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THE CALTECH SPACE CHALLENGE: LESSONS LEARNED AND FUTURE PLANS

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The Caltech Space Challenge is a 5-day student mission design competition for undergraduate and graduate students. A competitive pool of domestic and international students are formed into two teams, invited to Caltech, and tasked with designing a human space mission. It is a student-led program, and was originally started by Caltech graduate students Prakhar Mehrotra and Jonathan Mihaly in 2011. The mission objectives for each event are developed through collaboration between Caltech and NASA-JPL. In 2011, students were challenged to design a human mission to a Near-Earth Object. The problem statement for the 2013 Caltech Space Challenge was intended to build on the success of the 2011 competition, and students were challenged to design a human mission to a Martian moon. During the event, the two teams are provided with a lecture series (~10 lectures) consisting of speakers from NASA, international space agencies, and private industry. The lectures are designed to provide the participants with the basic information required for their mission designs. This includes lectures on topics ranging from team dynamics to orbital mechanics. Teams interact directly with each of the speakers, and are supported throughout the week by volunteer mentors from both NASA and industry. The technical products of the Caltech Space Challenge include conference and journal publications based on the teams' final mission proposals. In addition to academic publications, this program also creates a strong professional network among the student participants, and between the participants and the industry sponsors, which can help facilitate full-time positions for the participants in the future. The focus of this paper is on the organizational and planning lessons learned by the student leaders. Plans for future events will also be discussed. Approximate time-lines for the program will be highlighted, including fund-raising, applicant selection, publicity, technological/administrative support, and the structure of the workshop. The Caltech Space Challenge program is an intensive, student event that yields a professional product in only 5 days.

I. INTRODUCTION

The Caltech Space Challenge is a 5-day student mission design competition. Students from all over the world are invited to Caltech, formed into two teams, and tasked with designing a space mission of national and international importance. The competition brings together students from various disciplines, equips them with the necessary tools, and challenges them to produce a viable mission architecture and design. It is intended that the innovative solutions produced by the students will be considered by NASA when designing future space flight missions. Lectures and workshops are also provided for the participating students on topics such as conceptual mission design, human spaceflight challenges, and recent advances in space studies. Throughout the week, the two teams work on their own mission proposals independently. Midway through the week the teams are required to present their progress at a preliminary design review presentation, and the Space Challenge culminates with the submission of a final report and final presentation by each team. These results are evaluated by a jury consisting of representatives from the aerospace community, who determine the winning team.

The Caltech Space Challenge is student-led, and was originally started by Caltech graduate students Prakhar Mehrotra and Jonathan Mihaly in 2011, and was hosted by the Keck Institute for Space Studies (KISS), and the Graduate Aerospace Laboratories at Caltech (GALCIT). The event was made possible through a call by KISS for student lead programs under an initiative started by the KISS Director, Professor Tom Prince, to engage the student body. The original idea for the event was inspired by the founders' experiences at the University of Stuttgart's Space Station Workshop and the NASA Academy. The program was also motivated by an interest to bring an immersive spaceflight mission

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design program to the Caltech campus, which could utilize the local expertise of JPL.

Due to the administrative requirements of the event, the event is held every two years at the California Institute of Technology, in Pasadena, California. In 2013, Caltech graduate students Nick Parziale and Jason Rabinovitch were the student co-leads. The event was hosted by GALCIT, and took place from March 24th to March 29th, 2013.

The program mission objectives for both of the previous competitions were developed through a collaborative effort between the Caltech student co-leads and NASA-JPL mentors. All of the chosen mission topics are related to human space missions. Human missions are chosen in part due to the broad appeal of these missions, which encourages student participation. In addition, human missions require a large variety of technical skills that are not necessary for robotic missions (life support, human factors, etc.), which helps to attract a larger applicant pool, and ultimately results in more qualified student participants. Finally, the use of general scaling rules and relationships can easily be incorporated in the human mission design process for sizing habitats, life support systems, etc., which allows significant progress to be made by the participants in 5 days. The mission topic is also chosen to be relevant to current NASA and industry projects.

