Society of Petroleum Engineers
Drilling Systems Automation
Technical Section (DSATS)

Drillbotics™ Guidelines

International University Competition
2016 - 2017

1. Introduction

This year marks the third competition for the title of Drillbotics champion and a chance for sponsored travel to present a paper at the next SPE Annual Technical Conference and Exposition (ATCE) at an event organized by DSATS. The past two years involved undergraduates, masters and doctoral students from a variety of disciplines who built innovative drilling machines and downhole tools while developing a deeper understanding of automating the drilling process. Everyone involved claims to have had a lot of fun while learning things that are not in the textbooks. This year's contest promises to be more challenging and hopefully more fun.

How did the competition first come about? The origins began in 2008 when a number of SPE members established the Drilling Systems Automation Technical Section (DSATS) to help accelerate the uptake of automation in the drilling industry. DSATS' goal was to link the surface machines with downhole machines, tools and measurements in drilling systems automation (DSA), thereby improving drilling safety and efficiency. Later, at an SPE Forum in Paris, the idea of a student competition began to take shape. A DSATS sub-committee was formed to further develop the competition format and guidelines. Several universities were polled to find out the ability of academic institutions to create and manage multi-disciplinary teams. The Drillbotics committee began small in 2014-2015 to see if the format could succeed. With fine tuning, we continue along those lines as we start the 2017 process.

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The DSATS technical section believes that this challenge benefits students in several ways. Petroleum, mechanical, electrical or control engineers, gain hands-on experience in each person's area of expertise that forms a solid foundation for post-graduate careers. They also develop experience working in multi-disciplinary teams, which is so important in today's technology driven industries. Winning teams must possess a variety of skills. The mechanical and electrical engineers need to build a stable, reliable and functional drilling rig. Control engineers need to architect a system for real-time control, including selection of sensors, data handling and fast-acting control algorithms. The petroleum engineers need an understanding drilling dysfunctions and mitigation techniques. Everyone must work collectively to establish system functional requirements understood by each team member, properly model the drilling issues, and then to create a complete package working seamlessly together.

The oil and gas industry today seeks lower costs through efficiency and innovation. Many of the student competitors may discover innovative tools and control processes that will assist drillers to speed the time to drill and complete a well. This includes more than faster ROP, such as problem avoidance for dysfunctions like excessive vibrations, stuck pipe, and wellbore stability issues. Student teams built new downhole tools using 3D printing techniques of designs that would be difficult, if not impossible to machine. They used creative hoisting and lowering systems. Teams modeled drilling performance in particular formations and adjusted the drilling parameters accordingly for changing downhole conditions. While they have a lot to learn yet about our business, we have a lot to learn about their fresh approach to today's problems.

Good Luck!
From the DSATS Drillbotics Committee

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2. *Objectives for the 2016 Competition*

2.1. During the school year beginning in the fall of 2016, a team of students will organize themselves to solve a drilling related problem outlined in item 4 below. The team should preferably be a multi-disciplinary team that will bring unique skills to the group to allow them to design and construct hardware and software to demonstrate that they understand the underlying physics, the drilling issues and the usual means to mitigate the issues. We cannot stress enough the need to involve students with different technical training and backgrounds. They will need to develop skills to understand drilling dysfunctions and mitigation strategies, but they must also have the mechanical engineering capabilities to design the rig/drilling package. In past years, some entrants have not adequately considered the control network and algorithms needed for autonomous drilling. They have often misunderstood the need for calibrated sensors and fast, accurate data handling. All of this and more is needed to build and operate a complete automated drilling system.

2.2. The students could produce novel ideas leading to new drilling models, improved drilling machines and sensors, and the ability to integrate the data, models and machines that will hopefully create new, more efficient ways to drill wells in the future. Any such innovation will belong to the students and their university in accordance with the university's written policies.

2.3. The students, working as a multi-disciplinary team, will gain hands-on experience that will be directly applicable to a career in the upstream drilling industry.

