- ***What is DSTR?***

The DSTR Robot, which stands for Digital Systems Teaching and Research Robot, is a small form factor robotic platform that was developed in the Mobile Integrated Solutions Laboratory at Texas A&M University. Over the span of a little over a year, it's managed to be featured in STEM outreach and recruiting; curriculum for middle school, high school, and college level freshman engineering courses; and a handful of research projects - some of which may end up in space!

- ***Why is it important as an educational program?***

The state of the engineering world has always been in flux. Nowadays, we are often seeing a need for engineers that know more than just a specialized focus in their field. The main reason for this it that it is becoming increasingly hard to imagine a product (or system) that doesn't make use of more than one engineering discipline, just think of all the different engineering backgrounds that went into designing your car. For this reason, it is especially important for engineers on modern day engineering projects to be able to work in a team environment and have an understanding of all the separate parts of their system.

The DSTR presents a "system of systems" approach to teaching engineering where a fully functioning robot is split up into subsystems. A team of students is then created where each student is given responsibility of their subsystem's creation and functionality. In a general engineering environment this provides two beneficial outcomes: First, each student essentially takes on a leadership role for their subsystem and is responsible for making sure everyone else in their team understands what this subsystem will need to integrate with the rest of the subsystems. Second, students are able to choose a bit of a focus area that they are interested in, whether that's mechanical, electrical, embedded intelligence, power, etc. This type of choice has allowed students to enhance their contribution to their team, as they are able to pursue a focus that they are interested in. The leadership roles, however, ensure that each member of the team will still learn the parts that they didn't do themselves from their teammates. Students often learn best when hearing material explained from the perspective of their peers, and that's exactly what the DSTR has helped foster.

- ***What's its future look like?***

From the first time an ASEP Mini, the original classification of the DSTR, was fully assembled, to the first time it was moving, none of us realized quite how much of an impact these little robots would have on our lab, STEM outreach and recruiting, and general engineering education here at Texas A&M. We constantly look for new ways to advertise and show off DSTR to potential students. This exposure has brought us very unique opportunities. The end of this Spring semester marks the end of the first engineering course to make use of the DSTR, and it occurred right here in College Station on the main Texas A&M campus. Two sections of a freshmen engineering course, ENGR-112, used the DSTR as an introduction to engineering projects and approaching an engineering product as a "'system of systems." In the upcoming Fall '17 semester, there will only be three sections of ENGR-112, and DSTR will be used as the course project for all three of them! Depending on the reception we receive from these courses, DSTR will continue to expand and take over more sections during the Fall semesters when there are many more sections of ENGR-112 than can currently be supported by DSTR.

We will also continue to look for opportunities to hold summer workshops involving the DSTR and young students. In the past, we have had workshops with students ranging in age from thirteen to nineteen. This summer, we have been contracted by the Youth Adventure Program to provide a weeklong robotics camp which reached its attendance cap very quickly.

The last big step for the future of DSTR could potentially be on the Moon itself. A team at NASA is putting together a proposal to return to the lunar surface for sample collection. They are very interested in using DSTR as a replacement for the sample collection arm that has been used in previous missions. Some of the advantages offered to this mission by the DSTR are its small mass, small form factor, and its ability to retrieve samples further from the lander.

- ***What other kinds of applications could be controlled by the controller you built?***

The controller is currently sending data using UDP packets over a Wi-Fi connection to a specified port. As long as the receiver sets up the Wi-Fi with the same name that the controller is looking for, the two will connect. Once the connection is there, the receiver needs to read incoming packets on the port that the controller is using. After that, anything you want can be transmitted from the controller to the receiver. In our case, we are transmitting control commands based on inputs from the joystick, but future iterations could use the tilt of the gyroscope to move the robot, use the buttons to change to a different mode, etc. The size of the packet being transferred can be lengthened or shortened, so additions such as actuators or servos can be made on the receiver side. Once somebody has an idea for what they want to control on the receiver side, the controller side can make use of many different inputs including the joystick, buttons, and sensors to send different commands or data sets.

- ***Why did you build this type of controller for the DSTR robot? What is the benefit of this controller vs. controlling it via a phone application?***

This type of controller was conceptualized when we started incorporating first-person view into DSTR. When you're wearing goggles on your face, using the phone application can be difficult to maneuver because there's no tactile feedback, the screen could rotate without you knowing, and on some phones there's even the possibility of accidently closing out of the app. We had worked with the Educational BoosterPack MKII before and decided that the onboard joystick would be perfect for providing this tactile feedback that we were looking for. In addition, the DSTR robot was already run on the CC3200 LaunchPad, so it was fast and easy to prototype a compatible stack out of existing TI LaunchPads and BoosterPacks.

The outer casing of the controller allows for the user to comfortably access the controls. It provides a more natural way of holding the controlling device that sits better in the user's hands than a phone would.