In 2011, the problem statement for the competition was inspired by President Obama's initiative to send astronauts to a Near Earth Object (NEO).[1] Students were challenged to design a mission in 5 days to send humans to a NEO, collect samples, and return safely to Earth. The problem statement for the 2013 Caltech Space Challenge was intended to build on the success of the 2011 competition, and to stay consistent with the flexible path approach advocated by the Augustine Committee.[2] Students were challenged to design a human mission to a Martian moon of their choosing (Phobos or Deimos), collect samples, and return safely to Earth.

The focus of this paper is the organizational aspects of the Caltech Space. Herein, we describe the goals of the competition, fundraising efforts, the general event organization, the event impact, event feedback, and continuity of the event.

II. COMPETITION GOALS

The student mission designs are intended to be of a quality sufficient to help provide innovative solutions to a challenging problem, help identify international or commercial collaborations, and possibly serve as a starting point for NASA or other space agency missions. Student education is paramount, and the competition immerses the participants in an intensive week of mission design that includes lectures from world leaders in the space and aerospace fields. This provides the opportunity for students to interact with speakers and mentors, while working closely with an international group of highly-motivated and talented students. Such an experience provides the opportunity for the students to learn from established leaders in the aerospace industry, while also interacting with future members of the international aerospace community.

In addition, it is intended that the challenging and exciting environment experienced at the Caltech Space Challenge will encourage the student participants to pursue a career in the aerospace industry. By inviting both NASA and industry speakers/mentors to come to Caltech during the competition, the student participants are able to make strong contacts with professionals within the aerospace community, representing both government and private industries. These interactions with established professionals help educate the students on what a career in the aerospace industry post-graduation entails. Furthermore, the professional network created between the students and aerospace companies results in employment opportunities for the student participants after the competition is completed.

Finally, the competition also connects highly motivated students from around the world. The organizers hope that some of the friendships made during the Caltech Space Challenge will continue to connect the participants as they graduate, and eventually help facilitate future international collaborations between national space agencies from around the world.

III. FUNDRAISING AND EVENT SUPPORT

This event would not be possible without the continued support of Caltech, NASA-JPL, and KISS. The event takes place on the Caltech campus, so the continued support of the Caltech administration, and personnel support from GALCIT is necessary for the Caltech Space Challenge to be successful. NASA-JPL support is largely provided by NASA-JPL employees acting as advisors to the organizing student leaders, lecturers, mentors to the student participants, and serving as jury members. Finally, KISS was the primary hosting organization for the inaugural Caltech Space Challenge, and continues to provide financial support for subsequent events.

Once Caltech administrative support is secured, including commitment from Caltech faculty and JPL advisors, fundraising efforts begin in order to host the highest calibre event possible. To raise the required funds, the student organizers work closely with the Caltech Development Office and Corporate Partnerships Office. This leverages all of the Caltech connections available, and allows the maximum number of potential donors to be identified for the event.

When interacting with potential corporate sponsors, the main strategy used by the event organizers is to

highlight that sponsoring companies are provided first-hand access to a competitively identified, highly talented and motivated group of students who are interested in entering the aerospace industry. Different sponsorship levels allow differing levels of interactions with the participants. For example, benefits to sponsoring companies can include: receiving copies of participants' resumes, having a company representative serve as a member of the jury, and permitting a representative to address the participants in a private setting during the week. The participation of the aerospace industry is intended to be mutually beneficial for both the sponsors and the students. Industry participation both provides critically important financial support, and also adds a sense of legitimacy to the event by having leaders of the aerospace community interact with the student participants.

After interacting with previous event sponsors, it was determined that any minor publicity or exposure that the companies would gain from the event paled in comparison to the benefits they gained from interacting with the student participants. Current and future fundraising efforts have been changed to take this fact into account.

