Vaughn College Journal of Engineering and Technology
April 2020

"The only source of knowledge is the experience."
Albert Einstein

The Vaughn College Journal of Engineering and Technology (VCJET) is published annually in preparation for the Technology Day Conference. It includes events and activities of the Department of Engineering and Technology such as faculty professional development, student engagements, robotics competitions, UAV activities, poster competitions, conference presentations, and the best student research papers.

Given the rapid pace of technological change, the Journal is intended to assist Vaughn engineering students in the development of an appreciation of lifelong learning to meet their future professional challenges. The ultimate goal of the journal is to engage and prepare students for their future in engineering research and innovation. VCJET further strengthens student learning outcomes related to critical thinking, problem solving, communication, and teamwork. These learning outcomes, embedded in engineering and engineering technology programs, are further developed through the activities outlined in this publication. The events reported in this journal also contribute to student development of leadership and entrepreneurial skills.

A journal paper project must be produced and investigated in a manner that satisfies the learning objectives of engineering education. Some of the learning objectives emphasized in the development of a technical paper are:

1. Intention plan (Abstract): Developing a proposal that outlines the details of a project and its impact on local and global society
2. Application: Identifying the use and application of the project in global society
3. Methodology: Providing a brief description of methods and solutions
4. Teamwork: Identifying team members and their responsibilities in the project's development
5. Modeling: Providing a complete and precise drawing of the project
6. Analysis: Providing all necessary analysis and analytical tools used to satisfy the system's safety and computing requirements
7. Conclusion: Discussing the result(s) and the contribution of the project to local and global society
8. Reference: Identifying research references
9. Presentation: Presenting the selected design paper in a Microsoft PowerPoint format to the industry advisory members, faculty, and other members in the audience during the Technology Day Conference

The Journal's topics include technical papers related to computational mechanics, solid mechanics, mechatronics, robotics, avionics, electronics, and other topics pertinent to the engineering and engineering technology fields.

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A Brief Review of Vaughn College's Eleventh Annual Technology Day Conference, April 19, 2019

Vaughn students, faculty, alumni, and industry professionals convened in April 2019 for the College's Eleventh Annual Industry Advisory Meeting and Technology Day Conference. Advisory Council members were given updates on recent developments in the Engineering and Technology Department such as progress reports on: faculty and student professional engagement, programs' assessment and preparation for the ABET 2019 programs reaccreditation, adaptation of new "1 through 7" EAC and "1 through 5" ETAC student learning outcomes, HSI-STEM grant activities including the development process of stackable manufacturing certificate programs that lead to a BS in the advanced manufacturing program, the development and implementation process of manufacturing laboratories (CNC machining, composite, additive manufacturing, and UAS), the qualification of Vaughn's Robotics teams for 2019 VEX U world championship, the selection of Vaughn's UAV team by the American Helicopter Society (AHS) as a finalist in the 7th annual Micro Air Vehicle (MAV) student challenge competition, and the engineering clubs' (SWE, EWB, NSBE, Robotics, SAE, SHPE, UAV) annual STEM outreach activities.

Vaughn College's President, Dr. Sharon DeVivo, welcomed the guests and thanked our advisory members and alumni for their active participation and support of student success and our institution. Academic Vice President, Dr. Paul LaVernge, thanked our advisory members and provided a plan for developing a Cyber Security certificate program which will eventually lead to the development of both AAS and BS programs in Cyber Security.

Dr. Hossein Rahemi, Chair of the Engineering and Technology Department, thanked the advisory members for their continuous support and valuable feedback on every aspect of the department's programs and on student success. He updated the advisory members about the department's preparation for 2019 reaccreditation and provided an overview of the department's assessment process in the measurement and attainment student learning outcomes within various engineering and engineering technology programs. He announced that the department is currently in the process of completing self-study reports for 6 programs based on 8 ABET criterions (Students, PEOs, Student outcomes, Continuous improvement, Curriculum, Faculty, Facilities, and Institutional support). He also provided insight regarding the assessment and continuous improvement process within programs which is based on both direct and indirect measures. As a direct measure, the department uses the Faculty Course Assessment Report (FCAR), Capstone Degree project evaluation survey, and the laboratory evaluation survey to assess attainment of student outcomes through courses and programs. Also, constituents' evaluation surveys (Employer, Internship supervisors, Tech Day capstone advisory evaluation surveys) are used as a direct measure to assess attainment of student outcomes. As a further direct measure, the department uses student exit and alumni surveys to assess student outcomes. He explained how programs' "a through k" outcomes were mapped against new "1 through 5" ETAC student outcomes, and those outcomes were mapped against "1 through 7" EAC student outcomes in engineering to assess attainment of ABET's criterion 3 student outcomes.

Dr. Rahemi informed advisory members about the Department of Education title III HSI-STEM grant funded activities, including the development process of manufacturing laboratories (CNC and Composite labs), stackable certificate programs in Computer Aided Design & Additive Manufacturing, Composite Manufacturing, and CNC machining, currently approved by New York State Education Department (NYSED). He further explained that the PD and grant management team are currently in the process of developing additional certificate programs in PLC & Automation, and a new BS in the Advanced Manufacturing program. Dr. Rahemi's presentation provided insight regarding students' professional and scholarly activities, including the success of the Vaughn College Robotics team at the 2018-2019 regional VEX U Robotics competitions, as well as their qualification to participate in the 2019 VEX U World Championship; participation of Vaughn's UAV team as finalists in both manual and autonomous categories by The Vertical Flight Society (VFS) for the Annual Micro Air Vehicle (MAV) Student Challenge competition on May 13, 2019 at University of Pennsylvania; participation of Vaughn's SAE team at the 2019 Formula SAE competition; student participation and presentations in paper and poster sessions of technical conferences; and updates on student and faculty professional development and engineering club STEM outreach activities.

The third speaker of the morning session conference was Prof. Jesus who introduced the audience to the laboratory enhancement of both CNC machining and the 3D Maker space center. Also, he introduced the advisory members to descriptions of laboratory equipment related to 3D scanning, CNC lathe, and other equipment that can support implementation of both additive manufacturing and CNC machining certificate programs.

Robotics, UAV, SWE, EWB, Automotive Clubs' presentation (11:00 pm to 12:00 pm)

- Vaughn's UAV club presented their annual activities as well as their design and development process for two manual and autonomous quadcopters for participation in the 2019 Vertical Flight Society Micro Air Vehicle Competition. Vaughn's UAV team was selected as finalists, along with Penn State, University of Maryland, and Drexel University, to participate in the 7^{th} annual Micro Air Vehicle (MAV) student challenge competition at the University of Pennsylvania on May 13, 2019. Both manual and autonomous drones for this competition are designed to perform vertical takeoff & landing (VTOL) with onboard flight-stabilization and camera. The drone's weight should be less than 500 grams and should have delivery, pickup, obstacle avoidance, and hover/landing capabilities. For both autonomous and manual, a drone with a package will take off from a base station, move around an obstacle and drop off the package on a pre-identified delivery station. The drone must then takeoff from the delivery station and land on the pickup station to pick up a 2^{nd} package, finally flying back to the base station to land and deliver the package. This is a tough and challenging competition, and only the top teams who have supporting documentation and videos, who have proven that their drones can complete the tasks, are invited as finalists to compete in the Annual American Helicopter Society Micro Air Vehicle (MAV) competition. In 2018 Vaughn's UAV team project was selected as one of the finalists along with Penn State and University of Maryland to participate in the 6^{th} annual Micro Air Vehicle (MAV) student challenge competition at Phoenix Convention Center on May 14, 2018. Vaughn's remote control team was the only team that completed three flawlessly successful runs within the 10 minutes permitted time and they won the first place "Best Remotely-Controlled Target Search" award with a $2000 check. Vaughn's autonomous team is the only team who, for the past three years, has been able to execute vertical take-off and partially complete the autonomous category, and for this accomplishment they received the "Honorable Mention" award with a $1000 check.

Vaughn's UAV Club Presentation

- The Vaughn Robotics Club discussed several stages of their robotics design for VEX U Robotics regional, international, and world championship competitions. Invitation to the VEX U Robotics World championship will only be granted to a team that is a tournament champion, tournament finalist, and/or an 'Excellence' award recipient of a regional competition. Vaughn's Robotics team (VCAT) received the Excellence Award at Vaughn College Regional Robotics Competition; the tournament champs and Excellence award for the **New Hampshire** regional competition, as well as the finalist and skills award for the Mexican VEX U Reeduca International robotics competition. The Vaughn Robotics Club discussed their innovative robotics design, in which both robots can perform quickly in both forty-five second autonomous periods followed by a one minute and fifteen second (1:45) driver-controlled period. From April 24-27, Vaughn's Robotics teams will be competing with seventy eight national and international universities and colleges for the 2019 VEX U Robotics World Championship in Louisville, Kentucky Freedom Expo Center.

Vaughn's Robotics Club Presentation

- The Vaughn Racing team presented their annual club activities as well as their design, development, and building process of a racing car for preparation in the 2019 Formula SAE competition. Vaughn's Racing team was selected, along with 131 national and international teams, to participate in the 2019 Formula SAE competition at Michigan International Speedway from May 8-11, 2019.

Vaughn's Racing SAE Club Presentation

- The Engineers Without Borders (EWB), the Vaughn Society of Women Engineers (SWE), the Vaughn National Society of Black Engineers, and the Vaughn Society of Hispanic Professional Engineers made presentations regarding their annual activities, extra-curricular involvement, and STEM outreach activities. The EWB talked about their recent trip to Kibingo, Rwanda and their water project to improve the quality of water and develop an implementation plan for a sustainable, highly reliable system for the residents of the area. The Vaughn SHPE members discussed their active participation in the Society of Hispanic Professional Engineers (SHPE) Conference and their involvement in the Extreme

Engineering Challenge of this annual conference. They presented the accomplishments and successes of their team members Darwing Espinal, who won 3rd place in 2017, and Angel Calderon, who won 1st place in the 2018 Nissan Design challenge for his design idea "**Adaptive Air Intake** – Enhancing efficiency of existing engines and reducing carbon footprint".

Vaughn's EWB, SWE, NSBE, SHPE Presentations

<u>Student Technical Paper Presentation, 1:00 pm to 3:00 pm</u>

Vaughn graduating students gave presentations about their capstone research projects during afternoon paper and poster sessions of the 2019 Technology Day Conference. The top 3 research papers were selected by our Industry Advisory members as the recipients of the Best Student Paper awards of this session. The winning papers included: Two First place research paper winners, 1) **Design and Fabrication of Small-Scale Supersonic Wind Tunnel** by Deron Hurley and Johnny Arteaga, 2) **Walking Wise Camera Sensor Smart Cane** by Jevoy James, Richi Ramlal, and Ali

Abdullah; second place research paper winner, "**Object Detecting Competition Robot**" by Eric Grieco and John Hernandez; and two third place research paper winners, 1) **Affordable Strain Gauge Indicator (ASGI)** by Norrin Abreu and Thomas Wolday, and 2) **3D Printed Brain-Controlled Robotic Prosthetic Arm** by Sam Maddaloni, Grace Davis, and Raiyan Mohammed.

Students' Capstone Paper Presentation

<u>Students' Capstone Poster Session Presentation, 3:00 pm – 3:30 pm</u>

The top 3 capstone degree project posters were selected by our Industry Advisory members as the recipients of the Best poster awards of this session. The winning Degree Project posters included: First place poster winner "**Ground Station and Antenna Tracking System**" by Muhammad Galib and Chamathke Perera; second place poster winner **"Design and Fabrication of a Small-Scale Supersonic Wind Tunnel"** by Deron Hurley and Johnny Arteaga; two third place poster winners 1) **Portable IV Module** by Kevin Bastidas and Christina Deluca, 2) **Winter Warrior Mask** by Okera Bullen and Ousmane Thioune.

Students' Capstone Degree Projects Poster Session

Eleventh Annual Advisory Meeting and Technology Day Conference, April 19, 2019

Supplemental Instruction

Supplemental Instruction (SI) is a student academic assistance program which increases academic performance and retention through the use of collaborative learning strategies. The SI program at Vaughn targets challenging mathematics, engineering, and physics courses and provides regularly scheduled, out-of-class, peer-facilitated sessions giving students further opportunity to process the information learned in class. Supplemental instruction is a proactive approach to student learning and engagement which increases student persistence and retention. In an effort to increase learning effectiveness, during the spring of 2009 a formal supplemental learning program was introduced. In addition, during the spring of 2012, as part of the Hispanic-Serving Institution (HSI) STEM grant, the SI program has been further enhanced to assist and improve student understanding in fundamental engineering and engineering technology courses. In these courses, such as statics, dynamics, strength of materials, AC/DC circuits, Robotics, automation, and Computer Aided Design, highly talented students who have already completed those courses are selected to sit-in on the classes for a second time, with the instructor, and serve as a designated Supplemental Instructor (SI) for these courses and laboratory exercises. The student SI is assigned the task of reviewing class lectures, conducting problem solving sessions and communicating with the faculty member about the areas where students need reinforcement for successful course completion. This SI program was initiated in conjunction with the Teaching and Learning Center (TLC). The current HSI-STEM title III grant provides additional funding ($60,000/year, 2016-2021) to further enhance the SI program through more fundamental courses that can improve the attainment of student learning outcomes in all STEM related programs.

The student SI is scheduled for ten hours per week to assist students in the fundamental engineering and engineering technology courses. This includes three hours per week that the SI attends the class with the instructor for the second time, and another seven hours per week to assist students with problem solving sessions. For the spring 2020 the student supplemental instructors and their schedule are presented in the following table.

Spring 2020 SIs for the Corresponding Courses and Course Schedule

Course	Faculty	Supplemental Instruction Tutor	Class Schedule	Out-of-Class Academic Success Center Schedule
EGR380 Engineering Project Management	M. Benalla	**Nurullah Khan**	T, Th: 4pm – 5:30pm	**M: 2pm-4pm** **T: 2pm-4pm** **W: 2pm-4pm** **Th: 2pm-3pm**
CHE231 General Chemistry	M. Goya	**Jonahz Pedro Hernandez**	M: 11am-12pm W: 10am-11am	**W: 11am-3pm** **Th: 11am-3pm**
ELE326 Microprocessors	S. He	**Juan Aguirre Rodriguez**	W: 12pm-3pm	**T: 3pm-5pm**
EGR220/EGR225 Strength of Materials I/II	H. Rahemi	**Abdalmonem Anwar**	M, W: 10:30am-12pm	**M: 12pm-2pm** **T: 11am-5pm** **W:12pm-6pm**
EGR455 Aircraft Structural Analysis	Y. Budhoo	**Abdalmonem Anwar**	M, W: 8am-9:30am	**M: 12pm-2pm** **T: 11am-5pm** **W:12pm-6pm**

EGR235 Material Science and Composites	Y. Budhoo	**Anil Parbhudial**	M, W: 10am-12pm	**M: 12pm-3pm** **W: 2pm-5pm**
MEE345/EGR345 Fluid Mechanics	G. Benbelkacem	**Ariel Ferrera**	T, Th: 12pm-3:30pm	**T: 9am-1pm** **W: 4pm-6pm** **Th:11am-3pm**
FLT120 Intermediate Aeronautics	D. Henneberry	**Debra Cassidy**	T, Th: 12pm-2pm	**M: 11pm-2pm** **W: 12pm-2pm** **Th: 11am-12pm**
MEE220 Mechanics of Materials	D. Jahnke	**Samantha Vitez**	M, W: 12pm-1:50pm	**M: 8am-10am; 2pm-4pm** **T: 8am-9am; 4pm-6pm** **W: 8am-9am** **Th: 8am-9am; 4pm-5pm**
MCE410 Mechatronics I	S. He	**Michael Panico**	T: 8am-11am Th: 9am-11am	**M: 10am-12pm** **T: 11am-12pm** **W: 12pm-2pm**
MEE370 Finite Element Analysis	H. Rahemi	**Jacqueline Oricchio**	M, W: 12pm-2pm	**M, T: 10am-12pm** **W: 2pom-4pm**
ELE350 Control Systems	M. Bustamante	**Fabian Lituma**	M: 10am-12pm, W: 9am-12pm	**T: 2pm-3pm** **W: 1:30pm-5:30**

2019 Department's Activities and Highlights

1. **STEM related student engagement (Technical Competitions, STEM workshops and Conferences):**
   - ❖ **2020 Vaughn's Robotics Tournament:** On Friday, February 28, 2020, Vaughn College hosted its sixth Annual VEX U College Regional Robotics Tournament. A total of thirteen college teams participated at this event. The participant teams included Aquidneck Island Robotics (AIR), Johnson & Wales University (JWU1), South Dakota Schools of Mines and Technology (MINES), New Jersey Institute of Technology, New York Institute of Technology (NYIT), (NYIT2) and (NYIT3), Florida Polytechnic University (POLY1), Rutgers University (SKAR), University at Buffalo (UBR), Vaughn College of Aeronautics and Technology (VCAT) and (VCAT2), and Worcester Polytechnic Institute (WPI). In this regional completion, Vaughn's robotics team won both first place "Robot Skills" and "Excellence" awards which qualifies them to participate in the 2019 VEX U world championship..
   - ❖ **2019 Mexico's International VEX U Signature Reeduca Robotics Competition:** From December 12-14, Vaughn College Robotics participated and competed in this Signature VEX U Challenge competition in the Univeredad Technologica De La Riveria Maya, Cancun, Mexico. Seven members of VCAT robotic club (Jason Becker, Atif Saeed, John Sutera, Joseph Crowley, Maharshi Patel, Tim Tullio, and Kevin Tsang) and their advisors represented Vaughn College at this competition. The team finished second place overall in the competition and won the Build Award of this international

robotics competition.

- **2019 Society of Hispanic Professional Engineers (SHPE) National Conference:** From Oct 30 – Nov 3, 2019 a group of 13 engineering students from Vaughn College attended the 2019 **Society of Hispanic Professional Engineers (SHPE) Conference** in Phoenix, Arizona. Vaughn's students participated in the Extreme Engineering competition as well as in various professional development workshops designed to promote leadership, unity, and exposure to the diverse career opportunities in the STEM fields. Vaughn's engineering student, **Angel Calderon**, won the third place award of the Extreme Engineering Challenge competition along with a $1500 check.
- **2019 SWE Annual Conference:** From November 7-10, Vaughn College's SWE chapter attended, presented, and held a "Drones for Good" STEM workshop during the "lightning talk" session of SWE19 Annual Conference in Anaheim, California. On Saturday November 9th, Vaughn College SWE Chapter was invited to host a STEM workshop at the "Invent It. Build It." Expo. This expo was designed for K-12 students to experience the creative and innovative sides of engineering, through hands-on projects alongside real engineers. SWE-VCAT held a propeller powered car workshop, which taught students the basics of circuitry and thrust as they also learned more about Vaughn College
- **2019 AIAA Region I Young Professionals, Students, and Educator (YPSE) Conference:** Three Vaughn's Engineering students, Peter Kalaitzidis, Sagufta Kapadia and Syed Misbahuddin, along with department chair Dr. Rahemi, and faculty advisor Dr. Amir Elzawawy, participated in the 2019 AIAA Region I Young Professionals, Students, and Educator (YPSE) Conference. The conference took place on November 15th at the Johns Hopkins University Applied Physics Lab in Laurel, Maryland. Vaughn's students presented their senior capstone abstract project entitled "Autonomous Life Emergency Rescuing Transmitter - A.L.E.R.T" in the afternoon presentation sessions of the 2019 YPSE AIAA Mid-Atlantic Section
- **2019 EWB-USA Conference:** From November 7 – 10, a group of four students: Amanda Camacho, Kiki Kuonqui, Michael Boller and Johann Cole from Engineers-Without-Boarders Vaughn Chapter and Faculty adviser Dr. Miguel Bustamante attended the EWB-USA conference hosted at Pittsburgh, PA. The EWB-USA is a annual national conference where industry professionals and their respective student chapters share important information and volunteer for projects.
- **2019 COMSOL Conference:** Two of Vaughn's Engineering students, Johnny Atreaga and Deron Hurely, along with their advisor Dr. Amir Elzawawy, participated in the 2019 COMSOL Multiphysics conference. The conference was held in Boston from October 2nd to 4th, 2019. Vaughn's students presented their senior capstone project entitled "Design and Fabrication of Small-Scale Supersonic Wind Tunnel" in both the poster and oral presentation sessions of this annual gathering.
- **2019 International Mechatronics Conference:** From October 22-25, two Vaughn Mechatronic Engineering students, Syed Misbahuddin and Sagufta Kapadia, participated and presented a paper in the 2019 International Mechatronics Conference & Exhibition at Oklahoma State University (Stillwater, Oklahoma). Their Paper entitled "Autonomous Position Control of an Unmanned Aerial Vehicle (UAV) Based on Acceleration Response for Indoor Navigation" received the **Best Presenters award of Mechatronics Application technical session.**

- **LACCEI 2019 International Conference:** From July 23-26, the following Vaughn student research papers were selected to compete among ten finalists for the student paper session of the LACCEI 2019 conference in Montego Bay, Jamaica.
  - **"Vehicle Design For Formula SAE 2019 Competition"** by Ryan Lewis and Andriy Belz
  - **"Smart Braille Learning Block Systems"** by Niki Taheri and Atif Saeed. **Recipient of Second Place award for student paper session competition.**
  - **"Autonomous Search and Rescue Project (ASAES)"** by Ryan B. Tang Dan. **Recipient of First Place award for student paper session competition.**
  - **"Walking Wise Camera Sensor Smart Cane"** by Jevoy James, Richi Ramlal. **Recipient of Third Place award for student paper session competition.**
  - **"A Study of Notched Beam Stress Concentration"** by Aderet Pantierer and Shumul Pantierer

  During Thursday's Gala dinner gathering, award recipients for the best paper and poster presentations were introduced. This year, all three top awards (first, second and third place) for the best paper presentations in the student paper session competition were presented to Vaughn's engineering students
- **2019 AUVSI UAS Competition:** From June 11-15, Vaughn's UAV team participated at the 2019 AUVSI UAS Competition alongside seventy five other top-recognized national and international engineering schools (Harvard, Cornell, Virginia Tech, UCLA, Penn state, University of Maryland, and many others) and they received the 26th place ranking in the challenging 2019 AUVSI competition.
- **2019 ASEE annual conference:** The Vaughn student research paper "**Early Learning Braille Block Language System**," **by** Niki Taheri and Atif Said was presented during the **Manufacturing Session** (Monday, June 17, 1:30pm-3:30 pm) at the 2019 ASEE annual conference, in Tampa, Florida.
- **2019 VFS Micro Air Vehicle student challenge competition:** Vaughn's UAV team was a finalist along with Penn State, Drexel University, and University of Maryland in both autonomous and manual categories in the 2019 Vertical Flight Society (VFS) Micro Air Vehicle student challenge competition, at the University of Pennsylvania on Monday May 13, 2019. Among all participating teams, only teams from Vaughn College and the University of Maryland were able to complete the remotely-operated tasks within the ten-minute time limit. For the autonomous session, both Vaughn College and the University of Maryland were able to fly their drone with vertical takeoff and partial hovering around the field. Both Vaughn teams were invited to attend the Tuesday evening award ceremony. On Tuesday May 14, Judges from aerospace industries evaluated teams' performance for both the remote and autonomous control categories. Maryland's UAV teams received the highest score in both categories and received the 1st place award and Vaughn's UAV teams received the 2nd highest scores and received the 2nd place award for both remote control and autonomous categories with a $1750 check.
- 2**019 VEX U Robotics World championship:** From April 24-27, the Project Director and twelve members of Vaughn's Robotics club traveled to Louisville, Kentucky to participate in the 2019 VEX U Robotics World championship. Seventy six (76) national and international universities and colleges were invited to the 2019 World Robotics Championship. Invitation to the VEX U Robotics World championship was only

granted to a team that is a tournament champion or Excellence award recipient in a regional competition. The Louisville World Championship was an intense three day competition where our team continuously modified their robots and autonomous programming to be competitive with other top teams in this tournament. During the qualifying matches, Vaughn's team (VCAT) competed against 10 teams, and they won seven out of the 10 matches advancing to the Saturday afternoon playoff round. During single elimination of the playoff round, the top sixteen teams competed, and Vaughn's team lost to a top team from China. For six years in a row, Vaughn's team retained their standing as one of the top competitors in this world championship by advancing to the playoff round of this intense competition..

- ❖ **COE 2019 Annual Experience and Technical Fair:** From February 24 to 27, Three Vaughn engineering and technology students, along with department faculty, participated in Dassault systems solution 'Community of Experts' Annual Experience and TechniFair held in New Orleans, Louisiana. From 4 pm to 7 pm on Tuesday Feb. 26, Vaughn students, Atif Saeed, Ryan Tang, and Chamathke Perera presented their project **"Smart CATIA Based Drone Design for AHS Challenge"** to this annual gathering, during the student poster session of COE2019. Their project demonstrated the use of both CATIA and SolidWorks in the design process of frame and pickup/delivery mechanisms for both manual and autonomous drones in the American Helicopter Society (AHS) Micro Air Vehicle student challenge. On Wednesday, February 27, Judges selected Vaughn's project as the **First Place award recipient of the COE2019 poster session competition** which involved more than twenty teams.
- ❖ **2019 New Hampshire VEX U Regional Robotics Tournament:** On Saturday February 23, 2019, Vaughn College's Robotics team participated at the New Hampshire VEX U Robotics Regional Tournament. A total of eight colleges and universities participated in the event, at which Vaughn's robotics team finished first and won both first place "Robot Skills" and "Excellence" awards which qualifies them to participate in the 2019 VEX U world championship..
- ❖ **2019 Southern Biomedical Engineering Conference:** From February 22-23, two Vaughn engineering students, Raiyan Mohammed and Abdullah Ali, along with their faculty advisor Dr. Mohammed Benalla participated and presented their research papers in the 35th Southern Biomedical Engineering Conference at the University of Southern Mississippi, Hattiesburg MS. Abdullah Ali's presentation entitled "Motion Tracking Robotic Arm" received the **2nd Best Presenters award** and Raiyan Mohammed's presentation entitled "Brain Controlled Prosthetic Arm" received the **3rd Best Presenters award** in the critical therapeutics session of this annual gathering**.**

2. **Lab Equipment, Laboratory Enhancement and Development:**
    - ❖ In spring 2019, the renovation of our CNC lab at the Aviation Training Institute (ATI) building in Astoria was completed and the department completed the installation of the CNC (CNC lathe, CNC milling, and 3D Coordinate Measuring Machine-CMM) equipment at this location. In fall 2018, Mr. Rachid Nafa, who has more than twenty years extensive background and expertise in all CNC Machines (2, 3, 4, 5 axis), CATIA, SolidWorks, Unigraphics NX3, and Master Cam was appointed as the CNC manufacturing Lab Tech specialist.. This lab will be used to teach and conduct hands-on courses within our newly approved CNC manufacturing certificate program.
    - ❖ In fall 2018, the engineering and technology department placed a purchase order (total

of $112,000) through U.S. Didactic Inc and in the fall of 2019 the department completed installation of six more subsystem Industrial Mechatronics Systems (IMS5-Processing, IMS6-Testing, IMS7-Handling, IMS8-Storage, IMS8-Storage, IMS9-Routing, and IMS10-Buffering) to accommodate the additional student enrollment in the mechatronics engineering program. With this addition, this lab now has dedicated seating to instruct 15 students.

- ❖ In spring 2019, renovation of our composite lab at the Aviation Training Institute (ATI) building in Astoria was completed and the equipment (Autoclave, ply cutting table, Vacuum bagging kits, hot bonders, vacuum pump, oven and other accessories) purchase (total of $234,000) and installation was completed during the summer and fall of 2019. This lab will be used to teach and conduct hands-on courses within our newly approved composite manufacturing certificate program. .
- ❖ In fall 2019, the engineering and technology department completed a $24,000 purchase order for industrial automation PLC hardware through Power Resources International, Inc. This equipment in our PLC lab will be used to teach and conduct hands-on industrial automation courses in our engineering degree programs.

3. **Faculty Training, Workshops, and Conference Participation:**

- ❖ **Composite workshops:** On Tuesday, June 11-12, 2019, Dr. Douglas Jahnke attended Composite workshops at the Composites Prototyping Center in Plainview, NY. The workshop was a great opportunity to learn about composite design and the manufacturing process. The two-day training sessions introduced participants to Vacuum Infusion, Reinforce Thermoplastic, Additive Manufacturing, Composite Tooling, Automated Fiber Placement, Silicone Vacuum Bags, and much more.
- ❖ **TITANS of CNC Workshop:** In the 2nd week of June, Prof. Manuel Jesus, CNC and Additive manufacturing curriculum designer, started an online HAAS CNC curriculum workshop consisting of part designs, and CNC CAD training. The learning community is sponsored by HAAS, DMG MORI, and Autodesk.
- ❖ **Additive Manufacturing Workshop:** From June 17-20, Prof. Manuel Jesus, CNC and Additive manufacturing curriculum designer, completed MIT XPRO additive manufacturing workshop and plans to adapt knowledge acquired in this course to our additive manufacturing certificate program as well as to the BS Advanced Manufacturing program.
- ❖ **Project Catalyst Workshop – How to Engineer Engineering Education:** Dr. Miguel Bustamante and Dr. Shouling He, assistant professor and associate professor in Vaughn's engineering and technology department attended the Educational Workshop, Project Catalyst – How to Engineer Engineering Education, held by Bucknell University during July 17-19, 2019. The workshop explored how to use instructional objectives and active and cooperative learning to efficiently improve professors' teaching performance as well as how to assess student learning outcomes.
- ❖ **Siemens hands-on training workshop:** From Aug 13-15, Vaughn's Mechatronic and additive manufacturing lab specialist, Alaric Hyland, attended a **3-day Siemens hands-on training workshop** at Corning Community College Auxiliary Aviation Corporate Campus, 360 Daniel Zenker Dr, Horseheads, NY. Day one training covered the general interface of Siemens TIA Portal, which is similar in design to Siemens Step7. Day 2 training covered complex logic programming in the form of bitwise operations

(including AND, OR and XOR logic), latches, and timers, and day 3 covered training on the HMI interface, and on manipulating the provided window to show the proper information.

- **Coordinate Measuring Machine Training:** From Aug 16-20, CNC Curriculum Designer, Prof. Manual Jesus and Manufacturing Lab Tech, Rachid Nafaa attended a hands-on training class in coordinate measuring machine (CMM) to learn the AIMS Metrology CMM system in Dayton, Ohio. CMM is used to measure the physical geometric properties of a part. The five day course first reviewed core concepts such as Cartesian coordinates and vectors, then geometric tolerance concepts through the use of the CMM as a measuring tool. Geometric tolerance was explored by programming the CMM to inspect a part using approach, probe, and retract commands developed via a command line interface or a more intuitive graphical user interface.
- **2019 ASEE Annual Conference:** The department chair along with two other faculty members attended the 2019 ASEE annual conference in Tampa, Florida and participated in technical sessions related to Manufacturing, Curriculum development, ABET accreditation, and technical workshop sessions (June17-20 2019). Vaughn Faculty Prof. Ryan Tang's project **"A STEM Training Program to Improve High School VEX Competition Outcomes,"** was presented during the **STEM Poster Session** (Tuesday June 18, 11:30am-1:30 pm) at the 2019 ASEE annual conference.
- **2019 LACCEI International Conference:** From July 23-26, 2019, the department chair, Dr. Hossein Rahemi, along with two other faculty members (Dr. Mohammed Benalla and Prof. Khalid Mouaouya) attended the 2019 LACCEI International conference in Montego Bay, Jamaica and participated in technical, educational, and workshop sessions related to program assessment and ABET accreditation.
- **2019 ABET Symposium**: From April 10-12, academic vice president, Dr. Paul LaVergne and engineering department chair, Dr. Hossein Rahemi attended the 2019 ABET Symposium in Dallas, Texas. The Symposium provided information related to transitioning from previous "A through K" learning outcomes to new "1 through 7" EAC and "1 through 5" ETAC student outcomes as well as on assessment, gathering data and the evaluation process. The plenary sessions by a panel of experts in Cyber Security such as Mike McConnell, Vasu Jakkal, Martin Libicki, and Chris Inglis addressed some of threats on the cyber landscape, cyber war, as well as its solution by understanding the underlying technology and developing necessary strategies to eliminate cyber security threats.
- **INTERNATIONAL MATERIALS RESEARCH CONGRESS – IMRC 2019:** from August 18th to 23rd, 2019, Assistant professor Dr. Ghania Benbelkacem attended the 28th International Material Research Congress IMRC held in Mexico – Cancun. The congress is organized by the Sociedad Mexicana de Materiales (SMM) and the Materials Research Society (MRS). A range of symposium topics were covered, from Nanotechnology and Biomaterials to Structural Materials and Metallurgy. The meeting provides an opportunity for interaction and exchanges with researchers and students from different countries.
- **2019 American Society of Nondestructive Testing (ASNT) Conference:** From November 19th to 21st 2019, Dr. Budhoo, Composite Curriculum Designer, attended the ASNT annual conference held in Las Vegas, Nevada. The knowledge obtained from this conference will be beneficial for the Composite Manufacturing certificate program

at Vaughn College, and this conference provided him with better insight into the selection of appropriate equipment for the nondestructive course..

4. **Hosting STEM related Conferences, Workshops, Seminars:**
   - **2019 Vaughn College 5th VEX U Robotics Regional Tournament:** Vaughn College hosted its fifth VEX U College Regional Robotics competition on Friday, February 8th, 2019. Vaughn faculty members and staff served as the judges, and Vaughn's robotics team served as manager, referees, announcers, and event planners for this event. In this regional competition, Vaughn's robotics team won the first place Skills' award and the Excellence award.
   - **2019 Vaughn College 5th High School Robotics State Qualifier Competition:** Vaughn College hosted its fifth high school state qualifier robotics competition on Saturday, February 9th, 2019. A total of 46 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties attended the February VEX state qualifier at Vaughn College. Vaughn faculty members and staff served as the judges and Vaughn's robotics team served as manager, referees, announcers, and event planner for this event. An alliance of Newfield High School and Farmingdale High School won the tournament championship, while a team from and KG Computech won the "Excellence" Award, and KG Computech won "Robot Skills." Tournament champions, "Excellence" Award, and "Robot Skills" winners qualified to participate in the New York State VEX Championship.
   - **2019 Vaughn's STEM Day Workshop:** The engineering and technology department hosted its first STEM Day workshop for community college students on Friday, March 8. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Bergen, and Suffolk Community Colleges and Uncommon Charter High School. In the morning session, Vaughn's STEM Pathway Liaison, Ms. Lisa Limbach and STEM project director, Dr. Hossein Rahemi talked about Vaughn College's program offerings in engineering and engineering technology as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 12:00 pm, Vaughn's CNC lab specialist and faculty introduced participants to several hands-on sessions on part design and the manufacturing process using the HASS VF-2SS CNC milling and cutting machine, 3D additive and subtractive manufacturing, and the aircraft avionics system related to radar, navigation and communication. In the afternoon session, from 1:00 pm to 3:00 pm, Vaughn's UAV and Robotics clubs engaged participants in hands-on STEM workshop sessions on building a drone and robotics design and construction.
   - **5th Annual Manufacturing Day Conference:** The department hosted the 5th annual manufacturing day conference on Friday, November 1 (10 am to 2 pm) to celebrate National Manufacturing Day. The guest speakers addressed the Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of Industry 4.0, Development of digital Twin, Sensors for Aerospace Industry, Additive manufacturing with desktop metal 3D, and Integration of CMM with CNC machining and manufacturing process.
   - **5th Annual Manufacturing Day STEM Workshops:** On Friday, November 1, in a parallel session, from 10 am to 2:00 pm, Vaughn's Robotics, UAV, SWE, and NSBE clubs organized and hosted STEM workshops (CAD, building a drone, robotics design, and autonomous programming) for high school students. More than sixty students from

Queens and Long Island high schools (Westbury, Bayside, Thomas Edison, and Hillcrest high schools) participated in a STEM workshop session at this national event. A drone practice flying session allowed the participants to fly their drones in the Vaughn hangar flying arena.

- **11th Annual Technology Day Conference:** On Friday, April 19, 2019, the Engineering and Technology department hosted its Eleventh Annual Industry Advisory Meeting and Technology Day Conference. Dr. Rahemi updated Advisory Council members on recent developments in the Engineering and Technology Department such as: progress reports on faculty and student professional engagement, program assessment and preparation for the ABET 2019 programs reaccreditation, adaptation of new "1 through 7" EAC and "1 through 5" ETAC student learning outcomes. He updated the group on HSI-STEM grant activities including the development of stackable manufacturing certificate programs that lead to a BS in the advanced manufacturing program, the development and implementation process of manufacturing laboratories (CNC machining, composite, additive manufacturing, and UAS), the qualification of Vaughn's Robotics teams for the 2019 VEX U world championship, the selection of Vaughn's UAV team by the American Helicopter Society (AHS) as a finalist to participate in the 7th annual Micro Air Vehicle (MAV) student challenge competition, and the engineering clubs' (SWE, EWB, NSBE, Robotics, SAE, SHPE, UAV) annual STEM outreach activities.
- **Annual International Drone Day STEM Workshops:** On Saturday, May 4, 2019, the engineering and technology department hosted several drone workshops such as CAD Modeling of Quadcopters, Build a Drone, and Programming with Python in order to celebrate International Drone Day. The event allowed visitors and students to design, build, and test their own drones in the netted flying arena of the college hangar. The participants for the workshops and drone flying session were invited guests and students from Robert F. Kennedy Community, Thomas Edison, and Bayside high schools. .
- **Industry Connection and Engineering Seminar Series:**
    - **Electric-Powered Helicopter:** On Tuesday, April 2, 2019, the industry guest speaker, Mr. Laurent Ducruet, Director of Business development at Thales, addressed the Vaughn community as part of the College's Industry Connection Seminar series. Mr. Ducruet's presentation focused on the future trend in drone taxi service, specifically passenger transportation via an autonomous UAV. Topics he discussed included the next stage of legal obstacles, as manufactures seek to put autonomous drones into the air.
    - **Energy-Focused Presentation on Solar Generation:** On Tuesday, April 23rd, Mr. Nicholas Giannasca and Mr. William Freidman of Davis Wright addressed the Vaughn community about industry sector programs featuring an energy-focused presentation on solar generation. Their presentation provided an overview of the solar generation market, the basics of solar generation financing and operation, and the important legal, economic, and regulatory issues for customers considering solar installation.
    - **Embraer and Future Trend of Aerospace Industry:** Mr. Gray Spulak, President of Embraer Aircraft Holding addressed the Vaughn community on Tuesday, September 10 as part of the College's Industry Connection Seminar series. Following a welcome from Vaughn College President Dr. Sharon B. DeVivo, Spulak detailed company plans and strategies including joint partnerships, efficient

energy management systems, biofuels and safety, supply chain optimization and the production and maintenance of secure aircraft that operate in high density areas.

- **The opportunities available to contribute to the world through TOM**: On Tuesday, September 19, Mr. Edun Sela and Ms. Maayan Keren of TOM Global addressed the Vaughn community as part of Vaughn College's Industry Connection Seminar series with a presentation on Tikkun Olam Makers (TOM) and the opportunities available to contribute to the world through this organization. Their presentation introduced audiences to the TOM movement, communities, and vision. During this gathering, the engineering department chair and Vaughn's technical clubs' leaders (UAV, SWE, and Robotics) expressed their interest and willingness to work with the TOM organization to create a TOM community at Vaughn and to host a Makeathon "maker" event at our college in the near future.
- **Designing and Modeling Electronic Packages for the Next Gen OPIR:** On Tuesday, Dec 5, 2019, Mr. Mohammed Hossain, a senior student in the Mechanical Engineering Technology program who participated in a ten-week summer internship program with Raytheon, addressed the Vaughn community about his summer internship project and the life-long learning experiences he gained through this project. His presentation covered his work designing electronic packages in the Next Generation Overhead Persistent Infrared (Next Gen OPIR) program. For this project, he was part of the mechanical team and responsible for developing designs, prototypes, and baselines for the electronic packages.
- **Entrepreneurship:** On Thursday, Dec 5, 2019, Mr. Stauffer, an alumnus and Chair of Vaughn's Board of Trustees, addressed the Vaughn community as part of the College's Industry Connection Seminar series; he made a presentation on startups, entrepreneurship, current technology, and engineering education. He also discussed the traits of entrepreneurs (not satisfied with the status quo, curious, ceative, embrace risk, highly competitive), and the large company versus the entrepreneurial start-up.

5. **STEM Outreach and other Department's related Activities:**

❖ **Career Advisement Day – Career Conversations with Students:** On Thursday, September 19, the engineering and technology department arranged and hosted a roundtable career advisement day with students in engineering and engineering technology programs. This roundtable discussion with faculty covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. The department chair, faculty and senior students discussed, in detail, several career strategies for obtaining a successful career in the STEM fields.

❖ **ME and EE annual progress report:** In September 2019, the department chair submitted the 2018-2019 annual progress report for both ME and EE programs including information/updates on: new/refurbished facilities, faculty and staff, and preparations for ABET evaluation to the NYSED. Every September an annual report needs to be submitted to the NYSED until the department receives EAC-ABET accreditation for both of these programs.

❖ **STEM Day Presntation by Engineering Clubs:** On Thursday, October 3, 2019, Vaughn's engineering Clubs and professional student chapters (UAV, Robotics, SAE, NSBE, SHPE, EWB, and SWE) hosted a STEM Day presentation to introduce incoming freshman students to their annual professional activities. Each club provided a detailed discussion of their annual STEM activities and encouraged all students to join them and become involved in extra-curricular club activities. They emphasized how involvement in technical clubs and student chapters of professional societies further enhances career opportunities, fosters creative ideas, introduces one to innovations in the STEM fields and provides professional networking opportunities with engineering industries.

- **STEM Outreach:** On Friday, October 25, Prof Manual Jesus, Additive manufacturing and CNC curriculum developer, provided a day workshop on 3D printing and additive manufacturing for thirty five students and ten teachers from Pablo Casals middle school (MS 181). The workshop covered 3D SolidWorks, part and assembly design, and additive manufacturing process.
- **STEM Field Trip:** On October 11th, 2019, 15 students from Vaughn College of Aeronautics and Technology had the opportunity to attend the Lockheed Martin facility tour in Stratford, CT. These students got to see Igor Sikorsky's office and to learn how the company was founded and how it has evolved over the years. They also learned about the various aircrafts the company has developed for different purposes and how they are being used today.
- **Workshop - Writing a Conference Paper:** Prof. Donald Jimmo organized a workshop during Common Hour on Thursday, November 14, 2019. The workshop was an informative discussion on the merits of writing a conference paper. Freshmen, sophomores, and seniors from each engineering program attended and interest was high as students and faculty eagerly participated in the discussion.
- **Hosting "Drones for Good" Workshop at 2019 SWE Annual Conference:** From November 7-10, Vaughn College's chapter of the Society of Women Engineers attended, presented, and held a "Drones for Good" STEM workshop during the "lightning talk" session of the SWE19 Annual Conference in Anaheim, California. The 9 VCAT-SWE attendees were extremely successful. Vaughn students received 22 interviews with companies such as Northrop Grumman, Boeing, Lockheed Martin, Dell, United Technologies, General Motors, ASML, Daimler Trucks of North America, BAE Systems, and Raytheon.
- **Hosting K-12 STEM Workshop at 2019 SWE Annual Conference:** On Saturday, November 9th, Vaughn College SWE Chapter was invited to host a STEM workshop at the "Invent It. Build It." Expo. This expo was designed for K-12 students to experience the creative and innovative sides of engineering through hands-on projects alongside real engineers. SWE-VCAT held a propeller powered car workshop which taught students the basics of circuitry and thrust while they also learned about Vaughn College.
- **Program Articulation:** On Thursday, October 31, the department chair signed a program articulation with Hillcrest High Scholl. As part of this articulation, Hillcrest Junior and Senior level students may enroll for MCE101 (Introduction to Robotics, 1 credit, 3 contact hours), CDE117 (Engineering Graphics, 2 Credits, 4 contact hours), CSC316 (C++ Programming, 3 credits) at Vaughn College and upon successful completion of these courses, with a grade of C or better, they can be applied towards a Vaughn College engineering and engineering technology degree.
- **4+2 Agreement with Freeport High School: The** department chair with **the** assistance of the Associate Vice President of Academic Affairs is establishing a 4+2 agreement

with Freeport high school for both AAS Aeronautical Engineering Technology and AAS Electronics Engineering Technology-Avionics. During the summer, the plan is for intense academic instruction on the Vaughn campus for the Freeport HS students. Fall and spring would likely be on the Freeport high school campus with either hiring, training and certifying Freeport teachers as Vaughn adjunct faculty or sending our faculty to the Freeport campus. We are ensuring the lab courses (which take special equipment) are taught at Vaughn, while courses that don't require equipment beyond what is used at high school can be taught there.

- **EAC and ETAC ABET site Visit (Oct 13-15) for the reaccreditation of six Engineering and Engineering Technology Programs:** From Sunday, October 13 to Tuesday, October 15, both the Engineering Accreditation Commission (EAC) and the Engineering Technology Accreditation Commission (ETAC) made a simultaneous visit to Vaughn College for the purpose of reviewing and reaccrediting one engineering and five engineering technology programs. These include two AAS (Aeronautical Engineering technology and Electronics Engineering Technology) and 4 BS programs (Mechatronic Engineering, Mechanical Engineering Technology – Aero and CAD options, Electronics Engineering Technology –Avionics, and Electronics Engineering Technology - Electronics). During the three days site visit, they reviewed all supporting materials related to faculty course assessment reports (FCARs), rubric surveys for outcomes assessment, outcomes sample materials, course sample materials, meeting minutes, programs' presentations to the industry advisory board, program assessment, students and faculty conference publications, and Vaughn College Journal of Engineering and Technology for the past six years. They also talked to students, faculty and Vaughn's industry advisory members. During Tuesday's exit briefing, they identified as strengths: students' involvement in professional activities, industry involvement in curriculum enhancement, and the continuous improvement process within these programs. ABET's team found Vaughn College in complete compliance with all 8 criterions, and there were no findings for five engineering technology programs.
- On Thursday, May 9, **the** engineering and technology department chair updated the board of trustees on department annual activities, assessment & preparation for the fall 2019 ABET site visit, new stackable manufacturing certificate programs that lead to a BS in advanced manufacturing, student engagement (UAV Robotics, and Formula SAE competitions, conference, and scholarly activities), industry connection seminar series, and other department issues.
- In January 2019, the department chair, with the assistance of the Grants Manager, completed an application for a CNC Machining and Manufacturing Certificate program which was submitted to the NY State Education Department for their review and approval. This certificate program has a total of 15 credits and provides a "well-rounded" education to prospective engineers and technicians in CNC subtractive manufacturing field. Students will gain hands-on experience in developing CAM programs with G-Code, Mastercam, and Catia for the Hass mill and Okuma Lathe CNC machines. <u>In March 2019, we received approval from the NY State Education Department for this certificate program</u>. The grant advisory team is currently working on PLC and Automation certificate programs.

- ❖ **Industry Advisory Meeting:** On Thursday, January 9, 2020, the department chair organized a meeting with the Engineering and Technology Industry Advisory Board to discuss new changes to EAC of ABET regarding Criterion 3, Student Outcomes and Criterion 5, curriculum. In this meeting, he updated advisory members with the department assessment process, the self-study development, and the preparation for the initial EAC-ABET accreditation of mechanical and electrical engineering programs. Dr. Rahemi thanked advisory members for their continuous support and input in every aspect of the department, student success, and the institution. His presentation covered items regarding changes to ABET's student outcomes and curriculum as well as new "1 through 7" student outcomes assessment based on performance indicators. .

Laboratories, Upgrade, Enhancement, and New Manufacturing Certificate Programs

For the past several years, as a result of the Title III grant funding support, the engineering technology department has been able to establish several state-of-the-art-laboratories such as the Thermo-Fluid lab, the Robotics and Control System lab, the automation lab, the Energy Conversion and Smart Grid Power Systems lab, and the 3D innovation Center. These new facilities and upgraded existing facilities contribute to student success in both scholarly activities and technical competitions.

The current title III grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students," will further enable the engineering department to develop an advanced manufacturing program as well as laboratories associated with this program. This new grant will allow the department to enhance the current additive manufacturing center and the CNC machining lab. It will further assist the department with development of state-of-the-art composite manufacturing and UAS laboratories. Vaughn's faculty and staff are confident that through the effective and efficient use of grant funding, the college will successfully accomplish its vision for the future.

In 2018-2019 academic year, the department completed purchase of the following of laboratory equipment:

1. Equipment for composite lab (autoclave, Ply cutting table, hot bonders, Vacuum bagging kits, vacuum pump, accessories and supplies for composite manufacturing), Price **$178,039.89**
2. Automation Sub-System lab equipment (IMS Processing, testing, handling, Storage, Routing, Buffering, and UniTrain Interfaces+ Experimenters, Price **$112,485.83** for the Automation Lab.
3. Industrial automation PLC hardware through Power Resources International, Inc. In fall 2019, department completed a **$24,000** equipment for PLC lab.

This laboratory equipment allows Vaughn to provide students with practical STEM hands-on training in composite manufacturing and automation that are current with today's manufacturing industry standards.

This laboratory equipment will allow Vaughn to provide students with practical STEM hands-on training in additive manufacturing, CNC machining, composite, and automation that is current with today's manufacturing industry standards.

- **NEW CNC Machine Shop**

The renovation of the new CNC machine shop at Vaughn's Aviation Training Institute (ATI) building has been completed in spring 2019 and this lab is currently equipped with CNC related equipment (HASS VF-2SS CNC milling and cutting machine, Okuma Genos lathe machine, and Coordinate Measuring Machine -CMM for manufacturing part inspection). Both faculty and students are able to use CNC machine shop for manufacturing parts for the laboratory testing samples, CAM and Prismatic Machining course assignments, and parts and components for their capstone degree projects. Also, this lab will be used to teach and conduct hands-on courses toward our new CNC programming and manufacturing certificate program.

<u>CNC Subtractive Manufacturing Certificate Program</u>

This certificate program will cover CNC manufacturing equipment and systems used in the subtractive manufacturing field. Students will gain hands-on experience developing CAM programs with G-Code, Mastercam, and Catia for the Hass mill and Okuma Lathe CNC machines. Best industry practices for safety, machine shop management, and organization will be demonstrated to students in preparation for entry into the manufacturing field. Part inspection will be conducted using traditional gauges and a granite inspection table along with precision measuring using a Complex Measuring Machine (CMM) from Aims Metrology and Renishaw. Upon completion of this program students will have a strong foundation in real world CNC and CAM problem solving skills for manufacturing.

1) CNC100: Precision Measurement for CNC
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: None
Course Description: This course will introduce students to the world of precision part inspection. After completion of the course, students will understand the multi-view orthographic drawing and its importance in all stages, from development to design and inspection. Students will be able to identify all print abbreviations and use common systems of measurement in their designs. Geometric dimensioning and tolerance concepts will be explored as used in manufacturing. All major instrumentation used in measuring geometric tolerances will be covered, including gauges, micrometers, go and no-go gages, calipers and Coordinate Measuring Machines (CMM). Measurements of surface finish and thread gauges will be covered, in addition to the use of an indicator to perform open setup inspections. At the completion of this course, students will have hands-on experience in the major aspects of part inspection.

2) CNC201 CNC (Computer Numerical Control) Manufacturing I
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Co-requisites: CNC100
Course Description: Students will learn about CNC machine operation though the use of the Haas VF2SS mill and Okuma lathe. Basic CNC terms such as MCU, MDI keys, and the grid coordinate system movements will be explored. Machine tool operations, speeds, feeds, and their use in part development will be covered, in addition to coolant use and chip removal. As the course progresses, students will practice manual machine controls and program execution. Machine shop best practices, organization, and safety will also be covered through hands-on exercises. At the end of the course, students will be able to run a job and prepare all work holding, as they safely operate the machine.

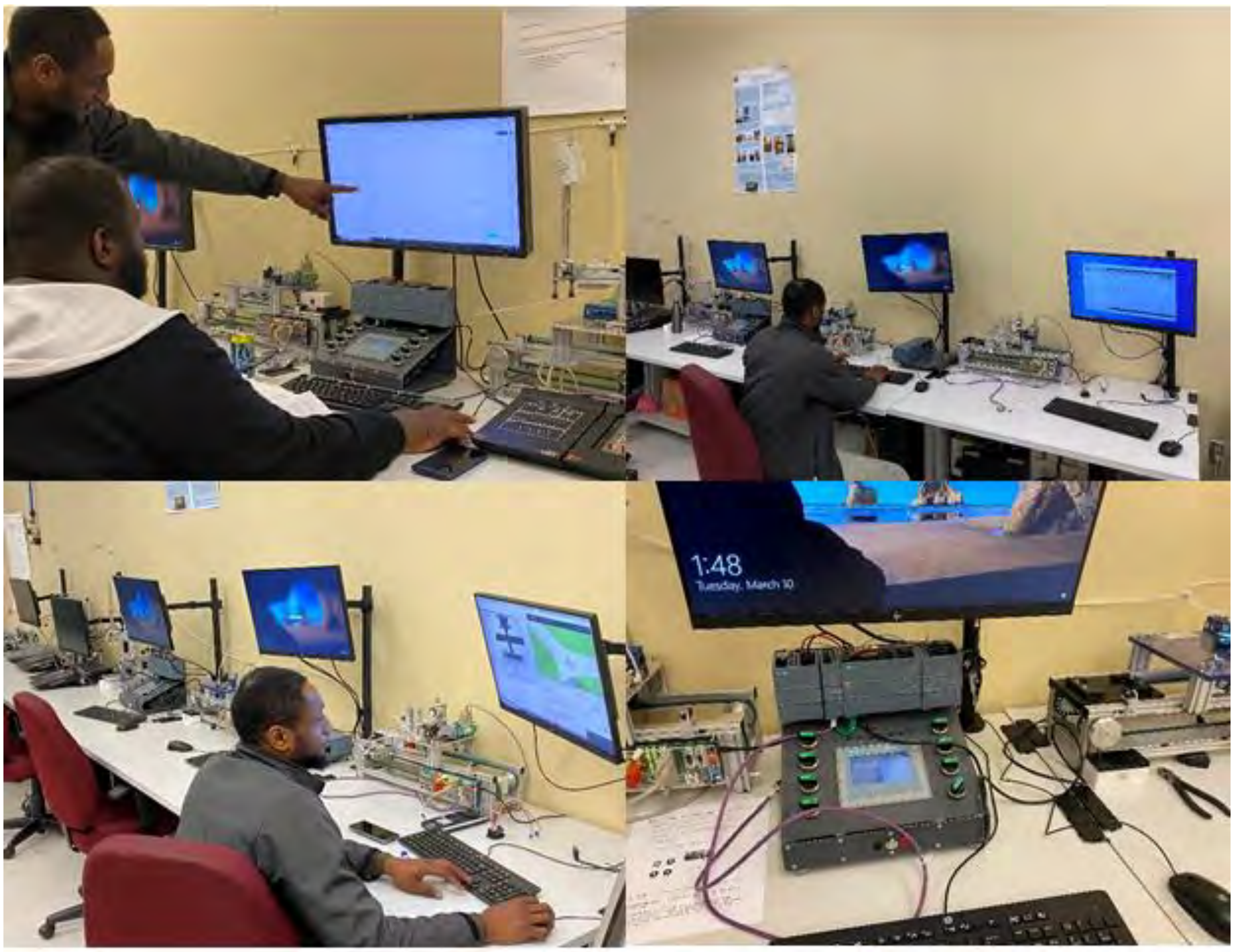
3) CNC202 CNC G code Programming Fundamentals
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: This course will cover G-Code from both the programmer perspective and the machine operator standpoint. Students will learn to code parts and troubleshoot common problems in CNC programming. Program blocks, G, L, M, and T codes are explored in relation to programs and subprograms. As the course progresses, conversational, absolute, and incremental programming is covered in addition to subprograms. Program inspection, execution, and testing through the use of a dry run will be covered, along with program edits and coordinate adjustments. Students will leave the course with a strong understanding of the G code programming process in the context of CNC manufacturing.

4) CNC203 CNC (Computer Numerical Control) Manufacturing II
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: An introduction to 3 and 4 axis CNC machines as a system to run part programs, ranging from small parts to production runs on the HAAS CNC mill and Okuma lathe. Setting tool length and work offsets using manual and probed methods will be explored using the Hass MCU and Renishaw Probe. Tooling geometry, live tooling, and tool selection will be taught for mill and lathe operations. Towards the end of the course, G-Code Program edits using the MCU will be shown in depth to optimize production runs. To insure quality parts in CNC, the importance of part inspection during the machining process will be presented.

5) CNC204 CNC (Computer Numerical Control) CAM Programming
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: The computer will be explored as both a design tool and a CAM programming tool. Mastercam and Catia software will be used to produce parts and tool paths for CNC manufacturing throughout the course. Students will learn how to develop part designs for machining on the Haas and Okuma range of CNC machines. All the industry standard tooling paths, work holding, and machining operation tasks will be covered in the context of CAM using 2.5, 3 and 4 axis systems. At the end of the course, students will be able to design a part in CAD and deliver post processed G-CODE for manufacturing on the Haas Mill and Okuma Lathe.

- **PLC and Automation Sub-System Lab**

In fall 2019, the department completed the purchase ($112,000) and installation of six more subsystem Industrial Mechatronics Systems (IMS5-Processing, IMS6-Testing, IMS7-Handling, IMS8-Storage, IMS8-Storage, IMS9-Routing, and IMS10-Buffering) to accommodate the additional student enrollment in the mechatronics engineering program. With this addition, this lab now has dedicated seating to instruct 15 students. Also, in fall 2019, the engineering and technology department completed a $24,000 purchase order for industrial automation PLC hardware through Power Resources International, Inc. This equipment in our PLC lab will be used to teach and conduct hands-on industrial automation courses in our engineering degree programs.



- **3D prototyping innovation center**

The 3D printing center was developed as a resource to foster student engagement in academic projects and personal designs. Students are encouraged to develop and print parts at zero cost; however, 3D printed content is closely monitored by faculty. Introductory CAD classes familiarize students with the product development process, through a focus on assembly development for 3D printing.

The design for this facility was inspired by the Maker Space trend in STEM education. However, while researching peer institutions, we discovered an overreliance on the use of a sole vendor for all 3D printing endeavors. The engineering and technology department opted to broaden its selections, since the 3D printing marketplace is evolving at such a swift pace. The rapid prototyping lab employs a diverse range of technology consisting of 3D printers, desktop CNC, and 3D scanners from companies such as Makerbot, Creality, Form Labs, 3D Systems, Stratasys, Carbide 3D, Artec, and Mark Forged. Our 3D printing methods range from Fused Deposition Modeling (FDM) machines to higher end industrial Stereo lithography (SLA) machines capable of mass production.

Such a diverse range of technology has empowered students with the skills to develop faster design iterations during project development. Students will often start with a low fidelity FDM print then progress to a high fidelity SLA print. At the end of the process, they gain hands-on experience required to contribute to Robotics Club activities and to professional industry opportunities.

The support of the new Title III grant will assist the department in the complete establishment of Vaughn's state-of-the-art 3D prototyping innovation center by adding a Form Labs Fusion (SLA Powder based SLS printer capable of printing fully assembled products with minimal cleanup), 3D Systems HD3600 3D printer, Fusion laser engraver, and a Forged Desktop Injection Molding Machine. In the academic year 2018, the department added the (model D45-01) Digilab 3D Printer, one ProJet MJP 2500, Plus a 3D Printer to this lab.

This center will be used to teach hands-on computer-aided design and 3D printing manufacturing courses within all engineering and technology programs. Also, this center can be used by Capstone Degree Project students and UAV and Robotics clubs to design and build mechanical parts for their projects.

Computer Aided Design for Additive and Subtractive Manufacturing Certificate Program

This certificate program will cover manufacturing systems utilized in the additive and subtractive manufacturing fields. Students will gain hands-on experience developing CAM programs for Haas CNC machines. Rapid prototyping will be covered via 3D Printing systems such as Form 2, Stratasys Fortus 250 MC, 3D Systems ProJet 3600, and Magics 3D printing software. Reverse engineering through the use of 3D scanning will be explored to develop parts using Artec Eva Scanners, Catia, Geomagic, and SolidWorks. At the end of the program, students will have a strong foundation in real world computer-aided design, problem-solving skills, and fabrication techniques.

1) CDE 117: Computer Aided Design with Solidworks
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: None
Course Description: The goal of this course is to provide an introduction to engineering graphics and computer-aided design engineering standards using Sold Works CAD software. This is accomplished by examining the role of the computer in the present design process. Topics include computer graphics, computer aided-design and drafting, (CAD) geometric construction, orthographic projection, dimensioning, section and auxiliary views, detail drawings, 3D modeling, and introduction to assembly drawings. Students will also gain skills in developing part assemblies for 3D printing.

2) CDE 385: Catia Fundamentals
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Co-requisites: CDE 117
Course Description: This course introduces students to Catia, one of the leading parametric modeling packages in the aerospace and automotive manufacturing industries. Practical solid modeling techniques will be covered in a project based approach. Real world examples will take students through the various Catia Workbenches such as Part Design, Assembly Design, Drafting, Wireframe Surface Design, and Generative Sheet Metal Design. Students will gain the knowledge required to design parts suitable for 3D printing and manufacturing through hands on lab projects.

3) CDE 375: Computer Graphics for Additive Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: CDE 117, CDE 385
Course Description: Students will work on computer graphics techniques related to additive manufacturing through the use of 3D printing and 3D scanning equipment. Image acquisition in 2D and 3D will be covered in Adobe Photoshop and Artec Scan Studio, where students will learn about graphic image formats, and 3d scan data processing. Autodesk 3ds Max and Maya will be used as a tool for fast 3D surface development STL file repair. Reverse engineering will be covered through the use of Artec 3D scanners in conjunction with Solid Works and Catia surface modeling techniques. Students will learn to operate and maintain production quality 3D printers, such as the Fortus 250MC FDM printer, Form2 SLA printer, and Makerbot range of 3D printers.

4) CDE 487: Catia for Prismatic Machining and Subtractive Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: CDE 117, CDE 385
Course Description: This course will present the basics of CAM (Computer Aided Machining) and subtractive manufacturing with the Catia CNC Prismatic Machining Workbench. Computer

controlled three axis milling and drilling will be covered extensively through the use of real time simulation and program verification. Fundamental milling operations consisting of facing, profile contouring, pockets, drilling, curve following, point to point, and surface machining will be covered in detail. The CATIA prismatic machining module will be used to virtually design and machine a series of parts suitable for output on the Nomad desktop CNC and HAAS CNC machines. Finally, design verification techniques will be explored with the Vericut CNC simulator. Upon completion of the course, students will feel a sense of accomplishment in part design, development, and manufacturing.

- **Composite Manufacturing Center**

As part of Title III grant funding support, the college is establishing a State-of-the-art composite manufacturing center at the Aviation Training Institute (ATI) building to support the implementation process of both the composite design certificate program and the future BS in advanced manufacturing program. As shown in the table below, this center will be equipped with practical hands-on composite manufacturing equipment that provide students with knowledge and skills current with today's manufacturing industry standards.

Composite Manufacturing EQUIPMENT
1. Oven (for curing composite layup)
2. Autoclave
3. Ply cutting table
4. Two hot bonders
5. Five Vacuum bagging kits
6. Two vacuum pump and accessories
7. Supplies for composite manufacturing (resin, fabric, tapes, films, peel ply)

Also, testing equipment such as RAPTOR Imaging Flaw Detector, EPOCH 650 Digital Ultrasonic Flaw Detector, and Micro II-Compact PCI AE system will be used to study nondestructive failure.

In spring 2019, renovation of our composite lab at the Aviation Training Institute (ATI) building in Astoria was completed, and installation of equipment (Autoclave, ply cutting table, Vacuum bagging kits, hot bonders, vacuum pump, oven and all other accessories and supplies for composite manufacturing) totalling $234,000 was completed during the summer and fall of 2019. This lab will be used to teach and conduct hands-on courses within our newly approved composite manufacturing certificate program. .

Autoclave

Oven for Composite Manufacturing

Vacuum bagging kit

Phased array ultrasonic testing equipment (flaw detector)

Eddy current testing equipment

Certificate Program in Composite Materials

This certificate program provides a "well-rounded" education to prospective engineers and technicians who are interested in composite materials. Students will be introduced to the analysis of composite materials, along with hands-on experience in composite manufacturing. Students will also be introduced to mold fabrication and adhesive bonding of composite and metals, which is an integral part of composite manufacturing. Finally, students will be exposed to the most common and latest Non-Destructive Inspection (NDI) equipment and methods and techniques used in the field of composite inspection.

1) Introduction to Engineering Materials
Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hours
Prerequisites: None
Course Description: The purpose of this course is to present to students the basic principles necessary to understand structure-property relations in engineering materials. The student will be introduced to concepts of structure from bonding to microstructure. They will then study the relationships between structure and property of a material. Properties ranging in nature from mechanical, thermal, electrical, optical, magnetic, to chemical will be considered. This course will also introduce the concepts of stress, deformation, and strain in solid materials. Basic relationships between loads, stresses, and deformation of structural and machine elements such as rods, shafts, and beams will be developed. The load-carrying capacity of these elements under tension, compression, torsion, bending and shear forces is considered.

