

PRIZES AS A MEANS
TO FOSTER INNOVATION:
A CASE STUDY ANALYSIS

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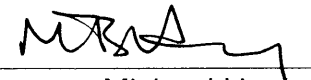
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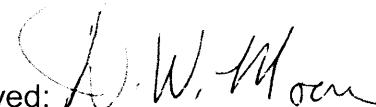
A thesis submitted to the Faculty and Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science of Engineering and Technology Management

Golden, Colorado

Date 4/10/07


Signed: 
Alexander N. Schroeder

Approved: 
Michael Heeley
Thesis Advisor

Approved: 
David Moore
Thesis Advisor

Golden, Colorado

Date 4/12/07


Roderick Eggert
Professor and Division Director
Division of Economics and Business

ABSTRACT

The purpose of this thesis is to determine the criteria administrators considered when conducting an inducement prize. Prior theoretical work put forth by Wright (1983), Kremer (1998 and 2000), Davis (2004), and Newell and Wilson (2005) were used to develop a set of propositions that provided a theoretical baseline. The research propositions were evaluated through a case study analysis to determine the level of correlation between theory and real world examples and also identify any additional criteria that were found in the case studies, but not present in the studied literature. The propositions fell into the categories of organization type and prize objectives, knowledge of costs and market opportunities, funding, participant eligibility requirements, visibility and market transformation, political climate, and prize competition parameters. The Super Efficient Refrigerator Project (SERP), the Ansari X Prize, and the DARPA Grand Challenges were selected as the three cases to be studied and were mapped according to the propositions. Overall, the propositions put forth in the literature review were supported by these case studies. The main goals of the prizes studied were found to be market development and transformation, public exposure and education, information gathering, and regulatory influence/compliance.

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I would like to dedicate this thesis to the memory of my father, the man that could do everything he set his mind to and do it with unassuming modesty. You taught me so much and I still have a lot to learn from you.

CHAPTER 1

INTRODUCTION

This thesis examines the use of incentive prizes and the selection criteria that administrators consider when selecting prizes as the method of procuring innovation. Previously identified criteria were examined and expanded upon to the motivations and considerations behind an administrator's choice to offer a prize. This expanded set of criteria will allow an administrator to make a more informed decision on whether or not prizes are an appropriate medium for stimulating innovation and satisfying particular goals. This is accomplished through a literature review and case study analysis of the Super Efficiency Refrigerator Project (SERP), the Ansari X Prize, and the DARPA Grand Challenges. The analysis contributes to the research on innovative mechanisms in the following ways:

- An expanded view of when prizes can contribute to the advancement of technology.
- A comprehensive set of case studies that consolidate previous literature with additional information and analysis to bring forth new insights. This includes the identification of new or modified decision criteria that emerges from the case studies.
- A determination on the level of correlation between real-world applications and theory.
- The identification of future research topics.

The discussion of incentive prizes as an effective method to spur innovation dates back to the 1800's with prominent English politicians and economists championing the approach (Shavell and Van Ypersele, 2001). Despite this early push, academic research on innovative mechanisms has since

been devoted primarily to patents with a few relatively recent exceptions that highlight the merits of prizes (e.g. Wright, 1983; DeLaat, 1996). An examination of where prizes are the method of procurement reveals that, while neglected by scholars, prizes have been very active in encouraging many innovations that may have been out of the reach of more traditional methods. Notably, prizes are responsible for the advent of the chronometer, canned food, early developments in inorganic chemistry, many of the advances in early aviation including Lindbergh's Trans-Atlantic flight, and recently the development of the first privately built spacecraft.¹ Several of the more recent accomplishments have prompted the federal government to further study the utility of prizes and commence prize programs at both agencies such as the National Aeronautics and Space Administration (NASA) and the Defense Advanced Research Projects Agency (DARPA).

In general, prizes can be separated into two different categories: recognition prizes and incentive prizes. Recognition prizes are given as a reward or honor for an individual or team's work in a particular field or circumstance. Prizes of this nature generally involve an application process and the submission of previously completed work(s) to qualify for consideration of the award. Some familiar examples of recognition prizes include the Nobel Prize and the Presidential Medal of Honor. Prizes of this nature have undoubtedly had an effect on encouraging research and development activities, but are awarded *ex post*, which makes it difficult to develop a concrete connection between a researcher's intentions and the recognition prize. Accordingly, recognition prizes are not considered in this thesis.

Incentive prizes, also referred to as inducement prizes, set a specific objective and award entities that achieve this objective. An incentive prize works

¹ For more information on some of these prizes see, for example:
<http://www.xprize.org>
Lindbergh, Charles. *The Spirit of St. Louis*. Charles Scribner Publishing, 1953.
Dash, Joan. *The Longitude Prize*. Farrar, Straus and Giroux, 2000.

under essentially the same principles as a recognition prize, but in the opposite order. Incentive prizes have been administered in a variety of different ways, but typically involve a set objective, some form of guidelines and rules, an ex-ante prize amount, and a judging committee to validate the achievement of the objective.

In 1999, the National Academy of Engineers concluded that the continued and expanded use of incentive prizes, under the right context, can complement existing mechanisms to increase innovative research and development in particular markets. An examination of both existing academic research and successful incentive prize programs helps to shed light on some of the unique features that prizes present in comparison to more traditional procurement methods such as patents and contracts.

The connection between the existing theoretical framework and the actual criteria that prize administrators consider when offering prizes is a subject area where little research has been done to either validate or expand upon. Wright (1983) constructed an economic model in which the merits of prizes, patents, and contracts were judged on the basis of net social welfare. Wright's economic model of procurement decisions is, by his own admission, dependent upon many strict assumptions which may or may not translate to real world conditions. One of his major assumptions is that research is to be stimulated by a public entity, which under his definition, operates with the goal of maximizing net social welfare. In this analysis, the distinction is made between the government (referred to as a public entity), which seeks to maximize net social welfare and non-government entities, which are assumed have other motivations (and is referred to as a private entity).

In reality, several of the most recent prize competitions (e.g. the X Prize) have been funded privately with myriad goals and noteworthy results. This thesis

addresses such discrepancies and introduces new criteria through a comparison of the theory of prizes with actual incentive prize programs.

Given the publicized results of recent prize programs, it was hypothesized that prizes, relative to patents and contracts, will produce unique outcomes that administrators consider when determining that a prize is the preferred method of procurement. The following literature review identifies the theoretical work that has been completed to this end.

CHAPTER 2

LITERATURE REVIEW

The recent record of procuring research and development is dominated by patents and contracts as the incentives of choice in driving innovation. The application and analyses of patents and awarding contracts have been documented extensively in academia and reached some level of maturity in their theoretical development. Both processes have been very successful at contributing in specific innovative environments, but are often regarded as the optimal method to procure research without regard for alternatives (Wright, 1983). Papers published in the last 25 years have shown that patents and contracts may indeed be optimal in particular situations, but that under certain conditions incentive prizes create a more effective approach (see Wright, 1983; Kremer, 2000; Shavell and Van Ypersele, 2001; Gallini and Scotchmer, 2002; and Davis 2004).

While most research concedes that patents potentially have an informational advantage over prizes, there is a tradeoff between this and several fundamental restrictions on the efficiency of patents. Patents use market forces and knowledge of prior research to provide an accurate ex post valuation. This advantage can be offset by the common pool problem and deadweight loss, which is an inherent flaw in patents (Wright, 1983). Dixit (1988) asserts that an award, or incentive prize, can be an effective policy instrument to mitigate these effects.²

² This is not to say that patents, contracts, and prizes are mutually exclusive. Indeed, one of the stipulations of an incentive prize may include certain intellectual property rights or future contract opportunities. The interaction between hybrid prize/patent/contract systems is looked at in Shavell and Van Ypersele (2001)

Prior research illustrates that allocative problems create inefficiencies in procuring research whether it be through patents, contracts, or prizes. Wright (1983) proposed the three previously mentioned categories of patents, contracts, and prizes as being the most common methods of providing a public stimulus towards R&D. He constructed a model to evaluate the relative merits of each of these approaches by building its criteria around three principle allocative problems in public market intervention: lack of appropriability of knowledge, deadweight loss, and the common pool problem. These three factors all create inefficiencies in the output social welfare of a given incentive.

The common pool problem occurs if an entity acts selfishly in protecting innovations and depleting resources that would produce greater societal benefits under a certain degree of coordination with rivals. When defining the context for the common pool problem, it is implicit that the resources are necessary, scarce, and must be accessed from a common source.

Deadweight loss is incurred by inferred monopoly pricing privileges on the part of a patent holder. Accordingly, an innovator can set the market equilibrium at a level that is not Pareto Optimal (at least one individual can not be made better off without adversely affecting others). Deadweight loss can be affected if the patent holder does not know how to realize the full value of the patent (due to lack of market and application knowledge, for example) and another able firm is prevented by the patent from maximizing its social value. In contracts and prizes, deadweight loss can occur through administrative and overhead costs.

Appropriability of knowledge refers to inherent restrictions on knowledge generated in a particular research effort that prevents an innovator from capturing the full value of an idea or invention. In other words, a patent holder will not likely have knowledge of all potential applications for a specific patent and the regulations that surround a patent prevent others from realizing these applications.

In his model, Wright offers two cases. In the first case, researchers and administrators have identical, or symmetric, knowledge of benefits and costs. In the second case, there is asymmetric information between the administrators and researchers, which is defined by a probability distribution. The output of the model is organized into a set of scenarios where the net loss caused by the preceding allocative problems is minimized for patents, prizes, or contracts. The points where allocative problems are minimized corresponds to a local maximum of net social welfare.³

A comparison of Wright's two models reveals that in the case of symmetric public knowledge of an innovation, there is no conclusive evidence towards criteria for a best procurement mechanism; the deadweight loss produced by patents renders them always inferior to prizes and contracts. In the second scenario, the model reveals that an optimal choice for procurement can be found only when the private sector (or someone other than the administrator) has some amount of exclusive information. Wright explains this result by noting that an administrator would be able to adjust the value of a patent or prize to a level that would lead researchers to act as though the knowledge is symmetric.⁴

When the administrator has exclusive information, contracts are superior to both patents and prizes when there is a high probability of success and the supply of research is moderately elastic. If these conditions are not met, the choice between patents and prizes is dependent on the extent to which a patent incorporates ex-post informational advantages (as described earlier) to minimize deadweight loss.

³ Wright calculates maximum net social welfare as the lowest ratio of social loss to social benefit in terms of probability of success and the elasticity of research supply.

⁴ In the case of a patent, the administrator could adjust the length of the patent to affect its value. A Prize administrator would simply adjust the value of the prize.

The following is a summary of Wright's conclusions on the optimal procurement method in the case of exclusive public information:

- Prizes are likely to be the optimal procurement method for projects with an intermediate probability of success and inelastic supply of research.
- Patents are often optimal when the probability of success is low and supply elasticity is moderately low.
- Contracts should be used for activities that are routine in other markets where supply of research is fairly elastic and the probability of success is high.

Wright's paper provided the foundation for future work that presents information asymmetry as a key variable in determining whether prizes, patents, or contracts emerge as the optimal procurement method. Several authors have built upon Wright's work to assess the benefits of a hybrid patent-prize incentive program and further investigate how more general issues of intellectual property pertain to the choice for procurement (see deLaat, 1996; Kremer, 1998 and 2000; Shavell and Van Ypersele, 2001; Gallini and Scotchmer, 2002; and Davis 2004).

Beyond some of the more theoretical work, a series of papers written by Kremer (1998 and 2000) offer several practical solutions to mitigate the allocative inefficiencies that Wright identified. The papers, written for the World Health Organization (WHO), discuss a method to develop and distribute vaccines through pre-negotiated purchase agreements. These purchase agreements are analogous to a more traditional cash incentive prize, but seek to rectify informational asymmetry through a market adjusted (ex-post) valuation of the innovation. Following a similar line of thought, Kremer (1998) also proposed hybrid patent-prize competitions, which would auction off the intellectual property.

Kremer proposed that researchers would be asked to develop a particular vaccine and the resulting intellectual property would then be auctioned off to governments for placement in that country's public domain. Kremer justifies his proposed scheme of patent buyouts through several fundamental features of the pharmaceutical industry:

- Markets would be relatively competitive in the absence of patents
- Monopoly markups are large
- Drugs are non-durable
- Considerable information is generated during FDA trials
- Inventing around patents is a common

Kremer argues that the combination of these approaches further minimizes allocative problems and makes the use of incentive prizes more attractive. This expands upon Wright's model, which assumes patents, prizes, and contracts as being mutually exclusive. In his work Kremer incorporates many of Wright's decision criteria and also introduces funding sources, competition parameters as additional criteria.

Newell and Wilson (2005) follow Kremer's industry specific approach and posit that the use of prizes to address controversial topics like greenhouse gas regulation can help to sidestep political stalemates. The concept involves incentivizing technologies that would reduce GHG emissions to induce a market-based technology that produced the same effect as GHG limiting legislation. Newell and Wilson go on to discuss the importance of prize design in ensuring success. The authors constructed their underlying framework around Wright's model and put forth political concerns and institutional setting as decision criteria.

Davis (2004) takes an even more practical look at prizes than Kremer and conducts case studies to examine three prizes offered in the 20th century. Besides many of the decision criteria discussed by Wright and Kremer, Davis

introduces spillover effects, reputational gains, and participant requirements as necessary considerations. While Davis' case studies are insightful, they lack a rigorous framework and rely on historical documentation as the sole source of evidence.

The combination of Wright (1983), Kremer (1998 and 2000), Davis (2004), and Newell and Wilson's (2005) papers, along with other literature, provides a useful roadmap for understanding and addressing the theoretical criteria considered when determining whether or not to offer a prize. The criteria put forth in each of these respective papers served as mapping criteria for this thesis, which will be explained in the following methodology section.

CHAPTER 3

RESEARCH METHODOLOGY

Given the objective of the thesis, the scope of existing literature, and indeterminate quantifiable data, the case study method was used as the framework for analysis. The case study approach is advocated when research is focused on a contemporary phenomenon within some real-life context (Yin, 2003). This thesis does just that by seeking to identify a connection between the selection criteria that is considered by administrators and that posed by previous literature when determining that prizes are the preferred method of procurement.

A case study protocol was designed to create consistency in how the case studies were approached so that valid and meaningful results would come out of their analysis. The case study protocol provides a "cookie cutter" that can be laid over the cases being examined to produce uniform results. It consists of a set of field procedures, case questions, and an outline for the case study reports (Yin, 2003).

The initial theory outlined in the previous literature review guided the case selection criteria and initial data gathering. The cases were mapped using propositions that stemmed from the literature view. These propositions allowed for the cases to be compared and contrasted in an integrated case analysis (see the end of this section for the full table of propositions). The integrated analysis was used to draw broad conclusions from the cases about the criteria that prize administrators considered and provided a baseline for comparison with existing theory.

The detailed framework posed by Yin (2003) on how to conduct a multiple case study analysis serves as the benchmark for data collection, analysis, and making connections between the selected cases and existing academic theory. The analysis and data collection of the case studies was focused towards drawing analytical inferences. Data collection was gathered from several sources to reinforce the validity of findings and included an examination of documentation, archival records, and interviews. The interviews were conducted by phone with administrators involved in each of the prizes. The type of information being sought out in all of these sources was guided by the table of propositions to ensure uniform data collection and relevant findings.

The table of propositions used in the case studies were based on the literature review and more specifically, Wright (1983), Kremer (1998 and 2000), Davis (2004), and Newell and Wilson (2005). A summary of the findings in these papers and the resulting propositions can be found in Table 1, which details the case mapping criteria used in this analysis.

Table 1 – Research Propositions

Category	Author(s)	Proposition	Question
Type of Organization	Wright	Government and private entities will have different objectives when considering the use of a prize	What were the public goals of the prize? What other goals existed?
	Kremer, Davis, Newell and Wilson	Prizes are a viable alternative for both public and private entities to achieve their goals	At the time, why were prizes seen as the proper means to accomplish the particular objective for the specific type of entity?