IV. EVENT ORGANIZATION

This section outlines the logistical aspects of planning the Caltech Space Challenge. Fundraising efforts, and choosing future mission challenges start approximately two years prior to an event. This section focuses on organizational aspects that begin roughly six months prior to a competition.

Event Publicity

In order to attract as many talented applicants as possible, efforts to publicize the event to students from around the world begin five to six months before the competition itself. Publicity efforts are made through all means possible. In the past, using university mailing lists as well as alumni mailing lists for programs attended by event organizers have been effective for publicizing the Caltech Space Challenge to prospective applicants. In addition, personal contacts at other academic institutions have aided in publicizing the event. After the first successful event in 2011, it was possible to ask the "Caltech Space Challenge Alumni" to advertise the event at their home institutions, and this attracted many new, highly qualified applicants. The event organizers have also advertised the event at academic conferences, while presenting results from previous events. Finally, some advertising is done via social media (Facebook and Twitter), which was found to have only a minor impact on the number of applicants for the past events. In the future, the organizers plan to gather more information from the applicants regarding how they learned about the Caltech Space Challenge.

Application Process and Applicant Selection

A simple, streamlined application process has been used successfully for the past two competitions. Applicants are required to submit a PDF document containing a short personal statement and resume. In addition, a single letter of recommendation from an advisor or supervisor is required for each applicant. In 2011, this resulted in over 270 student applications from over 100 universities in over 25 countries world-wide. In 2013, this resulted in over 175 student applications, again representing countries from all over the world. It is believed that the reduction in number of applications in 2013 was due to the scheduled timing of the event. In 2011, the event took place in September, while in 2013, due to logistical issues, the event took place in March. Applications are due 3-4 months prior to the start of the competition, which gives the organizers sufficient time to review the applications, notify the accepted students, and then allow participants to make their own travel arrangements.

When judging the applications, the student leaders place a large emphasis on teamwork and leadership experience. Due to the short duration of the event, any time wasted due to inefficient team dynamics can jeopardize the success of an entire team. Therefore, by selecting applicants with a strong history of leadership experience and teamwork activities, it is intended to maximize the likelihood that teams will function more efficiently when they meet in person at Caltech.

After evaluating the original applications, approximately 40 students were selected in both 2011 and 2013 for Skype interviews. Interview questions focused on judging an applicant's interest in space exploration, as well as focusing on teamwork and conflict resolution questions.

After all Skype interviews are completed, 32 students are selected as participants, with a few applicants kept on a waiting list. In 2011, a total of 12 different nationalities were represented by the student participants. In 2013, 11 different nationalities were represented by the participants. The highly international nature of the event made the event extremely unique, as participants collaborated and interacted with other student scientists and engineers from all over the world. Both undergraduate and graduate students participated in the event, with 12 undergraduate and 20 graduate students in 2011, and 6 undergraduate and 26 graduate students in 2013. Coincidentally, during both the 2011 and 2013 events, there were 21 male and 11 female student participants.

In addition to academic merit and leadership qualities, applicants are selected in such a way as to maximize the breadth of knowledge possible for each team. At the minimum, it is ensured that each of the two teams have a combination of engineers and scientists.

Applicants with more specialized skills (such as medical sciences, graphic arts skills, etc.) are also sought after during the selection process. Finally, considerations are made to limit (within reason) the number of selected applicants from a single institution.

For each of the past two competitions, it was possible to select 32 highly qualified student participants. Once the participants were selected, notified, and had accepted their acceptance offers, the student co-leads are required to divide the participants into two teams, Team Voyager and Team Explorer. Great care is taken in order to ensure that the teams are as balanced as possible. This included ensuring that each team had sufficient knowledge to complete all aspects of mission design, balancing the number of domestic and foreign participants on each team, splitting up participants from the same institution, equalizing the number of undergraduate and graduate, and trying to balance the male/female ratio on both teams.