2) Introduction to Composite Materials
Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hours
Prerequisites: None
Course Description: This course introduces basic terminologies used in composite design and manufacturing. An introduction to the various composite manufacturing processes is also introduced. The foundations for the mechanics of composite materials are presented with special emphasis on the long-fibre and woven lamina. On both a micro-mechanics and macro-mechanics level we study the elastic behavior and strength of a composite lamina, i.e. a single layer of unidirectional fibers within a matrix. On the macro-mechanics level we also study composite laminates (two or laminae stacked together) with respect to elastic behavior, hydrothermal effects, stress, and failure analysis.

3) Introduction to Composite Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Prerequisites: Introduction to Composite Materials
Course Description: Students will work with prepreg carbon fiber unidirectional tape to explore the effects of orientation, balance and symmetry in a laminate. Students will also work with dry glass fabric and liquid epoxy resin to understand the fundamental vacuum bagging, bleeder & breather concepts. Work with prepreg glass and aramid fiber harness-satin fabrics, along with honeycomb and polyurethane foam core materials and the construction of sandwich panel structures and the utilization of laminate "nesting" techniques will be presented in detail. Finally, basic repair methods and techniques will be presented along with the performance of a "wet layup" repair in the lab. The final repaired part will be cut in half for evaluation of the manufactured and repaired panel.

4) Mold Fabrication and Adhesive Bonding of Composite and Metals
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Co-requisites: Introduction to Composite Manufacturing
Course Description: This course is designed to teach students about designing and building molds and fixtures using advanced composite materials. In this course, students will learn about tool design techniques that contribute to both dimensional stability and tool longevity. Students will also gain skills in adhesive bonding technology, while acquiring a deeper understanding of the surface preparation and the fundamental adhesion principles necessary to achieve a good bond to both (polymeric) composite and metallic surfaces.

5) Non-Destructive Testing Techniques for Composite Materials
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Co-requisites: Introduction to Composite Manufacturing
Course Description: This course is designed for students interested in identifying and quantifying defects in new or damaged composite panels using the latest equipment, methods, and techniques. The course is very "hands-on" in nature. Four of the most commonly used NDI techniques will be discussed and practiced in class. These techniques include Visual Inspection, Tap Testing (both manual and instrumented tap testing), Resonance Bond Testing, Acoustic Emission testing, Radiographic testing, and Ultrasonic Inspection.

Industry Advisory Council

At Vaughn College, the industry advisory members play a pivotal role in program delivery and thus in students' subsequent success. The industry advisory members work closely with the faculty members of the engineering and technology department in developing new course offerings and program modifications. Their valuable recommendations and comments continuously make our program delivery stronger and more competitive with the growing demand of today's technology. Furthermore, the close partnership with these industrial companies, such as Sikorsky, Northrop Grumman Corporation, CYIENT, Defense Contract Management Agency, Corning, Lockheed Martin, SciMax Technologies, RCM-Tech, Rockwell Collins, Pavon Manufacturing Group, FAA, CPI-Aerospace, Wunderlich-Malec, Kedrion Biopharma, US Didactic, Con-Edison, and MTA, allow our students to explore careers or internship opportunities with top engineering enterprises.

Internship Programs

Vaughn's internship program is a key part of an engineering curriculum to prepare students for the workplace. For the past several years, our students were involved with both summer and school year internship programs with top engineering companies such as Daimler, John Deere, NASA, Sikorsky, Northrop Grumman Corporation, Lockheed Martin, RCM-Tech, Rockwell Collins, Federal Aviation Administration (FAA), Alken Industries, Cummins Engine, MTA, GE, Pall Corp., Pavon Manufacturing Group, Raytheon, Safe Flight Instruments, Toyota, Robotics Education and Competition Foundation (RECF), and Naval Research Enterprise Internship Program (NREIP). These internships provide students with a greater appreciation for engineering education and expand their hands-on and career-building experiences. As a result of these internships, many of our graduates are currently working with these companies as new advisory members for our programs and assisting our current students in pursuing internships with these companies.

Faculty Professional Engagements and Workshop Participation

To improve the quality and effectiveness of instructional delivery and student learning, the engineering and technology department encourages faculty members to participate in conferences and workshops designed to enhance faculty understanding of new technological discoveries and innovations to maintain teaching quality. For the past few years our faculty members have been active participants in many educational and technical conferences and workshops such as the American Society for Engineering Education (ASEE), Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), Aircrafts Electronics Association (AEA), Institute of Electrical and Electronics Engineers (IEEE), American Institute of Aeronautics and Astronautics (AIAA), Society for Experimental Mechanics (SEM), and American Society of Mechanical Engineers (ASME). Also, faculty were involved with the development and implementation process of two new mechanical and electrical engineering programs, laboratory development/enhancement, and learning communities for NSF scholarship recipients.

During the calendar year 2018–2019, faculty in the engineering and technology department participated in the following professional engagements and workshops:

Hossein Rahemi

1. In spring 2019, the Project Director submitted an annual progress report for the Title III STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" that includes information/updates on facilities, faculty and staff, and the development process of stackable manufacturing certificate programs, on the as well as process for developing the advanced manufacturing program.
2. The PD published the eleventh Annual Vaughn College Journal of Engineering and Technology (VCJET). This journal includes annual department's activities, laboratories upgrade and development, faculty and student professional engagements, graduate success stories, industry tours, engineering seminar series, industry connection seminar series and student technical research papers (April 2019).
3. On Friday, April 19, 2019, the Engineering and Technology department chair hosted its Eleventh Annual Industry Advisory Meeting and Technology Day Conference. Dr. Rahemi updated Advisory Council members with recent developments in the Engineering and Technology Department, such as: progress reports on program assessment and preparation for the ABET 2019 programs reaccreditation, HSI-STEM grant activities including the development process of stackable manufacturing certificate programs in CNC machining, Composite, and 3D additive and subtractive manufacturing that lead to a BS in advanced manufacturing program, the development process of manufacturing laboratories (CNC machining, composite, additive manufacturing, automation, and UAS), qualification of Vaughn's Robotics teams for 2019 VEX U world championship, the selection of Vaughn's UAV team by the Vertical Flight Society (VFS) as a finalist alongside Penn State, University of Maryland, Drexel University to participate in the 7th annual Micro Air Vehicle (MAV) student challenge competition at university of Pennsylvania (May 13, 2019), participation of the Vaughn Racing team in the 2019 Formula SAE competition at Michigan International Speedway from May 8-11, 2019.

4. From spring to fall 2019, the PD submitted a monthly progress report for the Title III STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" that includes information/updates on student engagement, facilities, faculty and staff, and the development process of the stackable manufacturing certificate programs as well as the process for developing the advanced manufacturing program.
5. From April 24-27, the department chair, along with twelve members of Vaughn's Robotics club, traveled to Louisville, Kentucky to participate in the 2018 VEX U Robotics competition. Seventy six (76) national and international universities and colleges were invited to the 2019 World Robotics Championship. Invitation to the VEX U Robotics World championship was only granted to a team that is a tournament champion or Excellence award recipient of a regional competition. The Louisville World Championship was an intense three day competition where our team continuously modified their robots and autonomous programming to be competitive with other top teams in this tournament. During the qualifying matches, Vaughn's team (VCAT) competed against 10 teams and won seven out of the 10 matches, advancing to the Saturday afternoon playoff round. During the single elimination of playoff round, the top sixteen teams competed, and Vaughn's team lost to a top team from China. For six years in a row, Vaughn's team retained their standing as one of the top competitors in the world championship by advancing to the playoff round of this intense competition
6. On Saturday, May 4, 2019, the engineering and technology department hosted several drone and Robotics workshops such as CAD Modeling of Quadcopters, Robotics, and Programming with Python in order to celebrate International Drone Day. The event allowed visitors and students to design, build, and test their own drones in the netted flying arena of the college hangar. The participants for the workshops and drone flying session were invited guests and students from Robert F. Kennedy Community, Thomas Edison, and Bayside and other high schools.
7. On Thursday, May 9, **the** department chair updated the board of trustees with department annual activities, assessment & preparation for the fall 2019 ABET site visit, new stackable manufacturing certificate programs that lead to a BS in advanced manufacturing, student engagement (UAV Robotics, and Formula SAE competitions, conference, and scholarly activities), industry connection seminar series, and other department issues
8. Under the Chair's oversight and support of other UAV advisors, Vaughn's UAV team project was selected as one of the finalists along with Penn State, Drexel University, and University of Maryland to participate in the in the 7th annual Micro Air Vehicle (MAV) student challenge competition. Vaughn's UAV was selected as a finalist for both autonomous and manual categories for the 2019 Vertical Flight Society (VFS) MAV competition, at the University of Pennsylvania on Monday, May 13, 2019. Among all participating teams, only teams from Vaughn College and the University of Maryland were able to complete the remotely-operated tasks within the ten-minute time limit. For the autonomous session, both Vaughn College and the University of Maryland were able to fly their drone with vertical takeoff and partial hovering around the field. Both Vaughn teams were invited to attend the Tuesday evening award ceremony. On Tuesday, May 14, Judges from aerospace industries evaluated the teams' performance for both the remote and autonomous control categories. Maryland's UAV teams received the highest score in both categories and received the 1st place award, and <u>Vaughn's UAV teams received 2nd highest</u>

scores and received the 2nd place award for both remote control and autonomous categories, with a $1,750 check.

9. From June 11-15, the department chair supported Vaughn's UAV team to participate at the 2019 AUVSI UAS Competition alongside seventy five other top-recognized national and international engineering schools (Harvard, Cornell, Virginia Tech, UCLA, Penn state, University of Maryland, and many others) and received 26th ranking in the 2019 AUVSI challenging competition.
10. From June17-20, 2019, the department chair, along with two other faculty and students, participated at the 2019 ASEE annual conference at the 2018 ASEE annual conference, Tampa, Florida. Vaughn's students' research papers "**Early Learning Braille Block Language System**," **by** Niki Taheri and Atif Said was presented during the **Manufacturing Session** (Monday June 17, 1:30pm-3:30 pm). Vaughn's Faculty's project **"A STEM Training Program to Improve High School VEX Competition Outcomes,"** by Ryan Bobby Tang and Shouling He was presented during the **STEM Poster Session** (Tuesday June 18, 11:30am-1:30 pm).
11. From June 20-25, the department chair completed and uploaded Self-Study reports for six engineering and engineering technology programs (BS Mechatronic Engineering, BS Mechanical Engineering Technology – CAD and Aero options, AAS Aeronautical Engineering Technology, BS Electronics Engineering Technology _electronics, BS Electronics Engineering Technology –Avionics, AAS Electronics Engineering Technology – Avionics) on the ABET website, with all supporting documentation for the reaccreditation of those programs. The site visit for ABET team will take place from October 13-16, 2019.
12. On Tuesday, July 9, 2019, the department chair and grant manager met and discussed issues related to the cost of student engagement associated with STEM activities (technical competitions, professional society participations and publications). Based on the 2018 recommendation by PD and the approval by the project officer, the College's current Title III grant provides necessary funding to support further student involvement in STEM related scholarly and practical hands-on activities. Since further expense is involved in engaging students in technical competitions (Robotics, UAV, SAE, and others), we agreed to reduce the number of supplemental instructors from 15 to10 and to use additional funding for student engagement in STEM related activities.
13. From July 23-26, 2019, the department, chair along with two faculty and 10 students, participated in the LACCEI international engineering conference. The following Vaughn student research papers were selected to compete among ten finalists for the student paper session of the LACCEI 2019 conference in Montego Bay, Jamaica.
    - **"Vehicle Design For Formula SAE 2019 Competition"** by Ryan Lewis and Andriy Belz
    - **"Smart Braille Learning Block Systems"** by Niki Taheri and Atif Saeed. **Recipient of the Second Place award for the student paper session competition.**
    - **"Autonomous Search and Rescue Project (ASAES)"** by Ryan B. Tang Dan. **Recipient of the First Place award for the student paper session competition.**
    - **"Walking Wise Camera Sensor Smart Cane"** by Jevoy James, Richi Ramlal. **Recipient of the Third Place award for the student paper session competition.**

- **"A Study of Notched Beam Stress Concentration"** by Aderet Pantierer and Shumul Pantierer

During the Gala dinner gathering, award recipients for the best paper and poster presentations were introduced. This year, all top three awards (first, second and third place) for the best paper presentation of the student paper session competition were presented to Vaughn's engineering students.

Six of Vaughn's student team posters were selected to compete for the student poster session of LACCEI2019 conference and among 30 participating teams, Vaughn's **"Rwanda Potable Water Project"** by Samantha Maddaloni received the **first place award for the best poster presentation of the LACEEI 2019 poster session competition.**

14. From July 17–19, the department chair and four of Vaughn's engineering program coordinators attended a face-to-face meeting with both EAC and ETAC team chairs in preparation for the fall's ABET team site visit (Oct 13-16) for the reaccreditation of six engineering and engineering technology programs (BS Mechatronic Engineering, BS Mechanical Engineering Technology, BS Electronic Engineering Technology – Avionics, BS Electronic Engineering Technology – Electronics, AAS Aeronautical Engineering Technology, and AAS Electronic Engineering Technology – Avionics).
15. From July 31 to Aug 4, the department chair supported two leaders of Vaughn's SHPE student chapter to participate in the four-day SHPE's National Institute of Leadership Advancement Conference in Phoenix Arizona. The purpose of this conference is to equip and provide SHPE's chapter leaders with the knowledge and skills required to be a successful leader. Vaughn's SHPE leaders attended workshops related to Strategic Thinking and Business Planning, Young Professionals Roundtable Discussion, and Unlock Your Entrepreneurial Mindset with Engineering Precision. Also, Students attended SHPE's NILA Commencement and Banquet with the Keynote Speaker from the Exxon Mobil Corporation.
16. From Aug 13-15, the department chair supported Vaughn's Mechatronic and additive manufacturing lab specialist to attend a **3-day Siemens hands-on training workshop** at Corning Community College Auxiliary Aviation Corporate Campus, 360 Daniel Zenker Dr, Horseheads, NY. Day one training covered the general interface of Siemens TIA Portal, which is similar in design to Siemens Step7. Day 2 training covered complex logic programming in the form of bitwise operations (including AND, OR and XOR logic), latches, and timers, and day 3 covered training on the HMI interface and manipulating the already-provided window to show the proper information.
17. From Aug 16-20, the department chair supported the CNC Curriculum Designer, Prof. Manual Jesus and the Manufacturing Lab Tech, Rachid Nafaa to attend a hands-on training class in coordinate measuring machine (CMM) to learn the AIMS Metrology CMM system in Dayton, Ohio. CMM is used to measure the physical geometric properties of a part. The five day course first reviewed core concepts such as Cartesian coordinates and vectors, then geometric tolerance concepts through the use of the CMM as a measuring tool. Geometric tolerance was explored by programming the CMM to inspect a part using approach, probe, and retract commands, developed via a command line interface or a more intuitive graphical user interface.

18. On Aug 29, the PD and Grant manager met with the President and Vice President to update them about grant activities, laboratory development, student engagement, STEM outreach activities, and plans for developing the UAS laboratory and certificate program.
19. The Chair submitted the fourth annual progress report for both ME and EE programs including information/updates on: new/refurbished facilities, faculty and staff, and preparations for ABET evaluation submitted to the NYSED on September 2019. Every September an annual report needs to be submitted to the NYSED, until the department receives EAC- ABET accreditation for both of these programs.
20. On Thursday, September 19, the department chair arranged and hosted a roundtable career advisement day with students in engineering and engineering technology programs. This roundtable discussion with faculty covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. PD, faculty and senior students discussed, in detail, several career strategies for obtaining a successful career in STEM fields.
21. On Thursday, October 3, 2019, the department chair arranged a STEM Day presentation to be hosted by Vaughn's engineering Clubs and professional student chapters (UAV, Robotics, SAE, NSBE, SHPE, EWB, and SWE) to introduce incoming freshman students to their annual professional activities. Each club provided a detailed discussion of their annual STEM activities and encouraged all students to join them and to become involved in extra-curricular club activities. They encouraged involvement in technical clubs and student chapters of professional societies, because these activities further enhance career opportunities, promote creative ideas, introduce one to innovations in the STEM fields and provide professional networking opportunities with engineering industries.
22. On Thursday, October 31, the department chair signed a program articulation with Hillcrest High Scholl. As part of this articulation, Hillcrest Junior and Senior level students may enroll for MCE101 (Introduction to Robotics, 1 credit, 3 contact hours), CDE117 (Engineering Graphics, 2 Credits, 4 contact hours), CSC316 (C++ Programming, 3 credits) at Vaughn College and upon successful completion of these courses with a grade of C or better, they can be applied towards a Vaughn College engineering and engineering technology degree. .
23. The department chair organized and hosted the 5th annual manufacturing day conference on Friday, November 1, 2019 (10 am to 2 pm) to celebrate the national manufacturing day. The guest speakers addressed Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of Industry 4.0, Development of digital Twin, Sensors for Aerospace Industry, additive manufacturing with desktop metal 3D, and Integration of CMM with CNC machining and manufacturing process. In a parallel session, from 10 am to 2:00 pm, Vaughn's Robotics, SWE, NSBE, and UAV clubs organized and hosted STEM workshops on CAD, building a drone, robotics design, and autonomous programming for the high school students. More than fifty students from Westbury, Bayside, Thomas Edison, and Hillcrest high schools participated in STEM workshop session of this national event
24. From Oct 30 to Nov 3, with the support of HSI-STEM grant and assistance of the department chair, a group of 13 engineering students from Vaughn College attended the 2019 Society of Hispanic Professional Engineers (SHPE) Conference in Phoenix, Arizona.. Vaughn's students participated in the Extreme Engineering competition as well as in various professional development workshops that aimed to promote leadership and unity, and to expose students to the diverse career opportunities in the STEM fields. Vaughn's

Engineering student, Angel Calderon, participated in the Extreme Engineering Challenge and won **third place** in this challenging competition. He was recognized as a lead engineer by showing strong leadership skills among his team members and team leaders throughout their project.

25. From November 7–10, the department chair supported a group of four students: Amanda Camacho, Kiki Kuonqui, Michael Boller and Johann Cole from Engineers-Without-Boarders Vaughn Chapter and Faculty adviser Dr. Miguel Bustamante to attend the EWB-USA conference hosted at Pittsburgh, PA. The EWB-USA is an annual national conference where professionals in the industry and their respective student chapters share important information and volunteer for projects (Attachment 5 – 2019 EWB Conference).
26. From November 7-10, with the support of HSI-STEM grant and assistance of department chair, Vaughn College's chapter of the Society of Women Engineers attended, presented, and held a "Drones for Good" STEM workshop during the "lightning talk" session of SWE19 Annual Conference in Anaheim, California. The 9 VCAT-SWE attendees were extremely successful. As a whole, Vaughn's students received 22 interviews with companies such as Northrop Grumman, Boeing, Lockheed Martin, Dell, United Technologies, General Motors, ASML, Daimler Trucks of North America, BAE Systems, and Raytheon. Of those 22 interviews, 1 internship offer was made as well as 8 full-time job offers. On Saturday, November 9th, Vaughn College SWE Chapter got invited to host a STEM workshop at the "Invent It. Build It." Expo. This expo was designed for K-12 students to experience the creative and innovative sides of engineering through hands-on projects alongside real engineers. SWE-VCAT held a propeller powered car workshop teaching students the basics of circuitry and thrust while they also learned about Vaughn College.
27. On Thursday, January 9, 2020, the department chair organized a meeting with the Engineering and Technology Industry Advisory Board to discuss new changes to EAC of ABET regarding Criterion 3, Student Outcomes and Criterion 5, curriculum. In this meeting, he updated advisory members on the department assessment process, self-study development, and preparation for the initial EAC-ABET accreditation of mechanical and electrical engineering programs. Dr. Rahemi thanked advisory members for their continuous support and input in every aspect of the department, student success, and the institution. His presentation covered the changes to ABET's student outcomes and curriculum as well as the new "1 through 7" student outcomes assessment based on performance indicators.
28. On Friday, Feb 28, 2020, the department chair, along with the Vaughn College Robotics team, hosted its Sixth Annual VEX U College Regional Robotics Tournament. Vaughn's Robotics Team won the 2020 VEX U Skill Challenge and Excellence Awards
29. On Saturday, Feb 29, 2020, the department chair, along with the Vaughn College Robotics team, hosted its Sixth Annual High School VEX state qualifier Robotics competition. A total of 58 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk and other NY counties attended the February VEX state qualifier at Vaughn College.
30. On Friday, March 6, the engineering and technology department chair organized and hosted the second Annual STEM Day workshop for community college students. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Bergen, and Queensborough Community Colleges. In the morning session, Vaughn's STEM Pathway Liaison and STEM project director, Dr. Hossein Rahemi, talked about Vaughn College's

program offerings in the engineering and engineering technology disciplines as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 11:30 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. From 11:30 pm to 12:30 pm, Prof. Manuel Jesus, CNC and Additive manufacturing Curriculum developer, hosted a workshop at Vaughn's 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines. In the afternoon session, from 1:00 pm to 2:00 pm, Vaughn's UAV and Robotics clubs engaged participants in hands-on STEM workshops sessions on building a drone, and from 2:00 pm to 3:00 pm, Vaughn's CNC lab specialist, Mr. Rachid Nafa, introduced participants to a hands-on session on part design and the manufacturing process using the HASS VF-2SS CNC milling machine, the Okuma lathe machine, and the Coordinate Measuring Machine (CMM).

31. In spring 2020, the Project Director submitted an annual progress report for the Title III STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" that includes information/updates on facilities, faculty and staff, and the development process of stackable manufacturing certificate programs, as well as on the process for developing the advanced manufacturing program.
32. **Industry Connection and Engineering Seminar Series:** The department chair organized and invited several industry leaders as guest speakers for the fall and spring Industry Connection Seminar Series. The name, date, and topics of presentation for those who accepted our invitation are as follows:
    - **Energy-Focused Presentation on Solar Generation:** On Tuesday, April 23rd, Mr. Nicholas Giannasca and Mr. William Freidman of Davis Wright addressed Vaughn community about industry sector programs featuring an energy-focused presentation on solar generation. Their presentation provide an overview of the solar generation market, the basics of how solar generation projects are financed, developed, and operated, and the important legal, economic, and regulatory issues that customers who are contemplating a solar installation should consider.
    - **Embraer and Future Trend of Aerospace Industry:** Mr. Gray Spulak, President of Embraer Aircraft Holding, addressed the Vaughn community on Tuesday, September 10 as part of the College's Industry Connection Seminar series. Following a welcome from Vaughn College President Dr. Sharon B. DeVivo, Spulak detailed company plans and strategies including joint partnerships, efficient energy management systems, biofuels and safety, supply chain optimization and the production and maintenance of secure aircraft that operate in high density areas.
    - **The opportunities available to contribute to the world through TOM**: On Tuesday, September 19, Mr. Edun Sela and Ms. Maayan Keren of TOM Global addressed the Vaughn community as part of Vaughn College's Industry Connection Seminar series with a presentation on Tikkun Olam Makers (TOM) and the opportunities available to contribute to the world through this organization. Their presentation introduced audiences to the TOM movement, communities, and vision. During this gathering, the engineering department chair and Vaughn's technical clubs' leaders (UAV, SWE, and Robotics) expressed their interest and willingness to work with the TOM's organization to create a TOM community at Vaughn and to

host a Makeathon “maker” event at our college in the near future.

- **Designing and Modeling Electronic Packages for the Next Gen OPIR:** On Tuesday, Dec 5, 2019, Mr. Mohammed Hossain, a senior student in the Mechanical Engineering Technology program who participated in a ten-week summer internship program with Raytheon, addressed the Vaughn community about his summer internship project and life-long learning experiences he has gained through this project. His presentation covered his task of designing electronic packages on the Next Generation Overhead Persistent Infrared (Next Gen OPIR) program. For this project, he was part of the mechanical team and was responsible for developing designs, prototypes, and baselines for the electronic packages.
- **Entrepreneurship:** On Thursday, Dec 5, 2019, Mr. Stauffer, an alumnus and Chair of Vaughn’s Board of Trustees, addressed the Vaughn community as part of the College's Industry Connection Seminar series with a presentation on topics related to startups, entrepreneurship, current technology, and engineering education. He talked about the traits of entrepreneurs (not satisfied with the status quo, curious, creative, embrace risk, highly competitive), and the large company versus the entrepreneurial start-up.
- **An Overview of the NASA, STEM Workforce Challenges**, and NASA’s Internship Programs, Mr. Matthew Pearce, NASA Education Programs Specialist and Ms. Ms. Rosalba Giarratano, Pathways Intern for Space Studies, Feb 25, 2020.
- **Designing and analyzing Medical Device such as Reamers and Oscillating Saw** - A Summer Internship Project at Stryker, Mr. Ariel A. Ferrera, ME Senior Student, March 3, 2020.
- **Rolls-Royce Engine Models through 3dsMax** - A Summer Internship Project at Rolls-Royce, Ms. Jacqueline Oricchio, Mechatronic Engineering Senior Student, March 3, 2020.

Amir Elzawawy

1. Participated with a team of students in AIAA-YPSE Conference held at Johns Hopkins University, Applied Physics Lab, Laurel, MD on November 15, 2019. The project presented “Autonomous Life Emergency Rescue Transmitter (A.L.E.R.T.)” by S. Kapadia, P. Kalaitzidis, and S. Misbahuddin.
2. From October 2nd to 4th 2019, participated with group of students in COMSOL Multiphysics conference. The students presented their work, entitled “Design and Fabrication of Small-Scale Supersonic Wind Tunnel”, in two conference sessions on October 3rd. The 1st session was part of the oral presentation in CFD and FSI session. The 2nd session was in the poster presentation session. The annual conference was held in Boston, MA.
3. Attended ABET’s institution representatives meeting with team chairs for both EAC and ETAC, Baltimore, MD on July 11 to 13.
4. Participated with Vaughn’s UAV team in the AUVSI-SUAS competition held at Patuxent River Naval Air Station in Southern Maryland from June 12 to 15. Vaughn’s UAV team was ranked 26 out of 75 participating teams and ranked 24th in mission execution.
5. May 4th, Advised UAV club to host Vaughn College Annual Drone Day. The event is open the public and features multiple workshops for high school students.
6. Participating MAV (Micro Ariel Vehicle”) Competition at AHS (American Helicopter

Society) 75th Annual Forum, May 13th, Philadelphia, PA. Vaughn's UAV teams have won the second place for the manual competition and Honorable Mention in the autonomous competition.

7. Advised two teams of students to present papers and poster presentations" at the 11th annual Technology Day Conference and publish their work in the annual VC-JET journal.
8. Attended COE conference sponsored by Dassault Systems, Feb. 24 to 27, New Orleans, LA, where the UAV team won first place in the undergraduate E-Poster competition at the COE conference February 26, New Orleans, LA.
9. On December 12, attended UAS training at Quanser Facility in Markham, Canada. The training was on the equipment that will be used in the new UAS laboratory planned for 2019.
10. On October 26th, invited as a panelist on the Engineering, Architecture & Robotics Commission to review Bronx Aerospace High School Curriculum.
11. Served as the chair of the academic program in the College's strategic planning (September 2018 thru July 2019)
12. Served as the VP of the faculty senate for the academic year 2018/2019.

Shouling He

1. Served as a program coordinator of the Mechatronic Engineering (MCE) Program: (1) evaluated students' qualifications for program applications, arranged the offered courses and faculty teaching load; (2) assisted the department chair to collect department exit, internship supervisor, employer and alumni surveys; (3) developed, checked and helped faculty members to write faculty course assessment reports (FCARs); (4) wrote the fall 2018 MCE Program Assessment Report, (6) assisted the department in checking and preparing all samples for ABET SLOs 1-7 Assessment; (7) assisted the department in checking and preparing teaching materials and samples for all courses listed on the MCE curriculum.
2. Served as a program coordinator for the Electrical Engineering (EE) program during the 2018-2019 academic year, coordinated the offered courses, examined students' qualifications for the program applications, collected the FCARs from EE program faculties, wrote the EE Program Assessment Report for future ABET board visiting (completed in June, 2018), held the meeting and wrote meeting minutes for the future improvement of the EE program.
3. Participated 2019 ABET Institutional Representatives Meeting to meet Engineering Accreditation Committee Team Chair and discussed the on-site visit as well as ABET documents issues, July 18, 2019.
4. As a faculty advisor, participated in Student Career Advising Day to advise students on career and course selections, October 1, 2019.
   Co-authored educational research paper entitled "A STEM Training Program to Improve Middle and High School VEX Competition Outcomes" accepted and published at the 126th ASEE Annual Conference and Exhibition, Tampa, Florida, June 16-19, 2019.
5. An author of education research paper entitled "Integrating Linux and ROS in Mechatronics Engineering Education" accepted at the 2019 ASEE Mid-Atlantic Conference, *Engineering for Everyone*, The Cooper Union, New York, Nov. 1-2, 2019.
6. Advisor for three student capstone projects and a student research project for presentation at the 2019 VCAT Tech Day Conference and the developed research papers for publication in the 2019 VCJET.

7. Participated in the Educational Workshop, *Project Catalyst – How to Engineer Engineering Education*, held by Bucknell University during July 17-19, 2019.
8. Wrote additional narrative on planned research activities with students for NSF-STEM Grant, March 2019.
9. Participated as a judge for VEX Robotics Competition at the 5th Freeport High School Competition in February 2, 2019, and Vaughn College VEX Robotics Competition in February 9, 2019.
10. Participated in the Webinar, "Developing a Roadmap for Mechatronics and Robotics Engineering Education" held by Mechatronic Education Community, November 9, 2018.
11. Participated in Power System Training, including power electronics, electric machine, power system with certificate, the trainer, Ralf Linnertz, Product Manager from Lucas Nuelle Company, November 12-14, 2018.
12. Participated in Industrial Connected Seminar, held by Carlo Asaro, Avionics System Engineer at Sikorsky Aircraft Corporation, November 2, 2018.
13. Participated in the 4th Annual Manufacturing Conference Day at Vaughn with R. Brown, chief engineer at Lockheed Martin, on the evolution of Sikorsky rotor craft development; S. A. Gerb, academic ambassador of Dassault Systèmes, on designing heat tiles for space shuttle; M. Blackman, the industrial software specialist at GE Power, on manufacturing with a twist, a big data twist; M. Jesus, engineering professor on computer graphic modeling and additive manufacturing and Dr. Y. Budhoo, engineering professor on addressed damage evaluation in composite materials, October 19, 2018.
14. Worked as a club advisor for Society of Women Engineers (SWE) to help SWE club students holding the Vaughn College booth to teach Elementary/Middle School on how to build small cars at 2018 NYC Make Faire, September 22-23, 2018.
15. Participated in IEEE Symposium, Advanced Communications, Stevens Institute of Technology, Hoboken, NJ, September 15, 2018.
16. New courseware, data acquisition board Q2-USB, from Quanser, has been added to the course ELE450/ELE450L Data Acquisition and Applied Control Systems: introducing hardware-in-loop system using Quanser real-time control software QUARC with the design of feedback controller and observer.
17. A new EE course ELE355/ELE355L Microprocessor System Designs and Interfacing has been developed by the introduction of computer interfacing with stepper motors and keypads using interrupt approaches, AD converters, and capture, compare and PWM modes.
18. Attended the workshop of media relations and effective message communication, held by Maureen Kiggins, Assistant Vice President, Public Affairs, June 19, 2019.
19. Served as a faculty performance evaluator to conduct course observation and write recommendations and review for the promotion and tenure of junior faculty members, March - April 2019.
20. Wrote more than 15 recommendation letters for MCE/EE students and alumni to apply jobs, graduate schools and scholarships.

Yougashwar Budhoo

1. Advised students of the SHPE club at Vaughn College.
2. Developed a Non Destructive evaluation of composite material course to be taught as part of the composite material certificate program.

3. Advised and mentored students to develop research journal papers for VCJET 2019. The projects were presented in the afternoon session of Eleventh Annual Vaughn College Technology Day Conference in April, 2019.
4. Advised students to publish and present a conference paper, entitled "Stress Concentration Factor due to Combined loading". This work was presented at the 2019 LACCEI International Multi-Conference of Engineering, Education and Technology which was held in Jamaica, July 2019.
5. Attended 2019 ASNT annual conference in Las Vegas, Nevada (November 19 to 21, 2019).
6. Worked closely with department chairman and members of the Vaughn community in preparation for the MET program ABET visit.
7. Developed and taught MEE390, mechanics of composite materials, a new course in the mechanical engineering curriculum
8. Completed course and program level assessment for courses in the Mechanical Engineering Technology (MET) Program in preparation for the fall 2019 ABET site visit. .

Douglas Jahnke

1. Advisor for the Society of Automotive Engineers (SAE) chapter at Vaughn College. 2018 – present
2. Member of ASME – The American Society of Mechanical Engineers, New York, NY, 2010 – present
3. Served on Student Retention Committee to develop ideas to improve student retention at Vaughn College. 2018 – present
4. Served as co-chair of Marketing and Enrollment working group for Vaughn College's strategic planning initiative. 2018 – present
5. Attended Advanced Composite Structures: Fabrication & Damage Repair-Phase 1, Abaris Training, Reno, Nevada, January 7-11, 2019
6. Attended Fall 2018 National Science Foundation (NSF) Grants Conference in New Orleans, Louisiana, November 8-9, 2018
7. Attended SME Smart Manufacturing Seminar Series: Metal Additive Manufacturing Developments, Philadelphia, Pennsylvania, October 24, 2018
8. Attended Formula SAE Michigan with the Vaughn SAE club, Michigan International Speedway, Brooklyn, MI, May 8-11, 2019
9. Attended By Air, By Land, By Sea: Composites Get You There two-day workshop by Composites One and the Closed Mold Alliance in partnership with IACMI – The Composites Institute, Plainview, NY, June 11-12, 2019
10. Participated in preparation of grant proposal for NSF S-STEM proposal, Increasing Student Enrollment and Achievement in Engineering and Engineering Technology, submitted March 2019
11. Participated in ABET program accreditation review, including preparation of course and assessment materials, for Fall 2019 ABET visit
12. Attended Industry Connection Seminar Series, Vaughn College, Flushing, NY, 2018 and 2019.
13. Attended Annual Technology Day Conference, Vaughn College, Flushing, NY, April 20, 2018

14. Attended 4th Annual Manufacturing Day Conference, Vaughn College, Flushing, NY, October 19, 2018
15. Attended Open House at Vaughn College during Spring and Fall 2018, and provided information on the engineering and engineering technology program offerings to prospective students.
16. Attended Annual Technology Day Conference, Vaughn College, Flushing, NY, April 19, 2019
17. Attended STEM Day with Engineering Clubs, Vaughn College, Flushing, NY, April 19, 2019
18. Attended 5th Annual Manufacturing Day Conference, Vaughn College, Flushing, NY, November 1, 2019
19. Publication: Yildiz, S., Andreopoulos, Y., Jensen, R. E., Shaffren, D., Jahnke, D., and Delale, F., 2019, "Characterization of Adhesively Bonded Aluminum Plates Subjected to Shock-Wave Loading," International Journal of Impact Engineering, 127, pp. 86–99.

Mohammed Benalla

1. Reviewer and Chair of the thirty-sixth Southern Biomedical Engineering Conference, SBEC, session of computational bioengineering, New Orleans LA, March 6-8, 2020
2. Advisor for two student poster presentations in 2020 SBEC conference. The first one is "Haptic Thermal Feedback Prosthetic Brain-Controlled Arm" presented by Saeed Atif and second one is "Autonomous Medicine Dispenser" presented by Sebastian Valencia. Both Students' papers were accepted for publication with the Biomedical Science Instrumentation Journal.
3. Developed course assessment reports in preparation for 2020 ABET initial accreditation of EE program.
4. Participated in teaching and mentoring the Engineering Learning Community class in Vaughn College and attending all their meetings.
5. Attended Open House for undergraduate students at Vaughn College during spring and fall 2019 and presented engineering and engineering technology programs to prospective students and parents.
6. Developed a new elective course "Biomedical Engineering Instrumentation - ELE456" for Mechatronic Engineering program.
7. In progress:: "ABET – Evaluation of Capstone Project for Mechatronic program", Mohammed Benalla, Hossein Rahemi, Khalid Mouaouya, 127th ASEE, Montreal, Quebec, Canada June 20-24, 2020 (in progress)
8. Advisor for student paper publication: "Brain Controlled Robotic Prosthetic Hand", Sam Maddaloni, Grace Davis, Raiyan Mohammed, and Atif Said, Biomedical sciences Journal, January 2019, Volume 55(1)
9. Advisor for student paper publication: "Motion Tracking Robotic Arm", Abdullah Ali, and Mina Botros, Biomedical sciences Journal, January 2019, Volume 55(1)
10. Advisor for student paper titled "Walking Wise Camera Sensor Smart Cane", Jevoy James, Nizamadeen Khedaru, Richi Ramlal, 17th LACCEI, Montego Bay, Jamaica, July 24 – 26, 2019
11. Advised and mentored two groups of students on two research journal papers for VCJET

2019. The projects will be presented in the afternoon session of 12th Annual Vaughn College Technology Day Conference, April 2020

Miguel A. Bustamante

1. Advised and mentored multiple teams of students to develop research journal papers for VCJET 2020. The projects will be webcast at the student session of 12th Annual Vaughn College Technology Day Conference, April 2020.
2. Mentor-Connect Cohort 8 conference, a team composed of Dr. Miguel Bustamante, Professor Rodney Dash and Grant manager Natasha Waldron, participated on the Technical Assistance and Grant writing workshop hosted in New Orleans, January 28 to the 31, 2020. The objectives for this workshop were to engage participants in the ATE community and prepare college teams and their accompanying grant writers and/or administrators to initiate a fundable NSF ATE grant proposal. This Mentor-Connect was entered as a competition and our team from Vaughn College was selected to participate on this journey.
3. On November 7–10, 2019, a group of four students: Amanda Camacho, Kiki Kuonqui, Michael Boller and Johann Cole from Engineers-Without-Boarders Vaughn Chapter and Faculty adviser Dr. Miguel Bustamante from Vaughn College attended the EWB-USA conference hosted in Pittsburgh, PA. The EWB-USA is a national conference hosted yearly where professionals in the industry and their respective student chapters share important information and volunteer projects.
4. On July 22-25, 2019 a group of Faculty and Staff members, Dr. Miguel Bustamante Assistant Professor of Electrical Engineering, Professor Dash Rodney from Arts and Science Department, Dr. Edgar Troudt Associate Vice-president of Academics Affairs, Natasha Waldron Grants Manager and Lauren Cajade Assistant Director Higher Education Opportunity Program (HEOP) from Vaughn College attended the HI-TEC conference hosted at St. Louis Missouri. HI-TEC is a national conference on advanced technological education where secondary and postsecondary educators, counselors, industry professionals, trade organizations, and technicians can update their knowledge and skills. HI-TEC is produced by the National Science Foundation Advanced Technological Education (NSF ATE) community.
5. Dr. Miguel Bustamante and Dr. Shouling He, assistant professor and associate professor in Vaughn's engineering and technology department attended the Educational Workshop, Project Catalyst – How to Engineer Engineering Education, held by Bucknell University during July 17-19, 2019. The workshop explored how to use instructional objectives, and active and cooperative learning to efficiently improve professors' teaching performance, as well as how to assess student learning outcomes. Forty-six faculty from different universities, such as John Hopkins University, University of Pennsylvania, Pennsylvania State University, Drexel University, as well as New Jersey Institute of Technology, joined the workshop.
6. On April 9, 2019, Dr. Miguel Bustamante, Assistant professor of Engineering and Technology department at Vaughn College of Aeronautics and twelve Learning Community students from Vaughn College's Engineering and Technology Department visited the Brookhaven National Laboratory (BNL) on Long Island, New York. The tour was organized by Jessica Caron, Director of Career services at Vaughn College and included visits to the Superconducting Magnet Division (SMD) and Central Chilled Water Facility.

7. Engineers Without Borders (EWB-USA)-Water testing Research Project trip to Kigali, Rwanda Feb18-28, 2019. The goal of this project is to design and implement a potable water system in a town of 1,500. The project will depend on the finding of this first trip. Recommendations will be given on a future second trip to the Kibingo village to provide safe portable water system for its residents.
8. EWB-USA Water testing workshop-Jan 19, 2019. One day training on how to take measurements of water contaminant and proper record data from the optical sensors. There was also biological testing for e-coli contaminants on water sources. We also learned how to avoid cross contamination of samples.
9. Participated at Vaughn's 5th Annual Manufacturing Day, November 1, 2019. The guest speakers addressed Vaughn community, faculty, and invited guests about current manufacturing innovations in the area of Industry 4.0, Development of digital Twin, Sensors for Aerospace Industry, additive manufacturing with desktop metal 3D, and Integration of CMM with CNC machining and manufacturing process.

<u>Manuel Jesus</u>

1. Advised students on degree project additive manufacturing, 3D Scanning, and CAD related tasks. (Ongoing)
2. Participated at Vaughn's 11th Annual Vaughn College Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students' capstone degree projects as well as networking with industrial leaders, April 19, 2019.
3. On Thursday September 19, attended a roundtable career advisement day with students in engineering and engineering technology programs. This roundtable discussion covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. In this roundtable gathering, we discussed several career strategies for obtaining a successful career in STEM fields.
4. Participated and presented a topic on Additive Manufacturing at Vaughn's 5th Annual Manufacturing Day, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing. Nov 1, 2019
5. Participated and hosted a 3D Printing and Manufacturing workshop at Vaughn's 2nd Annual STEM Day, a one-day STEM workshop for students and faculty from Passaic, Queensborough, and Bergen community colleges, March 6th, 2020.
6. Printed 3D models for the Robotics club and other Vaughn College students using the Fortus 250mc 3d Printer, 3D Systems MJP 2500, and Form 2 printers. (Ongoing)
7. Attended Atlantic Design and Manufacturing Conference in New York (June 2019)
8. Attended MAGICS Advanced Additive Manufacturing Materialize courses in Detroit, Michigan (June 2019)
9. CMM Hardware and Modus Software course at AIMS Renshaw in Ohio, (July 2019)
10. Conducted 3D Printing and 3D Scanning Workshops for NYC Middle School Students (Nov 2019- March 2020)
11. Tooling U online CNC courses from Society of Mechanical Engineers (Ongoing)
12. CAM Instructor CNC for Instructors Course. Toronto, Ontario (Ongoing)

Khalid Mouaouya

1. Participated in 2019 ASEE Annual Conference and Exhibition, Tampa, Florida, June17-20.Advised students and attended technical sessions of this annual gathering.
2. Participated and attended ABET workshop and technical sessions in 2019 LACCEI international engineering conference, Montego Bay, Jamaica, July 23-26, 2019.
3. On Thursday September 19, attended a roundtable career advisement day with students in engineering and engineering technology programs. This roundtable discussion covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. In this roundtable gathering, we discussed several career strategies for obtaining a successful career in STEM fields.
4. Participated with Vaughn's Robotics team in the Signature Mexico's VEX U Reeduca Robotics Challenge competition in the Univeredad Technologica De La Riveria Maya, Cancun, Mexico, December 12-14, 2019.
5. Participated in all Vaughn's spring and fall 2019-2020 Industry Connection Seminar Series, and Engineering Seminar Series.
6. Participated at Vaughn's 5th Annual Manufacturing Day, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing. Nov 1, 2019
7. Participated at Vaughn's 11th Annual Vaughn College Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students' capstone degree projects as well as networking with industrial leaders, April 19, 2019.
8. Attended Open House for undergraduate students at Vaughn College during spring and fall 2019 and presented engineering and engineering technology programs to prospective students and parents.

Ghania Benbelkacem

1. Participated at Vaughn's 5th Annual Manufacturing Day, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing. Nov 1, 2019
2. Participated at Vaughn's 11th Annual Vaughn College Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students' capstone degree projects as well as networking with industrial leaders, April 19, 2019.
3. Advised students through their capstone degree projects, spring 2020.
4. Attended all of Vaughn's spring and fall 2019-2020 Industry Connection Seminar Series, and Engineering Seminar Series.
5. Member of American Society of Rheology. ASME and ASAA Member. Reviewer for Journal of Rheology.
6. Served as a member of a committee for faculty evaluation, 2019.
7. Attended the 18th International Materials Research Congress, Mexico, August 2019.
8. Attended the 2019 AMSE MEED summit in New Orleans, LA (March 2019) that focused on the inclusion and implementation of digital tools and packages (i.e. CAE) into the traditional mechanical engineering curriculum.
9. Attending "STEM day" for high school girls who are visiting Vaughn College to promote future female students. 2019
10. Involved with Vaughn college clubs: Society of Women Engineers, Engineers Without

Borders

11. Attended lab safety training and fish use in laboratory NYU - Manhattan (Summer 2019).
12. Conducted research at Tandon school of Engineering on Rheotaxi of Zebra fish. Built an experimental device and conduct experiment to study single and couple Zebra fish behaviors in water flow (Summer 2019).
13. Attended Research Seminars and Teaching Workshops at NYU – Tandon School of Engineering. 2019.

<u>Mudassar Minhas</u>

1. Conducted program assessment for both EET-Electronics and EET-Avionics and use the results to:
    - Enhanced program curricula and course content based on results of direct measures and feedback from current students, graduates, faculty, industry advisory members and employers of program graduates.
    - Collaborated with student advisement center, teaching & learning center, student support services and department faculty to institute course-wide or program-wide corrective action plans based on results of program assessment to address any deficiencies related to achievement of student learning outcomes.
2. Helped prepare self-study reports for both EET-Electronics and EET-Avionics for ABET ETAC accreditation visit.
3. Conducted team visit activities for ABET ETAC including facility tours, faculty and student interviews and providing additional information.
4. Actively involved with students in design, development and completion of their senior degree projects.
5. Attended ABET ETAC Institutional Representatives Conference, Marriot, Baltimore, MA. July 20, 2019
6. Actively developed avionics lab content and exercise for various courses.
7. Served as judge for VEX Robotics Competition at Freeport High School, Feb 2020.
8. Represented Vaughn College at Passaic County Community College for STEM Makerspace event, Feb 2019.
9. Advisor to Student Capstone Projects and prepared them for the poster session of 2019 Annual Technology Day Conference, April 19, 2019
    - “Fly-by-Wireless Control System” by Muhammad Al-Mehmadi
    - “Global Autonomous Maintenance and Emergency System” by Noah Argaw
    - “Pilot Vitals Monitoring System” by Reynaldo Francis
10. Prepared a complete list of concentration courses and course syllabi for MBA in Engineering Management, Jul 2018.
11. <u>Certifications</u>
    - ASTM NCATT Aviation Electronics Technician (AET) certification
        a. Autonomous Navigation Systems endorsement
        b. Radio Navigation Systems endorsement
    - Project Management Professional (PMI® PMP)
12. <u>Publications</u>
    - Mudassar Minhas, “From Canned Experiments to Professional Skills: Addressing Professional Skills in Avionics Education”, Nov 8, 2019.

- Mudassar Minhas, “Trends in Instructional Design and Technology: Exploring the Potential for AR in Engineering Education”, LinkedIn, Dec 9, 2019.
- Mudassar Minhas, “The Importance of Preparing Engineering Graduates for Corporate Social Responsibility”, LinkedIn, Nov 25, 2019.
- Mudassar Minhas, “How to Comply with the Elusive – Design Standard – Requirement for ABET ETAC Criteria”, LinkedIn, Nov 18, 2019.

13. Training
    - Troubleshooting, quick tips and operating procedures for the ProLine family of avionics, by Collins Aerospace, Mar 25, 2019.
    - FAA Drug and Alcohol Inspection Items: Be prepared for your next audit, by FAA, Mar 25, 2019.
    - UAVs and Evolving Regulatory Landscape, NPRM, ANPRM and other regulatory developments, Mar 25, 2019.
    - Honeywell Avionics Mechanical Protection Plans (HAPP & MPP) – Avoid unplanned maintenance costs, downtime and unnecessary stress through reduced customer effort, Mar 25, 2019.
    - AeroVue Touch and xVue Touch displays installation, KI300/Aeroflight EADI installation, KFC230/Aerocruze autopilot installation training, by Bendix King, Mar 26, 2019.
    - Quoting a project can make you or break you, understanding customer expectations and avoiding common mistakes, by ACS Avionics, Mar 26, 2019.
    - Understanding DataComm requirements for FAA NextGen, by Universal Avionics, Mar 26, 2019.
    - Comprehensive DO-260B compliant ADS-B out solutions and training guidance using Collins TDR-94/94D transponders meeting FAA 2020 mandate, Mar 26, 2019.
    - Update on ADS-B out mandate by FAA, ADS-B Focus Team Lead, Mar 27, 2019.
    - Everything you need to know about DataLink, extensive full day training course on FAA DataComm, ACARS, CPDLC, FANS-1/A, ATN-B1, ADS-C, VHF and SATCOM datalink, Mar 27, 2019.
    - Safety Management Systems (SMS) and Risk Management, Managing Risk, and Human Factors in Maintenance, by AEA, Mar 27, 2019.
    - GoDirect Routers and Internet Security. Understand the benefits of the distributed architecture, configuration in the Cloud, remote database loading, on-wing threat detection and benefits to the operator, by Honeywell Avionics, Mar 28, 2019.
    - ADS-B System test and troubleshooting methods using IFR6000 to perform complete AC20-165B performance testing of installed avionics, by Viavi Systems, Mar 28, 2019.
    - Training on IFD550, SkyTrax ADS-B and Citation Jet Program, by Avidyne Avionics, Mar 28, 2019.
14. Courses
    - Course in “The Science of Success”, University of Michigan, Feb 2020.
    - Course in “Academic Research Foundations”, by Prof. R. Moe at Seattle Pacific University, Jan 1, 2020.

- Specialization track in “Leading People and Teams”, Ross School of Business, University of Michigan, Dec 2019.
- Course in “Be at Better Manager by Motivating your Team”, by BigThink, Oct 30, 2019.
- Course in “Coaching and Developing Employees”, National Association of State Board of Accountancy (NASBA), Society for Human Resource Management (SHRM®), and Human Resource Certification Institute (HRI®) Continued Professional Credit – 1.6, Oct 24, 2019.
- Course in “Making it Stick”, by Chris Croft, Project Management Institute (PMI®) PDUs: 2.75, Oct 23, 2019.
- Course in “Own your voice: Improve Presentations and Executive Presence”, by GenConnectU, Oct 6, 2019.
- Course in “Create a Growth Mindset”, National Association of State Board of Accountancy (NASBA) Continuing Professional Credit – 1.6, Oct 4, 2019.
- Course in “Persuasive Coaching”, National Association of State Board of Accountancy (NASBA) Continuing Professional Credit – 1.0, Oct 3, 2019.
- Course in “Learning how to learn: Powerful mental maps to help students master tough subjects”, UC San Diego, McMaster University (online), Aug 2019.

Jonathan Sypeck

1. Introduced Simpleplanes educational video game into EGR450 (Aircraft Configuration Design) to improve students’ understanding of design decision making and outcomes associated to them.
2. Attended Open House for undergraduate students at Vaughn College during spring and fall 2019 and presented engineering and engineering technology program offerings.
3. Attended the 2019 AMSE MEED summit in New Orleans, LA (March 2019) which focused on the inclusion and implementation of digital tools and packages (i.e. CAE) into the traditional mechanical engineering curriculum.
4. Attended weekly Seminar presentations hosted by The City College of New York (CCNY), CUNY while pursuing PhD on advanced topics and advancements in several fields of Mechanical Engineering, including the Thermo-Fluid sciences, Robotics, and Solid Mechanics.
5. Conducted several hands-on training sessions in D2L for faculty, specifically in the use of synchronous learning with its built-in Virtual Classroom feature. This was part of Vaughn College’s response to the COVID-19 crisis in the Spring of 2020.
6. Continued to work one-on-one with faculty from both the academic and Aviation Training Institute sides of the College to maintain their online presence and synchronous lectures during the COVID-19 crisis in the Spring of 2020.
7. Participated in all Vaughn's spring and fall 2019-2020 Industry Connection Seminar Series, and Engineering Seminar Series.
8. Participated at Vaughn’s 5th Annual Manufacturing Day, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing. Nov 1, 2019
9. Participated at Vaughn’s 11th Annual Vaughn College Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students’ capstone degree projects as well as networking with industrial leaders, April 19, 2019.

Graduate Success Stories

In order to prepare students for the growing demands of today's technology and to aid them in their future careers, the Engineering and Technology Department at Vaughn College adopted a set of in-class and out-of-class academic activities reflective of ongoing technological change. These activities are designed to instill in students an awareness of the importance of lifelong learning in meeting the challenges in their future professions.

Whatever path our engineering and engineering technology students choose, their Vaughn education thus provides them with an edge for success.

Zechariah Gajadhar, Class of 2015
Manufacturing Engineer
CPI Aerostructures
Bachelor's Degree in Mechatronics Engineering, 2015

Chris Grosser once said, "Opportunities don't happen. You create them." After I obtained an undergraduate degree in Mechatronics Engineering from Vaughn College, this statement resonated with me. My time at Vaughn was filled with aspirations and rewards. In my freshman year, I was one of two recipients of the Kenneth E. Senior Aerospace Foundation Scholarship. This scholarship provided me with the opportunity to intern at Alken Industries, a manufacturer of aircraft parts and structural assemblies. In my junior and senior years, I also served as a supplemental instructor for several engineering courses, and this was one of the highlights of my time as a student, since this position allowed me to enjoy and appreciate engineering even more. In addition, I was also honored to represent Vaughn College at several engineering conferences (ASME, LACCEI, and Vaughn's Technology Day), where I presented technical papers and degree projects.

Shortly after graduation, I was hired as a Mechanical Engineer for PLX Inc. PLX develops high accuracy optical instruments and monolithic technology for a variety of defense and aerospace applications. I worked closely with the engineering team to develop new prototypes as well as to make improvements on existing designs. PLX was fascinating because it involved both design and testing of customized products for high-profile customers like NASA and Lockheed Martin. While working full-time at PLX, I also pursued a graduate degree in Mechanical Engineering from Stony Brook University. I had always desired to pursue a graduate degree to further my career, as well as to provide me with the opportunity to teach on the college-level.

After receiving my graduate degree and working on several cutting-edge optical assemblies at PLX, I transitioned to my current position as a Manufacturing Engineer for CPI Aerostructures. CPI Aero builds critical and complex structural assemblies for the defense and commercial markets. I am a part of a highly devoted team consisting of program managers, quality engineers, expeditors and purchasers. In addition to my day to day activities as an engineer, I was recently hired by Vaughn as an adjunct professor in the Engineering department, thus achieving a long-term goal of mine. I currently teach Reliability Methods in Structural Mechanics.

I am constantly on the lookout for more opportunities to develop. A great deal of hard-work, sacrifice, determination and discipline is required to continue reaching one's highest level of success.

Michael Wroblewski, Class of 2015
Manufacturing Engineer
Circor Aerospace and Defense
B.S. in Mechatronic Engineering, 2015
B.A. in Communications and Media Arts, 2008

I've never been subject to boredom, because I thrive on constant learning. Ever since I can remember, I've been fascinated with the way everything in this world has come to be. I have mostly gravitated towards discovering the way things are made and work, whether it is a pencil, a photocopy, a circuit, a program, a camera, a movie, or a business. When I wasn't taking things apart or reading about various forms of tech, I was creating. These creations ranged from robots to drawings, scale models to homemade movies, and Rube Goldberg machines to woodworking projects. Imagination, as well as an innate desire to learn and to create, have always been driving forces in my life.

In high school, my mother and I moved from Long Island, NY to coastal NH. The change was tough, but I adjusted and I began to focus on my long-standing passion for the art of cinema. Having always spent a lot of time escaping into the fictional world depicted at 24 FPS and re-enacting favorite scenes as projected from my imagination, I found an outlet for my joys and hobbies. Making movies allowed me to create, using my expressive imagination, and I also devised functioning props. Problems would arise, and I would then enjoy developing some resolution or film gimmick. Although I found film in NH, my heart was still with the city life of NY. I thus enrolled in the College of Mount Saint Vincent in the Bronx, to focus on film production.

Throughout my time studying film, I began to face the reality of my shyness and the attendant difficulties this posed in working in a highly social industry. I became more curious about engineering, yet I did not want to quit after I had put so much work into my arts degree. Ultimately, I finished my degree and worked on a feature-length documentary for a little over a year with a small media company. We toured the country for the release, and although I loved all the hard work, the cinematography, the time on the computer and the promotion of it all, the financial strain and stress I observed turned me in a different direction.

So, I decided to go back to school and knew I wanted to be an engineer. Researching various engineering disciplines, I came across the multi-discipline, electro-mechanical automation-based degree called Mechatronics. This was my obvious choice. Choosing to stay in NY, the choice was clear that I would apply to Vaughn, a small school, within the 5 boroughs. Not only had I decided that I was going to be an engineer, I also decided it was time to end my timidity. I was accepted and I have never turned back. I joined the leadership team, the robotics club, and began holding creative events for students of the Vaughn community to express their other talents. Vaughn became my home. The community itself allowed me to put down roots in a place where I could grow with others. My biggest focus became the robotics club. After my first year with the club, I was handed the reigns and worked hard to build the club up from the small closet in which it had started. Juggling rigorous classwork, working on the leadership team, hosting art exhibits, working a full-time job, and running a robotics club competing yearly on a global level, was challenging but fun. The best part of Vaughn for me though, was every single connection I made,–with professors, staff, and my peers. These are connections I know will last a lifetime. These are also connections that often lead to jobs.

And that's what happened. I had been working as a restaurant manager at a culinary school while finishing my degree at Vaughn, when the school announced it would be closing the restaurant. Out of respect, I stayed there until they closed, but also because of their amazing offer to take any course for free. I knew that I would be learning wine studies once the restaurant closed, but I did not have an engineering job lined up. During the restaurant's final week, I received a call regarding a job opening. It was for a design engineer position at Stark Products, a small company in Queens. Ultimately, I took the job and got my foot in the manufacture engineering door. I learned all that I could, while observing each process and technical decision. In my three years at that company, I grew to become more than a designer. I bridged from engineering to fabrication, and incorporated my knowledge to make processes more efficient and easier on the workers, all while optimizing time and cost. By the time I left the company, I was overseeing the entire production floor, controlling multiple automated machines to create production parts, and still optimizing designs for more efficient production.

I had hit the ceiling and I wanted to grow more. Right before the start of 2019, I landed a job as a Manufacturing Engineer at Circor Aerospace in Hauppauge, NY. At Circor, my sole responsibility is to optimize processes. This may include anything from automating a mechanical process, to developing more efficient assembly procedures, to optimizing a prototype for production, to working with PLCs and DAQs. Circor produces military and life-saving products, so there is no room for error, only growth. With growth, production will certainly expand. Manufacturing engineers are crucial in optimizing efficiency and allowing great production demands to be met on-time and to exceed quality standards. Currently, I am heading a new product launch for a major defense company. This involves analyzing and developing a flow for the process and quantifying and declaring every step concisely and thoroughly. My position requires technical translation and good communication skills. It also requires a creative and resourceful mindset which can solve problems. Vaughn and its community provided me with the preparation needed to handle these requirements. I now believe that success is based not simply on knowledge, but more on one's ability to work with others.

Filed Trip and Industry Tour

1. **February 2019, Vaughn's EWB Filed trip to Kibingo, Rwanda (Water Project).**

Students of the Engineering without Boarders-USA Vaughn College chapter took their engineering skills, compassion, and work ethic on the Rwanda mission to provide portable clean water for more than 900 villagers. These future engineers are learning to provide engineering solutions for communities without clean water around the world, while working under the great leader mentorship of Engineering Without Boarders-USA. These professional engineering mentors are the key to providing professional work experience in worldwide projects solutions and engineering applications. Students had their first assessment trip to Rwanda this past February 2019. They used their knowledge of mathematics, science and computer-aided design gained from their classes and applied these skills to a real-world scenario. Analysis of the collected data yielded the following results: the water exceeds microbial limits established by the NPDWS (National Primary Drinking Water Standards set by the United States Environmental Protection Agency).

Microbial contamination (E. coli and other bacteria): 0 mg/L
Turbidity: 5 NTU
Specific Conductivity/Total Dissolved Solids: 500 mg/L
Chlorine: 4.0 mg/L
PH: 6.5-8.5
Nitrates/Nitrites: 10mg/L as Nitrates, 1 mg/L as Nitrites

The water test revealed what was expected from the preliminary assessment before the trip. The current water sources (Lake Kivu, the stream, local springs, existing RWC systems, and the pipeline) are unsafe and inadequate for safe consumption. Students must start crafting an engineered solution system to provide enough clean water to serve over 250 families in the village of Kibingo, Rwanda.

Children from Rwanda and the guest house where the team was hosted while working in the village.

Village conditions where children have to obtain water unsuitable for drinking; after they collect water, they go to their respective school

EWB-Vaughn chapter doing community work during Umaganda (an event held once a month where they come together to accomplish a common goal to help the village); the village Chief Modest.

EWB-Vaugh Chapter with the local school headmaster, Jean Claude. The team met with many local leaders: representative NYANDWI Donathiere, the Executive Secretary of Kibingo Cell. (Photo on right).

2. Field Trip to Brookhaven National Laboratory
April 9, 2019

On April 9, 2019, Dr. Miguel Bustamante, Assistant professor of Engineering and Technology department at Vaughn College of Aeronautics and twelve Learning Community students from Vaughn College's Engineering and Technology Department visited the Brookhaven National Laboratory (BNL) in Long Island, New York. The tour was organized by Jessica Caron, Director of Career services at Vaughn College. The tour included visits to the Superconducting Magnet Division (SMD) and Central Chilled Water Facility.

We met with Karl C. Clarke, our tour guide and BNL liaison, and he explained to the groups the rules and regulations at the site. He also informed students about internship opportunities at the BNL. Our first tour was to The Superconducting Magnet Division of the Relativistic Heavy Ion Collider (RHIC). At the center we met with Joseph Muratore, an expert on the magnetic field. He explained to the students about super-conducting wires and their importance in creating magnets. Students asked many questions of interest toward the subject. The tour continued at the Central Chilled Water Facility where we were greeted by Keith Radich and his coworkers. They conducted a brief on safety followed by a full description of the facility. We had the chance to see Programming Logic Controllers (PLC) being used to control and manage the chilled water towers. Mr. Radich explained to the students that they are about to upgrade the PLC's to new ones and to change the current ladder programming to the Structured Text programming. We have a course at Vaughn College that teaches students structured text programming. Mr. Clarke also insisted that the students apply to the internship for next summer.

The Vaughn College faculty, students, and staff expressed their appreciation to Mr. Karl Clarke, stakeholder Relation Office, Joseph Muratore, Superconducting Magnet Division and Keith Radich of the Central Chilled Water Facility for the exceptional explanation of the facilities of the BNL

BNL Briefing of the facility given by Mr. Karl Clarke and group picture of the students from the Learning Community class.

Joseph Muratore, Superconducting Magnet Division giving the students an explanation on how semiconductors work and on the achievements of the NBL

Keith Radich of the Central Chilled Water Facility explaining how the facility works and how PLC’s are used to maintain the Chilled Water at a constant desirable temperature.

3. SWE Tours to ULC Robotics and Learns about the Utility and Energy Industry

Friday, May 3, 2019, the Society of Women Engineers (SWE) organized an industry tour of the ULC Robotics facility in Hauppauge, New York where they focus on applying robotics and UAV in the utility and energy industries. The ten SWE students attended the tour and had the opportunity to speak with engineers about VTOL automation for the inspection of cable lines and ground robots for the inspection of pipe lines. The students were also given a presentation on the company and its goals. The presenter spoke about possible opportunities for college graduates at the company and how students can apply for positions. After the presentation, the students were given a tour of the facility, during which they were able to see the various projects and ask questions. The students also connected the skills they are developing in school to projects such as 3D Printing, CNC machining, and the use of CAD software such as SolidWorks. This tour opened another door of opportunity for the students, as they learned about the company.

4. Field Trip to Sikorsky, a Lockheed Martin Company, October 11, 2019

Friday, October 11, 2019, 15 students from Vaughn College of Aeronautics and Technology had the opportunity to attend the Lockheed Martin facility tour in Stratford, CT. These students got to see Igor Sikorsky's office and to learn about how the company was founded and how it has evolved over the years. They also learned about the various aircraft the company has developed for different purposes and how they are being used today. Additionally, the tour guide gave an overview on the current projects the company is working on and the job and internship opportunities with the company. Along with learning about the company, the students also had the opportunity to see the production line for the Black Hawks and the King Stallion CH-53K. Students were able to see how various parts of the helicopters are made using different methods such as forging and casting. After the tour of the facility, the students were taken to the simulation lab for the S70 OPV program, where they were given the opportunity to fly the Black Hawk simulation. Overall, this tour provided the students with a comprehensive perspective on this company.

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Career Advisement Day: Career Conversations with Engineering Students
Thursday, September 19, 2019
11 am – 12 pm
Room W155B

The engineering and Technology department hosted a roundtable career advisement day with students in engineering and engineering technology programs. This roundtable discussion with faculty covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn.

Department chairs, faculty and senior students discussed, in detail, the following ten career strategies for obtaining a successful career in STEM fields.

