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PRIZE-BASED CONTEST CONSIDERATIONS FOR FEDERAL PROGRAM MANAGERS

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Open design is the concept that organizations can make greater use of external ideas and work performed outside their system within their own organization. Open designs work off of network based models where there is not necessarily a central hub and most of the activity occurs at the periphery. This paper specifically focuses on the open strategy of prize-based contests used in the government sector. Contests leverage work outside an organization by incentivizing a large number of diverse participants to solve well-defined problems. Contests have been used sporadically throughout history to solve difficult challenges. Today, there has been a movement from isolated contest experiments to a broader policy initiative to leverage the benefits of contests within the government sector. Federal program managers who had successfully used contests within NASA and the U.S. Patent and Trade Office were interviewed to gain insight on the necessary considerations for point solution contest use. This paper organizes these considerations within the framework of a program manager's "five competing demands" defined by the Project Management Institute's Project Management Body of Knowledge as: scope, risk, time, quality and cost. Finally, this paper dives into the last demand by providing a cost accounting example of a contest and defines one cost efficiency analysis strategy for point solution contests.

I. INTRODUCTION

NASA is challenged to embark on a new great adventure, reach farther into our solar system and accomplish something no government agency or commercial provider has done before. They must do this while both providing value to stakeholders and surviving under tight budgetary restrictions. To accomplish this feat, NASA must assume the various challenges that come along with it. In particular, the advanced technologies required can be a barrier to success for future human spaceflight missions. However, even if the knowledge to overcome the technological barrier could be obtained, the vast resources necessary to implement such missions are generally agreed to be impossible for one nation to acquire alone. Therefore, NASA must allow for both domestic and international contributions through various implementations of open design.

Open design strategies have started to carve out a permanent place in the for-profit world and there is an increasing interest for its application in the government context.[1] The changing environment of technology access and increasing rate of information exchange have encouraged companies to leverage open strategies by both spinning out unused technologies and incorporating outside ideas and technologies into their own organization[2].

On his first full day in office, President Obama signed the Memorandum on Transparency and Open Government which led government agencies, including NASA, to outline their initiatives to increase transparency, participation, and collaboration within their organizations[3].

This paper focuses on the collaboration aspect of this initiative and how government agencies can address this through the use of prize-based contests. Contest driven innovation is one way organizations can leverage the benefits of open design. With prizes, an organization can incentivize a large number of diverse participants to solve their specific problem.

In recent years, NASA has pursued this type of innovation strategy through grand innovation contests like the Centennial Challenges as well as smaller innovation contests run on the TopCoder, Innocentive, and WeHack.it platforms.

While contests have proved effective in various situations, this innovation strategy is not appropriate for all problems. This paper proposes a consideration framework for program managers who may be thinking of infusing a contest into their program.

To create this framework, program managers at the U.S. Patent and Trade Office (USPTO) and NASA who had successfully designed a contest for the first time were interviewed about their experience. Their considerations were organized within the context of the five competing demands that program manager must balance for any project: scope, time, risk, quality and cost.[4]

The following sections are presented as follows: First, a historical context of prizes and contests as well as their recent use in government is presented. Second, the insight gained from scoping interviews with program managers with contest experience was used to determine a contest consideration framework. Finally, the *cost* demand is explained through a detailed cost accounting example of a successful contest sponsored

by USPTO and a strategy for cost efficiency analysis is proposed.

II. PRIZES AND CONTESTS AS INCENTIVE MECHANISMS

Challenging crowds to compete to find a solution by providing prize incentives has been used throughout history in various industries. In 1714, the British government offered up to 20,000 pounds for a simple method that could accurately determine a ship's longitude. The main winner was John Harrison, a clockmaker that developed an improved clock design called a marine chronometer that could be used to accurately determine your ship's longitude.[5]

In 1919, a New York hotel owner, Raymond Orteig offered $25,000 to the first aviator to fly non-stop from New York City to Paris or vice-versa. Several famous aviators attempted this feat but the prize was ultimately won by relatively unknown American Charles Lindberg in his aircraft, the Spirit of St. Louis.[6]

A more recent example of a successful contest program implemented in the aerospace sector is the Ansari X Prize competition. This contest offered a ten million dollar prize for the first non-government organization to build a spacecraft capable of carrying three people to an altitude of 100 kilometers twice within two weeks[7]. Twenty-six teams from seven countries spent more than $100 million toward the pursuit of this prize. Ultimately the challenge was won by famed aerospace designer Burt Rutan and his company Scaled Composites.

