AC 2008-2883: THE TEXAS SPACE GRANT DESIGN CHALLENGE PROGRAM

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THE NASA / TEXAS SPACE GRANT CONSORTIUM
DESIGN CHALLENGE PROGRAM
A Systems Engineering Educational Program

Abstract

The Texas Space Grant Consortium [TSGC] Design Challenge Program offers students enrolled at TSGC members institutions a hands-on opportunity in systems engineering design. This non-competitive NASA-sponsored program, now in its sixth year, motivates undergraduate student teams to design solutions to issues of importance identified by NASA with funding for project research and development, associated travel and merit-based scholarships. The overall experience pairs the student team and faculty advisor with a NASA mentor; offers peer-reviews of paper submissions; proposal writing guidelines and instruction; and affords undergraduate student team members of any level with the opportunity to engage in relevant scientific research, hands-on discipline-related design, career information, opportunities in meeting presentation and educational outreach.

Introduction

Sponsored as part of a NASA Workforce Development initiative since 2002, the TSGC Design Challenge [TDC] has continued to deliver a unique academic experience to the undergraduate student teams that participate: the opportunity to propose, design and fabricate a mission-relevant design solution for NASA. Design Challenge project topics are submitted to TSGC for design team consideration by engineers and scientists working within the NASA community. The program requires that each team member earn academic credit toward graduation and accommodates a variety of design sequences taught in institutions of higher learning across the State of Texas: one-semester design, two-semester design, and design and build programs.

Team progress is driven by a series of required milestones, called “Levels” and “Option Areas.” By satisfying milestones, a team earns program funding increments to support their project. The guidelines and rewards attached to each deliverable provide structure to the semester; and motivation, instruction and funding to the team as projects grow and develop from a preliminary idea-stage to an acceptable design solution. Peer reviews provided by graduate-level students with expertise in related disciplines provide additional guidance and technical advice after each proposal submission. Earned funding increments are supplemented by travel grants to promote off-campus collaboration and learning opportunities; stipends to supplement second semester model building; and “Bonus Awards” that recognize and reward individual team accomplishments.

The Texas Space Grant Consortium [TSGC]

Formed as part of a National Space Grant network in 1989, TSGC is one of fifty-two Space Grant consortia making up the national-level membership; with over 850 affiliates from universities, colleges, industries, museums, and state and local agencies involved. The Texas

Space Grant Consortium ranks as the largest consortium with a current membership that includes thirty-four academic institutions, two industry partners, two government agencies, two not-for-profit organizations, and one museum that work together to develop a balanced program of space related higher education, research infrastructure and public service projects.

TSGC sponsors a wide range of exceptional educational initiatives statewide, that include:

- sharing of space related course materials among the Consortium's academic institutions
- development of multi-institutional space research efforts that team industry/academia
- promoting high quality undergraduate/graduate-level space research
- encouraging participation in science and math through space-science
- using the broad appeal of space to foster programs and curricula in public schools
- increasing the pool of high school graduates — with an emphasis on under-represented minorities and women — who enter college to study science, technology, mathematics, and engineering [9]

Program Background

The Texas Space Grant Consortium Design Challenge Program has its roots in the NASA/USRA Advanced Design Program [NASA/USRA ADP] that existed from 1985 through 1995 [5]. This program, administered for NASA by the Universities Space Research Association [USRA], promoted NASA-focused design efforts at forty universities across the United States, and provided the impetus for the improvement of engineering design education at many institutions nation wide. In this program, NASA funded design course teaching assistants and student travel at participating institutions. Funding ranged from approximately $25,000 per year for institutions new to the program, to nearly $17,000 per year for institutions that had been in the program three years or longer. Design projects undertaken by USRA ADP teams were suggested by NASA-based engineers, associated contractors and university faculty. At the end of the academic year, each team presented its design work in a non-competitive conference held at a NASA center.

When the NASA/USRA ADP ended in 1995, the Texas Space Grant Consortium adopted the model in order to sponsor its own statewide version of the USRA ADP: the TSGC ADP. This precursor to the current Design Challenge Program was a space-related, multi-disciplinary, student design project program in which students from various TSGC institutions participated. The program was administered in a similar fashion to the NASA/USRA program, but operated on a much smaller scale and at a lower funding level. From 1996 through 2001, the TSGC ADP sponsored non-competitive design project involvement to be undertaken by student teams at member institutions, providing each participating institution with $2000 for each semester of participation. The funds supported student travel, design software, and all associated design team activities. The program ended in the spring of 2002.