1. Keep Grades Up – Having a GPA of 3 or better increases a student's chances of both obtaining an interview for an internship and employment with many engineering industries.
2. Build hands-on teamwork and communication skills – These career building skills can be attained through hands-on laboratory projects, capstone courses, and involvement in technical clubs (Robotics, UAV, SAE, et) and student chapters of professional societies (SWE, SHPE, EWB, NSBE, LACCEI).
3. Build Analytical and Computer Skills –Analytical and computer coding knowledge and capabilities are two important skills for pursuing a successful career in STEM Fields.
4. Participate in Extra-Curricular Activities – To further enhance career opportunities and cultivate creative ideas, one should consider involvement in extra-curricular activities such as technical clubs, competitions, and STEM workshops.
5. Participate in an Internship Program – Internship programs not only introduce one to the industry environment but also expose one to real-world engineering projects and career-building skills.
6. Participate in Student Chapters of Professional Societies - Involvement in student chapters of professional societies introduce one to innovations in the STEM fields and provide professional networking opportunities with engineering industries.
7. Participate in Technical Club Activities – Involvement in technical clubs such as Robotics, UAV, SAE, increase creativity and provide an opportunity to apply classroom knowledge to the actual building of an engineering system. The creative mindset acquired through these experiences provides a lifelong edge in one's professional career.
8. Participate in STEM outreach activities - Organizing and hosting STEM workshops during Vaughn's Annual Manufacturing Day, Annual International Drone day, SWE Annual Conference, and Vaughn's Regional High School and College Robotics competitions further enhances leadership and career opportunities in STEM fields.
9. Participate in Scholarly Activities - Publications and presentations at technical conferences such as ASEE, SEM, LACCEI, ASME, SWE, AHS, COMSOL, IEEE, and

VCJET integrate career-building skills and contribute to success in professional careers and in continued education.

10. Connect with Vaughn's Career Service Department – We encourage everyone to be in touch with Vaughn's Career Service and to participate in their workshops and events related to resume writing, internships, career fairs, and graduate school fairs.

Finally, I would like to express my sincere thanks to our senior students Sagufta Kapadia (internship with Lockheed Martin), Aderet Pantierer (internship with Boeing), Atif Saeed (internship with Lockheed Martin), Sam Pantierer (internship with SciMax), Abdalmonem Anwar (internship with Pratt and Whitney) who participated in this roundtable discussion and shared their summer internship and extra-curricular experiences with all participating students.

Career Advisement Day with Engineering Faculty and Senior Students, Sep 19, 2019

VAUGHN LEARNING COMMUNITY POSTER PRESENTATION

On Wednesday Oct.16, Dr. Ducharme, the Director of the 2018 Engineering Learning Community is presenting “From Creation to Autonomy: Drone-centered Learning communities at Vaughn” at the 2019 Atlantic Center for Learning Communities Curriculum Planning Retreat in West Hartford, CT, Oct. 16-18, 2019. ***Innovation through Integration: Using Collaboration to Recharge, Renew, and Remain Sane.***

Full time, multi-semester learning communities were recently re-introduced to the engineering major at Vaughn College. At first, instructors were concerned about how we could bring together such diverse courses as Electrical circuits, English, and Physics in the first semester, and Calculus, C++, and Career Development in the second, while still achieving all of the course objectives. However, in the course of the development of our learning community, the faculty developed a signature project that led students from their first semester in which they designed, built, and flew a drone, into their second where they created the coding for an autonomous drone.

At the showcase event at the end of each semester, the students demonstrated a variety of skills, such as oral communication (through presentation of their work to an audience comprised of both specialists and lay faculty), mastery of technical knowledge (through answering technical questions), integrative learning (through applying course content to the creation of the drone), and critical thinking (through solving engineering problems by applying principles of mathematics and science).

This poster highlights the successes of this multi-semester learning community which saw students develop skills in robotics, coding, application of mathematical skills, and technical writing by applying them to this fascinating and interactive public final project.

VAUGHN COLLEGE 2019 COMMON READING SPEAKER SERIES

On Tuesday, Sept. 24, Dr. Baz Dreisinger addressed Vaughn College with a presentation on her book ***Incarceration Nations***, which was the common reading selection for students at Vaughn College in fall 2019. Dr. Dreisinger, a 2018 Global Fulbright scholar, is the founder and academic director of the John Jay College Prison-to-College Pipeline program, offering college courses and re-entry planning to incarcerate individuals. Her work, ***Incarceration Nations*** was named a notable book of 2016 by the ***Washington Post***.

Dr. Dreisinger has also produced on-air segments about global culture for National Public Radio, as well as two nationally-aired documentaries about hip-hop, criminal justice, and the prison industrial complex.

Approximately 130 students were in attendance, and they had the opportunity to communicate their thoughts to her and to ask their questions about her book. She spoke to students after the presentation as well, and she stayed to sign each of their books. After her presentation, students completed a survey focusing on issues related to the question of whether prison works primarily as a "correction" or as a "punishment."

A group of seven highly motivated students were invited to a lunch with Dr. Dreisinger, and throughout the meal, the discussion on restorative justice was engaging and thought-provoking.

Vaughn Students and Dr. Margaret Ducharme with Dr. Baz Dreisinger in the Vaughn College tower, Sep 24, 2019

STEM Day Presentation by Engineering Clubs

Thursday, October 3, 2019
11 am – 12 pm
Room W155B

On Thursday, October 13, 2019, Vaughn's engineering Clubs and professional student chapters (UAV, Robotics, SAE, NSBE, SHPE, EWB, and SWE) hosted a STEM Day presentation to introduce incoming freshman students to their annual professional activities. Each club provided a detailed discussion of their activities as listed below

1. STEM Workshop
2. STEM Outreach
3. Involvement in Student Chapters of Professional Societies
4. Conference Participation, Presentations, and Publications
5. Technical Competitions
6. Accomplishments
7. Career Fairs

They encouraged all students to join them and be involved in Extra-Curricular clubs activities. They emphasized how involvement in technical clubs and student chapters of professional societies, further enhances career opportunities, cultivates creative ideas, introduces one to innovations in the STEM fields and provides professional networking opportunities with engineering industries.

STEM Day Presentation by Engineering Clubs

STEM Workshop for students from Pablo Casals middle school - MS 181

On Friday, October 25th Vaughn College hosted a day of STEM workshop for students from **Pablo Casals middle school** (MS 181) in Co-op City, Bronx, New York City. Two groups of 30 students and 10 mentors were treated to a tour of the Vaughn College Additive manufacturing lab through a series of 3D printing and 3D scanning demonstrations.

Professor Manuel Jesus, Additive manufacturing and CNC curriculum developer, demonstrated 3D printing as a method for rapid prototype development in the additive manufacturing field. Students were shown a diverse range of 3d printing technology including FDM, SLA, and Material Jetting. Part design for 3D printing was explored with SolidWorks, Artec Scan Studio, and Z Brush software. Real time 3D scanning was performed on student volunteers who learned about the use of 3D scanning for reverse engineering and visual effects. Later, students were able to get their scans 3D printed on the Form 2 high resolution SLA printer. After the 3D scanning lesson, a question and answer session was held regarding topics such as course offerings, manufacturing, and computer graphics for video games. After the Q& A session and a quick lunch, students were given tours of the Robotics Club, UAV lab, and hangar bay. Vaughn College students were eager to share their experiences regarding college life at the school and to explain all the club activities and national competitions. At the end of the day, students wished they could have taken their 3D prints home but learned that high resolution 3D parts take some time to print. Vaughn College agreed to mail the final prints and to scan data to the middle school students for use in their own future projects.

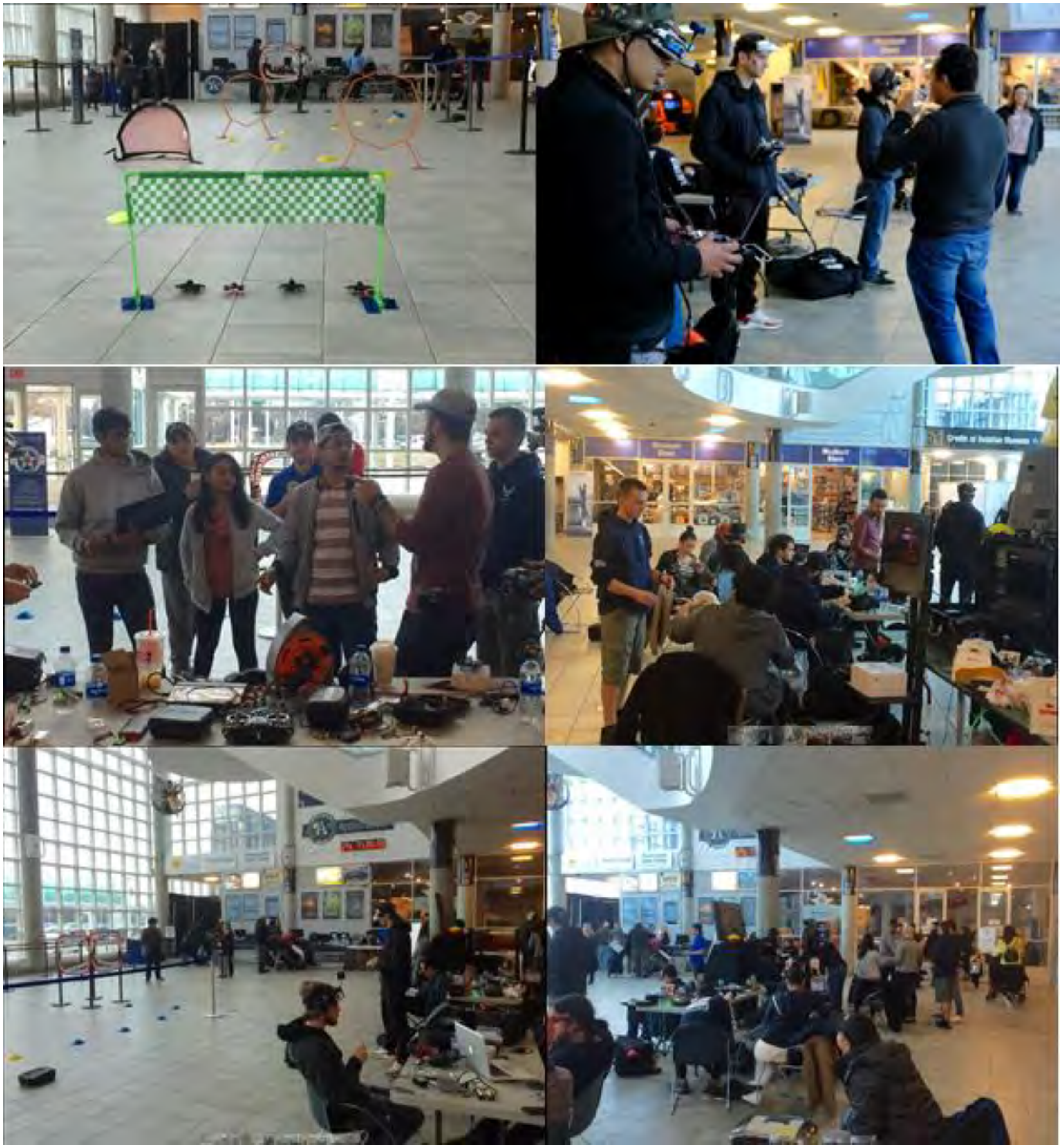
Workshop: Writing a Conference Paper
Donald Jimmo
November 14, 2019

Every year Vaughn Engineering students, with support of their faculty advisors, write papers for engineering conferences such as ASEE, LACCEI, ASME, AIAA, SWE, and others. This is additional work that does not count toward their grade point average. The work is sometimes grueling, frustrating and tedious, but there is always a reward. These papers are reviewed in a double-blind judging process with rejection as a real possibility. And every year, more papers are written by more students, with enthusiasm!

In preparation for the upcoming 2020 conference season, a workshop was held during Common Hour on Thursday, November 14, 2019. The workshop was an informative discussion on the merits of writing a conference paper and twenty students and six faculty attended. Freshmen, sophomores, and seniors from each engineering program attended and interest was high as students and faculty eagerly participated in the discussion. As the workshop concluded thirteen students readily signed up to write conference papers.

Community Outreach Fun Fly and Tiny Whoop Race, Saturday February 1st

The Vaughn College UAV Club hosted its first "Community Outreach Fun Fly and Tiny Whoop Race" event at the Cradle of Aviation Museum on February 1st. The event was free and open to the community. Many drone hobbyists and FPV pilots, as well as the locals from the area, attended the event. All visitors had the opportunity to fly at the event. Some flew their own drone during the free fly period, or during the race to flying drones that UAV club brought for the visitors. The UAV club also held a raffle for a hands-free drones and many excited attendees took part. There were also prizes given to the winners of the races. The hobbyists, the FPV pilots and the Vaughn College students truly enjoyed having the opportunity to fly in the race at the Cradle of Aviation, while the younger children who attended the event had fun flying during the free fly period. The younger attendees also really enjoyed watching the Tiny Whoops go through the hoops and around the obstacles as the pilots raced each other. After the race the attendees were able to free fly again, and many younger attendees enjoyed speaking to the pilots who took part in the race. The event was concluded by announcing the raffle winner and the winners of the race. This event provided the pilots with the opportunity to show off their skills, and it allowed the community to learn more about drones by speaking to drone hobbyists as well as to the Vaughn UAV club.



Community Outreach: Tiny Whoop Race at the Cradle of Aviation, February 1, 2020.

Industry Connection Seminar

Tuesday, April 23, 2019
11 am – 12 pm
Room E101

Topic: Energy-Focused Presentation on Solar Generation
Presenter: Nicholas A. Giannasca and William Friedman of Davis Wright Tremaine LLP

On Tuesday, April 23rd, Mr. Nicholas Giannasca and Mr. William Freidman of Davis Wright addressed the Vaughn community as part of the Industry Connection Seminar series. Following an introduction and welcome from Vaughn College Vice President Dr. Paul LaVergne, Giannasca and Freidman provided a detailed presentation about industry sector programs, featuring energy-focused solar generation.

The Giannasca and Freidman presentation covered an overview of the solar generation market, the basics of how solar generation projects are financed, developed, and operated, and the important legal, economic, and regulatory issues governing solar installation. Their presentation was followed by a 15 minute session of open discussion.

Industry Connection Seminar

Tuesday, September 10, 2019
11 am – 12 pm
Room E101 and E103

Topic: Embraer and Future Trend of Aerospace Industry

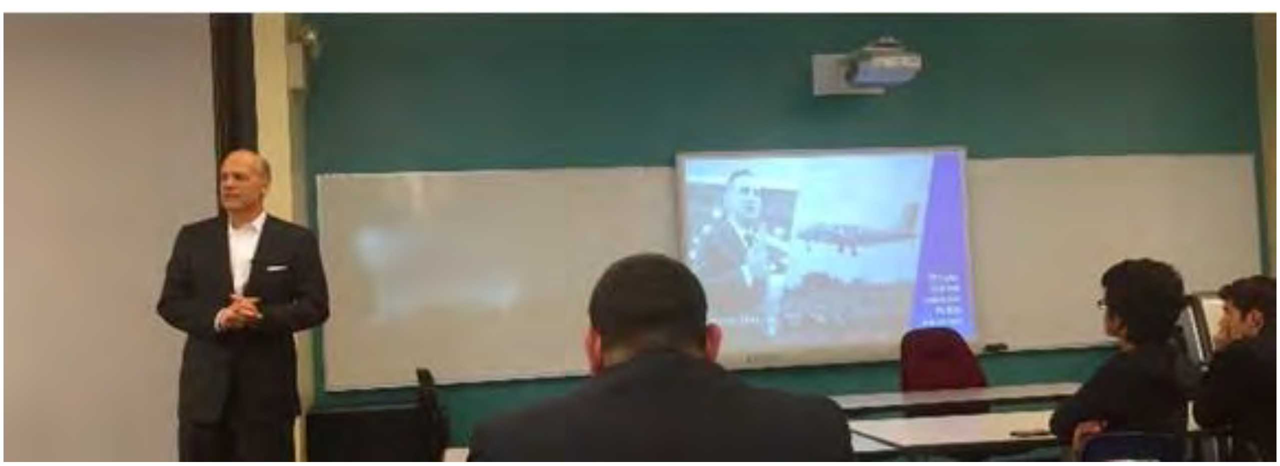
Presenter: Mr. Gray Spulak, President of Embraer Aircraft Holding,

Mr. Gray Spulak, President of Embraer Aircraft Holding, addressed the Vaughn community on Tuesday, September 10 as part of the College's Industry Connection Seminar series. Following a welcome from Vaughn College President Dr. Sharon B. DeVivo, Spulak detailed company plans and strategies including joint partnerships, efficient energy management systems, biofuels and safety, supply chain optimization and the production and maintenance of secure aircraft that operate in high density areas.

Mr. Spulak talked about the history, present state, and future of Embraer Company as one of the world's leading aircraft manufacturers with the broadest portfolio of business jets in the market. His presentation included the following topics:

1. Embraer competitiveness and strategic pathway
2. Embraer Continuous Evolution of E-Jets series
3. Program launch and development of a virtually new design E-Jets E2 (2016) with new engine, new Avionics, new wing, new fuselage, new interior, new landing gear, and entirely new aircraft systems.
4. Flight Plan for 2030 with Embraer^{X} eVTOL, a simple and intuitive air taxi that ensures peace of mind, is community friendly, and is safe.

He elaborated on recent advancements in eVTOL (electric vertical takeoff and landing) aircraft and how these developments can lead to future autonomous operation with partners like Uber. He also talked about engineering and robotics careers with Embraer and encouraged Vaughn's engineering students to take advantage of those career opportunities with his company. His presentation was followed with a 15 minute session of open discussion.




FLIGHT
PLAN
2030


NEW 4TH GEN FULL
FLY-BY-WIRE

Industry Connection Seminar

Tuesday, September 24, 2019
11 a.m. to 12 p.m., Rooms 155B

Presenters: Mr. Edun Sela, CEO of TOM Global, and Ms. Maayan Keren Director of North America TOM Communities.
Topic: The opportunities available to contribute to the world through TOM

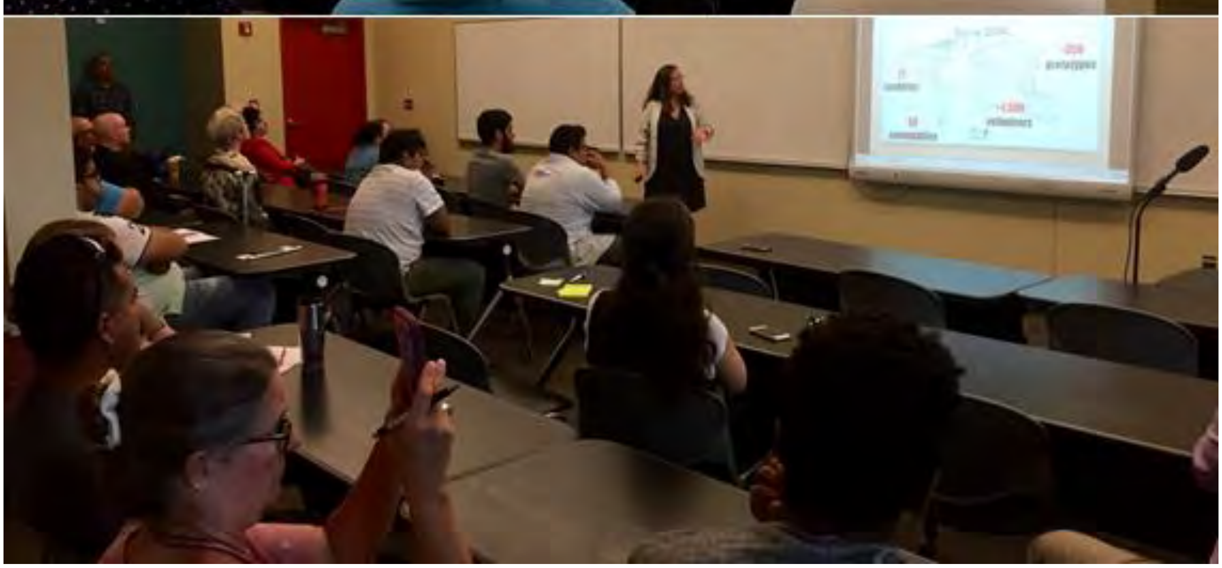
Mr. Edun Sela and Ms. Maayan Keren of TOM Global, addressed the Vaughn community on September 24 as part of Vaughn College's Industry Connection Seminar series with a presentation on Tikkun Olam Makers (TOM) and the opportunities available to contribute to the world through this organization.

Their presentation introduced audiences to the TOM movement, communities, and vision. They explained how “the TOM Movement is made up of local TOM Communities, which create and disseminate affordable solutions to the neglected challenges of people with disabilities, the elderly and the poor. Each TOM Community is comprised of Makers (engineers, designers, developers) and 'Need-Knowers' (individuals with a personal understanding of a neglected challenge)”.

They explained how universities collaborate with TOM to solve the neglected challenges of people with disabilities, and they encouraged Vaughn’s faculty, students and club leaders to join this movement. They also discussed Makeathon, a 2-3 day Maker Event, in which students and faculty of the local TOM’s universities get together to share their prototype projects with students and the local community. At the conclusion of the event, the presenters answered questions from students and faculty.

During the luncheon meeting which followed, the engineering department chair and Vaughn’s technical clubs’ leaders (UAV, SWE, and Robotics) expressed their interest and willingness to work with the TOM’s organization to create a TOM community at Vaughn and to host a Makeathon “maker” event at our college in the near future.


Moonshot
objective



Industry Connection Seminar
Thursday, Dec 5, 2019
11 am – 12 pm
Room W155A
Topic: Entrepreneurship

Presenter: Mr. Ken Stauffer, CEO and Co-Founder of Technology Assurance Labs and Co-Chair of the IEEE Entrepreneurship committee

Mr. Stauffer is an alumnus of our former institution, the Academy of Aeronautics, and he currently serves as the Chair of Vaughn's Board of Trustees. After finishing his degree in Electronic Engineering Technology at the Academy, he went on to receive a master's degree in Electrical Engineering from Polytechnic University in New York City, and he began his career at AT&T Bell Laboratories, which for many years was a major international technology think tank. Currently he is CEO and Co-Founder of Technology Assurance Labs as well as Co-Chair of the IEEE Entrepreneurship committee.

In this seminar, Mr. Stauffer talked about his professional experiences as well as topics related to startups, entrepreneurship, current technology, and engineering education. He talked about the traits of entrepreneurs (Not satisfied with the Status Quo, Curious, Creative, Embrace Risk, Highly Competitive, etc.) and the large company versus the entrepreneurial start-up. He also elaborated on how to move from an idea to a product, intellectual properties protection, the US patent process, product development and marketing, and financing options.

His presentation followed with a 20 minute open discussion session.

Engineering Seminar Series

Tuesday, December 3, 2019
11 a.m. to 12 a.m., Rooms E101

Presenter: Mohammed Hossain, MET Senior Student
Topic: Designing and Modeling Electronic Packages for the Next Gen Overhead Persistent Infrared (OPIR) at Raytheon

In this seminar, Mohammed Hossain, a senior student in the Mechanical Engineering Technology program who participated in a ten-week summer internship program with Raytheon, addressed the Vaughn community about his summer internship project and life-long learning experiences he gained through this project.

Mohammed received an interview and internship offer from Raytheon while he was attending the SHPE 2018 national conference. For this internship program he was assigned to the Hardware Engineering Center's Design team for the task of designing electronic packages on the Next Generation Overhead Persistent Infrared (Next Gen OPIR) program. For this project, he was part of the mechanical team and was responsible for developing designs, prototypes, and baselines for the electronic packages. He elaborated on how the knowledge he gained through courses such as strength of materials, computational engineering, and finite element analysis helped him to successfully complete this internship program.

By the end of his internship program, after presenting a poster board summarizing his responsibilities and activities to all the visiting employees of Raytheon Space and Airborne Systems, a full-time job offer was extended to him from Raytheon's Hardware Engineering Center, upon his graduation in spring 2020. .

His presentation followed with 20 minutes of open discussion.

Industry Connection Seminar

Tuesday, Feb 25, 2020
11 a.m. to 12 p.m., Rooms E101, 103

Presenters: Mr. Matthew Pearce, NASA Education Programs Specialist
Ms. Rosalba Giarratano, Pathways Intern for Space Studies
Topic: An introduction to NASA, NASA Goddard Space Flight Center, NASA Goddard Institute for Space Studies and NASA Internship Opportunities

Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed the Vaughn community on Tuesday Feb 25 as part of the College's Industry Connection Seminar series. Mr. Pearce's presentation gave an overview of NASA, NASA Goddard Institute for Space Studies, and NASA STEM Workforce Challenges. Ms. Rosalba Giarratano talked about NASA's Internship, Fellowship, and other career opportunities with NASA.

Mr. Pearce spoke about the space station opportunities for researchers, students, and educators, NASA climate change research initiative (CCRI), the NASA Moon to Mars mission, and research benefits for humanity. He talked about the current state of the workforce and how NASA research teams are also using drones to measure the urban heat island effect.

Ms. Rosalba Giarratano's presentation provided an insight into current internship options for students, STEM engagement, and NASA's internship application and interview process. Her own experiences as an intern resonated with students. She provided tips to students about what is best to include in their applications, opportunities presented to interns once hired, and the importance of the work they accomplish.

They both encouraged Vaughn’s engineering and engineering technology students to apply for opportunities within NASA’s valuable career-building options. Their presentations were followed by 20 minutes of open discussion with students, as well as a visit to the UAV and Robotics rooms. During this visit, UAV club students shared their recent accomplishments and success at the 2019 Vertical Flight Society (VFS) of Micro Air Vehicle Student challenge competition.

Engineering Seminar Series

Tuesday, March 3, 2020
11 a.m. to 12 a.m., Rooms E101 & E103

Presenters: Ariel A. Ferrera, senior Mechanical Engineering student and Jacqueline Oricchio senior Mechatronic Engineering student
Topics: 1) Designing and analyzing Medical Device such as Reamers and Oscillating Saw Blades, 2) Rolls-Royce Engine Models through 3dsMax

In this seminar, Ariel and Jacqueline, who participated in a ten-week summer internship programs with Stryker and Rolls-Royce, addressed the Vaughn community about this summer internship project and life-long learning experiences they both gained through their projects.

Ariel Ferrera, a senior mechanical engineering student, talked about his assigned tasks with the Stryker (Medical Device Company) in the Research and Development department, where he worked on designing and analyzing medical device tools such has reamers and oscillating saw blades to reduce thermal necrosis in orthopedic knee surgery. For this project, he used finite element analysis and was able to preliminary test design concepts for critical bone cutting tools. He explained how the knowledge he gained through courses such as computational engineering and finite element analysis helped him to successfully complete this internship program.

Jacqueline Oricchio, a senior mechatronic engineering student, talked about her assigned tasks with Rolls-Royce, in the civil and defense aerospace division. Her first internship with Rolls-Royce was in the summer of 2018 when she worked as a Customer and Product Training Intern and her assigned tasks consisted of taking 3d pdfs of engines and making the proper adjustments to them. These tasks included putting components in their proper locations, adding textures to the models, or separating the engines into separate modules. Her second internship in the summer of 2019, consisted of working with the Industrial Engineer team on updating their Optimizers, as well as working directly under the Chief Manufacturing Engineer to make a procedure/policy for lifting, transporting, and presenting parts in two departments.

Both Ariel and Jacqueline explained how the knowledge they gained through technical courses within their degree programs helped them to successfully complete their internship programs.

Their presentation followed with 15 minutes of open discussion.

An overview of summer internship programs with Stryker and Rolls-Royce

Vaughn's 5th Annual Manufacturing Day, Nov 1st 2019, 10 am to 2 pm

The Engineering and Technology department hosted its 5th Annual Manufacturing Day conference on Friday, November 1st to celebrate National Manufacturing Day. Vaughn College invited three industry leaders and two faculty members to address invited guests and the Vaughn community about: manufacturing innovation in the area of Industry 4.0, development of digital Twin, Sensors for Aerospace Industry, additive manufacturing with desktop metal 3D, and Integration of CMM with CNC machining and manufacturing.

Mr. Tony Oran, the Vice President of Sales and Marketing at Festo, talked about industry 4.0 and its impact on the advancement of the manufacturing process. He explained how, in the past decade, modern manufacturing has shifted in a big way because of the Industrial Internet of Things and the fourth industrial revolution (Industry 4.0). Industry 4.0 has ushered in an increasing demand for highly skilled labor. With the implementation of new technologies and processes, industry needs new skill sets. Production workers need to have the competence to implement and manage MES (Manufacturing Execution Systems), Cyber Security, RFID (Radio Frequency Identification), Digital Twins, Smart Sensors, Condition monitoring and Smart Maintenance. There are not enough workers with the skills needed to qualify them for these roles.

Festo and NC3 (National Coalition of Certification Centers) have teamed up to fill this gap through the Festo Industry Certification Program (FICP). The Festo/NC3 Industry 4.0 Certification Program is a comprehensive certification program developed by industry experts and educators that ensures students have qualifying skills upon completion in the areas mentioned above, including soft skills such as effective communication, managing others, and critical thinking. FICP is easily integrated with existing certificate, associate's and bachelor's degree programs, and offers three levels of stackable credentials. These skills will enable manufacturing to move into the 4th Industrial Revolution to keep pace with the growing demands of flexible and efficient production.

Our second guest speaker, Mr. Michael Robinaugh, Director of Global Channel Sales Development for Dassault Systemes, talked about the development of the Digital Twin and the advantages of having the 3D model "at your fingertips". He provided a brief background about his responsibility as a director for all "Digital Enterprise Lean Manufacturing Interactive Application" (DELMIA) channel sales through Dassault Systemes' worldwide network of business partners. Since January 2000, Dassault Systèmes formed DELMIA as a brand for digital manufacturing and production solutions. Dassault Systèmes DELMIA is a Global Industrial Operations software that specializes in digital manufacturing and manufacturing simulation. He explained how 3D simulation, digital production, and manufacturing through Dassault Systèmes' 3D Experience is the factory of the future.

Our third presenter, Mr. Carlo Asaro, Senior Aircraft Avionics Engineer with Sikorsky, talked about sensors for Aerospace and Industry. Sensors are the most important components for aerospace and industrial applications, because without them it would not be possible to control a machine or any equipment that requires a system process. In the aerospace industry, sensors are the nervous system of an airplane, rocket, or satellite, etc. The difference between aerospace and industrial applications resides in the quality, qualification and packaging of these parts. Sensors for industrial application are more economical, because they don't need special qualifications such as EMI, Vibration, Radiation, etc. These are a few of the reasons that the manufacturing of sensors for aerospace application is more complex and expensive. Moreover, industrial sensors, don't need special packaging metal protections, since most of them are constructed using hard industrial grade plastic which makes the fabrication fast and inexpensive.

Leadership Session of Manufacturing Day Conference – Presentation of Industry Leaders

Our fourth presenter, Prof. Manuel Jesus, CNC and 3D curriculum designer, talked about the future of additive manufacturing through Metal X 3D printing. Prof. Jesus' presentation covered the price, reliability, and resilience of the 3D Metal X system as well as its minimum HVAC reliance. The addition of this 3D printer will help Vaughn's UAV, SAE, and Robotics clubs as well as capstone degree project students to develop more reliable machine parts and components for their technical projects. Our last presenter, Mr. Rachid Nafa, CNC lab specialist, talked about the integration of the Coordinate Measuring Machine (CMM) in the CNC machining and manufacturing process. He explained how sa coordinate measuring machine has a probe sense device that measures the geometry of physical objects on the surface of the milled components. Hence, integration of CMM helps to develop a CAD/CAM design with high accuracy for CNC machining and manufacturing.

In conclusion, Dr. Rahemi, expressed his sincere gratitude to all guest speakers, industry advisory members, and invited guests for their participation at Vaughn's 5th annual manufacturing day conference as well as for their continuous support of every aspect of the department and institution.

Faculty presentation to invited guests and Vaughn community

STEM Outreach Workshops

In a parallel session, from 10 am to 2:00 pm, Vaughn's UAV, Robotics, SWE, and NSBE clubs organized and hosted STEM workshops on CAD, building a drone, robotics design, and autonomous programming for the high school students from Westbury, Bayside, Thomas Edison, and Hillcrest high schools. The Build a Drone workshop introduced participants to the building and manufacturing process of flying robots. A drone practice flying session allowed the participants to fly their drones in the Vaughn hangar flying arena. Overall, students had the opportunity to experience the different disciplines of engineering. The robotics club conducted a workshop related to robotic design using SolidWorks and instructed students in the structural design process necessary for the creation of a robot that will perform quickly and accurately during a competition.

In conclusion, Dr. Rahemi thanked all participants and the support provided by the Department of Education federal fund as part of Title III, Part F, HSI-STEM and Articulation grant.

UAV, SWE, NSBE, and Robotics Workshops Session

Vaughn’s STEM Day Workshop
March 6, 2020, 10 am to 2 PM

The engineering and technology department hosted its second Annual STEM Day workshops for community college students on Friday March 6.

This event introduced participants to the following STEM related activities

- **Welcome:** A presentation of Vaughn College's program offerings and student involvement in professional and scholarly activities.
- **Avionics Workshop:** Introduction to avionics with hands-on experiences related to aircraft radar, communication and navigation systems.
- **3D Printing and Additive Manufacturing Workshop:** Introduction to 3D and surface modeling using Solid Works and CATIA with 3D additive manufacturing processes.
- **Student STEM Engagement:** Introduction to student engagement in technical clubs, competitions, conference participation, presentation and publications.
- **Build A Drone Workshop:** Introduction to building and manufacturing processes of flying robots.
- **CNC Workshop:** Introduction to HASS VF-2SS CNC milling and cutting machine, Okuma lathe machine, Coordinate Measuring Machine (CMM), and manufacturing processes.

The participants of Vaughn’s STEM Day workshop were students and faculty from Passaic, Queensborough, Bergen community colleges. In the morning session, Vaughn’s STEM Pathway Liaison and STEM project director, Dr. Hossein Rahemi, talked about Vaughn College’s program offerings in engineering and engineering technology disciplines as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 11:30 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. From 11:30 pm to 12:30 pm, Prof. Manuel Jesus, CNC and Additive manufacturing Curriculum developer, hosted a workshop at Vaughn’s 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines.

During the lunch break, Vaughn Mechatronic's junior student, Sagufta Kapadia and two other engineering students talked about their experiences and after-class involvement in professional clubs, as well as their conference participation, presentations and publications. They emphasized how involvement in both technical competitions (Robotics and UAV) and scholarly activities helped them to get several internship offers as well as full-time positions with companies such as Lockheed Martin, Boeing, Easy Aerial, Northrop Grumman, and others.

In the afternoon session, from 1:00 pm to 2:00 pm, Vaughn's UAV and SWE clubs engaged participants in hands-on STEM workshops sessions on design and building a drone for UAV competitions (VFS Micro Air Vehicle Student Challenge and AUVSI-SUAS). Finally, from 2:00 pm to 3:00 pm, Vaughn's CNC lab specialist, Mr. Rachid Nafa, introduced participants to a hands-on session on part design and manufacturing process using HASS VF-2SS CNC milling machine, Okuma lathe machine, Coordinate Measuring Machine (CMM).

Acknowledgement: In conclusion, Dr. Rahemi, thanked all partner institutions for their participation and expressed his sincere gratitude to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support for laboratory development to engage students in manufacturing hands-on activities that are current with today's industry standards. .

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Vaughn’s International Drone Day, May 4, 2019 10 am to 3 pm

On Saturday, May 4, 2019, the engineering and technology department hosted several drone and robotics workshops such as CAD Modeling of Quadcopters, Build a Drone, Programming with Python, and Robotic design and programming for International Drone Day. The event allowed visitors and students to design, build, and test their own drones in the netted flying arena of the college hangar.

These workshops, organized by the engineering and technology department and the Unmanned Aerial Vehicle (UAV) and Robotics clubs, were coordinated in an effort to raise awareness of these flying devices. The CAD workshop provided participants with insight into 3D design and the modeling of Quadcopters. The Build a Drone workshop introduced participants to the building and manufacturing process of flying robots. The Python workshop introduced participants to programming and coding with Python, and the Robotics workshop provided participants with insight into design, modeling, and programming of a robot.

In a parallel session, the UAV club organized a drone practice flying session, and the participants were able to fly their drones in the Vaughn hangar flying arena. The participants for the workshops and drone flying session were invited guests and students from New York City and Long Island high schools. Vaughn’s UAV team flew their drone, which had been selected by the Vertical Flight Society (VFS) as a finalist in both remote control and the autonomous categories of the 2019 VFS Micro Air Vehicle (MAV) competition. This MAV competition will take place on May 13, 2019 at the University of Pennsylvania. This is a challenging competition in which only the top teams with supporting documentation and videos proving their drones can complete the tasks are invited as finalists to compete in the Annual Vertical Flight Society Micro Air Vehicle (MAV) competition. For the manual control competition, Vaughn College, Drexel University, and University of Maryland were selected as finalists, and for the autonomous competition, Vaughn College, Penn State, and University of Maryland were the selected finalists.

Vaughn’s UAV team provided a brief presentation of their drone design and programming in preparation for the 2019 VFS MAV competition. They explained their drone design and construction process, which employs 3D printing parts and autonomous programming, to the participants of Vaughn’s International Drone Day. Also, service awards were presented to the current graduating UAV president (Chamathke Perera) to celebrate his contribution and accomplishments in the advancement of Vaughn’s UAV team.

In conclusion, Dr. Rahemi thanked all participants, clubs’ members, and support provided for STEM workshops by the Department of Education federal fund as part of Title III, Part F, HSI-STEM and Articulation grant.

Workshops: CAD Modeling of Quadcopters, Build a Drone, Python Programming, Robotics, and Drone Panel Discussion - Vaughn's International Drone Day, May 4 2019

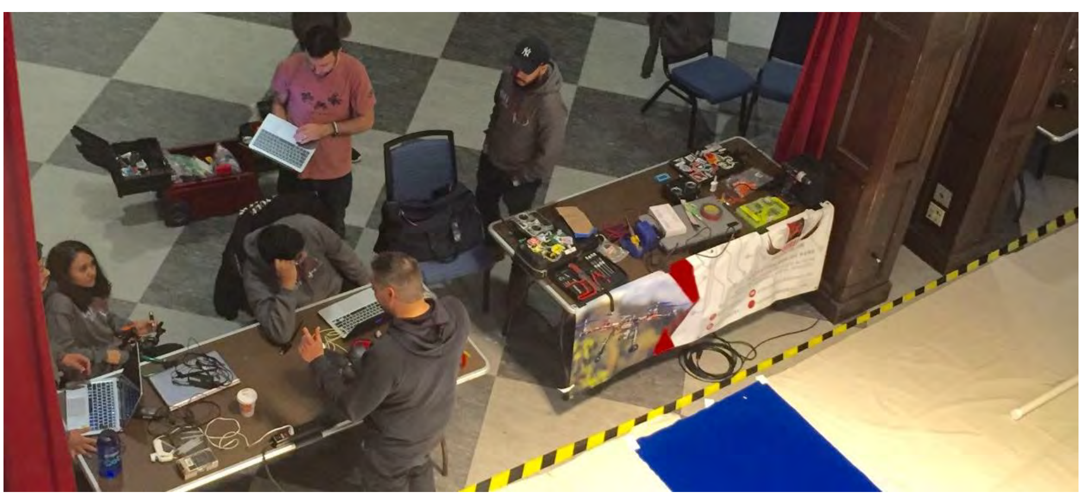
Drone practice flying session in the Vaughn hangar flying arena, May 4, 2019

Vaughn's UAV team participated in the Vertical Flight Society Micro Air Vehicle (MAV) competition, May 13, 2019 - Vaughn's UAV team received 2nd place award at the 2019 MAV Student Challenge Competition

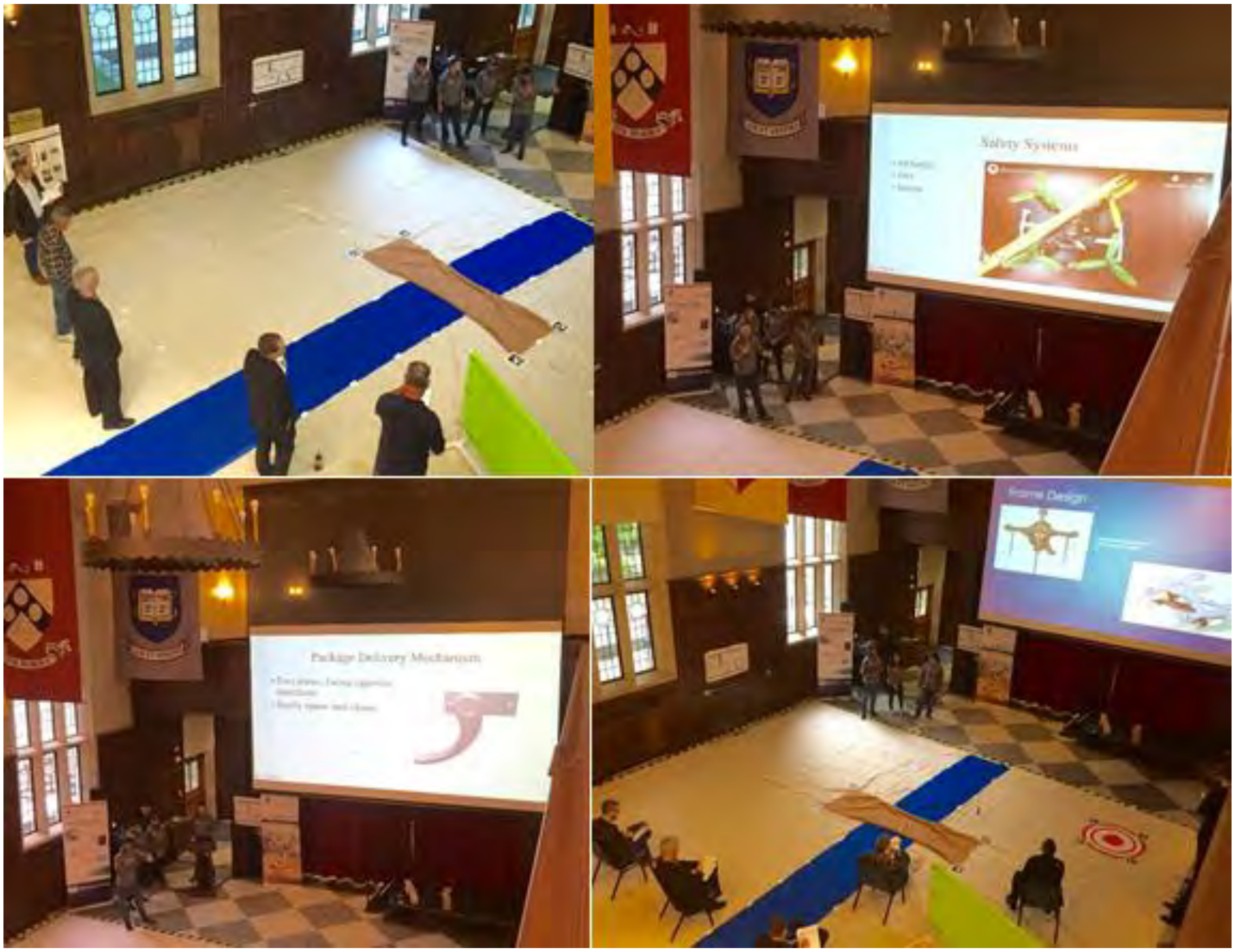
Vaughn's UAV team project was selected as one of the finalists along with Penn State, Drexel University, and University of Maryland to participate in the 7th annual Micro Air Vehicle (MAV) student challenge competition at the University of Pennsylvania on Monday, May 13, 2019. Vaughn's UAV team developed two drones to compete in both manual and autonomous categories. Both drones were designed to perform vertical takeoff & landing (VTOL) with onboard flight-stabilization and camera. The drone's weight should be less than 500 grams and should have delivery, pickup, obstacle avoidance, and hover/landing capabilities. Vaughn's drones are designed to be lightweight, while not sacrificing their autonomous, computational and flying control.

For both the autonomous and manual challenges, a drone with a package will take off from a base station, move around an obstacle and drop off the package on a pre-identified delivery station. The drone will then takeoff from the delivery station and land on the pickup station to picking up a 2nd package to then finally fly back to the base station to land and deliver that package. Among all participating teams, only teams from Vaughn College and the University of Maryland were able to complete the remotely-operated tasks within the ten-minute time limit. For the autonomous session, both Vaughn College and the University of Maryland were able to fly their drone with vertical takeoff and partial hovering around the field. Both Vaughn teams were invited to attend the Tuesday evening award ceremony.

On Tuesday May 14, Judges from aerospace industries evaluated the teams' performance for both the remote and autonomous control categories. Maryland's UAV teams received the highest score in both categories and received the 1st place award and Vaughn's UAV teams received the 2nd highest scores thus receiving the 2nd place award for both remote control and autonomous categories with a $1750 check. Seven members of the Vaughn College UAV team (Muhammad Galib, Chamathke Perera, Sagufta Kapadia, Syed Misbahuddin, Peter Kalaitzidis, Andrew Jairo Ramos, and Kevin Gonzalez) all participated in the 2019 VFS-MAV student challenge competition.



Drone Inspection and Preparation for Matches



Vaughn's Manual and Autonomous Team Presentation to Judges

Group Picture with Participating Teams

Award Ceremony: Vaughn's UAV received 2nd place awards in both remote control and autonomous categories in the 2019 Vertical Flight Society Micro Air Vehicle (MAV) Student Challenge Competition

Vaughn's UAV team at the 2019 AUVSI SUAS Annual Competition ranked 24th on Mission Execution and 26th Overall

The Vaughn UAV team participated for the first time in the AUVSI-SUAS Annual Competition at Webster Field, Patuxent River Naval Air Station in Maryland, June 12-15, 2019.

In order for a team to qualify, the competition requires that they demonstrate the following elements: Proof of Flight documented by a video; Safety Pilot Log of three hours of manual flying including 10 take-offs and landings; and Flight Readiness Review delivered within a video presentation detailing the testing results and the team's competition preparedness.

In this year's competition, 75 top-recognized national and international engineering schools (Harvard, Cornell, Virginia Tech, UCLA, Penn state, University of Maryland, and many others) qualified, but only 47 teams were flight-ready by registration day. The Vaughn UAV team passed all of the requirements and was one of the 47 teams qualified to fly in the competition.

The 2019 competition mission is for the team to deliver a package to a customer using an Unmanned Aerial system (UAS). The UAS must follow a prescribed path, avoid obstacles such as buildings, identify potential drop locations, drop the package to a safe location via a rover, and then autonomously deliver the package, via rover, to the customer's location.

All teams must also pass a preflight safety inspection through which they identify their mission communication protocols, safety pilot, and mission safety plan. The flight order was determined by lottery among the participating teams, and Vaughn's team flew as the 38th team.

Vaughn's UAV team was set to fly on June 15th at 7:00 am. Even though the team members confronted many challenges, they managed to achieve multiple milestones, such as: taking off to above 100 ft and hovering autonomously, executing the required communication protocols, and achieving a safe landing without crashing. This demonstration put the team in 24th place on Mission Execution and 26th place overall.


Eight members of the Vaughn College UAV team (Aderet Pantierer, Sagufta Kapadia, Syed Misbahuddin, Muhammad Galib, Chamathke Perera, Peter Kalaitzidis, Juan Rodriguez, and Shumul Pantierer) and two advisors, Dr. Amir Elzawawy and Prof. Ryan Tang represented Vaughn College at this competition. In the words of Dr. Elzawawy, the club advisor: "This is quite an achievement for the UAV club, which was established only 4 years ago, and we have now, for the first time, participated in one of the most challenging international UAV competitions. We have learned many design and mission techniques in our first year, and we will now improve going forward." He also highlighted the judges' comments praising the team's professionalism and strong safety awareness.

Vaughn's UAV team at the 2019 AUVSI SUAS Annual Competition

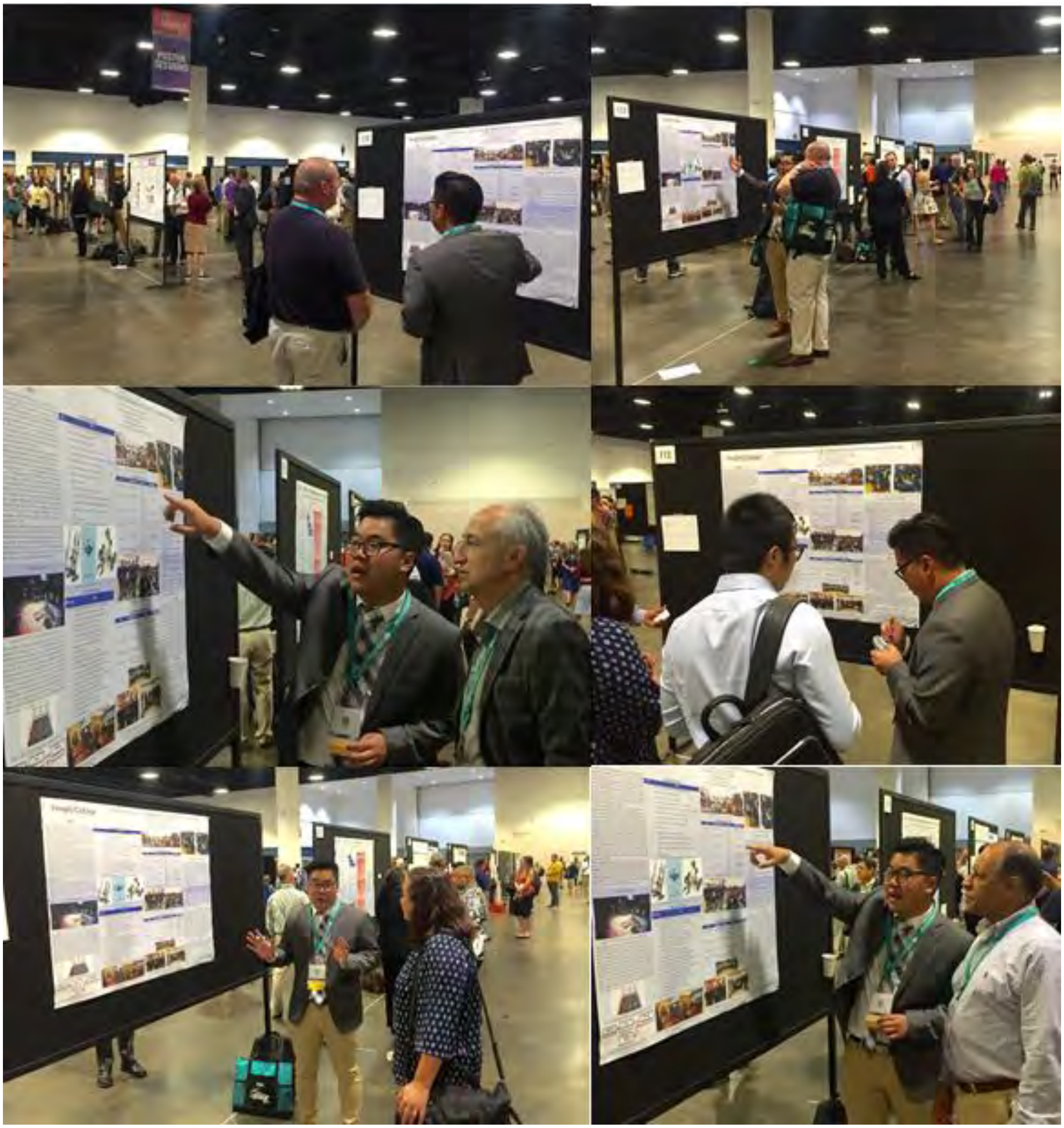
Dr. Rahemi expressed his appreciation for the support provided by the Department of Education federal fund as part of the Title III, Part F, HSI-STEM grant, making it possible for our institution to engage students in every possible STEM related activity and competition.

Vaughn's engineering students and faculty present their research projects at the 2019 ASEE Annual Conference and Exposition.

From June 17 through June 20 Vaughn faculty and students attended the American Society for Engineering Education (ASEE) 126th annual conference in Tampa, Florida.

On Monday, June 17, Vaughn students Niki Taheri and Atif Saeed presented their project paper "**Early Learning Braille Block Language System**,**"** during the **Manufacturing Session** of this annual gathering. Their presentation detailed the development process of a braille block language system for people who are blind or visually impaired. The main objective of their project is to develop an inexpensive, small, user-friendly braille cell learning device. Their presentation covered braille block language design concept, working mechanism of design, manufacturing process using 3D printing, and electrical construction and Arduino software design of the braille block.

On Tuesday, June 18, Vaughn faculty Prof. Ryan Dan Tang presented his STEM Robotics project **"A STEM Training Program to Improve High School VEX Competition Outcomes,"** during the Pre-College Engineering Education Division Poster Session of ASEE annual conference. His poster detailed the topics, syllabus, and methods to prepare and engage middle school and high school students with the hands-on VEX robotics competition. The project is focused on preparing students for the VEX robotics competition through working with experienced VEX Competition team members after-school and weekends during the school year. This was a one-year training program including courses in principles of mobile robots, engineering design, computer aided design (CAD), mathematics, physics, computer programming, and technical writing.



From June 17 – 20, the Department Chair, along with two other Vaughn engineering and technology department faculty members, attended the 2019 ASEE annual conference and participated in sessions related to Manufacturing, Curriculum, ABET accreditation, and technical expertise at this annual gathering.

We at Vaughn College are thankful to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) for providing necessary funding support to engage students in scholarly and STEM related activities

Vaughn's Engineering Faculty and Students Participated in LACCEI2019 Conference; Vaughn's Students Take First, Second, and Third Place in LACCEI 2019 Paper session Competition and First Place in Poster Session Competition

From July 23-26, Vaughn's engineering and technology students, along with Dr. Hossein Rahemi, engineering Department Chair and faculty members Dr. Mohammed Benalla and Prof. Khalid Mouaouya attended the LACCEI 2019 Conference in Montego Bay, Jamaica. Six Vaughn student team research papers were accepted for presentation and publication in the LACCEI 2019 international conference. Five Vaughn student papers, as listed below, were selected to compete among ten finalists for the student paper session, and all six submitted papers were also accepted for the poster session of LACCEI 2019.

Finalists for LACCEI Paper Session :

1. Vehicle Design For Formula SAE 2019 Competition by Ryan Lewis and Andriy Belz
2. Smart Braille Learning Block Systems by Niki Taheri and Atif Saeed
3. Autonomous Search and Rescue Project (ASAES) by Ryan B. Tang Dan
4. Walking Wise Camera Sensor Smart Cane by Jevoy James, Richi Ramlal
5. A Study of Notched Beam Stress Concentration by Aderet Pantierer and Shumul Pantierer

From 11 am to 1 pm on Thursday, July 25, five of our student team papers, as listed above, were presented to the international conference audience during the student paper session of LACCEI 2019.

Ryan Tang's paper addressed the design and development process of an **Autonomous Search and Rescue UAV for the 2019 AUVSI-SUAS Annual Competition** that took place at Webster Field, Patuxent River Naval Air Station in Maryland, June 12-15, 2019. The 2019 competition mission was for the team to deliver a package to a customer using an Unmanned Aerial system (UAS). The UAS had to follow a prescribed path, avoid obstacles such as buildings, identify potential drop locations, drop the package to a safe location via a rover, and then autonomously deliver the package, via rover, to the customer's location. Judges selected Ryan's paper as a first place award recipient in the 2019 LACEEI student paper session competition.

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Taheri and Saeed talked about their **"Smart Braille Learning Systems"** project. Their presentation detailed the development process of a braille block language system for people who are blind or visually impaired. The main objective of their project is to develop an inexpensive, small, user-friendly braille cell learning device. Their presentation covered braille block language design concept, working mechanism of design, manufacturing process using 3D printing, and electrical construction and Arduino software design of the braille block. Judges selected Taheri's and Saeed's paper as the second place award recipient of the 2019 LACEEI student paper session competition

James and Ramlal presented their Smart Cane project. Their paper presentation covered the design, development, and manufacturing process of the Smart Cane and its benefit for people who are blind. Judges selected James' and Ramlal's paper as the third place award recipient in the 2019 LACEEI student paper session competition.

This was a great accomplishment for Vaughn's engineering students to receive all top three awards (first, second, and third place) in the student paper session competition of the 2019 LACCEI Conference.

LACCEI2019 Student Paper Session Presentation

Lewis and Beltz's paper was one of ten finalists, and it provided a detailed presentation about the design of a vehicle for the Formula SAE 2019 Competition. Their paper addressed the design of a Chassis, Drive Train, Air Intake System, and Suspension system. They also discussed the safety of a vehicle Chassis structure using CATIA finite element.

Finally, the Pantierer paper addressed the development process of the stress concentration factor of a notched beam due to combined axial and bending loads. They used both CATIA and Patran-Nastran finite element to develop a factor of safety graph based on the variation of distance between two notches and notch radius. As part of their future work, they are planning to use an Instron Tensile machine to determine the stress concentration factor of a notched beam due to combined axial and bending and compare these to results obtained through CATIA and Patran-Nastran.

LACCEI2019 Student Paper Session Presentation

LACCEI 2019 Poster Competition

From 2:30-4:30 pm on Thursday, July 25, a total of 30 posters were presented during the poster session of the LACCEI 2019. Vaughn's Engineers Without Border poster **"Rwanda Potable Water Project"** presentation by Samantha Maddaloni provided insights into Vaughn's Engineers Without Border activities as well as to their very first water Project and trip to Kibingo, Rwanda. This project defined what EWB stands for: "Making a better and sustainable future for people." Their team, along with their Faculty Advisor Dr. Bustamante, visited Rwanda in Feb 2019 and inspected the quality of water. During this ten day trip, they developed and implemented a plan for a sustainable, highly reliable water system for the residents of the area. She explained how EWB team immediately got to work and involved themselves in the community. The first step was to understand the issues faced by the local community, in order to appreciate how important and essential this work is to them. The skills we learned from the water testing workshop at Vaughn were put to the test when we started testing different local bodies of water. She shared how successful for the community and how educational for the EWB students this mission proved to be.

LACCEI2019 Student Poster Session Presentation

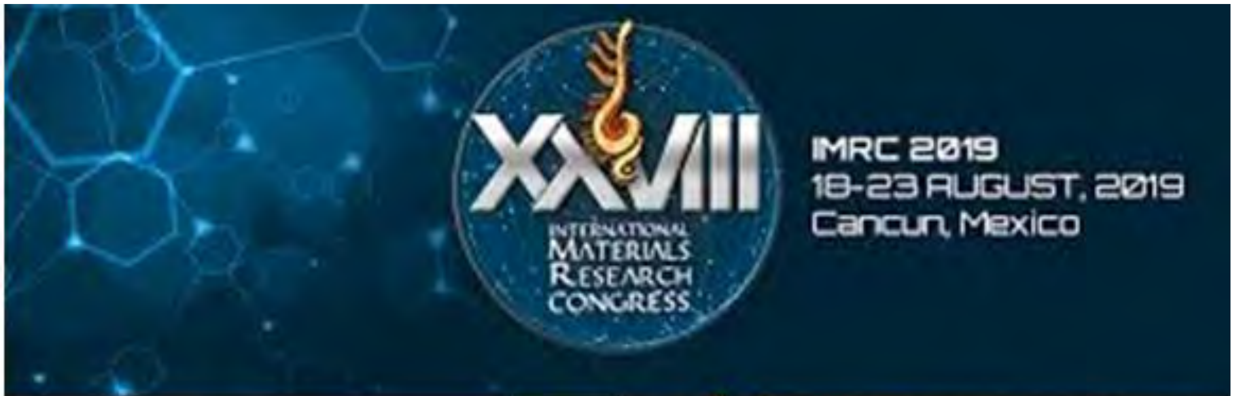
Gala Dinner

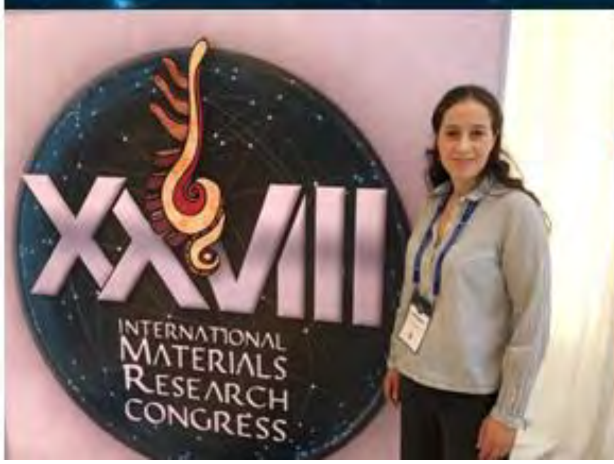
During Thursday's Gala dinner gathering, award recipients for the best paper and poster presentations were introduced. This year, all top three awards (first, second and third place) for the best paper presentation in the student paper session competition were presented to Vaughn's engineering students. The "**Autonomous Search and Rescue Project"** by Ryan B. Tang Dan won the first place award; the **"Smart Braille Learning Systems"** by Niki Taheri and Atif Saeed won the 2nd place award; and the "**Walking Wise Smart Cane"** by Jevoy James, Richi Ramlal, and Nizamadeen Khedaru won third place award of LACCEI student paper session competition.

Vaughn's Engineers Without Border poster **"Rwanda Potable Water Project"** by Samantha Maddaloni received the **first place** award for the best poster presentation of LACEEI 2019 poster session competition.

Vaughn's Engineering students receiving their awards for the best presentation of student paper and poster sessions competitions from executive director of LACCEI, Dr. Maria Petrie.

Group picture with awards recipients, judges, and faculty mentors





XXVIII INTERNATIONAL MATERIALS RESEARCH CONGRESS - IMRC 2019

Assistant professor Dr. Ghania Benbelkacem attended the 28th International Material Research Congress IMRC held in Cancun, Mexico from August 18th to 23rd, 2019. The congress is organized by the Sociedad Mexicana de Materiales (SMM) and the Materials Research Society (MRS). The goal is to offer a range of symposium topics of interest to the material research community. Presentations, special events, technical sessions and tutorials were held in different symposiums. From Nanotechnology and Biomaterials to Structural Materials and Metallurgy, the meeting provides an opportunity for interaction and exchange of ideas among researchers and students from different countries.

Among the talks Dr. Benbelkacem attended one was “Supported transition metal nanoparticles: what makes a good catalyst”. The speaker presented some recent examples of research based on relatively noble metal catalysts, Au, Ag and Cu used for industrially relevant processes. Catalysts are necessary for the production of fuels, chemicals and materials, and for energy storage and conversion. They consist of transition metal nanoparticles as an active phase, supported on a porous material that provides stability to the system. The effectiveness of a catalyst is a combination of three parameters: activity, selectivity, and stability. The speaker demonstrated how the interplay of different structural parameters allows a more systematic understanding of what determines the effectiveness of a catalyst under realistic reaction conditions.

The speaker for “Solid-liquid interfaces: a new surface science frontier” highlighted new techniques and methods used to study detail interfaces in atmospheric environments and in electrolytes for energy (batteries), and photoelectron-chemistry. He presented current progress in liquid interface research, covering topics such as the melting of ice near the triple point, segregation of ions to the surface of droplets of saline solution, growth-wetting films on surfaces, and the electrical double layer in electrified solid-liquid interfaces.

One of the plenary presentations Dr. Benbelkacem attended was entitled “Recipe for 3D printed stable Nanocrystalline Metals”. It gives an answer to the next generation of lightweight extreme-performance metal parts that lies at the intersection of two emerging technologies: 3D printing – to take advantage of infill architectures and optimized component geometries, and stable nanocrystalline metal – to achieve near-theoretical optimal mechanical properties. The speaker developed the steps and requirements from basic science to engineering development, in order to achieve this combination of optimum material and geometry. The 3D printer using different alloys is now available as desktop Metal studio 3D printing.

Other than plenary sessions and presentations, the congress offers tutorials, technical sessions, and exhibitions about current methods and devices. Dr. Benbelkacem attended the “Additive manufacturing (AM) and non-destructive test by computed tomography for aerospace industry” tutorial. She was given clarifications about where and when AM technologies are suitable to develop new products. In addition, she was informed about new horizons in technology from the material science viewpoint.

Dr. Benbelkacem attended the technical session presenting “Labscale production and rheological characterization of advance polymer material”. This session showed the workflow for the development of advanced materials as polymer composites, as well as their small-scale production and rheological characterization.

In addition, Dr. Benbelkacem attended a special event entitled “Research Funding Opportunities” presented by the U.S Army, Navy and Air Force. These speakers presented the possibility of funding fundamental research and indicated the processes to follow. Information is an important key to obtain grants for future research projects.

Furthermore, Dr. Benbelkacem learned about specific fields in Material research and benefitted from her experience at the XXVIII International Material Research Congress - 2019. This meeting is a potential destination for some of Vaughn College’s future students to present their work in a poster session and to meet with other students from around the world.

Poster session at the XXVIII International Material Research Congress - 2019

Vaughn College Students Participating at COMSOL Multiphysics Conference in Boston, October 2-4, 2019

Two Vaughn Mechanical Engineering students, Johnny Atreaga (class of '19) and Deron Hurely (class of '19), along with their advisor, Dr. Amir Elzawawy, participated in the 2019 COMSOL Multiphysics conference. The conference was held in Boston from October 2nd-4th, 2019. Vaughn's students presented their senior capstone project "Design and Fabrication of Small-Scale Supersonic Wind Tunnel" in both the poster and oral presentation sessions of this annual gathering.