The applicant selection procedure and the division of teams are strongly correlated to the overall success of the event. The calibre of the mission designs created by the teams is directly related to the quality of student participants. In addition, if the combined knowledge of one team is not sufficient to cover the multi-disciplinary nature of a mission design, the final product will be lacking and incomplete. Due to the great number of applications that were received for the 2011 and 2013 events, it was possible to select applicants with a wide variety of skills and expertise. This enabled the formation of two balanced, multi-disciplinary teams.

Project Topic Selection

The topics selected for the past Caltech Space Challenges have all been related to human space missions, and currently the goal is to continue to focus on human missions for future events. The topics are selected through collaboration between the Caltech student leaders and JPL mentors. It is desired to pick a topic that will not only be interesting to the students, but that is also relevant to the aerospace industry and NASA in general. In addition, due to the support that NASA-JPL provides for the competition, it is desired to pick a topic such that NASA-JPL will be able to provide some lecturers and mentors who are experts in the chosen mission topic. By ensuring that the competition topic is relevant to aerospace companies in addition to government agencies, the competition becomes more attractive to potential corporate sponsors.

The scope of the project is limited so that an ambitious and talented team of 16 students can make significant progress on the challenge in only 5 days. The efficiency of the teams is aided by supplying them with detailed background information about the mission topic, and organizing a series of lectures and mentors to interact with the teams during the week. Even though the technical scope and rules of the competition do limit some of the possible design solutions, the mission statement is constructed to allow for flexible and creative solutions. If done correctly, this also makes it more likely that the final mission designs created independently by each team will have significant differences. The goal of finding a balance between a narrowed scope (feasible for a 5 day event) and one which facilitates creative design solutions is something that is still being improved upon as the competition matures.

Student Support

In order to attract the most talented applicants, and with the goal of preventing financial issues from prohibiting the participation of international students, a large percentage of the event budget goes towards supporting the student participants. As the event budget is directly dependent on the success of the fundraising campaign, the student expenses are prioritized in the following manner:

1. Food and lodging
2. Student travel reimbursement
3. Student prizes

The budget for food, lodging, and some travel reimbursement for the participants is considered a requirement for the event. If the minimum amount of money is not raised to cover these expenses, the event will be cancelled. Student prizes, while desired if possible, are not a requirement, and are one of the first budgetary items to be dropped if funding is limited.

Supporting Documents/Activities

The project organizers provide support material to the student participants in order to maximize the productivity of the participants once they arrive at Caltech. Before the competition begins, a binder is compiled that includes a detailed mission statement, an overview of the Caltech Space Challenge, information about the speakers, mentors, jurors and sponsors, and technical information relevant to the current mission project. The participants receive this information at the welcoming ceremony hosted on campus during the evening before the first full day of the competition.

Before the participants meet in person, the teams are put in contact via email in order to facilitate some basic introductions. The teams are also intentionally only supplied with basic information about the mission statement before the competition begins. This allows primary background research to be performed before the teams arrive at Caltech, but precludes the teams from finalizing a mission design before the competition has started. Suggested reading documents are also uploaded to the event website to direct the participants towards relevant reference documents.

In addition to background materials supplied by the event organizers, the participants are also provided with two other main areas of support: a public lecture series, and mentors.

Public Lecture Series

A public lecture series is hosted on campus during the Caltech Space Challenge that includes approximately 10 lectures. Based on student feedback, the majority of the lectures are scheduled early in the week in order to give the teams as much time as possible to include information from the lectures into their mission designs. The goal of the lectures is to provide the teams with a wide variety of background information related to the mission challenge. In addition, the lectures are open to members of the community free of charge, and serve to introduce the public to a wide array of topics related to space. The speakers are chosen to represent different government agencies, both domestic and international, as well as private aerospace companies. The number of international speakers invited depends on the relevance of the mission topic to international organizations, and on the budget available. Speaker travel and room and board are accounted for in the event budget. As an institutional policy, no speakers are given any form of payment or honorarium for speaking at the Caltech Space Challenge.