Category	Author(s)	Proposition	Question
Knowledge of Costs and Market Opportunities	Wright	The division of knowledge (asymmetry) on market and cost information between administrators and researchers will influence the choice for procurement	What type of due diligence was conducted prior to arriving at the decision to use a prize?
			How uncertain was the administrator about the market applications and costs of the objective? Did an outside entity have information on this uncertainty? What steps were taken to address the uncertainty?
Funding	Kremer	Public and private entities will have access to different types of funding sources	What types of funding options were considered for the prize? What was the actual source of funding and why?
	Wright, Kremer, Davis, Newell and Wilson	The source of funding will have an influence on how a prize is administered	What was the proportion of overhead cost in administering the prize to the expected benefit of the result?
			How did the funding option chosen effect the administration of the prize?
Participant Eligibility Requirements	Wright	The probability of success of a prize will increase with the size of the participant pool to an upper limit; this upper limit is determined by the common pool problem and the elasticity of supply of research	How were entrants screened?
			What factors were considered when deciding where to target participation in the prize competition?

Category	Author(s)	Proposition	Question
Visibility and Market Transformation	Davis	Prizes create signaling and market visibility, which in turn increases the probability of success	What value did public exposure add to the prize? Was this considered when valuing the prize? Was publicity integral to the success of the prize?
			How was the prize advertised to attract participants?
			What benefits beyond achieving the research goal were considered when making the decision to offer a prize?
		The open-ended nature of prizes creates a market impetus, which may not be achievable by a patent or contract	What type of supporting activities were used to supplement the prize?
			What type of effect did the prize have on the overall market? Would this same effect be possible through patents or contracts?
Political Climate	Newell and Wilson	Political concerns influence the decision to use a prize	Did political influences affect the decision to use a prize?
Prize Competition Parameters	Wright	The value of the prize is related to the value of the innovation, the time limit of the prize competition, knowledge of the market, research, and production costs, and the difficulty of contracting	What was the value of the prize? How was the value of the prize determined?
	Wright	The perceived supply of research had an effect on the time horizon for a prize	What was the length of the prize competition? How was the length of the prize competition determined?
	Davis, Newell and Wilson	The subjectivity of the judging process is a negative drawback in prizes	How was the prize judged?
	Davis	Duplication of effort is more present in prize competitions than other forms of procurement	How was progress monitored?

Category	Author(s)	Proposition	Question
Additional Criteria	N/A	The criteria presented in Wright, Kremer, Newell and Wilson, and Davis is incomplete	What was the administrating body's policy for intellectual property ownership with the participants' entries? How about participant confidentiality?
			What other criteria was considered when deciding to use a prize?

The optimal number of cases to be used in a multiple case study depends on the problem at hand and the information available (Yin, 2003). In order to determine the proper cases for this analysis, the following conditions were specified to increase the likelihood that information would be available, accurate, and provide for a robust cross-analysis:

- 1) The prize must have been offered in the last 15 years
- 2) The prize value must be greater than \$1 million
- 3) The prize competition must have been completed
- 4) There must be a significant amount of publicly accessible data on the prize
- 5) One prize must be administered by the public sector, one by the private sector, and one jointly administered by the public and private sector.

These criteria identified three candidates for prizes to be studied: The Super Efficient Refrigerator Project (SERP), The X Prize, and the DARPA Grand Challenges.

CHAPTER 4

CASE STUDIES

The following cases studies on the Super Efficient Refrigerator Project (SERP), the Ansari X Prize, and the DARPA Grand Challenges were performed . Information was gathered through analysis of archival records, documentation, and telephone interview with prize administrators. Dr. David Goldstein (SERP), Dr. Peter Diamandis (Ansari X Prize), Dr. Tom Strat (DARPA), and Col. Joe Negron (DARPA) participated in telephone interviews to assist in this case study analysis (see Appendix B for a sample questionnaire from these interviews).

4.1 Case Study - The Super Efficient Refrigerator Project

The Super Efficient Refrigerator Project was established in 1991 with the expressed purpose of offering up to \$30 million to an appliance manufacturer that successfully developed, marketed, and distributed a more efficient refrigerator (Sandahl, Ledbetter, Chin, Lewis, and Norling, 1996). The project stemmed out of a collaborative effort between a consortium of electric utilities (listed in appendix III), the Natural Resources Defense Council (NRDC), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the Washington State Energy Office, and the American Council for an Energy Efficient Economy (ACEEE). The formal interaction between these entities and the prize program was facilitated through SERP, Inc., which was created by the utilities specifically to administer the prize (Sandahl, et. al, 1996). SERP Inc. issued a draft request for proposals (RFP) in the spring of 1992 for comment and released the final RFP in July 1992. In its RFP, SERP stated that the \$30 million prize would be awarded on a per-unit sold basis to the appliance manufacturer that produced a refrigerator that was 25% more efficient than the 1993 federal

appliance efficiency standards, was free of Chlorofluorocarbons (CFCs), and had a purchase price comparable to a non-SERP unit.⁵ SERP also required bids to not only propose a design, but to also demonstrate a capability to produce, market, and distribute the appliance on a national level. Part of this requirement was the implementation of a tracking system that would account for the quantity and geographic location of the units sold.

By December of that same year, SERP used a scoring metric provided in its RFP to narrow the field of applicants down to two and required both companies to provide a prototype of their design for testing (Sandahl, et al, 1996). The prototype refrigerators were submitted for a safety review and performance judging, which was conducted by a third-party testing laboratory. On June 29, 1993, less than a year after the final RFP was issued, Whirlpool emerged victorious over Frigidaire as the winner of the SERP prize. Their design was 22 cubic feet, CFC-free, and 29.3% more efficient than 1993 federal standards. By early 1994, Whirlpool's refrigerator was available to consumers (Sandahl, et al, 1996). In May 1995, a second generation of SERP refrigerators was produced by Whirlpool that were 38-41% more efficient than 1993 standards.

In its proposal, Whirlpool committed to selling 250,000 units, but in actuality fell "substantially" short of that goal (Ledbetter, Norling, Edgemon, Parker and Currie, 1999). An exact figure of units sold was not found to be available by previous researchers (Lee and Conger, 1996), but estimates are that fewer than 100,000 units were sold (Gillingham, Newell, and Palmer, 2006). Lackluster sales were attributed to falling electricity prices and insufficient marketing efforts on the part of Whirlpool.

⁵Chlorofluorocarbons are typically used as refrigerants, propellants, and cleaning solvents. Their use was greatly restricted in the Montreal Protocol, which deemed that CFCs contributed to ozone depletion.

4.1.1 Organization Type and Prize Objectives

SERP Incorporated was formed in 1991 as a nonprofit mutual benefit corporation whose board of directors was composed of executives from 24 public and private electric utilities (Sandahl, 1996). Several reasons were documented in a 1996 report by Pacific Northwest Laboratory (PNL) to justify the formation of an independent corporation including:

- No single utility was willing to manage the whole project
- It would allow utilities to keep the SERP effort separate from other demand-side management (DSM) programs that they were participating in
- A centralized organization would facilitate quick decision making
- Limited liability for individual utilities
- Tax-exemption benefits

The service areas of these utilities represented about 21% of U.S. households, which were scattered across different parts of the country (Treece, 1998). Membership privileges on the SERP Board were divided into two tiers with privileges being based on the financial contribution that each individual utility provided towards the project. Upon the decision to participate, the utilities entered into a contract with SERP (Sandahl, 1996).

Some utilities were publicly traded companies, while others were operated by municipalities or as cooperatives. Even though these utilities were from a common industry, geographic and regulatory differences influenced each member's incentive to participate. For example, the Wisconsin Public Utilities Commission (PUC) required that its electric utilities participate (Sandahl, 1996).

The SERP prize is unique from the other case studies in the breadth of interests that rallied behind its goals. While the SERP organization was comprised solely of electric utilities, it dealt with issues that interested regulators and advocacy groups, both of which were instrumental throughout the various stages of SERP. Organizations such as NRDC, DOE, and EPA were not given official SERP board member privileges, but their opinions were solicited and given weight in decision making (Goldstein Interview, 2006). The support of these groups created viability for the project by demonstrating broad support for both the issues and approach taken (Goldstein Interview, 2006).

Given the multitude of interests that were either directly or indirectly involved with SERP, there was an equally set of diverse goals that each group wanted to take away from the prize. The 1996 PNL report stated that SERP's mission was to:

- "Utilize existing market forces and provide incentives to manufacturers to design, develop, and distribute super efficient refrigerators during the years 1994 to 1997. This program will put super efficient refrigerators on the market years ahead of when they would be available in the absence of the program, effectively transforming the refrigerator market to higher levels of energy efficiency."
- "Ensure that any refrigerator distributed under the program meets high standards for energy efficiency, pollution control, and consumer satisfaction."
- "Ensure that refrigerators developed under the program have adequate market appeal to ensure purchase by consumers."
- "Ensure accountability in the program, so that utility members can appropriately document relevant costs, kilowatt hours (kWh) of energy

savings and efficiency. Such accountability will be an inherent part of the SERP, Inc., program."

The report also revealed that many utilities weighed additional benefits when deciding whether or not to participate in SERP. Motivation for the utilities to join SERP included positive publicity, customer service benefits, regulator support, market transformation potential, and the collaborative approach being promoted through SERP.

In his interview, David Goldstein of NRDC provided yet another set of goals that he had in mind when helping to formulate the prize competition parameters. In the previous 20 years, manufacturers had increased refrigerator efficiency primarily through the use of CFCs (Treece, 1998). CFC's were set to be phased out in 1996 as part of the Clean Air Act Amendments of 1990. Goldstein continued by stating that appliance manufacturers claimed that it was impossible to increase the energy efficiency of refrigerators while eliminating CFCs; the introduction of CFCs was how manufacturers had previously increased appliance efficiencies. This belief was not universal and Goldstein saw a large incentive as a way to get manufacturers to change their thinking.

Another motivation for both utilities and advocates alike was the fact that new 1998 energy efficiency standards were set to be reviewed by Congress. The thought was that developing a cost-competitive, CFC-free, and energy efficient refrigerator would lead to more stringent appliance standards than would be realized without SERP (Sandahl, et al. 1996). Increased appliance energy efficiency requirements are issues that are often advocated by groups like the EPA, NRDC, and utilities.

As alluded to earlier, there was a certain amount of political capital at stake. Participating utilities were given the opportunity to strengthen their ties and build rapport with regulatory agencies such as the EPA and PUCs. The National

Association of Regulatory Utility Commissioners (NARUC) supported SERP and encouraged members to participate. Additionally SERP, the EPA, and the U.S. Department of Energy (DOE) were all required to help promote the winning design, which provided positive public exposure for the utilities (Sandahl, 1996).

Considering the aforementioned common and entity-specific goals, stakeholders initially could not agree on the best method to tackle them. One study cited that American utilities had offered over 1,000 programs to encourage energy efficiency and conservation with only moderate success (PR Newswire, 1992). Ray Fahrang, CEO and chairman of the SERP board, said that utilities realized that they had been trying for years to get consumers to buy energy efficient products, but had not done anything to incentivize manufacturers to produce more efficient products (Stein, 1995).

Refrigerators were chosen because they provided a large sales volume base and made up a large portion (14%) of residential electricity consumption (CITE). The idea of promoting air conditioners was also considered, but eventually scrapped because they have a variable load pattern (they are operated during peak usage times i.e. in the summer and during the day) (Sandahl, et al. 1996). Utilities thought that PUCs would be more interested in total energy savings than load shaping. Utilities also rationalized that setting the required efficiency improvement at 25% would lead to the production of appliances that were deemed to be substantially more efficient, but provide a reasonable target so as not to discourage participation (Sandahl, et al. 1996).

In my interview with Goldstein, he described the initial planning meetings between stakeholders as collaborative discussions that were concentrated purely on economics. The complications presented by the breadth of interests, resources, and geography required for such a competition made participants second-guess the effectiveness of an incentive prize initially. However, SERP concluded that no single manufacturer could afford to develop the desired

refrigerator on their own because the product would cost more than consumers would be willing to pay and there was already low demand for energy efficient appliances (Lippman, 1992). SERP was seeking to “increase refrigerator efficiency in the next three years by the same order of magnitude as has been accomplished since 1972,” which was 20 years previous to the date of the SERP RFP (Lippman, 1992).

The group ultimately reached the conclusion that a "super-incentive" or "golden carrot" was needed to stimulate the interests of appliance manufacturers and lead them away from CFCs. It was thought that offering a direct incentive to manufacturers would have a greater effect than rebates to consumers (Sandahl, et al. 1996). The SERP utilities believed that no matter who got the \$30 million award, "everyone wins" because other refrigerator manufacturers would have at least an initial design to improve upon in order to compete with the victor (Treece, 1998). Utilities claimed that “market forces” would encourage teams other than the finalists to develop and market an energy efficient refrigerator in order to stay competitive (Sandahl, 1996). For this reason, SERP decided that the competition would be winner-take-all. While the utilities referred to SERP as the golden carrot to manufacturers, the manufacturers mockingly referred to the program as the "orange shaft." (Goldstein Interview, 2006) They preferred an award that would be made to any manufacturer that could reach a certain level of efficiency and argued that the winner-take-all approach linked the future of the program to a single manufacturer (Sandahl, et al. 1996).

4.1.2 Knowledge of Costs and Market Opportunities

Despite this perceived snub by SERP towards manufacturers, the manufacturers were very involved in developing the program. Manufacturers were given the opportunity to review and comment on the draft RFP and were

recognized by SERP as essential to both the design and marketing of a successful product (Goldstein Interview, 2006).

Goldstein stated that the \$30 million prize value was a rough estimate of the expenses that would be incurred by a single manufacturer in developing an efficient refrigerator from the drawing room to the market. Utilities, regulators, and interest groups were trumpeting the enormous benefits that society would reap as a result of the new refrigerator design, which were primarily calculated by savings gained through efficiency gains.

- EPA administrator William Reilly predicted that consumer electricity bills would fall by \$240 million per year by 2000 (Lippman, 1992) and carbon dioxide emissions would decrease by at least 650,000 tons (Simpson, 1993).
- NRDC calculated that each refrigerator would save consumers \$500 over the life of the unit (Lippman, 1992).
- Ray Farhang of SERP estimated that the winning manufacturer could generate \$2 billion in sales (Berg, 1992).

4.1.3 Funding

While such a sharp decline in electricity revenues doesn't seem to be advantageous from the perspective of the utilities, they have found that energy efficiency sometimes produces a greater cost benefit than an alternative such as paying for new power plants (Treece, 1998). Some utilities were also required by regulatory agencies to invest in energy efficiency programs. These considerations allowed the utilities to justify taking a financial stake in SERP.

The primary funding for SERP came in the form of contributions from member utility's dues. Utility contributions were really the only option that was explored as a source of funding because of the large prize value and the anticipated interest amongst electric utilities (Sandahl, et al. 1996).

Pacific Gas and Electric (PG&E) and Southern California Edison (SCE) were the first to commit to SERP and pledged \$13 million to the program (Goldstein Interview, 2006). SERP built upon this early momentum and continued to solicit utilities through a full-fledged marketing effort by recruiting new members directly and through regulators and trade organizations. Goldstein noted that the utilities were very competitive, particularly those that had service areas in close proximity to one another, and in some situations (such as SCE and PG&E) tried to one up each other with their contributions.

SERP required a minimum annual payment of \$5,000 which provided one vote in the election of the board of directors and on other issues (Sandahl, et al. 1996). Additional votes and privileges were garnered through contributions above the \$5,000 requirement. SERP dues were divided among funding for the prize (86%), administrative expenses (10%), and establishing a cross-border account to compensate utilities for units purchased in one utility's service area and installed in another's (4%) (Sandahl, et al. 1996).

4.1.4 Participant Eligibility Requirements

The decision to create such a large incentive was aligned with a desire to attract large and capable appliance manufacturers to participate. Goldstein noted that big manufacturers were targeted because in his opinion, the critical challenge was not to develop radical new technology, but rather to use existing technology to develop and market refrigerators that are more energy efficient and cost competitive. SERP believed that only the large manufacturers would be able to

do this in the desired timeframe (Goldstein Interview, 2006). Accordingly, SERP stipulated in its RFP that entrants have an existing national sales and retail network and sales of 14.5-26.7 cubic foot refrigerators exceeding 100,000 units or more in each of the preceding three years. Companies that did not meet these qualifications could still enter, but had to sufficiently prove to SERP that they had the capital and distribution resources that would be necessary to meet sales requirements. The manufacturer had from January 1994 to July 1997 to produce the energy savings outlined in the bid. Initial estimates were that the \$30 million would produce the equivalent of about \$100 rebate per refrigerator to the manufacturers (Treece, 1998). Based on Whirlpool's actual bid of 250,000 units, the prize would have provided a credit of \$120 per refrigerator.

