_review
[9] Macauley, Moll K. "Advantages and Disadvantages of Prizes in a Portfolio of Financial Incentives for Space Activities" 8.
[10] Id.
[11] Id.
[12] The prize is roughly the equivalent to $12 million today after being adjusted for inflation and exchange rates.
[13] Dash, Joan, *The Longitude Prize,* 9.
[14] Dash, Joan, "The Longitude Prize, 84.
[15] Harrison was not awarded the full prize until three years before his death in 1776
[16] Prendergrast, Curtis, *The First Aviators*, 85
[17] In the article, "When Will We See the Golden Age of Spaceflight", Gregg Maryniak provides a listing that shows at least 52 prizes offered in aeronautics between 1901 and 1913. Forty-four of these prizes were offered between 1909 and 1913.
[18] Villard, H.S. "Contact! The Story of the Early Birds," 127.
[19] http://www.charleslindbergh.com
[20] Maryniak, Gregg. "When Will We See the Golden Age of Spaceflight." 24.
[21] "Concerning Federally Sponsored Inducement Prizes in Engineering and Science." 7.
[22] Pae, Peter. "In Capital Venture, Rocket Reaches the Edge of Space." 1.
[23] Id.
[24] http://www.xprize.org
[25]The President's Commission on Implementation of United States Space Exploration Policy, June, 2004. 32.
[26]Pae, Peter, "In Capital Venture, Rocket Reaches the Edge of Space." 1.
[27] www.xprize.org
[28] DARPA was the only modern prize to specify tax responsibility of the prize purse by placing it on the winning team.
[29] http://www.darpa.mil/grandchallenge
[30] Id.
[31] "Concerning Federally Sponsored Inducement

Prizes in Engineering and Science." 1.
[32]The President's Commission on Implementation of United States Space Exploration Policy. June, 2004. 33.
[33] http://centennialchallenges.nasa.gov