3. *Background*

3.1. What is DSATS?

3.1.1. DSATS is a technical section of the Society of Petroleum Engineers (SPE) organized to promote the adoption of automation techniques using surface and downhole machines and instrumentation to improve the safety and efficiency of the drilling process. More information is available about DSATS at the DSATS homepage (http://connect.spe.org/DSATS/Home/).

3.1.2. The Drillbotics website at www.Drillbotics.com includes official updates to the competition guidelines and schedule, as well as FAQs, photos, and previous entrants' submittals and reports. Questions and suggestions can be posted here, or teams can email the sub-committee at 2017@Drillbotics.com.

3.2. Why an international competition?

3.2.1. DSATS, as part of the SPE, is a group of volunteers from many nations, connected by their belief that drilling automation will have a long-term, positive influence on the drilling industry. This diversity helped to shape the direction of the organization. The group feels that the industry needs to attract young professionals from all cultures and disciplines to advance drilling practices in all areas of the world. The winners of the competition will receive a grant for economy class transportation and accommodations to attend the next SPE Annual Technical Conference and Exhibition and will present an SPE paper that will be added to the SPE archives of One Petro[1]. Additional teams may have an opportunity to present their work at the DSATS automation symposium preceding the conference, and may receive a grant for economy class transportation and accommodations[2]. DSATS believes recognition at one of the industry's leading technical conferences will help encourage student participation. Also, the practical experience with drilling automation systems increases the students' visibility to the companies that are leading automation activities.

4. Competition Guidelines

4.1. Problem statement for the 2016-2017 competition:

Design a rig and related equipment to autonomously drill a vertical well as quickly as possible while maintaining borehole quality and integrity of the drilling rig and drillstring.

4.2. Two Project Phases

Fall Semester 2016

The first phase of the project is to organize a team to design an automatic drilling machine to solve the project problem. It is not necessary to build any equipment in this phase, but it is okay to do so. Design considerations should include current industry practices and the team should evaluate the advantages and shortcomings of today's devices. The design effort may be assisted by university faculty, but the students are encouraged to introduce novel designs for consideration. The level of student, faculty and technical staff involvement shall be reported when submitting the design.

Spring Semester 2017

During the second phase, the finalist teams selected by DSATS to proceed to the construction and drilling operation will use the previous semester's design to build an automated drilling machine. As per industry practices, it is common during

[1] Publication is subject to the ATCE program committee's acceptance of the abstract/paper.
[2] Subject to approval of the DSATS Board of Directors and organizers of the symposium.

construction and initial operations to run into problems that require a re-design. The team may change the design as needed in order to solve the problem.

4.2.1. Teams may use all or part of a previous year's rig.

4.3. Phase I – Design Competition

Design an automated drilling machine in accordance with the rules below.

4.3.1. DSATS envisions a small (perhaps 2 meters high) drilling machine that can physically imitate the functionality of full-scale rig machinery. The machine will be the property of the university and can be used in future research and competitions. New and novel approaches that improve on existing industry designs are preferred. While innovative designs are welcome, they should have a practical application to drilling for oil and gas.

4.3.2. The drilling machine will use electrical power from the local grid not to exceed 25 horsepower. Lower power consumption resulting from energy efficient designs will receive additional consideration.

4.3.3. The design must provide an accurate and continuous measurement of Weight-On-Bit (WOB) and other drilling parameters, as well as a digital record across the period of the test.

4.3.4. The proposed design must be offered in Phase I of the project, but changes are allowed in Phase II, as long as they are reported to the Committee via students' monthly reports. A summary of all significant changes, including the reason modifications were necessary, must be included in the students' final report.

4.3.5. Design submittal by the students shall include:

4.3.5.1. Engineering drawings of the rig concept, mechanical and electrical and auxiliary systems, if any

4.3.5.2. Design notes and calculations

4.3.5.3. Control system architecture. (The response time of measurements, data aggregation and control algorithms should be estimated.)

4.3.5.4. Key features for any models and control software

4.3.5.5. Proposed data handling and display

4.3.5.6. Specification for sensors and instrumentation, including the methods planned for calibration before and after the Phase II testing.