The lessons learned from TSGC ADP administration helped jump-start interest and provide a model for the development of a new design projects program: the TSGC Design Challenge. Created in response to a NASA workforce development initiative in the fall of 2002, a pilot

version consisting of three teams from three Texas universities tested the workability of the new milestone-based model. The current program is the outgrowth of this successful pilot.

Design Challenge Goals and Objectives

As the TSGC flagship higher-education initiative, the Design Challenge Program has excelled in providing participating students with an opportunity to engage in meaningful research, invention and design. The program model has demonstrated its capability in encouraging students to study and seek careers in Science, Technology, Engineering and Math [STEM] related fields; in furthering faculty research and teaching opportunities; and in promoting the inclusion of hands-on project design to coursework required for graduation.

Design Challenge goals and objectives purposely align with those identified by TSGC, the State of Texas, NASA, and on a National level as significant in improving and/or maintaining student interest in STEM-based educational and career pursuits. Sound program objectives and interest in meeting set goals have enabled the Design Challenge to provide a consistently high quality student experience.

- Goal: provide students with a meaningful classroom design experience via real-world projects of interest
  - Objective: establish design teams at TSGC member institutions to work with projects proposed and offered by NASA
- Goal: encourage institutions of higher learning to implement, improve, or expand design project curricula
  - Objective: offer design project opportunities that consider student interest, motivate a high level of performance, provide funding and work well within the framework of required courses
- Goal: develop opportunities for substantive student research, training, and design
  - Objective: seek out mission relevant design project opportunities from NASA researchers that provide students with projects they can envision seeing in use
- Goal: engage and partner students, faculty and mentors in the design process
  - Objective: pair mentors from NASA and industry with student teams and faculty to work toward the common goal of engineering a relevant design project
- Goal: retain student interest in academic pursuits in Science, Technology, Engineering and Mathematics
  - Objective: offer challenging project opportunities to student teams that create excitement and interest in pursuing STEM-related futures
- Goal: advance diversity by promoting collaborations outside academia to include the community-at-large
  - Objective: bridge the diversity gap by encouraging teams to participate in far-reaching and meaningful education and public outreach (EPO) activities within K-12 communities, museums and engineering day events; promote collaboration outside the academic nest and within a diverse professional community at large; reward participation in professional meeting participation and presentation
- Goal: provide participation motivation to students and faculty through resources and rewards

- Objective: provide access to opportunities that directly benefit individual students and faculty: careers information/professional enhancement; extended learning opportunities; summer internships/faculty appointments

o Goal: facilitate bonds and foster high-level teaming between academia and industry via student/mentor and faculty/mentor relationships
  - Objective: ensure as successful an experience as possible between faculty, team and "customer" in order to secure and sustain opportunities for future faculty/mentor mentor/student relationships and avenues for higher level teaming

Equally important in achieving the program's success is consideration of ABET Engineering outcomes (a) – (k) where students enrolled in engineering programs must demonstrate success.[1] The list below reproduces each of the ABET required outcomes (a) – (k), followed by a brief statement of how the program addresses that outcome. An engineering program must demonstrate that graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering
-- TDC participants apply knowledge of mathematics, science and engineering in the development of the designs to meet NASA requirements

(b) an ability to design and conduct experiments, as well as to analyze and interpret data
-- TDC participants must analyze and interpret data that results from their design trade studies in order to choose from design alternatives

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
-- TDC is based on design, and each design satisfies this requirement

(d) an ability to function on multi-disciplinary teams
-- Teaming is required in the Design Challenge. Many TDC teams involve students from several engineering disciplines.

(e) an ability to identify, formulate, and solve engineering problems
-- All engineering design processes require students to identify, formulate and solve engineering problems

(f) an understanding of professional and ethical responsibility
-- TDC provides materials and guidelines that serve to promote an understanding of professional and ethical responsibility. Whether these are used is up to the individual instructor.

(g) an ability to communicate effectively
-- Student teams are required to submit written reports and make an end-of-term oral presentation to their NASA mentors.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
-- TDC projects have an education and public outreach component (EPO). Teams go out and present their requirements to public school classes, make videos explaining their activities, deliver activities or demonstrations that relate basic STEM concepts to their design project .

(i) a recognition of the need for, and an ability to engage in life-long learning
-- TDC presents learning challenges to participants. Whether this translates to a recognition of the need for life-long learning is an open question.

(j) a knowledge of contemporary issues
-- Program participants are working on contemporary design problems, presented by professionals in the field. They do learn about contemporary technical problems.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
-- Participants use many modern engineering tools in their design work. They use CAD programs, computer simulations, solid modeling systems, etc.

How the Design Challenge Program Works

Prior to each academic semester, Design Challenge topics are solicited from NASA scientists and researchers. Project topic descriptions with preliminary design specifications are submitted to TSGC well before the start of the semester so that design instructors at member institutions will have an opportunity to preview projects that align with their course.