X Prize has since scaled this competition model to challenges in the area of energy and environment, ocean exploration, education and global development and life sciences.

Benefits of Contests

A prize-based contest is an attractive incentive mechanism because it allows a contest sponsor to attract many diverse actors to their specific problem. During a contest, a relatively large number of individuals are approaching a well-defined challenge independently, conducting different experiments to find a solution. The combination of these various "trials" leads to an increased probability of a contest sponsor finding one particularly good, extreme value solution.[8]

Commonly cited benefits of contest use from a government perspective include the ability to:[9]

- Stimulate private sector investment that is many times greater than the prize itself
- Increase the number and diversity of the individuals and organizations addressing a particular national or international issue
- Establish an important goal without having to select a specific approach or individual that is most likely to succeed
- Award prize money *only* if the goal is achieved
- Improve skills of participants in the competition
- Further an agency's mission by enlisting public participation around a defined program goal

However, others have pointed out that from an economic perspective, some contests may be considered to be socially wasteful specifically *because* they stimulate private sector investment many times greater than the prize itself.[10] While in certain cases this additional effort can lead to the creation of a new industry, it is crucial that contest sponsors take into consideration the cost assumed by participants.

For NASA specifically, prize-based contests could be used as an alternative to traditional procurement in certain situations. Currently, the NASA acquisition process is regulated by the principle set of rules within the Federal Acquisition Regulation (FAR) contracting mechanism. Due to the upfront cost required to navigate the complexity of the FAR contract, it can be a large barrier to entry for small companies and newcomers to partner with NASA.[11]

By employing prize-based competitions, NASA can lower the barrier to collaboration and partner with individuals who previously did not have the resources to work with NASA. As this engages more of the American public in NASA's missions, it can also help garner more public support which will in turn help satisfy the needs of Congress. Additionally, under a contest strategy, payment is only awarded when specific milestones are met, which lowers the risk of investment for NASA.

Recent Contest Initiatives

Over the past few years, there has been a movement from isolated experiments to broader contest policy initiative intended to better leverage the benefits of prizes in the government sector.

Initiatives from the President and OMB have provided guidance to agencies who seek to use contests and prizes, while legislation under the America COMPETES Reauthorization Act offers authority for agencies to fund these challenges.[12] Government agencies now have the responsibility to understand how to use prizes and contests to better drive technological innovation within their agency.

Private companies have emerged as "challenge platforms" to help firms and government agencies design and run contests. These challenge platforms offer years of contest design experience to organizations

seeking to implement a contest into their programs. TopCoder, Innocentive, and WeHack.it are some of the more popular challenge platforms that currently exist and are described below.

- *TopCoder:* An online challenge platform that broadcasts software and digital challenges submitted by organizations to the TopCoder community of over 400,000 programmers worldwide. Since its inception over a decade ago, TopCoder has run over 10,000 competitions. TopCoder competitions have approximately a 90% success rate of being solved.[13]

- *Innocentive:* An online challenge platform that broadcasts a broad range of challenges to the Innocentive community of over 250,000 solvers with varied experiences. Over 1,400 public challenges have been posted and over $35 million has been awarded to solvers. Innocentive competitions have about a 50% success rate of being solved. Prizes typically range between $5,000 and $100,000.[14]

- *WeHack.it:* A new online hackathon platform that can host hackathons for organizations. Fourteen hackathons have been run through this system since the company announced its first hackathon in February, 2012.[15]

TopCoder has a higher success rate for competitions than Innocentive because TopCoder focus specifically on software and digital challenges while Innocentive is more broad and welcomes more complex challenges that can involve detailed product development.

Each of these companies will work with organizations on problem definition, prize setting and time framing for specific competitions. The insight gained from hosting many successful competitions allows these challenge platforms to work with organizations and strategically set competition characteristics to meet the needs and goal's of the organization.

NASA has already successfully piloted large contests through the Centennial Challenges and smaller contests through challenge platforms like TopCoder, Innocentive, and Tongal. But these contests are happening with limited budget, for a small sector of technologies, and only occurring at a couple NASA centers.