4.3.5.7. Plan for instrumentation of sensors in the BHA, as well as a method to utilize these sensors for real-time control of the drilling process.

4.3.5.8. An explanation of the implementation of the output of the BHA sensors to improve the trajectory of the wellbore and other drilling concerns.

4.3.5.9. Cost estimate and funding plan

4.3.5.10. A design summary video used to outline the design submittal not to exceed five (5) minutes in length. Videos shall be the property of the university, but DSATS shall have the rights to use the videos on its websites and in its meetings.

4.3.5.11. All design, construction and operation of the project are subject to the terms and conditions of section 11.

4.3.5.12. A safety case shall be part of the Phase I design. Include a review of potential hazards during the planned construction and operation of the rig, and for the unloading and handling of any rock samples or other heavy items.

4.3.6. A committee of DSATS members (the Committee) will review the Phase I designs and select the top five (5) teams[3] who will progress to Phase II of the competition.

4.3.7. DSATS shall also award a certificate of recognition and publication on its website for the most innovative design. The design video will also be shown at the DSATS automation symposium at the ATCE.

4.3.8. DSATS will not fund any equipment, tools, software or other material, including labor, for the construction of the rig.

4.4. Phase II – Drilling Competition

4.4.1. In the spring term of 2017, qualifying teams will build the rig and use it to drill rock samples provided by DSATS. Drilling a vertical well efficiently though the sample while controlling drilling dysfunctions is the primary technical objective of the competition. The use of downhole measurements to control the drilling process in real-time is mandatory.

4.4.2. Once drilling commences, the test will continue until the depth reaches the bottom or the rock sample or two (2) hours, whichever comes first.

4.4.3. Drilling performance will be observed and measured by DSATS members invited to attend and witness.

4.4.4. DSATS will survey the completed wellbore and compare their survey with that of the students' downhole measurements.

4.4.5. The final test will be scheduled late in the school year or soon after graduation. The test will occur at the participating university in accordance with the timeline per section 8 below.

4.5. Rock Samples

[3] The number of finalists could be increased or decreased by the DSATS Board of Directors subject to available funding.

4.5.1.1. DSATS will prepare a set of nearly identical samples (appx. 12”W x 12”L x 24”H (30 x 30 x 60 cm) that will be packaged in a crate and shipped to each of the teams that qualified for the actual drilling test. The crates shall not be opened or tampered with, as the rock and formations shall remain unknown until after the test.

4.5.1.2. The rock sample will be a manufactured using cement, varying soil samples and perhaps some materials that are not typically encountered during regular drilling, but will imitate unusual downhole conditions experienced in some drilling programs. All simulated formations may not be parallel to each other (e.g. formation dip).

4.5.1.3. The university and/or students may acquire or produce rock samples as needed to verify the design and allow students to practice using their machine prior to the test. Drilling of the samples provided by DSATS prior to Phase II testing is not allowed and could lead to disqualification.

4.6. Bits

4.6.1. DSATS will send a drillstring and bit to the finalist teams for use in Phase II. It is expected that the BHA and pipe will cause some difficulty, both for causing drilling dysfunction and for sensor integration and data telemetry. The judges will look for creative concepts supported by sound reasoning showing an understanding of how the BHA, bit and drillstring function together, and how the downhole system measures, samples and truncates the drilling data.

4.6.2. Upon request, the bit shall be returned to the Committee following Phase II testing for reconditioning for use in future competitions.

4.6.3. One (1) bit, roller cone or PDC, will be provided by DSATS to be used during the Phase II tests. For 2016-2017 the bit will be:

4.6.3.1. PDC micro-bit will be 1.125" in (28.6 mm) diameter, with brazed cutters and two nozzles.

4.6.3.2. Cutter backrake is 20 degrees; Cutter diameter is 0.529 inches

4.6.3.3. Nozzles are 2.35mm diameter, two each at approximately 180 degrees.

4.6.4. Students are encouraged to consider bit wear prior to the final test and its impact on drilling performance during the onsite testing.