Atreaga's and Hurely's project detailed the design, development, and fabrication of small-scale supersonic flow technology used for testing and analysis of aerospace structures and components at speeds greater than Mach 1. In terms of infrastructure, a compression configuration is vital in producing the difference in pressure required to achieve flow greater than the speed of sound, along with the desired convergent-divergent nozzle geometry. Modeling is conducted using CAD software, followed by analytical calculation using CAE and FEA. Construction and fabrication is conducted using CNC. Assembly and testing occurs after the model has been finalized.

2019 COMSOL Multiphysics Conference, Boston, October 2-4, 2019

2019 International Mechatronics Conference & Exhibition, Oklahoma State University, October 22 – 25, 2019

From October 22-25, two Vaughn Mechatronic Engineering students, Syed Misbahuddin and Sagufta Kapadia, participated and presented a paper in the 2019 International Mechatronics Conference & Exhibition at Oklahoma State University (Stillwater, Oklahoma). Their Paper entitled "Autonomous Position Control of an Unmanned Aerial Vehicle (UAV) Based on Acceleration Response for Indoor Navigation" was presented during the Mechatronics Applications technical session of this international conference.

Misbahuddin's and Kapadia's presentation detailed the implementation process of an autonomous indoor drone navigation system, including the inability to use a Global Position System (GPS). As of now, Unmanned Aerial Vehicles (UAVs) either rely on 3D mapping systems or utilize external camera arrays to track the UAV in an enclosed environment. This research introduces an algorithm that allows the UAV to be navigated indoors using only the flight controller and an onboard companion computer. In this paper, open source libraries are used to control the UAV, which will only use the onboard accelerometer on the flight controller to estimate the position through double integration. One of the advantages for such a system is that it allows for low-cost Micro-Aerial-Vehicles (MAV) to autonomously navigate indoors without advanced mapping of the environment or the use of expensive high-precision-localization sensors such as 360° LIDAR. The algorithm also allows easy integration of additional systems such as computer vision and package delivery for a complete autonomous MAV.

Judges selected their paper for the Best Presenters Award of the Mechatronics Application technical session.

Vaughn Mechatronic Engineering students participated in paper and poster sessions of the 2019 International Mechatronics Conference and received the Best Presenters Award

Vaughn College Professor Presents Educational Research Paper at 2019 ASEE Mid-Atlantic Conference

November 1-2, 2019 ASEE Mid-Atlantic Conference, Engineering for Everyone*,* is held at the Cooper Union, Manhattan, NY. Dr. Shouling He attended the conference and presented a paper entitled “Integrating Linux and ROS in Mechatronic Engineering Education”. ROS (Robot Operating System) is being developed into the standard middleware for robotics applications. The searchers and practitioners world-wide contribute their results and publish software packages for ROS. Hence, a large number of state-of-the-art robotics algorithms become available for free use on the ROS platform. However, ROS runs on Linux Operation System (OS), which requires students gain more programming skills and know more about Linux OS. This paper introduced the practices of teaching Linux OS and ROS for Mechatronic Engineering students at Vaughn College. After her presentation, Dr. Shouling He discussed educational ideas with a number of educators.

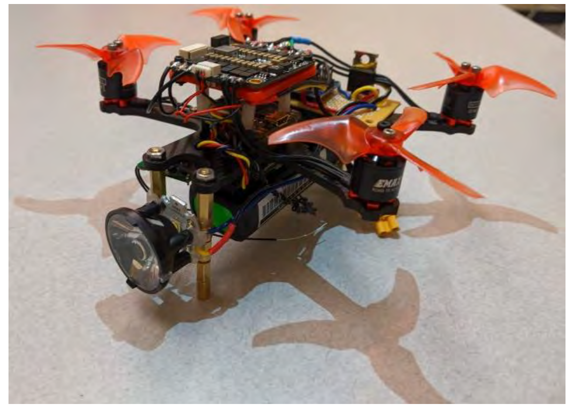
During the conference, the attendees visited the Material, Acoustic, Biomedical, Process Control, Robotics and Unmanned Aerial Vehicle laboratories at Cooper Union. Professors and students from NYU, Pennsylvania State University, Stevens Institute of Technology, Unite States Military Academy, Coast Guard Academy, New York City Tech, Howard University and CUNY Graduate College attended this conference.

AIAA Region I Young Professionals, Students, and Educators (YPSE) Conference, Johns Hopkins University, Applied Physics Lab, Laurel Maryland, November 15, 2109

The 2019 YPSE AIAA Mid-Atlantic Section took place on November 15th at Johns Hopkins University Applied Physics Lab in Laurel, Maryland. Three Vaughn engineering students, Peter Kalaitzidis, Sagufta Kapadia and Syed Misbahuddin had their abstract accepted for presentation at the conference. The abstract was on the device, A.L.E.R.T (Autonomous Life Emergency Rescuing Transmitter) that would provide for a triple tier S.O.S signal when in distress. The students successfully developed the first model of this device which they presented at the conference. After the presentation, many attendees approached these students with positive feedback, and students also made connections with these participants, from whom they can gain additional information regarding requirements for such a device.

AIAA Students Paper Session presentation

The model developed by the students allowed the attendees of the presentation to get a clear understanding of the functionality of the device. For instance, as the model was powered on, the attendees witnessed the high intensity of the LEDs and how they are pre-programmed to flash the S.O.S signal in Morse code. The students also explained how this model will be improved in the next iteration and additional functionalities that will be added to the final design.



Group Picture with Keynote Speaker, Astronaut Pierre Thuot

From November 7 – 10, a group of four students: Amanda Camacho, Kiki Kuonqui, Michael Boller and Johann Cole from Engineers-Without-Borders Vaughn Chapter and Faculty adviser Dr. Miguel Bustamante attended the EWB-USA conference hosted at Pittsburgh, PA. The EWB-USA is a national conference hosted yearly where professionals in the industry and their respective student chapters share important information and volunteer for projects. There were many college and university chapters represented within the conference, some of whom gave talks about their project successes and failures. Other chapters shared information about their past and future projects. Student chapters had the opportunity to listen and learn from top industry leaders on engineering projects. This conference also promoted educational opportunities concerning complex global challenges engineers face and how these can be solved using student ideas in conjunction with their professional mentors. Each student chapter had the opportunity to network with engineers around the country and the world. This was a great experience for EWB-Vaughn chapter students. They learned how, through work with their mentors, their educational experience and can help others around the world.

On Thursday, November 7, the poster session contained several diverse topics, such as "Student Reviving a Student Lead Chapter at the University of South Florida" presented by Itze Kennedy. She explained to our student chapter how they revived their chapter and kept it going on future engineering projects. "Modelling Irrigation Systems with numerical methods" was presented by Christian Moonaw. He explained how the Auburn University student chapter implemented a gravity-fed sprinkling irrigation system in Bolivia using numerical methods. "EWB University of Massachusetts Kenya Project" presented by Abigail Laughlin is a project similar to the Rwanda Project our student chapter is working on, and Abigail gave us information on the implementation of our own project.

On Friday, November 8, there were many excellent presentations, so our group divided to cover most of them. "Implementing Adaptability in Your Structural Design: A Water Infrastructure Case Study" was presented by Alvaro Canga-Ruiz who is part of the Arup Global Challenge, a multidisciplinary Engineering group partner with Engineers without Borders, and he discussed the delivery of a new water infrastructure in Guatemala. The structural engineering team developed a strategy for implementing continuous updates using design-build practices along with the autorotation process. The presenter also explained the design of a reinforced concrete spring-box.

The second session "Guatemala Portable Water Standards" was presented by Tatiana Maldonado and Michael Paddock. Engineers Without Borders are now working with government agencies to develop standards for water quality within the country. In Guatemala, design standards for portable water systems are provided by the ministry of Health (MSPAS) and the Institute of Municipal Development (INFORM). Water quality standards are provided by the Guatemalan

Standards Commission (COGUANOR). The standards are being shared with Engineers Without Borders and will be used in the design of any project in Guatemala.

The third session "Diversity-Equity-Inclusion (DEI): Understanding Human Dynamics Within Your Projects and Chapters" was presented by Walt Walker of EWB-USA. Diversity and inclusion recognizes that each person brings a distinct live experience to the table and that our constituents are diverse not only in gender, race, ethnicity, sexual orientation, disability, religion and age but also in cultural and educational backgrounds, professions, life experiences, thoughts and ideas. The presenter explained that we should hold ourselves accountable to the core values of EWB-USA to embrace the identities of our members and seek to elevate the voices of our partners and our communities. It is necessary to consider the moral, strategic and impact imperatives for expanding our human-centered design process into DEI.

The last session of the day "Engaging with Education at EWB-USA" was presented by Anna Floyd, Abi Johnson and Melissa Montgomery. The presenters explained on how EWB-USA provides opportunities for applied learning that go beyond the classroom and the workplace, including: practical online resources and training, real-world skill-development courses, multidisciplinary, cross-cultural and hands-on experiences through project work, and design challenges at universities. Their volunteers differ from many other college students through their exposure to meaningful professional and technical skill development, leadership opportunities, and cross-cultural communication capabilities. They also introduce a design challenge component into the new projects being developed by each student chapter.

Saturday, November 9, was another day with excellent technical sessions and presentations. The first, "Planetary Session: The Critical Need for WASH in Healthcare Facilities" panel discussion was presented by moderator Kevin Andresejewski and panelists David Douglas, Angelita Fasnacht-Cuellar and Michael Paddock. The panelists presented their point of view on healthcare around the world and the need for programs and volunteers to fulfill the WASH goals (Water Sanitation and Hygiene) in healthcare facilities worldwide. The second session, "Mentoring of EWB Student Chapters" was presented by Brad Hughes Madison Area Professional Chapter. He has mentored the UW Madison chapter of EWB-USA for ten years and has found being an EWB mentor a unique opportunity. He explained how new professional mentors often require some assistance and guidance for their successful involvement. He also explained that keeping mentors active can be a challenge if they do not have a good sense of how to engage with the students in a way that provides mutual benefit.

This conference was very important for the development of our ENB-Vaughn Student Chapter; the students who attended the conference now feel the need to engage and recruit new students to pass on this meaningful legacy of helping others. Students made connections with other student chapters, as well as with other EWB-USA Professional Chapters. They also had the opportunity to speak with and get to know their professional chapter mentors

EWB-Vaughn Student Chapter: From left to right: Johann Cole, Michael Boller, Kiki Kuonqui and Amanda Camacho.

Students engage at the conference learning from other students and professional mentors

EWB-USA Conference, Vaughn's students with faculty adviser

American Society of Nondestructive Testing (ASNT) Conference 2019

From November 19^{th}-21^{st} 2019, Dr. Budhoo, Composite Curriculum Designer, attended the ASNT annual conference held in Las Vegas, Nevada. The purpose of this conference was to provide a forum of theoretical, scientific and application information on the latest advances in nondestructive testing technology.

Nondestructive testing (NDT) is testing without destroying - to investigate the material integrity of the test object. More specifically, a nondestructive test is an examination of an object, material, or system in any manner which will not impair its future usefulness. The purpose of the test may be to detect internal or external flaws, to measure geometric characteristics, to determine material structure or composition, or to measure or detect some of the material's properties.

Attending the ASNT conference provided me with a good understanding of the current challenges and research in the field of nondestructive testing, especially challenges regarding composite materials. There were also great networking opportunities with companies and other universities and colleges already offering nondestructive testing courses.

The knowledge obtained from this conference is beneficial for the Composite Manufacturing certificate program at Vaughn College, since I now have better insight into the selection of appropriate equipment for the nondestructive course. I also increased my knowledge and found many research and project ideas for student engagement. Some notable presentations beneficial not only to the certificate program but to other programs as well are, "Current Challenges Facing Nondestructive Evaluation of Additively Manufactured arts and Surfaces", "Leak Testing: Composite Layup Bagging" and "Temperature Effects on Ultrasonic Readings".

Women Engineering Conference 2019

The Vaughn College chapter of the Society of Women Engineers (SWE) attended the 2019 Women Engineers Conference in Anaheim, California from November 7th-10th, 2019. During the conference, SWE students presented their STEM workshop. In addition to participating and presenting at WE19, these students had another item on their agenda: employment. Nine students from SWE went to the conference in search of internships or full-time employment, and they were very successful. Together they received a combined 22 interviews with industry leaders such as Northrop Grumman, Boeing, Lockheed Martin, Dell, United Technologies, General Motors, ASML, Daimler Trucks of North America, BAE Systems, and Raytheon. In addition, 1 internship position and 8 full-time positions were offered.

From right to left, the WE19 attendees are Anil Parbhudial, Fatin Saumik, Grace Davis, Aderet Pantierer, Sagufta Kapadia, Shmuel Pantierer, Atif Saeed, Juan Aguirre Rodriguez, Omomhene Eimunjeze, Jessica Caron (Career Advisor).

WE19 Conference Overview

Note: Some SWE members received job offers following their summer 2019 internships received through the WE18 conference.

Name	Company	Full-time Offer	Internship Offer
Sagufta Kapadia	Raytheon	Yes	
	Northrop Grumman	Yes	
	Lockheed Martin	Yes (SWE18)	
Grace Davis	Boeing	Pending	
Aderet Pantierer	Lockheed Martin	Yes	
	Northrop Grumman	Yes	
	Boeing	Pending	
Shmuel Pantierer	Lockheed Martin	Pending	
	Northrop Grumman	Yes	
	United Technologies	Pending	
Atif Saeed	Boeing	Yes	
	BAE Systems	Yes	
	Lockheed Martin	Yes (SWE18)	
Fatin Saumik	Lockheed Martin	Pending	
	Northrop Grumman	Pending	
	Navy Civilian Careers	Yes	
Omomhene Eimunjeze	Dell	Pending	
	ASML	Pending	
	Johnson Controls	Pending	
Anil Parbhudial	Lockheed Martin	Pending	
	Navy Civilian Careers	Pending	
	Airforce Research Laboratory	Pending	
Juan Aguirre Rodriguez	Daimler		Yes
	Boeing	Pending	
	General Motors		Pending
	Honeywell	Pending	

Lightning Talk

SWE-VCAT president, Sagufta Kapadia hosted, “Drones for Good” to a full house. This lightning talk shed light on the positive impact of drones in the community and aimed to clear common misconceptions that many tend to have about drones. Attendees at the lightning talk enjoyed the presentation, because many were not aware of how drones are being used in various fields such as in transport of medical products, search and rescue missions, and agriculture.

Summary of the lightning talk:

Technology has greatly advanced over the span of a short time. One technological advancement that has drawn great attention from various groups including politicians, engineers, and photographers is Unmanned Aerial Vehicles (UAV) or drones. There are various debates occurring regarding public safety and privacy; however, not enough light is being shed on the positive impact this technological marvel has made on society. Drones are now being used for search and rescue missions, emergency response, agricultural purposes, security, construction planning, inspection, etc. These vehicles can easily reach places where it is extremely dangerous or impossible for a human to reach. It is thus vital that the positive impact drones have made on our world is acknowledged for the continuous support and advancement of these vehicles.

Invent It. Build It Expo

The Invent It. Build It. Expo took place on Saturday November 9th. This Expo is for K-12 students to experience the creativity and innovation of engineering through hands-on projects alongside experienced professional engineers. SWE hosted a STEM propeller powered car workshop, which taught students the basics of circuitry and thrust, while learning about Vaughn College. The workshop was a huge success as the SWE-VACT booth was crowded throughout the event, and all of the 100 workshop kits were completed before the event ended.

SWE-VCAT members helping young girls make the propeller power car at the 2019 Invent It. Build It. Expo

SpaceX Tour

In addition to attending the WE19 Career Fair and hosting a workshop at Invent It. Build It. Expo, the SWE members had the opportunity to tour the SpaceX facility in Hawthorne, CA. The SWE members were able to network with SpaceX employees and learn more about career opportunities, as well as the work environment at the company.

Acknowledgement: We are thankful to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support to engage Vaughn's students in STEM related scholarly and professional activities.

SHPE Leading Hispanics in STEM | Vaughn College of Aeronautics and Technology

2019 Society of Hispanic Professional Engineers (SHPE) National Conference, Phoenix, Arizona, October 30 to November 3, 2019

A group of 13 engineering students from Vaughn College attended the 2019 Society of Hispanic Professional Engineers (SHPE) Conference in Phoenix, Arizona (The Phoenix Convention Center) from October 30 to November 3, 2019. Vaughn's students participated in the design competition, as well as various professional development workshops aimed to promote leadership, unity, and exposure to the diverse career opportunities in the STEM fields.

The Society of Hispanic Professional Engineers (SHPE) organization provides opportunities for SHPE chapter students and professionals from all over the nation who are seeking full time or internship opportunities, especially to network with major engineering corporations that follow SHPE's mission to "impact the world through STEM awareness, access, support, and development."

Vaughn's students received 17 interviews with companies such as Cummins, Ford, Aerotek, Huntington Ingalls Industries, Pratt & Whitney, Collins Aerospace, Boston Scientific, GM, Raytheon, Toyota, John Deere, and more.

The following is a list of members and the companies with whom they received interviews and/or pending offers.

FULL NAME	MAJOR	COLLEGE	COMPANY INTERVIEWS	OFFERS
Praneel Kumar	MET - Aero	Senior	Huntington Ingalls Industries Navy Civilian The Boeing Company	Pending
Luis Rosario	MET - Aero & CAD	Senior	UTC Pratt and Whitney	Pending
Yarelys Vazquez	MET - Aero & CAD	Senior	UTC Collins Aerospace	Pending
Bryan Gordillo	Mechanical Engineering	Sophomore	Toyota	Pending
Manolo Duenas	Mechatronics Engineering	Senior	Aerotek	Pending
Kastronepaul Thevasahayam	Mechatronics Engineering	Junior	UTC Pratt and Whitney National Security Agency (NSA)	Internship (Summer2020)
Cesar Valle	Mechanical Engineering	Senior	Boston Scientific John Deere	Pending
Alejandro Cueva	Mechatronics Engineering	Senior	General Motors	Pending
Parminder Singh	MET - Aero & CAD	Senior	The Boeing Company UTC Collins Aerospace	Pending
Angel Calderon	MET - Aero	Senior	The Boeing Company	Full-Time
Sebastion Valencia	Mechatronics Engineering	Senior	UTC Collins Aerospace	Pending
Nurullah Khan	Mechanical Engineering	Senior	Cummins	Pending
Kastrinpaul Thevasahayam	MET - Aero	Junior	Ford	Pending

Workshops:

At the SHPE National Convention, Vaughn's students were able to attend a variety of technical, career, and graduate workshop opportunities hosted by corporate representatives such as Raytheon, The Boeing Company, Lockheed Martin, General Motors, Chevron, Intel Corporation, and many more. These workshops occur throughout the duration of the SHPE National Convention event; the purpose of these workshops is to prepare students and professionals for the STEM career fair, including educational and technical opportunities that can be applied to everyday activities which help individuals to grow professionally in the career they are pursuing.

Extreme Engineering Challenge (Wednesday and Thursday):

At the SHPE National Conference, there are a variety of competition opportunities in which SHPE chapter students and professionals can participate, such as Engineering Science Symposium, Extreme Engineering Challenge, and Innovation Challenge. Vaughn's students are encouraged and supported to participate in these competitions. Due to the success that Vaughn's students had in the Nissan Design Challenge and Extreme Engineering Challenge, we are interested in hosting a similar event at Vaughn College to prepare our students for these competitions. When our members participate in competitions or attend conferences, these experiences also also provide the benefit of enriching their resumes.

This year, **Angel Calderon,** who won first place in the 2018 Nissan Design Challenge, participated in the 2019 Extreme Engineering Challenge. Angel, along with his team members, were placed in a structure simulating a work environment with deadlines, presentations, reviews, and other work obstacles in order to build awareness of and enhance the skills required to meet the demands of extreme engineering. At the conclusion of the challenge, Vaughn student, Angel Calderon won **third place** in this year's competition. This is the third time in a row that a student at Vaughn College has won the SHPE Extreme Engineering Challenge competition and was recognized as a lead engineer by showing strong leadership skills among his team members and team leaders in their project.

Extreme Engineering Third Place & Lead Engineers Recognition Award

The Vaughn community is very proud of Angel's success in this year's intense and challenging competition. We are thankful to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support to engage Vaughn's students in STEM Challenge competitions and activities.

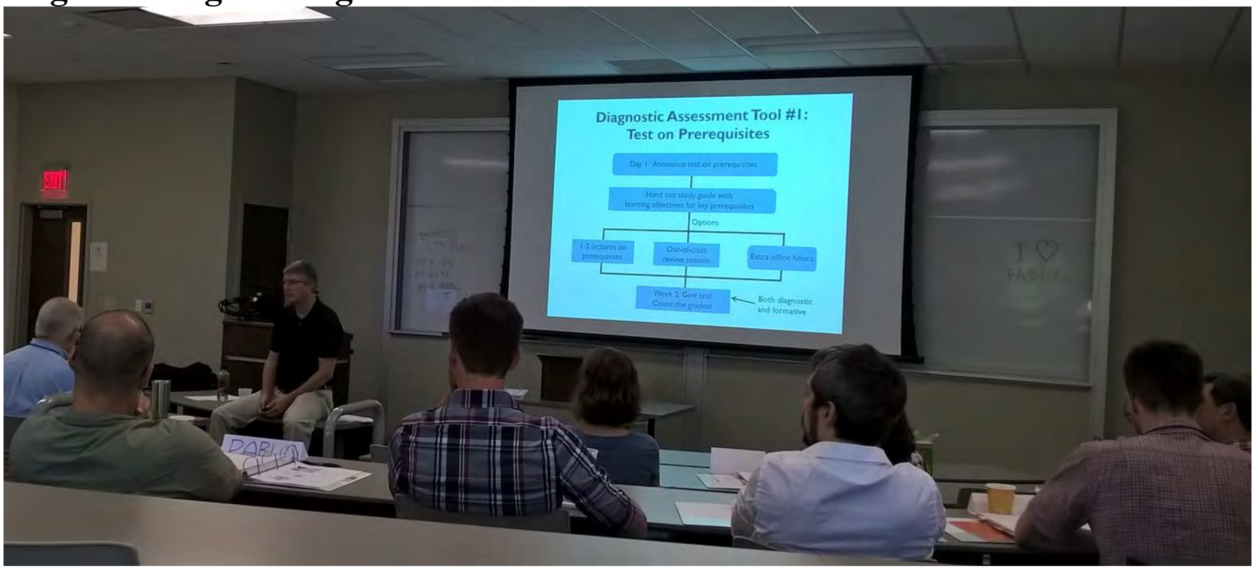
2019 ABET Symposium, Dallas, Texas, April 10-12, 2019

From April 10-12, Dr. Paul LaVergne, academic vice president, and engineering department chair and Dr. Hossein Rahemi attended the 2019 ABET Symposium in Dallas, Texas. The Symposium provided us with information related to transitioning from previous "A through K" learning outcomes to the new "1 through 7" EAC and "1 through 5" ETAC student outcomes, as well as information related to assessment, gathering data, and the evaluation process.

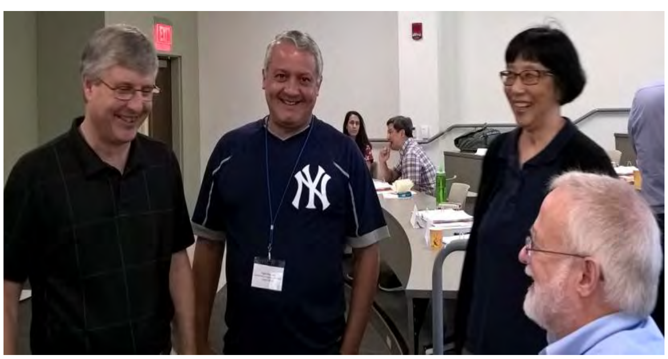
The plenary sessions by a panel of experts in Cyber Security, such as Mike McConnell, Vasu Jakkal, Martin Libicki, and Chris Inglis, addressed some threats in the cyber landscape, such as cyber warfare. The session also explored possible solutions through understanding the underlying technology and developing necessary strategies to eliminate these cyber security threats. Collaboration and partnership with industry, government, and private sectors, along with the leverage of technology, and education are key to the prevention of cyber security threats.

The ABET assessment workshops introduced us to a new assessment methodology to evaluate the degree to which students are attaining desired student outcomes by graduation. Based on this assessment methodology, each student outcome is subdivided into performance indicators (PI) to provide additional fidelity to the outcome, so that faculty can subsequently target improvement, should it be warranted. We will inform our faculty about this new assessment methodology and will take necessary steps to adapt and implement this new methodology into our future student outcomes assessment process.

Vaughn Professors Attend the Workshop of Project Catalyst - How to Engineer Engineering Education



Dr. Miguel Bustamante and Dr. Shouling He, assistant professor and associate professor in Vaughn's engineering and technology department attended the Educational Workshop, Project Catalyst – How to Engineer Engineering Education, held by Bucknell University, July 17-19, 2019. The workshop explored how to use the instructional objectives, active and cooperative learning, to efficiently improve professors' teaching performance, as well as how to assess students' learning outcomes. Forty-six faculty from different universities, such as John Hopkins University, University of Pennsylvania, Pennsylvania State University, Drexel University, as well as New Jersey Institute of Technology, joined the workshop.



The workshop was given by Dr. Michael Prince from the chemical engineering department at Bucknell University. The workshop started with Instructional Objective, a method where the faculty must set the objectives of the course by setting the relevance of the material and how-to asses the course. The motive is established by the relevance of the topic and how it allows students to be motivated to learn. That was set to be active learning. During the workshop, the attendees were organized to practice cooperative and collaborative learning and to discuss the concepts of active and inductive learning. At this workshop, faculty also discussed how to inspire students to learn fundamental and complex engineering concepts, how to clearly provide learning objectives, as well as how to develop instruments to effectively assess student performance. The workshop provided valuable experiences for the faculty at Vaughn College to continuously improve the quality of education in engineering and technology.

Bloom taxonomy was also covered. High level outcomes can be achieved by using Bloom's taxonomy of educational objectives. The taxonomy was classified in two sections. The Lower order skills which include:

1. Remembering--Reverberate
2. Understanding--Explain
3. Applying—Used in problems

- And Higher order skills:

4. Analyzing--Predict
5. Evaluating--Critique
6. Creating—Design

The value of Bloom's taxonomy includes improved relevance, alignment of goals, and assessment of teaching. The workshop also covered: Using objectives to design instruction by following three simple rules:

1. Guidance—Content must meet objectives
2. Practice—Activities must be driven by objectives
3. Feedback—On student's ability to meet objectives

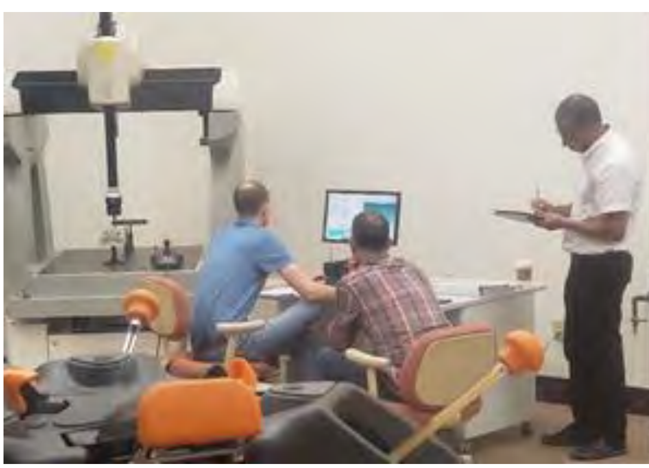
These objectives are based on how people learn. Another interesting topic was Active Learning where students are engaged in a class activity to learn the material rather than simply listening to the instructor or taking notes. There are several research papers that demonstrate how students during lectures are attentive for only ten to fifteen minutes. One proposed solution to increase engagement is to break the class into short lectures (ten to twelve minutes) followed by student interactions with peer group discussions and activities. This option provides higher memory retention. According to Felder and Brent in "Effective Teaching Workshop Design", the better the quantity and variety of activities, the better the workshop.

A five Day Hands-on Training Course in Coordinate Measuring Machine (CMM), Dayton, Ohio, August 16-20, 2019

From Aug 16-20, Prof. Manual Jesus and Rachid Nafaa, Vaughn's Manufacturing Lab Tech, attended a hands-on training course with the Advanced Industrial Measurement Systems (AIMS) to learn the AIMS Metrology CMM system in Dayton, Ohio. A coordinate measuring machine (CMM) is a device used to measure the physical geometric properties of a part. Complex parts require an accurate system to insure precision part manufacturing in aerospace, automotive, and manufacturing applications. Since part inspection is a crucial phase of CNC part development, our advisory board suggested that we consider developing courses that explore the concepts behind blueprint reading and part inspection.

The AIMS Renishaw CMM system uses a 5 axis robotic arm and a touch probe sensor to record coordinates of part features as a series of points in X, Y, and Z space. The collected points are then compared against a CAD file or blueprints to determine accuracy. Inspection data can be used to maintain quality control, reverse engineering, and dimensional analysis with greater versatility and accuracy than standard instruments. Another crucial benefit of the CMM process is the ability to develop a CMM inspection program to repeatedly measure identical parts in a production run to insure consistency.

Our course dealt with setting probe tools and calibrating probes for use with MODUS CMM software. The five-day course first reviewed core concepts such as Cartesian coordinates and vectors, then geometric tolerance concepts through the use of the CMM as a measuring tool. Geometric tolerance was explored by programming the CMM to inspect a part using approach, probe, and retract commands developed via a command line interface or a more intuitive graphical user interface. Use of the 5 Axis probe system insures a faster workflow, as an inspector doesn't always need to re-position a part once inspection has started. At the end of the course we had a good working knowledge of the system and were eager to apply what we learned back at the college.

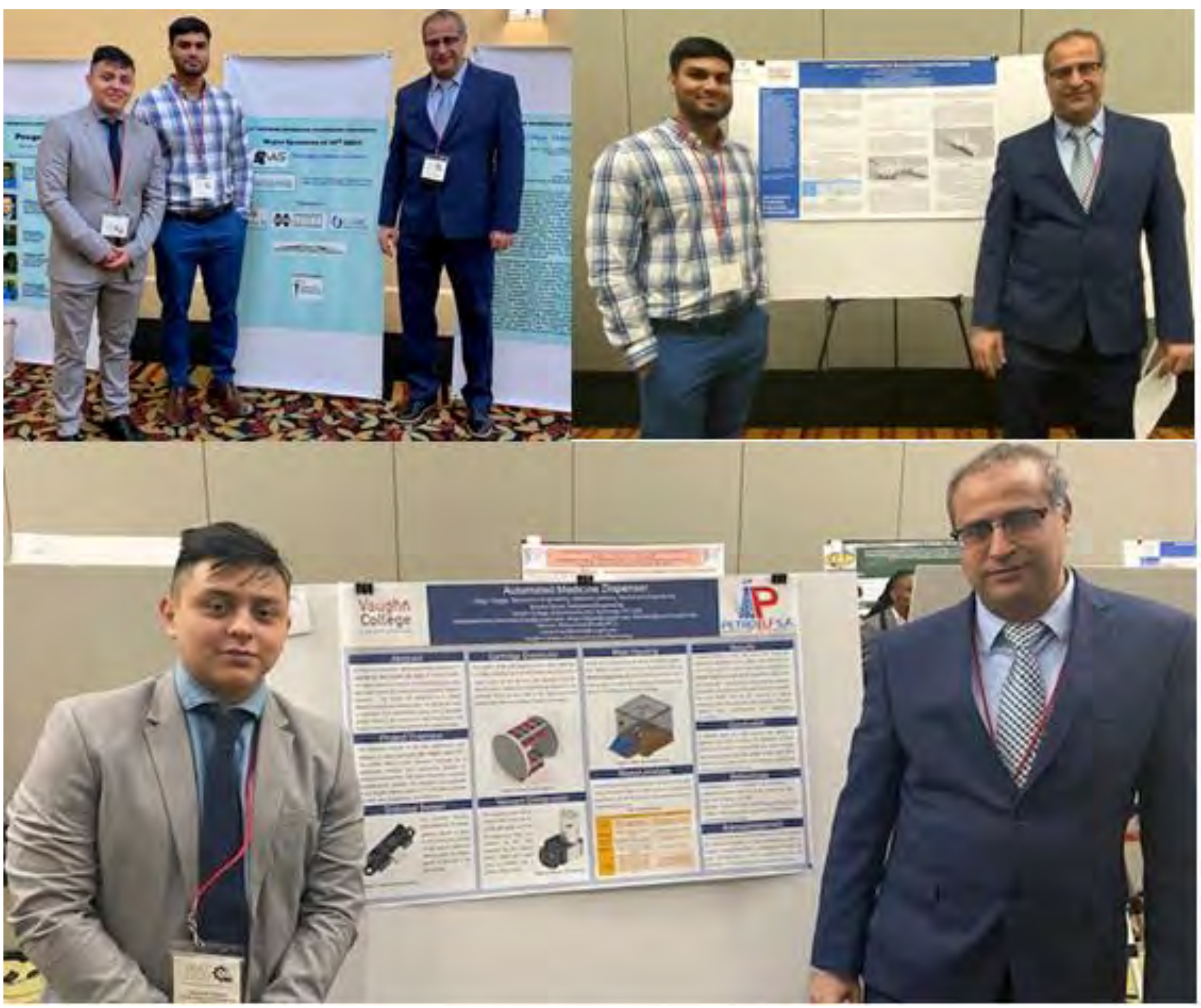


Southern Biomedical Engineering Conference, 36th Annual meeting, New Orleans LA, March 6-8, 2020

From March 6-8, two Vaughn engineering students, Atif Saeed and Sebastian Valencia, along with Dr. Mohammed Benalla, participated in the 36th Southern Biomedical Engineering Conference in New Orleans, LA.

Dr. Benalla chaired a session of Computational bioengineering, Saturday March 7th from 3:00 PM to 4:45 PM and Vaughn's engineering students Atif and Sebastian had poster presentations on Friday March 6th. The presentations took place between 6:00 PM and 7:30 PM. Atif Saeed presented "Haptic Thermal Feedback Prosthetic Brain-Controlled Arm" and he won the third place award in the undergraduate category, while Sebastian Valencia presented "Autonomous Medicine Dispenser". These two papers were also accepted for publication in the Biomedical Science Instrumentation Journal.

This occasion was a good opportunity for our students to publicly discuss their current projects and to receive feedback from biomedical grad and undergrad students, faculty, as well as researchers from different colleges and universities.

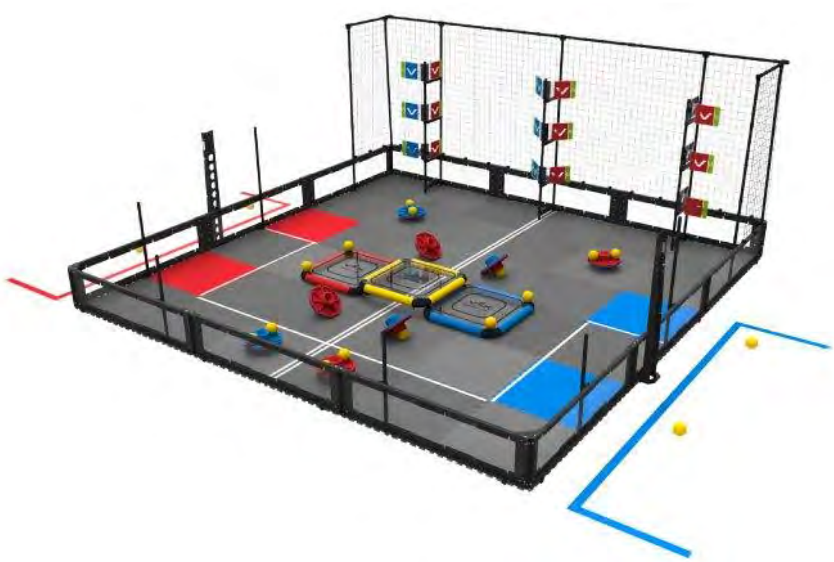


2019 VEX U Robotics World Championship Competition "VEX Turning Point Game" Vaughn Robotics Team advances to the playoff round in 2019 VEX U Robotics World Championship and wins 2019 World Create Award

Every year, VEX Robotics challenges the problem-solving skills of science, technology, engineering and math (STEM) scholars. Competition participants used robotics platforms and engineering processes to solve this year's challenge entitled "VEX Turning Point Game." For this purpose, Vaughn's team designed, built, and programmed two robots to compete in matches consisting of a forty-five second autonomous period followed by one minute and fifteen seconds of driver-controlled manipulation. The team constructed their robots to attain the following objectives:

1. Launch balls consistently and accurately from any location on the field to toggle low and high flags.
2. Perform fast with an effective mechanism to pick up the cap and place it on the post through both autonomous driver-controlled modes.
3. Operate with control algorithms for the best autonomous performance
4. Comply with the limitations and constraints of the challenge.

For "VEX Turning Point Game", two teams (two Alliances; one red and one blue) compete in each match and the objective is to attain a higher score than the opposing Alliance by High Scoring or Low Scoring Caps, by Toggling Flags, and by Alliance Parking or Center Parking Robots on the Platforms. The alliance with the higher score wins the match. The Figure below is an illustration of "VEX Turning Point" starting configuration.



The Game: The VEX Robotics Turning Point Competition is played on a 12 ft. X 12 ft. Foam mat arena, surrounded by a sheet metal and Lexan perimeter. The object of the game is to attain a higher score than the opposing Alliance by High Scoring or Low Scoring Caps, by Toggling Flags, and by Alliance Parking or Center Parking Robots on the Platforms.

Scoring:

Toggled High Flag	2 points
Toggled Low Flag	1 point
High Scored Cap	2 points
Low Scored Cap	1 point
Robot that is Alliance Parked	3 points
A Robot that is Center Parked	6 points
Autonomous Bonus	4 points

The Details: There are eight (8) Caps, six (6) Posts, nine (9) Flags, twenty (20) Balls, two (2) Alliance Platforms, and one (1) Center Platform. Each robot will have one (1) Ball available as a Preload prior to the match. Caps can be Low Scored on the field tiles, or High Scored on Posts, for the Alliance whose color is facing up at the end of the match. Flags can be Toggled to red or blue, and are scored for the Alliance whose color is toggled at the end of the match. Low Flags can be toggled by Robots, but High Flags can only be toggled by Balls. Turning Point is intended to be a back and forth game, in which no scored object is safe. Alliance Platforms can be used for Alliance Parking by Robots of the same color Alliance as the Platform. The Center Platform can be used by Robots from either Alliance for Center Parking. An additional bonus is awarded to the Alliance that has the highest total points at the end of the Autonomous Period.

From April 24-27, Seventy Eight national and international universities and colleges were invited to the 2019 VEX U World Championship in Louisville, Kentucky Freedom Expo Center. Invitation to the VEX U Robotics World championship was granted only to a team that is a tournament Champion, Finalist or "Excellence" award recipient of a regional competition. Vaughn's Robotics team (VCAT) finished first and won both first place "Robot Skills" and "Excellence" awards of the New Hampshire VEX U Robotics Regional Qualifier Competition, Excellence award for Vaughn College Regional, and First Place award for Robotics Skills in the Mexican VEX U Reeduca International robotics competition.

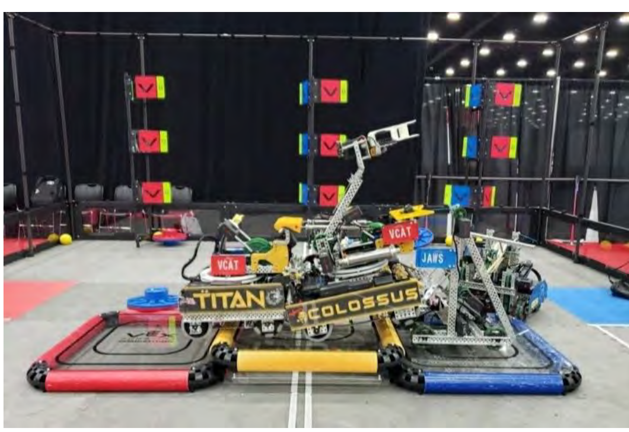
This intense three-day competition was challenging, and our team (VCAT) was continually modifying their robots and autonomous programming to be competitive with other top teams in this tournament. During the qualifying matches, Vaughn's team (VCAT) competed against 10 teams and won seven out of the 10 matches, advancing to the Saturday afternoon playoff round. During the single elimination of the playoff round, the top sixteen teams competed, and Vaughn's team lost to a top team from China. This is the sixth year in a row that Vaughn's team retained their standing as one of the top competitors in the world championship by advancing to the playoff round of this intense competition.

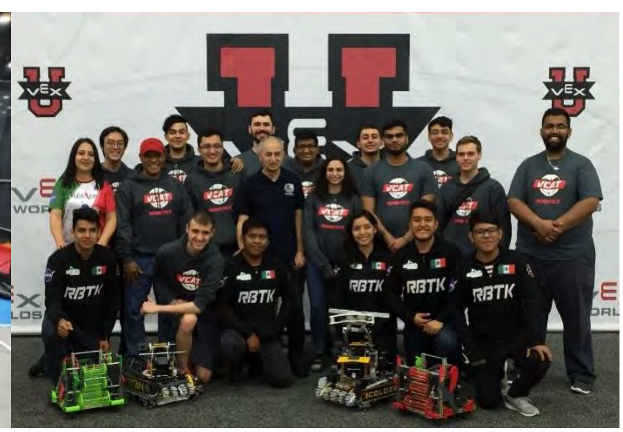



On Saturday, April 23, Judges awarded Vaughn's Robotics team with the 2019 World **Create Award**. The **Create Award** is presented to a team whose robot design incorporates a creative engineering solution to the design challenges of this season's game.
Key criteria:

- Robot is a well-crafted, unique design solution, demonstrating creative thinking
- Team has demonstrated a highly creative design process and methodology
- Team has committed to ambitious and creative approaches to playing the game
- Teamwork, interview quality, and team professionalism

The world championship is a tough competition in which only the top US regional and world champions qualify to participate. Even though our team had some issues with programming during the playoff round, they were able to retain their standing as one of the top competitors in the world championship by advancing to the playoff round of this intense competition for the sixth year in a row.

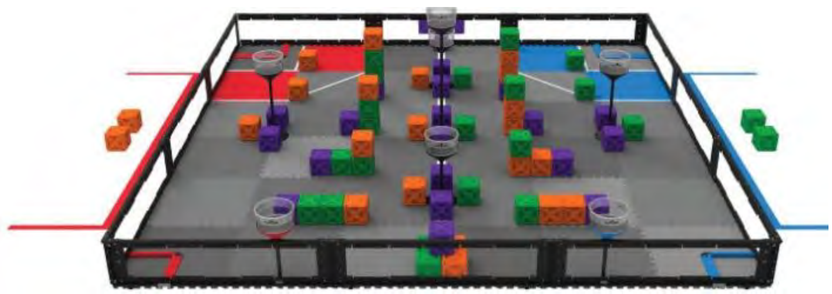




2019 VEX U "VEX Turning Point" Robotics World Championship Competition

2019-2020 Robotics VEX Tower Takeover Game: Every year, VEX Robotics challenges the problem-solving skills of science, technology, engineering and math (STEM) scholars. Competition participants used robotics platforms and engineering processes to solve this year's challenge entitled "VEX Tower Takeover Game." For this purpose, Vaughn's team designed, built, and programmed two robots to compete in matches consisting of a forty-five second autonomous period followed by one minute and fifteen seconds of driver-controlled manipulation. The team constructed their robots to attain the following objectives:

1. A robot with an effective mechanism that can Pick up cubes fast and accurately from any location on the field and place them in towers or to score stack of cubes in goals.
2. A robot with control algorithms for the best autonomous performance
3. A structurally reliable robot in compliance with the limitations and constraints of the challenge.



The Game: VEX Robotics Competition Tower Takeover is played on a 12'x12' square field configured as seen above. Two (2) Alliances – one (1) "red" and one (1) "blue" – composed of two (2) Teams each, compete in matches consisting of a forty five (45) second Autonomous Period, followed by a one minute and fifteen second (1:15) Driver Controlled Period. The object of the game is to attain a higher score than the opposing Alliance by placing **Cubes** in **Towers**, or scoring **Cubes** in **Goals**

Scoring:

Each Green Cube Scored in a goal	1 point + 1 point for every Green Cube Placed in Towers
Each Orange Cube Scored in a goal	1 point + 1 point for every Orange Cube Placed in Towers
Each Purple Cube Scored in a goal	1 point + 1 point for every Purple Cube Placed in Towers
Autonomous Bonus	6 points
Robot that is Alliance Parked	3 points

The Details: There are sixty-six 66 **Cubes** on a Tower Takeover Field. Twenty-two (22) **Green**, twenty-two (22) **Orange** and, twenty-two (22) **Purple**. There are also seven (7) **Towers** placed around the field. Five (5) of these are neutral, with the remaining two being alliance specific. Alliance specific Towers may only be utilized by robots of the same alliance. Cubes can be **Placed in Towers**, or **Scored in Goals**. Cubes are worth at least 1 point when placed in a Goal Zone. The exact value of each cube is determined by how many Cubes of that specific color have been placed in Towers. When Cubes are Placed in or removed from Towers, **the new values apply to ALL cubes**. So the actions of one Robot will impact the potential score for both their own alliance, and their opponents. The alliance that scores most points in the Autonomous period is awarded with (6) bonus points, added to the final score at the end of the match. The Alliance who wins this Autonomous Bonus is also **awarded 2 purple cubes**, which may be introduced at any time during the driver control period.

Mexico's VEX U Signature Reeduca Robotics Competition, December 12-14, 2019

The Vaughn College Robotics team, one of the top competitors in VEX U Robotics world championship, was invited to participate in Mexico's VEX U Reeduca Robotics competition as part of the 2019 **Torneo Internacional de Robotica VEX-Reeduca.** From December 12-14, Vaughn College Robotics participated and competed in this Signature VEX U Challenge competition in the Univeredad Technologica De La Riveria Maya, Cancun, Mexico. Seven members of VCAT robotic club (Jason Becker, Atif Saeed, John Sutera, Joseph Crowley, Maharshi Patel, Tim Tullio, and Kevin Tsang) and their advisors represented Vaughn College at this competition.

The competition was challenging; during the Friday December 13 qualifying competition, the VCAT team competed against 4 Mexican teams and won all 4 matches. Vaughn's team won two out of three of its Saturday morning qualifying matches, and with a total of 6 wins out of seven qualifying matches our team advanced to 2nd top position in the playoff round. In their quarterfinal match of the playoff round the team lost to Universidad Tecnológica de Matamoros in a close match (VCAT—6, TMAT2—7). The team finished second place overall in the competition and won the Build Award of this international robotics competition. For the past five years, Vaughn robotics team members consistently demonstrate persistence and drive in order to attain their title as champions (2015, 2016, and 2017) and top competitor in Mexico's VEX U Robotics competition (2nd place in 2018 and 2019).

We would like to extend our sincere appreciation to the US Department of Education (HSI-STEM grant), alumni and advisory members for providing necessary funding to support student engagement in robotics as well as other STEM related activities.

Build Award: To receive Build Award, a team must construct a robot that is high quality, robust, clean, and demonstrates effective use of materials. The robot must make efficient use of mechanical and electrical components. The robot is designed with a clear dedication to safety in conjunction with attention to detail. Furthermore, the robot must demonstrate reliability on the field and hold up under competition conditions. Most importantly, students must be able to understand and explain how they worked together to develop their robot.

Mexico's VEX U Reeduca Robotics competition, December 14, 2019

Vaughn Robotics Team wins Build Award

STEM Community Outreach: Vaughn's Robotics Team Assisted Freeport High School to host its Regional State Qualifier Robotics Competition on Saturday, February 1st 2020

On Saturday, February 1st, Freeport High School hosted its regional state qualifier robotics completion, and more than thirty five regional high schools participated in this competition. Nine members of Vaughn's robotics team, along with two faculty members, participated in assisting Freeport High School with this regional competition. The team was assigned the following tasks.

1. Prof. Minhas served as a judge for the event
2. Jason Becker served as a tournament manager, he made sure the software for the tournament is working at all times.
3. Maharshi Patel served as a head referee, called rule infractions.
4. Ricardo Tomala served as skills field manager, ran the skills field
5. Tatiana Jaimes: served as a robot inspector and team queuing
6. Mariah Villalon: served as a robot inspector and team queuing
7. Manolo Duenas: served as a score-keeping referee, recorded match scores
8. John Sutera served as a tournament manager
9. Kevin Tsang served as a skills field manager
10. Juan Aguirre Rodriguez served as a score-keeping referee

Also, during this regional completion, the VCAT team got a chance to participate in the skills match and the team was able to improve its current skills ranking to 3rd place in the world and 1st place in the US. The VCAT team is planning to host its regional VEX U competition on Friday Feb 28.

The table below provides the list of award recipients for the 2020 regional High School VEX Robotics State Qualifier Competition. An alliance of Overclock teams won the tournament championship, while a team from Jericho Senior High School won the "Excellence" Award, and Overclock won "Robot Skills." Tournament champions, "Excellence" Award, "Design" Award and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.

Award	Team #	Team Name	Affiliation	Location
Excellence Award (VRC/VEXU)	9932C	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Tournament Champions (VRC/VEXU)	16099B	Overclock	KG Computech	Flushing, New York, United States
Tournament Champions (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Innovate Award (VRC/VEXU/VIQC)	11040C	Highlander Bots	HERRICKS HIGH SCHOOL	New Hyde Park, New York, United States
Amaze Award (VRC/VEXU)	16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States
Build Award (VRC/VEXU)	98570A	Babylon Panthers	BABYLON JUNIOR-SENIOR HIGH SCHOOL	Babylon, New York, United States
Design Award (VRC/VEXU)	9932E	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Think Award (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Judges Award (VRC/VEXU)	98456C	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
Tournament Finalists (VRC/VEXU)	16699Z	Overclock MS	NY Youth Tech	Flushing, New York, United States
Tournament Finalists (VRC/VEXU)	98456B	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
Robot Skills Champion (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States

STEM Community Outreach: Vaughn's Robotics Team Assisted the Harvey School to host its Regional State Qualifier Robotics Competition on Saturday, February 15th, 2020

On Saturday February 15th, Harvey School District hosted its fifth high school robotics competition. A total of 57 regional high schools participated in this competition. Two members of Vaughn's robotics team attended as referees for the event. Maharshi Patel served a Referee and John Sutera served as tournament manager operator.

High School VEX Robotics State Qualifier Competition, Saturday, February 15th, 2020

The table below provides the list of award recipients for the 2020 regional High School VEX Robotics State Qualifier Competition. An alliance of Centereach High School and The Harvey School teams won the tournament championship, while a team from The Harvey School won the "Excellence" Award, and Centereach High School won "Robot Skills." Tournament champions, Tournament Finalists, "Excellence" Award, "Design" Award and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.

Award	Team #	Team Name	Affiliation	Location
Excellence Award (VRC/VEXU)	6277B	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
Tournament Champions (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States
Tournament Champions (VRC/VEXU)	6277B	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
Design Award (VRC/VEXU)	97140A	Kennedy Gaels	Kennedy Catholic High School	Somers, New York, United States
Judges Award (VRC/VEXU)	15239A	RoboBaller		Somers, New York, United States
Tournament Finalists (VRC/VEXU)	78792A	Mount Academy Eagles A	The Mount Academy	Esopus, New York, United States
Tournament Finalists (VRC/VEXU)	6277E	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
Robot Skills Champion (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States

STEM Community Outreach: Vaughn's Robotics Team Assisted JFK High School to host its Regional State Qualifier Robotics Competition on Saturday January 25th, 2020

John F. Kennedy High School hosted its first high school robotics competition on Saturday January 25th, 2020. A total of 34 regional high schools attended the January VEX state qualifier. Five members of Vaughn's robotics team acted as referees, judges, and event manager for this regional competition. John Sutera served as a scorer and tournament manager operator; Joseph Crowley and Tatiana Jaimes served as a scorers/field reset. Mariah Villalon and Misael Marquez served as the judges for this competition.

The table below provides the list of award recipients for the 2020 regional High School VEX Robotics State Qualifier Competition. An alliance of South Side High School teams won the tournament championship, while a team from Jericho Senior High School won the "Excellence" Award, and Newfield High School won "Robot Skills." Tournament champions, "Excellence" Award, and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.

Award	Team #	Team Name	Affiliation	Location
Excellence Award (VRC/VEXU)	9932D	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Tournament Champions (VRC/VEXU)	11570C	Cyclones Robotics	SOUTH SIDE HIGH SCHOOL	Rockville Centre, New York, United States
Tournament Champions (VRC/VEXU)	11570B	Cyclones Robotics	SOUTH SIDE HIGH SCHOOL	Rockville Centre, New York, United States
Design Award (VRC/VEXU)	6277B	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
Judges Award (VRC/VEXU)	11566A	Calhoun Colts	SANFORD H CALHOUN HIGH SCHOOL	Merrick, New York, United States
Robot Skills Champion (VRC/VEXU)	97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States

Vaughn College hosted VEX U Robotics Tournament on Friday, February 28th, 2020;

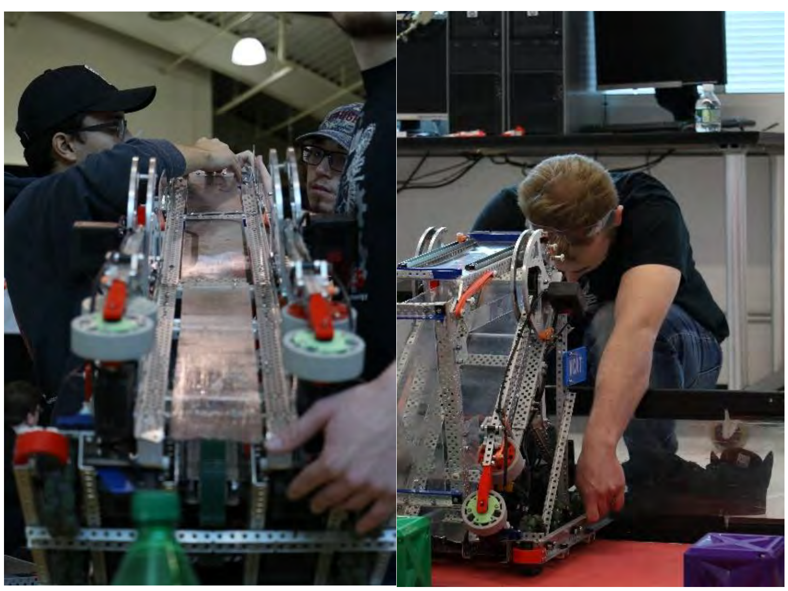
Vaughn Robotics Team wins 2020 VEX U Skill Challenge and Excellence Awards

Vaughn College of Aeronautics and Technology hosted its sixth Annual VEX U College Regional Robotics competition on Friday, February 28th, 2020. A total of thirteen college teams participated at this event. The participant teams included Aquidneck Island Robotics (AIR), Johnson & Wales University (JWU1), South Dakota Schools of Mines and Technology (MINES), New Jersey Institute of Technology, New York Institute of Technology (NYIT), (NYIT2) and (NYIT3), Florida Polytechnic University (POLY1), Rutgers University (SKAR), University at Buffalo (UBR), Vaughn College of Aeronautics and Technology (VCAT) and (VCAT2), Worcester Polytechnic Institute (WPI).

Members of Vaughn College robotic club (Jason Becker, Juan Aguirre, Tim Tullio, Maharshi Patel, Joseph Crowley, Tatiana Jaimes, August Rodriguez, Kevin Tsang, Misael Marquez, Manolo Duenas, Mariah Villalon, Daniel Doscher, John Sutera, Ricardo Tomala, Ariel Santos, Anthony Santos, Juan Cortes and Mahin Bhuya) represented the Vaughn teams (VCAT and VCAT2) at this competition. Also, Ariel served as referee, and Jason served as the event manager. Manolo served as announcer, while other Vaughn's robotics team members were involved with Robots inspection, setting up the fields and facilitating the implementation process for this event. Also, Professsor Donald Jimmo, Rachid Nafaa, Sagufta Kapadia, Syed Misbahuddin, Norberto Guzman, and Marino **Rodriguez** served as judges for this competition.

During the skills challenge matches, Vaughn's team finished first in "Robot Skills" (166 points). Each participating team had a total of seven matches. With four wins Vaughn's team received fourth ranking in qualification matches and advanced to the playoff elimination round. The Tournament Champion of this Competition was WPI winning by 3 point in the Finals Match with a score of 14-11.

In this regional completion, Vaughn's robotics team won both first place "Robot Skills" and "Excellence" awards which qualifies our team to participate in the 2019 VEX U world championship..



VCAT Preparing for Matches

Matches during VEX U Competition

VCAT Robotics Team

Vaughn College Hosted VEX High School Robotics Qualifier Competition on Saturday, Feb 29th, 2020

Vaughn College of Aeronautics and Technology hosted its sixth annual high school robotics competition on Saturday February 29th, 2020. A total of 64 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk and other NY counties attended the 2020 VEX state qualifier at Vaughn College. The list of high school participants is as follows:

Team List (62 Teams)

Team	Team Name	Organization	Location
144D	Men in Black	Men In Black	Flushing, New York, United States
699E	Atomic Endgame	Thomas A Edison Career And Technical High School	JAMAICA, New York, United States
699T	Robo Ravens	Thomas A Edison Career And Technical High School	JAMAICA, New York, United States
699Z	Z-Series	THOMAS A EDISON CAREER AND TECHNICAL HIGH SCHOOL	Jamaica, New York, United States
809A	Q.T. B.O.I.S.	LongWingsEdu	Great Neck, New York, United States
809F	NITRO	LongWingsEdu	Great Neck, New York, United States
817F	The Taiga Sparticles	EAST LONGMEADOW HIGH	East Longmeadow, Massachusetts, United States
1353P	VEXistential Crisis	FARMINGDALE SENIOR HIGH SCHOOL	Farmingdale, New York, United States
1353X	Biohazard	FARMINGDALE SENIOR HIGH SCHOOL	Farmingdale, New York, United States
1808B	Red Devil Robotics	FREEPORT HIGH SCHOOL	Freeport, New York, United States
1808C	Red Devil Robotics	FREEPORT HIGH SCHOOL	Freeport, New York, United States
1808E	Red Devil Robotics	FREEPORT HIGH SCHOOL	Freeport, New York, United States
6277A	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
6277C	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
6277F	RoboCavs	THE HARVEY SCHOOL	Katonah, New York, United States
8880B	STEP@ adelphi	Adelphi University STEP Program	Garden City, New York, United States
9458A	Robo Chiefs	MASSAPEQUA HIGH SCHOOL	Massapequa, New York, United States
9458B	Robo Chiefs	MASSAPEQUA HIGH SCHOOL	Massapequa, New York, United States
9717A	St. Catharine Comets	ST CATHARINE ACADEMY	Bronx, New York, United States
9717B	St. Catharine Comets	ST CATHARINE ACADEMY	Bronx, New York, United States
9932C	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
9932D	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
9932X	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
10128A	Turing Test	DALTON SCHOOL	New York, New York, United States
10128B	Analytical Engine	DALTON SCHOOL	New York, New York, United States
11442X	Hewitt Robotics	The Hewitt School	New York, New York, United States
11442Z	Hewitt Robotics	The Hewitt School	New York, New York, United States
11570A	Cyclones Robotics	SOUTH SIDE HIGH SCHOOL	Rockville Centre, New York, United States
11570B	Cyclones Robotics	SOUTH SIDE HIGH SCHOOL	Rockville Centre, New York, United States
11570C	Cyclones Robotics	SOUTH SIDE HIGH SCHOOL	Rockville Centre, New York, United States
11577H	Roslyn Robotics	ROSLYN HIGH SCHOOL	Roslyn Heights, New York, United States
11577R	Roslyn Robotics	ROSLYN HIGH SCHOOL	Roslyn Heights, New York, United States

11791A	STONEWALL	New Energy Education Center	Syosset, New York, United States
11791M	OrinGE guiCe	New Energy Education Center	Syosset, New York, United States
11791X	Arsenal	New Energy Education Center	Syosset, New York, United States
12357A	Infinite Robotics	Infinite Robotics	Jericho, New York, United States
15239A	RoboBaller		Somers, New York, United States
15552A	EF Coders	EF Academy	New York, New York, United States
16099A	Overclock	KG Computech	Flushing, New York, United States
16099B	Overclock	KG Computech	Flushing, New York, United States
16099C	Overclock	KG Computech	Flushing, New York, United States
16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States
16699Z	Overclock MS	NY Youth Tech	Flushing, New York, United States
19396A	Bayside	Bayside High School	BAYSIDE, New York, United States
19396B	Bayside	Bayside High School	BAYSIDE, New York, United States
24642T	The Prodigies		Farmingdale, New York, United States
38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States
39255A	Hawks	HILLCREST HIGH SCHOOL	Jamaica, New York, United States
47114A	VEXcellent Girls	North Shore Coding and Robotics Club	Great Neck, New York, United States
62880A	Real Steel	C2C Robotics	Bayside, New York, United States
68602A	GC Robots	Garden City High School	Garden City, New York, United States
68602B	GC Robots		Garden City, New York, United States
68602C	GC Robots		Garden City, New York, United States
88288A	Universal Scereal Bowls	RoboMindTech	Bayside, New York, United States
90115W	Future Engineers	WESTLAKE MIDDLE SCHOOL	Thornwood, New York, United States
97140A	Kennedy Gaels	Kennedy Catholic High School	Somers, New York, United States
97140B	Kennedy Gaels Too	Kennedy Catholic High School	Somers, New York, United States
97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States
98456A	Robo Frog	St. Mary's Episcopal Church	Carle Place, New York, United States
98456B	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
98456C	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
99588A	PIA	PIA TECH LEAGUE	Great Neck, New York, United States

The members of the VCAT robotics team organized and acted as referees for the event. Jason Becker served as manager and event planner; Manolo Duenas served as the announcer; Maharshi Patel served as head referee. Faculty and staff from Vaughn (Dr. Margaret Ducharme and Mr. Rachid Nafaa), Jericho High School (Mr. David Herbert), Freeport High school (Mr. Kevin Harrison), Farmingdale High School (Ms. Ann Grady), Newfield High School(Cory Fitzgerald) as well as two of VCAT members (Mariah Villalon and Alanke Perera) served as the judges for this competition.


ROBOTICS
COMPETITION

VaughnCollege
VEX
ROBOTICS
COMPETITION

VaughnCollege
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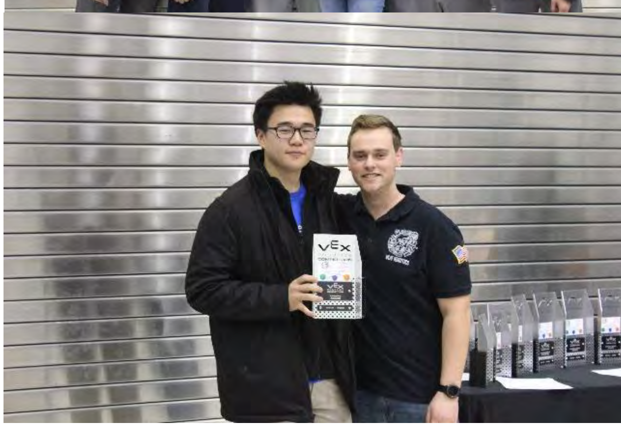
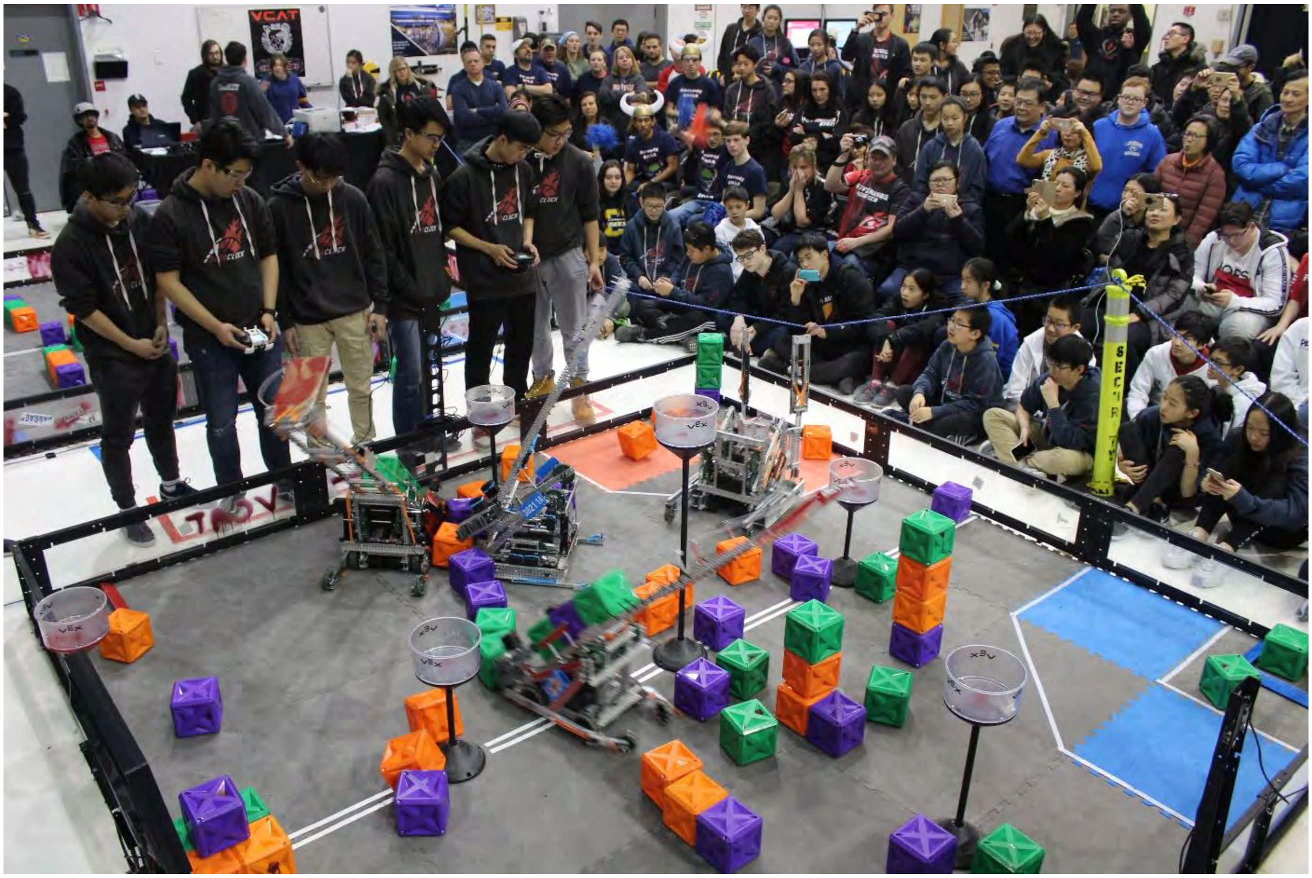
ROBOTICS
COMPETITION
JERICHO ROBOTICS

TRACK & FIELD


VEX



High School VEX Robotics State Qualifier Competition, Saturday, February 9th, 2019

The table below provides the list of award recipients for the 2020 regional High School VEX Robotics State Qualifier Competition. An alliance of Newfield High School and Centereach High School won the tournament championship, while a team from Newfield High School won the High School "Excellence" Award, Jericho High School won the "Design" Award and KG Computech won "Robot Skills" and Middle School "Excellence". Tournament champions, "Excellence" Award, "Design" Award and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.