III. IMPLEMENTATION CONSIDERATION FOR POINT SOLUTION CONTESTS

While there is an external push to include prizes and contests as a tool for managers to solve problems, there are a number of important items to consider before moving forward with this type of innovation strategy. Using contests to drive innovation in government is increasing in popularity, however a useful framework to which program managers can refer in regards to implementation does not yet exist.

This paper introduces the concept of "contest architects" which are program managers who work to design and implement contests. It is important that contest architects are equipped with the necessary tools to implement prize-based contests effectively. Concepts from program management literature are applied to the context of prizes and contests. Insight gained from scoping interviews with four contest architects at NASA and at USPTO as well as managers at TopCoder was used to provide a consideration framework. The goal of this framework is to help program managers think through the process of adapting a contest strategy to their problem and to be made aware of the implications associated with contest use.

While it is difficult to generalize the experience from any one contest, a number of shared considerations emerged. These common considerations are explored within the framework of project management and will be investigated further through follow-up interviews as well as interviews with new contest architects.

This section does not address, however, the steps required to either (1) change internal organization structure to meet the needs of prize-based contests or (2) adapt a prize-based contest to current organization infrastructure. Before moving forward with a contest strategy, program managers will want to ensure proper internal legal, budgetary, and procurement policies can accommodate prizes and contests.

Project Management Considerations

Over the past decade, a number of different standards have been proposed to increase the professionalism of project management. However, the strategies and processes outlined in the Project Management Institute's Project Management Body of Knowledge (PMBOK®), have gained widespread recognition and have "become the de facto global standard for project management." [16] PMBOK® defines project management as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements."[4] In describing the primary work of a project manager, the first chapter identified five competing demands within a project that must be considered: scope, time, risk, quality and cost.

(1) Scope (2) Time (3) Risk (4) Quality (5) Cost

Table 1: Five Competing Demands for Program Managers

The following sections apply these five considerations to the context of prize-based contest design. Each section introduces a primary question that concerns contest architects within these demands and addresses the question using the context provided by PMBOK®. Finally, common considerations for contest architects within the respective competing demands are outlined.

Scope

Contest Architect Question: What is the appropriate scope of a contest problem definition?

Overview: Point solution prizes can be used for a broad range of problems and challenges. Software challenges like those run on the TopCoder platform are designed to be solved within a few weeks, while grand innovation prizes like those run by the X-Prize foundation can run over the course of several months or even years. Because of this, the deadline for the required technical solution must be considered when defining the problem and outlining the contest schedule. Along the same lines, the contest architect must ensure accessibility to the resources required (e.g. budgetary deadlines, time required by expert judges, etc) during the life of the project. For more complex and longer contests, knowledge of the resources required in the long term may be uncertain ex ante. Finally, the problem definition will guide participants in their development of a solution. Therefore, the problem definition must be linked to the intended goals of the contest.

Processes: There are five main scope processes that PMBOK® outlines for a project manager: Initiation, Scope Planning, Scope Definition, Scope Verification, and Scope Change Control.

A contest can be initiated for a number of reasons: to fulfil a government initiative, to solve an old problem that could not be sufficiently solved through traditional means, to leverage the benefits specific to contests and prizes, or simply to fulfil a request from upper management. If a contest is initiated to reach specific goals, the judging metrics which will guide competitors' solutions should be linked to these goals.

Scope planning, definition, and verification include involving input from the stakeholders in the project and receiving formal acceptance for the contest proposal.

Finally, scope management will likely be more difficult for grand innovation contest than for shorter contests. This is due to the inherent complexity and potential ambiguity of longer contests. It is difficult to predict the nature of solutions ex ante. Because of these reasons, the design of longer and more complex contests must include room for flexibility as contest architects learn more about the nature of the solutions throughout the contest. For any contest, however, the problem must be defined in a way that it is solvable within the timeframe of the contest

Considerations

- If one contest seems too complex, it can be broken down into multiple contests or designed as a series of contests where one contest builds off of the best solutions from the previous contest.
- Problem definition and judging criteria selection are likely the most important phases of contest design. This will shape the solutions that are received.
- Upfront costs to the competitor must be considered. If costs are too high, it may be difficult to attract a large number of diverse competitors. This risk can be mitigated by subsidizing the cost to competitors.

Time

Contest Architect Question: How long will it take my team to design a contest?

Overview: If an organization is new to using prizes and contests, the timeline for contest development will include inherent uncertainty. Because of this, it is imperative to identify and decompose tasks required for the main contest phases listed below.