Student teams are recruited when the *Announcement of a Funded Student Opportunity* is circulated to engineering design course instructors at TSGC member institutions. Inquiries into topic availability follow and once classes begin, participating students form potential teams familiarize themselves with project specifications detailed on the program website [www.tsgc.utexas.edu/challenge] and make a topic selection.

The number of teams that can participate in the program is limited to an average of ten teams per semester. Interested teams must submit an electronic "Design Brief" to indicate interest in participation by a specified deadline. Teams that meet the criteria for participation are accepted to participate on a first-come/first-served basis. Once accepted, two important pieces of information are forwarded to the team and faculty advisor: [1] the mentor's contact information to enable a project dialogue to begin, and [2] a Letter of Award to facilitate the establishment of a team project account within the team's department.

The Design Challenge program website [www.tsgc.utexas.edu/challenge] contains extensive information central to which is the Design Team Notebook offering a range of detailed program guidelines and instructions on: proposal writing, travel grants, role of the team leader, collaboration, how to conduct an outreach activity, mission patch design and more. Semester deliverables include: weekly Tuesday Tag Up reports to inform the program manager of team status; initial and midterm proposals; power point presentation; design of a team mission patch; and final technical report. Teams are also required to submit a budget profile, project timeline, and travel expense reports. At each major submission interval [end of Level I and II], graduate student reviewers assist TSGC in reviewing and providing comments to the teams about paper format and presentation; design goals and objectives; and technical considerations.

At the end of the semester, the students deliver poster, model and oral presentations showcasing their work to an audience of mentors, faculty and TSGC representatives at a location near the NASA Johnson Space Center. The conference is limited to one day so as not to interfere with student academic schedules; with oral presentations limited to thirty minutes per team.

Project Topics and Mentors from NASA and the contractor community are key to the success of the program. The range of relevant projects offered, coupled with the close association of mentors representing the "face of NASA" helps to attract student team participation in the Design Challenge. Because the program strives to encourage student interest in STEM-related careers, and at the same time bridge the school-to-work experience; meaningful projects serve to whet student appetites for future opportunities in research and design. As of the Spring 2008 semester, 131 teams and 214 project topics had been offered for TSGC Design Challenge team selection. Design topics to be undertaken during the spring 2008 semester provide a good example of the typical range of project offerings available to students each semester:

- Design of a Food Warmer for a Transit Mission to Mars
- Advanced Robotics Technology
- Biomedical Systems for Space Application
- Mars Drill Automation
- Initial Human Moon or Mars Exploration Village
- Design of a Hand Held Lunar Dust Removal Brush
- Medical Diagnostics for Space Application
- Design of a Water/Ice Transportation System for the Moon's South Pole
- Design of a Food Stowage System for a Mission to Mars

The NASA division submitting each project topic agrees in advance to provide the team with a team mentor for the duration of the project [one or two semesters]. Twelve major units at the Johnson Space Center [JSC] have been instrumental in providing projects and mentors to Design Challenge teams – resulting in 131 mentor/team pairings since 2002.

Research groups providing topics and mentors for the upcoming Spring 2008 are representative of the units that typically work with Design Challenge teams:

- Space Shuttle Systems Engineering and Integration Office
- Constellation Program Office
- University of Texas Center for Space Research with the JSC Exploration Office
- Habitability and Human Factors Branch, Space Food Systems Laboratory
- Biomedical Systems Branch, Systems Architecture and Integration Office
- Propulsion Branch, Energy Systems Division
- NASA Headquarters, Advanced Capabilities Division
- EVA Technology Development Group, Crew and Thermal Systems Division
- NASA Exploration Systems Mission Directorate

Since 2006, the Design Challenge has partnered with the Exploration Systems Mission Directorate to offer additional design project opportunities, internships and faculty summer placements as part of the ESMD Space Grant program.

Program Timelines, Milestones and Deliverables accommodate a variety of design sequences taught at Texas institutions of higher learning. Seven team-directed milestones build upon one-another throughout the semester to provide structure and take teams from the beginning idea to a

final product: Base Level, three progressively difficult Design Levels, and three Option Areas. As milestones are completed and the peer-review process is completed, teams earn project, travel and scholarship funds. Program schedule, milestones, activities, deliverables, available grants and funding levels are profiled in Figure 1 below.