4.6.5. Student teams may build or buy similar drill bits to test their design with the rock samples they sourced.

*4.6.6.*Students are also allowed to design and use their own bits for the Phase II on-dite test, within the dimensional limits of 4.6.2.1 above.

4.7. Drillpipe

4.7.1. The drill string provided by DSATS will be chosen to ensure drilling dysfunctions will be encountered. How these dysfunctions are mitigated is a key objective of the competition. Final details of the construction of this drill string will be furnished in late fall of 2016 to all entrants upon request. Preliminary specifications are listed below to assist with the mechanical and electrical design of the rig.

4.7.2. The drill pipe specifications for the 2016-2017 competition are subject to change, but should be:

4.7.2.1. Round Aluminum Tube 3/8 inch diameter x 36 inches long; 0.016 inch wall or equivalent

4.7.2.2. DSATS will provide the finalists four (4) joints of pipe. Any additional pipe needed can be purchased by the student teams or university if needed.

4.7.2.3. Tubing is usually available from various hobby shops such as K-S Hobby and Craft Metal Tubing and via Amazon and other suppliers. http://www.hobbylinc.com/htm/k+s/k+s9409.htm

ROUND ALUMINUM TUBING

OUTSIDE DIAMETER INCHES	WALL THICKNESS	ID
3/64 (.047)	.014	.019
1/16 (.0625)	.014	.035
5/64 (.078)	.014	.050
3/32 (.094)	.014	.066
	.016	.062
7/64 (.109)	.014	.081
1/8 (.125)	.014	.097
9/64 (.141)	.014	.113
5/32 (.156)	.014	.128
11/64 (.172)	.014	.144
3/16 (.187)	.014	.159
	.022	.143
	.035	.117
	.049	.089
13/64 (.203)	.014	.175
7/32 (.219)	.014	.191
	.022	.175
	.035	.149
15/64 (.235)	.014	.207
1/4 (.250)	.014	.222
	.016	.218
	.022	.206
	.035	.180
	.049	.152
9/32 (.281)	.014	.253
	.016	.249
5/16 (.312)	.014	.284
	.016	.280
	.035	.242
	.049	.214
11/32 (.344)	.016	.312
3/8 (.375)	.016	.343
	.035	.305
	.049	.277
13/32 (.406)	.016	.374
7/16 (.437)	.016	.405
	.035	.367
15/32 (.468)	.016	.436
1/2 (.500)	.016	.468
	.035	.430
17/32 (.531)	.016	.499
9/16 (.562)	.016	.530
5/8 (.625)	.016	.593

4.8. Tool joints

4.8.1. Students may design their own tooljoints as long as the design concept is included in the Phase I proposal.

4.8.2. Alternately, students may use commercially available connectors/fittings attached to the drillpipe using threads, epoxy cement or other material, and/or may use retaining screws if desired, as long as the design concept is included in the Phase I proposal. (A fitting used successfully in 2016 is available from Lenz (http://lenzinc.com/products/o-ring-seal-hydraulic-tube-fitting/hydraulic-straight-connectors) uses a split-ring to allow a torque transfer across the fitting.

4.8.3. Students must state WHY they choose a tooljoint design in the Phase I proposal.

4.9. Bit sub/drill collar/stabilizers

4.9.1. Upon request, DSATS will provide a bit sub 3/8" NPT box down by ¼" NPT box up by 3"long. However, it is expected that each team will design and build their own bit sub.

4.9.2. Additional weight may be added to the bit sub provided by DSATS, or surface weight/force (above the rock sample) may be applied to provide weight on bit and drillpipe tension. However, the additional weight shall not directly impose lateral forces to stabilize the drillstring. This weight is meant to add to string tension/compression but shall not improve steering through interaction with the rock.

4.9.3. The student team will be evaluated on how the weight is designed and how it attaches to the drill string. Advise the committee of your choice and why and include this in the Phase I design.

4.9.4. Stabilizers are permitted, but excessive stabilization to stiffen the drillstring to avoid buckling or torsional failure is disallowed. The maximum combined length of stabilizers is 3.5" (8.9 cm). This year's shorter stabilizers should make steering more of a challenge than in previous years. The student team will be evaluated on how the stabilizers are designed and how they attach to the bit sub. Advise the committee of your choice and why and include this in the Phase I design.