(1) Problem Definition (2) Contest Design (3) Contest Operations (4) Judging (5) Solution Implementation

Table 2: Main Contest Phases

In some cases, an additional phase of Advertising may be desired before Contest Operations. It is also important to consider the time required to ensure that the necessary internal legal, budgetary, and procurement policies are in place.

Processes: There are five main time processes that PMBOK® outlines for a project manager: Activity

Definition, Activity Sequencing, Activity Duration Estimating, Schedule Development, and Schedule Control.

Although these processes are familiar to project managers, communication with a challenge platform will provide expert insight to inform each of these processes in the context of the contest phases stated above. While this insight will help guide managers through the definition and sequencing of activities, PMBOK® specifically cites the benefits of referring to historical examples of projects to inform likely durations for each task. Because there are few historical examples of government contest use, it is important to work closely with the challenge platform that is hosting the contest to determine activity duration, mandatory activity dependencies as well as external dependencies.

Another important consideration is the possibility that the solutions submitted do not meet the standards of the contest architect. If this were to happen, a follow-up contest that would build on the results of the first contest is an option. Follow-up contests are common and often employed at TopCoder. A follow-up allows the contest architect to redefine judging criteria based on knowledge of competitors and their solutions from the first contest. The possibility of the need for a follow-up contest should be considered when outlining a schedule and identifying methods of schedule control.

Lastly, the contest architect must minimize the work required for solution implementation. The nature of the solution and internal organization policies will affect the time required for implementation. The contest architects interviewed worked to minimize implementation time by setting specific design standards for submissions. Requiring solutions to be submitted in specific programming languages is a simple way this can be applied.

Considerations:

- The potential need of a follow-up contest should be considered when developing the contest schedule.
- Implementation time can be minimized by setting required standards for submissions.
- The contest duration should be appropriate for the difficulty level of the contest problem.

Risk

Contest Architect Question: How does infusing a contest into my project affect the risk profile of my program?

Overview: One of the main concerns of selecting a contest over traditional procurement is the risk that no acceptable solution is found. This could happen for the following reasons: (1) the problem was not defined sufficiently and while the submissions may be "good", they were not what the contest architect was looking for; (2) due to the difficulty of the problem, contributors did not have sufficient time or resources to submit acceptable solutions; (3) the prize architect did not provide sufficient information necessary for contributors to generate acceptable solutions.

In addition to this risk, the contributor of the winning solution is not held accountable for possible problems with the solution post-implementation. Because of this, there is the risk that the contributor is unavailable when problems arise.

Lastly, contests are sometimes used for problems that have been worked internally for a long period of time without the identification of an acceptable solution. If this is the case, the cultural implications of "outsourcing" an employees work to the public should also be considered.

Processes: There are six main time processes that PMBOK® outlines for a project manager: Risk Management Planning, Risk Identification, Qualitative Risk Analysis, Quantitative Risk Analysis, Risk Response Planning, Risk Monitoring and Control.

Risk management planning includes creating a work breakdown structure and clearly defining roles related to the creation and management of a contest. Because the contest platform will be responsible for a significant portion of this work, it is imperative to consult them during this process. The prize architect should acknowledge the main risks outlined above and identify any further risks associated with publicizing a problem through a contest. Once these risks are identified, the impact and likelihood of each risk should be analyzed. This can be used to inform the prioritization of risks and the creation of a response plan should a risk occur.

One way the contests architects interviewed addressed some of these risks was by designing contests around problems that were not on the critical path of their program. For example, some of the contests were designed to simply improve upon existing solutions. A contest was deemed as a time and cost-efficient tool to improve optimization. Additionally, prize architects planned ahead for the necessity of follow-up contests that would improve the quality of submissions.

Considerations:

- To avoid affecting the risk profile of a larger program, contest architects can design contests around problems that do not lay on the critical path to success.
- The risk of negative cultural implications from outsourcing a problem to the public should be considered.

Quality

Contest Architect Question: How do I control the quality of submissions?

Overview: The desired quality of a submission must directly inform the judging criteria which is presented to contributors at the start of a contest. Implementing these criteria will likely be more straight forward in software contests than it will be in contests that require product design. For software-based solutions, it may be possible to automate the process by which submissions are graded. Product-based solutions, however, will likely require the attention of expert judges

Processes: There are three main quality processes that PMBOK® outlines for a project manager: Quality Planning, Quality Assurance, and Quality Control.