Award	Team #	Team Name	Affiliation	Location
Excellence Award - High School (VRC/VEXU)	97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States
Excellence Award - Middle School (VRC/VEXU)	16699Z	Overclock MS	NY Youth Tech	Flushing, New York, United States
Tournament Champions (VRC/VEXU)	97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States
Tournament Champions (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States
Tournament Finalists (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Tournament Finalists (VRC/VEXU)	16099B	Overclock	KG Computech	Flushing, New York, United States
Tournament Semifinalists (VRC/VEXU)	16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States
Tournament Semifinalists (VRC/VEXU)	15239A	RoboBaller		Somers, New York, United States
Tournament Semifinalists (VRC/VEXU)	9932C	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Tournament Semifinalists (VRC/VEXU)	11791X	Arsenal	New Energy Education Center	Syosset, New York, United States
Robot Skills Champion (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Amaze Award (VRC/VEXU)	16099C	Overclock	KG Computech	Flushing, New York, United States
Build Award (VRC/VEXU)	98456B	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
Create Award (VRC/VEXU)	24642T	The Prodigies		Farmingdale, New York, United States
Design Award (VRC/VEXU)	9932X	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Energy Award (VRC/VEXU)	699E	Atomic Endgame	Thomas A Edison Career And Technical High School	JAMAICA, New York, United States
Innovate Award (VRC/VEXU/VIQC)	97140A	Kennedy Gaels	Kennedy Catholic High School	Somers, New York, United States
Judges Award (VRC/VEXU)	47114A	VEXcellent Girls	North Shore Coding and Robotics Club	Great Neck, New York, United States
Sportsmanship (VRC/VEXU)	11442X	Hewitt Robotics	The Hewitt School	New York, New York, United States
Think Award (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States

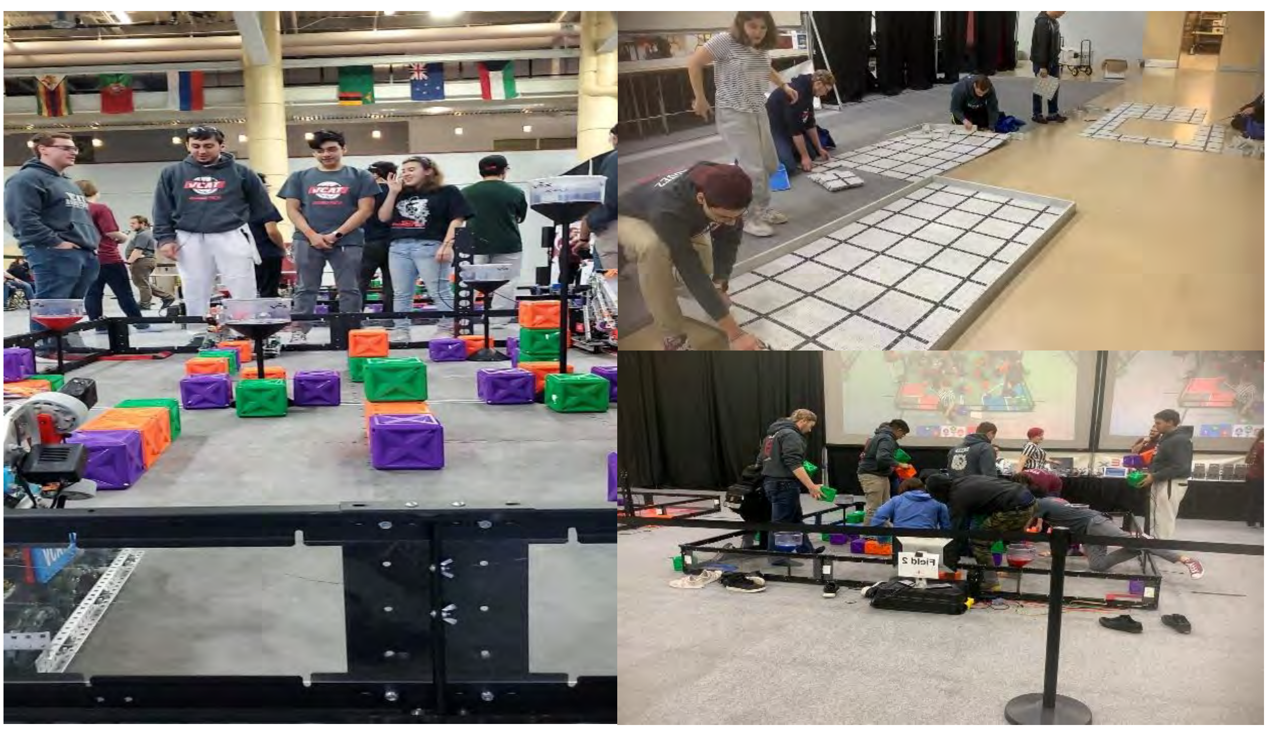
2020 West Virginia VEX U Robotics Regional Qualifier Competition, March 6, 2020

On Friday, March 6, 2020, Vaughn College's Robotics team participated at the Fairmount State University VEX U Robotics Regional Tournament. The team was composed of nine members (Jason Becker, Manolo Duenas, Kevin Tsang, Ariel Santos, Tatiana Jaimes, Timothy Tullio, Misael Marquez, Maharshi Patel, and Joseph Crowley).

A total of fourteen colleges and universities participated in the event. The participant teams included University of Maryland Baltimore (UMBC), one team from College of Southern Maryland (CSM), Aquidneck Island Robotics (AIR), Purdue University (BLRS), Kennesaw State (OWL1 & OWL2), Pennsylvania State (BLITZ), Liberty University (FR7), University of Illinois (ILLIN1), Northern Virginia Community College (NOVA2), Rochester Institute of Technology (RIT1), Marshall University (SQL), West Virginia University (WVUR1), and Vaughn College of Aeronautics and Technology (VCAT and VCAT2).

Each participating team had a total of eight matches. Vaughn's team (VCAT2) went undefeated in all eight qualifying matches. With eight wins, Vaughn's team (VCAT2) received **1st ranking** in qualification matches and advanced to the quarterfinal of playoff rounds of this regional VEX U competition.

During the quarterfinal of playoff rounds, VCAT2 was defeated by OWL1. In the final matches BLRS came out on top as champion and UMBC as tournament finalists. Currently, both VCAT and VCAT2 are qualified to participate in the 2020 World VEX U Robotics Championship. During the skills challenge matches, Vaughn's team (VCAT2) finished 2nd in "Robot Skills."



VCAT teams volunteering at the 2020 West Virginia VEX U regional competitions

Vaughn's NASA Rover Club: Blasting Off to Victory

Vaughn's NASA Rover Club is a new organization focused on designing and assembling a rover that can win the NASA Human Exploration Rover Challenge. The challenge began after the crew of Apollo 14 completed their expedition to the moon. During the mission, two astronauts had to travel great distances across the moon's surface to collect materials for study. One of the astronauts, Alan Shepard, had his heart rate reach 150 beats per minute because of the physical exertion required to complete the task. Both Shepard and his partner, Edgar Mitchell, would sweat in their suits and frequently needed breaks to catch their breath. In addition, they pushed resources and time constraints to the limit with their large intake of oxygen and their lack of speed and mobility.

Figure 1: Example of 2019 NASA Rover

In response to these issues, the Great Moonbuggy Race was established, which evolved into the NASA Rover Challenge. The criteria of the current challenge are to traverse half a mile of land, and complete objectives with the use of custom-made tools. A variety of terrains must be traversed to simulate an exoplanetary landscape. These terrains include an ancient stream bed with pebbles, a simulated field of asteroid debris, and erosion ruts and crevices of various dimensions. The objectives of the challenge are to deploy a solar power cell, to perform a core sample extraction, to take four photographs, and to collect 3 soil samples and 3 separate liquid samples.

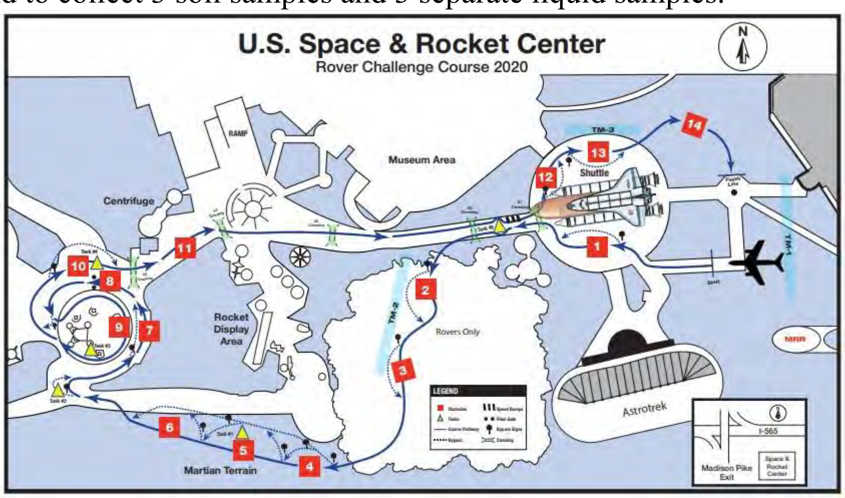


Figure 2: 2020 Rover Challenge Course

The Rover Club E-Board is comprised of 5 freshmen students, President Alina Santander, Vice President Michael Boller, Secretary Tatiana Machare, Treasurer Kevin Velasquez and Event coordinator/Social media manager Kacper Olchanowski. President Alina Santander has invaluable experience leading a NASA Rover Team to 1st place victories in multiple competitions.

Figure 3 Founding members of Vaughn's NASA Rover Club

The members interested in participating in the club's management all have an equal opportunity to do so. Elections are to be held once a year, and every member may vote for the person whom they believe will best fulfill the duties of each position.

Candidates and members with experience in mechanical engineering, mechanical engineering technology, mechatronic engineering, or any type of trade are especially beneficial to the cause. Although it is preferred that members be proficient in these skills, it is not required. Fellow members will always assist each other with completing tasks and improving skills. Teamwork plays the most important role in every organization's success: therefore, we seek students who are willing to help as well as to learn. Creativity from all members is highly encouraged, and every idea is taken into consideration.

To construct a rover for the NASA Rover Challenge, participants must understand the rules and goals of the competition. Deciding which prize the team will set as a goal is important, for the design of the rover must be devised with this choice in mind. Generally, in order to best meet the requirements for the rover, materials must be chosen that are cost effective, strong, durable, and lightweight. All rules, obstacles, and tasks pertaining to the competition are in the Guidebook on the NASA Rover Challenge website.

Figure 4: 2020 Rover GuideBook

Skills students acquire during this endeavor are applicable to a variety of STEM fields, including but not limited to, computer programming, mechanical and mechatronics engineering, ATI, and data science. Most of these areas of expertise are often covered in classes at Vaughn College of Aeronautics and Technology. Participation in the NASA Rover club, allows students to apply class knowledge in hands on activities, leading them to acquire a deeper understanding of their various subjects. The skills the students develop are:

- 3D modeling, using SolidWorks to create tools, parts and a final Computer-Aided-Design of the rover
- 3D printing the modeled parts and tools
- Experience working with welding materials
- Experience working with machining parts
- Use of basic tools and power tools
- Collaboration and efficient use of time

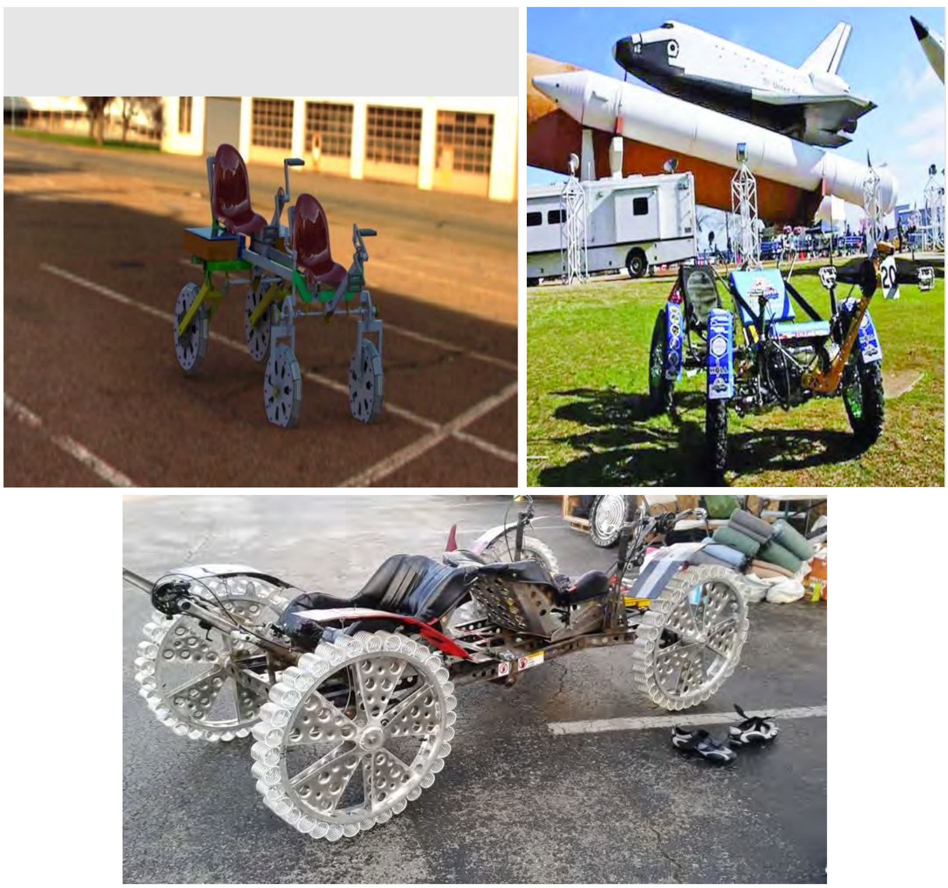


Figure 5 Rovers with design features

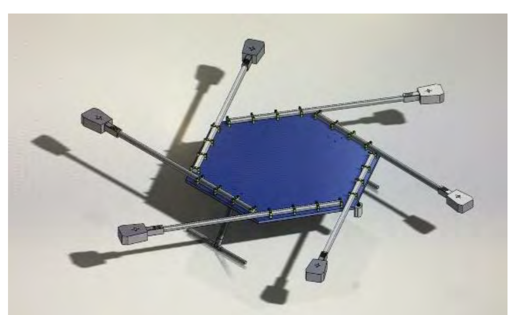
All of these skills are relevant in the work force, and contribute to members becoming avid candidates for internships and careers. In addition, skills practiced here can be applied back in the classroom, in the form of labs, classes, or degree projects; these experiences increase any student's chances of making it into their desired field.

Vaughn College UAV Club 2019-2020 Activities Report

The Unmanned Aerial Vehicles (UAV) club at Vaughn College had a successful year where the club participated in 2 competitions with 3 different teams working towards different competition requirements. The UAV Club came in 2nd place at the national VFS MAV Autonomous and Manual categories competing against Penn State, University of Maryland, and Drexel University. The UAV club came in 26th Place out of 75 teams at the Student Unmanned Aerial Systems (SUAS) competition hosted by the Association for Unmanned Vehicle Systems International (AUVSI) which was a major milestone for the club as a rookie team. The UAV club now strives to build upon these achievements to continue as a top performing team at these competitions, as well as to maintain its community service impact.

AUVSI SUAS

For the second year at the AUVSI SUAS competition, the UAV Vaughn team has begun the meticulous process of designing a system from the ground up to perform in the top percentile at the competition. The team equipped with the latest manufacturing machines provided by Vaughn College has chosen to design, build, and manufacture the UAS completely inhouse. The 2020 AUVSI SUAS competition has requirements to build an autonomous UAS with the capability to execute long range missions while being equipped



Custom Heavy Lift Drone Design

with high resolution cameras to perform image detection on the ground. Additionally, the UAS must also carry and deploy an autonomous rover at a specified point as part of the requirement. The AUVSI SUAS competition serves as a basis for leading-edge technology in the Search and Rescue (SAR) operations in humanitarian aid in case of any catastrophe.

VFS MAV

The UAV Club also has teams working on indoor navigation of drones as part of the Micro Air Vehicle (MAV) student competition hosted by the Vertical Flight Society (VFS) at the 76th Annual Forum in Montreal, Quebec. The indoor navigational challenge is to deliver as much sand as possible using either Manually operated or Autonomous drones in a limited amount of time. The UAV Club has chosen to participate in both the Manual and Autonomous Category. Both teams have worked diligently to satisfy the Gate 1 proposal designs as well as the feasibility studies on both drones.

Carbon Fiber/Nylon hybrid Design

Outreach

Throughout the year the UAV Club hosts various workshops and events to educate the community about the UAV world, as part of its STEM outreach. Members of the club host various workshops and events that are tailored to specific attendees. The UAV Club hosted drone workshops for Vaughn College's Annual Manufacturing Day. Build a drone workshop taught students the intricate process of soldering components as well as techniques such as wire management, part selection, and build verifications. Students also had the opportunity to build with some of the advanced components such as Pixhawk Cube flight controller and single board computers that the club uses for its autonomous flight testing.

The UAV Club also hosted a learn to fly workshop in a netted environment in the Vaughn College Hangar. Students flew small remote-control drones and were able to learn the basics of flying. Club members taught the students skills such as altitude control to perform 360-degree flips using the built-in functions.

The UAV Club also hosted its 2nd Tiny Whoop Race in the partnership with the Cradle of Aviation Museum. The UAV Club got permission to set up a racetrack around an F-11A Blue Angel Jet in which the micro drones could compete. Members of the professional First-Person View (FPV) drone-racing community were invited to race as well. Several Prizes were awarded to the race winners and a Hands-free Drone was raffled off to event attendees. This event provided the pilots with the opportunity to show off their skills, and it allowed the community to learn more about drones by having the opportunity to speak to drone hobbyists as well as to the UAV club.

The UAV Club has also partnered with the Vaughn College STEP Program to host a drone workshop at the STEP conference hosted at Vaughn College. STEP is New York State funded program dedicated to preparing historically underrepresented and economically disadvantaged secondary school students for entry into postsecondary degree. Through this workshop, the UAV Club strives to impact its community and to spark the interest of the young generation of students.

The UAV Club will host its signature event, Vaughn Drone Day in May again this year. Vaughn Drone Day is an annual event held at Vaughn College, where everyone is invited to attend free of charge. At this event, the UAV Club has various workshops for participants to attend, and the hanger is set up with a net within which people can fly drones. Drone enthusiasts and professionals show off their drones and equipment at their booths, and a discussion panel is held regarding drone rules and regulations. Every year people come from all over the 5 boroughs to take advantage of this event.

2019-2020 National Society of Black Engineers (NSBE) Club Activities

The National Society of Black Engineers is a worldwide organization focused upon member success both in and out of school. There are several programs and events throughout the year that provide our membership and the student body with internship and networking opportunities. Multiple events, such as host study groups and fun outings, are held within this organization. Our national club goal, stated within the NSBE mission statement, is “To increase the number of culturally responsible black engineers who excel academically, succeed professionally, and positively impact the community." While the national mission is to generally advance the progress of black engineers, our chapter is open to all engineers who are interested in our goals and projects

The Vaughn College Chapter of The National Society of Black Engineers was officially established in February 2017. Even though it’s a new chapter, there has been a growing number of active members and of events which uphold the mission of the organization. During the fall semester of 2019, our chapter was successfully assimilated into the Metro/LI NSBE Zone, giving us access to new resources, as well as opening relations for cross chapter collaborations with other schools in the Metro/LI zone.

We are dedicated to the professional, cultural, and educational advancement of all our members, and we accomplish this by informing our members of events, workshops, and seminars that aimed at these developments.

NSBE 45th National Conference – March 27th-31st, 2019

The National Convention for NSBE was held in Detroit, Michigan, on March 27th, 2019. This convention showcased black students and professionals who have a passion for science, technology, engineering and math (STEM), are high achievers in these fields, and channel their dedication to their communities and society at large. The convention held in the Motor City, was a record-breaker, with an all-time high attendance of more than 14,000 and the highest-ever number of exhibitors, nearly 350, at the event's Career Fair. A few of our members represented our chapter at the convention. This event exposed our members to workshops that prepare them for academic and professional success, as well as for having a positive impact on their local communities. In addition, a career fair was held for two days, which allowed members to receive an internship or full-time position from among over 350 companies. The career fair also provided members with the opportunity to pursue success in both pre- and post-graduation job opportunities.

Northrop Grumman Q&A - September 5th, 2019

At the start of the semester, a member of the club who had a job offer from Northrop Grumman during the NSBE 45th regional conference invited a recruiter from Northrop Grumman to come to the college to talk about opportunities in the company, as well as to provide insights about skills and paths leading to a successful career in the industry. The recruiter also happened to be a member of the NSBE professional group registered in Florida. The event was designed to be in the form of an open discussion and it was open to both members as well as non-members

Intel AIDC Summit Series - September 19th, 2019

In a series of zone related professional development opportunities, Vaughn College's NSBE chapter was invited to the Intel AIDC Summit Series on September 19th, 2019. At this summit the applications of machine learning were demonstrated through free, hands-on workshops offering small-group training on Intel® hardware and software and guidance on open source tools available for AI development. Each attendee was given Intel's computer vision co-processor, the Intel Movidius neural compute stick as a souvenir.

Facebook Open House - September 24th, 2019 & Facebook Skill Building Night - September 26th, 2019

Vaughn's NSBE Chapter was also invited to two Facebook hosted events, the first being the Facebook Open house on the 24th of September 2019. Attendees were given the chance to talk to recruiters, network with other attendees, and become aware of the wide scope of opportunities available to engineers in the company. As a follow-up to the open house, the chapter was extended an invitation to attend Facebook's 'skill-building night' on the 26th of September 2019. Attendees were given the chance to learn skills being used on a day to day basis in the workplace of Facebook. These workshops ranged from hardware to software and even data analysis and interpretation.

Quantum Levitation Stem Outreach Demonstration Manufacturing Day 2019

The NSBE chapter was able to explore the concept of quantum levitation or ‘Magnetic’ levitation. Club members then presented the demonstration and explained the concept governing it during Vaughn College’s Manufacturing Day. The concept states that at normal temperatures, magnetic fields can pass through the superconductors normally. Once it is cold enough to exhibit superconductivity, however, those magnetic fields are expelled, demonstrating the effect of quantum locking, which enables the superconductor to levitate above a magnetic track. And with the magnetic track club members put together, allows the superconductor not just to levitate in place but also to move around the track while levitating. The engineering department not only sponsored the purchase of the items needed for this project, but also allowed the club the platform of Manufacturing Day to enable club members to share the knowledge of this fascinating science with a younger generation

Region 1 Fall Regional Conference (FRC) - November 2019

During the fall semester, 6 members attended the fall regional conference in Niagara, New York. During the conference, members learned new networking skills and about engineering certifications and licenses that will be helpful to them throughout their engineering careers. The resume boot-camp workshop was very helpful, as it allowed professionals in the engineering industry to provide feedback on the member’s resumes. The career fair allowed members to network and find the best fit career-wise. The chapter was also invited to attend a historical tour provided by M&T Bank, and members had the opportunity to network with professionals in an environment that put them at an advantage during the career fair the next day. This conference has many opportunities to get students out of their comfort zones, as they are encouraged to communicate and come up with ideas. This experience provides students with a better understanding of critical thinking, which enhances their career skills.

Society of Women Engineers (SWE) Activities

The Vaughn College of Aeronautics and Technology (VCAT) Chapter of the Society of Women Engineers (SWE) is an organization supporting and empowering female students who are specializing in the field of engineering. The Chapter's goal is to highlight the importance of diversity and strengthen its legacy in a very competitive field. Not only does the Chapter groom its members to excel as engineers, it also helps them to become well-prepared professionals who will be highly productive in their chosen field of endeavor. Furthermore, the Chapter prides itself on its STEM Outreach work, in hopes of increasing future female involvement and current student interest in engineering.

Women Engineering Conference 2019

The Vaughn College chapter of the Society of Women Engineers (SWE) attended the 2019 Women Engineers Conference in Anaheim, California from November 7th through November 10th, 2019. During the conference, SWE students presented and held a STEM workshop. In addition to participating and presenting at WE19, these students had another item on their agenda: employment. Nine students from SWE went to the conference in search of internships or full-time employment, and they were very successful. Together they received a combined 22 interviews with industry leaders such as Northrop Grumman, Boeing, Lockheed Martin, Dell, United Technologies, General Motors, ASML, Daimler Trucks of North America, BAE Systems, and Raytheon. In addition, 1 internship position and 9 full-time positions were offered.

During the conference, Vaughn's SWE members, Sagufta Kapadia hosted, "Drones for Good" to a full house. This talk shed light on the positive impact of drones in the community and aimed to clear common misconceptions that many tend to have about drones. The attendees of the lightning talk enjoyed the presentation, because many were not aware of how drones are being used in various fields, such as in transporting medical products, in search and rescue missions as well as in agriculture.

Summary of the lightning talk:

Technology has greatly advanced over the span of a short time. One technological advancement that has drawn great attention from various groups including politicians, engineers, and photographers is the Unmanned Aerial Vehicle (UAV) or drone. There are various debates about UAV's, regarding public safety and privacy; however, not enough light is being shed on the positive impact this technology has had on society. Drones are now being used for search and rescue missions, emergency response, agricultural purposes, security, construction planning, and inspection, etc. These vehicles can easily reach places where it is extremely dangerous or impossible for a human to reach. Thus, it is vital to acknowledge the positive impact drones have made on our world, in order for the continuous support and advancement of these vehicles.

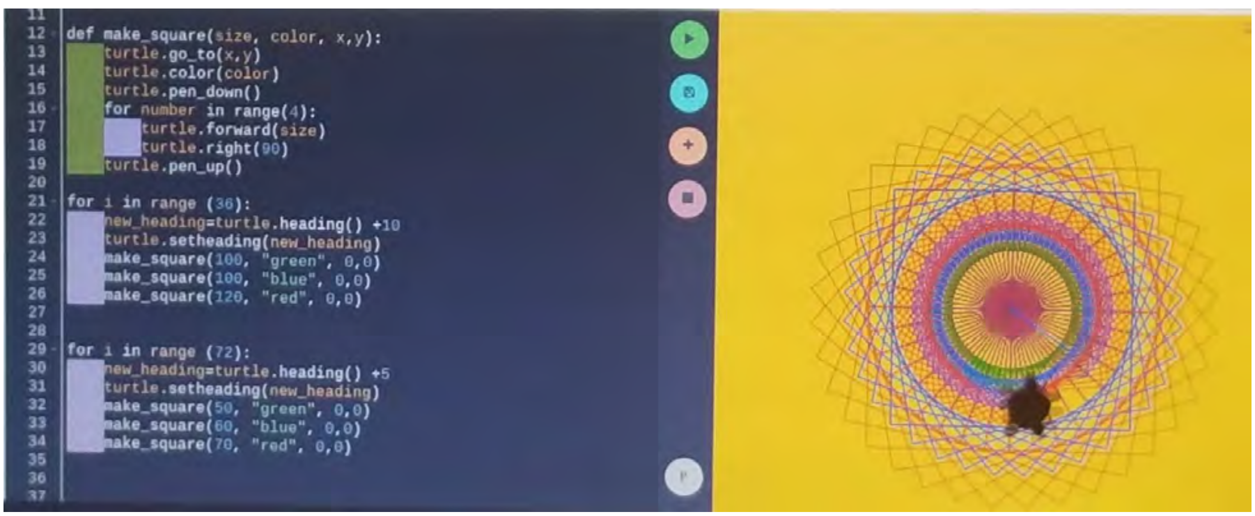
Invent It. Build It Expo

The Invent It. Build It. Expo took place on Saturday, November 9th. This Expo is for K-12 students to experience the creativity and innovation of engineering, through hands-on projects alongside experienced professional engineers. SWE hosted a STEM propeller powered car workshop which taught students the basics of circuitry and thrust while learning about Vaughn College. The workshop was a huge success as the SWE-VACT booth was crowded throughout the event, and all of the 100 workshop kits were finished before the event ended.

SWE-VCAT members helping young girls make the propeller power car at the 2019 Invent It. Build It. Expo

SWE STEM Outreach

Our first STEM Outreach workshop was held by Shmuel Pantierer and Aderet Pantierer on November 1st, during **Vaughn's Annual Manufacturing Day**. They successfully presented the "Computer Aided Design (CAD)" workshop to 20 high school students. Students were taught the fundamentals of how the CATIA software can be used to design a part and how CATIA is used in the industry. After learning the basics, the students were given step-by-step instructions on how to design an iPhone case. This hands-on process allowed the girls and boys to better understand what had been previously demonstrated. The workshop also promoted teamwork and problem-solving skills, which are important skills to have if students want to pursue a future in engineering.



Mariah Villalon, a freshman and a new SWE member, was tasked with developing a programming workshop for a group of high school students. She decided to use the Codester program to show the students the basics on programming in python. She began her workshop by giving a presentation on the applications of programming in today's world. Then she went on to explaining the basic structure of programming. The students were then given the opportunity to program using the given code. After the students had finished programming, they were able to edit and change the code on their own to better understand how the code works. Throughout the workshop, students were trouble shooting their code if it gave an error when they ran it and asking questions to gain a better understanding.

On February 8th Sagufta Kapadia hosted the "Get Noted" workshop for a group of high school students. The students were first given a presentation on the basics of electronics, as this workshop involved various electronic components. The students learned about current, resistors, capacitors, 555 timers, breadboards and batteries. The students were then given the piano kit to build their own mini piano on a breadboard, along with instructions. The workshop required that the students pay attention to details, as every electronic component plays an important role in the circuit and misplacing one or not placing a component can cause the circuit not to function. Overall, this workshop presented the students with a fun way to learn the basics about electronics.

Professional Development

In between STEM Outreach Workshops, the Society of Women Engineers spends a lot of time with the professional development of its members. This includes workshops on resume writing, portfolio development, and cover letters. In addition to these, the chapter also reviews the STAR format, interview questions, and how to create an intriguing elevator pitch for recruiters. These skills are reviewed throughout the school year and help prepare VCAT-SWE members for conferences and the engineering facility tours that they arrange.

Lockheed Martin Tour

On October 11th, 2019, 15 students from Vaughn College of Aeronautics and Technology had the opportunity to attend the Lockheed Martin facility tour organized by SWE in Stratford, CT. These students got to see Igor Sikorsky's office and learn about how the company was founded and how it has evolved over the years. They also learned about the various aircrafts the company has developed for different purposes and how they are being used today. Additionally, the tour guide gave an overview on the current projects the company is working on and the job and internship opportunities with the company. Along with learning about the company, the students also had the opportunity to see the production line for the Black Hawks and the King Stallion CH-53K. The students were also able to see how various parts of the helicopters are made using different methods such as forging and casting. After the tour of the facility, the students were taken to the simulation lab for the S70 OPV program, where they were given the opportunity to fly the Black Hawk simulation. This tour provided the students with a great overview of this company.

SHPE Leading Hispanics in STEM | Vaughn College of Aeronautics and Technology

2019-2020 Society of Hispanic Professional Engineers (SHPE) Club Activities

Hispanic Heritage Month [Sept 2019]

Hispanic heritage month was a time when The Society of Hispanic Professional Engineers (SHPE) could shine. This event let the chapter grow closer with the school community by providing a trivia game along with free food, all related to our member's Hispanic heritage. All of the members had some part in making the event lively, by manning the food station, giving out prizes, judging, or even reading out the problems. Everyone relaxed for an hour and learned a little more about the Hispanic community.

Open House [Oct 2019]

For two Saturdays our members talked to high schoolers interested in applying to Vaughn College. Our members showed the potential and opportunities that the club, along with the school, can supply to new students. All the members met individuals who were more convinced to attend the school, due to the variety of clubs the school has to offer. Our members were actively engaging with new potential freshman who will attend Vaughn College.

SHPE National Convention Readiness [Oct 2019]

Before SHPE’s largest event, all attendees are required to attend several events to ensure the best possible outcomes for each member. These events include resume building, company research, dress to impress, interviewing skills, and even mock interviews. Each member reserved time with Mohammed (Antenna Mechanical Engineer - Raytheon), Anwar (Associate Structural Engineer - Pratt & Whitney) along with SHPE chapter leaders and experienced SHPE member volunteers.

SHPE National Convention Readiness [Oct 2019]

Events like the resume building seminar incorporate previous member's resumes as well as resumes reviewed by the career center at Vaughn College. With every resume, there should be a good portfolio attached to it. All members attending the conference will have a concise portfolio, containing any projects they have made on their own time and any projects they have created in the school year. With the help of previous SHPE alumni and members who have experience at well-known engineering companies, members learn what will be asked of them at any interview opportunity presented to them. This ensures that when all our members secure a slot for an interview at one of the companies, they are ready to answer any relevant question.

SHPE National Convention [Oct 2019]

The Society of Hispanic Professional Engineers (SHPE) is a great opportunity for students to network and to develop professionally. SHPE helps members to develop a lot of soft skills and leadership skills. Also, the SHPE National Convention is the largest Technical and Career Conference that helps SHPE members to gain professional experience. This conference provides members with the opportunity of an interview, which will either give them an internship or a full-time opportunity with an engineering centered company. The Vaughn College SHPE chapter is very helpful to the future of its members. It provides them with professional skills, networking opportunities, and hands-on experiences.

Lead Engineer Award [Oct 2019]

After participating in the Extreme Engineering competition, Angel was drafted on to the Boeing Team. He fought for twenty-four hours straight in building, designing, and leading his team. As a result, he was noticed to be one of the best engineers leading his fellow drafted members by the judges. Angel was highly sought out by Boeing after this event. They offered Angel a full-time position for his excellence in the competition.

Vex Robotics Volunteering [Feb 2020]

Several of our members belong to the Vaughn College Robotics Team. This relationship brought us the opportunity to attend one of the various communities with whom they volunteer, to help run a High School Vex Robotics Competition. This Competition brings STEM skills to life by assigning teams of students to design and build a robot to compete against other teams in a game-based engineering challenge. SHPE members were in charge of scoring matches, inspecting robots, and running the skills field. Throughout this opportunity, our members had the chance to share the five pillars of SHPE with the students present (Academic, Professional, Leadership, Chapter Development, and Community Outreach). Furthermore, our members practiced an important standard of engineering by applying their skills to the benefit of local NYC communities.

Engineers Without Borders-USA is a national organization that works to create a better world through engineering projects that allow communities to meet their basic needs. The Vaughn College Chapter works to equip the engineering leaders of tomorrow by finding solutions to the developing world's most pressing issue, water security. The Vaughn College Chapter was founded in November 2015. This year we continue our first international water project in Rwanda.

FUNDRAISERS

Engineers Without Borders conducted two fundraisers and have more planned for this academic year. The first fundraiser was an off-campus event held at the Pelham Dave & Buster's site during November of 2019. Students socialized with their peers and enjoyed friendly competition during homecoming week. This turned out to be a team building experience, as we had the opportunity to learn about each other's strengths and weaknesses during sales and promotion. The second fundraiser was on campus, also in November of 2019. We partnered with a local Chipotle restaurant for our third Burritos Without Borders event. These events allow new members to take up various team and leadership roles, while also understanding the importance of fundraising for our cause.

CPR CERTIFICATION

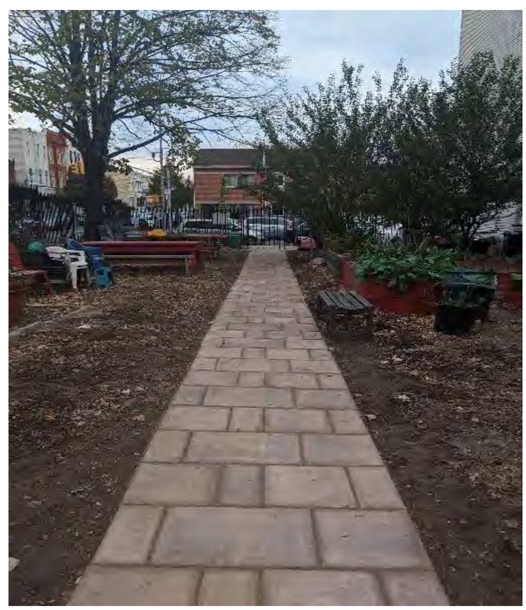
Nationwide Health LLC provided hands on CPR training to club members. This workshop is necessary for the members traveling to Rwanda for the implementation phase. Each member had the opportunity to learn about action plans during emergencies they may encounter. We also learned to work as a team to minimize errors during medical emergencies. This was one of the most educational workshops we attended, because we learned how to use basic skills in a real-life emergency. This workshop was beneficial, because during a medical emergency, a team should be able to carry out a plan under stressful circumstances.

ENGINEERS WITHOUT BORDERS CONFERENCES

From November 7th to 9th 2019, four members of the Vaughn chapter participated in the EWB-USA National Conference hosted in Pittsburgh, PA. These days were full of learning, experiences and accomplishments. All attendees participated in different workshops. These workshops were dedicated to understanding the skills required for various projects across the globe, as well as to recruiting and sustaining memberships. These workshops ranged from planning and executing a successful fundraising event, project management, leadership, technical aspects, and traveling tips. Our members established connections with other chapters who may assist us with resources required for this project. The New York City Chapters of EWB are launching a series of conferences during the spring of 2020, for which many of our members are already registered.

COMMUNITY ENGINEERING CORPS, SERVICE PROJECT

The Community Engineering Corps is the domestic side of Engineers Without Borders. During this service project, volunteers had the opportunity to finally roll up their sleeves. Jackson Forest Community Garden, located in the Bronx, saw a few Vaughn members, as they volunteered to construct a walkway for members of the community. This activity lasted for several months of hard labor. At this event, members were able to network with other chapter leaders as well as with representatives from the NY Professional Chapter.



RWANDA POTABLE WATER PROJECT, IMPLEMENTATION PHASE

The club's major achievement this year was the opportunity to travel and work to complete our very first Project in Kibingo, Rwanda. This project defines what EWB stands for, "Making a better and sustainable future for people." Earlier in the year, our team visited Rwanda, along with our Faculty Advisor Dr. Bustamante and our project mentor Patrick. Information from this trip was used to develop an implementation plan for a highly reliable, sustainable system for the residents of the area. Upon returning from this trip, a post-assessment report was written. The Vaughn chapter's report was added to the list of examples on Volunteer Village, the media used by Engineers Without Borders.


We're currently on the Alternative Analysis report, which describe our findings and debates which alternative will work best for the village. An ideal alternative is one that's low cost, provides a sustainable source of clean water and doesn't require a lot of maintenance. This experience is highly educational, because members are learning how to work cooperatively on reports. The club is currently working towards securing sponsorship from Pratt & Whitney.

STEM OUTREACH

In April 2019 and on October 14th 2019, our club delivered a presentation to members of the Vaughn Community. The purpose of these presentations is to show the audience what our club has accomplished and what are our goals for the future. The presenters spoke about the solutions we're considering for our clean water project, fundraising ideas, and the impact we've had so far in Rwanda.

This would not have been possible without the help of the local people of the area. Our team partnered with a local NGO. They will guide and help us as we move forward with our project. This experience made our team more excited to help our fellow Rwandans.

HSI-STEM Grant Activities

Through "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students," Vaughn College continues to develop a much needed pathway for Hispanic students to increase accessibility to the College's engineering degree programs. Project goals include:

1. Close academic achievement gaps where students are at high risk of failure or withdrawal, including increasing the percent of Hispanic and low-income students who participated in grant-supported services or programs and who successfully complete gateway courses, and increasing the percent of Hispanic and low-income students who participated in grant-supported services or programs and who are in good academic standing
2. Expand focus on persistence to include the development or redesign of instructional programs and support strategies that facilitate Hispanic and low-income student transition through upper division studies in high demand STEM fields.
3. Strengthen college capacity for offering opportunity equity for all students through stronger outreach to high school and community college students.

Progress Summary: We are very pleased with the significant progress made toward meeting overall goals and objectives, including steady increases in enrollment in STEM related programs. The Engineering and Technology department is making significant progress toward implementation of these goals. Below are current initiatives the College is implementing to attain these goals:

- Supplemental Instruction (SI) and Mentoring group is a student academic assistance program that increases academic performance and retention through the use of collaborative learning strategies. The SI program at Vaughn targets challenging mathematics, engineering, and physics courses and provides regularly scheduled, out-of-class, peer-facilitated sessions that give students the opportunity to process the information learned in class. Supplemental instruction is a proactive approach to student learning and engagement which increases student persistence and retention.

  Under the current College's Title III grant, Vaughn assigned Thirteen SIs in spring 2019 and ten SIs in fall 2019 to assist and improve students' performance through fundamental engineering and engineering technology related courses. Also, Vaughn's two writing specialists, in the Teaching and Learning Center (TLC) assisted many students with their capstone degree projects, technical writing and presentations. As a result of this program, some of our students' research projects were accepted for publication and presentation in technical conferences such as the annual conference of American Society of Engineering Education, YPSE AIAA Mid-Atlantic Section conference, Dassault systems solution 'Community of Experts' Annual Experience conference, COMSOL Multiphysics conference, International Mechatronics Conference, annual conference of the Society of Women Engineers, Southern Biomedical Engineering Conference, Latin American and Caribbean Consortium of Engineering Institutions, and Society of Hispanic Professional Engineers (SHPE) (**attaining goals 1 & 2**).
- The College's current Title III grant (P031C160021) provided additional funding support to further expand student involvement in STEM related scholarly and practical hands-on

activities. This includes student engagement in paper and poster session competitions of technical conferences (ASEE, LACCEI, IEEE, AIAA, SWE, and SHPE) as well as their involvement in robotics, UAV, and formula SAE clubs activities and competitions. As a result of this program, Vaughn's engineering students participated and presented their research papers in 2019 LACCEI International Conference and received all top three awards (first, second, and third place) of the student paper session competition. Two of Vaughn's Mechatronic Engineering students participated and presented in the 2019 International Mechatronics Conference and they received the Best Presenters award of the Mechatronics Application technical session. Two of Vaughn's engineering students participated and presented in the 35th Southern Biomedical Engineering Conference and they received 2nd and 3rd best presenter's awards in this regional conference. Vaughn's UAV club participated as a finalist in the 2019 Vertical Flight Society (VFS) Micro Air Vehicle competition and finished second in both the autonomous and the remote control categories in this challenging competition. Vaughn's Robotics club finished second in the 2019 VEX U International Mexican Robotics competition. Also, Vaughn's SHPE student chapter participated in the 2019 Society of Hispanic Professional Engineers (SHPE) Conference, and this is the third year in a row that a student from Vaughn won the Nissan Design Challenge in this annual conference (**<u>attaining goals 1 & 2</u>**).

- For the academic year 2018-2019, students in Vaughn's technical clubs (Robotics, UAV, and SAE) and Vaughn's student chapter of professional societies (SWE, EWB, NSBE, and SHPE) organized and hosted several STEM related workshops for middle school and high school students during Vaughn's Annual Manufacturing Day, Vaughn's International Drone Day, and Vaughn's Annual STEM Day. They also provided assistance to many high schools to host their regional robotics and drone competitions. Vaughn's UAV team continues to assist the Cradle of Aviation Museum in developing and hosting drone games and competitions for high school students. The PD, along with faculty, attended some of these events to increase awareness about Vaughn's engineering programs (**attaining goal 3-outreach).**

- **<u>Program Articulations:</u>**
  - As part of the program articulation agreement with Robert F. Kennedy Community High School, junior and senior level students enrolled for Introduction to Robotics, one credit **MCE101** (three contact hours) at Vaughn College. Upon successful completion with a grade of C or better, this course can be applied towards a Vaughn College Engineering Program degree.
  - On Thursday, October 31, the PD signed a program articulation with Hillcrest High School. As part of this articulation, Hillcrest Junior and Senior level students may enroll for MCE101 (Introduction to Robotics, 1 credit, 3 contact hours), CDE117 (Engineering Graphics, 2 Credits, 4 contact hours), CSC316 (C++ Programming, 3 credits) at Vaughn College, and upon successful completion with a grade of C or better, these courses can be applied towards a Vaughn College engineering and engineering technology degree.
  - In November 2019, the PD along with **the** assistant to the Associate Vice President of Academic Affairs established a 4+2 agreement with Freeport high school for both AAS Aeronautical Engineering Technology and AAS Electronics Engineering Technology-Avionics. The goal is for summers to be intense academic sessions on the Vaughn campus for the Freeport HS students. Fall and

spring would likely be on the Freeport high school campus, and the college would either hire, train and certify Freeport teachers as Vaughn adjunct faculty or send our faculty to the Freeport campus. We are ensuring the lab courses (which take special equipment) are taught at Vaughn, and courses that don't need equipment beyond what is at a high school, can be taught there.

- Currently the PD and STEM Pathways Advisor and Transfer Liaison are reviewing newly drafted ME and EE program articulation agreements with LaGuardia Community College to include current EE and ME program modifications.

➢ **Advanced Manufacturing Training and Workshops:**

1. On Friday, October 25, Prof Manual Jesus, Additive manufacturing and CNC curriculum developer, provided a day workshop on 3D printing and additive manufacturing for thirty five students and ten teachers from Pablo Casals middle school (MS 181). The workshop covered 3D SolidWorks, part and assembly design, and additive manufacturing process.
2. From November 19th to 21st 2019, Dr. Budhoo, Composite Curriculum Designer, attended the ASNT annual conference held in Las Vegas, Nevada. The knowledge obtained from this conference will be beneficial to the Composite Manufacturing certificate program at Vaughn College, since Dr. Budhoo now has a better insight to the selection of appropriate equipment for the nondestructive course (attachment#6-American Society of Nondestructive Testing (ASNT) Conference.
3. From Aug. 13-15, Vaughn's Mechatronic and additive manufacturing lab specialist attended a **3-day Siemens hands-on training workshop** at Corning Community College Auxiliary Aviation Corporate Campus, 360 Daniel Zenker Dr, Horseheads, NY 14845. Day one training covered the general interface of Siemens TIA Portal, which is similar in design to Siemens Step7. Day 2 training covered complex logic programming in the form of bitwise operations (including AND, OR and XOR logic), latches, and timers, and Day 3 covered training on the HMI interface and manipulation of the already-provided window to show the proper information.
4. From Aug 16-20, CNC Curriculum Designer, Prof. Manual Jesus, and Manufacturing Lab Tech, Rachid Nafaa attended a hands-on training class in coordinate measuring machine (CMM) to learn the AIMS Metrology CMM system in Dayton, Ohio. CMM is used to measure the physical geometric properties of a part. The five-day course first reviewed core concepts such as Cartesian coordinates and vectors, then geometric tolerance concepts through the use of the CMM as a measuring tool. Geometric tolerance was explored by programming the CMM to inspect a part-using approach, probe, and retract commands developed via a command-line interface or a more intuitive graphical user interface.
5. **STEM Pathway Workshop:** On Friday, March 8, 2019 the PD with the grant team and STEM pathway Liaison organized and hosted its first STEM Day workshops for community colleges. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Bergen, and Suffolk Community Colleges and Uncommon Charter High School. In the morning session, Vaughn's STEM Pathway Liaison, Ms. Lisa Limbach, and STEM project director, Dr. Hossein Rahemi, talked about Vaughn College's program offerings in engineering and engineering technology disciplines, as well as student involvement in various STEM related clubs and professional activities.

From 10:30 am to 11:30 am, Vaughn's CNC lab specialist, Mr. Rachid Nafa, introduced participants to a hands-on session on part design and manufacturing process using HASS VF-2SS CNC milling and cutting machine. From 11:30 am to 12:15 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. In the afternoon session, from 1:00 -2:00 pm, Vaughn's UAV and Robotics clubs engaged participants in hands-on STEM workshop sessions on building a drone and on robotics design and construction. Finally, from 2:00-3:00 pm, Prof. Manuel Jesus hosted a workshop at Vaughn's 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines.

6. On Tuesday, Dec 11, Aeronautical Curriculum Designer, Dr. Elzawawy conducted a day training workshop with Quanser Inc in Markham, CA. The training focused on Autonomous Vehicles Research Studio (AVRS) and UAV flight control equipment such as 2 DOF flight control using PID, 3 DOF Hover, Aero-Gimbal, and QDrone The knowledge gained through this training will be helpful in the development of UAS and the automation certificate program.
7. From January 7-11, 2019, Dr. Douglas Jahnke participated in an Advanced Composite Structures related to Fabrication & Damage Repair-Phase 1 course at Abaris Training in Reno, Nevada. The course balanced theoretical and practical presentations with hands-on exercises.

These hands-on workshops and training courses helped the grant management team with valuable lessons in the development process of facilities and laboratory equipment that will allow Vaughn to provide our students with practical hands-on STEM manufacturing training that is current with today's industry demands.

- **Stackable Certificate Programs:** In spring 2019, the grant management team was able to complete the following manufacturing certificate programs.
    1. **CNC Machining and Manufacturing Certificate program:** In early January, the PD with the assistance of the Grants Manager completed an application for a CNC Machining and Manufacturing Certificate program which was submitted to the NY State Education Department for their review and approval. This certificate program has a total of 15 credits and provides a "well-rounded" education to prospective engineers and technicians in CNC subtractive manufacturing. Students will gain hands on experience developing CAM programs with G-Code, Mastercam, and Catia for the Hass mill and Okuma Lathe CNC machines. In March 2019, we received approval from the NY State Education Department for this certificate program. Currently, the grant advisory team is working on PLC and Automation certificate programs.
    2. **PLC and UAS Certificate Programs:** Currently, the PD and grant advisory team are working on PLC/Automation certificate and UAS certificate programs. We expect to complete and submit these certificate programs to the NY State Department of Education in academic year 2020-2021.

In addition, during the academic year 2017-2018, the grant management team and the PD completed two certificate programs in **1) 3D Additive & Subtractive Manufacturing 2) Composite Design & Manufacturing.** Both certificates received approval from the NY State Department of Education. The Department will begin to offer courses within these certificate programs, after laboratory renovation and the purchase of supporting equipment.

- **BS in Advanced Manufacturing:** The Manufacturing Curriculum Committee, in collaboration with the industry advisory board, is developing a new BS program in Advanced Manufacturing to introduce students to practical hands-on manufacturing skills. Students of this program will acquire knowledge in the area of Computer-Aided Design and 3D Printing, Computer-Aided Manufacturing and Prismatic Machining, Composite Manufacturing and repair process, CATIA Composite Product Design, CNC Machining, and UAV construction and applications. Besides hands-on technical courses, students are required to take courses in basic engineering sciences and application (applied statics & strength of materials, applied thermos-fluid, and mechanical testing) to further enhance their understanding in the advanced manufacturing process and design. To complete this program, students are required to take a total of 128 credits: 61 credits in liberal arts, math, and science courses; 29 credits in engineering science; 10 credits in computer-aided design and computer-aided manufacturing; 9 credits in composite design and manufacturing; 6 credits in CNC machining; 10 credits in UAS and automation; 3 credit manufacturing capstone project.
- **Laboratory Development:** The Engineering and Technology Department established two new state-of-the-art facilities: the Composite Manufacturing Center and the CNC Machining Center, and is currently establishing a UAS Center. During the academic year 2018-2019, HSI-STEM grant funding support allowed the department to make enhancements to its currently established 3D Makerspace Center and PLC & Automation laboratory. In the 2018-2019 academic year, the department completed purchase of the following laboratory equipment:
    1. Equipment for the composite lab (autoclave, Ply cutting table, hot bonders, Vacuum bagging kits, vacuum pump, accessories and supplies for composite manufacturing) Price: **$178,039.89**
    2. Automation Sub-System lab equipment (IMS Processing, testing, handling, Storage, Routing, Buffering, and UniTrain Interfaces+ Experimenters) Price: **$112,485.83**, Automation Lab.

  This laboratory equipment allows Vaughn to provide students with practical STEM hands-on training in composite manufacturing and automation that is current with today's manufacturing industry standards.

- **Students' accomplishments and success:** Below is a list of students' accomplishments and success that are a direct result of the current HSI STEM grant and its implementation process:

1. The Vaughn College robotics team participated in numerous local, state, and world championships, winning or placing high in all of them. Vaughn's robotics team has been a great outreach tool as well as a great intervention to increase engineering student retention and success.

    - Vaughn's robotics team received top ranking in the Innovate division of the 2019 world championship, out of 78 participating teams. Vaughn's team retained their standing as one of the top competitors in the world championship by advancing to the quarter-final of the playoff round in this intense competition, for the sixth year in a row. On Saturday, April 23, Judges awarded Vaughn's Robotics team with the **2019 World Create Award**. The **Create Award** is presented to a team whose robot design incorporates a creative engineering solution to the design challenges of this season's game.

- From December 12-14, 2019, the Vaughn College Robotics team, one of the top competitors in the 2019 VEX U Robotics World Championship, was invited to participate in Mexico's VEX U International Reeduca Robotics competition in Cancun, Mexico. The team finished second place overall in the competition and won the Build Award in this international robotics competition. For the past five years, Vaughn robotics team members consistently demonstrate persistence and drive in order to attain their title as champions (2015, 2016, and 2017) and as top competitors in Mexico's VEX U Robotics competition (2^{nd} place in 2018 and 2019).
- Vaughn College is planning to host the Vaughn College VEX U Tournament on Friday February 28 and the Vaughn College VRC Tournament on Saturday February 29.
- On Saturday, March 6 2020, Vaughn College's Robotics team participated in the West Virginia VEX U Robotics Regional Tournament. Vaughn's robotics team finished first during the qualifying matches and finished 2^{nd} place in "Robot Skills".
- In spring 2019, Vaughn College's robotics team is planning to participate in more regional qualifier events
- **<u>Robotics Outreach Activities:</u>**
    - ✓ The PD, Faculty, and Vaughn Robotics team will assist Vaughn College in hosting its sixth annual state qualifier high school robotics competition on Saturday February 29, 2020. A total of 35-40 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties are planning to attend the February VEX state qualifier at Vaughn College.
    - ✓ Vaughn's Robotics team hosted a robotics workshop for community college students during Vaughn's Annual STEM Day Workshop on Friday March 6, 2020.
    - ✓ Vaughn's Robotics team assisted John F. Kennedy High School in hosting their regional high school robotics competition on Saturday January 25, 2020.
    - ✓ The PD, Faculty, and Vaughn Robotics team are invited as judges, referees, and announcers to assist Freeport High School in hosting their regional high school robotics competition on Saturday, Feb 1, 2020,
    - ✓ Vaughn's Robotics team hosted Robotics workshops for High School students (Westbury, Bayside, Thomas Edison, and Hillcrest high schools) during Vaughn's Annual Manufacturing Day conference on Friday, November 1, 2019

- ✓ Vaughn’s Robotics team hosted Robotics workshops for High School students during Vaughn’s Annual International Drone Day On Saturday, May 4, 2019.

2. Since 2016, the Vaughn College UAV team participated in Micro Air Vehicle completion of the Vertical Flight Society (VFS) Conference and won top place in the MAV student challenge completion.
   - Vaughn's UAV team project was selected as one of the finalists along with Georgia Tech, Penn State, North Dakota State University, University of Maryland, and Concordia University to participate in the 5th annual Micro Air Vehicle (MAV) student challenge competition at Dallas Fort Worth Convention Center on May 8, 2017. Vaughn’s UAV team won the 2nd place award in this competition with a $1,000 check award.
   - Vaughn's UAV team project was selected as one of the finalists, along with Penn State and University of Maryland, to participate in the 6th annual Micro Air Vehicle (MAV) student challenge competition at Phoenix Convention Center on May 14, 2018. The Vaughn UAV team finished first, with a $3000 check award, in both remote control and autonomous categories in this challenging competition.
   - Vaughn's UAV team project was selected as one of the finalists along with Penn State, Drexel University, and University of Maryland to participate in the 7th annual Micro Air Vehicle (MAV) student challenge competition at the University of Pennsylvania on Monday, May 13, 2019. On Tuesday, May 14, Judges from aerospace industries evaluated teams’ performance and <u>Vaughn’s UAV teams received 2nd place awards for both remote control and autonomous categories with a total $1750 check.</u>
   - From June 11-15, Vaughn’s UAV team participated in the 2019 AUVSI UAS Competition, along with seventy five other top-recognized national and international engineering schools (Harvard, Cornell, Virginia Tech, UCLA, Penn state, University of Maryland, and many others) and ranked 26th in the challenging 2019 AUVSI competition.
   - **<u>UAV Outreach Activities:</u>**
     - ✓ Since 2016, Vaughn’s UAV team assisted the **Cradle of Aviation** Museum with UAV workshops and competitions for middle school and high school students. On Saturday, February 1st 2020, the UAV team organized and hosted a drone competition at the Cradle of Aviation Museum for middle school and high school students.
     - ✓ Since 2015, Vaughn’s UAV team hosted several STEM workshops for High School students on learning how to build a drone as well as a drone flying session in Vaughn’s hangar during **Vaughn’s Annual Manufacturing Day conference**.
     - ✓ Since 2016, Vaughn’s UAV team organized a day of drone workshops related to Arduino Programming, CAD Modeling of Quadcopters, and Learn to Build a Drone to celebrate **International Drone day.**
     - ✓ Vaughn’s UAV team hosted a drone workshop for community college students during Vaughn’s Annual STEM Day Workshop on Friday, March 6, 2020.

3. **LACCEI 2019 International Conference:** From July 23-26, the following Vaughn student research papers were selected to compete among ten finalists for the student paper session of the LACCEI 2019 conference in Montego Bay, Jamaica.
   - **"Vehicle Design For Formula SAE 2019 Competition"** by Ryan Lewis and Andriy Belz
   - **"Smart Braille Learning Block Systems"** by Niki Taheri and Atif Saeed. **Recipient of the Second Place award for the student paper session competition.**
   - **"Autonomous Search and Rescue Project (ASAES)"** by Ryan B. Tang Dan. **Recipient of the First Place award for the student paper session competition.**
   - **"Walking Wise Camera Sensor Smart Cane"** by Jevoy James, Richi Ramlal. **Recipient of the Third Place award for the student paper session competition.**
   - **"A Study of Notched Beam Stress Concentration"** by Aderet Pantierer and Shumul Pantierer

   During Thursday's Gala dinner, award recipients for the best paper and poster presentations were introduced. This year, all top three awards (first, second and third place) for the best paper presentation of the student paper session competition were presented to Vaughn's engineering students
4. **2019 International Mechatronics Conference:** From October 22-25, two Vaughn Mechatronic Engineering students, Syed Misbahuddin and Sagufta Kapadia, participated and presented a paper at the 2019 International Mechatronics Conference & Exhibition at Oklahoma State University (Stillwater, Oklahoma). Their Paper entitled "Autonomous Position Control of an Unmanned Aerial Vehicle (UAV) Based on Acceleration Response for Indoor Navigation" received the **Best Presenters award in the Mechatronics Application technical session.**
5. **2019 Society of Hispanic Professional Engineers (SHPE) National Conference:** From Oct 30 – Nov 3, 2019 a group of 13 engineering students from Vaughn College attended the 2019 **Society of Hispanic Professional Engineers (SHPE) Conference** in Phoenix, Arizona. Vaughn students participated in the Extreme Engineering competition as well as in the various professional development workshops aiming to promote leadership, unity, and exposure to the diverse career opportunities in the STEM fields.. Vaughn's engineering student, **Angel Calderon**, won the third place award in the Extreme Engineering Challenge competition, along with a $1500 check.
6. **2019 SWE Annual Conference:** From November 7-10, Vaughn College's SWE chapter attended, presented, and held a **"Drones for Good" STEM workshop** during the "lightning talk" session of SWE19 Annual Conference in Anaheim, California. On Saturday, November 9th, Vaughn College's SWE Chapter was invited to host a STEM workshop at the "Invent It. Build It." Expo. This expo was designed for K-12 students to experience the creative and innovative sides of engineering, through hands-on projects alongside real engineers. SWE-VCAT held a propeller powered car workshop, which taught students the basics of circuitry and thrust, while they learned about Vaughn College

In addition to the above accomplishments, the HSI STEM grant enabled the participation of Vaughn students in scholarly activities and student paper and poster sessions in regional, national and international conferences and competitions (ASEE, LACCEI, SWE, ASME, SHPE, AIAA, and IEEE) and to receive top ranking in those events. Also, the HSI STEM grant provided necessary funding support for clubs such as SWE, EWB, SHPE, and NSBE and for involvement in professional development, activities, and STEM related workshops at Vaughn College. The Student engagement section of the VCJET journal provides more details regarding these activities, student successes, and accomplishments.

List of 2018 Placement Activity

The following table provides graduate career placement statistics within the Engineering and Technology Department for the 2018 calendar years. This can be used as an indicator to evaluate the effectiveness of the program in producing graduates who are sought by the general engineering industry and by graduate schools. During the academic year 2018, our students obtained internships and accepted employment at several corporations, including Boeing, Daimler, Sikorsky Aircraft, Toyota, Siemens, Cummins, Easy Aerial, Pratt and Whiney, John Deere, Rolls-Royce, Volvo, Harris Corporation, Magellan Aerospace, Collins Aerospace, FAA, Safe Flight Instruments, CPI-Aero, Cox & Company, Cyient, and many others. These corporations have employed our graduates as mechanical engineers, design engineers, mechatronics engineers, control engineers, structural engineers, avionics engineers, and project engineers. The department of engineering and technology views such placements as a strong indicator of our students' value to the industry and of our programs' success in meeting our objectives.