All of the invited speakers are asked to interact with the student teams on campus after their lectures, schedule permitting. In the past, some speakers have stayed on campus to work with the teams for a few hours, while some speakers have spent the entire week at Caltech interacting with the participants. Generally, speakers aid teams with specific questions and design challenges. This is a unique opportunity for students to interact with leaders in the aerospace industry on a personal level. Not only are the speakers able to offer technical advice to the student participants, but the speakers themselves have greatly enjoyed working with the students, and working in a very fast-paced, high-energy environment.

Mentors

A group of dedicated mentors are also provided for the teams throughout the entire week. The mentors generously volunteer their time and spend much of the week on campus, interacting with the teams. These mentors are generally aerospace professionals local to the Los Angeles region. Food and lodging is provided for all mentors as needed.

The mentors are either experts in a field directly related to the mission challenge, or professionals who have had long and successful careers working in the space industry with managerial experience. The mentors advise the teams on technical details, as well as offer advice on team structure, team interactions, concurrent engineering, etc. Mentors may also serve as mediators in the event of inter-team disagreements that may not be resolved by the students themselves.

Team Dynamics

Another unique aspect of the Space Challenge is that participants are not assigned to a specific technical role, sub-group, or leadership position by the organizers before the event. The organization, structure, and roles of each team are determined by the students themselves. Suggestions are made for different sub-groups relevant to the mission design, but the overall team structure is not dictated or enforced by the event organizers. In the past, team leaders have quickly become apparent, and the teams have chosen to divide the necessary labour among different subgroups.

The event organizers interact with members of NASA-JPL's A-Team[3] and Team-X,[4] in order to familiarize themselves with the rapid mission design process that is conducted at JPL.[5] Many of the JPL mentors and advisors for the competition are members of the A-Team or Team-X, or have participated in studies run by these groups. The opening lecture for the 2013 Caltech Space Challenge was given by Kelley Case, Concept Design Methods Chief – JPL Innovation Foundry. Ms. Case gave an overview of Team-X and how a concurrent engineering design team functions. Many topics were introduced, ranging from division of labour to optimizing work room layout for maximum efficiency. It is intended that the design principles that the participants are introduced to will not only help them during the Space Challenge, but will also aid them in other group projects that they pursue.

There are several large differences between the Caltech Space Challenge design process, and JPL's Team-X and A-Team design processes. The team sizes for the Caltech Space Challenge are larger than those used by JPL, and no discipline-specific team roles are assigned for the Space Challenge. Sixteen participants is close to the upper limit for a large team that can still operate efficiently; communication issues between sub-groups have been observed in previous years. Great effort has to be taken by the mentors and teams to ensure that communication remains open and that all team members are working with the same information. In addition, both the A-Team and Team-X have very well defined roles for each participant to hold, yet the Caltech Space Challenges requires the teams to structure themselves efficiently based on the talent available.

Given the initiative for student-determined team structure, the original emphasis placed on leadership and team work qualities during the applicant selection process is necessary for a successful competition. The two teams are supplied with all the necessary tools and

resources needed to create a professional-quality final product, but if the participants cannot work together efficiently, the event will not be a success.

Jury

A group of aerospace professionals are gathered to judge the final mission proposals that the two teams produce. The head juror is either a representative from Caltech or NASA-JPL, and the rest of the jury consists of the event speakers, Caltech Professors, and representatives from aerospace companies. The size of the jury varies depending on personnel availability, and how many sponsoring companies need to be represented. It is generally desired to have approximately 10-15 members of the jury. The head juror and the student co-leads discuss a judging metric prior to the event, but the student organizers do not have a vote in determining the winning team.

Technological/Administrative Support

The event organizers try to ensure that the participants have all the necessary physical tools and equipment needed to work efficiently. Each team is assigned a large classroom dedicated as their main work room for the entire week at Caltech. From a logistical stand point, this also limits when the competition can be held, as the classrooms must be empty for an entire week. In the past, the competition has been held in September (before first quarter classes start), or during spring break, in March.

In each of the workrooms, desktop computers are provided for the participants, and internet access for everyone is supplied through wireless or wired connections. Teams are given full control over their workspaces, and are able to re-arrange the workspaces as desired. The teams often do, following some direction provided by the mentors or speakers.