Project quality must address both the management of the contest and the end product of the contest itself. Assuring the quality of a contest will include clear guidelines for participation, a transparent judging process conducted by experts (if necessary), and clearly stated prizes. The contest architect can most directly affect the quality of submissions through clear judging criteria. Sometimes, desired submission attributes cannot be easily quantified. In these situations, it is especially important to outline clear judging criteria and promote fair transparent processes.

Considerations:

- The selection of judging criteria is the simplest and most direct way a contest architect can affect quality of submissions. The contest architect can also increase submission quality by subsidizing participant efforts.
- To assure the quality of the contest itself, judging criteria must be made clear at the start of the contest.
- More time and resources will likely be required to assure quality of product-based contests than it will be for software-based contests.

Cost

Contest Architect Question: How much will it cost to acquire technology through a contest?

Overview: A common benefit of a contest strategy is the ability to pay less for more diverse and a larger quantity of solutions [17](lower downstream costs) compared to that of traditional procurement. However, the time and resources required to design a contest (upstream costs) may be comparable or potentially more than those of traditional procurement. This section describes the different types of costs associated with prizes and contests and one suggested strategy to determine the cost efficiency of a contest *ex post*. Because the cost aspect is a crucial difference between contests and traditional procurement strategies, this demand is explained in further detail with a contest cost accounting example in the next section.

Processes: There are four main cost processes that PMBOK® outlines for a project manager: Resource Planning, Cost Estimating, Cost Budgeting, and Cost Control.

For a new contest architect to work through these four processes, he or she must understand how to account for the costs associated with contest design. While there is no standardized process by which to do this yet, one proposed strategy for contest cost accounting is provided below.

Cost Accounting Process: The cost of running a contest can be broken down into three main sources of costs: challenge posting fees, labor, and prize purses. Challenge posting fees and labor fees make up the upstream costs while the prize purse is attributed to downstream cost. This distinction becomes important when comparing the costs of contests to that of procurement. Challenge posting fees will differ depending on both the organization that is hosting the contest and the organization that is sponsoring the contest. For TopCoder, there is a monthly platform fee and also a fee per contest. These fees will differ depending on the number of contests the challenge sponsor plans to run on their TopCoder platform throughout the calendar year.

Upstream ←	(1) Challenge Posting Fees
	(2) Labor Fees
Downstream ←	(3) Prize Purse

Table 3: Main Sources of Contest Costs

The prize purse for a given challenge may be given as one sum to one individual or it can be awarded to multiple solvers who submit top solutions. The prize purse can also either be awarded once at the end of a competition or broken down and awarded at different phases of a given contest. While prize purses and challenge posting fees can generally be considered as flat rates, the cost of labor will depend on the hours worked per individual throughout the contest lifetime.

The lifetime of a contest has been broken down into five phases: (1) Problem definition, (2) Contest design, (3) Contests operations, (4) Judging and Solution Selection, and (5) Solution implementation. Labor costs can be calculated *ex post* by identifying the amount of hours required to complete each task within a phase. The hours can then be multiplied by the pro-rated

burdened salary per hour of the employee responsible for the respective tasks.

Due to the small sample size of contests used as a procurement strategy it is difficult to compare the cost of a contest to historical examples. Because of this, the evaluation of the contest costs is based on a cost avoidance method. This method identifies the difference between the cost of obtaining a technology through a contest and the total cost expected from obtaining that same technology through the traditional method of hiring a contractor.

The quality of solutions is judged by the challenge sponsor. Judging guidelines are provided at the beginning of a contest so that the participants know what the challenge sponsor will be looking for. For many programming challenges that have a goal of completing a task as quickly as possible, solutions can be graded quickly. However, contests that are more complex, include product development, or are open-ended will likely require judges to comb through each solution and grade them on a set of preselected metrics. The time the judges spend grading each solution must also be accounted for.

Creating Counterfactuals: A counterfactual can be designed to compare the costs of obtaining a technology through a contest to those of procuring a comparable technology with a contractor. Due to the uncertain nature of the solution ex ante, this cost avoidance method is more appropriately applied after the contest is completed and the solution is known. The upstream costs for procurement are incurred through the acquisition process. This process, simplified here, includes: (1) Release of public notice of solicitation, (2) Request for proposals, (3) Judging proposals, (4) Selection of Top Proposals, (5) Acceptance of Best and Final Offers, and (6) Award notice. The labor costs associated with this process should be compared to the sum of the challenge platform and the labor fees. That being said, however, it can be very difficult to estimate this cost for theoretical acquisitions.