Figure 1: Design Challenge Program Timeline and Deliverables

Program Timeline and Deliverables				
Milestone	14 Wk Timeframe	Team Responsibilities	Deliverables	Award
BASE	~2 wks after semester begins	• Meet Criteria to Participate • Form Team / Faculty Advisor • Select a Design Topic	• Design Brief	00
Level I	~4 wks after BASE	• Project Research	• Formal Proposal • Team Photos	$$
Level II	~4 wks after Level I	• Develop Concept Variants • Site Visit	• Midterm Report • Draft Oral Presentation • Team Mission Patch	$$
Level III	~4 wks after Level II	• Finalize Design • Prepare to Present Design at Showcase	• Showcase Attendance • Poster, Model, Oral Presentation • Final Technical Report • Program Evaluation	$$
Option Area I	EPO Activity	• Present a STEM concept to any audience or community group.	• Outreach Report • K-12 Lesson Plan • Photo Documentation	$$
Option Area II	Meeting Presentation	• Present project work in a professional setting	• Presentation Report • Photo Documentation	$$
Option Area III	Website Development	• Design team website	• URL	$$
Grants	Travel	• Associated field trips, site visits, outreach, meeting presentation	• Trip Report • Photo documentation	$$
	Long Distance / Large Team Supplement	• Supplements travel for teams traveling > 300 miles to Showcase	• Trip Report • Photo documentation	$$
	Semester II Grant	• Supplements second semester model building	• Model Report • Photo documentation	$$

Program Incentives are provided to motivate, educate, and to encourage team building. Project funds and merit-based scholarships reward achievement in milestone completion and excellent performance in a wide range of areas. Additional incidental incentives include NASA educational films, project related reference materials, team t-shirts, and program mission patches.

The **TSGC Design Challenge Showcase** is a major motivating factor for Design Challenge participants. Held near the Johnson Space Center at the conclusion of each semester, this student conference exposes teams to the experience of a professional-level conference and allows them the opportunity to showcase their semester's accomplishment to a distinguished audience made up of peers, NASA mentors and researchers, TSGC representatives, members of academia and the contractor community. For many students this will be the first time attending and presenting

at a professional conference; excitement and anticipation run high as teams come together to make their own presentations and review the work presented by other participating teams.

An informal "Team Meet and Greet" [bowling, Space Center Houston dinner, astronaut lecture, etc] is held the evening before presentations begin to allow teams to meet one another and socialize. JSC Co-op students are invited to attend so that teams can ask questions of students their own age about what it's like to be a NASA employee. One Co-Op student attending the Spring 2007 dinner event was a Design Challenge alumnus.

"Showcase Presentation Day" includes a poster and model session, an oral presentation and a question and answer period directed toward each team. A "Job-a-Rama" display offers career and educational opportunity information provided by a wide range of recruiters. The event culminates with Bonus Award presentations that include recognitions for the "best of" in team milestone deliverables. Judges from TSGC and the Johnson Space Center evaluate and select the top teams in poster, oral and model presentation. The Top Design Team is awarded a $3,000 scholarship from TSGC.

Program Administration.

The Design Challenge Program is administered by a TSGC program manager who develops and designs all program guidelines, activities and materials; semester planning, team management and conference preparation. Sample tasks include: negotiating projects / mentors; website maintenance; guidelines and information development and preparation; evaluation of all deliverables; monitoring team progress; securing graduate student reviewers for technical review; reviewing proposals and providing comments; reviewing and responding to required weekly Tuesday Tag Up reports from teams; maintaining budget and accounts; evaluating team progress for bonus award and scholarship determination; plan, prep and oversight of the Design Challenge Showcase; program data and statistics; student, faculty and mentor consultation.

Design Challenge Representation and Outcomes

The program has continued to attract a diverse and talented pool of student team participants since its inception in Fall 2002.

- 131 teams have participated from 2002 – 2007.
- An average of 10 teams participate each semester.
- The largest number of teams to participate in one semester is 16; the smallest 8.
- 16 universities have participated to date. University representation includes those designated as Minority Serving Institutions, State Institutions and Private Institutions
- 26% of teams from 2002 – 2007 attended institutions designated as Minority Serving
- Of the 686 students that participated through Fall 2007, approximately 65% were male and 35% female and 39% ethnic minority.
- The full range of academic levels and disciplines have been represented by participants from undergraduate freshmen through senior level; graduate masters to doctoral candidates; every engineering discipline has been represented.
- Topics most often selected: Heat Transfer, Moon and Mars Exploration, Biomedical Systems and Advanced Robotics Technology
- Most common major represented: Mechanical Engineering

Figure 2 below provides a summary of the program's level of activity.