SERP narrowed its entrant pool down to two contestants by scoring submissions to the RFP. The scoring was assigned in the following manner:

- 75 points on total energy savings⁶
- 20 points for corporate capability and reliability
- 2 points for the proposed tracking system
- 2 points for eliminating CFCs
- 1 point for having separate airflows between the freezer and refrigerator

The fact that 75% of the points in the bid were allocated to total energy savings tended to favor manufacturers with larger market shares since they had the greatest potential for savings. The market share of the top three appliance manufacturers around the time of the SERP competition was approximately 30% GE, 25% Whirlpool, and 17% Frigidaire (Treece, 1998).

⁶ Assumes \$0.07/kWh, 6% discount rate, and a 19-year life span

SERP weighed the bids to produce two finalists, which were then asked to submit prototypes for testing. Despite GE's inherent advantage, Whirlpool and Frigidaire emerged as the finalists from the RFP bid scoring (Lippman, 1992).

4.1.5 Visibility and market transformation

Outside of the RFP, little was done by SERP to promote the competition (Goldstein Interview, 2006). SERP met privately with manufacturers and did not really advertise the project. Word of mouth and general interest is what ultimately catapulted SERP into the public eye. Contrasting with the conservative marketing approach taken by SERP are the results of a survey performed by the Pacific Northwest Laboratory (PNL), which cites publicity as a main driver for participation by utilities. According to Goldstein of NRDC, the positive public exposure obtained by utilities and manufacturers alike proved to be a huge boon and was underestimated by many at the onset of the program.

The program was also designed to give appliance manufacturers a boost since their industry had recently undergone a decade of consolidation and restructuring prior to the SERP prize (Treece, 1998). Appliance manufacturers were concentrated on eliminating CFCs from designs to meet regulatory requirements and saw increased efficiency in opposition to this goal. Goldstein stated that SERP was successful at accelerating the market at a pace that otherwise might not have been possible and described the project as both "monumental" and "necessary." The \$30 million prize competition is cited by Goldstein as driving them to look at new technologies and their product development processes.

4.1.6 Political Climate

Political influences were very apparent in the development of SERP and influenced both participation levels and the parameters of the actual competition. Various regulatory agencies played a significant role in the promoting and planning the SERP competition. For utilities this could either be viewed as a threat to participate or as an opportunity to establish or further ties with these agencies.

It has also been mentioned several times that CFCs were slated to be phased out by 1996 and that energy efficiency standards were set to be reviewed and possibly enhanced by Congress. By raising the bar for energy efficiency in refrigerators, utilities, the EPA, NRDC, and ACEEE thought that they could push for more stringent standards.

4.1.7 Prize Competition Parameters

The \$30 million award was not paid out to the winner in lump-sum, but rather on a per-unit basis as refrigerators were shipped to retailers (Simpson, 1993). The incentive to manufacturers could not exceed \$0.375 per kilowatt-hour (kWh) of savings in the first year and was paid out of the trust that was established through the SERP dues (Sandahl, et al. 1996). It is estimated that Whirlpool sold 100,000 units at most, which would have produced a cumulative award of \$12 million with a \$120 per unit award.

\$30 million reflected an estimate of the capital costs that were required to set up an assembly line for new appliances and was admittedly fudged to some degree (Goldstein, 2006). Utilities also sought to create a prize value that would

build up enough competition in each service area to achieve 5% market penetration with the new SERP refrigerators (Sandahl, et al. 1996).

One of the interesting complications of SERP was the tracking system that utilities required so that they could track both efficiency and financial gains in their service areas. Appliance manufacturers were required to track at least 25% of SERP refrigerators with the proposal being weighed as part of the RFP score (Sandahl, et al. 1996). This in turn, brought on another difficulty because the utility service areas were not consistent with those of appliance distributors. Since the award was paid out on a per-unit basis, utilities were wary that some units purchased in their region would be installed in another. The solution was a complicated agreement reached by the SERP utilities that set aside a little over 4% of dues that would be doled out as compensation for such occurrences (Sandahl, et al, 1996).

The timeline for a manufacturer to apply for and compete in SERP was relatively short compared to the other prize competitions studied. The RFP was issued on July 7, 1992 with a due date of October 25 of that year. The selected finalists (Whirlpool and Frigidaire) then had until January 1 to construct a working prototype for testing.

Prototypes of the two finalists were submitted to ETL Testing Laboratories Inc. for testing to verify performance claims. The manufacturers were worried about the state of the ETL's testing equipment claiming that it had not kept pace with the rest of the appliance testing industry due to its lax investment in new equipment (Treece, 1998).

Ironically, these concerns were raised by Whirlpool who was announced as the winner on June 30, 1993 (Treece, 1993). Commercial deliveries of the SERP refrigerator began shortly thereafter and arrived in retail outlets in early 1994 (Sandahl, et al. 1996). This tight timeframe was attributed to the efficiency

standards that were soon to be reviewed and the perception from utilities and regulators that manufacturers were doing the minimum to meet them (Goldstein Interview, 2006). The "golden carrot" approach that they devised sought to provide an incentive instead of a mandate, or "stick", to entice manufacturers to accelerate their forward progress.

SERP predicted that by assisting in the development of one manufacturer's product that others would have to follow suit in order to stay competitive (Lippman, 1992). This train of thought is consistent with Goldstein's comment about the issue at hand being economic feasibility and not radical technology development. Under this premise, duplication of effort is desirable because it will lead to an aggregated shift in the appliance industry towards cost-effective, energy efficient appliances.

4.1.8 Additional Criteria

The broad stakeholder involvement in the SERP process made for several unique criteria that were considered in this competition and that did not exist in others. With the actual SERP award based on units sold, manufacturers were required to develop a tracking mechanism to ensure that utilities were given a return that was proportional to its contribution. The units were also distributed geographically by Whirlpool in proportion to the contribution of that region's participating utility. Utilities required these assurances before committing any funds to the project. The issue of cross-border sales, a refrigerator sold in one service area and installed in another, also had to be rectified before some utilities would agree to participate. A separate fund was set aside from the general prize fund to compensate for any discrepancies along these lines.

SERP's membership created yet another headache when antitrust concerns were raised. SERP was worried that its administrative structure would

potentially create a stir within the U.S. Department of Justice on the grounds of collusion by utilities and that SERP is trying to influence the price of the SERP refrigerator. These concerns were circumvented by applying for, and obtaining, a Business Review Clearance from the Department of Justice (Sandahl, et al. 1996).

Beyond organizational issues, the SERP program also had operational features that differentiate it from the other prizes being examined. The manufacturers were given a little over a year and a half to put together a proposal, submit their design for prototype testing, and have the finished product in retail outlets. There were concerns about replacing CFCs without adequate time for testing. A 1992 article in the New York Times noted GE had tried to upgrade its compressor in 1988 and had to recall the product at a cost of \$450 million. As a result of this and other experiences, manufacturers worried that they were putting customer satisfaction at risk.

Throughout the SERP process, participant confidentiality agreements were very strict and all IP belonged to the appliance manufacturers. Several appliance representatives cite that they had no idea what the competition was working, which created suspense until the final decision was made (Treece, 1993). It is also hard to imagine that the utilities that administered SERP had a strong interest in acquiring the IP of products being developed as part of the competition.

4.2 Case Study - The Ansari X Prize

The X Prize was established May 18, 1996, in St. Louis by a group of investors and space enthusiasts who sought to “promote the development and flight of spaceships able to provide low-cost commercial transport of humans into space” (<http://web1-xprize.primary.net/about/index.php>). \$10 million was offered

to the team that could construct a reusable spacecraft that demonstrated its ability to carry three passengers to an altitude of 100 km (62.5 mi.), return safely, and repeat the feat within two weeks.

The X Prize was inspired by Charles Lindbergh's famous Spirit of St. Louis" Trans-Atlantic crossing that put St. Louis on the map as a hub for aviation activity and innovation (Diamandis Interview, 2006). The X Prize Foundation was established as an effort to return St. Louis to that same level of prominence and the X Prize served as its major platform in doing so (Uhlenbrock, 1996). Fellow St. Louis residents, space enthusiasts, and several Lindbergh family members supported the cause of the X Prize Foundation, which created momentum heading into its official announcement to the public.

The X Prize held a joint press conference with the heads of the FAA and NASA, 20 astronauts, and members of Charles Lindbergh's family were to announce the prize to the world (Diamandis Interview, 2006). Despite the strong initial support, the X Prize Foundation struggled in its fundraising efforts and teams were not lining up in the numbers that were initially anticipated.

After several slow years, the X Prize eventually turned the corner and began receiving both more interest and publicity. Legendary aircraft designer Burt Rutan had officially entered the competition with the backing of Microsoft co-founder Paul Allen. The Ansari family made a substantial contribution to the X Prize Foundation and the competition was officially renamed the Ansari X Prize. The founder of the X Prize Foundation, Peter Diamandis, provided testimony twice before Congress on the merits of prizes and to encourage Congress to authorize NASA to initiate a prize program as a way to encourage innovation. Even still, the X Prize Foundation did not have \$10 million to finance a winner. The Foundation took out an insurance policy, which would cover the \$10 million award if claimed before January 1, 2005.

On July 27, 2004, Mojave Aerospace Ventures (Rutan and Allen's company) announced that SpaceShipOne would make an official attempt at the prize in the fall of that same year. The flights were made on September 24 and October 4 and were both successful (<http://www.xprize.org>). Mojave Aerospace Ventures had won the \$10 million X Prize and received a great deal of publicity in doing so. According to Reuters, the successful flights of SpaceShipOne were the #2 news story of 2004 and had managed to attract 1.5 billion print impressions in less than two weeks (<http://www.xprize.org>).

4.2.1 Organization Type and Prize Objectives

The X Prize was first conceived in 1994 by Diamandis and Gregg Maryniak, after Maryniak finished reading a book on the Lindbergh flight across the Atlantic Ocean (<http://www.xprize.org>). The Lindbergh flight was accomplished in an attempt to win the Orteig Prize, which was a \$25,000 award to be given to the pilot that could successfully complete a non-stop flight from New York City to Paris. Diamandis saw many parallels between Lindbergh's flight and the subsequent development of commercial aviation and his goal of opening up spaceflight to the public so that he may one day be able to experience space. He stated that, "Lindbergh fundamentally changed the consciousness of the world about aviation; we in the space community desperately need the same conscious shift (Arnold, 1997). Two major factors created the billion-dollar aircraft industry – warfare and prizes" (Lacey, 1996)

Indeed, over 100 aviation prizes offered between 1905 and 1935 that led to impressive achievements in the early development of the air transport industry (<http://www.xprize.org>). These prizes encouraged brave entrepreneurs to attempt feats that were deemed too risky for corporate or government backing. Diamandis also commented that, "prizes are about more than just the money,

they are about working towards a noble and human cause" ("\$10M Prize Awaits New Lindbergh")

Diamandis envisioned the same potential for private space travel claiming that the wealth was available and willing, but that there was no incentive to reach "critical mass" (Diamandis Interview, 2006). This realization led Diamandis to form the X Prize Foundation in 1995 with Gregg Maryniak, and several others as a 501(c)(3) non-profit educational organization. Diamandis thought that by setting up a non-profit organization that he would be able to attract more players to the competition (Diamandis Interview, 2006). The X Prize Foundation was initially established in Maryland, but soon set up shop in St. Louis and hoped to revive the city's reputation in the early 1900's as an international aerospace leader (<http://www.xprize.org>). On its website and in documentation supporting the competition, the X Prize Foundation laid out the following goals:

- Organizing and implementing competitions to accelerate the development of low-cost spaceships for travel, tourism, and commerce
- Creating programs which allow the public to understand the benefits of low-cost space travel
- Providing the public with the opportunity to directly experience the adventure of space travel

In an interview, Diamandis summarized these specifics into an overarching theme that will "change the way that people think about space travel" (Uhlenbrock, 1996). Traditionally, U.S. space travel had been considered exclusively under the auspice of NASA. Despite what might be viewed as competition, the vision of the X Prize was shared by those in NASA. Then-current NASA administrator Daniel Goldin, claimed that "it is the private sector that will finally build the machines that provide the greatest access to space" (Arnold, 1997).

While Diamandis admitted that the goal of the X Prize was a little selfish because he had a strong personal interest in opening up space travel for civilians, he also saw a great economic opportunity (Diamandis Interview, 2006). Diamandis likened the development of the private market for space to the personal computer (PC): initially they were bulky, expensive, and used almost exclusively by the government - now PCs are both affordable and commonplace (Diamandis Interview, 2006). "The goal is that the winner will commercialize its prize and make a ton of money. The prize will stimulate the creation of dozens of different spacecraft designs, and the setting-up of a consumer market" (Lacey, 1996).

Prizes were also viewed as a way to force the issue of private space travel with the government. At the time, there were no rules governing private space travel. In this, Diamandis saw an opportunity to rally the support of the Federal Aviation Administration (FAA), which he reasoned would have a strategic interest in supporting private space travel because it would expand its authority and help to ensure its operation into the future (Diamandis Interview, 2006).

Private organizations also backed Diamandis' vision. In a newspaper article in *The Independent*, commercial aerospace firm owner Gary Hudson remarked that, "The problem is that there has been an elite cadre of individuals and organizations involved in space exploration and engineering for decades and, not necessarily intentionally, it has made the whole business of going into space, especially with human beings, more difficult. If the X Prize succeeds, the floodgates will be opened" (Lacey, 1996). To address this thought, the X Prize had stringent restrictions on the type and amount of government assistance that any competing team receives.

4.2.2 Knowledge of Costs and Market Opportunities

Commenting on the state of private space travel, Diamandis claims that, "the technology exists, the market exists, the only problem is that the spaceships to carry the space tourists don't exist" (Lacey, 1996). The costs of space programs at NASA can be found in Congressional appropriations and often are spoken of in the billions of dollars. Each individual launch of the space shuttle can cost between \$500 million and \$1 billion. While these numbers provide a ballpark for the current costs of the technology employed by NASA, the X Prize was looking to create a discontinuity that would bring this price tag down substantially so that the technology could be enjoyed by the masses.

As additional leverage, the X Prize Foundation placed its bets on the presence of an incentive beyond the \$10 million prize that was being offered: the potential to establish a foothold in a new and developing market. By the end of the competition, the number of companies that participated and the sheer investment that they made almost made Diamandis' vision a self-fulfilling prophecy by creating a competitive marketplace.

Actual statements about the costs required to win the X Prize as well as the investment made by competing teams became more concise as the prize competition went on suggesting that while the X Prize may have had an initial idea of costs, the competition refined that prediction towards actual costs. Near the beginning of the project in 1997, Diamandis stated that he thought that the designs submitted by teams would cost anywhere from \$10 million to \$80 million (Hoversten, 1997). In an issue of *Science Magazine*, Diamandis is cited as saying that as of 2004 teams had spent anywhere from \$100 million to \$400 million. Most recently, while providing Congressional Testimony in 2006, Diamandis stated that aggregate investment of 26 teams was "over \$100 million." It is estimated that Mojave Aerospace Ventures spent an estimated \$30 million developing SpaceShipOne (Kintisch, 2004). Mojave's investment was rewarded

in the form of a \$121 million contract with Richard Branson and Virgin Group to commercialize the technology (<http://www.xprize.org>).

4.2.3 Funding

Despite the potential for a large payout and all of the vocal support that the X Prize Foundation was receiving from government agencies and private foundations, Diamandis, said that arranging funding for the X Prize was the greatest obstacle his organization had to overcome (Diamandis Interview, 2006).

Fundraising efforts began on two fronts. The New Spirit of St. Louis Organization (the original Spirit of St. Louis Organization funded Lindbergh's flight) was established in 1996 as a fundraising arm of the X Prize Foundation and required members to contribute a minimum of \$25,000 towards the X Prize; an amount that was symbolic of the prize that Charles Lindbergh claimed (Uhlenbrock, 1996). Eventually the organization included 100 members that contributed over \$1 million to the cause of the X Prize (<http://www.xprize.org>).

Diamandis was also working on his own to recruit CEOs and wealthy individuals to support the prize. By 1997, 16 teams had registered for the X Prize and \$1.5 million had been raised to support (Arnold, 1997). Later that year Diamandis is quoted in the as saying that he expected to have the remainder of the money raised by next year (Hoversten, 1997). In this search he was hoping to find a corporate sponsor or benefactor that would shoulder a bulk of the costs. He had no such luck. One of the obstacles that he cited at a June 2004 NASA conference was that companies and individuals were hesitant to place their endorsement or company logo on technology that posed a risk for a high-profile event that could end in personal injury or death. The failure to attract corporate dollars was echoed in 2006 Congressional Testimony provided by Diamandis where he expressed his surprise that traditional NASA contractors were not

supportive of the X Prize Foundation and noted that they were some of the greatest benefactors of the technology developed through the X Prize competition.