Next, the prize purse (downstream cost) should be compared to expected cost of hiring a contractor to develop a comparable technology. This cost can be estimated by requesting quotes from contractors with relevant experience.

Considerations: Often, there are benefits that derive from the use of contests that cannot necessarily be graded or quantified. Therefore, the cost efficiency of a contest is not necessarily the best metric for evaluation. Qualitative benefits can result from the use of contests that would not emerge from procurement alternatives. These benefits can include agency or department goals that were met through the use of a contest strategy (e.g. educating the public on a topic, reaching out to a minority group, attracting new customers/users to your company or system, etc). It is also important to consider the likelihood of upstream costs reducing over time as the use of contests becomes more frequent and the process becomes more streamlined.

IV. POINT SOLUTION CONTEST EXAMPLE

The authority for prize use in government has been provided by the America COMPETES Reauthorization Act. While this external framework was necessary for federal agencies to move forward, a contest architect must identify a strategy to leverage this framework within their agency.

This section describes one successful implementation of a point solution contest within a government agency. The fifth program management demand, cost, is the focus of this analysis.

This section begins by describing the problem faced by USPTO and the considerations that led the program manager to select a contest as the tool to acquire the necessary technology solution. It proceeds with a cost analysis of the contest itself. Lastly, a counterfactual is created to determine if the contest was a cost efficient method of obtaining this particular technology.

Problem Identification

The USPTO has over 8 million patents on file.[18] For a patent to be issued, it must fulfill a number of qualifications, including the condition that the concept has not already been patented. To ensure that this condition is met, patent applications must be carefully reviewed and compared to similar patents already on file. One of the more time consuming tasks for patent reviewers is the process of scrolling through patents to locate figures that are referred to throughout the text. This particular problem inspired the Patent Labeling contest.

The NASA Tournament Lab, together with USPTO launched the Patent Labeling Contest hosted by TopCoder to develop new algorithms to aid in patent identification. The contest challenged software developers, academics, and the TopCoder community to develop an algorithm that identified patent figures and figure parts. Contest participants had to make use of text recognition, image analysis, and the construction of bounding boxes to complete the challenge.[19]

A contest was selected as the tool to acquire the necessary technology for a couple different reasons. First, because an external interest to understand the use and benefits of contests exists, external prize funding was made available to USPTO for this contest. While the prize purse was only a fraction of the contest development costs, this funding helped the program manager to "try out" a contest for the first time. Second, the challenge platform TopCoder allowed USPTO to

take advantage of an existing community of "solvers." The USPTO Patent Labeling contest was advertised to TopCoder's community of software developers (200,000 at the time of the contest) who compete regularly to solve different types of programming challenges. USPTO was also able to leverage the experience and expertise of TopCoder to develop their first contest.

Contest Overview

The USPTO Patent Labeling Contest invited developers to help solve the problem of text and image recognition within the patent review process. Participants were provided with an image of a patent drawing page, which contained one or several figures. Each figure had a title and consisted of many parts. Each part was labeled with a certain text (typically a number). Some parts had multiple labels. To complicate matters, many drawing pages also included additional data that did not belong to any of the figures. The goal of the challenge was to extract the following data from patent drawing images:

1. for each figure, its location and title;
2. for each part label, its location and text.

The contest was designed to run for four weeks between the end of 2011 and the beginning of 2012. The total prize purse summed to $50,000 with top ranking players receiving up to $10,000.* Additionally, all competitors received a limited edition t-shirt to acknowledge their efforts in participation.

Ultimately 232 teams (463 participants) signed up for the competition, of which 70 teams (30%) submitted software code. Twenty-nine countries were represented among those participants who submitted solutions. This group of submitters included roughly half (49%) professionals, 39% students, and the remainder reporting not working or part time. The majority of participants ranged between 18 and 44 years old. Seven of the participants were academics (PhD students, professors, or other research positions). Most (80%) of the non-student participants were self-described software developers of various kinds.

The top submission resulted roughly 80% efficiency in identifying all figure locations and titles and all label locations and text. While this was considered a "success" to the contest architect, a follow-up contest was pursued to improve on the top submissions of this contest.