- ***Can you tell us more about the STEM outreach with the DSTR and your team? (What are you doing/why, etc.)***

The STEM outreach we do with the DSTR Robot primarily revolves around summer workshops. One of the nice things about the workshop we've developed is that it is modular, so it can be modified to fit the needs of different age groups, skill levels, and time constraints. The ones we've done so far have involved kids ranging from 6th to 12th grade and lasting 3 to 5 days.

The workshops allow kids to learn what it's like to work in a team environment where they're responsible for one aspect of the robot, but they have to work as a team to integrate their part into the system as a whole. Teams typically consist of 4 to 5 students where they can choose to be in charge of the mechanical structure, the electronics and wiring, the embedded intelligence, or the App development. The students will then have x amount of days to learn about and complete their portion of the robot. These sessions are generally lead by undergraduates who work in MISL, making it mutually beneficial. We're firm believers that you don't truly understand something until you have to explain it to someone else, especially when that someone is much younger than you and has probably isn't familiar with what you're talking about. Once their respective parts are done, they will be given time to integrate the sections together one at a time, testing after each of these steps and making changes and improvements as necessary. The last day is typically spent doing any last minute testing and optimization and then they get to race their robots! We feel that adding a competitive aspect makes it not only more fun, but also more fulfilling regardless whether you win or lose because they still had to work together with a team (that they had probably never met) and put together a functioning robot.

We feel that using the DSTR Robot in STEM outreach is important for a number of reasons, whether the kids are interesting in engineering or not. It introduces them to problem solving in a setting that they're probably not used to and gets them familiar with teamwork and working on a team with people they've probably never met before, both of which are important life skills.

- ***What all partners are involved in this project? How are they involved? (Can you specifically hit on your potential partnership with NASA and what that would look like?)***

During a day when a couple NASA scientists were in our lab working on a system which is now operating on the International Space Station, the DSTR was being driven around outside for some initial testing of the control communications. One of the scientists stepped outside for a break and was very intrigued by the small robot that was racing around seemingly unstoppable while it climbed up small ledges and curbs and rolled down sets of stairs. He was especially interested in how light the robot was while maintaining the ability to maneuver over obstacles and recover from sharp drops over ledges.

Months later we were contacted by this scientist to arrange a meeting with other members of his team who were interested in the possibility of using DSTR as a sample collector on the lunar surface. Since that meeting, our lab has worked with the team at NASA to develop modifications to the DSTR such as a controllable arm with a rotating scoop which allows the DSTR to collect dirt and sand. A Electronics Systems Engineering Technology capstone team, named Enclave, has been developing a possible control method for the DSTR which integrates an IoT environment so that commands and sensor data are sent over a Wi-Fi connection using

MQTT to a broker. Enclave made a presentation to the NASA scientists around mid-April and this presentation, along with demonstrations of the DSTR crawling around NASA's rock yard using its brand new scoop attachment, amazed the team of NASA scientists. The quote of the day we received in reference to our work and its impact on this mission and future NASA missions was, "This is a game changer."

- ***What have you learned about electronics working together in a system from this project?***

Regardless of how many times you've put together one of these robots, or how many times you've soldered everything together and wired up the boards, something can always go wrong. Something our team has taken away from our experiences in workshops and other outreach events is that there is almost always more than one way to fix a problem. Once you identify what is causing your system to not work properly, sometimes you may have a choice in how you want to approach a solution. If the error was caused from two signals being swapped, do you want to unplug the wires and swap them physically, or, in the case of the wires being hard to reach, would you rather go and reprogram your board to swap the signals in your code? Several of us joke that we have developed what we have come to call a, "Masochistic love of debugging." Something being wrong with a system isn't a heartache, it's just another learning opportunity. By learning to troubleshoot and fix common problems with these robots, we have taught ourselves how to approach nearly any engineering system with the thoughts of, "What COULD cause this" and "What haven't we checked?"

One of our courses in ESET is Electronics Test, in which undergraduates learn to use Teradyne testers. No other university in the world has these testers available to use at an undergraduate level. The last set of labs that are performed in the class are debug labs, where a previously working program is loaded onto the tester with ten errors added into the program. Each student has half an hour to try to find and fix all ten errors. Only a small percentage of students ever find all ten, but three out of the four that found them this semester were from our lab. Coincidence?

- ***How have the classes you've been taking contributed to this project – or how have they come to life through it?***

One of the unique things about the program we're in (Electronic Systems Engineering Technology) is that it has several different focuses including software, hardware, and networking. Taking several programming classes has definitely played a role in not only developing the software that controls the DSTR Robot, but also in developing the software for various in-class activities and labs in Freshman Engineering and workshops.

Circuit analysis has also made subtle appearances in the development of this project, especially as we further develop the electronics and make enhancements. Even seemingly simple add-ons like LEDs or a camera require some thought to how they're going to affect the circuit as a whole. How much current with the device draw? Can the system handle it? Will it be added in series or parallel? All these things and more need to be considered before we can decide whether or not we can make the addition, or what changes to the system need to be made in order to accommodate the addition.

It’s exciting to take knowledge and experiences from the classes we’ve taken and really apply it to a real-life situation.