The Foundation decided to take a different approach and took out what is called a "hole-in-one" insurance policy (Diamandis Interview, 2006). As the name suggests, this type of insurance policy is geared towards competitions that involve long odds, but a high reward. In 2001, the X Prize Foundation paid \$5 million for a policy that would double its investment if the X Prize was claimed by December 17, 2003; the date that marked the 100th anniversary of the Wright Brothers historic first flight (Kintisch, 2004). The X Prize Foundation also hedged its bet by purchasing an option to extend the policy to January 1, 2005 (Kintisch, 2004). One of the important consequences of the insurance policy was that the X Prize Foundation was forced to put a deadline on the competition. The purchase of this rather pricy insurance policy was made possible largely due to a substantial contribution from Anousheh Ansari, which had aspirations similar to Diamandis of one day experiencing space. After their contribution, the competition was renamed to the Ansari X Prize. There is no word on how much the Ansaris donated, but the X Prize foundations tax documents show \$2.6 million in contributions for the year of their donation, as compared with an average of \$379,000 in the preceding years (Kintisch, 2004).

This was only part of the funding picture as the X Prize Foundation also needed to raise money to support its operating activities. The approach to the project was structured around creating maximum publicity and also involved the use of large facilities for the testing of SpaceShipOne. The Foundation has not released any specific figures citing the overhead costs required to support the X Prize, simply noting that it was 'not too expensive to administer' (Diamandis Interview, 2006).

4.2.4 Participant Eligibility Requirements

A minimal amount of the money that the X Prize Foundation raised came from the teams itself. A \$1,000 registration fee was required of all teams as a way to cover entry processing fees. This fee was refundable until the publication of the final rules, after which teams have 30 days to review the rules and may request a refund of the entry fee (<http://web1-xprize.primary.net/about/index.php>).

Besides the entry fee, the competition was open to "anyone that abides by the rules" (Diamandis Interview, 2006). Teams were required to submit proposals to a committee of aeronautic experts. The committee was designated by the X Prize Foundation and was charged with evaluating designs to be both scientifically sound and safe. It is noted that several proposals had to be turned down because they were deemed unsafe (Hoversten, 1997).

It is noteworthy that, unlike the other two prizes being looked at, the X Prize drew entrants from seven countries. In all, 26 teams officially entered the X Prize competition.

4.2.5 Visibility and Market Transformation

Given the high level of interest and strong support from federal agencies, it is not surprising that the X Prize garnered a great deal of press. Whether or not the publicity is what drew teams to enter the X Prize or vice-versa is a chicken and egg argument. Regardless, Diamandis placed an emphasis on public exposure throughout the duration of the X Prize competition (Diamandis Interview, 2006). On May 18th, 1996, the administrators of the FAA and NASA, members of Charles Lindbergh's family, and 20 astronauts gathered with Diamandis under the St. Louis Arch to announce the X Prize (<http://web1->

xprize.primary.net/about/index.php). Diamandis stated that this "created tremendous credibility" for the prize. Additional support was drummed up through celebrity endorsements and donations from the likes of Tom Hanks, Tom Clancy, Buzz Aldrin, John Glenn, U.S. Senators, and a number of space organizations such as the National Space Society (<http://web1-xprize.primary.net/about/index.php>). The X Prize Foundation also required all spacecraft to "prominently display" the logo of the New Spirit of St. Louis Organization (<http://web1-xprize.primary.net/about/index.php>).

This high profile set the stage for the type of public exposure that the X Prize would receive. Between May 1996 and January 2004, the X Prize could account for 2 billion international print impressions including 4,000 newspaper articles and 25 documentaries (<http://www.xprize.org>). This number grew at staggering rate in 2004 as the anticipation grew of the first official launches. In the seven months between May and December 2004, the X Prize drew 5 billion print impressions with 1.5 billion of those coming in a 10 days span (<http://www.xprize.org>). This was enough for Reuters to declare SpaceShip One as the #2 news story of 2004, which was also a U.S. Presidential Election year (Diamandis Interview, 2006). The X Prize and spaceship One were featured on the front pages of major newspapers, Time Magazine, Life Magazine, Popular Science, the Economist, and Newsweek to name a few (<http://www.xprize.org>). Even Diamandis was taken aback by the level of PR that the X Prize received and noted that the level of attention was amplified by the competition that the X Prize created. He noted that the Foundation's strategy was to place an emphasis on the teams rather than the X Prize organization itself (Diamandis Interview, 2006).

In the same spirit, the X Prize Foundation relied initially on word of mouth to attract contestants. Diamandis was hoping to lure in smaller scale companies and avoid the typical aerospace behemoths such as Boeing and Lockheed (Diamandis Interview, 2006). The X Prize concept was first promoted in an

article in *Ad Astra Magazine* and continued to get coverage in both space enthusiast and trade magazines, which built some momentum up to the big splash announcement at the press conference (<http://www.xprize.org>).

As the prize matured, Diamandis and other X Prize officials seized opportunities to promote the prize by speaking at conferences and providing testimony before Congress. This eventually led to the creation of the NASA Centennial Challenges, which tapped the expertise of the X Prize foundation to assist NASA in creating a similar prize program within the Agency.

The X Prize also had plans internally to create some continuity with the momentum developed through the X Prize. The X Prize Foundation reached a \$9 million deal with the state of New Mexico to host the X Prize Cup, which consisted of space-themed races and challenges between teams (<http://www.xprizecup.org>). The first X Prize Cup was held October 20-21, 2006 and attracted over 12,000 people that came to watch teams compete for \$2.5 million in prize money (<http://www.xprizecup.org>). There are plans to host the event again in 2007.

4.2.6 Political Climate

As the previous section suggests, the X Prize Foundation had a strong working relationship with relevant government agencies. One of the goals of the X Prize was to create a paradigm shift in space travel from government to the private sector (Diamandis Interview, 2006). Not only would this involve a shift in resources, but it would also require new regulations to govern civilian space activities. The FAA was very cooperative with the X Prize in this sense and issued special permits that were designed to accommodate the competition's launch activities (Diamandis Interview, 2006). Diamandis noted that by creating

regulations for space travel, the FAA would be expanding its scope considerably and would likely also require increased funding (Diamandis Interview, 2006).

NASA was also supportive and several ex-NASA officials and astronauts helped to advise the X Prize Foundation on both technical and management matters. As previously mentioned NASA liked the idea of prizes for space technology so much that they submitted an appropriations request to Congress. This benefited the X Prize in several ways beyond the obvious support from NASA. By submitting Congressional testimony, the X Prize was given both a national stage and credibility of its concept of using prizes to promote a market for private space activities.

4.2.7 Prize Competition Parameters

According to Diamandis, the value of the X Prize was based primarily on coming up with a number that would attract both entrepreneurs and public attention, while at the same time trying to avoid the attention of larger and more traditional NASA contractors (Diamandis Interview, 2006). The X Prize Foundation had also initially planned to award four \$25,000 prizes annually to the top space innovations coming from the private sector, but this never came to fruition (Uhlenbrock, 1996).

With \$10 million sounding like the right number, the X Prize Foundation was left to construct the rest of the parameters of the prize. Diamandis stated that the expected timeframe for the X Prize needed to allow time enough time to organize, raise money, and build the spacecraft (Diamandis Interview, 2006). In 1997, Diamandis predicted that the prize would be won by 2001 at the latest (Arnold, 1997). Ultimately, the length of the X Prize was determined by the hole-in-one insurance policy that became the final method used to award a potential winner. The X Prize Foundation was required to select an expiration date so that

the insurance company could calculate a premium. The original insurance policy was set to expire in December 2003, but the foundation also held an option to extend their hole-in-one insurance policy until the end of 2004.

Specific rules for the X Prize were determined by the X Prize Rules Committee with the guidance of an advisory board that included astronauts, ex-NASA officials, CEOs, and professors (<http://web1-xprize.primary.net/about/index.php>). The Rules Committee reserved the freedom to create rules as problems arose during the contest under a clause in the general guidelines, which stated that rules would not be finalized until the prize money was raised, and the input of the sponsor(s) was received. The X Prize Foundation allowed any team to withdraw with a full refund of the \$1,000 entry fee after the final rules were published. The advisory board was also tasked with reviewing applicant designs for safety and scientific soundness (<http://web1-xprize.primary.net/about/index.php>). In addition, teams were also required to submit documents acknowledging compliance with local, state, federal, and international rules regarding their activities (<http://web1-xprize.primary.net/about/index.php>).

The winning bid was required to have two demonstrated methods of verifying altitude to ensure that the spacecraft actually reached the required 62 km altitude (Diamandis Interview, 2006). The X Prize did not require formal progress reports, but were generally well-informed of a given team's status (Diamandis Interview, 2006). To ensure this, competitors were required to notify the X Prize Rules Committee with take-off and landing location and date more than 30 days prior to a flight attempt. Final judging decisions were made the X Prize Review Board (<http://web1-xprize.primary.net/about/index.php>).

4.2.8 Additional Criteria

The X Prize stands out from other prizes in recent memory because most people have heard of it in one form or another. The publicity that the competition drew was enormous and Diamandis cites his competition as the motivation for others such as the DARPA Grand Challenges, the NASA Centennial Challenges. Unlike many other prizes, the X Prize foundation was very conscious of the impetus and press coverage that its activities were generating.

The magnitude of the X Prize was very dramatic and required competitors to put themselves at a great risk in the name of technical innovation. While this brought the X Prize a great deal of positive publicity, it also created its fair share of legal and liability issues. Teams were required to sign waivers. Fundraising was difficult because sponsors did not want to endorse a product or competition that could lead to death or serious injury.

While fundraising was difficult, attracting competition seemed to come easy to the X Prize. 26 teams invested near \$100 million competing for the X Prize. In his 2004 Congressional Testimony, Diamandis attributes the success of the X Prize to its basic parameters; "Writing the rules is more than 80% of the battle."

If these things can be done, Diamandis noted that prizes have the ability to attract alternate funding sources, draw the media spotlight, bypass bureaucracy, and transcend disciplinary and national boundaries.

4.3 Case Study - The DARPA Grand Challenges

In January 2003, The Defense Advanced Research Projects Agency (DARPA) issues a press release announcing the Grand Challenge as the first of

a series of prizes designed to 'spur the accelerated development of autonomous robotic ground vehicle technology for military applications' ("DARPA Plans Grand Challenge"). The Challenge consisted of a \$1 million award that would be given to a team that could build an autonomous vehicle that could successfully navigate through rugged terrain over a 300-plus mile course from Los Angeles, CA to Las Vegas, NV in a given timeframe.

On March 13, 2004 fifteen vehicles attempted to complete the course (which was scaled down to 142 miles) with the most successful team making it 7.4 miles and only nine vehicles making it out of the starting area ("American Innovators"). Despite these discouraging results, DARPA saw success and potential in the program through increased visibility and fanfare for autonomous ground vehicles.

Less than three months after the first Grand Challenge, DARPA announced a follow-on competition that would closely mirror the 2004 competition. The 2005 DARPA Grand Challenges would offer \$2 million to the team that could complete a 132 mile course in less than ten hours. Stanford University's entrant, "Stanley", claimed the \$2 million prize by finishing the course in 6 hours and 54 minutes ("A Huge Leap Forward").

After finding success in 2005, DARPA raised the bar for its 2007 competition by requiring competitors to build a vehicle that is capable of navigating through mocked up urban areas. DARPA is providing funding to 11 teams of up to \$1 million, which is based on submitted proposals. DARPA has also introduced awards for the top three finishers which will be \$2 million, \$1 million, and \$500,000 respectively. The 2007 Grand Challenges are to be held on November 3, 2007.

4.3.1 Organization Type and Prize Objectives

DARPA is an agency of the United States Department of Defense (DOD) and was formed in 1958 as a response to the Soviet Union's Sputnik launch (<http://www.darpa.mil/>). The agency has the expressed goal of promoting cutting edge technology in defense applications and preventing technological surprises from adversaries. Many mainstream technologies have roots at DARPA including the Internet and the Global Positioning System (GPS). DARPA has a staff of approximately 240 people and its annual budget averages around \$2 billion (<http://www.darpa.mil/>).

DARPA is essentially a funding agency and engages contractors in projects that are aligned with its mission. In 2003, Congress granted authority to DARPA to offer cash prizes for technology advances through the 2003 National Defense Authorization Act (NDAA). The Congressional authorization made several stipulations that are relevant to the parameters of the type of prize program that DARPA eventually developed:

- The prize technology must have potential for military applications
- Each prize was limited to an amount not to exceed \$1 million; the budget cap for prizes in any given year was not to exceed \$10 million
- The prize must be competitive and widely solicited
- DARPA's authority to offer prizes expires September 30, 2007⁷

Coupled with Congressional authority, DARPA's direction in offering prizes was also shaped by the 2001 National Defense Authorization Act, which set a goal for the U.S. military to have 1/3 of all operational ground combat vehicles unmanned. While DARPA was already receiving general direction from

⁷ DARPA's Congressional approval to offer prizes expires in Sept. 2007. The Department of Defense has provided a separate authorization to DARPA allowing it to offer the 2007 Grand Challenge.

Congress, internal review was also pointing DARPA towards autonomous ground vehicles as being a ripe prospect for incentive prizes.

At the time, ground autonomous vehicles were not advancing as quickly as air autonomous vehicles. The advances in ground autonomous technologies were relatively incremental and by DARPA's calculations, were not sufficient to meet the goal set in the 2001 NDAA (Negron Interview, 2006). DARPA attributed the lapse in technology advance partially to its limited list of traditional contractors (Negron Interview, 2006; Strat Interview, 2006). By expanding the reach of its funding capabilities, DARPA hoped to solicit non-traditional and unique ideas, spark enthusiasm in robotics, and provide a benchmark for the state of ground autonomous vehicle technology.

When determining the level with which to promote the prize, there was an initial difference in opinion regarding the size of the competition. Dr. Tony Tether, Director of DARPA, initially envisioned a smaller, more limited competition that would conclude with a 6 or 8 team "beer and pizza party" (Bigelow, 2004). Col. Jose Negron, DARPA Grand Challenge Program Manger, however, was advocating for a much larger scale competition that could to create a "buzz" in the robotics field.

4.3.2 Knowledge of Costs and Market Opportunities

DARPA's decision to use a prize came after years of slow advances in contracting for autonomous ground vehicles (Negron Interview, 2006). DARPA offered industry briefings to define issues that they would like to be addressed and request submissions on possible solutions. DARPA was constantly looking for a potential suitor for ground autonomous technology at these events, but always came back with the same list of participants. Because of its lack of

success in attracting a capable contractor, DARPA's information about the state of ground autonomous vehicle technologies was very vague. In our interview, Col. Negron saw prizes as a way for DARPA to assess the state of the art so that the Agency could align itself better towards the goal set out in the 2001 NDAA. One of the major technological uncertainties that DARPA faced is what type of entrants the Grand Challenges would attract. He was also convinced that a significant development in ground autonomous vehicle technology would require DARPA to expand its list of potential contractors.

4.3.3 Funding

One issue that DARPA did not have to deal with, and that has plagued many program managers, is funding. DARPA's authority to offer incentive prizes was backed by Congress before the first Grand Challenge was even formulated. For this reason, both DARPA and Grand Challenge participants were able to operate with a guarantee that the prize purse was funded from the start.

The actual prize value of \$1 million in the first year and \$2 million in the second year proved to be much smaller than the cost of administering the Grand Challenges. The overhead costs of the first Grand Challenge were estimated at being close to \$12 million (Start interview, 2006). A great deal of this was not for administrative purposes, but rather safety provisions and setting up the Challenge.

Expenses for the first Grand Challenge included renting the California Speedway for qualifying runs, an insurance policy for the race, and providing chase vehicles and helicopters to track the competitors' vehicles (Negron Interview, 2006; Strat Interview, 2006). The second Grand Challenge in 2005 was, however, much cheaper to administer because much of the required equipment remained from the first challenge and the DARPA staff was more

knowledgeable of the process of administering an incentive prize competition (Negrón Interview, 2006; Strat Interview, 2006). DARPA's 2006 report to Congress noted that around \$7.8 million was spent on administering the second prize (not including the \$2 million award).

4.3.4 Participant Eligibility Requirements

The Grand Challenges were designed to include "anyone with an SUV and a laptop" (Strat Interview, 2006). Strat noted that DARPA purposely set low barriers to entry so that teams could legitimately enter the competition for less than \$20,000. DARPA also sought to attract a wide range of interests to the Grand Challenges ("Report to Congress").