* Embedded within this event was a social science experiment to investigate different team formation mechanisms. The details of that work are beyond the scope of this paper.

Cost Summary

The following cost analysis follows the strategy for cost accounting outlined in the previous section. Costs are broken down into (1) Challenge Posting Fees, (2) Labor Fees, and (3) Prize Purse. The *upstream costs* here are the challenge posting fees and the labor fees, while the *downstream cost* includes the prize purse. The TopCoder fees are accounted for within the challenge posting fees. Because NTL is a joint project between NASA and Harvard, the labor fees are broken down as such. The total costs of the contest were estimated to be $68,000. A summary of the total cost breakdown are provided below.

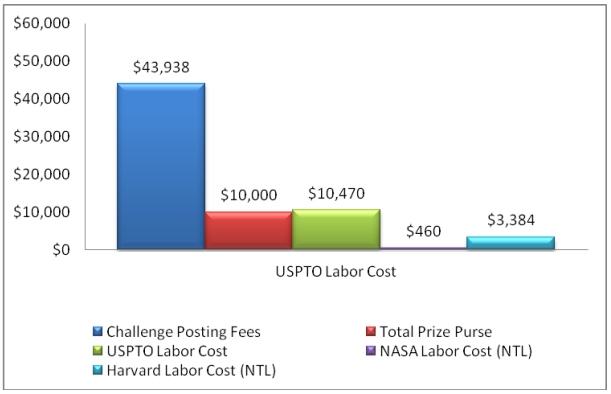

Fig.1: Cost Accounting Summary for the USPTO Patent Labeling Contest.

The upstream costs contributed to 85% (~ $58,000) of the contest's total costs with TopCoder (challenge posting) fees at 64%, and labor fees at a combined total of 21%. The downstream cost only contributed to 15% ($10,000) of the total contest costs.

Labor Costs

The estimation of labor costs was generated through enumeration of all tasks required for each contest phase (1) Problem definition, (2) Contest design, (3) Contest operations, and (4) Judging and solution selection. The fifth contest phase, solution implementation, is not accounted for here because a follow-on contest was implemented to improve upon these contest results. The identification of these tasks along with their duration was found through multiple interviews with USPTO, NASA, TopCoder and Harvard. The cost for each task was calculated by multiplying the task duration by the pro-rated burdened salary of the individual responsible.

A summary of the labor costs for each individual task over the four phases of the USPTO contest are outlined in the graph below. Each bar represents an individual task charted over the 15-month period of the development of the contest. Stacked bars represent tasks with multiple contributors.

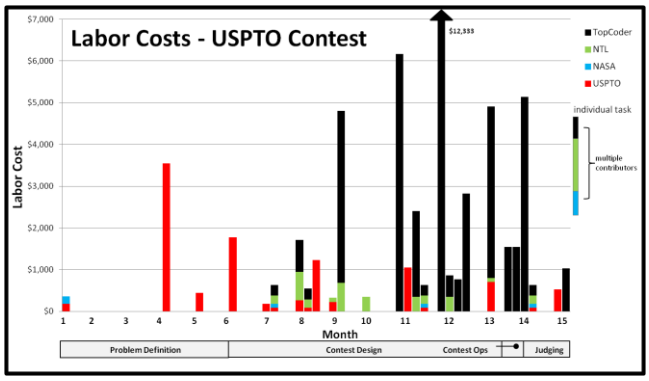

Fig. 2: Labor Cost Summary for USPTO Patent Labeling Contest.

The labor cost summary shows that the majority of work in the initial phases was completed by the contest sponsor (USPTO) while much of the latter work of contest design and operations was dominated by the contest host (TopCoder). NTL acted as a liaison between USPTO and TopCoder to facilitate communication between the contest sponsor and contest host.

Counterfactual

One method of determining whether a contest is a cost efficient way to acquire a technology is by comparing it to estimated traditional procurement costs. This can be labeled as a "cost avoidance" methodology. However, it should be noted that when deciding to employ a contest, contest architects must combine cost efficiency with other considerations including the non-financial benefits that are associated with contest use.

To analyze the cost efficiency of this contest, upstream and downstream costs of this contest were compared to the upstream and downstream costs estimated to occur if a contractor was hired to develop the same technology.