The computers are loaded with software relevant to mission design, including Matlab, Mathematica, Solid Works, and Microsoft Office. Two computers are specified per team for the use of AGI's Systems Tool Kit (STK), which is used for trajectory design. AGI has generously supplied student licences for STK for free, and has also allowed the students to use STK months before the competition to gain some prior experience with the software.

This event also requires the full support of the department administration. Dimity Nelson, the GALCIT Department Administrator, was involved with the entire planning process for the 2013 Caltech Space Challenge. This included helping to organize student housing, meals, reimbursement of travel expenses, the event budget, and other miscellaneous tasks. During the week of the Caltech Space Challenge, many other GALCIT staff also aided with the competition.

Michele Judd, the Managing Director of the Keck Institute for Space Studies, served in a similar role in 2011, and was fundamental to hosting a successful event. The KISS staff have also graciously supported both of the previous events.

Team Balance

A large emphasis is placed on treating the two teams equally throughout the entire duration of the Caltech Space Challenge. As previously discussed, this begins with the student organizers picking two teams that are as equal as possible in terms of both technical skills and diversity. For the rest of the competition, the organizers make great efforts to maintain parity between the two teams. For example, the organizers ensure that both speakers and mentors interact for an equal amount of time with each of the teams. Similarly, if a question related to the mission statement is answered or clarified for one of the two teams, the other team will also be informed of the question and answer. Speakers and mentors also maintain confidentiality of each team's design when interacting with the teams. This helps maintain a friendly competition, and each team knows very little about the other team's mission design until the final presentation.

V. EVENT IMPACT

There are several tangible and intangible outcomes from the Space Challenge. Each team is required to undergo a preliminary design review mid-week, and the competition culminates with each team producing a final report and a final presentation. The final team presentations are open to the public. The jury members attend the final presentations and receive a copy of the final reports. The teams are given a few weeks after the competition to submit a final copy of the report that will be posted online. Both the final report and the final presentation are used by the jury to pick a winning team. The winning team is announced at the final banquet, and prizes are given to both teams (budget depending).

It is expected that each team will also produce a conference or journal publication after the competition. After two successful competitions, four publications have been produced outlining the technical aspects of the various mission designs.[6,7,8,9] The student organizers are particularly pleased with the level of production from the past competitions. These written products are public, and include the following benefits: 1) the student-participant interested in pursuing an advanced degree has been exposed to, and completed, the process of producing an academic work. This is of importance to the graduate admissions process; 2) the student-participant interested in pursuing a career in industry has been exposed to, and completed, report writing with many (16) contributors. This is of importance because it

demonstrates the ability to work in teams and document ones efforts; and 3) the prestige of the CSC increases in a non-linear way because prospective speakers/mentors/sponsors take the program more seriously, and the students are more attracted to the program because it helps build their resumes.

Besides these tangible deliverables, a strong network among the Caltech Space Challenge alumni has also been created. Past participants are still in contact with each other via social media, and there have been many mini-alumni reunions around the world. It is hoped that as participants advance in their careers, these connections will provide a professional advantage.

Furthermore, interactions between the participants and the speakers, mentors, and jurors have resulted in employment opportunities. Many of the past participants have worked as interns at NASA-JPL or Caltech. Additionally, several of the past Space Challenge participants are now full-time employees at NASA-JPL, Lockheed Martin, Boeing, and SpaceX, among others. The main advantage for the industry sponsors is access to talented students, and thus far, it appears that these connections have proved advantageous to both sides. A database is maintained by the event organizers containing contact and employment information of past participants, in order to track where past Space Challenge participants are currently employed.

VI. EVENT FEEDBACK

In order to ensure that this event continues to improve every year it is hosted, the student participants are given a short survey at the end of the event.