The press release announcing the first Grand Challenge called for "advertisers and corporate sponsors, artificial intelligence developers, auto manufacturers and suppliers, computer programmers, futurists, inventors, motor sports enthusiasts, movie producers, off-road racers, remote-sensing developers, roboticists, science fiction writers, technology companies, universities, video game publishers, and other trailblazers" to enter the competition ("DARPA Plans Grand Challenge"). Inviting such a huge range of potential entrants would not have been practical under the confines of DARPA's traditional contracting procedures. The wide scope of competitors allowed is consistent with DARPA's goals of both increasing its contractor base and stimulating a general interest in robotics ("Report to Congress").

For purposes of administration, expenses, and practicality the number of teams that competed in the actual Grand Challenge race was narrowed through preliminary screening. In the first Grand Challenge, teams were required to submit technical papers from which DARPA selected finalists. Initially, DARPA

had wanted to do site visits to each team, but the fact that they had over 100 applicants made this impossible (Negron Interview, 2006).

In retrospect, Col. Negron, saw this requirement as the biggest downfall of the first Grand Challenge. Strat agreed, noting that teams would write about a specific design and show up with something completely different (Strat Interview, 2006). This requirement was tweaked in the second Grand Challenge with teams being required to submit technical papers, which were then judged and followed up with a site visit if the design seemed reasonable. This review process was also a way for DARPA to determine the level of duplication of effort.

4.3.5 Visibility and Market Transformation

DARPA's emphasis on broad participation was based on the thinking that publicity would be gained through the creation of unique and intense competition. Col. Negron remarked in our discussion that he "wanted to make it a media spectacle." He noted that in order to achieve the exposure and participation that was desired, DARPA publicized the Grand Challenges through an official announcement at DARPA's technical conference, which is generally attended by around 1500 companies. The initial announcement was followed by presentations at robotics conferences, some advertising, and press coverage from magazines, newspapers, and TV stations. Col. Negron also pushed to make the prize available to an international audience. To culminate all of its PR efforts, DARPA held a competitors' conference to explain the competition in more detail and create a forum for the teams to interact; the event was covered by an array of technical magazines.

The result of this approach garnered an amount of publicity that amazed DARPA. Around 48 million hits were recorded on the Grand Challenge web

page the day of the first challenge (Strat Interview, 2006). The event was also covered in over 100 radio stories, 400 newspaper articles, and was the topic of several TV documentaries. Strat noted that despite the fact that no team completed the course in the first challenge that the exposure that the event generated has increased robotics activity all over. He cites a high school team that entered the competition and shortly thereafter began offering a robotics class at the school. The class soon became the most popular at the school drawing over 350 students (Strat Interview, 2006). While one of DARPA's goals was increased exposure, the massive and unexpected public interest also placed an unexpected strain on DARPA's staff because their attention was often diverted from program management to public relations management (Negron Interview, 2006).

4.3.6 Political Climate

As noted earlier, DARPA's ability to take such a broad approach is possible through its relative autonomy from DOD and the Congressional authorization. There were however, several political influences that played into the development of the Grand Challenges. The first is Congress' goal to have 1/3 of all operational ground military vehicles operate autonomously by 2015. The second influence affected the timeframe of the prize and was a result of DARPA's Director being a Presidential appointment. Managers at DARPA thought from the beginning that the prize would have to be run at least twice in order to be successful (Negron Interview, 2006). Since DARPA Director Tony Tether had a four year appointment, DARPA planned on running two 18-month programs as part of the Challenges (Negron Interview, 2006).

4.3.7 Prize Competition Parameters

Given the agency motivations of DARPA and the Congressional goals that were presented to DARPA in its authorization as a prize authority, the agency still had to lay down the rules which would govern the Grand Challenge. The issues of prize amount, the length of the competition, and judging metrics were examined to determine how DARPA constructed the competition's parameters.

Congressional authorization allowed DARPA to award prizes of up to \$1 million; anything beyond that would require additional approval. There was not a lot of discussion or thought given to adjusting this number for the first Grand Challenge other than predicting that \$1 million would cover the costs of any team competing (Negron Interview, 2006). DARPA was also not well informed on the state of the technology, nor did it attempt to predict the cost of the innovation sought. In defense of this logic, DARPA did not expect a winner to emerge from the first Grand Challenge, but rather to create a strong impetus that would be carried into subsequent competitions (Negron Interview, 2006).

As mentioned before, the length of time given to prepare for the Grand Challenge competition was motivated somewhat by political influences. Col. Negron noted that DARPA did not attempt to make an estimate of the time required to develop the technology required to win the Challenge.

As DARPA acknowledged, one of the important aspects of the competition was to maintain transparency, particularly in regard to the judging of the competition (Strat interview, 2006). In the Grand Challenge, the winner of the competition was spelled out clearly as the first team to cross a finish line under a set time.

Despite the fact that no team made it much past the seven-mile marker of the course in the first Grand Challenge, DARPA's Director decided it was a

rewarding enough experience to offer the prize a second time. DARPA had the benefit of past experience and numbers from the first Challenge that enabled the prize administrators to be more exact in specifying the parameters. DARPA estimated that they received \$10-20 million in equivalent research in the first Challenge and decided to raise the stakes in the second competition (Strat Interview, 2006).⁸ Despite the increased award, Col. Negrón stated that he thought the chance of a team winning the second time around was between 10-20%. Since DARPA was only authorized to provide prizes up to \$1 million, they had to ask DOD for permission to increase the prize value to \$2 million (Strat Interview, 2006).

4.3.8 Additional Criteria

DARPA made a cognizant decision to use prizes for the particular technology that was being promoted in the Grand Challenges. DARPA essentially made a low-risk investment in promoting its agency goals under the assumption that the Grand Challenges would serve as an incubator for ground autonomous vehicles until the technology was ripe for the military. The Challenges were a multi-step project from the very beginning and DARPA were not optimistic about a team finishing the challenge, even in the second competition (Negrón Interview, 2006). Given this, it is reasonable to question what factors other than those previously discussed drove DARPA to use a prize as the mechanism to encourage the desired innovation.

Given its role as a funding agency, DARPA was mindful in considering the some of the fundamental differences between prizes and contracting. Its lack of success with previous contractors led DARPA to seek out a way to include non-traditional participants; prizes satisfied that requirement. DARPA's existence as a funding agency also lent an advantage towards the type of approach that was

⁸ It is not clear if this figure includes factoring in any duplication of effort on the part of the teams.

taken in the Grand Challenges. DARPA was able to leverage its contracting prowess to attract significant investment from great deal of competitors. These competitors may have been more inclined to participate in the Challenges on the premise of increasing exposure to an agency with such a large spending budget. As a related incentive, it is also noteworthy that all intellectual property rights that were developed as a result of the competition were left with the competitors.

The Grand challenges were also an undertaking that may not have been possible by a non-government agency. The Bureau of Land Management (BLM) and the U.S. Fish and Wildlife Service were concerned about the environmental impacts that the race would have on the Mojave Desert (Negron Interview, 2006; Strat Interview, 2006). This concern was magnified by the fact that the race was scheduled during the peak of tortoise mating season. Col. Negron stated that he doesn't believe that the agreement that was reached between these agencies and DARPA would have been possible with an entity from the private sector (Negron Interview, 2006).

Another noteworthy observation is Col. Negron's description of cross-promotional benefits that were realized by the simultaneous running of the Grand Challenge and the X Prize. The fact that two high profile incentive prizes were being offered during the same time period created additional exposure to each of the projects.

CHAPTER 5

INTEGRATED CASE STUDY ANALYSIS

The following integrated analysis was constructed through an examination of the three case studies performed. These case studies were "mapped" based on propositions that stemmed out of the work of Wright, Kremer, Davis, and Newell and Wilson. All three cases are discussed in the context of these propositions, which are used to draw overarching conclusions about the criteria that prize administrators consider when choosing to offer a prize. As mentioned previously in the discussion of the methodology, the level of correlation will be classified as none, mild, medium, and strong depending on the number of cases that refute or affirm the proposition.

5.1 Organization Type and Prize Objectives

Proposition - Public and private entities will have different objectives when considering the use of a prize.

In general, the case studies revealed two types of goals. For the purpose of this analysis, these goals are classified as primary and secondary goals. Primary goals were publicly stated in the prize competition as the desired end result of the competition and were well known to contestants and administrators alike. Secondary goals were the outcomes that administrators hoped would be created by achieving the primary goal; they were not necessarily publicly disclosed. Essentially, primary goals were the "what" and secondary goals are

the "why". A complete summary of the primary and secondary goals of each of the three cases can be found below.

X Prize:

Primary Goal

- To build a privately financed spacecraft that can be proven to successfully and safely reach carry three passengers to an altitude of 62 km twice in two weeks.

Secondary Goals

- Accelerate the development of low-cost spaceships
- Convey the benefits of low-cost space travel to the public
- Provide the public an opportunity to directly experience space travel
- Paradigm shift from government to private sector
- Establish regulations for private space operations
- The founder was personally interested in experiencing space travel

DARPA:

Primary Goal

- To build an autonomous ground vehicle that can successfully and safely navigate across a course of rugged terrain and obstacles.

Secondary Goals

- Accelerate the pace of robotics technology
- Solicit new contractors
- Spur an interest in robotics among the public and researchers
- Provide a benchmark for the state of ground autonomous vehicles
- Move closer to the goal of having 1/3 of all military ground vehicles as autonomous

SERP:

Primary Goal

- To design, manufacture, and distribute a refrigerator that is 25% more efficient than existing energy efficiency standards, is CFC-free, and is cost-competitive with current designs

Secondary Goals

- Create more stringent 1993 federal appliance energy efficiency standards
- Decrease electricity demand growth; harness pollution
- Provide an incentive to manufacturers not consumers
- Transform the refrigerator market to higher levels of efficiency
- Positive publicity for the utilities
- Improved government relations
- Customer service benefits
- Meet CFC phase-out deadline

Several common categories emerged among the secondary goals as reasons that public and private entities pursued prizes.

- Market development and transformation
- Public exposure and education
- Information gathering
- Regulatory influence/compliance

There was only mild support for this proposition in the cases studies. The difference between public and private goals was not particularly distinct other than some limitation on the several of the scope of the prize competition. The X Prize sought to create social welfare by providing an impetus in what the X Prize Foundation deemed an underdeveloped and ripe market. DARPA sought to do the same for ground autonomous vehicle technology, but did so under the construct of Congressional guidelines and goals.

Proposition - Prizes are a viable alternative for both Public and private entities to achieve their goals. Prizes are chosen when there is an intermediate chance of success and the supply of research is relatively inelastic.

The technologies that SERP and the X Prize were seeking did not require a great deal of breakthrough developments, rather an adaptation and scaling of existing technology. In this sense they were seeking an application development more than a technological development. With SERP, the prize was essentially a push to entice manufacturers to make an investment in energy efficiency refrigerators and follow through by marketing them. Utilities predicted that market forces induced by the \$30 million reward would be too strong for manufacturers to ignore. SERP also had an established industry that they were soliciting, which likely enabled them to enforce relatively short deadlines.

The X Prize on the other hand was drawing from a relatively unorganized market where most of the competitors were start-up companies. One of the notable exceptions was Burt Rutan, who designed the eventual winning entry, SpaceShip One. Rutan was long seen as an aeronautics maverick choosing to work on his own while collecting a long list of accolades including designing the first aircraft to fly around the world non-stop.

DARPA, however, was looking to develop new technologies and were not successful at stimulating innovation using traditional contracting procedures. They also sought to develop a deeper understanding of the state of technology and identify new players in the market. DARPA felt that their traditional contracting base failed to demonstrate their ability satisfy the goals put forth by Congress and used prizes as a way to remedy this perceived failure. The agency expected that several attempts would be required before a team successfully completed the competition. They did not think that any team would win the first Grand Challenge and had already planned a second challenge as a follow on.

While these three entities had different levels of government involvement, the administrators were all pleased with the outcomes of the prize and felt that they had achieved most of their initial goals. In each of the three cases, the prize was aimed at a market development that the administrators felt would not have occurred in the desired timeframe without an incentive to do so. This being said, the innovation posed by each of the prizes was not too radical or far-fetched as to discourage the participation of the targeted research communities. Accordingly, there is a strong connection between this proposition and the case studies.

5.2 Knowledge of Costs and Benefits

Proposition - The division of knowledge (asymmetry) on market and cost information between administrators and researchers will influence the choice for procurement.

Wright's paper shows that the degree of knowledge asymmetry between an administrator and researchers on the costs and benefits of a given objective will be a deciding factor for concluding one procurement mechanism as superior to another. An asymmetry of knowledge of costs, technology, and market applications was present in each of the three cases.

DARPA thought that the ground autonomous vehicle market was underdeveloped and did not have a solid picture of who the players were and what the state of technology was. The Grand Challenges were partly an effort to close the knowledge gap between DARPA and researchers so that future programs could be more effective.

With the X Prize, Diamandis stated that the technology and market both existed prior to the X Prize, but that entrepreneurs needed a push to bridge the two. There was previously existing financial information on space travel, but the market was relatively undeveloped. While national organizations like NASA conduct a multitude of human space activities, their missions are funded by the government, often serve purely scientific purposes, and are done on a massive scale. Diamandis was looking to scale both the technology and costs so that sending humans into space would transform into more a more accessible market. In 1997, he predicted that the cost of the winning entry would not exceed \$80 million, although it is not clear what knowledge led him to make this statement. The eventual winning entry is estimated to have cost \$30 million to develop.

In the SERP case, there was a good understanding of the technology required, but the administrators lacked the marketing and manufacturing expertise that appliance manufacturers had. SERP administrators were relatively confident that manufacturers could address technological hurdles and the prize was used as a way to motivate them to take action and invest in costly manufacturing equipment. The \$30 million prize was an estimate of the extra costs that would be incurred by manufacturers in setting up to produce a fridge employing SERP technology. It was also envisioned that the "market forces" created by the prize would pull several manufacturers into the competition merely out of a fear of losing a competitive edge.

Given the varying knowledge of technology, it was fitting to look at whether or not prize administrators considered other options before going ahead with offering a prize. In two of the three cases, a prize was not the primary option considered for inducing the desired technology. For years, DARPA had used its traditional methods to solicit contractors to develop autonomous ground vehicle technologies, but was unsuccessful. While DARPA was struggling with how to tackle this challenge, Congress authorized the use of prizes at DARPA. DARPA saw the authorization of prizes as a way to stir up its stagnant autonomous ground

vehicle program. The SERP utilities also did not initially look offer a prize for energy efficient refrigerator development. The concept was eventually developed through collaborative meetings between utilities, government agencies, and advocacy groups where prizes were one of several other ideas were kicked around. Prizes were not the popular choice at first, but emerged as the most effective way to accomplish the desired goals after deliberation. Prizes were, however, the only means of procurement considered by Diamandis and the founders of the X Prize Foundation. Diamandis' concept of the X Prize was inspired by a book that he had read on Charles Lindbergh's non-stop flight from New York to Paris, which Diamandis credited with creating the modern-day aviation industry. Diamandis envisioned that prizes could do the same for space travel.

Knowledge asymmetry played an unexpected role in the three cases studied. Most of the administrators admit that their valuation of the innovation, expressed through the prize amount, was more of an estimate than the result of an in-depth analysis. In fact, the prize administrators, particularly DARPA, used prizes as a means to bridge the information gap that existed between them and the researchers.

5.3 Funding

Proposition - Public and private entities will have access to different types of funding sources.

One of the major differences between patents, contracts, and prizes is the requirement and timing of funding. With a patent, no dedicated funding is necessary since innovation is driven and rewarded by the market. In a contract, the timing of funding can vary. Depending on the terms of a given contract,

funding can be acquired up-front and used as a means to finance the work of a particular project; it can also be awarded ex post after the terms of the contract have been satisfied. Prizes, however, do not need to be funded (except for administrative expenses) until the actual prize is awarded, which can be years from the prizes inception. The case studies show three different approaches being taken to fund the prizes. The method for funding the prize was found to be directly tied to the pool of resources available to each of the administering entities.

DARPA is a multi-billion dollar research funding arm of the Department of Defense and typically relied on contracting to achieve its mission. DARPA's relatively large budget provided them with a security blanket because the portion of the Grand Challenges with regard to their overall research portfolio was very small. Their budget also may have allowed them to attract a wider range of participants than if the prize were offered by a smaller entity. The potential for future large contracts definitely would serve as a selling point to entice competitors to enter the competition. With the X Prize and SERP, there were no apparent follow-up opportunities aimed at continuing the innovation from the prize or another contract altogether. This may have required SERP and the X Prize Foundation to put up a larger prize in order to have the same scale of effectiveness as DARPA.