Figure 2: Design Challenge Program History and Outcomes

TSGC DESIGN CHALLENGE • **Pilot '02** • **Launch '03** • **Growth '04** • **Expanded '05** • **Sustained '06** • **+ESMD '07**	**131 TEAMS AND STILL COUNTING . . .**	
	• Fall 2002: Pilot program tested • 3 institutions / 3 teams	• 11 students / 3 faculty • 3 self-developed project topics
	• Spring 2003: Full program launch • 4 institutions / 8 teams	• 37 students / 4 faculty • 28 project topics / 8 mentors
	• Fall 2003: • 7 institutions / 10 teams	• 72 students / 8 faculty • 16 projects / 9 mentors
	• Spring 2004: • 10 institutions / 15 teams	• 94 students / 15 faculty • 20 project topics / 15 mentors
	• Fall 2004: • 6 institutions / 10 teams	• 60 students / 10 faculty • 16 JSC topics / 10 mentors
	• Spring 2005: • 7 institutions / 16 teams	• 73 students / 12 faculty • 16 JSC topics / 14 mentors
	• Fall 2005 • 8 institutions / 14 teams	• 69 students / 10 faculty • 12 JSC topics / 10 mentors
	• Spring 2006 • 5 institutions / 8 teams	• 31 students / 8 faculty • 14 project topics / 9 mentors
	• Fall 2006 • 5 institutions / 12 teams	• 48 students / 5 faculty • 12 project topics / 8 mentors
	• Spring 2007 • 5 institutions / 11 teams	• 45 students / 5 faculty • 12 project topics / 8 mentors
	• Fall 2007 • 9 institutions / 13 teams	• 73 students / 10 faculty • 13 project topics / 7 mentors
	• Spring 2008 • 7 institutions / 11 teams	• 58 students / 7 faculty • 11 project topics / 11 mentors
TEAM WORK & COLLABORATION STRESSED	• Mentor Pairings – 131 • Peer Reviews – 262 • Contractors: 35 • K-12 Outreach - 54	• Teams: 131 • Projects Offered: 214 • JSC Units: 12 • ESMD Units: 2
INCENTIVES AS MOTIVATION	• Space Literature / Media • Program Specific Incentives • Field Trips/Site Visits • Individual Competitive Awards • Conference Participation	• NASA Projects / Mentors • Funded Design Projects • Professional Collaborations • Outreach Opportunities • Proposal Writing/Peer Review
RESULTS	• Professional Presentations: 1 Faculty / 25 Student • National Design Competition Winners/Presenters: 4 • Press Coverage of Team Success: 20 • Projects in use or "picked up" for further testing by NASA: 7 • Project patents / patent pending: 9 • Institutional Scholarships Established: 1 • New Design Courses/Programs Established: 2 • Spinoff Conferences Generated: 1+	

Program Outcomes, Spinoffs and Design Team Success

Due to the program's unique character and success, features of the program have been used to model new programs and events, design team efforts have experienced notable results, and program participants have praised the benefits of involvement in the program.

2002-2003

- *Development and Testing of a Tethered Satellite System for Creating Artificial Gravity Tethers. Texas Christian University – Frogs in Space*. Dept of Engineering, Spring 03. Tested via Reduced Gravity Student Flight Opportunities Program in Spring 03.

2003-2004

- *Solar Charging Station for an Electric Cart*. Lamar University – Outlaws, Dept of Electrical Engineering, Fall 03-Spring 04. The charging station and outfitted electric cart the team developed is currently in use at the Johnson Space Center.
- *Glovebox Crew Restraints for Long Duration Space Flight - Life Sciences Glove Box Crew Restraint Concept***.** Texas A&M University – H-Factor, Dept of Industrial Engineering, Spring 04 . Project was "picked up" for further testing aboard the KC-135A Zero-G aircraft. The team leader is currently employed by NASA.
- *Medical Equipment / Systems Improvement for the International Space Station - Vibrational Response of Bone Tissue and its Usage as a Diagnostic Tool.* Rice University –- Owls. Dept of Bioengineering, Fall 03 - Spring 04. Project was "picked up" for further testing aboard NEEMO [NASA Extreme Environment Mission Operations] – NASA's underwater laboratory.
- *Mars Drill Automation Process and Control.* University of Texas – Cincomachines, Dept of Electrical & Computer Engineering, Spring 04. The first all freshman independent study team to participate; the team's results were taken up for further review by the JSC Exploration Office and Baker Hughes International during Summer 04.
- *Advanced Robotics Technology – Autonomous Robotic System for Locating Air Leakage in Manned Space Vehicles*. University of Texas, Arlington – MavSpace, Dept of Mechanical and Aerospace Engineering, Spring 04. Team participated in the NASA Langley Research Center Aerospace Vehicle Systems Technology Office competition and took first tier prize. Team Leader Hisashi Inoue was named a TSGC Scholar.
- Dr. Satyajit Verma, Texas A&M Corpus Christi faculty advisor, presented *The Design Challenge Program in Support of the Engineering Design Graphics Course* at the ASEE Annual Conference and Exposition, 2004
- NASA Administrator's Fellow, Tony Kim, initiated a multi-discipline/multi-level design projects course at the University of Texas, Kingsville based upon involvement in the Design Challenge Program. Thirty-five students participated in a Balloon Satellite project that lasted two semesters, Fall 03 – Spring 04.