Upstream Procurement Costs: For traditional procurement, the costs associated with acquisition would fall under the upstream costs. Precise upstream acquisition costs were not found through interviews with relevant USPTO employees. Therefore, acquisition experts at NASA were interviewed to provide expected NASA acquisition costs. Acquisition costs for contracts less than $1M were estimated to be between 10% – 20% of the contract cost. For this analysis, it is assumed that USPTO would encounter a similar percentage for contract acquisition costs.

Downstream Procurement Costs: To estimate the downstream costs, relevant contractors were contacted for quote estimations. A total of six contractors with expertise in image recognition software development were contacted for this project. These contractors were only provided with the problem statement of the contest and a thorough description of the problem USPTO was hoping to solve. The characteristics of the winning solution were not made available for reference.

Three contractors responded and only two were willing to provide estimations for the total cost they would quote to USPTO if they were hired to develop a solution. These estimated quotes are listed in the table below.

Company	Estimated Costs
A	$200,000 - $800,000
B	$150,000

Table 4: Estimated Contracting Costs

Both Company A and Company B stated that their expertise could be applied to the USPTO problem statement provided. Company A is a company that provides software development services to leading technology providers and to end user organizations in need of specialized applications. This contractor stated that to develop a sufficient solution, it could cost anywhere between $200,000 and $800,000.

Company B offers software solutions for real-time pattern recognition that can be integrated into various applications. Company B believed that their pattern recognition technology could be easily adapted to solve this problem for around $150,000.

Results

The estimated findings for upstream and downstream procurement costs are compared to those found for the USPTO Patent Labeling Contest in the table below.

	Upstream	Downstream	Total
Contractor A	~$20,000	$200,000 minimum	~$220,000
Contractor B	~$15,000	$150,000	~$165,000
Contest	$58,000	$10,000	$68,000

Table 5: Upstream and Downstream Cost Summary

The minimum total cost estimated to acquire a comparable solution through traditional procurement methods was found to be about $165,000. Contest total costs were found to be less than half (41%) of this. While the upstream cost of the contest was approximately 400% more than that of procurement, the cost savings were found in the downstream costs where contest costs were roughly 6% that of procurement.

One important consideration is that the technical solution found within the four-week time span of the contest was only 80% efficient at identifying the required patent text, images, and labels. Because of this, a follow-up three-week contest that built off the best solutions was implemented shortly after the winners were announced. The follow-up contest, which had a

winning prize purse of $5,000 resulted in a technical solution that was 90% efficient. Because the follow-up contest built off the design work required to develop the first contest, minimal contest design labro was required. Ultimately, this contest architect invested an additional $5,000 for an increase in 10% efficiency.

A better comparison would be to compare the total contest costs with the cost of procuring an equally efficient solution. However, it is difficult to deduce the level of efficiency that the cited contractors would have achieved in their solutions. This analysis assumes that the quotes from contractors would result in a solution at or near 90% efficiency.

Ultimately, the total cost of the contest was less than the estimated cost of procuring the same technology. Because of this, it was determined that the USPTO Patent Labeling Contest was a cost efficient method of procuring this specific technology.

V. CONCLUSIONS

Prizes and contests have been used throughout history to ascertain solutions to difficult problems. Recently however, there has been a movement from isolated contest use to a broader policy initiative.

Program managers within government agencies now have authority to use contests and prizes as an alternative to procurement. This paper proposes a consideration framework for program managers thinking about using prizes within their program.

The proposed framework was built around the five competing demands provided by the Project Management Institute's Project Management Body of Knowledge: scope, time, risk, quality, and cost. The considerations were derived from interviews with prize architects at UPSTO and NASA.

For the last competing demand, cost, one strategy for contest cost accounting was presented. This cost accounting method was further explained through an example with the USPTO Patent Labeling Contest. The cost analysis of this contest showed that, for this specific example, a contest was estimated to be more cost efficient than traditional procurement.

While there are certainly many stories of successful contests used within the private and government sector, more work must be done to fully understand the science of this innovation strategy. Specifically the question of applicability is important to program managers considering contests. *For which problems are contests appropriate?* And similarly, *which type of contest is appropriate for my problem?* Another non-trivial consideration is the culture change that must occur for contest implementation to become a permanent tool in a program manager's innovation tool box.

As contests are used more frequently throughout government agencies, a larger data set on contest use will become available to those trying to understand contests as an incentive mechanism. It is important that this data be translated in a way that is informative and useful to program managers. Contests can be an effective way to innovate in certain situations, but program managers should be made aware where and how they can be used effectively.

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