SERP had planned from the beginning to have member utilities to provide the money for the administration of the prize as well as the award. The other groups did not have the resources that the utilities did and realized early on that their participation would be essential to having the contest funded. DARPA also had funding in place before commencing the prize competition. The difference between DARPA and SERP is that DARPA had funding in place before making the decision to offer a prize whereas SERP set a goal, raised the money, and then announced the prize. Both SERP and DARPA had acquired the sufficient funds prior to announcing the prize, which allowed administrators to focus their

efforts on managing the prize competition. Additionally, DARPA's funding was authorized by Congress and they likely would not have been able to conduct the Grand Challenges without previously allocated funding.

The X Prize came from an entirely different place than DARPA and SERP. The X Prize Foundation was established with no financial support from either corporations or government and took the opposite approach by setting a goal, announcing the prize, and then chasing funding. This created a number of headaches for the X Prize. Diamandis called fundraising the single greatest challenge of the X Prize. He noted that he often had to drop everything that he was doing in order to raise money to keep the X Prize Foundation running. The X Prize illustrated an inherent risk in a funding comes last approach, which was exacerbated by the nature of the competition.

The X Prize tried to attract a myriad of funding sources by beginning with a grassroots campaign to raise seed money and later targeting a large sponsor that would put up the bulk of the \$10 million. Investors were averse to placing their endorsement on a potentially lethal competition. In 2001, the X Prize ceased their fundraising efforts for the most part and took out an insurance policy that would provide funding if the prize produced a winning bid. It is not clear what would have happened if the X Prize had been won before funding for the award was in place; the X Prize Foundation likely would have had a financial obligation to reward a winner whether or not they had raised the \$10 million in time. At the very least, they would face a costly legal battle.

The comparative difficulty that the X Prize had in attracting money provides for some interesting insights about funding a prize. The fact that competitors agreed to participate in the X Prize without funding in place is surprising. It is unlikely that two parties would sign a contract without some type of assurance that the terms of the contract could be met.

Proposition - The source of funding will have an influence on how a prize is administered.

Given the funding choices selected by each of the three cases it is important to note how this influenced the administration of the prize. The X Prize, which had the most diverse mix of funding, had a good amount of leeway in keeping the prize along the lines that were initially intended. DARPA on the other hand was bound by Congressional direction on some aspects of how it could administer its prize such as its requirement that the prize be used for military applications, be widely solicited, and capped at \$1 million. SERP utilities, which provided the funding for the administration and award of the prize, were given votes on the board of directors in proportion to their contribution. There were special concessions made to utilities, such as cross border accounts that may not have been necessary with a smaller pool of sponsors. Other entities also played a role in advising SERP, but did not have an official role in the organization.

As previously mentioned, prize administrators also had to secure funding for the administration of the prize. The administrative requirements of a prize are not necessarily trivial and can require a significant amount of up-front funding. The proportion of administrative costs to the prize value varied in the X Prize, SERP, and DARPA cases. DARPA's first Grand Challenge had overhead costs of around \$12 million with many of the expenses being attributed to the risks posed by the competition. Expenses included an insurance policy, chase vehicles and helicopters, and renting the California Speedway for preliminary trials. DARPA notes that these costs went down considerably with the second

prize because they were more experienced with managing the prize and much of the acquired equipment could be reused.⁹

The overhead costs of administering SERP were roughly \$3.6 million with total project costs approaching \$35 million. The U.S. EPA projected that this investment would leverage itself to create an aggregate \$240 million in consumer savings while one of the utilities projected that the winning design could generate upwards of \$2 billion in sales for a manufacturer. The X Prize did not provide specific numbers on its administrative costs, but a newspaper article cites that the X Prize Foundation was more than \$1 million in debt by 2000, which was before the eventual insurance policy was taken out.

5.4 Participant Eligibility Requirements

Proposition - The pool of participants desired/allowed to compete in research will influence the choice for procurement.

Both the X Prize and the DARPA Grand Challenges used prizes as a way to promote entrepreneurial activity by smaller companies. Diamandis noted that the \$10 million award was seen as a way to filter out some of these larger companies because they would not be as intrigued or motivated by a reward of such a small scale. The irony in this is that the winning bid in the X Prize signed a \$120 million contract with Virgin. DARPA had similar intentions designing its program with the intent to include "anyone with an SUV and a laptop." One of DARPA's primary goals in the Grand Challenges was to identify new contractors, which is consistent with its low barriers to entry. Much like the X Prize, DARPA

⁹ It is important to note that DARPA was essentially offering the same prize twice. While the decrease in overhead costs indicate that they did experience some learning curve benefits, it is not clear if they would be applicable to a prize of a completely different nature.

saw the \$1 million cap set by Congress as an effective filter to discourage large companies from participating.

SERP, on the other hand, deliberately targeted its prize towards larger and more established manufacturers and also offered a much larger reward. The judging of the prize was weighted towards a manufacturer's market share providing the larger manufacturers with an advantage from the start. The prize was also awarded per unit sold, which reinforced the necessity of a strong marketing and distribution network. SERP stated that they took this approach because they were on a short-time schedule and wanted to have a winner awarded before Congress started to debate new appliance energy efficiency standards.

Proposition - The probability of success of a prize will increase with the size of the participant pool to an upper limit; this upper limit is determined by the common pool problem and the elasticity of supply of research.

All three case studies established mechanisms to screen and to some extent, limit competition in each prizes. The mechanisms included a requirement for proposals or technical papers, entry fees, and site visits to monitor progress. DARPA and the X Prize established separate panels to review submissions for both safety and technical legitimacy. With the exception of SERP, these mechanisms were not put in place to exclude participants, but rather to decrease liability, identify new technology applications, and provide a yardstick for progress. Not all of these screening mechanisms were found to be useful. DARPA pointed out that the technical paper requirement was sometimes not at all indicative of the final product and that site visits were burdensome to DARPA's administrative staff because of the associated time and cost commitment.

SERP, on the other hand, had requirements in its proposal that implicitly favored and encouraged larger appliance manufacturers. Entrants were required to demonstrate a high level of recent sales and distribution capabilities in their proposal. These proposals were then judged on a standard point system which placed its greatest emphasis on total energy savings; this gave the manufacturers with higher market share an inherent advantage. David Goldstein of NRDC explained that these decisions were made intentionally because SERP to have the design on the market before Congress debated new appliance efficiency standards. The underlying premise of the technology required by SERP was also very different than the other prizes. According to David Goldstein, the issue was not as much about creating technology discontinuity as it was in integrating existing technologies in a new design and getting it to the market as soon as possible.

The X Prize wanted to spoil the government's monopoly of space travel activity and activity in the U.S. and identify a Charles Lindbergh-like maverick. To ensure that entrants would not be funded or unfairly supported by access to government resources, the X Prize rules limited the use of government resources to those that were equally accessible to all. With DARPA, their desire to look beyond their list of traditional contractors influenced their decision to create low barriers to entry.

5.5 Visibility and Market Transformation

Proposition - Prizes create signaling and market visibility, which in turn increases the probability of success.

All three of the prizes researched benefited from high public awareness and visibility. The Grand Challenges, SERP, and the X Prize were covered in newspaper articles, national and trade magazines, TV documentaries, and NPR

stories. The X Prize was so successful at drawing publicity that it was declared by Reuters as the second biggest U.S. news story of 2004 based on volume publication (this was also a Presidential election year).

Diamandis insists that successful promotion is paramount to a successful prize and cites the fanfare that followed Charles Lindbergh's transatlantic flight as both a catalyst of the modern aviation industry and his desire to offer the X Prize. Accordingly, the X Prize set out to leverage public exposure from the beginning and incorporated the objectives of educating and inspiring the public into the Foundation's goals.

According to Diamandis, the X Prize was rolled out very strategically to create awareness and credibility. A large scale rollout under the St. Louis Arch held jointly with the heads the FAA and NASA, astronauts, and members of the Lindbergh family provided the credibility that Diamandis was seeking. After the initial roll-out and, the X Prize's promotional efforts seemed to be more self-sustaining as opportunities began to be presented instead of sought out.

In contrast to Diamandis' initial thinking, DARPA and SERP did not expect the amount of attention that they received, but acknowledged that it was a huge boon to their respective projects. While DARPA definitely sought to publicize the Grand Challenges, the exposure that was received was almost overwhelming at times. In the end, both program managers interviewed from DARPA thought that publicity added a lot to their cause of identifying new players and also helped create momentum for the second challenge.

SERP attempt at publicizing its cause involved little more than holding a meeting with appliance manufacturers and issuing an RFP. SERP did not anticipate the level of publicity that it received and did not really consider it in its initial deliberations of how to best promote energy efficient refrigerators.

However, in the survey performed by Pacific Northwest Labs, utilities cited that public relations gains were one of the main attractions to joining the program.¹⁰

Proposition - The open-ended nature of prizes creates a market impetus, which may not be achievable by a patent or contract.

In addition to public relations campaigns, both DARPA and the X Prize sponsored activities to supplement the prize competition. As part of an outreach effort, DARPA held a competitors conference at Petersen Automotive Museum to provide a venue for Grand Challenge participants to interact with DARPA and each other. The X Prize offered the X Prize Cup, which was essentially dubbed as a space race, was designed to carry momentum created by the X Prize forward and ultimately produce a "NASACAR-type" environment. The X Prize also advised NASA on creating a prize program and provided testimony in front of Congress to support such an effort. These activities were all performed in support of the respective prize.

The effect of the marketing push by the three cases provided for some interesting results. DARPA was extremely pleased with the results of the first Grand Challenge even though no team won and proceeded to offer the competition a second time. Col. Negron cited that a tremendous amount of progress had been made and that the first challenge was an important step in developing the technology that would allow several teams to finish the second race. The Grand Challenges were successful in identifying methodologies, technologies, and experts that were not previously exposed through DARPA's contracting procedures. Grand Challenge Program Manager Tom Strat also noted that the Challenges were very successful in stimulating an interest in robotics among students and researchers alike; a high school robotics class set

¹⁰ *It is unclear whether or not there were separate efforts undertaken to market to the public and potential participants. The implication is that the public are the "potential participants" and this would further differentiate prizes from contracts.*

up shortly after the first Grand Challenge is now the most popular course in the school and draws over 350 students.

SERP had much a different success with its offering. Unlike DARPA, the SERP prize was claimed the first time around with production models hitting store shelves a little more than half a year after Whirlpool was announced as the winner. With energy prices declining around that same period, the market never fully developed for energy efficient refrigerators and Whirlpool was not able to meet its sales targets. Still David Goldstein describes SERP as both "necessary" and "monumental" in advancing energy efficient appliance technologies.

The after effects of the X Prize are still unfolding, but the Foundation can claim victory in several of its goals. Along with gaining tremendous media coverage, the X Prize also led to the FAA establishing regulations to govern private space travel, which paves the way for future developments. The winning team, Mojave Aerospace Ventures signed a contract with Virgin to commercialize its technology shortly after its winning flight. Several other X Prize teams have continued to develop their technologies for a variety of uses.

5.6 Political Climate

Proposition - Political concerns influence the decision to use a prize.

An interesting finding in all three of the case studies was the political influence exerted on each prize. As Newell and Wilson proposed for greenhouse gas emissions reduction, prizes were used to remove the political element out of a particular issue by seeking a competitive solution. As previously mentioned the X Prize set out to establish entirely new regulations that would govern space activities by private companies. Similarly, SERP sought to influence government regulations through the establishment of more stringent appliance efficiency

standards. The impending ban on CFCs from refrigerators also influenced the competition because manufacturers had been using CFCs as a way to increase efficiency. By developing a cost-effective prototype, SERP was able to approach Congress with a working example that proved that energy efficient refrigerators can be both CFC-free and cost-competitive while creating societal gains through electricity savings and emissions reductions. SERP's desire to act prior to Congressional action clearly affected the parameters of the competition by soliciting larger appliance manufacturers.

DARPA's parameters in the Grand Challenge also had strong ties to political issues, which is logical given that it is a federal agency and its budget is approved by Congress. The Congressional authorization for DARPA to award prizes had specific language laying out the timeline, maximum award, and general scope for a DARPA prize. The timeframe of the Challenges was also tied to the political appointment of DARPA's director, which was for four years. Col. Negron stated that when discussing how long to make the competition, the director wanted to have two Grand Challenges under his belt by the end of his four-year term. DARPA accordingly set up two competitions that lasted approximately 15 months each.

5.7 Prize Competition Parameters

Diamandis said in his 2004 testimony to Congress that writing the rules is "80% of the challenge" in offering a prize. Several essential parameters can be found in the three case studies including the value of the award, the length of the prize competition, and how the competition is judged. The previous sections demonstrate that these prize parameters can have a multitude of influences and are not always weighted equally by prize administrators.

Proposition - The value of the prize is related to the value of the innovation, the time limit of the prize competition, knowledge of the market, research, and production costs, and the difficulty of contracting.

The X Prize, Grand Challenges and SERP all had very different prize purse values, which were, to some extent, based on an estimate of the predicted cost of the targeted innovation. David Goldstein admitted that the SERP award of \$30 million "was kind of made up", but did have some factual underpinnings. The amount represented an estimate of the additional costs that appliance manufacturers would incur in setting up a production line to accommodate a new energy efficient refrigerator. Utilities also thought that the \$30 million would create enough competition in the market to achieve 5% penetration with the refrigerator.

The X Prize award of \$10 million was set primarily as an amount that would be high enough to draw interest from entrepreneurs and the public, but low enough to discourage traditional aerospace heavyweights like Lockheed and Boeing from participating. Diamandis stated in 2001 that he thought that a team could put together a winning entry for less than \$80 million, meaning that the X Prize would cover at least 12.5% of the development costs. The winning entry ended up costing Mojave Space Ventures an estimated \$30 million.

DARPA did not really do any market research in setting the Grand Challenge award at \$1 million, which was instead spelled out in Congressional authorization. DARPA did, however, feel that after the first Grand Challenge a greater would be needed to support the second. DARPA had to ask the Department of Defense for the additional \$1million since it was not part of the initial authorization. The step up from \$1 million to \$2 million was again, not a calculated dollar amount, but seen simply as a greater draw for competitors.

Proposition - The perceived supply of research has an effect on the time horizon for a prize.

When the X Prize was announced in 1996, there was no stated deadline. Diamandis stated in an interview in 1997 that he thought the prize would be won by 2001. This was not to be the case, which was probably a blessing for the X Prize because they had not raised enough capital to reward a winner at that point. Shortly thereafter, the X Prize Foundation took out its hole-in-one insurance policy that required setting an expiration date. The X Prize also purchased an option to extend the policy until December 31, 2004. It is not clear what the X Prize would have done if the 2004 deadline passed without a winner.

DARPA did have a set deadline for the Grand Challenges, which was the event itself. The events were held approximately 15 months after the initial announcement. This timeline was established so that two competitions could be completed during the tenure of DARPA's appointed director. Similarly, SERP's timeline was also politically motivated because utilities sought to have the new SERP refrigerator on the market before Congress set new appliance efficiency standards the following summer.

Proposition - Duplication of effort is more present in prize competitions than other forms of procurement.

In the three cases examined, none of the administrators paid particularly close attention to the possibility of duplication of effort. Administrators did try to monitor progress, but not do so with the expressed purpose of monitoring duplicative work. SERP did not formally monitor progress, but had deadlines that were spaced out in months, which provided SERP with a frequently updated yardstick of progress. SERP can even be seen as encouraging duplication of effort as its goal was to and get as many energy efficient, CFC-free refrigerators

on the market as possible. Whether or not several manufacturers used similar technology was irrelevant to the end goal. The SERP case also points out that it may be difficult to enforce a policy designed to eliminate duplication of effort because teams are often protective of information related to their design.

As part of the Grand Challenges, teams were required to submit technical papers. In the second challenge, DARPA performed site visits. DARPA administrators stated that learned something about managing prizes and the state of technology from both the success in 2005 and the failed designs in 2004.

With the X Prize, no formal reporting mechanism monitored duplication of effort or even tracked progress. Teams were required to give 30 days notice prior to a scheduled launch. The X Prize Rule Committee reviewed the fundamentals of each design for safety and theoretical soundness. News stories also provided a means to track the progress of teams and, the X prize website provided updates on each teams work.