2004-2005

- *Exercise Countermeasures for Bone and Muscle Loss on Orbit*. Rice University – Team Cobra, Dept of Bioengineering, Fall 04 – Spring 05. The first Bioengineering team to win "first prize" at the NASA/USRA Revolutionary Aerospace Systems Concept - Academic Linkage (RASC–AL) competition for the final version of their countermeasures project

designed for use during long-term spaceflight: *Spine and Trochanter External Vibration Effecter (STEVE).* The team has since received a full patent on the device.

- *Mars Drill Automation*. Lamar University – Cardinal Drillers, Dept of Electrical Engineering, Fall 04 – Spring 05. Team leader, Wade Salazar, is currently employed by Hercules Drilling and served as a collaborator and mentor to Lamar University Robotics teams during the Fall 07 program.

2005-2006

- *Heat Pump for Thermal Control of Space Vehicles.* University of Texas – Zero-G, Dept of Mechanical Engineering, Spring 06. Team member Brandon Slaughter entered the graduate program in Biomedical Engineering at the University of Texas. He now continues to participate in the Design Challenge program as a "peer-reviewer."
- *Medical Equipment / Systems Improvements for the International Space Station*. Rice University – High Performance Ninjas (HPN), Dept of Bioengineering, Fall 05 – Spring 06. HPN took three top prizes at the 2006 RASC-AL Forum for the final version of their project: *Osteonexus Active Dynamizer* – a device that helps to heal fractures in the space environment. First Place Undergraduate Prize, Forum Favorite and the Dr. John L. Lucas Award for Study of Space Safety. The team then used their winnings to establish a McLucas Scholarship within the Department of Bioengineering at Rice University to provide seed money to benefit future BIOE 451/452 senior design class projects. The department received matching contributions as a result. Project is patent pending.
- NASA's Exploration Systems Mission Directorate (ESMD) launched a national Design Projects Program promoted to Space Grant Consortia in every state after discussions with TSGC about the Design Challenge Program. Now in its third successful year of operation ESMD plans to expand the design project team component.

2006-2007

- *Crew Exploration Vehicle [CEV] Exercise System.* Texas A&M University – BMEN Revolution, Dept of Biomedical Engineering, Fall 06-Spring 07. Working with both the Exploration Systems Mission Directorate and Wyle Laboratories, the project was "picked up" for further review and testing and is currently patent pending.
- Dr. Z. Maria Oden, a longtime Design Challenge Program participant and faculty advisor from Rice University, was nominated for the ASEE Fred Merryfield Design Award for her significant contributions in teaching engineering design.
- The Houston Society for Engineering in Medicine and Biology launched a "Student Design Showcase" in 2007 based upon the success and unique conference presentation opportunities offered to student design teams by the TSGC Design Challenge Showcase.
- NASA ESMD is considering holding a national level design projects conference, similar to the Design Challenge Showcase, for participating in the ESMD Space Grant program.

2007-2008

- An all new multi-discipline, multi-level design course was established at the University of Texas - El Paso highlighting participation in the TSGC Design Challenge.

Participant Evaluations and Comments.

At the conclusion of each semester, student, faculty and mentor participants are asked to submit program evaluations that provide frank or anecdotal comments about their participation in the Design Challenge. Anonymous submissions are accepted. All comments are considered and have been used over time to modify and mold the program to better meet the needs of program participants. The below comments have been gleaned from recent evaluation submissions; and are presented to indicate the positive impact the Design Challenge has had on its participants.