4.9.5. Students may add sensors to the drillstring, but are not permitted to instrument the rock samples. The sensors cannot appreciably increase the stiffness of the drillstring or add significant weight (see 4.9.2). They must have a smaller diameter than the stabilizers and bit by at least 10%. Please include design concepts in the Phase I design.

4.9.6. The addition of along-string sensors to measure vibrations, verticality and/or tortuosity or other parameters will receive extra consideration. They must have a smaller diameter than the stabilizers and bit by at least 10%.

4.10. Automated Drilling

4.10.1. Drilling automation should be considered a combination of data, control AND modeling so that the control algorithm can determine how to respond to differences between the expected and actual performance. Process state detection can often enhance automation performance. Refer to documents posted on the DSATS website for more information.

4.10.2. Once drilling of the sample commences, the machine should operate autonomously. Remote operation and/or intervention is not allowed.

4.11. Sensors

4.11.1. The team may elect to use existing oilfield sensors or may look to other industries for alternate sensors.

4.11.2. The team may develop its own sensors if so desired.

4.11.3. Sensor quality differs from data quality. Both are important considerations in this competition.

4.11.4. The final report shall address which sensors were selected and why. The sensor calibration process shall also be explained.

4.12. Data collection and handling

4.12.1. The team may elect to use standard data collection and recording techniques or may develop their own. Data handling techniques and why they were chosen should be described in the Phase I submittal.

4.12.2. The final report shall address which data systems were selected and why.

4.12.3. The observed response time of measurements, data aggregation and control algorithms should be compared to the Phase I estimate.

4.13. Data visualization

4.13.1. Novel ways of presenting the data and progress of drilling in real time while drilling will receive particular attention from the judges.

4.13.2. Visualization of the processes (automation, optimization, drilling state, etc. should be intuitive and easily understood by the judges, who will view this from the perspective of the driller operating a rig equipped with automated controls.

4.13.3. Data must be presented in a format that allows the judges to easily determine bit depth, elapsed drilling time, ROP, MSE, verticality/inclination, vibration, and any other calculated or measured variable used to outline the drilling rigs performance to the judges. Lack of an appealing and usable Graphic User Interface (GUI) will be noted to the detriment of the team.

4.13.4. All depths shall use the industry-standard datum of rotary/kelly bushing interface (RKB), which should be the top of the rig's "drill floor."

4.14. Measure and analyze the performance

4.14.1. The drilling machine should react to changing "downhole" conditions to select the optimal drilling parameters for improved performance, as measured by the rate of penetration (ROP), mechanical specific energy (MSE), verticality, cost per foot or meter, and other standard drilling measures or key performance indicators. Adding parameters such as MSE to the control algorithms will receive special attention from the judges.

4.14.2. Design limits of the drilling machine shall be determined and shall be incorporated in the programming of the controls during the construction phase.

4.14.3. The final report (see Clause 4.19) shall outline drilling performance and efficiency criteria and measured results.

4.15. The test well:

4.15.1. Will be drilled as a vertical well. Verticality and drift will be measured by the judges and compared with the students' measurements, so calibration issues should be carefully considered

4.15.2. Should be drilled with a maximum allowable Weight-On-Bit dependent on the rig and drillstring integrity.

4.15.3. Will not require a closed-loop fluid circulation system, but the bit and machinery should be cooled with air or fluid/water if needed. The design of the fluid system, if any, should be included in the Phase I design.

4.15.4. The rock sample may simulate the drilling of hydraulic hazards such as lost circulation, surge, swab and other effects, but no well control equipment for over-pressure considerations will be necessary. Note that the rock samples may leak at the junctions between the simulated formations, so a rig design that includes a containment system is strongly suggested.

4.15.5. Will not require casing or cement

4.15.6. Will not be drilled with a mud motor or turbine.

4.15.7. Will not require a rig move, walking or skidding, but the mobility of the rig will be considered in the design phase.