Proposition - The subjectivity of the judging process is a negative drawback in prizes.

All three of the prizes examined had easily measurable quantitative goals, which provided for a clear-cut winner. Both DARPA and X Prize administrators specifically noted that this was a priority in setting up their respective competition. The X Prize was measured by altitude and repeatability, DARPA's winner was determined by a tangible finish line, and the SERP winner was determined through third-party energy efficiency performance testing.

In the DARPA and SERP competitions, not all contestants were allowed to participate in the final competition. Instead, participation was determined by the proposal and technical paper submissions required by SERP and DARPA,

respectively. These submissions were judged for safety, performance, and feasibility by the prize administrator, which provided some level of subjectivity. SERP, however, weighted proposals based on a pre-defined scoring metric, which provided a layer of transparency that may offset some of the subjectivity in their selection process. The X Prize, however, did not limit the size of the entrant field beyond what was deemed unsafe by the X Prize Rules Committee. The winner was confirmed by the X Prize Review Board by providing two different and previously approved methods of demonstrating the required altitude.

5.8 Additional Criteria

Proposition - The criteria presented in Wright, Kremer, Newell and Wilson, and Davis is incomplete.

The criteria presented in Wright, Kremer, Newell and Wilson, and Davis was pertinent in each of the three prizes examined. There were, however, several criteria that emerged from the cases that either expanded upon or added to the existing criteria that were defined in these papers.

5.8.1 Accelerated Market Development

Wright (1983) cites prizes as means for market intervention. The cases revealed that indeed, all three administrators used prizes as a way to accelerate a particular market from its predicted trajectory. SERP sought to accelerate the development of energy efficient refrigerators, which it perceived to be a low priority for manufacturers with an upcoming ban on CFCs. As SERP utilities states, they were looking to create a "market transformation." Similarly, the X Prize was looking to integrate existing technologies in aeronautics and rocketry

and apply them towards a new market for private space travel. Essentially these three prizes were time-shifting a market by inducing an innovation to occur before it would have if no incentive would have been offered. While indeed, this effect may be possible through contracting or patents, prizes help to create a larger impetus by attracting a broad base of competitors, which in the case of the X Prize created a market that hadn't previously existed.

5.8.2 Administrative Structure

The non-government prizes (SERP and the X Prize) set up not-for-profit organizations to administer the prize. The reason for doing so varied significantly. Diamandis set up the not-for-profit X Prize Foundation because they thought that this would lend them additional credibility, which would in turn draw a larger base of competitors and provide additional opportunities for funding. Attracting participants and raising money were not the chief concerns of SERP, which was instead looking more into the decision making resource benefits, and tax benefits. By creating separate not-for-profit entity, the SERP utilities felt that they would be able to have a more centralized decision making chain, reduce liability, avoid having one utility provide a bulk of the required resources, realize tax benefits, and be able to differentiate between SERP and other energy efficiency efforts.

The organizational structure of SERP also provided an interesting insight into the complications of involving so many organizations. SERP's membership created a potential deal breaker through anti-trust concerns. These concerns stemmed out of the fact that SERP member provided electricity to 21% of the nation's population and it could be perceived that SERP was trying to influence the price of the refrigerator that it was promoting. These concerns were eased when SERP obtained a business license from the U.S. Department of Justice.

5.8.3 Intellectual Property

With the exception of SERP, the administrators did not have a financial stake in the outcome of the prize (even then the utilities' financial gain was based on the sales and installation of energy efficient refrigerators). Intellectual property was not retained by any of the administrators in any of the prize competitions, which indicates that they did not intend to profit directly from the innovations being developed, but rather aimed to place the technology in the market. All three prizes went to great lengths to ensure that participant confidentiality was adhered to. While DARPA required technical paper submissions that would be made public, the reports were short and often not indicative of the end result. Confidentiality with SERP was a key issue among manufacturers who were tight-lipped about their designs until the day that the winning announcement was made. SERP was respectful of the manufacturers' privacy and solicited their input during the development of the program. This being said, none of the prize administering organizations had the capabilities to commercialize the technology developed had they retained intellectual property. Accordingly, these organizations would have created a deadweight loss had they retained any of the IP developed in the prize competition.

The prizes were not completely philanthropic, however, and did address other goals such as Diamandis' desire to travel into space, SERP utility's desire to save money by decreasing electricity demand during peak usage, DARPA's quest to meet Congress' goal for autonomous vehicle development. Nonetheless, the previous table of primary and secondary goals shows that prizes were motivated more by increased visibility, market developments, and government influence than direct financial benefit.

5.8.4 Unique Award Considerations

As Kremer points out in his paper, the rules of the prize competition and how it's awarded can be tweaked to minimize inefficiencies given a particular industry's environment. With SERP, utilities were concerned that a refrigerator sold in their service area would be installed in another's and accordingly the other utility would reap the energy savings benefits. The solution was to create a "cross-border" account, which would be used to resolve this discrepancy. SERP also had market penetration as one of its priorities, which led them to award the \$30 million to the winning design on a per-unit basis, although it is not known exactly how much was awarded to Whirlpool. These two requirements placed an additional burden on the appliance manufacturers because they were required to track the sale of all units geographically.

5.8.5 Risk as a Barrier to Funding

The X Prize encountered unique problems related to its fundraising activities. Unlike the other two prizes, the X Prize Foundation did not have the government or corporations directly backing its initial efforts. The X Prize Foundation's confidence that it could launch the prize meant that they expected that they could raise the money before a competitor could put together a winning design. Diamandis said that some of the difficulties in attracting a large sponsor were related to the perceived risk of the competition. The idea that an X Prize launch could end in a catastrophic failure scared away many wealthy individuals and corporate executives from opening their checkbooks to the X Prize Foundation.

5.8.6 Resource Availability

Because the X Prize sought to develop a market for private space travel, the competition limited the use of government resources by competitors to those that were equally accessible to all teams. This was part of the overall effort to steer space vehicle development efforts away from government influence. On the opposite end, the Grand Challenges required some level of government agency cooperation in securing land for the Grand Challenge race, an agreement which was noted by Col. Negron as unlikely to occur with a non-federal entity.

5.8.7 Sequential Competitions

DARPA went into the first Grand Challenge with the expectation of offering at least one more in the future before their goal was accomplished. This raises an interesting question as to whether a prize is more effective if it is offered in several times refocusing activities every few years or as a long-term, one-shot deal such as the X Prize.

5.8.8 Competitor Funding

Unlike any of the other prizes studied, DARPA provided the opportunity for teams to apply for funding of up to \$1 million to teams competing in second Grand Challenge. This mixes the concepts of contracting with prizes, which blurs some of the lines in Wright's analysis.

5.8.9 Cross-Promotional Benefits

In the Grand Challenges, there were several interesting dynamics, both internally and externally, that helped to promote the prize. Col. Negron noted that there were benefits of running the DARPA Grand Challenges coincident with the X Prize. He thought that concurrent running of both prizes created additional credibility for the prize concept and provided for additional press opportunities. Additionally, DARPA had a large budget beyond the Grand Challenges, which provided a strong prospect of additional contracts for competitors; for this reason they may have gotten away with using a prize of lesser value than would have otherwise been possible

CHAPTER 6

CONCLUSIONS

Despite a general lack of academic review on the topic of incentive prizes, the three cases studies included in this thesis demonstrate that prizes have been successful at procuring innovation that may not have been possible through other methods. Given a renewed interest by some in offering prizes, it is prudent to determine when, both by historical example and economic theory, offering prizes make the most sense to encourage a desired technical innovation. The preceding analysis provided an expanded view of when prizes can contribute to the advancement of technology. Overall, the propositions that were put forth by Wright (1983), Kremer (1998 and 2000), Davis (2004), and Newell and Wilson (2005) were supported by the case studies. There were, however, several interesting insights and variations on the propositions examined. These insights and the general results of the propositions are summarized in Table 2 on the following page.

Table 2 - Research Results

Category	Author(s)	Proposition	Case Study Results
Organization Type and Prize Objectives	Wright	Public and private entities will have different objectives when considering the use of a prize	Objectives were not much different for public and private entities. The exception is that DARPA sought to comply with government regulations, whereas the X Prize and SERP sought to influence regulation.
	Kremer, Davis, Newell and Wilson	Prizes are a viable alternative for both public and private entities to achieve their goals	Prizes helped SERP, the X Prize Foundation, and DARPA achieve their goals

Category	Author(s)	Proposition	Case Study Results
Funding	Kremer	Public and private entities will have access to different types of funding sources	The funding source available to each of the three prizes studied varied. Limitations on funding were self-imposed by the X Prize since it did not want to use government money and restricted at DARPA, which receives all of its funding through Congressional appropriation. In the SERP case, the prize award was large enough that the only feasible way to provide such an award would be funding provided through a consortium of utilities.
	Wright, Kremer, Davis, Newell and Wilson	The source of funding will have an influence on how a prize is administered	Because DARPA is a government agency and receives its funding from Congress, it was required to stay within limits specified in its Congressional authorization to offer prizes. The X Prize's lack of funding forced administrators to spend some of their time that was budgeted otherwise into fundraising. SERP had to make special concessions to utilities (cross-border accounts, tracking schemes, etc.) because its funding source came from a geographically diverse set of electric utilities.
Participant Eligibility Requirements	Wright	The pool of participants desired/allowed to compete in research will influence the choice for procurement	The X Prize Foundation saw its \$10 million prize as a way to draw in start-ups and entrepreneurs, while not necessarily attracting the interest of larger aerospace companies. One of the reasons that DARPA used prizes as they did was to identify cutting edge companies that were not otherwise engaged with DARPA's contracting activities. SERP also saw prizes as an incentive to entice manufactures to produce more energy efficient appliances when previous efforts had been focused on providing rebates and incentives to consumers.

Category	Author(s)	Proposition	Case Study Results
Participant Eligibility Requirements	Wright	The probability of success of a prize will increase with the size of the participant pool to an upper limit; this upper limit is determined by the common pool problem and the elasticity of supply of research	All three prizes sought to screen entrants to some extent. SERP implicitly limited competitors through its applicant requirements. The X Prize also limited certain participants by placing restrictions on the type and degree to which government resources could be used.
Visibility and Market Transformation	Davis	Prizes create signaling and market visibility, which in turn increases the probability of success	Visibility and public awareness were goals in all three of the case studies. While this served as a cornerstone of X Prize's efforts, the other two cases did not make a concerted effort to create publicity and were surprised by the attention that they received.
		The open-ended nature of prizes creates a market impetus, which may not be achievable by a patent or contract	All three of these cases were seeking market acceleration. The environment created by the prizes created multiple solutions to the same problem, which in all three cases led to competing technologies. By attracting 26 teams to its competition, the X Prize created a market that didn't previously exist. Appliance manufacturers were drawn to the SERP prize because they thought it would be necessary to stay competitive with whoever the winner was.
Political Climate	Newell and Wilson	Political concerns influence the decision to use a prize	All three prizes sought to influence or comply with regulation. Political influences also affected DARPA's freedom in scoping its prize from both a technical and rulemaking standpoint

Category	Author(s)	Proposition	Case Study and Theoretical Correlation
Prize Competition Parameters	Wright	The value of the prize is related to the value of the innovation, the time limit of the prize competition, knowledge of the market, research, and production costs, and the difficulty of contracting	Both SERP and the X Prize a ballpark idea of the technology costs and the researcher community that they needed to engage. This being said, neither organization did any type of extensive analysis or market research to support the eventual parameters that were set. DARPA on the other hand was looking to gain knowledge of the market by offering a prize and also had limitations in the Congressional authorization that prevented them from modifying some of the prize's parameters to suit this desire
	Wright	The perceived supply of research had an effect on the time horizon for a prize	SERP thought only large appliance manufacturers would be able to meet their time requirements. DARPA's time considerations were based on the term of its director and the X Prize did not have hard deadline, although one was implicit thought the terms of its insurance policy.
	Davis, Newell and Wilson	The subjectivity of the judging process is a negative drawback in prizes	All three cases made a concerted effort to include a transparent and quantifiable objective.
	Davis	Duplication of effort is more present in prize competitions that other forms of procurement	In a way, SERP was promoting duplication of effort because they were more concerned with getting energy efficient refrigerators on the market than the technology developed. DARPA and the X Prize did not have any mechanisms in place to discourage duplication of effort.

Category	Author(s)	Proposition	Case Study and Theoretical Correlation
Additional Criteria	N/A	The criteria presented in Wright, Kremer, Newell and Wilson, and Davis is incomplete	Additional criteria including identified included accelerated market development, administrative structure, intellectual property considerations, unique award consideration, risk as a barrier to funding, sequential competitions, resource availability, funding the activities of competitors, and cross-promotional benefits.

Several of these general results had noteworthy implications that have a substantial effect on the theoretical underpinnings used to support the propositions. One interesting conclusion that came about was the operational definition of patents, prizes, and contracts. All three administrators sought to encourage market development, however, in contrast to Wright's model, the administrators did not have authority to grant patents. In this sense, the decision to rely on patents to procure an innovation would not require action on the part of these prize administrators. Patents can accordingly be viewed as a "do-nothing" option by administrators with regards to market intervention. The differentiating line between prizes and contracts became a bit blurry through the case studies. The prize administrators were essentially offering an open ended contract to any entity that met their requirements and goals. In this sense, a prize would be analogous to a request for proposals (RFP) in which an administrator solicits solutions to a produce a specific end result. The incentive for responding to the RFP is a contract with an attached value. The SERP case provided a direct example for this analogy. While, Wright differentiates contracting from prizes by qualifying contracts as "direct contracting", further analysis would aid in making this distinction more clear.

Wright's model of decision making was also based around the principle of maximizing net social welfare, but the case studies revealed that the decision to use a prize was based more on the premise of market acceleration. Nonetheless, a comparison of the relevant variables presented in Wright's model (i.e. knowledge asymmetry, elasticity of supply or research, and probability of success) provided relevant insights into three case studies.

The administrators' knowledge of the targeted market varied. In all three cases, the administrator took their knowledge of the market and costs into account when setting the value of the prize. While none of the administrators admitted to spending much time in determining the most efficient value for the prize, they all noted some level of consideration of how large the prize purse would need to be to attract the target audience. This consideration by the administrators ties back to Wright's discussion of elasticity of supply of research. While the prize value may not have been optimal from Wright's standard of net social welfare, it proved to be sufficient to satisfy both administrators and competitors in the three cases.

A related result that emerged from the case studies was that at least one administrator (DARPA) used prizes as a way to reduce knowledge asymmetry. This provides a twist on Wright's framing of knowledge asymmetry as an allocative inefficiency. Instead of viewing knowledge asymmetry as a drawback, DARPA sought to use prizes to gauge the state of ground autonomous technology.

DARPA also noted learning curve benefits gained by offering the Grand Challenges twice. Relative to the value of the prize DARPA had fairly high administrative costs in the first Grand Challenge. DARPA program managers noted that these costs as well as their knowledge of how to administer a prize improved significantly by the second Grand Challenge (administrative costs decreased by over 30%). This opens up interesting research possibilities to

study the benefits of sequential prize competitions and whether or not refocusing efforts through multiple competitions provide for more efficient administration and technology development.

The high costs of administering the Grand Challenges may not have been possible for a private organization like the X Prize Foundation. Where SERP and DARPA had funding in place before the competition began, the X Prize choose to seek out funding after the prize competition had been launched. With the X Prize having to spend so much of its time fundraising, administrative resources were often strained. Having to raise the money during the prize also exposed the X Prize Foundation to a certain amount of risk by leaving open the possibility of a team winning before the money was raised.

The targeted audience of each of the three prizes varied as one was seeking to specifically attract smaller companies (the X Prize) and another specifically targeted larger companies (SERP). The targeted audience in each of the prizes was related to the goals of the competition and accordingly affected its rules and parameters.

Each of the three prizes also had a political element, but in different areas than expected. Instead of using prizes to crack political stalemates, as Newell and Wilson suggest, political issues affected the length of the prize competition (DARPA) and also set out to influence future regulations (X Prize and SERP).

Davis (2004) suggests that market signaling and publicity are two benefits that need to be considered when evaluating the relative merits of prizes. This was one of the chief considerations of the X Prize Foundation and DARPA and brought an enormous amount of media attention to both competitions. The X Prize in particular caught the nation's interest, so much that it was the second most written about news story in 2004. SERP as well, was the benefactor of high visibility and utilities noted this as a reason that they agreed to participate in

SERP. As Diamandis noted, the competitive nature of prizes serves to drum up the public's interest, particularly when the innovation has some type of novelty and relevance.