In 2011 the majority of the constructive criticism received focused on the scheduling of the lectures. The teams believed that having more lectures early in the week would be more beneficial, as this would leave larger periods of time to work later in the week once the teams had had time to absorb information from the lectures. Overall, most of the feedback received was positive in nature. The reoccurring topics that students noted favourably included the international aspect of the invited participants and speakers, the overall quality of the participants, and the opportunity to interact with professionals in the aerospace field. Many participants indicated that interacting with the speakers and mentors provided insight into working for a given aerospace company, and that this helped them decide to pursue a career in aerospace after graduation.

In 2013, the lectures were scheduled for earlier in the week, based on the 2011 feedback. However, there was still some negative feedback related to the lecture schedule. Some students indicated that they wanted the lectures weighted even more towards the beginning of the week. The lecture schedule is heavily dependent on speaker availability, and thus compromises must be made. In addition, some comments were made by both the participants and the jury related to formalizing a judging metric for the event. This is also something that the organizers are evaluating for the 2015 event, and the judging rubric will be discussed with whoever will be the lead juror for the 2015 Caltech Space Challenge.

Overall, feedback from the 2013 event was similar to the 2011 event, with the majority of the student feedback being positive in nature. Once again, many students indicated that the high calibre of student participants and the ability to interact with leaders in the aerospace community were the best aspects of the event.

VII. EVENT CONTINUITY

To ensure event continuity, a few approaches are taken. Currently, the event is scheduled to be hosted every two years. The student leaders from an event act as advisors for the leaders for the next challenge. This allows a large database of organizational experience and aerospace contacts to be passed down from one set of organizers to the next. In addition, it is hoped that at least one of the student leaders has participated in a past Space Challenge. Discussion for the mission topic of future events starts almost immediately after the completed of a current Caltech Space Challenge.

VIII. CONCLUSION

The Caltech Space Challenge, a 5-day student mission design competition, has had two successful events in 2011 and 2013. It is intended to be held every two years at the California Institute of Technology. Thirty-two students are invited to Caltech, formed into two teams, and tasked with designing a space mission of national and international importance. This multi-disciplinary competition brings together students from all over the world, equips them with the necessary tools, and challenges them to produce a viable mission architecture and design. The final mission designs that have been created have been presented at academic conferences and published in journals. The professional networks that the event has created have aided many participants in finding full time jobs in the aerospace industry.

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[1] Remarks by the President on Space Exploration in the 21st Century, John F. Kennedy Space Center, Meritt Island, Florida, April 15, 2010.

[2] Augustine, N. R., *et al.*, "Review of U.S. Human Spaceflight Plans Committee: Seeking a Human Spaceflight Program Worthy of a Great Nation," Washington, DC, October 2009.

[3] Ziemer, J. K., *et al*., "Exploring Mission Concepts with the JPL Innovation Foundry A-Team," AIAA Space 2013 Conference and Exposition, San Diego, California, September 2013.

[4] B. Sherwood, B., *et al.*, "The New Team X: Concurrent Engineering Advancement at JPL," Presentation at the 58th International Astronautical Congress, Hyderabad, India, September 24-28, 2007.

[5] Sherwood, B., and McCleese, D., "JPL Innovation Foundry," Acta Astronautica, Volume 89, August–September 2013, pp. 236-247.

[6] Alibay, F., *et al.*, "Finding NEO: A manned mission to a Near-Earth Object," AIAA Space 2012 Conference and Exposition, Pasadena, California, September 2012.

[7] Rabinovitch, J., *et al.*, "Vault-1 - A Mission Architecture for Human Exploration of Near-Earth Objects," AIAA Space 2012 Conference and Exposition, Pasadena, California, September 2012.

[8] Bosanac, N., *et al.*, "Manned Sample Return Mission to Phobos: A Technology Demonstration for Human Exploration of Mars," 2014 IEEE Aerospace Conference, Big Sky, Montana, March 2014.

[9] Price, J., *et al.*, "A Design Proposal for Asaph-1: A Human Mission to Phobos," The Journal of Space Operations, Vol. 11 Issue 2, April-June 2014.