Student Name	**Program**	**Internship**	**Industry**	**Graduate School**
Jevoy James	Mechatronic Eng.	LIRR Sum 2018	Belcan - 2019	
Richi Ramlal			Volvo - 2019	
Charles Kwon	Mechatronic Eng.		CPI – Aero, June 2019	
Eric Grieco	Mechatronic Eng.	Precise LED Summer 2018	Trinova Inc., Sum 2019 Automation Engineer	
Deron Hurley	ME	NASA, Sum 2019	Raytheon, Fall 2019	
Raphael Cordina	Mechatronic Eng	Ecole Centrale de Nantes Summer 2019		
Chamathke Perera	ME	Easy Aerial, Inc., Sum 2018 and 2019	Easy Aerial, Inc, Fall 2019	
Aderet Pantierer	ME	Boeing, Summer 2019	Northrop Grumman, Sum 2020	
Shmuel Pantierer	ME	SciMax Technologies, Summer 2019	Northrop Grumman, Sum 2020	
Muhammed Galib	ME	Easy Aerial, Inc., Sum 2018 and 2019	Easy Aerial, Inc., Fall 2019	
Juan Cruz	ME	Con Edison – Summer 2019		
Peter Kalaitzidis	ME		Easy Aerial, Inc.-2019	
Niki Taheri	Mechatronic Eng.	Con Edison – Sum 2017 Long Island Rail Road-2018	Volvo Motor- Summer 2019	
John Hernandez	Mechatronic Eng.	Festo Summer 2018	Orics Industries – Fall 2019	
Omomhene Eimunjeze	Mechatronic Eng.	AMTRAK – Fall 2019		

Raiyan Mohammed	Mechatronic Eng.		Magellan Aerospace, Spring 2020	
Samantha Vitez	Mechatronic Eng.	NASA propulsion Lab – Summer 2018		
Fatin Saumik	Mechatronic Eng.		Naval Civilian Service–Sum 2020	
Emily German	Mechatronic Eng.	Daimler Summer 2017	Daimler, May 2018	
Lovedeep Kaur	Mechatronic Eng.	John Deere-Summer 2017	Lockheed Martin, Sikorsky Aircraft, May 2018	
Samantha Maddaloni	Mechatronic Eng.	Siemens, Atlanta GA, Summer 2018	Siemens, Fall 2019	
Maia Rivers	Mechatronic Eng.		Oshkosh, May 2018	
Jason Becker	Mechatronic Eng.	EJ Electric - Sum 2017 Brookhaven National Lab-Sum 2019		
Atif Saeed	Mechatronic Eng.	Lockheed Martin, Sum 2019	Lockheed Martin, Sum 202	
Jacqueline Oricchio	Mechatronic Eng.	Rolls-Royce, Sum 2018, 2019		
Hector Sabillon	Mechatronic Eng.	John Deere-Summer 2018	John Deere-Spring 2019	
Abdullah Ali	Mechatronic Eng.		Cummins, Fall 2019	
Ryan Lewis	Mechatronic Eng.	SciMax Technologies, Summer 2019		
Alyssa **Mitchell**			Con-Ed – Sum 2020	
Sagufta Kapadia	Mechatronic Eng.	Lockheed Martin, Sum 2019	Lockheed Martin, Sum 2020	
Juan Rodriguez	Mechatronic Eng.	Easy Aerial, Inc., Sum 2018 and 2019		
Jonahz Hernandez	ME	Rolls-Royce, Sum 2019		
Mitchell Werner	ME	SciMax Technologies, Spring 2020		
Ariel Ferrera	ME	Stryker, Summer 2018&2019		
Frandi Cueva	ME	Toyota, Co-op 2019		
Brandon Duran	ME	Hudson Technology – Summer 2018 & 2019		
Thomas J Dekenipp	MET		CPI-Aero, Spring 2019	
Jairo Chauca	MET	Harris Corporation, Sum 2018	Harris Corporation, Spring 2019	
Kirei Watson	MET		Collins Aerospace, Spring 2019	
James Bargfrede	MET		CPI Aero, Spring 2019	
Jairo Ramos	MET	Easy Aerial, Inc.-Sum 2019		
Angel Calderon	MET	Nissan, Summer 2019		
Robert Escobar	MET		Turner, Summer 2019	
Yarelys Vazquez-Marquez	MET	Pratt & Whitney, 2019	Pratt & Whitney, Sum 2019	
Mohammed Hossain	MET	Raytheon – Summer 2019	Raytheon – Summer 2020	
Abdelmonem Anwar	MET	Pratt & Whitney, 2019	Pratt & Whitney, 2020	
Grace Davis	MET	Daimler Summer 2018 Eaton, Summer 2019	Northrop Grumman-Spring 2020	
Darwing E. Mota	MET	Exelon – Summer 2017 Gulfstream, Summer 2018	Raytheon, Summer 2019	
Omar Ramos	MET		FAA, Summer 2019	
Dale Fortin	EET		Safe Flight - Fall 2019	
Andrew Sohn	EET		Air China	
Sixin Nie	EET		Panasonic Avionics	
Johnny Jiminez	EET		SafeFlight Instruments	
Mahendra Taramal	EET		OSHA - NYC	

Modular Torque Wrench Extension with Heads-up Display

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ABSTRACT

Torque control is a critical component of the assembly process within the manufacturing industry. Costly repairs and damages arise if this is not properly addressed. Once a product is put into service and a fastening error is detected, it can result in severe damages to the structure and in fatalities. Incorrect torqueing of a fastener can cause a manufacturer millions of dollars in repairs and liabilities. However, the solution to this problem is to utilize a torque wrench during the assembly process, but as the current technology stands, these are expensive. Torque wrenches are unnecessarily bulky and still run the high probability of over or under torqueing a bolt because they rely on mechanical parts requiring calibration after a period of use. A distracted user can also increase the likelihood of a fastening error. The objective of this project is to design a compact, affordable, and precise torque wrench extension with a heads-up display. The product aims to provide modularity between varieties of ratcheting wrenches and provide the user with live torque feedback displayed on safety glasses to prevent any fastening error.

Keywords: Torque, Modularity, Heads-up

1. INTRODUCTION

Within the aerospace manufacturing and maintenance industry, line workers manually torque bolts to a specific torque value using a digital torque wrench or oftentimes a manual torque wrench, Fig.1. A worker must research the specific torque value of a bolt using an instruction manual and set the torque wrench each time. Many discrepancies can be made when following this procedure. Incorrectly torqueing a bolt on an aircraft can lead to a catastrophic failure of the aircraft structure, resulting in millions of dollars in damages and fatalities. With the modular torque wrench extension and a heads-up display, line workers will have a preset torque value for a specific bolt and will have the ability to see the real-time torque value on their safety glasses to allow for precise torque while being fully aware of their environment.

Figure 1: Technician using Torque Wrench for Engine Change [1]

The objective of this project is to create a user-friendly and affordable real-time torque-sensing torque wrench along with a heads-up display. When the torque wrench is used in conjunction with the heads-up display attached to the worker's safety glasses, it will allow the user to accurately and precisely torque a bolt to the required specification. Furthermore, this product will prevent over and under torqueing of a bolt by highlighting key specification values through the heads-up display.

2. BACKGROUND RESEARCH

In torqueing applications, the purpose is to ensure that a mechanical force constitutes the following forces; A clamping force, a preloading force, a shearing force, and a tension force, Fig. 2. The clamping force is desired for creating tension between two parts to ensure that the components which the bolt was passed through will remain tight and ultimately secure. The preloading force is responsible for creating the ideal no-slip condition involving the threads of the bolt and the nut. The turning of the bolt causes the threads to "catch" onto the bolt due to friction and stretch as more torque is applied. The sheer force is the force that is transverse to the long axis of the bolt and can be present when the bolt is in tension or not. Finally, the tension force is the internal force experienced by the bolt along the long axis that correlates with the stretching of the bolt as it is turned.

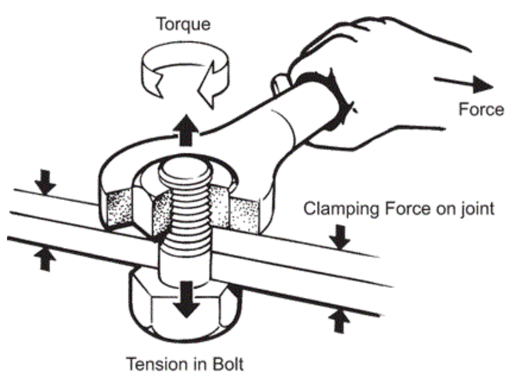

Figure 2: Force Diagram of Bolt Torqueing [2]

There are various methods to torque down a bolt. The torque control tightening method is most commonly implemented. The technique is based on using tables or by calculation from the determination of the relationship between the torsional stress and the bolts yield stress, as shown in Table I. Although commonly used, this method has significantly more room for improper torqueing, due to variances in the friction from bolt to bolt (rust can affect friction), which greatly affects the preload of a bolt.

Table 1: Torque Control Tightening [3]

Bolt Size	TPI	Tensile Stress Area	Fastener Coating	Bolt Torque & Clamp Load	10,000 psi	25,000 psi	SAE J429- Grade 2	SAE J429- Grade 5	SAE J429- Grade 8	ASTM A574 Socket Head Cap Screw
3/8 UNC	16	0.0775		Clamp Load (Lb)	775	1,937	3,196	4,940	6,974	8,136
			Lubricated	Torque (Ft-Lb)	4	9	15	23	33	38
			Zinc Plated		4	11	18	28	39	46
			Plain - Dry		5	12	20	31	44	51
3/8 UNF	24	0.0878		Clamp Load (Lb)	878	2,196	3,623	5,599	7,905	9,222
			Lubricated	Torque (Ft-Lb)	4	10	17	26	37	43
			Zinc Plated		5	12	20	31	44	52
			Plain - Dry		5	14	23	35	49	58
7/16 UNC	14	0.1063		Clamp Load (Lb)	1,063	2,658	4,385	6,777	9,568	11,162
			Lubricated	Torque (Ft-Lb)	6	15	24	37	52	61
			Zinc Plated		7	17	29	44	63	73
			Plain - Dry		8	19	32	49	70	81

The angle controlled tightening method or the turn to tighten method involves using a torqueing instrument to reach a relatively low torque specification and then rotating the bolt a particular number of times or degrees (based on predetermined values from testing trials) that ideally approaches the yielding point of the bolt. The torqueing instrument can be seen in Fig. 3.

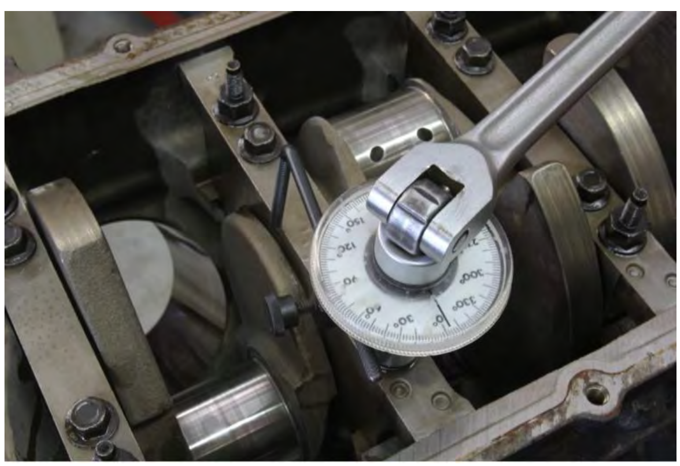

Figure 3: Angle Controlled Tightening Method [4]

The yield-controlled tightening method is a much more technical approach to torqueing. It utilizes a control system that is sensitive to the torque which indicates when the yield point has been reached then and stops the tightening process. Fig. 4 shows the relationship between the clamping force and the angle of rotation. When the bolt exceeds the yield clamp force is when the bolt is no longer tightened. The clamping force and rotation angle are no longer a linear relation indicating that the yield point has been reached. This is achieved by incorporating sensors to read torque and angle during the tightening process [5]. This approach can be considered a "tailored" approach, because sensors are used to consider the particular conditions of an individual bolt.

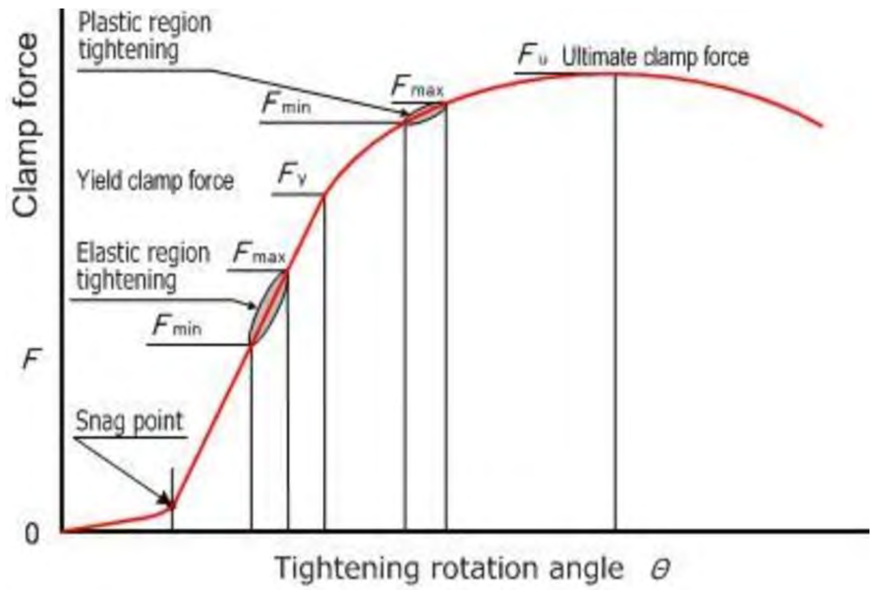

Figure 4: Yield Controlled Tightening Method [6]

In the case of a military operation using an unmanned aircraft in Afghanistan, a malfunction that caused the crash of an air vehicle was determined to be caused by an improperly secured part. The article reads "Post-mishap analyses of in-service LRU-X-1 cap screws reflect a significant departure from required values of 18-22 inch-pounds above prevailing torque," [7] reads the report. "Improper torque, insufficient use of thread locking compound or reuse of a deformed lock washer could allow cap screws to vibrate loose during flight operations" [7]. New maintenance procedures were immediately implemented for the remainder of the vehicles, in consideration of improperly torqued parts.

Figure 5: Bolt Fracture [8] (left), **Plastic Deformation** [9] (right)

3. ENGINEERING REQUIREMENTS AND DESIGN CONSTRAINTS

3.1. Bolt Specification:

a. Bolt Diameter: 10 mm

b. Maximum Torque: 80 N·m

3.2. Device Inputs:

a. Device should operate under dry conditions only.

b. Maximum input voltage to the microcontroller cannot exceed 9 volts.

3.3. Economics and Manufacturability:

The cost of the machine should be affordable with easy mass production values for small businesses owners to purchase.

3.4. Health and Safety:

Since the machine will be more reliable than traditional wrenches, it will diminish the failures of structures due to improper torqueing, resulting in reduced fatalities and injuries.

3.5. Programming Language:

The machine should be programmed in the Arduino programming environment. The Arduino Nano can also be programmed in C. The program should be simple and easy to understand so changes can be made if needed.

3.6. Communication:

The machine should have a few settings that the operator can choose from, depending on the bolt being torqued. The user should easily understand what the torque settings are and what to do in each situation.

3.7. Marketing Requirements:

a. Precise and Accurate: The machine will be able to consistently replicate a desired output by working within tolerance limits.

b. Safe: Operation will not differ much from the conventional use of a digital torque wrench in order to minimize user error. Good ergonomics will enhance machine handling and protection from any moving parts, thus reducing the chance of injury.

c. User Friendly: Inputs will be performed through a series of buttons and monitored through a display requiring short and simple training to become proficient in machine operation.

d. Pricing: The machine will be priced competitively compared to products that aim to perform the task of torqueing a bolt without the augmented enhancement.

e. Efficiency: The machine will allow technicians to perform their jobs more quickly and more consistently knowing that their work has been monitored and checked by their equipment. Quality assurance is gained from performance of this task.

f. Compact: The tool will offer no more inconvenience than a conventional set of goggles and a tool wrench. Spatial dimensions will not vary significantly from current industry standard equipment; therefore, no special accommodations will be needed.

g. Reliability: Construction of the modular torque wrench and heads-up display unit must be robust enough to withstand daily use and impact forces similar to a manually adjusted torque wrench. Furthermore, the modular torque wrench must be able to maintain precise calibration to provide accurate torque readings to the user.

4. PRELIMINARY DESIGN EVALUATION

To implement a strain gauge into our design, it is necessary to understand how it functions. The strain gauge converts an applied force into a change in electrical resistance. The applied force can be a tensile force or a compressive force. Variations in resistance are dependent on the change in length of the strain gauge. With the change in length of the object in a particular direction there are stress and strain forces involved which result in a change in electrical resistance of the strain gauge [10]. A strain gauge uses a Wheatstone Bridge circuit, which is responsible for converting the change in resistance into an equivalent voltage change. The Wheatstone Bridge circuit will use a stable DC power supply for excitation.

For this project, two strain gauges will be positioned at 45 degrees from the longitudinal axis and evenly on the midplane of the longitudinal, in order to place the sensor as far as possible from the location of the applied load. It is necessary to calibrate the sensor to develop the torque wrench extension. Conducting theoretical calculations and using a known reference standard for the material in use will allow for accurate calibration of the gauge sensor to the applied force [11]. The torque sensing strain gauge that is to be used has been designed for static or reaction torque applications, since the torque wrench extension does not experience a high rpm application and deformation occurs within much less than one rotation of the strain gauge implementation.

Based on Von Mises theory, the shear strength of the wrench extension can be related to the tensile strength by (1).

$$YSS = \sqrt{3}\,YTS \tag{1}$$

Where, YTS is the yield tensile strength of the material and YSS is the shear strength of the material. Using a yield tensile strength of 415 MPa for 4140 steel [12], the yield shear strength of the material is found to be 240 MPa.

Next, to determine allowable shear stress, the wrench extension can perform under based on a specified factor of safety and the shear strength, (2) is used.

$$\tau_{all} = \frac{YSS}{FS} \tag{2}$$

Where FS is the factor of safety, YSS is the yield shear strength of the material (in MPa), and τ_{all} is the allowable shear stress in (in MPa). Using an aerospace grade factor of safety of 1.5 and the yield shear strength of the material of 240 MPa, the allowable shear stress is found to be 160 MPa.

The maximum torque that can be applied can be calculated using (3).

$$T = \frac{\tau_{all} \times J}{R} \tag{3}$$

Where τ_{all} is the allowable shear stress in, T is the torque (in N·m), R is the radius (in m), and J is the polar moment of inertia (in m^4).

Since the wrench extension that is used is a solid shaft, the polar moment of inertia, J, can be calculated using (4)

$$J = \frac{\pi R^4}{2} \tag{4}$$

Where J is the polar moment of inertia (in m^4) and, R is the radius (in m). Using a radius of 0.00615 m the polar moment of inertia is calculated to be 2.036 x 10^{-9} m^4. With the polar moment of inertia and an allowable shear stress of 160 MPa, the torque is found to be 58.46 N·m.

Alternatively, instead of using the yield tensile strength of the 4140 steel alloy, the ultimate tensile strength of 655 MPa can be used. With this, the ultimate shear strength becomes 378.16 MPa. By applying a factor of safety of 1.7, the allowable shear stress becomes 222.45 MPa, which is below the yield shear strength previously determined; thus even by utilizing the ultimate shear strength of the material with a factor of safety of 1.7, the wrench extension will only undergo elastic deformation. By apply the same equation and calculations used previously, the maximum torque is found to be 81.27 N·m.

The shear strain of the corresponding torque wrench extension is calculated using (5).

$$\gamma = \frac{4 \times T(1+\upsilon)}{E \times \pi \times R^3} \tag{5}$$

Where T is the torque (in N·m), υ is the Poisson's Ratio of the material, R is the radius of the torque wrench extension (in m), and E is the elastic modulus of the material (in Pa)

Using the Wheatstone Bridge configuration with 2 strain gauges with a gauge factor of 2 and two known resisters with 1000-ohm resistance. Equation (5) can be formulated into (6) to understand the output voltage at an applied torque value.

$$\frac{V_o}{V} = \frac{GF \times T(1+\upsilon)}{E \times \pi \times R^3} \times 10^3 \, \frac{mV}{V} \tag{6}$$

Where V_o is the output voltage (in mV), V is the excitation voltage (in mV), and GF is the gauge factor of the strain gauge.

Using (6), with a GF of 2, R of 0.00615 m, T of 81.27 N·m, Poisson's ratio of 0.29, and an Elastic modulus of 205 GPa; the output voltage from the Wheatstone Bridge circuit is 1.4 mV for every volt of excitation provided to the circuit. The result for maximum torque that can be applied to the wrench extension that was previously calculated are simulated in Autodesk Fusion 360 to confirm the results, as seen in Fig 6.

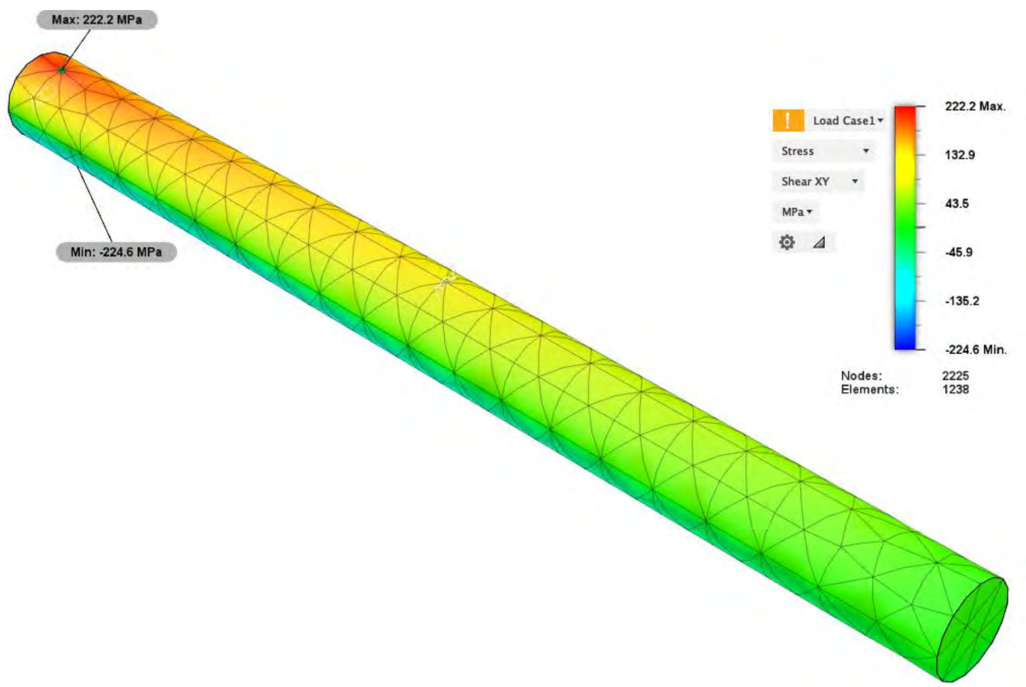

Figure 6: Maximum Shear Stress Simulation

4.1. MECHANICAL DESIGN

The electronics and sensor used for measuring applied toque will be housed in a mechanical fixture that surrounds the shaft of the 3/8th inch extension. Similarly, electronics for the augmented reality lens are contained within a mechanical fixture that attaches to safety glasses. The conceptual design for the shaft housing and augmented reality lens housing can be seen in Fig. 7.

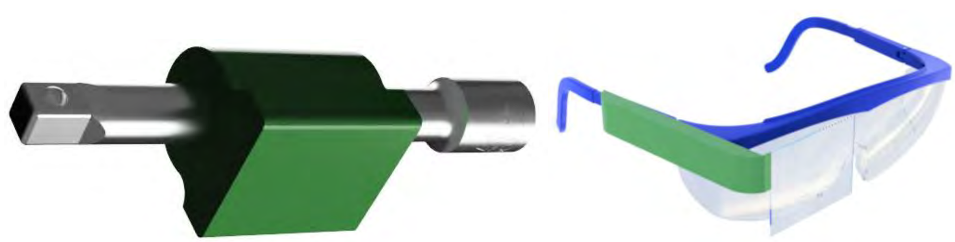

Figure 7: 3/8th inch Shaft Electronics Housing (left) **& Heads-up Display Housing** (right)

4.2. ELECTRICAL DESIGN

For the proposed system to fully operate, the following electrical diagrams are adopted, shown in Fig. 8 and Fig. 10.

Fig. 8 represent the electrical schematic for the torque sensor, consisting of an Arduino Nano, XBEE transmitter module, HX711 load cell amplifier, two strain gauges, and two resistors.

Fig. 10 represents the electrical schematic for the augmented reality lens, consisting of an

Arduino Nano, an organic light-emitting diode (OLED) display, and an XBEE receiver module.

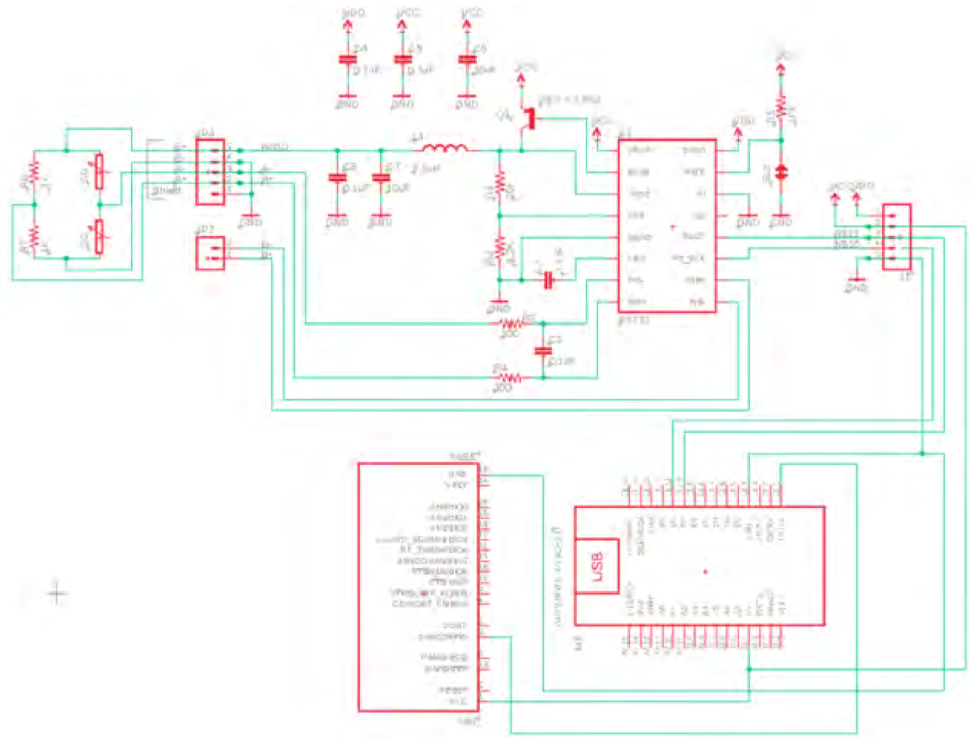

Figure 8: Torque Wrench Extension Electrical System

The HX711 connects to the Arduino Nano using four connections; VCC, GND, DOUT, and PD_SCK. The VCC and GND are used to power the HX711 load cell amplifier module from the Arduino Nano. Whereas, the DOUT and PD_SCK (Data and clock) allow for a two-wire interface for communication. The left portion of the HX711 module consists of the Excitation and Amplifier, which is connected to the strain gauges. A closer look at the strain gauge wiring can be seen in Fig. 9.

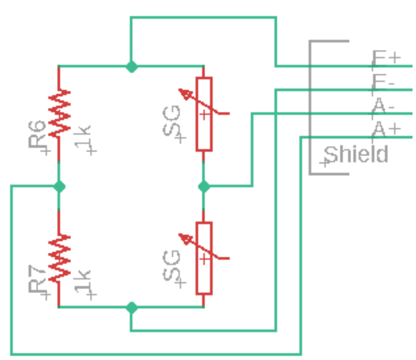

Figure 9: Wheatstone Bridge Configuration

The HX711 module connects to two 1000-ohm resistors and 2 strain gauges. These components are connected in a Wheatstone Bridge configuration. The Wheatstone Bridge allows us to measure an unknown resistance value by maintaining a balance between two circuit legs. In our case, we want to obtain the changing resistance values as the torque is applied to measure the voltage change. To achieve this, the excitation (+ and -) are connected in between the known resistor and the strain gauge. The amplifier (+) is connected between the two known resistors and the amplifier (-) is connected in between the two strain gauges. The excitation from the HC711 module provides the Wheatstone Bridge with 4.08 V and the amplifier measures the voltage change.

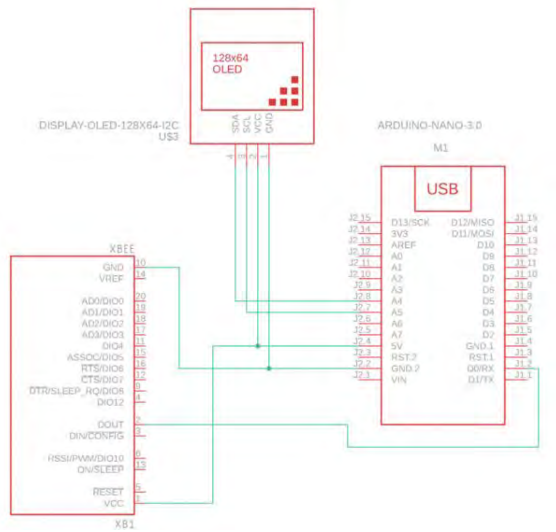

Figure 10: Heads Up Display Electrical System

5. PROTOTYPE

5.1. COMMUNICATION

The communications aspect of the torque wrench extension with heads-up display is based on the transmission of data from one Arduino Nano to another. The project entails using wireless communication to create simplicity for the end-user and to reduce any restriction in mobility of its user. To enable wireless communication between the Arduinos two Xbee S2C modules are used. The Xbee S2C modules have antennas that operate at a programmable frequency. In addition to the communication modules, the OLED display is used for confirming that data was transmitting from one Xbee S2C to the other.

The connectivity status of the Arduino Nanos was then determined by powering on the Nano using a USB Type-A male cable to a USB Mini male. The power supply was the computer used for programming the Arduino and its modules. The OLED display was supplied with 3.3V from the Arduino Nano. The Xbee S2C was powered using the 5V pin from the Arduino Nano. To test the Xbee S2C modules, they were connected to an Xbee USB Adapter Board that allows for direct interaction of the Xbee S2C and the computer used to program the communication module. Both Xbee's were connected to the computer at the same time and set up on XCTU; the chosen radio frequency communication platform for programming the Xbee S2C's was set. The communications parameters were adjusted to enable communication in a point to point communication manner. The emitter was labeled "Coordinator" and the Receiver was labeled as "Router".

After programming the communication parameters, it must be proven that the modules are, in fact, able to transmit data. By using the XCTU software and the terminal tab, serial data can be transmitted out from one module at a time and by switching to another module any received data can be seen [13].

5.2. TORQUE WRENCH

To properly obtain an applied torque value from the torque wrench, it must be fitted with a strain gauge. As a load is applied the strain gauge's resistance changes, with this change in resistance we can measure the torque that is applied by the user and display it on the headset.

The process of applying the stain gauge onto the torque wrench extension is an extremely complex and delicate procedure due to contamination. Any foreign debris including oil excretions from the user's hand can negatively impact the reading obtained by the strain gauge.

To begin the stain gauge application process, the surface of the torque wrench extension was sanded using 320-grit silicon- carbide paper, where the strain gauge would be applied. This allows the gauge to properly adhere to the surface. Next, M-Prep Conditioner A was applied to the surface and slowly wiped through the surface using a gauze sponge. M-Prep Conditioner A is a mild phosphoric-acid compound which acts as a mild etchant while accelerating the cleaning process. The M-Prep Conditioner A was followed by M-Prep Neutralizer 5A. The surface was scrubbed using a cotton swab. With a single wiping motion, the area was cleaned again using a gauze sponge to prevent contaminants to be redeposited. A pencil was used to mark to the surface, to ensure the stain gauge was centered correctly.

After the surface was prepped, the strain gauge was removed from its packaging using tweezers and placed onto the torque wrench extension using the previously marked areas as guides. A single piece of tape was placed over the gauge and rolled back slowly at a 45-degree angle to bring up the gauge with tape. The tape was pulled back far enough, so the specimen was lifted but a portion of the tape was still attached to the torque wrench extension. Next, a single bead of Loctite 496 was placed on the torque wrench extension, right below the tape and specimen. The tape was rolled onto the surface using a single motion. Immediately after, firm thumb pressure was applied to the gage and terminal area for roughly 5 minutes. This allowed proper bonding while also accelerating curing time due to heat generation from the user's finger. Finally, 24-hours of cure time, the tape was removed. The surface was inspected, and any excessive adhesive was wiped using isopropyl alcohol [14].

All the components used during the strain gauge application process can be seen in Fig. 11 and the torque wrench extension with the applied strain gauge can be seen in Fig. 12.

Figure 11: Torque Wrench Strain Gage Assembly Kit

Figure 12: Torque Wrench with Strain Gage

After successful completion of wiring the electrical components to the strain gauge, the Arduino Nano is programmed using Arduino Integrated Development Environment (IDE). Arduino IDE, a cross-platform application, allows users to write functions in C and C++. Once the program is written and debugged, users can upload it to a compatible microcontroller within the IDE. The program used for testing the torque wrench extension can be seen in Fig. 13.

```
#include "HX711.h"

// HX711 circuit wiring
const int LOADCELL_DOUT_PIN = 7;
const int LOADCELL_SCK_PIN = 8;

HX711 scale;

void setup() {
  Serial.begin(9600);
  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
}

void loop() {

  if (scale.is_ready()) {
    long reading = scale.read_average(4);
    Serial.print("HX711 reading: ");
    Serial.println(reading);
  } else {
 //   Serial.println("HX711 not found.");
  }

  delay(1);

}
```

Figure 13: Torque Wrench Test Program

To begin the code, the HX711 header file is included in the code. The header file contains definitions for the HX711 library, which includes commands (functions) and needed variables. Next, the data and clock pins previously connected from the HX711 module to the Arduino Nano are declared with their corresponding general-purpose input/output pin. Within the main program loop, readings from the strain gauge circuit is taken. The code reads four measurements and averages them before displaying it to the user to provide a steady baseline. After the code is uploaded to the Arduino Nano, using the serial monitor function within the Arduino IDE, the fluctuations as torque is applied, can be graphed and displayed to the user. The graphed data read by the HX711 module can be seen in Fig. 14.

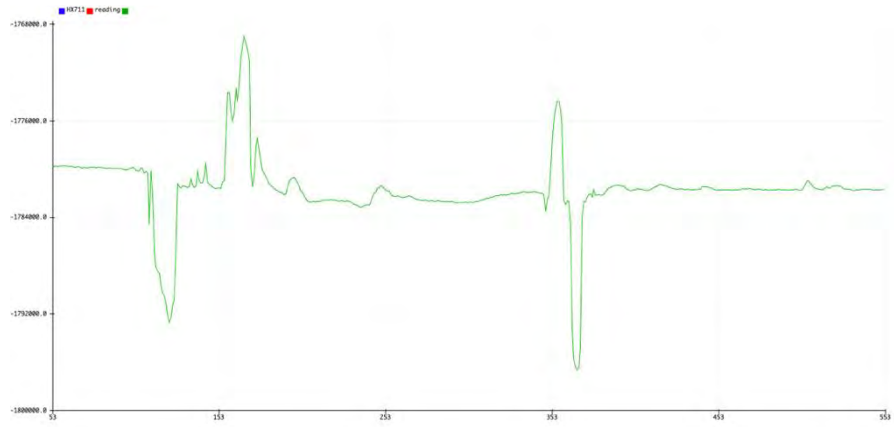

Figure 14: Arduino Strain Output

Observing the serial monitor graph of the HX711 module, it becomes evident that there are four large spikes from the baseline reading. The two large upward spikes show that torque was applied to the wrench extension in a clockwise direction. Whereas, the two large downward spikes show that torque was applied to the wrench extension in a counterclockwise direction.

5.3. HEADSET

The Headset works by using different methods to deliver the screen's output to the user. The applied principle is reflection. By the law of reflection, for specular surfaces (Mirror-like) the angle at which the light wave hits the surface will be equal to the angle at which it is reflected. Inside the headset, there will be a small and thin mirror, which provides one of the most common models for specular light reflection.

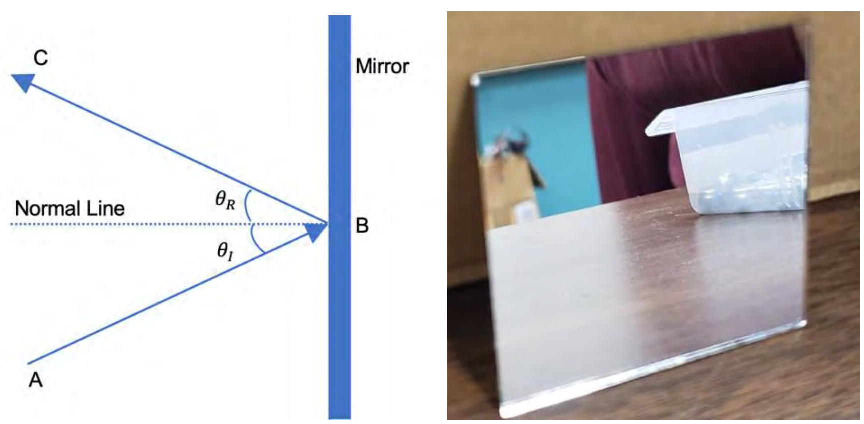

Figure 15: Reflection on Specular Faces

In the diagram Fig. 15, a light ray AB strikes a vertical mirror at point B, and the reflected ray is BC. By projecting an imaginary line through point O perpendicular to the mirror, known as the normal, we can measure the angle of incidence, θi and the angle of reflection, θr. As stated before, $\theta i = \theta r$, the angle of incidence equals the angle of reflection. Using these formulae, it is possible to formulate the angle of incidence for the headset, which is 45 degrees, since the normal line of the mirror is set to also be at 45 degrees from the input OLED screen. This will output a reflection at an exact angle of 90 degrees from the OLED display.

Once a reflection is obtained, a new problem is presented, the reflection would be a flipped image from what the OLED is outputting. For this reason, a focal lens is placed after the reflection from the mirror on the headset. The lens that is used on the headset is a Biconvex focal lens. Which is composed of two convex surfaces in spherical form, usually these surfaces have the same radius of curvature. This type of lens is also referenced as a convex-convex lens.

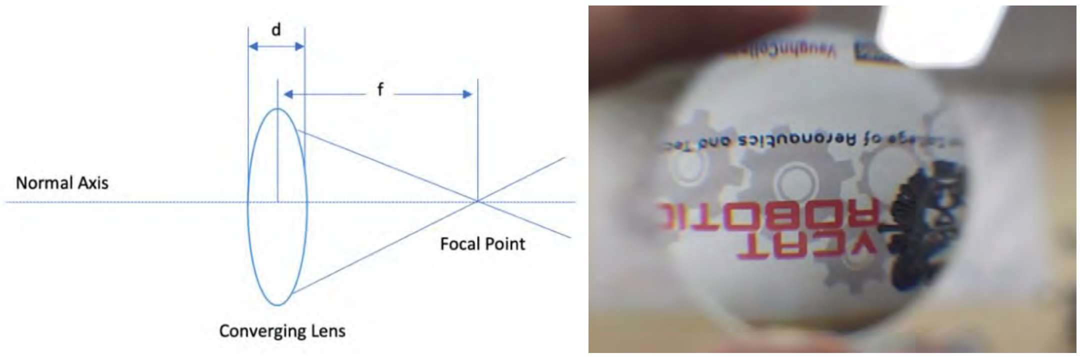

Figure 16: Bi-convex Lens Characteristics

In a biconvex lens, a beam of light passes through the lens and converges at a specific point or focus after the lens Fig. 16. The distance between the lens and this focused point is referenced as the focal length of the lens. Since there is a curvature on both sides of the lens, there will be around two focal points and two centers, which helps to invert the beams of light from one side to the other. A 100-millimeter focal lens is used so that the lens would take the inverted light coming from the mirror and revert it [15]. The focal lens along with the mirror is enclosed within a 3D printed housing shown in Fig. 17.

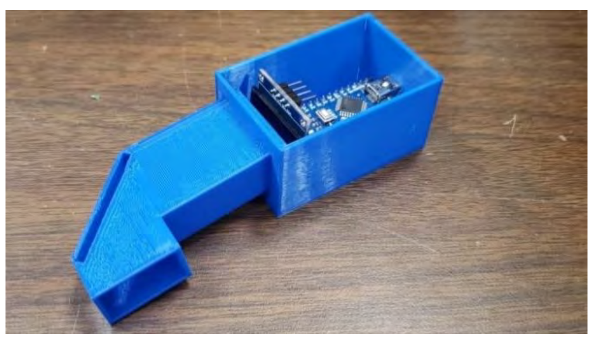

Figure 17: Headset Prototype

6. IMPACTS

6.1. SOCIAL IMPACTS

A device capable of easing the manufacturing process may be perceived as a risk. An argument may be made against the device that it may lessen the mental fortitude required to assemble structures. Technicians must be attentive to what they are doing. As a counter to this argument, there is no attention benefit derived from a technician continually setting his or her torque wrench between each bolt and shift. By simply eliminating the tedious task of setting a torque wrench, the device will assure a consistent and easily settable torque that does not subtract from the assembler's attention. Rather, the technician's attention will increase, since the glasses will provide the meaningful feedback required to keep the technician engaged in this work.

6.2. ECONOMIC IMPACTS

This innovative device presents companies with savings on monthly calibrations including material processing, handling of paperwork, shipping, and the actual calibration process. Also, there is high reliability implemented by the use of this device when it comes to the torqueing of hardware/fasteners. For instance, maintenance time and costs are reduced by the time technicians spend on completing a task. Also, companies do not have to deal with the improper handling of parts because of the over-torque of hardware that occasionally leads to the removal and replacement of expensive components.

6.3. ENVIROMENTAL IMPACTS

This device eliminates the need for manuals used to find the specific torque of any hardware/fasteners. In other words, companies are not required to print a hard copy of manuals or references for a technician to complete his/her assigned task. Thus, this device is eco-friendly by not contributing to air, water, and land pollution. Furthermore, this sophisticated device has the reliability of reducing or even eliminating the common issue made by technicians when they over-torque hardware. This hardware becomes wasteful resources that companies must dispose into the environment.

7. CONCLUSION

The need for better equipment in terms of safety, quality, preciseness, dependability, and usability is consistently on the rise. Cutting edge industries like the aviation industry have extremely high technical standards that offer very little to no compromises in safety. By bridging the gap between technological advancements and conventional bolt torqueing methods, a more favorable product can be designed. For this reason, this project is aimed to meet those standards by offering a product that contributes to those who seek to keep the demanding industry of quality manufactured and overhauled parts. The implementation of the torque wrench extension with heads-up display in bolt torqueing related applications will significantly improve technical operations and accelerate product output, without disrupting current operation methods. Simple workflow integration and minimal downtime for effective machine use can be accomplished through the use of this project, the modular torque wrench extension and heads-up display, Fig. 18.

Figure 18: Modular Torque Wrench (No Casing)

8. ACKNOWLEDGEMENT

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Remote-Controlled Yard Utility Bot – RYUB

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ABSTRACT

Homeowners are in a constant battle to keep their lawns maintained. The main battle with lawn maintenance is its ability to grow back rather quickly, especially when it is in its optimal environment. Due to this challenge, cutting grass can be a strenuous task to perform, especially for the elderly or the disabled. In order to make this task less demanding for the homeowner/user, the RYUB was created. The RYUB is a Remote-Controlled Yard Utility Bot designed to cut grass in an efficient manner. The RYUB has a built-in GPS tracker with data logging capabilities. After running the robot for the first time, the path is saved and stored for later use. For any usage after the first use, just place the robot in the starting position and hit go; the RYUB will retrace and follow the original path created on the first use.

1. INTRODUCTION

Homeowners are constantly working to keep their yards and properties healthy and attractive to the eye. One of the main ways to achieve this is to keep the lawn properly maintained. This could be a challenging task for some, especially for those who are disabled or elderly. Even for a younger person with no health problems, yard upkeep can be exhausting. On a hot summer day, mowing one's lawn can be a physically demanding task. Heat stroke, exhaustion, sunburn, dehydration are just a few of the problems one may experience in order to keep one's lawn looking pristine. Yard work is a necessary task for homeowners, whether they complete this task themselves or pay someone else to do so.

The RC Yard Utility Bot, otherwise known as the RYUB, is a semi-autonomous remote controlled robot meant to complete and/or lend a helping hand for mowing one's lawn. RYUB, at its core, will be a mobile robot capable of traversing diverse terrain and adapting and reacting to its environment through sensors, such as ultrasonic sensors and motor encoders. For first time use, it will be remote controlled by the user, while mapping the path that it is taking. Any time after that, the RYUB will autonomously repeat the path saved from the first use. The RYUB will also include the capability to map and save various paths. This allows the user to choose from multiple, pre-saved paths that they can preview from the HMI touchscreen.

2. PROJECT CONCEPT

The RYUB utilizes two motors for its drive train, geared for a rate of travel around a brisk walking pace, about 5.15ft/s. The bot also utilizes sensors. These sensors are used for collision avoidance, autonomous motion control, electronic braking if a slope or obstacle is detected, and also include an emergency stop button on both the robot and on the controller.

3. ENGINEERING REQUIREMENTS & DESIGN CONSTRAINTS

3.1. Engineering requirements

- Must utilize the concepts learned in our classes (pid, electrical circuits, modeling)
- Must apply an emphasis on programming and electrical aspects rather than mechanical
- Must be safe and ethical. Injury must be avoided; precautions to minimize risk must be taken.
- Must be a school appropriate project. This eliminates projects deemed to be weaponry, fire hazards, and other high-risk projects.
- Must solve a real world problem. The problems must have factual backing and the project must be a particular solution to the problem.

3.2. Design Constraints

- Materials - the materials chosen were done so to optimize the cost. Ideally light, strong materials, such as aluminum and composites, are best but we selected square steel tubing due to Mike's large stockpile from previous projects.
- Cost - Being college students, project's cost is always a concern for us. This consideration created a limitation on the components selection that could be purchased. The goal of the team was to optimize the overall performance to total cost.
- Size – The team plan was to make the RYUB as compact as possible to make it easier on the user when it comes to storage and movability.
- Feasibility/machinability - A homemade shop was used, so when it came to making all the necessary manufacturing, we made sure the creation was actually possible within the realm of available tools.
- Must be faster than human - The RYUB must move at a quicker pace than the average human to make it more beneficial for the user.

4. ANALYTICAL ANALYSIS

In order to create the RYUB, the team had to go through all the necessary calculations to guarantee its feasibility. The team started off by calculating the physics based formulas, such as forces required to move the RYUB. Using these formulas enabled us to spec out for the proper motors and battery needed to meet or exceed the required criteria. Alongside this, the team started to construct the physical design that would generate the maximum run time and the area covered. By knowing the selected motors spec, the RPM and HP of the motors, and the gear ratio and wheel diameter used, a calculation was conducted to determine the true speed, runtime, and maximum slope.

Table 1 shows the physical inputs of the RYUB. These inputs include the robot's weight, the rolling resistance, and the coefficient of static friction. These values are used to calculate the bot acceleration and max climbable grade.

TABLE 1 - Physical Inputs

VARIABLE	VALUE	UNIT	IMPERIAL	UNIT
BOT WEIGHT	150	lb	4.658	slug
ROLLING RESISTANCE [2]	0.012	#	0.012	#
COEFF_STATIC_FRICTION [1]	0.200	#	0.200	#

Table 2 shows the wheel inputs. This includes the drive wheel diameter, and the weight of the drive wheel. These are used to calculate forces from torques, and to determine inertial torques imparted on the robot by the wheel.

TABLE 2 - Wheel Inputs

VARIABLE	VALUE	UNIT	IMPERIAL	UNIT
DRIVE WHEEL DIAM	10	in	0.833	ft
WHEEL WEIGHT	3	lb	0.093	slug

Table 3 is used to store our motor specifications. The motor voltage, current, RPM, and rated HP will help determine the performance of the RYUB. These values will be used for numerous torque and force calculations, along with the runtime calculations.

TABLE 3 - Motor Inputs

VARIABLE	VALUE	UNIT	IMPERIAL	UNIT
MOTORS USED	4	#	4.000	#
MOTOR VOLTAGE	12	Volts	12.000	V
MOTOR RPM	118	RPM	118.000	RPM
MOTOR STALL CURRENT	20	Amps	20.000	A
MOTOR STALL TORQUE	958.2	oz-in	4.991	ft-lb
MOTOR USE %	60	%	0.600	#

Table 4 is where the battery information is entered; the reserve capacity will be used for the run time calculation.

TABLE 4 - Battery Inputs

VARIABLE	VALUE	UNIT	IMPERIAL	UNIT
BATTERIES USED	1	#	1.000	#
RESERVE CAP	140	min	140.000	min

Table 5 shows the calculations determining the acceleration time based on the selected motors. These results are based on motor torque and stall current, the amount to "push" the motor to (in percentage) and some physical robot values such as weight and wheel diameter.

Torque Available Calculation

$$\mathbf{T_a = T_{max} * \#\_of\_Motors * Use\% = 11.978\ ft\text{-}lb} \qquad (1)$$

Where

T_{max} = Stall torque of motors = 4.991 ft-lbs
Use% = How hard we want to drive the motors = 60%
#_of_Motors = 2

Horsepower calculation

$$\mathbf{HP = T_a * RPM / 5252 = 0.269\ HP} \qquad (2)$$

Where

RPM = Motor RPM = Wheel RPM = 118 RPM

Max speed calculation

$$\mathbf{v = 2*\pi*R_{wheel}*RPM = 5.149\ ft/s} \qquad (3)$$

Where

R_{wheel} = Radius of the wheel = 5in

Torque loss turning sprockets and wheels

$$\mathbf{T_{inertial} = (I_{sprockets} + I_{wheels})*a_{ang} = 0.814\ ft\text{-}lb} \qquad (4)$$

Where

$I_{sprockets}$ = Sum of all moment of inertias of the sprockets = 0.0379 lb-ft-s^2
I_{wheels} = Sum of all moment of inertias of the wheels = 0.0323 lb-ft-s^2
a_{ang} = angular acceleration = 11.578 rad/s^2

Force loss due to rolling resistance

$$\mathbf{F_{rolling} = W_{bot}*u_{rr}/R_{wheel} = 4.320\ lb} \qquad (5)$$

Where

W_{bot} = Weight of the robot = 150 lbs
u_{rr} = Coefficient of rolling resistance = 0.012

Final output force

$$\mathbf{F_{output} = ((T_a - T_{inertial})/R_{wheel})\text{-}F_{rolling} = 22.473\ lb} \qquad (6)$$

Acceleration using remaining force

$$\mathbf{a = F_{output}/m = 4.824\ ft/s^2} \qquad (7)$$

Where

m = Mass of the robot = 4.658 slugs

Time to reach max speed

$$\mathbf{t = v/a = 1.067\ s} \qquad (8)$$

Motor current draw

$$\mathbf{I = I_{max} * Use\%} \qquad (9)$$

Where:

I_{max} = Stall current draw = 20A

TABLE 5 - Force/Torque/Acceleration Results

VALUE	RESULT	UNIT
HP	0.269	Hp
MAX SPEED	5.149	ft/s
TORQUE AVAILABLE	11.978	ft-lb
TORQUE LOSS TURNING SPROCKETS & WHEELS	0.814	ft-lb
FORCE LOSS DUE TO ROLLING RESISTANCE	4.320	lb
FINAL OUTPUT FORCE	22.473	lb
ACCELERATION WITH REMAINING FORCE	4.824	ft/s^2
TIME TO MAX SPEED	1.067	s
MOTOR CURRENT DRAW	12.0	A

Table 6 shows the calculations needed to determine the runtime and distance that RYUB can cover. Some of these calculations consisted of calculating the true runtime and the square footage capable using an assumed 16 in mower blade.

TABLE 6 - Runtime and Distance Calculations

VALUE	EQUATION	RESULT	UNIT
BATTERY CAPACITY	CAPACITY	58.33	ah
RATED DISCHARGE TIME	TIME = CAPACITY/25A	2.33	h
RUN TIME FROM CAP WITHOUT TRUE CURRENT ADJUSTMENT	RUN TIME	72.92	min
RUN TIME CORRECTED FOR GREATER CURRENT DRAW (PEUKERT'S LAW)	RUN TIME TRUE	61.94	min
DISTANCE COVERED BASED ON RUNTIME AND SPEED	DIST COVER	19136.04	ft
DISTANCE REDUCTION PER 10 "START/STOP"		25.74	ft
SQ FT COVERED WITH 16" MOWER BLADE	SQ FT	25514.72	ft^2
AVG SUBURBAN FRONT LAWN	AVG FRONT LAWN	2000.00	ft^2
TIMES BOT COULD MOW FRONT LAWN	TIMES MOWED	12.76	#

These equations prove that the RYUB is a feasible robot. The forces applied and required for the robot to move are within the motors capability and overall project scope. It is important to note that the motors chosen are underpowered, and the overall robot weight is higher than ideal. These two factors reduce robot performance, but due to a resource limitation they will remain as is. Ideally the robots weight would be reduced, possibly using aluminum, and the motors would have higher torque ratings, allowing the robot to accelerate to more quickly.

5. TECHNICAL DESIGN

5.1. ELECTRICAL

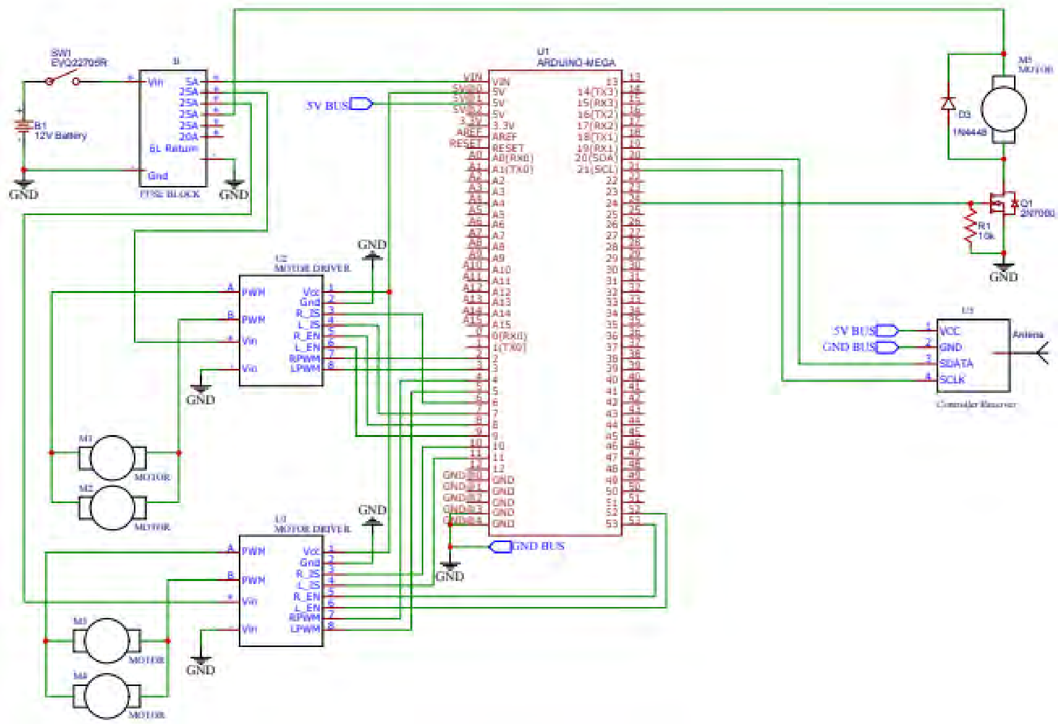

Figure 1: This is the final electrical schematic.

Arduino Microcontroller

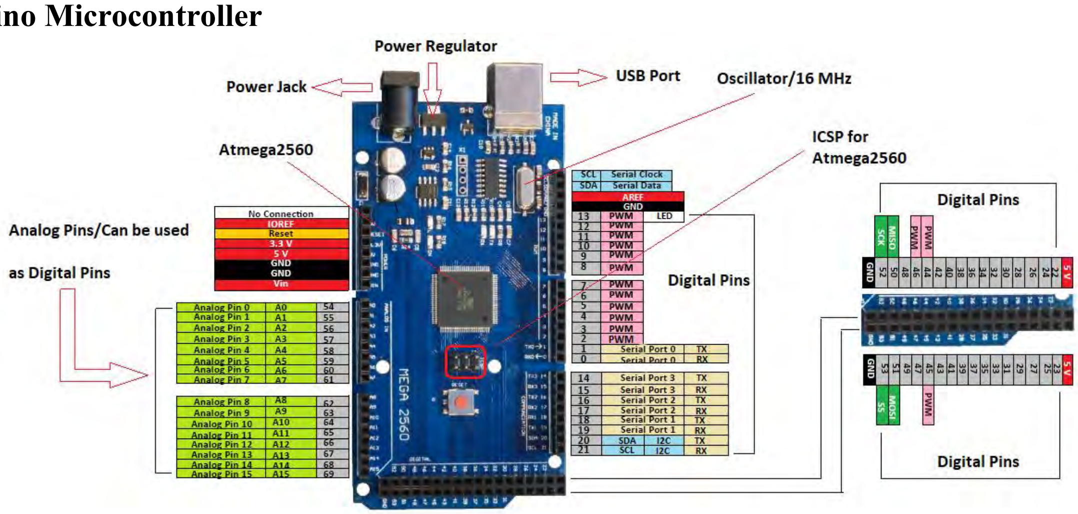

Figure 2: Arduino Mega 2560

The heart of the RYUB is the Arduino Mega 2560. This microcontroller has an operating voltage of 5V with an input voltage of 7-12V. It has a total of 54 digital input/output pins, 15 of which can be used as PWM outputs. Since we used multiple motors and sensors, the large amount of pins was necessary. The Mega has a flash memory of 256 KB, 8 KB of SRAM, and 4KB of EEPROM with a clock speed of 16 MHz. Having a large amount of memory was crucial because of the many longitudinal and latitudinal points that need to be saved for the paths created by the user [3].

Motor Driver

Figure 3: BTS7960B H-Bridge Motor Driver

The motor drivers used for the RYUB contain a BTS7960 chip composed of a full H-bridge driver module with thermal overcurrent protection. Through the use of a PNP and a NPN MOSFET, the H-bridge lets the operator control the directional of the DC motor. MOSFETs have the added benefit of isolating electrical signals because they do not add the gate current to the drain current. The gate of a MOSFET requires the presence of voltage, not a current flow to activate it. It also uses opto-isolation to transfer electrical signals between two circuits by using light. This adds another level of protection between the motors and the driving PLC, the Arduino. Opto-isolators work using a phototransistor and an LED each on a separate electrical circuit. When the LED is powered by the Arduino, it activates a phototransistor which then drives the H-Bridge and its internal mosfets [4].

Fuse Block

Figure 4: Fuse Block

The fuse block plays a key part in distributing the power from the battery to the rest of the RYUB. This is a 6-way fuse block with a negative bus. The fuse block also features a LED light indicator and a protective cover. All of the motors and the Arduino are powered through this block. The advantage that comes with this fuse block is the LED light indicator. This is because if there is a short or any other fault, the fuse block will be able to indicate where the problem is so it can easily be fixed [5].

Controller

Figure 5: Lynxmotion PS2 Controller V4

The selected controller is a 2.4 ghz wireless PlayStation 2 game controller. The controller comes with a small receiver module with a PS2 connector that has an indoor range of about 10 meters, which increases when outdoors. The controller has two analog joysticks and 16 buttons that could be used to control the robot. We chose this controller not only because of its decent range but because it pairs well with the Arduino [6]. The controller would ideally have a much greater range, allowing the user to control the robot from a great distance, possibly to stay out of the field being mowed. However, due limitations on time and money, this controller was considered satisfactory.

5.1.1. SENSORS Ultrasonic

Figure 6: HC-SRO4 Ultrasonic Sensor

The ultrasonic sensor is compatible with the Arduino Mega 2560. It has a detection range from anywhere between .78 inches to 16 feet. Ultrasonic sensors are selected and implemented for the use of detecting the environment around the RYUB. It can sense if there are any obstacles in its way, such as a tree or wall. This will also be used as a safety feature. If it senses something within its detection range, the RYUB will stop where it is. This can come in handy when a pet or child runs across the path of the robot [7].

GPS

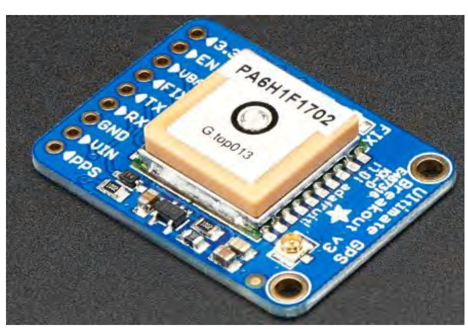

Figure 7: Adafruit Ultimate GPS Breakout

The Adafruit Ultimate GPS is a high quality GPS module that can track up to 22 satellites on 66 channels. It has a highly sensitive receiver with a built-in antenna with the ability to attach a bigger one via the uFL connector. It can do up to 10 location reads in a second. An extra bonus that comes with this GPS module is the built-in datalogging ability. The module contains a microcontroller that has a FLASH memory that can hold up to 16 hours of data [8].

Motor w/Encoder

Figure 8: HD Premium Planetary Gear Motor w/Encoder [9]

Running our gear train is the 118 RPM 12V DC motor with an attached encoder. The encoder type is a hall effect. Hall effect sensors consist of devices that are activated by an external magnetic field. One of the main uses of these sensors is to sense the position, distance, and speed of a system. Therefore, one of these motors is placed on both sides to help regulate the speed and distance created by the left and right wheels [10]. These encoders function using two hall effect sensors and 12 magnets. This changes reading resolution dramatically, allowing for 48 countable events per rotation of the motor shaft. The gearing of the motor results in about ~3,416 countable events at the output shaft (Geared 71.165:1). This level of resolution should allow for an accurate encoder reading and the PID controlling of the robot.

5.2. SOFTWARE

5.2.1. PROGRAM OUTLINE

The program will take in inputs and set output according. A simplified table shows how the robots will react to its inputs and set its outputs during its program.

Motor_L = Left drive motor; Motor_R = Right drive motor; Motor_B = Mower blade motor

Program state: Manual operation / Path recording		
Input	**Output**	**Notes**
Controller Analog Joystick (x,y)	Motor_L= Speed*(y+x) Motor_R = Speed*(y-x)	Motors will be PID controlled to ensure exact motion.
If... Front_Ultrasonic_Sensor <= 2" && Joystick(y) > 0	Motor_L = 0 Motor_R = 0	If anything is in front of the robot and it is trying to go forward, prevent motion.

If... Back_Ultrasonic_Sensor <= 2” && Joystick(y) < 0	Motor_L = 0 Motor_R = 0	If anything is behind the robot and it is trying to go backward, prevent motion.
If... Left_Ultrasonic_Sensor <= 2” && Joystick(x) < 0	Motor_L >= Motor_R Motor_R = Speed*(y-x)	If there is something to the left of the robot, does not allow the robot to turn left.
If... Right_Ultrasonic_Sensor <= 2” && Joystick(x) > 0	Motor_L = Speed*(y+x) Motor_R >= Motor_L	If there is something to the right of the robot, does not allow the robot to turn right.
If... E_Stop == 1	Motor_L = 0 Motor_R = 0 Motor_B = 0	Turn off the left and right drive motors, along with the mower blade motor.
If... Ft_Travled >= 1	GPS.Record()	Command the GPS to record the current position.

Additional program features:

The drive motors will be PID controlled during their moves. They will have a desired speed based on the program inputs, and they will have some true speed based on their encoder readings. Using these two values and a PID controller, overshoot will be eliminated completely, oscillation be reduced as much as possible, and rise time will be minimized. The motors also utilize a slow start and stop function. This function will prevent a sudden jolt of power into the motor, increasing the life of the motor, and smoothing the acceleration of the robot.

The GPS module will also feature a custom function designed to reduce error. This function will read the current position of the robot multiple times each time it is called. The robot will be progressing at a max speed of 5.15 ft/s, and the GPS is able to capture 10 data points per second, meaning every 5.15 ft, 10 data points can be captured. The robot will record 2 points every foot and average them together. It will track when it has progressed the proper distance using the encoders on the drive train.

Path playback is going to be done using the recorded position of the GPS module. The robot will know where it currently is, and where it should be. From this it can calculate a heading, and then progress to the next point. Error will be mitigated using another PID controller designed to improve final position accuracy. This PID controller is different from the one controlling each wheel as those ensure each wheel accurately matches its set point based on its true rpm, whereas the “playback” PID controller modifies the wheel set points to create accurate path playback. Both PID controllers will work in tandem to create smooth and accurate transitions between way points and correct wheel velocity to match the desired velocity of the robot.

6. MANUFACTURING

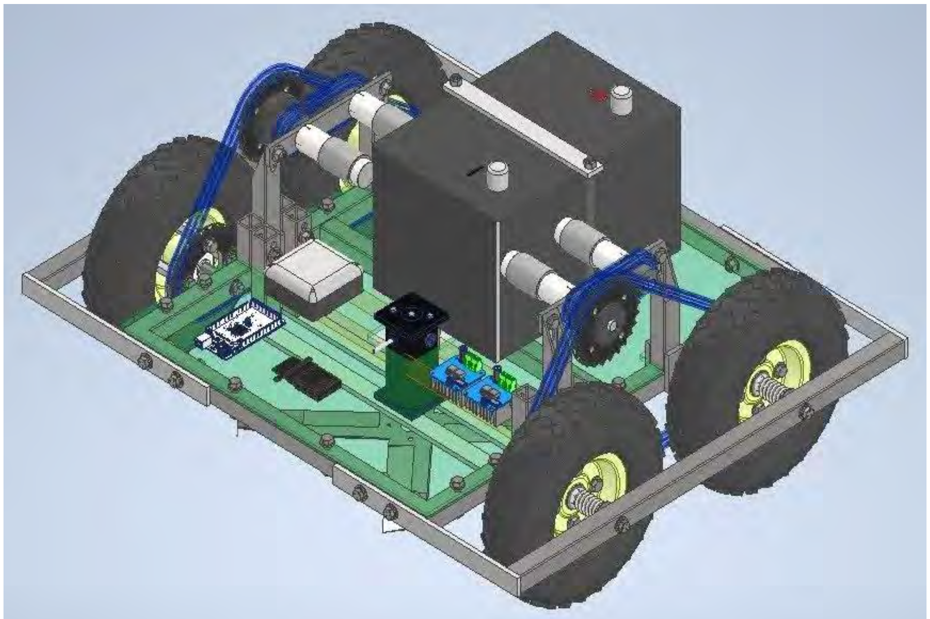

Figure 9: CAD Model of RYUB

Based on the CAD model found in Figure 9, the team followed the specs and dimensions it outlined to start creating the physical robot. The manufacturing process was mostly cutting and drilling operations, with some parts requiring slots milled into them. The slots were made to be used to increase tension on the chain. The drilling operations were performed using a drill press, while cutting operations were performed using a miter saw and a metal cut off wheel. Cuts were cleaned up and squared up using a joggable vice and a roughing end mill on a drill press. This same joggable vice was used to create the slots in the tubing.