4.16. Not included in the 2016-2017 competition

4.16.1. The drilling will not include automating the making or breaking of connections. If this is necessary due to the rig and drillstring design, connections should be made manually, and the time involved with the connections will be added with respect to its effect on drilling performance (rate of penetration reduction).

4.17. Presentation to judges at Phase II Testing

4.17.1. The judges will arrive at the university to meet with the student teams and advisors immediately prior to the Phase II testing. The university should provide a suitable meeting room for discussion lasting about two hours.

4.17.2. The students will present a BRIEF summary of their final design, highlighting changes from their Phase I design, if any. Include an explanation of why any changes were necessary, as this indicates to the judges how much students learned during the design and construction process. Explain what measurement and control features have been deployed. Describe novel developments or just something learned that was worthwhile. Also include how actual expenses compared with the initial estimate. (Previous teams used a short PowerPoint presentation of about ten slides or so. Use any format you like.) Be sure to include all your team members as presenters, not just one spokesperson. At some time during your talk, let us know who the team members are and what background they have that pertains to the project.

4.17.3. Judges will ask questions to ascertain additional details about the design and construction process and to see if all team members have a reasonable understanding how all the various disciplines used for the rig design and construction fit together.

4.18. Project report

4.18.1. The student team shall submit to DSATS a short monthly project report that is no more than one page in length (additional pages will be ignored) due on or before the last day of each month that will include:

4.18.2. Phase I

- Key project activities over the past month.
- Rig design criteria, constraints, tradeoffs, and how critical decisions were determined
- Cost updates
- Significant new learning, if any

4.18.3. Phase II

- Construction issues and resolution
- Summary of recorded data and key events
- Drilling parameters [such as WOB] and how they impact the test
- Other items of interest
- To teach students that their work involves economic trade-offs, the monthly report should include at a minimum a summary estimate of team member labor hours for each step in the project: design, construction, testing, reporting, and a cost summary for hardware and software related expenditures. Also include labor for non-students that affect the cost of the project. Labor rates are not considered, as to eliminate international currency effects. Labor is not considered in the cost limits of item 6.1, but should be discussed in the report and paper.

4.19. Final report and paper

4.19.1. The finalists shall prepare a project report that addresses the items in 4.19.6 below. We suggest you use the format of most SPE papers. For reference, please see http://spe.org/authors/resources/

4.19.2. The winning team shall update the report as needed to comply with SPE ATCE paper submittal guidelines to write a technical paper for publication by the SPE at its Annual Technical Conference and Exhibition. SPE typically requires that the manuscript is due in June. While the Drillbotics committee will make every effort to have the paper presented during the ATCE, the ATCE Program Committee has authority over which papers will be accepted by the conference. If the paper is not accepted by the conference, the Drillbotics committee will endeavor to have it presented at the DSATS Symposium and will use its contacts to have the paper published via other related SPE conferences.

4.19.3. The report, paper and all communications with DSATS shall be in the English language. The presentation will be made by at least one member of the student team.

4.19.4. The timing for submittal of the abstract and paper will be the published deadlines per the call for papers and conference guidelines as posted on the SPE's website (www.spe.org).

4.19.5. The abstract must generate sufficient interest with the SPE review committees to warrant publication, although DSATS will help promote acceptance where possible

4.19.6. The paper should address at a minimum

4.19.6.1. The technical and economic considerations for the rig design, including why certain features were chosen and why others were rejected.

4.19.6.2. The setup of the experimental test, the results and shortcomings.

4.19.6.3. Recommendations for improvements to the design and testing procedures.

4.19.6.4. Recommendations for improvements by DSATS of the competition guidelines, scheduling and provided material.

4.19.6.5. Areas of learning gained through the competition not covered in the university course material.

4.19.6.6. A brief bio or CV of the team members and their sponsoring faculty.

5. Team Members

5.1. DSATS envisions that the students would be at least senior undergraduate or Masters level, well versed in the disciplines needed for such a project. The maximum number of students per team is five (5) and the minimum shall be three (3). Any team that loses team members during the project can recruit a replacement.