Student Participant Evaluation Comments

- *First of all, thank you for everything! This semester has been a blast. I could not have found a better program to have participated in during my last semester. I learned so much about NASA, and about design in general. The Showcase was also very exciting. I loved it so much that I encouraged my brother, who will be graduating next year from high school, to take advantage of the program. It's hard to express my feelings about this program in words, but believe me when I say that it was great. Congratulations on a great job! Thanks again!* Alvaro Fernandez, University of Texas, El Paso – Minernauts – *Mars Drill Automation* – Spring 2005. Alvaro is applying to graduate school; his application was endorsed by his Design Challenge mentor.
- *I can't describe how much experience our team gained working on a project like this - this helped our whole group. We learned how to write a technical paper, how to work together to get a project done, how to meet deadlines that were approaching, and how to make an oral presentation. I think this experience is invaluable to us as we get closer and closer to entering the "job world" in our lives.* Laurie Crawford, Lamar University – B.E.A.S.T. – *Advanced Robotics Technology* – Fall 2007
- *Participation in this program gave me an in-depth idea of projects conducted by NASA. I always wanted to work on Aerospace related things in the future, and this project made me certain that I want to pursue a career in this field. The Design Challenge is an excellent program for undergraduate students and NASA should continue this.* Sanjana Datta, Texas Tech University – Red Raider – *Ice / Water Transportation System on the Lunar Surface* – Fall 2007
- *I loved the Design Challenge! It gave my team experience in writing documents, and practice in conveying our research in a succinct and professional manner. I think my favorite part of the Design Challenge was the Showcase. It was a feeling of satisfaction from completing the first steps and presenting, as well as learning about other research projects.* Eva Wang, Rice University, Team Phoenix – *Medical Diagnostics for Space Application*, Fall 2007
- *I enjoyed participating in the Design Challenge very much. It was a valuable learning experience and a well designed competition. The trip to Houston and to see the other teams ideas was definitely the most enjoyable part to see that other teams went through the same problems we did. Also, to see that they were having problems still with their ideas and they were not perfect. Out of all of my classes at Tech this project offered me the most insight into what a engineer does when coming up with a new design. It was a very challenging yet rewarding project and a very good way to get NASA's name out there because of the amount of people you talk while doing the project research.* Texas

Tech University - Red Raider - *Ice / Water Transportation System on the Lunar Surface* Fall 2007

Excerpt of High School Attendee Comments

The following excerpt from a Spring 2007 NASA Student Opportunities podcast with two high school students who participated in the NASA JSC/USRA Career Exploration Program in Spring 2007 and who attended the TSGC Design Challenge Showcase as part of that program. The interview focused on their impressions of the Design Challenge Showcase and how attending might have impacted their future college or career paths:

***Interviewer (Deanna)**: Do you think your observation of the Design Challenge Showcase will influence your college or career path?*
***Student 1 (Shannon)**: I think that it gave me a better insight as to what I can do in college in the field that I'm going into. And I definitely think it's something that I'd like to get involved in when I'm in college, if I can get a group together. I was really impressed with it and I had a lot of fun. I really enjoyed it. And it was kind of neat to get to see because those students were college seniors. As a high school senior, I'm looking at it, going, "These are things that could actually become real at NASA. So those are things I potentially could be working on when I'm employed at NASA." So that was neat!*

***Deana:** Can I get you to describe the day at the design challenge and what you observed?*
***Student 2 (Julia)**: I didn't know what to expect. I knew that they were doing a bunch of different presentations, but I thought that it was going to be a little bit like a science fair because I saw all the boards up. They had the tri-fold boards up there. But they actually had to do that -- they had to do a video, they had to do a PowerPoint and a presentation -- in front of all of us. Which I thought was really good, because a lot of people don't realize that, sometimes, in engineering, you have to do presentations, too. Those skills are really important as well. We got to watch the groups present. And then they let us ask questions, too. Which I thought was really cool, because then we got to see how they would answer the questions. The presentations were followed by the awards. And a lot of us agreed with who won the awards.*

***Deana:** Is the design challenge influencing your college or career plans?*
***Julia:** Actually, it really helped, because there were two groups from the University of Texas there, and, aside from asking them all the technical questions, I also got to ask them about the university environment. Actually, the head of biomedical engineering -- the dean -- was there, too. So I got to ask them a lot of important questions, and it kind of solidified my decision to go to UT.*

Sample of Faculty / Mentor Comments:

- *This program (TSGC Design Challenge) is simply the very best of the sponsored engineering design efforts I have seen in thirty years of teaching and our alumni speak fondly of their involvement with it.* Dr. Harley Myler, Chairman, Department of Electrical Engineering, Lamar University
- *I just read through the reviewer's comments. They have done an excellent excellent (repetition intended) job on commenting on the format, content and presentation of the*

reports. It would not have been possible for me in terms of time and effort and details to do for my students what they did in such a short time. Please convey my thanks to them. You have an excellent educational program. We get all this valuable help, support, and funding on top of that! Once again thanks to you, the mentors, and the reviewers.
Dr. Satyajit Verma, Assistant Professor, Engineering Technology, Computing and Mathematical Sciences, Texas A & M University - Corpus Christi