Once the parts were cut, drilled, and/or slotted, they were ready for assembly. This was done mostly through the use of fasteners (5/18 - 18 Bolts) with welds connecting permanent, more ridge assemblies. Welds are present are on the main frame of the robot, connecting all 4 sides to create the central, rectangular frame. Welding was also done to attach the front and rear wheel guards to the outer two tubes. These flat guards also function to increase rigidity of the wheels and to prevent bending of the axle.

7. IMPACTS

7.1. SOCIAL IMPACTS

The RYUB has many positive impacts on the user. It removes the strenuous task of mowing the lawn under the hot sun, by using the autonomous playback, and even when the user has to program the first path, the robot can be remotely controlled allowing the user to sit somewhere cool and comfortable, as long as the robot is within range. The RYUB also benefits those who are disabled and elderly. Their options are limited when it comes to lawn maintenance; they can either hire people to do it, let the lawn grow out of control, or risk their safety and well-being to do it themselves. The RYUB will allow the elderly the freedom to mow their own lawns, without facing any of these risks.

7.2. ECONOMIC IMPACTS

The RYUB is also economical. A lot of homeowners either don't have the time or energy to go through the trouble to mow their lawn. Because of this, they tend to hire landscapers every month to get the job done. However, the RYUB is a one-time payment, one time setup option that easily maintains one’s lawn. It saves the homeowner money, in the long run, without wasting the user’s time.

7.3. ENVIRONMENTAL IMPACTS

Most lawn mowers on the market are powered by a gas engine; whereas, the RYUB is fully electric. Due to this, our robot is environmentally friendly. Electric motors are more efficient at producing power than gas engines. They also produce next to no waste fumes/emissions unlike gasoline engines. On top of the standard emissions produced by gasoline engines, some lawn mowers utilize 2 stroke engines which use gasoline mixed with engine oil as a combustible fuel producing even more emissions.

8. CONCLUSION

In conclusion, the RYUB will help homeowners and users keep their lawns trimmed and beautiful without putting the operators’ health or safety at risk. The RYUB outlined in this report is a prototype model. Many design considerations were done not to increase performance, but to increase feasibility under our time and money limitations. Noteworthy upgrades would be the use of lightweight aluminum instead of the heavy steel tubing. Also, the massive flooded lead-acid battery would be replaced with a lithium battery to increase battery power while decreasing its size. Another change would be to upgrade the motors on the drive train to more powerful ones to increase the robots top speed, applied power, and acceleration time. As it stands, the current RYUB, with its oversized battery, heavy steel tubing, and underrated motors, is able to perform the tasks outlined. This proves the concept and the project's feasibility; given more time and resources, the RYUB would prove to be a revolutionary change to residential lawn mowing.

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Harvesting Power– Modular High-Rise Cooling Tower Hydro Turbine – Commercial Economizer Design**

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**This design adheres to *The National Society of Professional Engineers (NSPE)* Code of Ethics' first cannon: "Hold paramount the safety, health, and welfare of the public."

ABSTRACT

This paper presents and assesses the framework for harnessing the potential energy of rushing water used in commercial cooling towers and transferring the energy through a modular hydro-turbine system that generates electricity. Falling water from the top of the cooling tower passes through a venturi and spins the hydro-turbine which stores the electrical energy generated to power other facility loads. The modular system has its own bypass line with pressure sensors before and after the rushing water passes through the system. In case of emergency, valves automatically open to ensure a constant volumetric flow rate across the closed loop system. A thorough CFD Analysis, FEA, cost breakdown, and feasibility assessment prove the essential engineering design criteria.

Keywords: hydropower, energy conservation, hydro-turbines

1. INTRODUCTION

Consider the cooling tower on top of a high story building. A centrifugal pump moves water between the chiller in the basement of the buildings all the way up to the cooling tower on the roof. The cooling tower is a heat exchanger that allows water and air to come in contact after being pumped up to the roof to lower the temperature of the hot water. During this process, a small amount of water evaporates, lowering the temperature of the water that is being circulated throughout the cooling tower. The hot water is usually caused by air conditioning condensers or other industrial processes. That water is pumped through large pipes directly into the cooling tower. The chiller adds heat to the water flowing through the condenser and the cooling tower cools it down by rejecting heat into the atmosphere. The condenser water leaves the condenser of the chiller at around 32°C and the pump sends this water up to the cooling tower as mentioned. The reason for this design is so the condenser water leaving the cooling tower and the water entering the chiller condenser must be around 10°C $\Delta \boldsymbol{T}$. This is so, from a thermodynamic perspective, the water is able to pick up enough heat on its next cycle. There are many different types of chiller systems, but they all have essentially the same main components. The first main component is the compressor, which is the prime mover. It creates a pressure difference to move the refrigerant around the system. There are various designs of refrigerant compressors, the most common is the centrifugal, screw, scroll and reciprocating type compressors. The next component is the condenser, located after the compressor and before the expansion valve. The purpose of the condenser is to remove heat from the refrigerant which was picked up in the evaporator.

The design of the hydro turbine economizer is based off a water-cooled condenser. In a water cooled condenser system, which is used in a large variety of buildings, the hot refrigerant which enters the condenser from the compressor side, will transfer heat into the flowing water which is transported up to the cooling tower and rejected from the building as previously described. It is in this position that the venturi hydro-turbine economizer is to be placed to harness the falling water after it passes through the cooling tower and back down to the pumping station at the bottom of the building. Since the pump only operates to push the water up to the top of the building, the water exiting the cooling tower is dropped through the large pipes and accelerates back down to the pumping station at the bottom, where the entire process is repeated once again. Figure 1 shows the outlined system, before the addition of the new proposed design. Notice that the condenser water, pictured in yellow, rushes back down to the chiller which leads to the pump. Some buildings can have multiple chillers and pumps. The water's potential energy transfers to kinetic energy which will help spin the hydro-turbine economizer. This energy method of scavenging electricity from the accelerating water will be used to power other sections of the facility, helping reduce the carbon footprint of the plant by saving energy and cost.

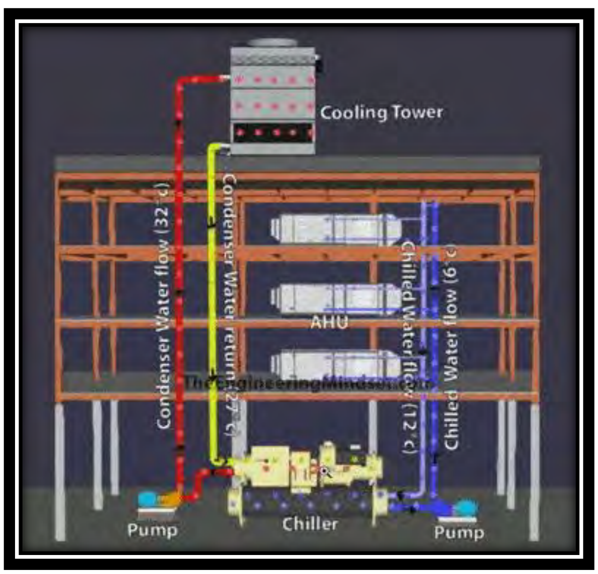

FIGURE 1: COOLING TOWER BUILDING DIAGRAM SIMPLIFIED

2. PROPOSED DESIGN DETAILS

As more and more different renewable energy sources begin to emerge, government agencies are enforcing new laws and policies that will lower emission output across major populated cities. The proposed design is offering a clean and alternative method of generating power and still lowering cost. It is important to note that the proposed design uses real world cooling tower information and specifications from 100 Centre St Ste 326, New York, NY, 10013. Since most cooling tower systems all share the same components, the hydro-turbine economizer design can be tailored to any building, with the proper installation. As previously discussed, the flowing water dropped from the cooling tower is pumped up to the roof by a pumping station at the bottom of the building. One of the challenging design criteria's is that the volumetric flow rate exiting the venturi must be the same to prevent pump cavitation. The proposed design sketch is seen in Figure 2.

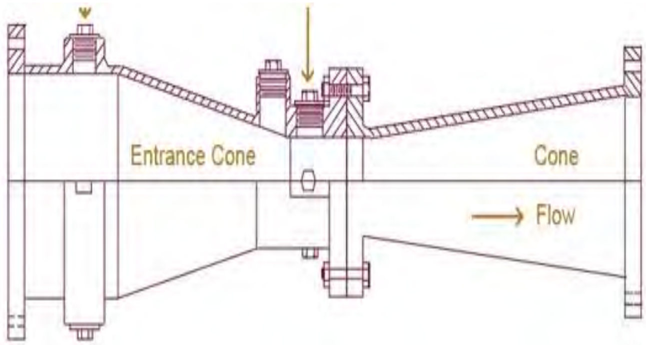

FIGURE 2: HYDRO-TURBINE VENTURI APPARATUS

The hydro-turbine is to be mounted in a venture, so that the proper flow parameters can be reached. The modular system will be placed a certain distance before the piping enters the pumping station. This will allow for the falling water to continue to accelerate, so that it does not affect the pumping station piping process. A bypass section is incorporated to the system as shown in Figure 3.

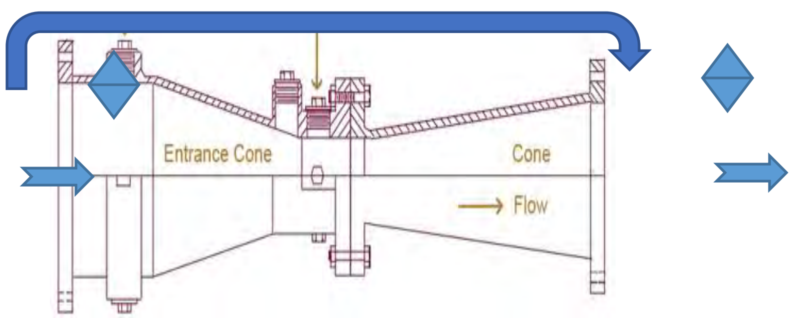

FIGURE 3: BYPASS LINE SAMPLE

Note that the bypass line is to be used for maintenance of the system and for an emergency fail safe method to ensure free falling water reaches the pump station regardless of malfunction the system. Section 2.1 discusses the flow parameters and specifications used to design the apparatus.

2.1 Specifications & Fluid Properties

As mentioned previously, the pumping station is located at the bottom of the facility. The specification for the pump that pushes water to the top of the cooling tower is as follows:

Condenser Water Pump	*Specifications*
Volumetric Flow Rate	0.1514 m^3/s
Power	44.74 kW 384,764 kWh

Efficiency	93.6%
Head	70

Note that head signifies head is the height difference between where the water enters into the hydro system and where it leaves it, measured in meters. Typically, this could be the height of a where the turbine or pump entrance is to where the water discharges from the turbine and returns. Fluid properties used for the design of the system are taken using engineering thermodynamic tables and listed below

Water Properties at outlet (25.5 °C, 1 atm)	*Values*
Density	996.10 kg/m^3
Saturation vapor pressure	3166.1 Pa
Specific Enthalpy (Liquid)	104.86 kJ/kg
Specific volume (Liquid)	0.001003 m^3/kg
Internal Energy (Liquid)	104.86 kJ/kg
Entropy (Liquid)	0.3672 kJ/kg K
Dynamic Viscosity	0.000891 kg/m s

Having the proper fluid properties and system specifications, the flow properties are calculated in Section 2.2

2.2 Flow & Power Calculations

The first series of calculations takes into account that since the system is closed loop, the volumetric flow rate entering and exiting the pump will be the same. This allows use to determine the mass flow rate exiting the cooling tower. Equation (1) signifies the mass flow rate entering and exiting the system using continuity equation.

$$\dot{m}_{in} = \dot{m}_{out} \tag{1}$$

The mass flow rate exiting the cooling tower can then be found using equation (2).

$$\dot{m}_{\substack{cooling \\ tower}} = \rho \dot{Q} \tag{2}$$

Where the density and volumetric flow rate are already known through Section 2.1, the following equation is used to determine the theoretical power generated by the flow. Notice that h in this case is what is going to be determined by the head of the turbine placed in the pipe.

$$Power = \dot{m} g h \tag{3}$$

Notice that this is the theoretical power generated; to calculate the actual power generated, the efficiency of the turbine must be considered. Equation (4) shows the true generated power produced by the hydro-turbine.

$$Power_T = (Power)(\eta) \quad (4)$$

The energy produced by the turbine can be found using equation (5).

$$E = Pt \quad (5)$$

Where the time in this scenario will only be for summer months, approximately (2,208.62 hours)

2.3 TURBINE SELECTION & DESIGN

The following equations all require a turbine to be used to start designing the modular system. The turbine selected for this apparatus is the Inline Hydro Turbine by SOAR. SOAR'S Inline Turbines are a series of compact, highly efficient hydro power generation units. These turbines are site specific for maximum efficiency but share a number of common parts for competitive pricing and quick lead times. The Francis turbine covers flows ranging from 100 to 30,000 GPM and heads from 25 to 570 feet. Flange-to-flange lengths of Inline Turbines are shared with common pressure reducing valves for drop-in replacement and the flanges are manufactured to meet ANSI standards. The system comes with a generator attached to the turbine. Figure 4 shows the updated modular system with the attached SOAR turbine.

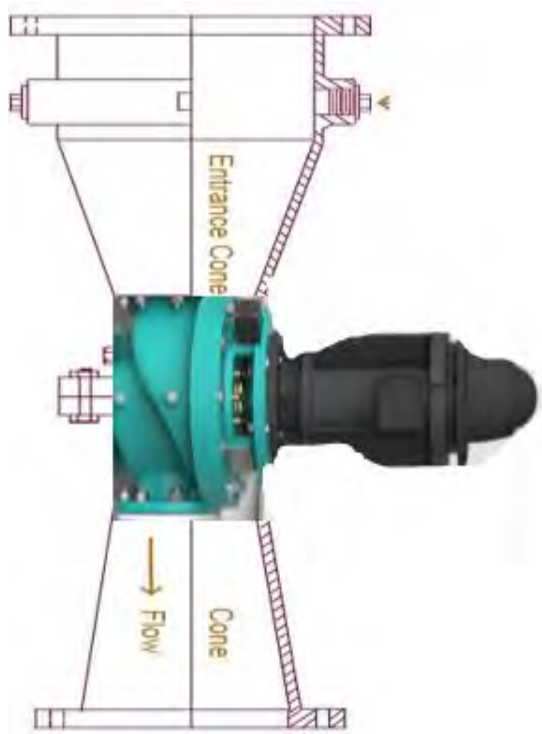

FIGURE 4: MODULAR HYDRO-TURBINE ECONOMIZER

The pump specifications can be seen in the table below for the standard ILT-08 series line.

Soar Turbine ILT-08	*Specifications*
Pipe Diameter	0.20 m
Max Volumetric Flow Rate	0.1647 m^3/s
Overall Length	0.645 m
Max Pressure Rating	16 Bar

Using the specifications from Section 2.1 and 2.2, the proposed design can be analyzed to determine the power generated, etc.

Proposed Design (Using Selected Turbine)	*Calculations*
Mass flow rate	150.93 kg/s
Theocratical Power Generated	45,129.40 W
Actual Power Produced	36,103.52 W
Energy produced during summertime	79,738.95 kWh

Notice that the efficiency used to calculate the power produced is 80%. Since most hydro turbines are well in the 90% region, this assumption allows for a safe representation of power. The system can be placed 51.82 m below the roof of the building. This will allow for an extra 10-15 m drop so that the water can continue to accelerate to the pumping station and not affect the chiller cooling system. It is important to note that the pipe material is black or galvanized steel piping, which complies with ASTM A 53/A 53M with malleable iron. The proposed design will incorporate these standard materials to allow for easy installation. Using CATIA, a preliminary design of the system is shown in Figure 5-7.

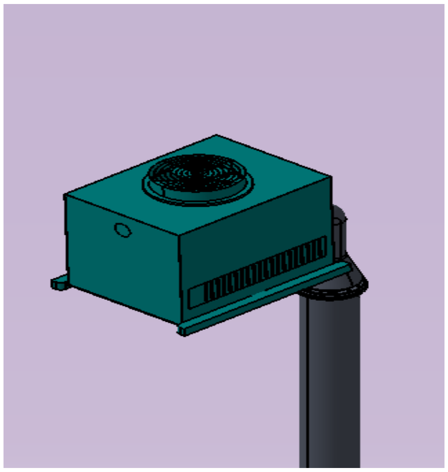

FIGURE 5

FIGURE 6

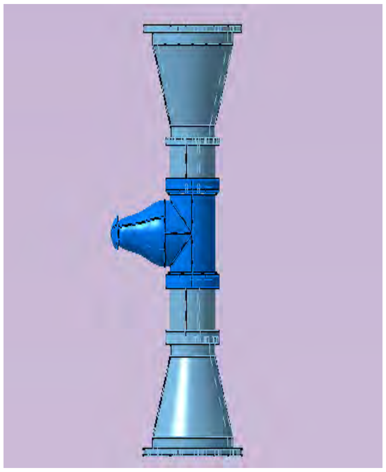

FIGURE 7

FIGURE 5: CAD MODEL - COOLING TOWER & RETURN LINE PIPING
FIGURE 6: CAD MODEL- TURBINE MODULAR SYSTEM INSTALLED
FIGURE 7: CAD MODEL-TURBINE MODULAR SYSTEM SEPERATLEY

The modular system shown in Figure 6 and 7 represents the preliminary modular system with a bypass line depicted in Figure 6. The system is composed of converging and diverging pipes at each end of the turbine. The outlet of the turbine diverging pipe may change length depending on the possible formation of flow vortices. Currently both inlet and outlet piping sections are the same length.

3. FURTHER DESIGN DETAILS

When reviewing building codes in the NY Metro area, some local laws that govern cooling tower installation are Sections 77. The only information gathered was that cooling towers must be rigorously maintained. Also, since most cooling towers have surfaces that are not constructed of anti-microbial materials, this allows bacteria to grow such as Legionella. Since the water entering the turbine is always in circulation, the buildup of bacteria will not be a concern. Foreign objects impinging the turbine will have to be addressed. The proposed design will have a mesh element for capturing debris as an added precaution. This will ensure that no foreign objects enter the turbine and the blades of the turbine are not damaged if debris enters the venturi section.

4. PRELIMINARY COST DETAILS/COST SAVINGS

As renewable energy is given more cost incentives, many companies are pushing towards implementing new forms of alternative energy like the modular hydro turbine. A preliminary benchmark can be made to assess the project Since electric power rates vary across region, the average rates of large city areas in the USA are approximately 12.84 cents per kilowatt hours. It has been estimated that the hydro turbine itself cost approximately $250,000-$270,000 for the first option turbine. A cheaper alternative will be discussed in upcoming sections, along with piping, controls, valves, and hardware options. It has been noted that for users to invest in the hydro turbine economizer, the payback for most renewable energy sources in this sector is anywhere from 6-7 years. Estimated cost savings per year, in the tri state area, with the preliminary specifications are approximately $18,857.70. Under the current payback time period, the system will save $132,003.90 not including installation cost or piping. The system can be analyzed for large and small high-rise buildings. Figure 8 shows the graph of the power generated during summertime months in the tri state area for large and small buildings utilizing this system.

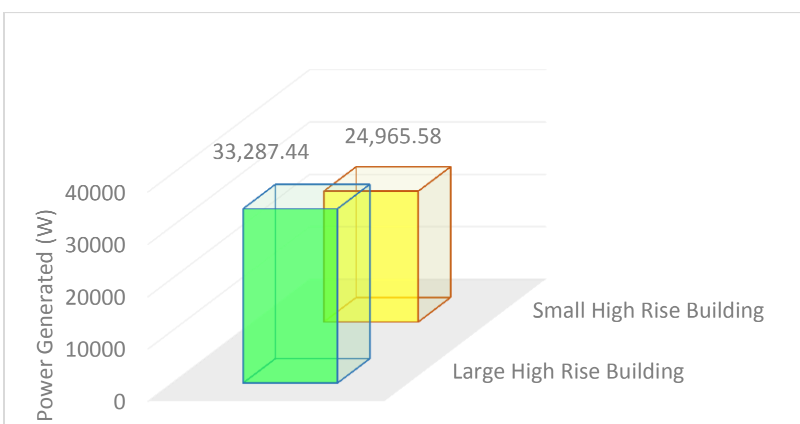

FIGURE 8: POWER GENERARTED FOR LARGE AND SMALL BUILDINGS

Notice that in Figure 8, the power generated for smaller buildings is lower since the pumps that would pump water to the cooling tower are smaller. Smaller size pumps will produce a lower volumetric flow rate across the loop. This will then reduce the amount of head that the modular system will create which decreases the power generated for the facility.

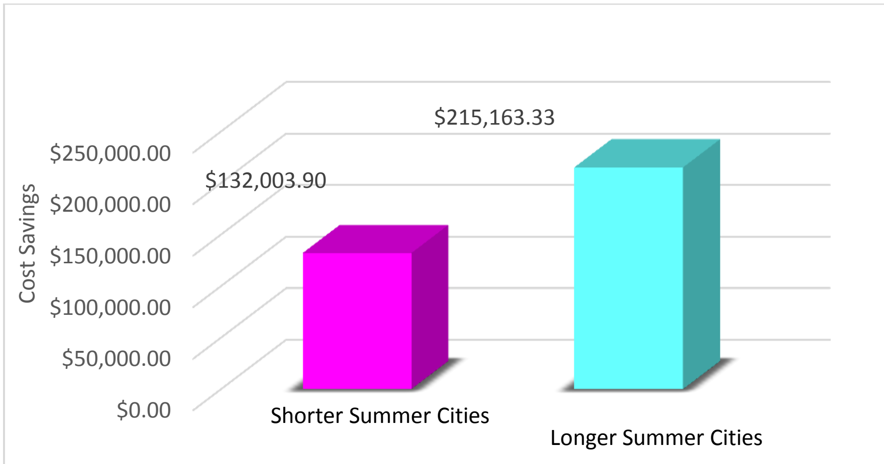

FIGURE 9: COST SAVINGS-VARYING SUMMER LOCATIONS

Figure 9 shows the difference in cost savings when the system is implemented in longer summer month cities such as Las Vegas. The longer summer months signify that the modular system will be operating more consistently and producing usable electrical power. In the current payback rate, longer summer cities will produce $215,163.33 per building in the designated payback time interval.

5. FLUID FLOW FORCES

Having implemented the modular system, there will be certain forces acting on the cone body itself due to the fluids momentum. This force must be found so that the mounting of the modular system can be designed to withstand the loads associated with the increase of flow velocity through the convergent cone. Figure 10 shows the control volume of the system.

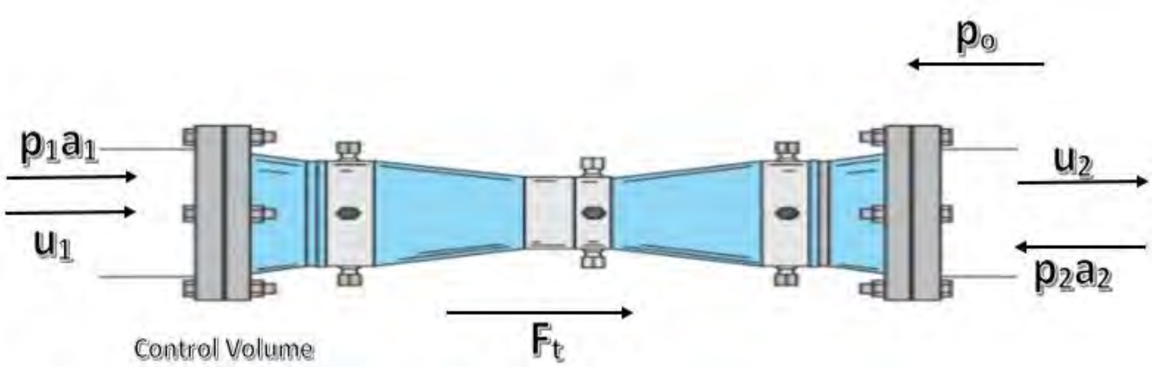

FIGURE 10: MODULAR SYSTEM EXTERNAL LOADS & VELOCITES

The external forces acting in the axial direction are shown in Figure 10. Application of the momentum equation to the contents of this control volume yields:

$$\int_{C.V\,low}^{C.V\,high} u\rho V \cdot n \, dA = P_1A_1 + F_t - P_2A_2 - P_o(A_1 - A_2) \quad (6)$$

Applying one dimensional flow and conservation of mass to equation (6) simplifies as

$$\dot{m}_{in}(u_2 - u_1) = PA_1 - P_2A_2 + F_t \quad (7)$$

Rearranging equation (7) to solve for the thrust force yields

$$F_t = -P_1A_1 + P_2A_2 + \dot{m}_{in}(u_2 - u_1) \quad (8)$$

The missing variable in equation (8) is the pressure after convergent pipe. In order to find the pressure at the exit, Bernoulli's Equation must be used. The following equation yields:

$$P_1 + \frac{1}{2}\rho u_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho u_2^2 + \rho g h_2 \quad (9)$$

Rearranging Bernoulli's Equation to find the pressure after the convergent pipe yields a pressure value of 102,640.93 Pa. The weight of the water must be taken into account, since the system is vertically inline. Using the water thermodynamic table, the density of water is found to be 996.10 kg/m^3. The volume of the modular convergent pipe is represented using an average radius value and a circular truncated cone volume as:

$$V = \frac{1}{3}\pi(r_1 + r_1r_2 + r_2)^2 h \quad (10)$$

The volume of the convergent piping is then 0.066 m^3 and the weight of water is 648.436 N. The final force acting on the system is then -14,349.571 N. The negative sign represents the direction of the force acting opposite to the flow. Using the force acting on the system, the bolt configuration and the mounting of the modular system can be analyzed for further design requirements for structural integrity.

6. STRESS ACROSS PIPE MEMBERS

Having calculated the force acting on the venturi piping, estimated stress approximations can be determined for the piping section. This will give an insight into correctly selecting the approximate bolt configuration for the mounting flanges of the piping sections. Pipe stress analysis is an analytical method in engineering to determine how a piping system behaves under certain initial boundary conditions. If the piping system is not subjected to outside forces, hand calculations are usually sufficient to determine the stresses across the member. If the piping system is high-pressure, high-temperature, hazardous-fluids system, or large outside forces are applied to the piping system, a computer-aided model and full finite element analysis is required for the complexity of the problem. There are many piping codes and standards that could be used during a pipe stress analysis, depending on the application and location. ASME B31.1 power piping declares that the physics of pipe stress analysis does not change with piping code. Stress analysis in piping increases the longevity of the piping system in buildings. Many will not consider piping to be equipment, but it is no different than pumps and motors. Both have moving parts and must be designed and maintained properly to ensure no critical stresses are ever reached. Pipe stress analysis also is used to protect equipment, since piping is no more than a large lever arm connected to an expensive piece of equipment. The piping in this system is connected to the modular turbine; if precautions are not taken then the turbine could be easily damaged causing major water system failure across the entire high-rise building.

There are five primary piping stresses that can cause failure in a piping system: hoop stress, axial stress, bending stress, torsional stress, and fatigue. A 3D element can be taken from the piping system, and the local stress can be found for the venturi piping shown in Figure 11.

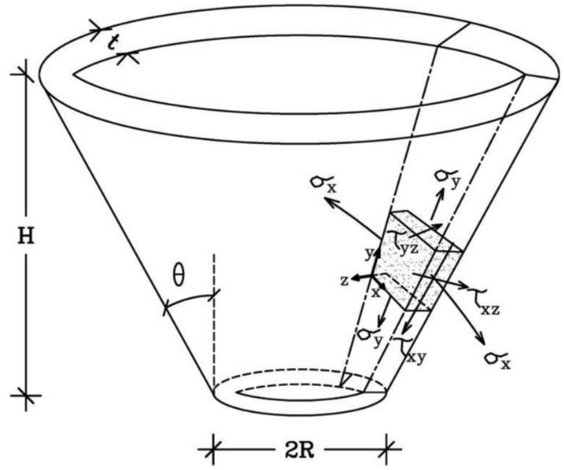

FIGURE 11: VENTURI CONE PIPING 3D STRESS ELEMENT

Note that hoop stress is considered to be uniform over a given length of pipe, but will change with diameter and wall thickness throughout the system. The following equations show the stresses acting on the thick-walled venturi piping.

$$\sigma_a = (P_i r_i^2 - P_o r_0^2)/(r_o^2 - r_i^2) \text{ , Axial Stress} \quad (11)$$

$$\sigma_H = \frac{P_i r_i^2 - P_o r_0^2}{r_o^2 - r_i^2} - (r_i^2 - r_0^2)(P_o - P_i)/(r_{avg}^2(r_o^2 - r_i^2)) \text{ , Hoop Stress} \quad (12)$$

$$\sigma_r = \frac{P_i r_i^2 - P_o r_0^2}{r_o^2 - r_i^2} + (r_i^2 - r_0^2)(P_o - P_i)/(r_{avg}^2(r_o^2 - r_i^2)) \text{ , Radial Stress} \quad (13)$$

Stress and Pipe Mounting & Standards

When calculating the stress across the venturi piping, the average radius was found for convergent and divergent ends from the previous volume (10) calculation. The radial, hoop, and axial stress were found to be -97.80 kPa, -93.81 kPa, and -102.11 kPa. These stress values are miniscule and can be neglected since the system's change in pressure is not significant to cause any design issues. According to standards and piping experts, the fluid has a greater impact as the pipe size becomes larger. It is stated that the water weight is more than the pipes weight for 12 in diameter nominal pipe size (NPS) for standard wall thickness or greater. In later analysis, the load found in the Section 5 will be used to determine mounting and supports for the system.

When concentrated loads, such as flanges, valves, and piping specialties, are present between pipe supports, the recommended span between pipes should be reduced to account for them. A pipe support should be placed within one-third the recommended span of a rotating equipment connection to minimize vertical load and moments at that specific connection. In most cases, this support should have a spring to help with adjustment and reduce vibration. When piping changes horizontal direction, the recommended span between pipe supports shall be reduced by 25% of the original size.

7. PIPING SUPPORT FINITE ELEMENT ANALYSIS

Having calculated the forces acting on the system from section 5, a support structure was designed to mount the system. The support piece must withstand the external load of 14,349.571 N. Figure 12 shows the support piece used to mount the system to a concrete slab. There are four mounting holes (20mm diameter), each used to bolt the system down. There are two circular rings that clamp on to the piping and are held in place by the pipping's center construct. This ensures that once the system is in operation, there is little to no displacement. As an added measure of precaution, dampers can be installed when mounting the piece to the concrete slab. This will reduce the vibration transmitted to the piping system to avoid resonance of the structure.

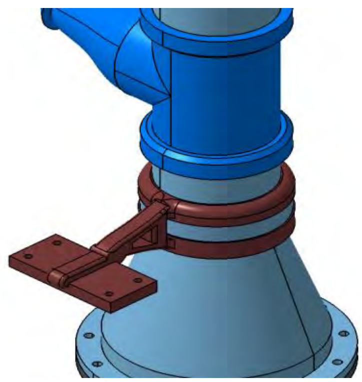

FIGURE 12: MODULAR SYSTEM-SUPPORT MOUNTING PIECE

Having understood how the support system will be mounted, the proper boundary conditions can be applied to the piece. The boundary conditions implemented to the finite element model were a distributed load of 14.35 kN and a clamped end to set displacement values of the fixed region to zero. A mesh convergence study was conducted to ensure the stress is independent of the mesh size on the part. Figure 13 shows the mesh study for the finite element model.

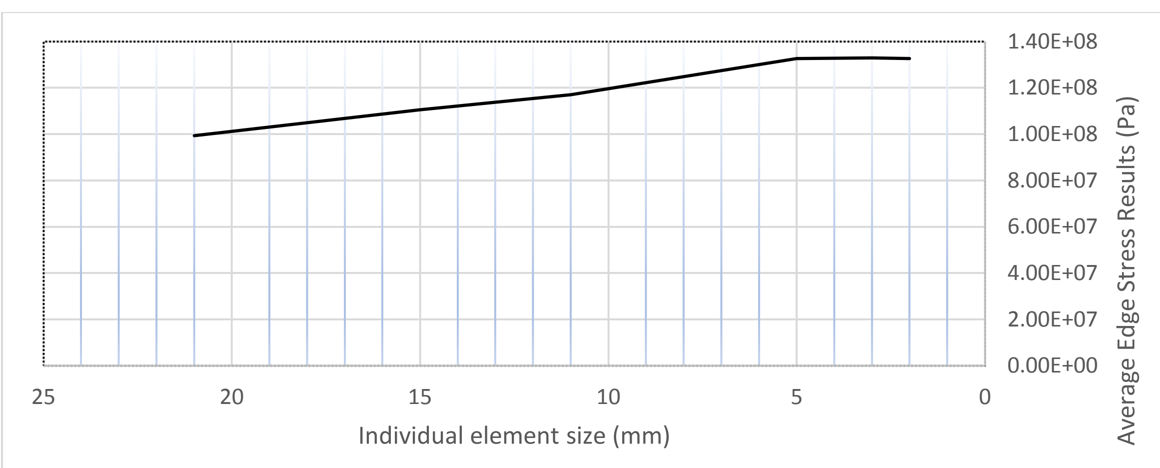

FIGURE 13: SUPPORT PIECE MESH CONVERGENCE STUDY

Figure 13 shows that after a 5 mm tetrahedral parabolic element size, the stress is independent of the mesh size. The section used to determine the mesh was a pre-selected edge where the average stress across the edge was found for each case. Figure 14 shows the selected edge surface used to determine the corresponding mesh. Figure 15 shows the total meshed elements for the modular system-support mounting piece.

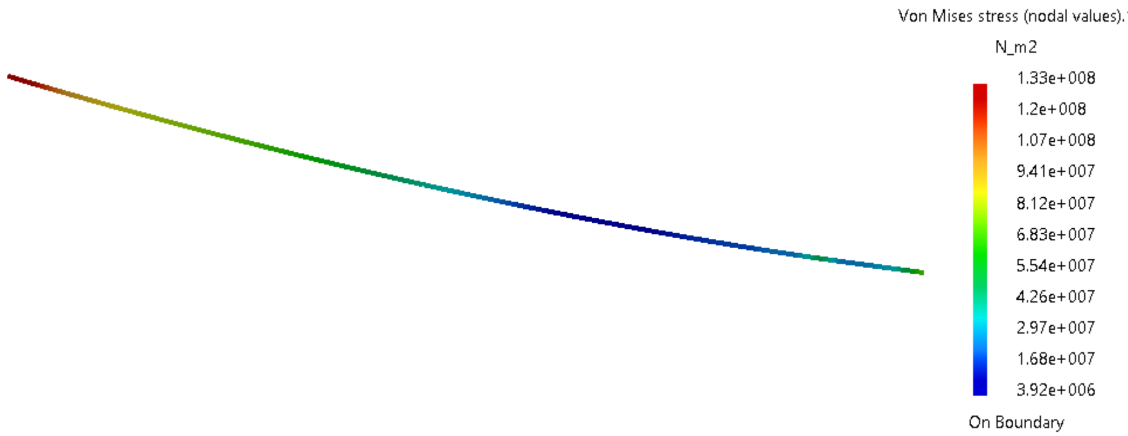

FIGURE 14: STRESS DISTRIBUTION OF SELECTED EDGE FOR MESH CONVERGENCE

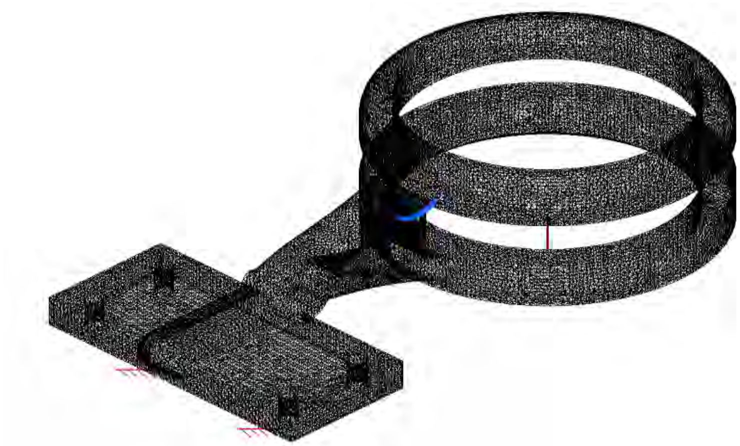

FIGURE 15: MESHED MODULAR SYSTEM-SUPPORT MOUNTING PIECE

Since the area of maximum stress is the specific location of interest. A finer mesh can be set only on that surface location. Figure 16 shows the finer meshed surface used for the analysis.

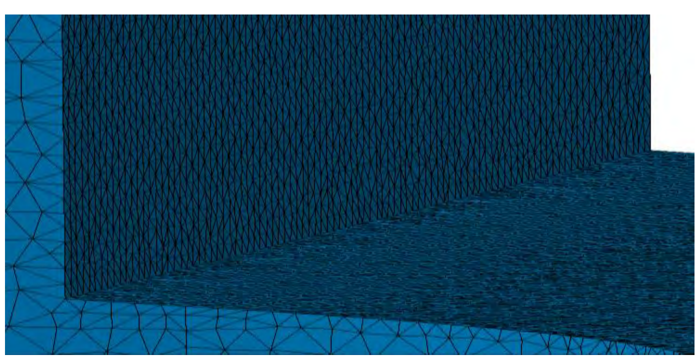

FIGURE 16: FINER MESHED SURFACE

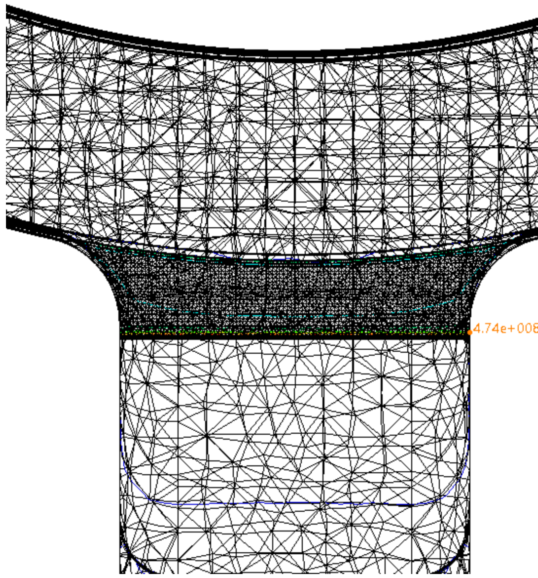

FIGURE 17: MAXIMUM STRESS LOCATION (TOP VIEW)

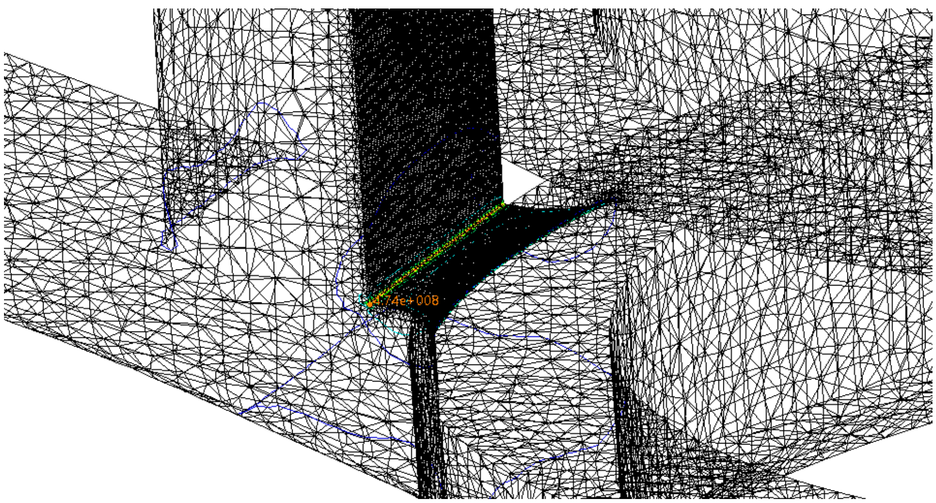

FIGURE 18: MAXIMUM STRESS LOCATION FULL

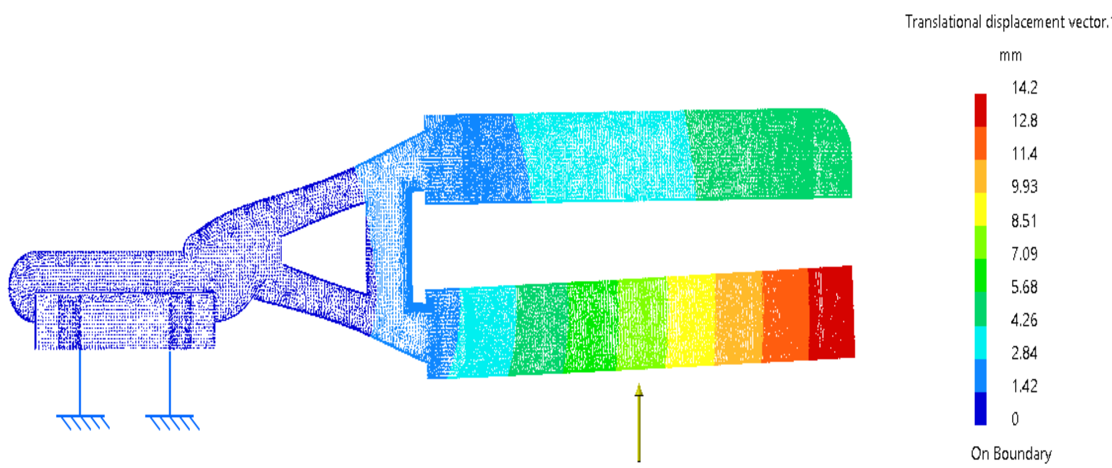

FIGURE 19: MAXIMUM DISPLACEMENT

Notice Figure 17 & 18 show the maximum stress experienced on the support piece. The max stress is located at the hinged section and is caused by bending in the y-axis of the support piece.

Notice that the maximum stress experienced is 474 MPa. Using safe design criteria:

$$\sigma_{max} \leq \sigma_{all} \tag{14}$$

Where the allowable stress is:

$$\sigma_{all} = \sigma_{yp}/Nfs \tag{15}$$

σ_{yp}: $Yield\ Strentgh$ (689.47 MPa) Steel, high strength alloy ASTM A514

Nfs: $Factor\ of\ Saftey$ (1.45)

The maximum stress (474 MPa) is less than the allowable stress (475.49 MPa) for the support structure. The maximum displacement of the support piece from the analysis is 14mm. The analysis is an overloaded situation, since it will not experience as large as a bending moment at the hinged section. The reason for this: since the piping will be in contact with the support piece, the mounting member will not deflect to the extent it did in the analysis, thus reducing the bending moment created at the hinged section and reducing displacement and stress.

8. COMSOL PIPE FLOW ANALYSIS

Due the implementation of converging and diverging piping in the modular system, pressure distribution above the pipe can be determined. For modeling representations, the turbine shaft and blades are not implemented in the analysis. This would further complex the fluid domain since rotational shafts would add some level of uncertainty. Since only the venturi section is be analyzed to determine the velocity and pressure distribution, the finite element model will help give a visual insight to the fluid flow through the piping section. Consider that the water entering the circular pipe is of uniform velocity. Because of no-slip condition, the fluid particles in the boundary layer meet the surface of the pipe, causing them to come to a complete stop. This also causes the fluid particles in the adjacent layers to slow down gradually as a result of viscous forces between the fluid medium itself. To make up for this velocity reduction, the velocity of the fluid at the midsection of the pipe increases to keep the mass flow rate through the piping system constant. Figure 20 shows the process of a fully developed velocity profile entering the pipe. This is important since this option will be used in the CFD analysis for the piping section.

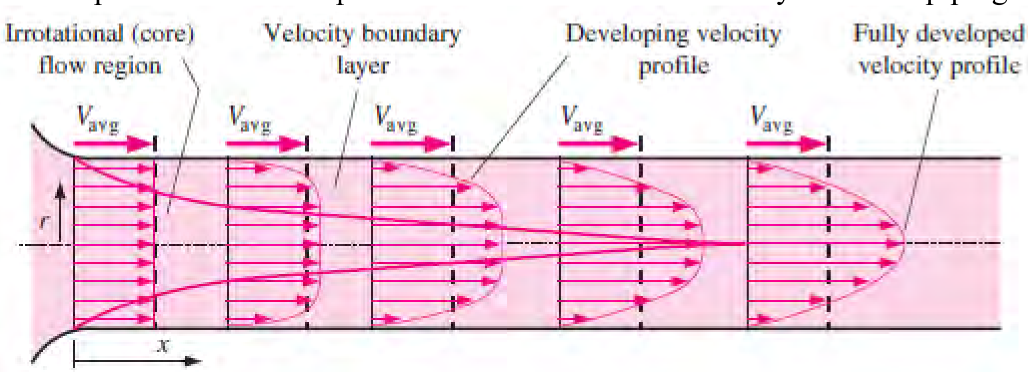

FIGURE 20: THE DEVELOPMENT OF THE VELOCITY BOUNDARY LAYER IN A PIPE

To fully analyze the entire venturi for velocity and pressure distribution, COMSOL is used. COMSOL is the dominant physics simulation software in which finite element method and partial differential equations are solved. COMSOL has various useful features and functions that have made this software beneficial across multiple industries. As a result, COMSOL has been a leading provider and developer in computing software. The physics set up for the analysis begins with single phase turbulent flow using the turbulence kinetic energy (k) and the specific rate of dissipation of kinetic energy (ω). This utilizes a low Reynolds number. It inherits nonlinearity, and thereby causes some values to not converge when compared to other turbulence models. It is quite sensitive to the initial guess of the solution, so all prior pressure and velocities must be known. The k-ω model is useful in internal pipe flows, hence the reason it was selected for the venturi piping. To reduce the amount of computation time, the venturi piping was cut, and symmetry was applied to the pipe member(2D-Axisymetric). The fluid properties for the corresponding temperature were entered to the materials section of the model. In the turbulent flow boundary conditions, the initial values of pressure were entered to 1 atm. The inlet pressure value (considers the weight of the fluid from above) and outlet volumetric flow rates were entered using the data from Section 2.1 and Section 5. A stationary study is observed for this system. Since the system is vertically mounted, gravity and buoyancy induced turbulence is selected for the fluid domain. The meshing of the venturi piping consists of one automatic mesh for the entire system (extra fine). The wall region has a more densely populated area of elements. Figure 21 shows the meshed venturi pipe section used for the analysis of the modular system. Notice that the inlet section consists of the larger cross-sectional area of the convergence cone. The outlet section is the smaller piping area that will hold the turbine blade and rotating shaft of the hydro turbine assembly.

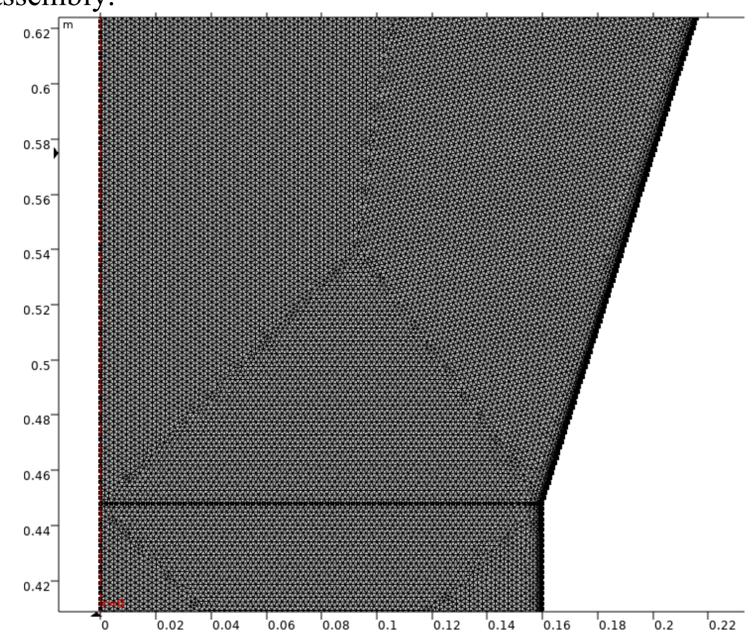

FIGURE 21 MESHED SECTIONED VENTURI PIPING

Having calculated and solved for the fluid computational domain of the system, the pressure and velocity groups are plotted to determine the distribution of pressure and velocity across the inner surface of the pipe. Figure 22, 23, and 24 show the distribution of both quantities of the 2D Axisymmetric analysis.

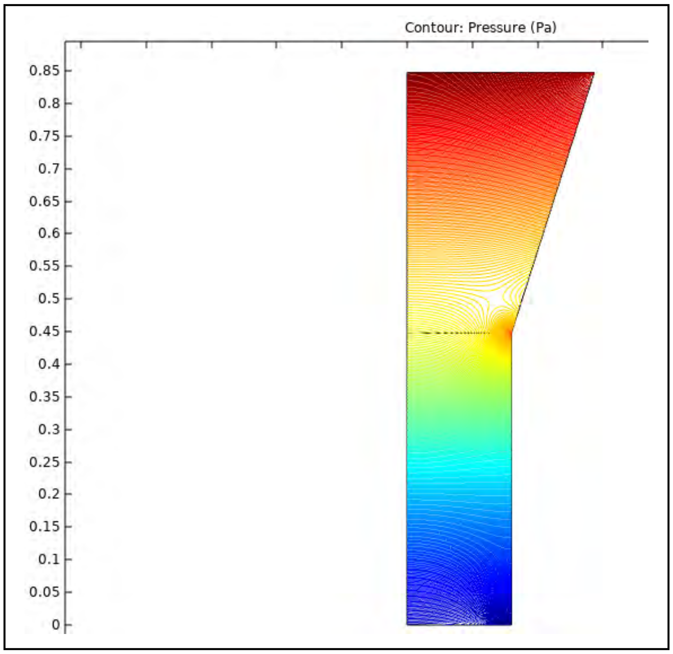

FIGURE 22: PRESSURE DISTRIBUTION ACROSS PIPE SURFACE

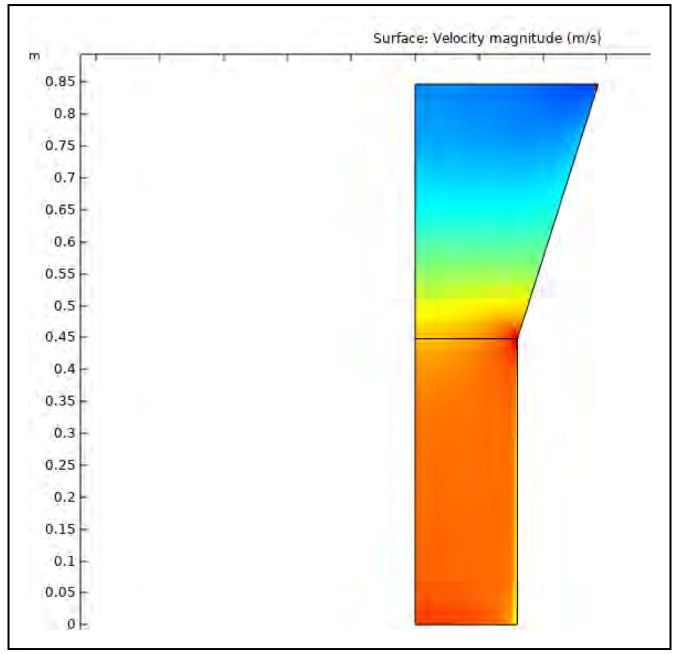

FIGURE 23: VELOCITY DISTRIBUTION ACROSS PIPE SURFACE

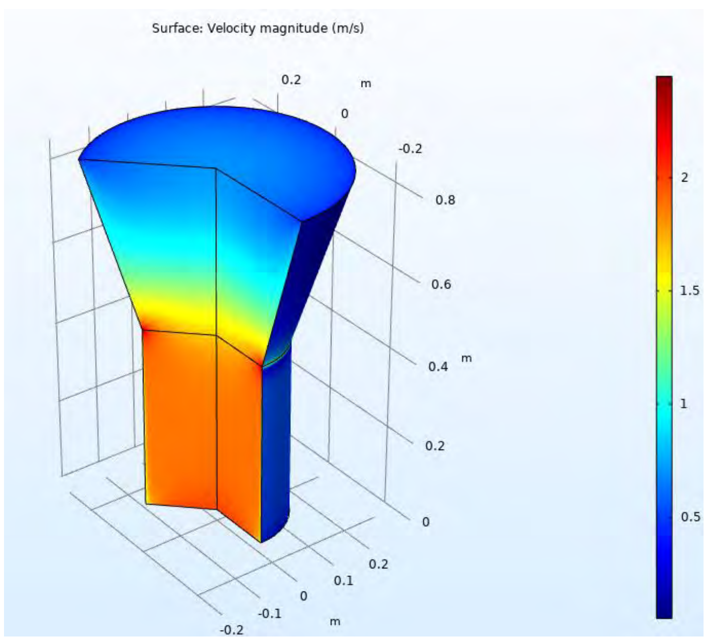

FIGURE 24: VELOCITY DISTRIBUTION ACROSS PIPE SURFACE 3D CUT PLANE

Notice that the pressure at the upper surface is higher due to the slower moving fluid particles. This ensures that enough head will be generated to spin the turbine. Also, the velocity increases as the piping is converging. The analysis showed an average velocity of approximately 2.2 m/s in the outlet section. The calculated velocity was 2.9 m/s. There are multiple factors that would affect the difference in results, such as fluid boundary conditions that were not taken into account in the hand calculation. The velocity at the walls was zero, due to the no slip condition previously discussed.

9. CONCLUSION

Currently, the globe is faced with an energy crisis. As population rates continue to rise and energy consumption across the globe increases, demand for energy is expected to increase year by year. This leads to the need for alternative forms of energy. These alternative forms of energy aim to satisfy the demand for electrical power and transportation, both of which depend mostly on fossil fuels. Many studies have been conducted and various works have been published in the field of power sector, renewable energy and solar energy. Renewable energy is the key solution to solve the energy crisis and to secure future food and economic needs. This energy crisis is an issue that has been overlooked for years, and if future generations are to continue to grow, power grids and large-scale energy sections must change dramatically by engineering new forms of renewable energy. The modular high-rise cooling tower hydro turbine has the capabilities of harvesting vertical fluid flow for large commercial buildings and converting the mechanical energy to usable electrical power. The modular system will save up to $215,000 dollars in heavy summer months. The system was also designed to withstand the fluid forces acting on the support piece. The linear static analysis proved that the systems structural integrity will not be compromised. In addition, the flow analysis using COMSOL showed the velocity and pressure distribution across a section of the piping. The flow velocity found in the simulation relatively matched the velocity found in the analytical section of the fluid calculations. The pressure distribution of the system validated the higher head formation that acts on the piping member. For future development, a more specific cost breakdown and vendor sourcing for parts will be considered. This includes sourcing individual components (turbine, pipping, fittings, sensors, and generator) for the modular system, so that the price of the system is significantly lower and there is a more exact financial quote. In addition, another configuration will be designed for buildings that have narrow space. This includes a horizontal modular system placement with more complex piping. Overall, implementation of this system will significantly assist buildings in heavily populated cities to lower their electrical consumption and possibly sell the remaining energy to energy vendors for certificates.

10. ACKNOWLEDGEMENT

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[16] *COMSOL* Turbulence Model Selection -CFD Application

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Autonomous Life Emergency Rescue Transmitter (A.L.E.R.T.)

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ABSTRACT

Emergency distress signals are used to indicate the need for help and immediate attention. Today, devices such as flares and radio beacons are commonly used for distress signaling. Flares can be pyrotechnics or LED-based that produce high-intensity light when needed to draw the attention, of other ships, rescue centers, or bystanders for help. This technique becomes ineffective when the victim is in an unpopulated area. Radio beacons, on the contrary, when activated send out a continuous signal with the GPS location of the individual in distress, thus allowing the search and rescue authorities to provide immediate help. However, radio beacons have limited range, and this range becomes more limited by the terrain. Thus, a solution that, in an emergency, provides both a better visual and longer range for a distress signal is under development. A.L.E.R.T. incorporates triple-tier life SOS signals. The aircraft utilize visual, radio, and satellite signals for triple redundancy. A.L.E.R.T. can fly higher than any flare and can be seen from further distances. The aircraft will continuously ascend and descend above the person in distress, to provide better visual contact with the rescue team. This will allow the rescue team to fly at higher altitudes, away from danger, and give them the ability to pinpoint the geolocation of the person in distress.

1 INTRODUCTION

Autonomous Life Emergency Rescue Transmitter (A.L.E.R.T.) has been designed to provide the most effective solution for emergency distress signaling used on boats and ships, as it utilizes triple-tier life SOS signaling. The aircraft is designed to ascend and descend above the person in distress to provide better visual contact with the rescue team. A.L.E.R.T. connects to GPS satellites to relay the GPS coordinates of the person for an accurate location. A low-frequency distress signal will also be sent to SOS channels for increased rescue range. Since A.L.E.R.T. is well above sea-level, the radio signal will reach further distances. The aircraft will be light-weight, compact, and autonomous, with proprietary software for autonomous take-off and navigation in emergency situations. The lightweight corresponds to increased operational life for each battery. A.L.E.R.T. will fly higher than any flare and will be visible from further distances.

The custom software will send the aircraft to high altitudes, increasing the range of the radio beacon and the visual indicator, thus, making it easier for the rescue team to locate the person in distress.

2 Background Research

In a time of distress, Visual Distress Signal Device (VDSD) is used to indicate emergency or potential danger via visual aid. VDSDs come in many shapes and forms, from special maritime flares to road flares used for car emergencies. These flares are very luminous; hence, they are a great way to catch attention when needed for immediate response. However, they don't last for a long time, nor are they visible from further distances.
Flares are a type of pyrotechnic that produces high intensity light. They are used as visual distress signals. Their purpose is to gain attention from nearby people, when needed for immediate help or to signal potential danger. Flares are only effective when there is someone present to see them, such as a nearby boat or plane, or if the shore is near and there are people present on the shore. Handheld flares can burn up to 15 minutes and can be seen from 3 miles; while a flare shot up using a flare gun will last for up to 30 seconds and can be seen 25 miles. Additionally, in figure 1.0, the visibility of different flares can be seen [1]. Another type of flare commonly being used is the flameless electric flare or S.O.S distress light. This device has a high intensity LED light that flashes an S.O.S signal for up to 60 hours and is visible up to 10 nautical miles. Although flares are effective in indicating an emergency, they require that there are rescuers within the visibility range to spot the flare in order to provide help. Thus, if the person in distress is in an area with no rescuers in the visibility range of the flare, his/her chances of receiving help are significantly reduced.

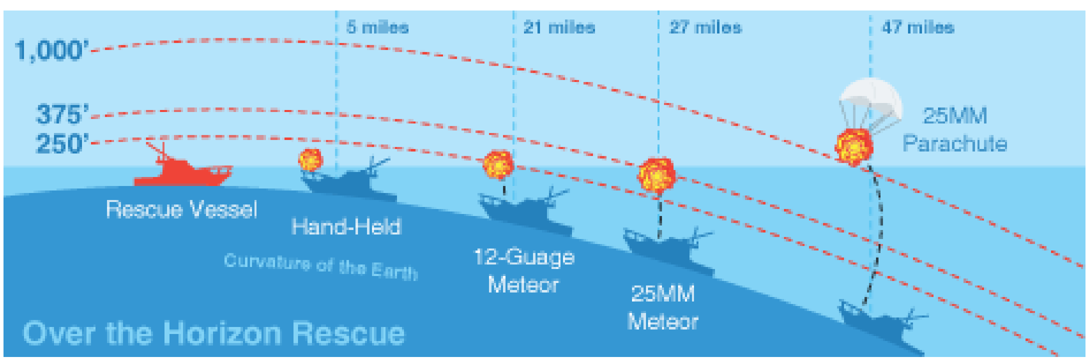


Figure 1.0: Visibility of Flare

Extensive research has been conducted on alternatives to flares. Since pyrotechnic flares are developed to produce a bright flash in case of an emergency, their environmental factors are not considered. Non-pyrotechnic flares have thus been developed as an alternative to flares. LEDs, flash tubes (which produce a bright arc using gas in a glass tube), and incandescent bulbs are some of the technologies used in distress signalling. Different factors such as effective intensity and beam width must be considered as photometric data to determine the most effective way to signal distress. According to Young et al [2], in their study conducted for the U.S. Coast Guard, LED based devices performed better in comparison to other alternatives due to their longer "on" time and effective intensity coupled with unique flash patterns. This means that even though LED's have a lower intensity compared to flashtubes, they "seem" brighter at longer distances due to the greater length of time they are on. Additionally, a study conducted by Posage, on behalf of Homeland Security, suggests that the cyan and red-orange color attracts more attention [3]; this means that using such colored LEDs on A.L.E.R.T. will significantly improve their visual aid.

Another product available on the market is the Splash Drone. The splash drone is a waterproof drone that is capable of carrying various payloads. The drone can be outfitted with a flare for signaling [4]. However, this drone does not provide any location data or any radio transmitting ability. A.L.E.R.T. provides a unique blend of capabilities which are a superior alternative to emergency signaling devices.

3 ENGINEERING REQUIREMENTS

Frame
- 7in propeller clearance
- Carbon Fiber base
- Polylactic Acid (PLA) outer shell

Motors
- Brushless Motor
- Min. Trust: 450g
- Power: 150W

Flight Controller
- Support 4 electronic speed controllers
- Compatible with Ardupilot ArduCopter firmware
- Small and lightweight (20mm x 20mm base)
- Onboard barometer and accelerometer

Electronic Speed Controller
- Has Battery Eliminating Circuit (BEC)
- Compact and lightweight (20mm x 20mm base)
- Take a 6s (24.4v) battery
- Support up to 30amps

Battery
- Lithium-Polymer Battery
- 6s (24.4V)
- 3000mAH

Light Emitting Diode
- Hight Luminosity
- Programmed to flash SOS signal
- Separate power source

Radio Transmitter
- Transmits at 121.5 MHz
- Transmit GPS Location and an emergency message

Global Positioning System (GPS) Module
- Obtain accurate GPS location (GNSS, GLONASS)
- Has a magnetometer

4 ENGINEERING CONSTRAINTS

U.S. Coast Guard Requirements [5]

(A) Each electric light must satisfy:

1. **§ 161.013-5 Intensity requirements**
   a) If an electric light emits light over an arc of the horizon of 360 degrees, the light must:
      1) When level, have a peak intensity within 0.1 degrees of the horizontal plane:
      2) Have a peak Equivalent Fixed Intensity of at least 75 cd; and,
      3) Have a minimum Equivalent Fixed Intensity within a vertical divergence of ±3 degrees of at least 15 cd.

   b) If an electric light emits a directional beam of light, the light must:
      1) Have an Equivalent Fixed Intensity of no less than 25 cd within ±4 degrees vertical and ±4 degrees horizontal divergence centered about the peak intensity: and,
      2) Have a minimum peak Equivalent Fixed Intensity of 2,500 cd.

   c) The Equivalent Fixed Intensity (EFI) is the intensity of the light corrected for the length of the flash and is determined by the formula:
      $EFI = I \times (tc - ti) / 0.2 + (tc - ti)$
      Where:
      I is the measured intensity of the fixed beam,
      tc is the contact closure time in seconds, (0.33 for this S-O-S signal), and
      ti is the incandescence time of the lamp in seconds.

   d) An electric light which meets the requirements of either paragraph (a) or (b) of this section need not, if capable of operating in both manners, meet the requirements of the other paragraph.

2. **§ 161.013-7 - Signal requirements**
   a) An electric light must have a flash characteristic of the International Morse Code for S-O-S and, under design conditions,
      1) Each short flash must have a duration of 1/3 second;
      2) Each long flash must have a duration of 1 second;
      3) The dark period between each short flash must have a duration of 1/3 second;
      4) The dark period between each long flash must have a duration of 1/3 second;
      5) The dark period between each letter must have a duration of 2 seconds;
      6) The dark period between each S-O-S signal must have a duration of 3 seconds.

   b) The flash characteristics described in paragraph (a) must be produced automatically when the signal is activated.

3. **§ 161.013-9 Independent power source**
   a) Each independent power source must be capable of powering the light so that it meets the requirements of § 161.013-3(a)(1) and emits a recognizable flash characteristic of the International Morse Code for S-O-S at a rate of between 3 and 5 times per minute after six hours of continuous display of the signal.
   b) If the independent power source is rechargeable, it must have a waterproof recharger designed for marine use.
   c) If the independent power source requires external water to form an electrolyte, it must operate in sea water and fresh water.