5.2. At least one member of the team must be a Petroleum Engineering candidate with sufficient coursework completed to understand the physics relating to the drilling problems and the normal industry practices used to mitigate the problem.

5.3. Students with a background in mining, applied mathematics, mechanical and electrical engineering, as well as controls, mechatronics and automation or software development, are the most likely candidates, but students with any applicable background is encouraged.

5.4. A multi-disciplinary team simulates the working environment in the drilling industry today, as most products and services are produced with the cooperation of technical personnel from differing backgrounds and cultures.

5.5. A university may sponsor more than one team but must submit only one team/design for Phase II evaluation.

6. Expenditures

6.1. Teams selected to advance to the second phase must limit the cost of the rig and materials to US$ 10,000 or its equivalent in other currencies. The students shall find a source of funding and report the source in the Phase I proposal. All funding and procurement should comply with university policy. These funds are intended to cover the majority of expenses for hardware, software and labor to construct and operate the team’s equipment. DSATS shall not be liable for any expenditure other than DSATS provided material and specified travel expenses.

6.2. DSATS will assist when possible to obtain free PLCs or similar control devices from suppliers affiliated with the DSATS organization. Such "in-kind" donations shall not be included in the team's project costs.

6.3. Students and universities may use other "in-kind" contributions which will not be included in the team's project costs. Such contributions may include modeling software, laboratory equipment and supplies, and similar paraphernalia usually associated with university laboratory projects.

6.4. Any team spending more than US$ 10,000, or its equivalent in other currencies, may be penalized for running over budget.

6.5. DSATS reserves the right to audit the team's and university's expenditures on this project.

6.6. Any devices built for the project will become the property of the university and can be used in future research and competitions. Any maintenance or operating costs incurred after the competition will not be paid by DSATS.

7. *Other Considerations*

7.1. The design concepts shall be developed by the student team under the supervision of the faculty. Faculty and lab assistants should review the designs to ensure student safety.

7.2. Construction of the equipment shall be supervised by the student team, but may use skilled labor such as welders and lab technicians. The use of outside assistance shall be discussed in the reports and the final paper. DSATS encourages the students to gain hands-on experience with the construction of the rig since this experience will be helpful to the career of individuals in the drilling industry.

7.3. University coursework and credit: Each university will decide whether or not this project qualifies as a credit(s) towards any degree program.

8. *Project Timeline*

Phase I - Design:	Fall 2016
Submit monthly reports	On or before the final day of each month
Submit final design to DSATS	31 Dec 2016, midnight UTC
Submit an abstract to DSATS*	31 Dec 2016, midnight UTC
Phase II – Construction and Testing	Spring 2017
DSATS to announce finalists	On or about 15 Jan 2017
Construction	Spring 2017
Monthly reports	On or before the final day of each month

Drilling Test	Specific on-site test dates at each university to be arranged not later than 31 March 2017. The testing will typically occur in late May or early June. All tests must be completed by 15 June.
Prepare and submit paper	Per SPE deadline*
Prepare and submit presentation	Per SPE deadline
Present paper at ATCE	Per SPE and DSATS schedule

*DSATS will submit an abstract to the SPE that will include excerpts from the student abstracts by the conference paper-submittal deadline, typically in mid-January, for consideration of a paper by the ATCE program committee.

9. Evaluation Committee

9.1. DSATS will select an evaluation committee from its membership

9.2. Criteria/Weighting (see chart):

Criteria	Parameter	Weighting
Phase I:		
a.Safety	Safety: construction and operation	10
b.Mobility of rig	Rig up, move, rig down	5
c.Design considerations and lessons learned		10
d.Mechanical design and functionality, versatility		25
e.Simulation/Model/Algorithm		25
f.Control scheme	Data, controls, response times	25
	Total	100%
Phase II:		
a.Creative Ability	Analysis, concepts, development	10
b.Engineering Skills	Problem/Goal, design criteria, feasibility	10
c.Construction Quality		10
d.Cost Control		10
e.Performance		20
Various parameters such as:	ROP, MSE, Landing Bit, Inclination, and other	
Are these used within the control algorithms		
	Optimal landing of bit	
f.Quality of wellbore		20
	Verticality, tortuosity, caliper, other	
g.Data	Data handling, data visualization, data comparison to judges' wellbore logs, and other	
	Total	100%
Intangibles	Additional score may be added or subtracted by the judges at their discretion	