- *Thanks so much for the opportunity to comment/evaluate the TSGC Design Challenge Program. The program is fantastic- in general all parts of it are positive and extremely beneficial for the students involved. Strong projects that meet our criteria result in excellent opportunities for our students to learn the process of design from initial concept to final device in a way that truly engages them.* Dr. Maria Oden, Rice University, Department of Bioengineering
- *I would like to express my appreciation for the outstanding work that you as Program Coordinator have done with the TSGC Design Challenge. All of my student teams have gained so much in working through the design, fabrication, and testing of their own real NASA projects. I know for a fact that the engineering students benefit immeasurably for the written reports and oral presentations required by TSGC of student teams. The fact that they have to research, design, manage the prototype development of a product forces the application of many theories learned in the classrooms. These students are being exposed to the real world of Engineering R&D; where as, there is a detachment from the real world in our classrooms. I wish that your program could be expanded in the number of teams that can participate in the Texas Space Grant Consortium Design Challenges in the coming years. Dr. Charles S. Lessard, Ph.D., Department of Biomedical Engineering.*
- *The things that I like most about the design challenge:*
  - *This is the first time that many of these students have worked in a team environment; it is a great learning experience for them*
  - *In most cases, the work done is of direct interest to NASA, and forms relationships between the students and mentors that can lead to later work, and perhaps even employment.*
  - *It gives the students a chance to see very interesting space work being done during their visits to NASA and CSR, and reinforces their decision to become engineers.*
  - *It is rewarding for the mentors to work directly with the students.*

  Dr. Humboldt Mandell, NASA Retired Manager of the Exploration Office – currently Research Fellow with University of Texas Center for Space Research.
- *The program is great! And as you know, we're using it as the foundation for the first in a series of educational/outreach events for a large project we have here*. Janis Connolly, NASA Johnson Space Center, Habitability and Human Factors Office Manager

Looking Ahead: The Design Challenge Program Future

The Design Challenge Program continues to grow in the success of its student teams, the maturity and sophistication of the projects undertaken and with faculty advisors who find it to be a useful and productive addition to the course curriculum. As far as interest goes, the program could easily be expanded to accommodate additional teams, but factors do exist that limit its expansion at the present time. Funding remains the primary obstacle in maintaining and/or expanding the program. The cost to support program needs in staff salary, equipment and

materials, incentives, team allotments and conference presentation rises every year. Current funding levels directly impact the number of teams that can participate, the number of awards and incentives that can be distributed, and Showcase conference consideration. Currently, an average of three teams per semester are turned away due to non-availability of space or funding.

- Funding. Currently, the funds allocated to the Design Challenge Program are the maximum that TSGC can devote to a single higher education program. Adding new features and expanding to include more teams translates into a higher budget need across the board. Although the Design Challenge Showcase is one of the most valuable features of the program, it is also the single most costly.
- Staffing: Expanding the program to include more features and student involvement opportunities is hugely desirable from an educational standpoint; however, the many administrative and management tasks involved require "man hours" and the program could easily become unwieldy to manage with the current staffing level limit of one program manager.
- Participating Teams: The program was designed to be a non-competitive avenue for design team participation – "first come / first served" continues to provide a good level of diversity to the semester make-up without having to "weight" applicants. As the program has grown in popularity, the number of teams seeking to participate has increased – with both faculty and teams "jockeying" to secure "spots" well in advance of the application submission period. Because institutional semester start dates vary by as much as three weeks, juggling the educational urgency to get started can become a challenge. In the future this may force a more competitive application process with variable start dates considered.

Conclusion

The TSGC Design Challenge Program has its origin in the design project programs that preceded it: USRA ADP and TSGC ADP. The successes and failures of these early design project efforts contributed valuable "lessons learned" that were instrumental in the development of this successful milestone-based program that provides structure, motivation and rewards to participating teams.

The 131 teams that have passed through the Design Challenge during its six years in operation demonstrate that students and faculty are hungry for the type of hands-on systems engineering experience that the TSGC Program offers. Students of every academic level and representing every engineering discipline have willfully taken on the extra work required of TDC teams in order to gain the opportunity to work on real-world relevant projects alongside a NASA mentor.

Motivation is provided on numerous levels: dedicated mentors, feedback, funding, scholarships and conference presentation. Structure is built into the program through milestone requirements and an extensive Design Team Notebook that details and guides students through aspects of the engineering process, teamwork, project management and accountability. Evaluations indicate that a measurable benefit is gained by all participants: the university, course instructor, student team members, project mentors and NASA in its aim to develop its work force. By affording teams the opportunity to engage in relevant scientific research and hands-on discipline-related

design, a level of excitement and interest is achieved that is difficult to accomplish in the traditional classroom.

Although Design Challenge Program success in several areas continues to grow, factors do exist that limit its capability for future expansion. Funding and staffing limits pose the greatest obstacle to increasing the number of teams that can take advantage of this exceptional opportunity.

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