Prizes are likely to play a continued role in encouraging innovation as they are realizing a more prominent role in how innovation is approached in the U.S. The X Prize Foundation had expanded its scope and is hoping to launch over \$200 million in new prizes in 2007 ("All Shall Have Prizes"). Richard Branson of Virgin has also announced a prize of \$25 million an innovation that will remove greenhouse gases from the atmosphere, which is a similar idea to that advocated by Newell and Wilson ("All Shall Have Prizes").

CHAPTER 7

FUTURE RESEARCH OPPORTUNITIES

Stemming out of the results of this analysis was the identification of future research opportunities. An expanded case study analysis to include more prizes, which could include prizes that were not won would help to further refine the findings provided in the conclusion. Including prize competitions that were not won to determine the level of correlation between the criteria considered in prizes that were won and those that were not. The current analysis was conducted with an a priori perspective of the prize competition. While an a posteriori examination and quantification of results was not a focal point of this analysis, this type of exercise would help one weight the benefits produced by a prize with those of other procurement methods (i.e. patents and contracts).

Several research opportunities also come out of the DARPA case in particular. An analysis of how prizes be effectively used to decrease knowledge asymmetry could have significant impacts on Wright's economic model of optimal research procurement. Additionally, an analysis of the learning benefits achieved through multiple prize competitions, which DARPA noted, could provide insight on the knowledge required to efficiently administer a prize and whether or not sequential competitions are an effective way of keeping competitors engaged and continuing to innovate.

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APPENDIX A

CASE STUDY PROTOCOL

Background

The discussion of incentive prizes as an effective method to spur innovation dates back to the 1800's with notable English politicians and economists championing the approach (Shavell and Van Ypersele, 2001). Despite this early push, academic research on innovative mechanisms has since been devoted primarily to patents with a few relatively recent exceptions that highlight the merits of prizes (e.g. Wright, 1983; DeLaat, 1996). Real world examples, however, demonstrate that prizes have been responsible for many innovations that may have been out of the reach of more traditional methods. Notably, prizes are responsible for the advent of the chronometer, canned food, early developments in inorganic chemistry, advances in early aviation including Lindbergh's Trans-Atlantic flight, advances in energy efficiency, and recently the development of the first privately built spacecraft.¹¹ Several of the latter

¹¹ For more information on some of these prizes see, for example:
<http://www.xprize.org>
Lindbergh, Charles. *The Spirit of St. Louis*. Charles Scribner Publishing, 1953.
Dash, Joan. *The Longitude Prize*. Farrar, Straus and Giroux, 2000.

accomplishments have prompted the federal government to further study the utility of prizes and commence prize programs at both NASA and DARPA.

Incentive prizes, also referred to as inducement prizes, work by rewarding entities for accomplishing specified objectives; in essence the incentive prizes work under the same principles, but in the opposite order of recognition prizes. Incentive prizes have been administered in a variety of different ways, but typically involve a set objective, some form of guidelines and rules, an ex-ante prize amount, and a judging committee to validate the achievement of the objective.

In general, there are two primary categories of prizes: recognition prizes and incentive prizes. Recognition prizes are given as a reward or honor for an individual or team's work in a particular field or circumstance. Prizes of this nature generally involve an application process and the submission of previous work(s) to qualify for consideration of the award. Familiar examples of recognition prizes include the Nobel Prize, the Presidential Medal of Honor, and the Department of Energy's Fermi Award. Prizes of this nature have undoubtedly had an effect on research and development activities, but are awarded ex post and accordingly do not directly influence efforts towards a specific activity or solution.

Prizes in the Context of Research Procurement

The recent record of procuring research and development is has primarily utilized contracts and patents as the incentive of choice to drive innovation. The application and analysis of patents and awarding contracts have been documented extensively in academia and reached some level of maturity in theoretical development. Both processes have been very successful at contributing in specific innovative environments, but are often regarded as the optimal method to procure research without regard for alternatives (Wright, 1983). Papers published in the last 25 years have shown that patents and contracts may indeed be optimal in particular situations, but that under certain conditions incentive prizes create a more effective approach (see Wright, 1983; Kremer, 2000; Shavell and Van Ypersele, 2001; Gallini and Scotchmer, 2002; and Davis 2004).

While most research concedes that patents potentially have an informational advantage over prizes, there is a tradeoff between this and several fundamental restrictions on the efficiency of patents. The advantage stems from the fact that patents use market forces and knowledge of prior research to provide an ex post valuation of the innovation. This, however, can be offset by the common pool problem and deadweight loss, which is an inherent flaw in patents (Wright, 1983). Dixit (1988) asserts that an award, or incentive prize, can be an effective policy instrument to mitigate these effects.

Theoretical Readings

Wright (1983) published a model that put forward theoretical criteria to consider when determining the most efficient way to stimulate R&D. In that model, Wright proposed contracts, patents, and prizes are the most commonly used methods of procuring research. Wright's model was constructed to maximize net social welfare of a research effort by minimizing what he describes as allocative problems that include the common pool problem, deadweight loss, and appropriability of knowledge. The model led Wright to following conclusions:

- Patents are the most effective mechanism when the anticipated probability of success is low and research capabilities are fairly immobile
- Contracts are the most effective mechanism when the anticipated probability of success is high and research capabilities are mobile
- Prizes are the most effective mechanism when the anticipated probability of success is moderate and research capabilities are immobile

In his model, Wright implicitly introduced decision criteria that include asymmetry of knowledge, elasticity of supply of research, prize value, and administrative structure. Wright's paper also laid the foundation for authors to do follow-on research.

One of those authors was Kremer (1998 and 2000) who wrote a series of papers for the World Health Organization that proposed using prizes as a way to develop and distribute vaccines to third world countries. Kremer introduced a hybrid prize competition that would offer a patent(s) or contract(s) as the reward of an incentive prize competition. Kremer argues that the combination of these approaches further minimizes allocative problems and makes the use of incentive prizes more attractive. This expands upon Wright's model, which assumes patents, prizes, and contracts as being mutually exclusive. In his work Kremer incorporates many of Wright's decision criteria and also introduces funding sources, competition parameters as additional criteria.

Davis (2004) takes an even more practical look at prizes than Kremer and conducts case studies to examine three prizes offered in the 20th century. Besides many of the decision criteria discussed by Wright and Kremer, Davis introduces spillover effects, reputational gains, and participant requirements as necessary considerations. While Davis' case studies are insightful, they lack a rigorous framework and rely on historical documentation as the sole source of evidence.

In 2005, Newell and Wilson published a paper positing that incentive prizes could be an effective mechanism to resolve the political stalemate in regulating the emission of greenhouse gases (GHG). The concept involves incentivizing technologies that would reduce GHG emissions to induce a market-

based and developed equivalent to GHG limiting legislation. Newell and Wilson go on to discuss the importance of prize design in ensuring success. The authors constructed their underlying framework around Wright's model and put forth political concerns and institutional setting as decision criteria. .

Objectives

The connection that exists between the previously described theoretical framework and the actual criteria that prize administrators consider when offering prizes is a subject area where little research has been done to rigorously validate or expand upon the criteria in offering a prize. This case study analysis will address this discrepancy and introduce new criteria through the comparison of practical and theoretical incentive prize programs. This will be accomplished through the following objectives:

- To understand what documented decision making criteria are considered compelling to prize administrators
- To identify new aspects of decision making that are considered compelling to prize administrators
- To use this information to contribute to a comprehensive model of decision making criteria for prize administrators to consider

Case Selection Criteria

The following prize selection criteria is designed around the perceived ability to obtain the most diverse and accurate sources of information possible for multiple cases. This will be accomplished by selecting recent, large-scale prizes that have been completed. An additional criterion with regard to differences in the administering entity will provide insight into the assumptions made by previous researchers, which have looked at prizes from the perspective of a social welfare maximizing entity. Implementation of these requirements leads to the following five criteria for selecting cases.

- 1) The prize must have been offered in the last 15 years
- 2) The prize value must be greater than \$1 million
- 3) The prize competition must have been completed
- 4) There must be a significant amount of publicly accessible data on the prize
- 5) One prize must be administered by the public sector, one by the private sector, and one jointly administered by the public and private sector.

Selected Cases

Research into the potential past incentive prize programs reveals three candidates for analysis: The X Prize, the DARPA Grand Challenges, and the Super Efficient Refrigerator Project (SERP).

SERP

Initiated by the EPA, NRDC, ACEEE in 1991 when 25 utilities pooled together nearly \$31 million to offer as a reward to the company that could manufacture and market a refrigerator that produced no carbon fluorocarbons (CFCs) and used 25% less energy than existing refrigerators.

The DARPA Grand Challenges

The original \$1 million Challenge asked entrants to build an autonomous vehicle that was capable of successfully navigating a course of obstacles and terrain in less than ten hours. In addition to constructing the vehicle, each team turned in a technical paper prior to entry detailing their design. Teams were unsuccessful in completing the course in the first DARPA Grand Challenge and no prize was awarded. The prize was reauthorized in 2005 with an increased

award of \$2 million; A Stanford team completed the Challenge and claimed the prize

The Ansari X Prize

The \$10 million X Prize was established May 18, 1996 in St. Louis by a group of investors/space enthusiasts to “promote the development and flight of spaceships able to provide low-cost commercial transport of humans into space.”

Procedure

Sources of Information

The objectives defined above will be achieved through the examination of documentation, archival records, and interviews in multiple case studies. These three sources will be collected in phases to ensure that the case studies are thorough and newly discovered information can be incorporated in interviews and additional research

Interviews

Interviews will be conducted with prize administrators by phone and will last approximately 30 - 45 minutes. The interviews will be taped and transcribed to ensure that an accurate account of the conversation is available for analysis. Each interview will be preceded by an invitation and explanation of the thesis project. Interviewees will be asked to fill out a short questionnaire prior to the interview in order to efficiently allocate time to key areas. Interviewees will also be asked to identify, if possible, potential sources of archive data and documentation that may contribute to this thesis. Ideally, two of the following candidates will participate in each case study.

Interview Candidates

SERP

- Howard Geller, Executive Director, Southwest Energy Efficiency Project, Former Director of ACEEE
- Marc Ledbetter, Pacific Northwest Laboratory
- Dr. Richard Harkness , Executive Director, SERP, Inc.,
- Dr. David B. Goldstein, Energy Program Co-Director, NRDC

X Prize

- Dr. Peter Diamandis, Chairman, X Prize Foundation
- Gregg Maryniak, Executive Director, X Prize Foundation
- Mike Kelly, Vice President, X Prize Foundation
- Brooke Owens, Director of Research, X Prize Foundation

DARPA Grand Challenges

- Dr. Tony Tether, Executive Director, DARPA
- Dr. Thomas Strat, Grand Challenge Deputy Program Manager
- Col. Jose Negron, Grand Challenge Program Manager
- Ron Kurjanowicz., Grand Challenge Program Manager

Interview Format

The interviews will be based around the following questions, which are also the questions that will be used in the preliminary questionnaire. The exact interview questions and their order will be refined prior to the interview based on the results of the preliminary questionnaire responses to ensure precise and complete answers.

- What were the public goals of the prize? What other goals existed?

- At the time, why were prizes seen as the proper means to accomplish the particular objective for the specific type of entity?
- What type of due diligence was conducted prior to arriving at the decision to use a prize?
- How uncertain was the administrator about the market applications and costs of the objective? Did an outside entity have information on this uncertainty? What steps were taken to address the uncertainty?
- What types of funding options were considered for the prize? What was the actual source of funding and why?
- What was the proportion of overhead cost in administering the prize to the expected benefit of the result?
- How did the funding option chosen effect the administration of the prize?
- How did the intended audience of researchers influence the decision to use a prize and the formation of its parameters?
- How were entrants screened?
- What factors were considered when deciding where to target participation in the prize competition?
- What value did public exposure add to the prize? Was this considered when valuing the prize? Was publicity integral to the success of the prize?
- How was the prize advertised to attract participants?

- What benefits beyond achieving the research goal were considered when making the decision to offer a prize?
- How well formed and responsive is the community and market surrounding the prize
- What types of supporting activities were used to supplement the prize?
- What type of effect did the prize have on the overall market? Would this same effect be possible through patents or contracts?
- Did political influences affect the decision to use a prize?
- What was the value of the prize? How was the value of the prize determined?
- What was the length of the prize competition? How was the length of the prize competition determined?
- How was the prize judged?
- How was progress monitored?
- What was the administrating body's policy for intellectual property ownership with the participants' entries? How about participant confidentiality?
- What other criteria was considered when deciding to use a prize?

Archival Data and Documentation

Archival records and documentation will be researched in tandem since the identification of one of these sources will likely point to an opportunity to research the other. Archival data consists of records and can include service records, organizational records, maps and charts, lists and names, survey data, and personal records. Documentation includes letters, memoranda, agendas, minutes, administrative documents, studies, newspaper clippings, and other sources of mass media (Yin, 2004). Archival data and documentation will be mapped over the same questions as in interview questionnaire to reinforce any findings.

Preliminary archival record and documentation sources

The following list identifies locations from which the search for archival and documentation data will begin.

SERP

- News clippings – Lexus Nexis
- Press releases – NRDC, EPA, Whirlpool, ACEEE, SERP Inc.
- Official competition rules
- Department of Justice memo (potential for antitrust filing)

- Studies – Nadel, Ledbetter, Geller
- Appliance manufacturer and electric utility company documents (annual report, 10-K)

X Prize

- News clippings – Lexus Nexis
- Press releases – Xprize.org
- Official competition rules
- Possible academic studies (?)
- Participant websites
- Public filings of participants (10-K)

DARPA

- News clippings – Lexus Nexis
- Press releases – DARPA
- Official competition rules
- DARPA Grand Challenge Forum
<http://dtsn.darpa.mil/ibb/categoryindex.aspx?boardID=1>
- Participant websites/program descriptions

Case Study Report Outline

- a. Background on case
 1. Prize Competition Parameters

2. Administrative structure

b. Case study analysis

1. Organization Type and Prize Objectives
2. Knowledge of Costs and Benefits
3. Funding
4. Participant Eligibility Requirements
5. Visibility and market transformation
6. Political Climate
7. Prize Competition Parameters
8. Additional Criteria

c. Sources

APPENDIX B

SAMPLE INTERVIEW QUESTIONNAIRE

Name
Organization
Date

What were the public goals of the prize? What other goals existed within the organization/administration?

At the time, why were prizes seen as the proper means to accomplish the administrative entity's goal?

What type of due diligence was conducted prior to arriving at the decision to use a prize?

How uncertain was the administrator about the market applications and costs of the objective? Did an outside entity have information that could have reduced this uncertainty? What steps were taken to address the uncertainty?

How was the value of the prize determined?

What types of funding options were considered for the prize? What was the actual source of funding and why was this method chosen?

How did the overhead cost of administering the prize compare with the value that was anticipated from the prize being won?

How did the funding option chosen effect the administration of the prize?

How did the intended audience of participant influence the decision to use a prize and the formation of its parameters?

How were entrants screened?

What factors were considered when deciding where to target participation in the prize competition?

What value did public exposure add to the prize? Was this considered when valuing the prize? Was publicity integral to the success of the prize?

How was the prize advertised to attract participants?

What benefits beyond achieving the research goal were considered when making the decision to offer a prize?

How well formed and responsive is the research community and market surrounding the prize?

What types of supporting activities were used to supplement the prize competition?

What effect did the prize have on the overall market? Do you feel that this same effect would be possible through patents or contracts?

What political influences affected the decision to use a prize?

What was the length of the prize competition? How was the length of the prize competition determined?

How was the prize judged?

How was progress monitored?

What was the administrating body's policy for intellectual property ownership with the participants' entries? How about participant confidentiality?

What other criteria was considered when deciding to use a prize?

APPENDIX C

SERP MEMBER UTILITIES

Arizona Public Service
Atlantic City Electric
Baltimore Gas & Electric
Bonneville Power Administration
Central Maine Power
Commonwealth Electric Co.
Cambridge Electric Light
Jersey Central Power & Light
Long Island Lighting Co.
Los Angeles Dept. of Water and Power
Madison Gas & Electric
New England Electric Service Co.
Northern California Power Agency
Northern States Power of Minnesota
Northern States Power of Wisconsin
PacifiCorp, Pacific Gas & Electric
Public Service Electric and Gas
Sacramento Municipal Utility District
Southern California Edison
Superior Water, Light and Power
Western Massachusetts Electric
Wisconsin Electric Power
Wisconsin Power & Light

Wisconsin Public Service Corp.