10. Prizes

10.1. The winning team will be sponsored by DSATS to attend the next SPE Annual Technical Conference and Exhibition. Upon submittal to DSATS of a valid expense statement (typically a spreadsheet supported by written receipts) covered expenses will be reimbursed by the treasurer of DSATS for the following:

10.1.1. Round trip economy airfare for the team and one university sponsor/supervisor to the gateway city of the next SPE ATCE conference. Entrants should use the SPE approved carrier where possible to minimize cost. Information of reduced fare flights is available on the ATCE website. Please note that reservations must be made before the SPE published deadline. Airfares that exceed the SPE rate must be pre-approved by the committee or the reimbursement will be limited to the SPE rate. The departure point will be a city near the university, the student's home, or current place of work, subject to review by the Committee. Alternately, a mileage reimbursement will be made in lieu of airfare should the entrants decide to drive rather than fly to the ATCE. The reimbursement is based on current allowable mileage rates authorized by the US Internal Revenue Service.

10.1.2. One rental car/van at the gateway city for those teams that fly to the ATCE.

10.1.3. Lodging related to one hotel room per team member will be reimbursed at a rate not to exceed the SPE rate. Note that the room reservations are limited, so entrants must book their rooms early. Room and taxes for the night before the DSATS symposium, the night of the symposium and for the nights of the conference are covered. Charges for the room on the last day of the conference need to be pre-approved by the Committee as most conference attendees depart on the last day of the conference unless there are unusual circumstances.

10.1.4. A per diem will be pre-approved by the Committee each year, which will vary with the cost of living in the gateway city. The per diem is intended to cover average meals (breakfast, lunch and dinner) and incidentals.

10.1.5. ATCE registration will be reimbursed. Students should register for the ATCE to obtain the student rate. Early registration is appreciated.

10.2. Individual award certificates will be presented to all participants, with special certificates given to all finalists.

10.3. DSATS may provide additional awards, at its sole discretion.

10.4. The evaluation and all decisions on any matter in the competition by the DSATS judges and DSATS board are final.

11. Terms and conditions

11.1. In no event will SPE, including its directors, officers, employees and agents, as well as DSATS members and officers, and sponsors of the competition, be liable for any damages whatsoever, including without limitation, direct, indirect, special, incidental, consequential, lost profits, or punitive, whether based on contract, tort or any other legal theory, even if SPE or DSATS has been advised of the possibility of such damages.

11.2. Participants and Universities agree to indemnify and hold harmless SPE, its directors, officers, employees and agents, as well as DSATS members and officers, and sponsors of the competition, from all liability, injuries, loss damages, costs or expenses (including attorneys' fees) which are sustained, incurred or required arising out of participation by any parties involved in the competition.

11.3. Participants and Universities agree and acknowledge that participation in the competition is an agreement to all of the rules, regulations, terms and conditions in this document, including revisions and FAQs posted to the DSATS and Drillbotics websites (see section 3.1).

11.4. Winning teams and finalists must agree to the publication of their names, photographs and final paper on the DSATS web site.

11.5. All entries will be distributed to the Drillbotics Committee for the purpose of judging the competition. Design features will not be published until after all teams have been judged and a winner is announced. Previous years' submittals, reports, photos and similar documentation will be publically available to foster an open exchange of information that will hopefully lead to faster learning for all participants, both new and experienced.

11.6. DSATS and the SPE cannot provide funding to sanctioned individuals and organization per current US law.

11.7. Participants must comply with all local laws applicable to this contest.

12. Marketing

12.1. Upon request, DSATS will provide a link on its website to all participating universities.

12.2. If university policy allows, various industry journals may send a reporter to witness the tests and interview students to publicize the project.

- End -