4. Float in fresh water with the lens surface at or above the surface of the water:
5. Be equipped with a waterproof switch; and

6. Meet the requirement of paragraphs (a) (1) through (4) of this section after floating for at least 72 hours followed by submersion in 5% by weight sodium chloride solution for at least 2 hours.

(B) The electric light may not be equipped with a switch mechanism which permits continuous display of a beam of light except that the light may be equipped with a switch which returns to the off position when pressure is released.

5 AIRCRAFT CONSTRAINTS

A. 90-degree Shutoff for user safety
B. Flight Time of 15mins
C. Flight ceiling at 500ft
D. Withstand windspeeds up to 30mph at sea level

6 ENGINEERING STANDARDS

This project fits under multiple engineering standards. The code 21840 is for ISO/IEC/IEEE International Standard - Systems and software engineering, this project involves integration of multiple systems which fall under the procedures described in the code. For instance, the project requires that the pre-programmed flight controller is constantly communicating with the ESCs and sending commands based on sensor feedback. This type of system is covered under the code 21840. Another engineering standard followed by our project is the IEEE 82079 IEEE/IEC International Standard for Preparation of information for use (instructions for use) of products. Since our project will be a product for consumers to use, it is required that this standard is followed for the conceptualization, creation, maintenance, translation, localization, integration of content, production, provision and evaluation, acquisition and supply of information for this project.

7 SYSTEM DESIGN

7.1 MOTOR SELECTION

Motor selection was an essential part of the project, as it would ensure that the quadcopter has enough thrust for a stable flight even in high wind conditions. As per the pre-determined specifications, the motors needed to withstand up to 30mph headwinds meanwhile lifting 1.2kg. Various motors from different drone motor manufacturers were researched, and the best motor for the purpose of this project was selected based on the simulated results. The aircraft specifications were first defined in the simulation. The simulation results were analyzed, and the results obtained for the RCtimer X4 motors proved that those motors were best fit for this project. Figure 2.1 shows that the hover time of the drone will be 16.5 minutes, with a Thrust-Weight ratio of 2.5, which is above expectation considering the high wind conditions the aircraft will be operating in. Additionally, RCtimer X4 motors had estimated best range to be between 24.9mph to 37.3mph (figure 2.2), which means that the motors not only fit the requirements but also will provide enough factor of safety. The motors were also tested at full throttle with load, and the results indicated that the motors will not overheat, nor will they fail with consistent use with these conditions as seen in figure 2.3. Thus, the RCtimer motors were finalized to be used for A.L.E.R.T.

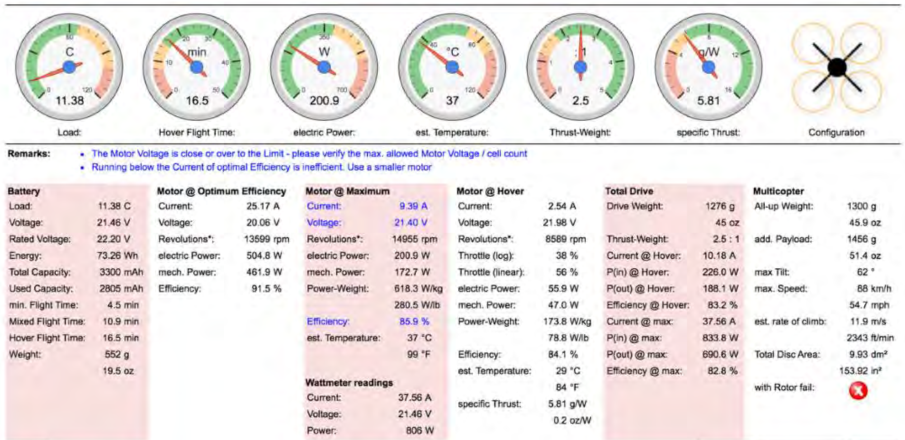


Figure 2.1: The results from the simulation for the RCtimer X4 motors with the drone specs

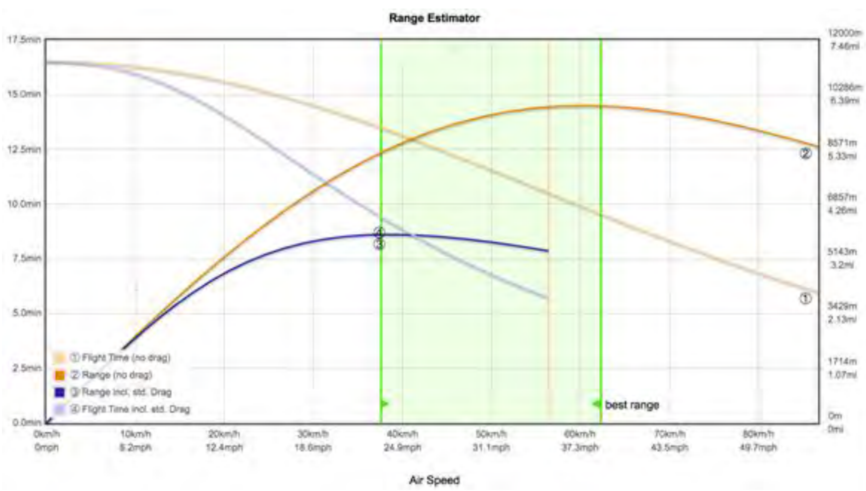


Figure 2.2: The best range estimates with the RCtimer X4 motors

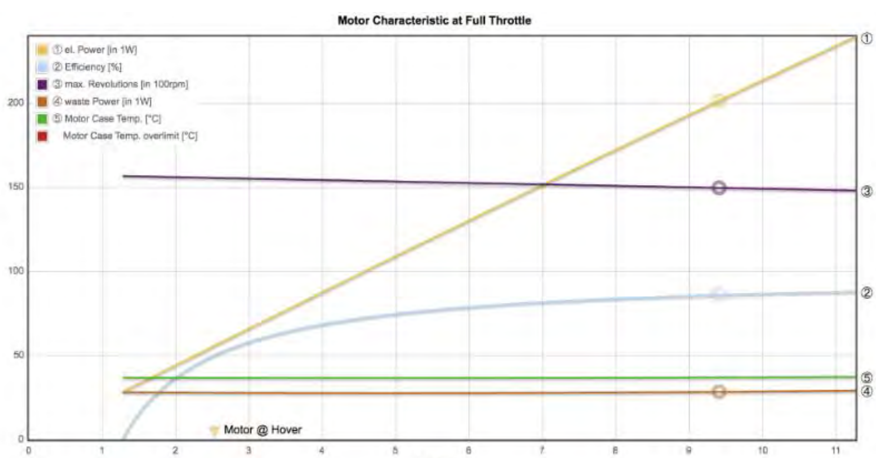


Figure 2.3: The response of the motor in simulation at full throttle with load of the system.

The simulation uses the following formulas to determine the efficiency of the motor:

The generated voltage of a motor and the rpm have a fixed ratio: the rpm constant K_v:

$$k_v = \frac{rpm}{V_i} \qquad (1)$$

The input power of a DC motor is the terminal voltage multiplied by the current:

$$P_{in} = V_{mot} I_{mot} \qquad (2)$$

The output power from a mechanical point of view is rotor torque multiplied by rotating speed (in radians per second):

$$P_{out} = M \frac{2\pi}{60} rpm \qquad (3)$$

The output power is calculated as input power minus the losses. V_{mot} is the voltage that can be measured at the motor terminals and I_{mot} is the motor current. However, not all the voltage counts for the output power, only the voltage generated in the rotor windings according to formula (1). A part of the voltage is lost at the inner resistance R_i when I_{mot} flows through it. Therefore, the voltage loss across the motor resistance R_i must be subtracted, which, according to Ohm's law $R_i * I_{mot}$ from the battery voltage is:

$$V_i = V_{mot} - R_i I_{mot} \qquad (4)$$

The motor torque caused by the idle current I_o is needed to compensate for the friction of the bearings and the alternator: there is no torque outside the motor from this part of the current, so it is subtracted from the battery current:

$$I_{eff} = I_{mot} - I_o \qquad (5)$$

The effective voltage is multiplied by the effective current to get the output power:

$$P_{out} = V_i I_{eff} = (V_{mot} - R_i I_{mot})(I_{mot} - I_o) \qquad (6)$$

The efficiency is the ratio between input and output power:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{(V_{mot} - R_i I_{mot})(I_{mot} - I_o)}{V_{mot} I_{mot}} \qquad (7)$$

This shows that the motor constantsR_i, I_o and k_v can be used to calculate all the values needed to determine motor efficiency.

7.2 SOS SIGNALING

As part of the United States Coast Guard requirements, a bright high-powered 100w LED was selected to act as the visual signaling device. The LED outputs 14000 lumens at a peak current of 10amp at 25v. The factory LED driver comes with standard 12v to 25v step up buck convertor. To reduce power loss during the step up, A.L.E.R.T. utilizes a custom LED circuit which operates at a 24.4v to 25V step up. Since the step up is significantly lower, the LED operation time is increased, and there is less power loss. The custom LED circuit includes a power amplifier transistor, which was chosen for its high current capabilities. The LED driver incorporates an Arduino Teensy for reliable operation as well as small form factor.

7.3 FRAME DESIGN

There are various types of drone frames that are being used today; however, the X configuration quadcopter frame, which is known for its stability and simplicity is commonly used for autonomous unmanned aircrafts. Thus, an X-configuration frame was selected for the purpose of this project. The frame consists of both 3D printed parts and CNC cut carbon fiber parts. The center plate is cut from 4mm carbon fiber plate and for the arms 12mm carbon fiber rods were utilized. To enclose the electronics, the top and bottom covers were custom designed on CAD software and 3D printed in PLA.

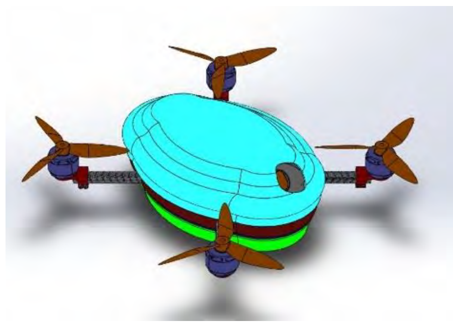


Figure 3.0: A.L.E.R.T. frame design

A static stress analysis was conducted on the bottom plate in a Computer Aided Design (CAD) software to determine its structural integrity and factor of safety under maximum loading conditions. The base plate is a CNC cut carbon fiber epoxy resin plate. A 3mm plate was chosen for its low-cost and availability. Factor of Safety (FS) refers to the actual load-bearing capacity of a structure. Thus, it is imperative that this plate is designed with factory safety that allows the whole system to survive, even in inclement weather. A very basic equation to calculate FS is to divide the maximum stress experienced on the part by the maximum allowable stress. The loading conditions were set to 49 newtons (from 5kg maximum thrust) on six mounting holes on the carbon fiber plate. Through the study conducted, it was determined that the factor of safety of the bottom plate is 15 with the maximum von mises stress reaching 1.6Mpa. This means that the bottom plate would be able to withstand 15 times heavier loading conditions than its requirements. This is a positive result, as the base plate can experience heavier loading conditions under high winds. The deformation of the bottom plate can be seen in figure 3.1, which shows that even under maximum loading stress the bottom plate would not fail.

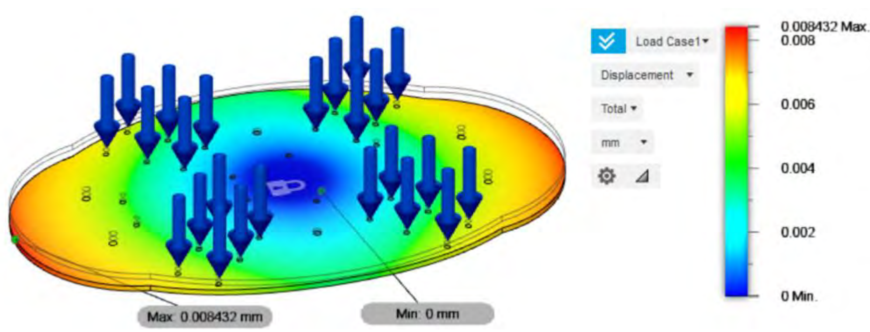


Figure 3.1: Stress analysis of bottom plate under maximum loading

7.4 RADIO TRANSMITTER

In order to increase the chances of rescue, A.L.E.R.T. incorporates a radio transmitter which relays the coordinates of the person in distress over an emergency band. The VHF guard frequency was chosen for its widespread listening devices. The VHF guard operates at 121.5 MHz, making it ideal for long range applications. A.L.E.R.T. utilizes the spread spectrum signal clock present on most single-board-computers (SBC) to reduce Electromagnetic Interference. The clock signal is used to generate a modulated signal with a 121.5 MHz frequency which outputs on a General-Purpose Input and Output (GPIO) pin available on the SBC. Since A.L.E.R.T. needs to broadcast the signal for a longer range, a radio frequency amplifier is used. The RF amplifier takes the signal from the SBC and transmits it at a power of 27dBm. To calculate the theoretical range of the transmitter, a Link Budget was used. The Link Budget incorporates multiple losses that would affect the transmission of the radio signal. The formula used is as follows:

$$P_{RX} = P_{TX} + G_{TX} - L_{FS} - L_M + G_{RX} \tag{8}$$

Where:
P_{RX} = Receiver Sensitivity, P_{TX} = Transmitter Power, G_{TX} = Antenna Gain [Transmitter], L_{FS} = Path Loss, L_M = Miscellaneous Loss, G_{RX} = Antenna Gain [Receiver]

The Path Loss when converted to MHz and miles is as follows:

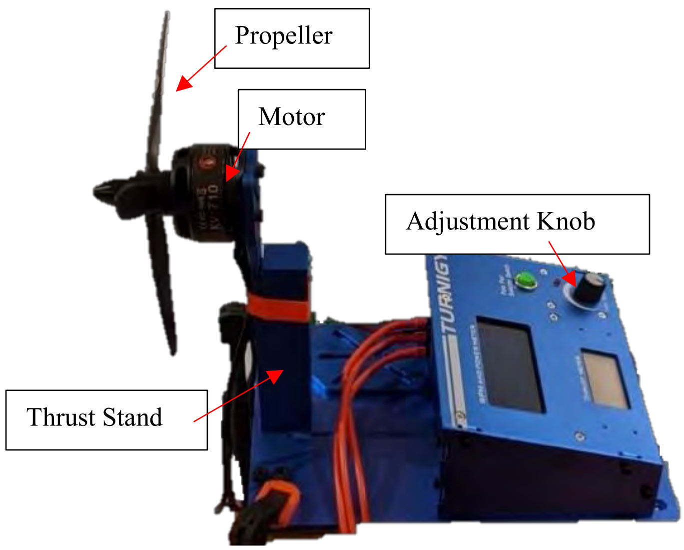
$$L_{FS} = 36.6dB + 20\log(f_{MHz}) + 20\log(range_{miles}) \tag{9}$$

The rf amplifier chosen was Texas Instrument TRF37D73EVM RF Amplifier development Kit. This kit was chosen for its low cost and its 27dBm transmitting power. Because the Link Budget incorporates the receiver as well, some assumptions must be made in calculating the theoretical range. The receiver sensitivity used was -103dBi based on popular Very High Frequency (VHF) Marine Radios receiver sensitivities from their manufacturer specification sheets. The receiver antenna gain was assumed to be 9dBi which is standard for 15' recreational boats. The theoretical range using the above parameters was 768 miles. This range is theoretical and will vary with the ships or receivers present in the geographical vicinity. The range could be significantly greater if the search and rescue radio station's receiver and antenna are considered.

8 SUB-SYSTEM TESTS

8.1 MOTOR TESTS

The motor test was conducted to ensure that the motor met the specs listed by the manufacturer, as well as to determine the thrust and current draw at varying throttle percentages. The motor and propeller combination were secured on the thrust stand as seen in figure 2.0, and the current, thrust, and the power reading were recorded (Table 1.0). The test was repeated 6 times at each voltage value, and the average was taken to obtain reliable data. This test clarified that even at full throttle the propellers will not over watt the motor or overheats the battery.



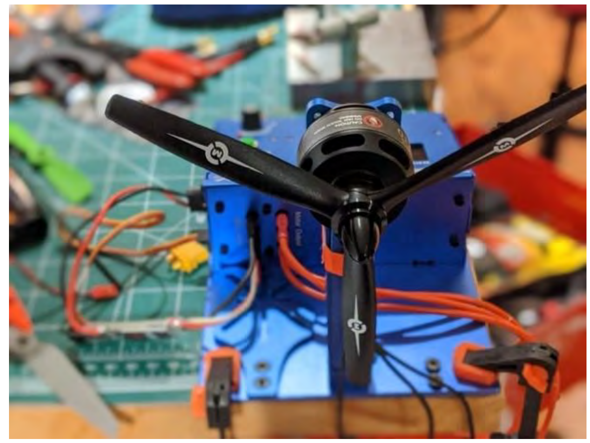


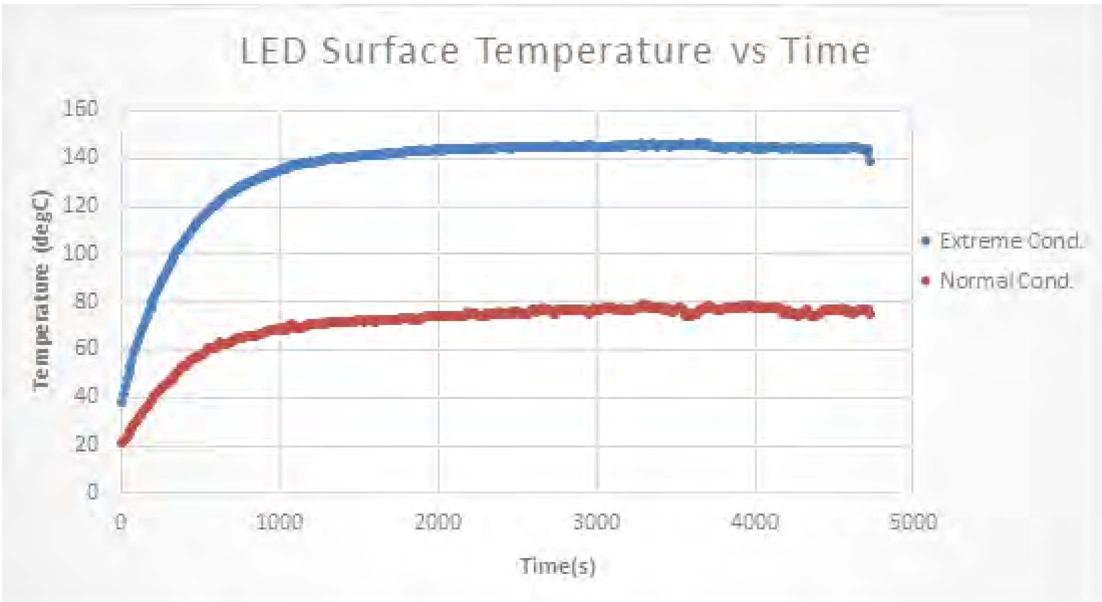
Figure 4.0 and 4.1: The figure above shows the set up for the Bench Test of the selected motor and propeller combination.

Table 1.0: Motor thrust and power characteristics from testing

Without Load			With Load				Props Size
Voltage (V)	Current(amp)	Speed (RPM)	Throttle %	Current (amp)	Thrust (g)	Power (W)	
24.2	0.5	9360	7	3	530	55	3 by 7*4
			14	8.4	721	100	
			21	11.3	1078	115	
			28	13.2	1407	120	
			35	14.4	1753	125	
			42	16.7	2422	135	
			49	17.6	2599	145	
			56	18.3	2726	150	
			63	19.8	2900	155	
			70	21.9	3803	160	
			77	22.4	3989	165	
			84	24.5	4359	170	
			91	25.0	4639	175	
			100	25.9	5000	176.4	

8.2 LED Test

This test was conducted to determine the steady state temperature of the LED under extreme and normal loads with a continuous operation (blink Morse code) using a 6s (24.4v) 3000mAh LiPo battery. The Arduino Nano was programmed to blink Morse code on the LED and to record the surface temperature. The battery that was powering the LED was also connected to the battery checker to ensure that it was charged sufficiently throughout the test, and a timer was set at the beginning of the test. Once the battery checker indicated that the battery had reached its discharge capacity, the timer was stopped, and the total test time was recorded. The temperature data obtained was used to make the Temperature vs Time graph, and the best fit curve was used to determine the steady state temperature. It was determined that the steady state temperature was 140ºC under extreme load, while it was 74ºC for normal load. The duration of continuous operation with a 6s 3000mAh was approximately 1 hour and 30 minutes. (See graph 2.0)



Graph 2.0: Surface Temperature of LED recorded over time under Extreme and Normal conditions

A COMSOL analysis was also conducted on the top cover to estimate the temperature distribution inside the shell of the drone. A Time Dependent study was run in the Heat Transfer in Solids and Fluids Module. The model was built with the material properties of Polylactic Acid (PLA) as the shell material. The LED was modelled as attached to a slim aluminum block for the smallest footprint. The Model included air as the material in as well as outside the shell. The aluminum was set at the temperature of 140 °C to model the extreme temperature from the LED stress test. As seen in Figure 5.0, the inside ambient temperature reaches only 40 °C. A small fan was added in the top shell to aid in some temperature regulation with external air flow.

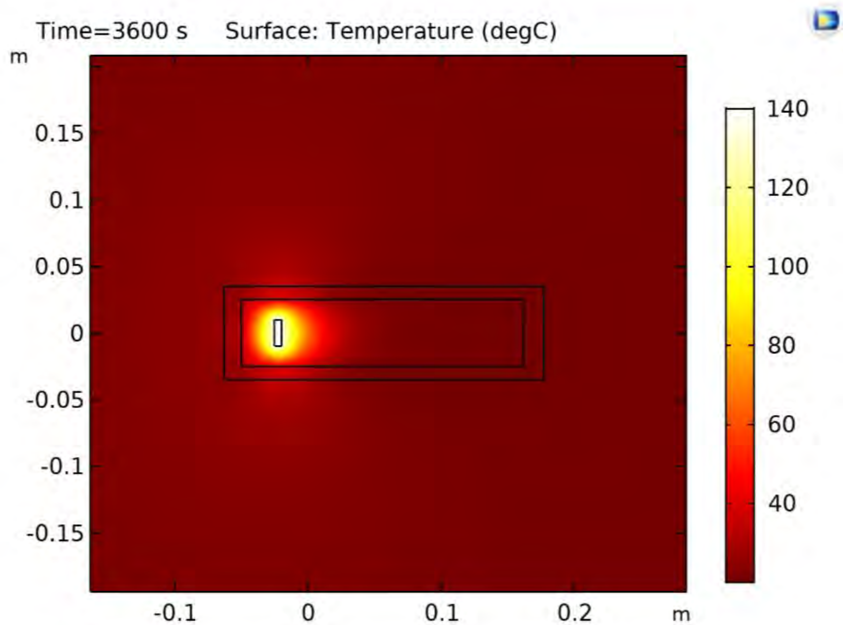


Figure 5.0: Surface Temperature at Extreme Conditions [140 °C] from COMSOL

9 SOFTWARE DEVELOPMENT

A.L.E.R.T. incorporates several different computing levels which need to be addressed seprately. Since the aircraft will be flying precise waypoints in possible high-wind senarios, a methodology was developed to determine the flyable conditions without any active sensor data from the environment. The methodology includes checking if the aircraft can hold its position over the person in distress, by comparing the target GPS position to its current GPS position. If in a situation where high winds do not allow the aircraft to hold the position at that elevation, the aircraft will descend 5m and repeat the process until a satisfactory elevation is reached above sea level.

As seen in figure 3.0, after the drone either ascends to 150m or a suitable altitude, it decends to 5m above sea level and checks for battery. This aids in better visual distress signal of the SOS LED, as the drone oscillates above the person in distress. The process repeats if the battery is not at a critical level.

Since the United States Coast Gaurd requires that the LED be operated from a stand alone sequence, the LED operation is independent of the drone operation and will be carried out until the battery is depleted. Additionally, the Radio distress call also operates independently of the drone battery and will transmit the distress call inconjuction with the SOS visual signal.

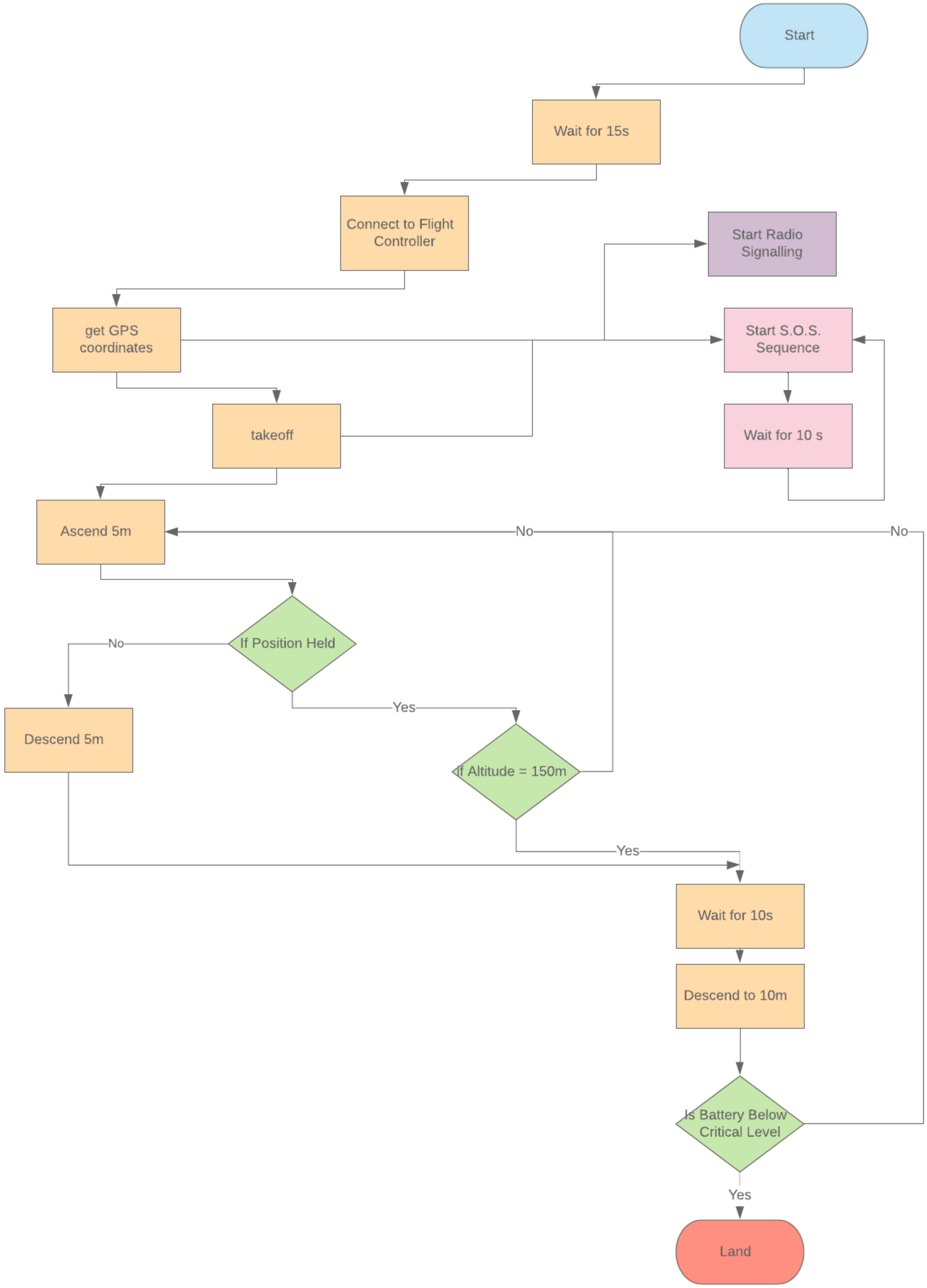


Figure 6.0: Logic Flow Chart of the System

10 Emergency Motor Shutoff

When designing the A.L.E.R.T. system, the safety of the user was significantly taken into account. The aircraft utilizes a dedicated inertial measurement unit (IMU) to constantly check the pitch angle of the drone. The IMU directly communicates with the onboard computer which sends commands to the flight controller. This Emergency motor shutoff is activated when the IMU reads that the aircraft is tilted 90 degrees, and based on this reading the onboard computer sends a command to the flight controller to shutoff all the motors immetiately. Additionally, to ensure that the motors don't shutoff during flight, this emergency mode is only active when the drone is below an elevation of 15ft. Having this mode allows the user to grab the drone using the bottom cover and to tilt it 90 degrees, immediately shutting off all the motors, in case of an emergency.

11 Impacts

11.1 Environmental

A.L.E.R.T. has been designed to minimize the impacts of the emergency signaling devices on the environment. Since pyrotechnic flares have a negative impact on the environment, the electric S.O.S. signaling is used as a direct alternative. Flares pose environmental risks which include polluting water when disposed of incorrectly. Thus, A.L.E.R.T. provides a safer alternative to pyrotechnic flares.

11.2 Economical

A.L.E.R.T. incorporates several different technologies onboard. As per USCG requirements, each vessel must carry different devices, which signal distress in day and night. Since A.L.E.R.T. incorporates LED distress signaling and the radio beacon, A.L.E.R.T. qualifies as a single device for both day and night operation. This will result in reduced costs for a distress signaling device. Additionally, not having to replace flares every three years also contributes to lower operational costs.

11.3 Social

Since A.L.E.R.T. incorporates triple-tier S.O.S. signaling, emergency aid will arrive faster and in a reliable manner. This device will significantly increase the likelihood that the person in distress will be rescued, as it utilizes not only visual aid but also radio and satellite. This means that the rescuers will be able to provide aid faster, as A.L.E.R.T. will transmit, on the emergency band, the exact GPS location of the person in distress. Therefore, A.L.E.R.T. provides a technologically superior distress-signaling device.

12 Conclusion

The drone industry has been on the rise in recent years. A complete drone solution with redundant systems for emergency protocols has not yet been developed. This project focused on developing a solution which considers strict coast guard requirements and different emergency techniques. A.L.E.R.T. has multiple functionalities, as it is a triple-tier SOS signaling device while being cost efficient, which makes it a competitive product in the market. Additionally, for further ease in emergency signaling, A.L.E.R.T. can be developed to have a personal ground station. Thus, A.L.E.R.T. is a novel solution to emergency distress signaling.

13 ACKNOWLEDGEMENTS

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Authorization and Disclaimer

Autonomous Medicine Dispenser

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ABSTRACT

The goal of this project is to create an autonomous system that will dispense pills of various sizes and shapes. The overall objective is to use the invention to assist in dispersing the appropriate amount of medication for patients at designated times. It is imperative to take the proper amount of medicine at the specific times prescribed. In today's fast-paced world, it is easy to forget to keep track of simple tasks, such as taking medications when needed for treatment of specific conditions. As people grow older, the ability to recall every day's tasks begins to deteriorate. The autonomous pharmaceutical dispenser is a mechanism that employs an x, y, and z axis movement to maneuver a suction unit in order to transport pills from a capsule to a delivery location. The dispenser stores a month's supply of tablets with the capability of dispensing up to twelve different types of medicines. The system comes with a wireless gadget that receives notifications from the distributor, alerting the patient to take his or her medication. In the event the user forgets to take this medication, the portable device receives a message. Moreover, an excel spreadsheet will record a detailed summary of the administered medicine. The objective is to create a cost-effective and reliable alternative product for patients to use for their medical needs.

1. Introduction

The need exists for an automated pill dispenser for those individuals who forget to consume necessary medications. There are also unwanted consequences when patients forget their medication doses. Because of failure to comply with prescribed treatment, over 100,000 people are estimated to die each year in the United States [1]. There are alternative solutions that assist patients in remembering to take their medication. For example, there are downloadable apps to help people to take their prescribed medication. On the other hand, there are unnecessary hospital admissions for about half of patients who do not take medications as prescribed, which costs the

U.S. healthcare system an estimated $290 billion a year [2]. As a result, doctors recognize the efficacy of high-tech approaches, such as smartphone apps, to send the patient reminders to take medication at the designated time. The use of new and convenient technological options are appealing; however, there is still a lack of supporting data to inform health provider decisions regarding the use of these devices. Technical applications may help resolve the problem but do not quite fulfill a person's required needs.

Pill-dispensing systems suit a wide range of patients; however, several studies have reported less than optimal results with these methods [3]. Many different systems are more efficient than previous models, but they have not yet reached the objective. Many of these devices are problematic due to their unreliability [4]. Consequently, improving the efficiency of the apparatus and offering an advanced product to society is the idea behind the innovation of a medical dispenser. The autonomous medical dispenser system presents a more reliable and trustworthy product. Building on the previous PharmAid design, the team intends to improve the distribution mechanism, the compactness of the product, and the removal of impractical components. After careful analysis, the team has a distinct approach towards enhancement of the prototype's performance.

2. Social Impact

Helping the elderly stay on track of their medication improves their overall quality of life. Through use of this device, there should be a reduction in the need for people to go to the hospital due to worsening conditions cause by neglect to attend their checkups or take their prescription medications. Between 33% to 69% of medication-related hospital admissions are related to failure to adhere to prescribed medication regimens [5]. It is estimated that about 125,000 deaths per year occur due to people not taking their medicine in the United States [5]. This device should lessen these unnecessary deaths by facilitating the patient's prescription regimen.

3. Environmental Impact

The automatic medicine dispenser uses a variety of 3-D printed parts. The material that was used for the 3-D parts is called polylactic acid, commonly known as PLA. PLA is a type of plastic made from fermented plant starch, usually from corn. The advantage PLA poses over many other materials is the fact that it is biodegradable, which means that PLA can decompose with biological elements. PLA provides the same utility and sanitation as some plastics do, while giving way to dispose of the material properly [18]. PLA burns less greenhouse gas for production, because it comes from a renewable carbon absorbing plant [18]. In 2018 more than half of the production of PLA filament was from recyclable resources. The use of PLA contributes to a reduction of non-environmentally friendly plastic products, a decrease of plastic in landfills, and this substance burns less energy to produce new polymers [8].

4. Economic Impact

Similar products include: the MedaCube, Automatic Pill Dispenser, and Livi Smart Home Medication Dispenser. Although these pill dispensers offer a game-changing solution they come at a hefty price. The economical comparison can be seen below. For this project

(PharmAid) a total of $574.17 was spent and it can be sold for $999. As shown below, there are similar products on the market, at a more expensive cost.

Table 1. Economical Comparison

	PharmAid	*Hero*	*MedaCube*	*Philips Lifeline Medication Dispenser*
Cost	$999 or Lease $74.99 per month + $99.00 Initial fee	$29.99 per month $99.99 Initial fee	Upfront of $1499 or rent for $99 per month	$ 59.95 per month + $99.00 installation
Medication Storage	10 Medications (20 to 90 pills each)	10 Medications (20 to 90 pills)	10 Medications (20 to 90 pills)	N/A 60 cups Approx. 10 pills/cup
Security System	Fingerprint + Passcode + Key	Passcode + Key	Passcode + key	-
Notifications	Phone + On screen + Sound + Lights + Buzzer + Wearable Gadget	Lights + Sound + Phone	Phone	Lights + Sound

5. Methodology

5.1.Focus

This innovation aims to make medicine dispensing as autonomous as possible. For this research, several analyses using an X-Y-Z mechanism proved to be an improvement in the automated medicine dispenser. Besides, different components such as a 24 V vacuum compressor and a humidity sensor were determined to improve the system. The idea behind these analyses is to strengthen the concept of the autonomous medicine dispenser by making it quicker and more productive.

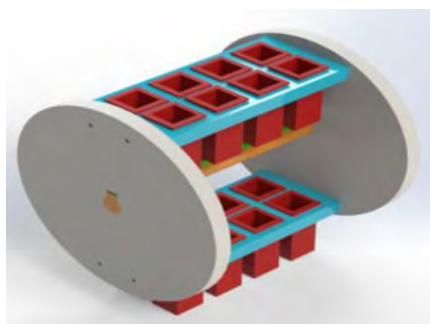

Figure 1: Cartridge Distributor or Product A

5.2.Mechanism & Programing

The project uses an X-Y-Z system similar to a 3D printer. The vacuum nozzle moves on the x-y axis using two motors. The motors are connected and collaborating using shafts and GT2 pulleys to run vacuum tubing to intended locations. Limit switches control the x-y axis to operate within the frame of the design. The switches prevent the motors from putting force on the frame. Also, a tray holds cartridges filled with medicine and connects to a lead screw. The plate moves up and down on the z-axis using a coupled motor. The mechanism uses a vacuum pump with an end tube nozzle in order to grasp one pill at a time, regardless of the size or shape of the given set of tablets. The cartridge holding mechanism shown in Fig. 1 is made to be efficient; however, a x, y, and z motion allows the machine to improve the fast response of the unit, while being practical at the same time. [8] The central unit works with a two-dimensional motion to control the suction system. Meanwhile, the code follows the concept of an algorithm, as do most CNC machines or 3D printers.

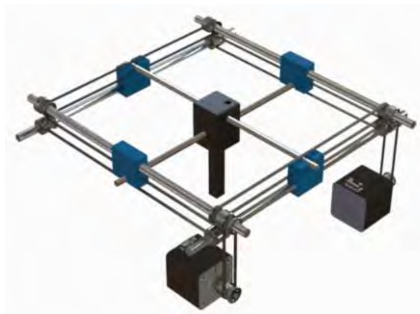

Figure 2: X-Y Axis Movement Mechanism

The z axis mechanism lifts the tray that holds the cartridges, aligning them to the right position of the suction system. As seen in Fig. 3, the stepper motor links to the lead screw, using a coupler, raising and lowering the plate.

Figure 3: Z Axis Movement Mechanism

5.3. Bresenham's Line Algorithm

Bresenham's Line Algorithm follows basic arithmetic concepts, where the slope of the line is unknown. Equation (1) provides the formulation to find the slope of the line. In this formula, "m" represents the slope, $(x_2,\ y_1)$ is the coordinate of the first point of the line, and $(x_2,\ y_2)$ is the coordinate of the second point of the line. The two coordinates can be represented by dx and dy.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \equiv \frac{dy}{dx}. \quad (1)$$

The points where the suction tube is going to pass is measured. Sometimes, the system passes through two different locations at the same time; then, the device has to choose one of the points to go. Bresenham's algorithm calculates the distance from the intersection points and selects the smaller one. The equation of the line (2) represented by 'y' (a point in the y-axis), 'x' (a point in the x-axis), 'm' (the slope of the line), and 'b' (y-intercept of the line).

$$y = mx + b. \quad (2)$$

The position coordinate provides a visual representation of Bresenham's line Algorithm. Through calculations, the slope of the line is determined. If the slope of the line is less than one, then 'x' will always be incremented. The first distance (3) between intersection point 'y' to the position 'y_k' is calculated. The second distance (4) with the upper section 'y_{k+1}' and intersection point 'y' is calculated.

$$d_1 = y - y_k. \tag{3}$$

$$d_2 = y_{k+1} - y. \tag{4}$$

Since x is always incrementing, the variable can be expressed as '$x_k + 1$' and 'y_{k+1}' as '$y_k + 1$'. The first and second distance subtraction (5) applying the slope of the line (2) provides the general expression.

$$d_1 - d_2 = 2\left(\frac{dy}{dx}\right) * (x_k + 1) - 2x_k + 2b - 1. \tag{5}$$

The distance difference (5) is multiply by 'dx' in both sides to obtain decision parameter (6) 'P_k' and the constant value (7) 'b'. The decision parameter and the constant value contributes with a smoother expression (8).

$$P_k = dx(d_1 - d_2). \tag{6}$$

$$b = 2dy + 2dx(b) - dx. \tag{7}$$

$$P_k = 2dy(x_k) - 2dx(y_k) + b. \tag{8}$$

The next parameter is the decision parameter upper level applying 'P_{k+1}' to the lower lever decision parameter (8). Combining the two expressions the change in decision parameter (9) is found.

$$P_{k+1} = P_k + 2dy - 2dx(y_{k+1} - y_k). \tag{9}$$

The following boundary conditions are considered:

- $P_k < 0 \therefore y_{k+1} = y_k$
  $$P_{k+1} = P_k + 2dy. \tag{10}$$
- $P_k > 0 \therefore y_{k+1} = y_k + 1$
  $$P_{k+1} = P_k + 2dy - 2dx. \tag{11}$$

For the initial decision parameter (12), the decision parameter (8) and the equation of the line (2) are being used.

$$P_o = 2dy - dx. \tag{12}$$

Equation (12) initial decision parameter is used when $m < 1$. On the other hand, if $m > 1$, the initial parameter (13) is going to change. The derivations shown above are the same, with the only exception of the slope of the line (1).

$$P_o = 2dx - dy. \tag{13}$$

5.4. Wearable Gadget

To ease life for users, a wearable gadget presents a solution for those in need to remember when to take their medication, even when they are away from the machine. Using an ESP32 module, the team was able to create a master and slave relationship from the main unit to the wearable gadget. The portable device allows the patient to be reminded at any given time, when around

1574 ft away from the main housing. The main unit (master) send signals to the portable device (slave) when it is time to take the pills.

Table 2: ESP32 Properties

Feature	ESP32-PICO-KIT
Timescale (Physical, interpretation delay)	0.1 ~ 1 s
Storage	520 KB SRAM
Interfaces/ resolution	12-bit ADC (0-1.1 V), 8-bit DAC (0-3.3 V), UART TTL (serial)
Network	WLAN/Bluetooth
Time Lagging	RTC (internal real time clock) +NTP (network time protocol)
Software	Arduino IDE
Power	5 Vdc, 3.3 Vdc

5.5. Electrical Engineering

The three stepper motors that guide the X-Y-Z axis are connected to a shield; the shield is connected an Arduino Mega, as shown below. In addition, five limit switches are connected to a shield to control the axes; these limit switches control the axes to send signals to the Arduino. On the other hand, an RA8875 driver is used to connect the LCD to the Arduino Mega. A distance sensor, temperature & humidity sensors, ESP32 (Master), and a pressure sensor are connected to the Arduino Mega as shown below. Also, the ESP32 (Slave) schematics are shown below. A vibrating motor, LED, buzzer, one-hundred-ohm resistor, and a coin cell are connected to the ESP32 (Slave).

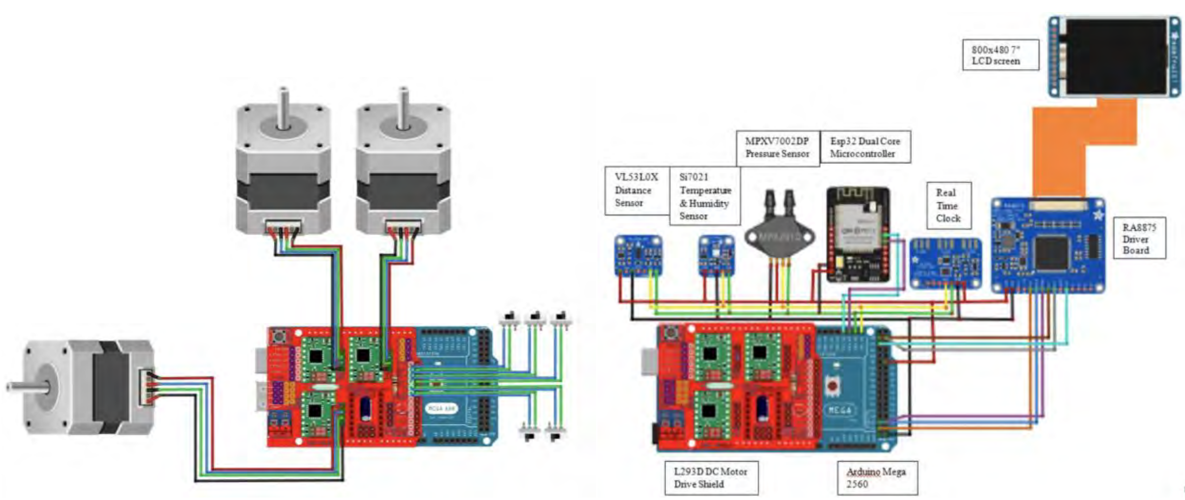

Figure 4: Main Housing Schematics

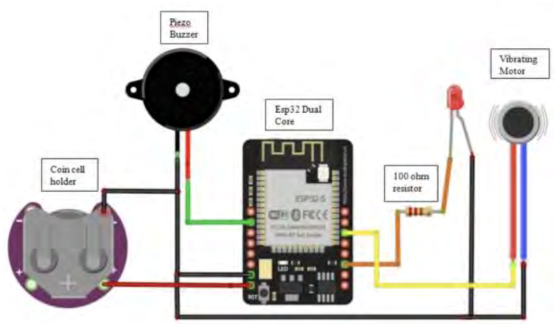

Figure 5: ESP32 Schematic

5.6. Safety Standard

The American Society of Health-System Pharmacist (ASHP) has regulations that the project followed. The most relevant standard is safety; therefore, a passcode grants the user access for the medicine. Besides, a key-locking door, as shown in Fig. 6, allows the patient to refill the cartridges [11]. Additional committees such as the American National Standards Institute (ANSI) demand close regulation of pharmaceutical concepts.

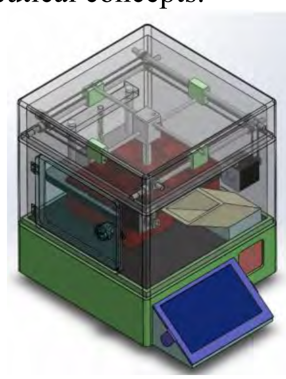

Figure 6: Product B - Main Housing & Locking Mechanism

6. Analysis & Results

6.2 FEA Simulation Results

Many elderly take different medicines daily. Keeping a record of the time, drug, and dosages can become a challenge for senior citizens. Throughout the research, the group identified the top nine medications most commonly used by the elderly, as shown below. Also, each medication weight provided an idea of the maximum weight being applied to the mechanism. As shown in Fig. 7, hydrocodone and metformin are the heaviest medications most commonly used, and levothyroxine is the lightest. The investigation takes into consideration the weights of common pills to calculate the suction force needed to pick up each pill and prevent failure. For this analysis, a factor of safety of 2 is utilized due to the properties of the medicine. A friction coefficient of 0.6 is used due to the rough surface of the medicine. For this case, the suction cup and the direction of the force are horizontal knowing that the acceleration of the Z-axis is $\frac{0.4\text{m}}{\text{s}^2}$. Considering the motion of the system and the known properties of the medicine, equations 14 and 15 are applied.

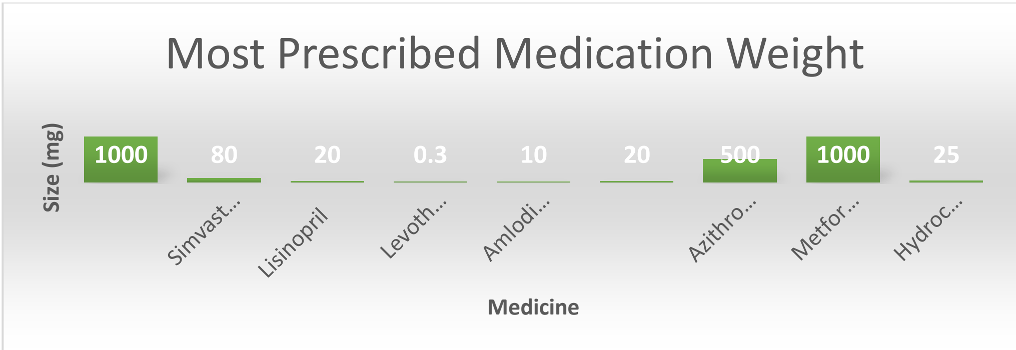

Figure 7: Medicine Weight Distribution

$$F_{TH} = m\left(g + \frac{a}{\mu}\right)S. \quad (14)$$

Where:
F_{TH}: Theoretical Holding Force [N]
m: Weight in [Kg]
g: Gravity $[m/s^2]$
a: Acceleration $[m/s^2]$
μ: Friction Coefficient
S: Factor of Safety

$$F_S = \frac{F_{TH}}{n}. \quad (15)$$

Where:
F_{TH}: Theoretical Holding Force [N]
F_S: Suction Force [N]
n: Number of Suction Pills

The suction force considers 30 pills per cartridge. The theoretical force and suction force results of each medicine can be seen in table 4.

Table 3. Suction Force Apply on Medicine

Medicine	Weight (kg)	Theoretical Force (N)	Suction Force (N)
Hydrocodone	0.001	0.019753333	0.000658444
Simvastatin	0.00008	0.001580267	5.26756E-05
Lisinopril	0.00002	0.000395067	1.31689E-05
Levothyroxine	0.0000003	0.000005926	1.97533E-07
Amlodipine	0.00001	0.000197533	6.58444E-06
Omeprazole	0.00002	0.000395067	1.31689E-05
Azithromycin	0.0005	0.009876667	0.000329222
Metformin	0.001	0.019753333	0.000658444
Hydrochlorothiazide	0.000025	0.000493833	1.64611E-05

The following analytical models represent the pill-holding plate, which is driven by the Z-Axis mechanism, experiencing the maximum load it may undergo from the heaviest pills (1000mg) filling all twelve cartridges. After physically testing with sample pills and a printed cartridge, it was found that roughly 30 of these 1000mg pills would fill each cartridge completely. In order to do any simulated work on this plate, the maximum load was first calculated. Since the plate is given the correct material (PLA) in the simulation, with the corresponding material properties (shown in Fig. 15), the load from the weight of the plate is accounted for. Using a software called Cura, which is a tool used to create 3D printed models, the exact mass of each pill cartridge (47 grams) was found using the correct PLA plastic material. The maximum load from the twelve pill cartridges filled with thirty 1000mg pills was found to be 9.064N. The total load was applied to the edges of each pill cartridge, as shown in purple in Figure 8. The stress, strain, and displacement simulation for this loading case was completed using SolidWorks and is shown in Figures 8-10.

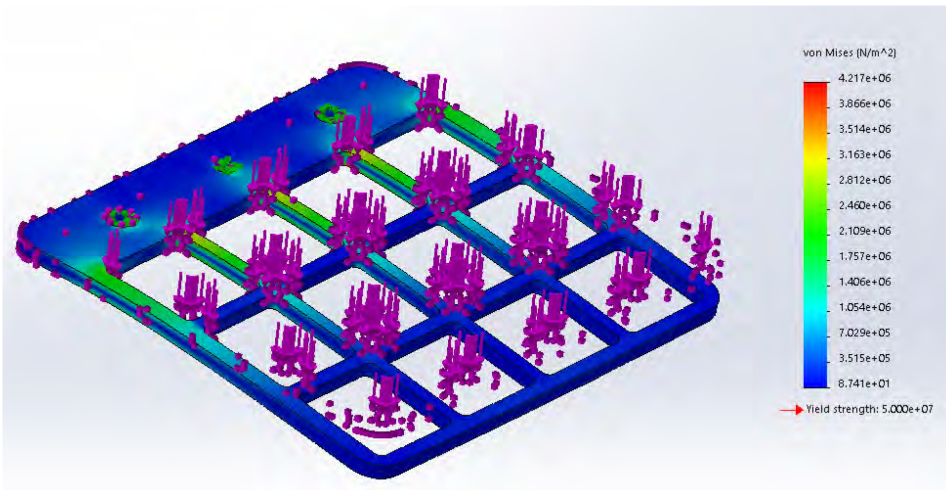

Figure 8: Stress Simulation

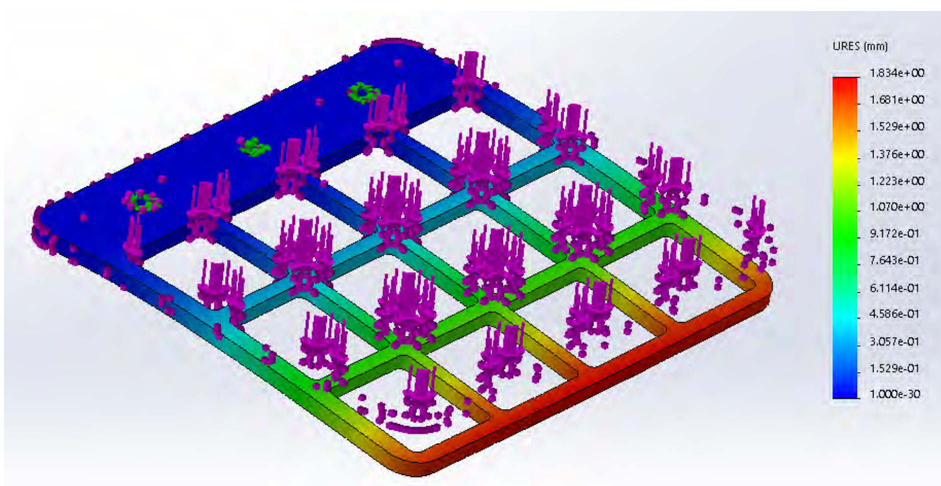

Figure 9: Strain Simulation

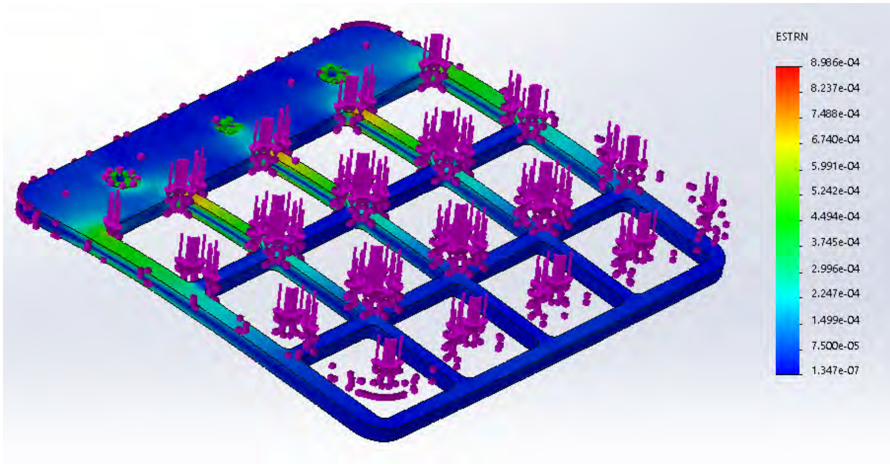

Figure 10: Displacement (Deformation) Simulation

The factor of safety of the plate is calculated using equation 16 with the simulated values. These simulations represent the maximum load that the pill holding tray may experience using the heaviest common pill (1000mg) to fill up each cartridge (30 pills). This tray has a thickness of 0.25inches and has a factor of safety of **11.9**, in comparison to the previous version which was 0.5 inches thick and had a factor of safety of **52** in a 3-D analysis.

$$F.S. = \frac{\sigma_M}{\sigma_W}. \tag{16}$$

Where:
$F.S$: Factor of Safety
σ_M: Material Ultimate Strength [Pa]
σ_W: Working Stress (Applied Stress) [Pa]

$$F.S = \frac{50\ MPa}{4.2\ MPa} = 11.9$$

A high factor of safety is wanted for this part, in case of any added accidental weight when refilling the cartridges. Although the previous model had a higher factor of safety, it was deemed unnecessary, which lead to the change in thickness. Modelling the plate as a 2D cantilevered beam, a shear-moment diagram was created from a free-body-diagram of the loading case. Here, the maximum load from the pills and cartridges and the load from the weight of the tray was needed, as well as the centroids of both forces. The fixed support was created at the center of the guide rail holes on the plate. The load from the weight of the plate was calculated to be roughly 1.628N using Cura to find the mass (166grams). The centroids of the loads were found using the section properties tool in SolidWorks.

6.3 Analytical Stress and Factor of Safety Analysis

In this section, analytical approach has been implemented to calculate applied load on each panel of the plate, modeling and identifying a panel that carries maximum load, conducting stress analysis, and finally obtaining factor of safety of the plate against ultimate material strength.
Figure 11 shows free body diagram of load distribution through the plate structure that is produced from the twelve pill cartridges filled with thirty 1000mg pills and weight of the plate.

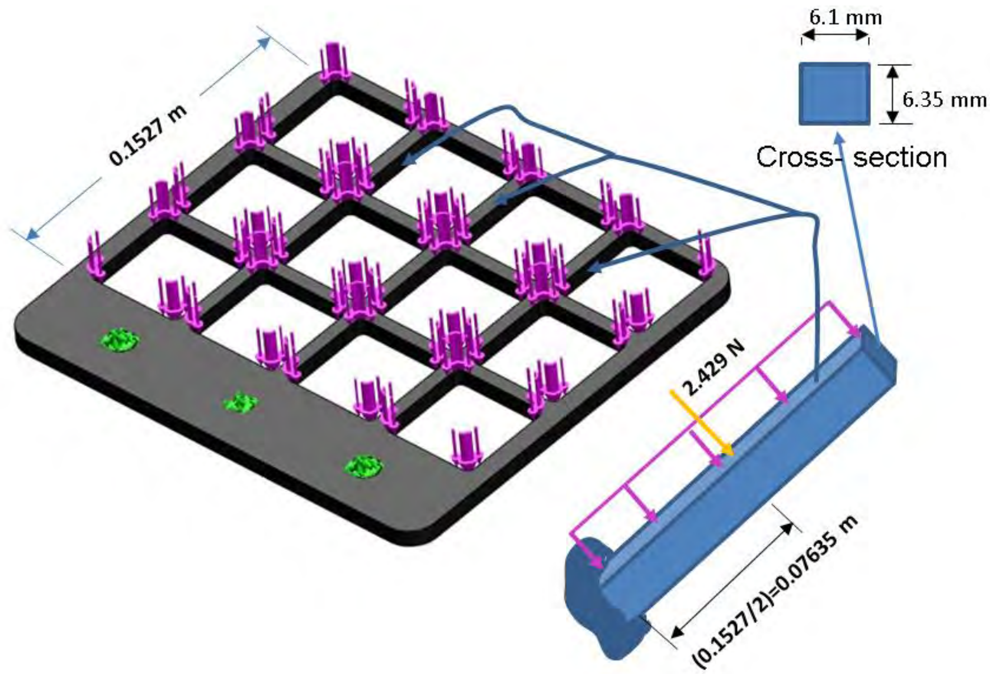

Figure11: Load Distribution Free Body Diagram

Total load from the twelve pill cartridges, $P_T = 9.064\ N$

Load carried by two neighboring beam panel = $\frac{3(9.064)}{12} = 2.266\ N$

Load carried by each exterior beam panel = $1.133\ N$

Load carried by each middle beam panel = $2 * 1.133 = 2.266\ N$

Calculations above show that the middle beam carries the maximum load and hence maximum stress.

The load from the weight of the plate is 1.628N and by using the beam panel volume (0.1527*0.00635*0.0061 m^3) to the total volume, the weight for each beam panel is calculated as 0.163 N. Hence, the total load (TL), as a result of both the twelve pill cartridges filled with thirty 1000mg pills plus weight of teach beam panel, for each middle beam panel can be calculated as

$$TL = 2.266 + 0.163 = 2.429\ N$$

Figure 12, shows the load distribution through each middle panel that carries a maximum total load of 2.429 N. The maximum bending stress as a result of total load has been calculated based on the support cross section dimensions of the panel and factor of safety has been obtained against ultimate material strength.

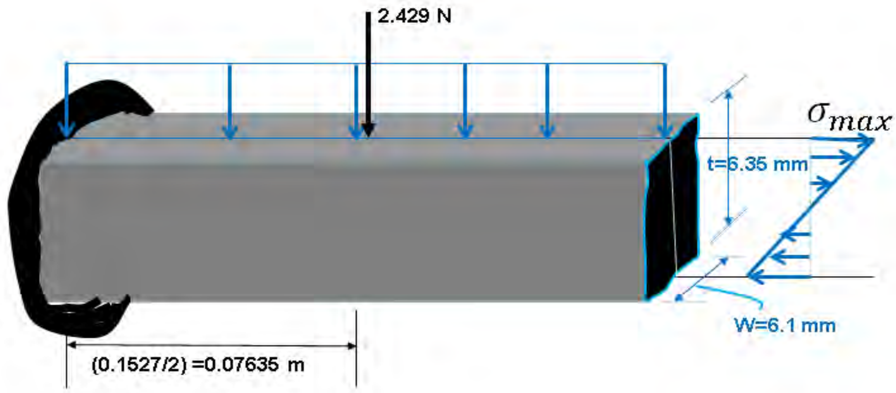

Figure12. Forces Acting on the Structure

$$C = \frac{6.35}{2} = 3.175\ mm \tag{17}$$

$$I = \frac{1}{12}(0.0061 * 0.00635^3) = 1.302 \times 10^{-10}\ m^4 \tag{18}$$

$$M_{max} = 2.429(0.07635) = 0.18545\ N - m \tag{19}$$

$$\sigma_{max} = \frac{M_{max} * C}{I} = \frac{0.18545 * 0.003175}{1.302 \times 10^{-10}} = 4.5 \times 10^6 \frac{N}{m^2} = 4.5MPa \tag{20}$$

$$F.S = \frac{\sigma_{Ultimate}}{\sigma_{(\max)\ applied}} = \frac{50 \times 10^6}{4.5 \times 10^6} = 11.12 \tag{21}$$

$$\%\ error = \frac{\sigma_{\max Analytical} - \sigma_{\max Simulated}}{\sigma_{\max Analytical}} = \frac{4.5 - 4.2}{4.5} * 100\% = 6.66\% \tag{22}$$

Through SolidWorks FEA simulation, a maximum stress value of 4.2 MPa was found from the loading conditions, while the analytical maximum stress was found to be 4.5 MPa. Above calculations demonstrate that the maximum stress results lay within a reliable range (within a 6.6% variation) in comparison to FEA analysis. In addition, the same can be said for the factor of safety evaluation using both SolidWorks' FEA and the analytical approach.

7. Discussion

Preliminary trials of the two medicine dispenser designs were conducted comparing the behavior of the devices. The test done on the mechanisms shows that both machines A (PharmAid) and B (New model) are accurate and reliable. Through some modifications to the previous prototype, the team improved the dispensing time by altering the mechanism and the cartridge holder. The distributor for product A (Fig. 1) rotates about a principal axis using a stepper motor. The cartridges have a flat shape on the bottom. However, device B implements a narrow end on the cartridges, facilitating the suction system to obtain a pill more efficiently. Also, product B uses the X-Y-Z system for a faster response. The two apparatuses were under analysis to confirm that by making such modifications, the device would conduct its task more efficiently. Throughout these implementations, the team plans to create a quicker response while remaining efficient. A graph comparing time against the number of pills dispensed (Fig. 13.) shows that product B has a faster response in dispensing medicine. The plot indicates that the time difference to administer one medication noticeably improved by a few seconds. The decision of changing the distribution mechanism, and the shape of the cartridge holder was correct. Product B shows a reduction in time of up to 21.34% compared to product A. Prototype A takes about six minutes and forty-three seconds to dispense twelve pills. On the other hand, product B takes about five minutes and one second to dispense twelve medicines. This product is intended to help people who require from eight to twelve different medications a day. The results prove that administering only one pill would not increase drastically; however, improving the time to dispense different medicines at once is a relevant development. Taking into consideration the new mechanism and the modification of the cartridges, one can agree that the results satisfy people's needs. Perhaps the rotation distributor took a few seconds longer to align the suction system with the cartridges, making the system slower in operation.

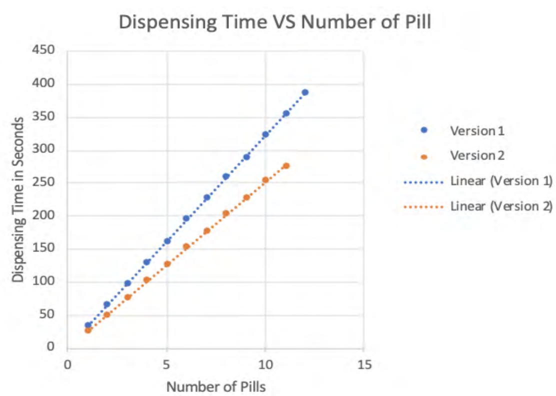

Figure 13. Time Response of Product A and B

Moreover, PharmAid deals with electronic components that create heat throughout the machine. Medicine is a delicate subject to work with as heat can melt pills or capsules, leading to severe consequences. Implementation of fans is necessary for prototype B to prevent complications. A comparison diagram (Fig. 14.) provides temperature disclosure of the two different models. Prototype A has a room temperature while in sleeping mode; however, the dispensing mode can bring the temperature up to 86 Fahrenheit, which can be more than enough to melt a medicine. On the other hand, Prototype B has fans, and a humidity sensor that controls the heat and detects the change that can alter electrical currents and temperature in the air. As shown in Fig. 6, product B reduces the dispensing mode temperature up to 10.47%, creating a working environment for the average medicine.

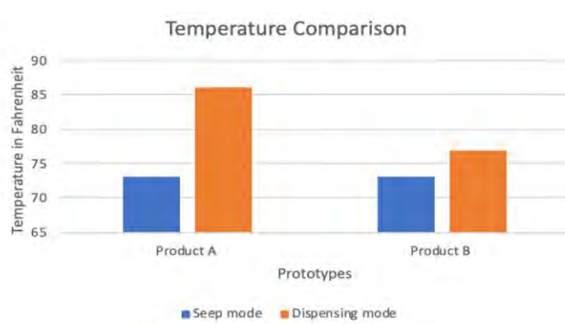

Figure 14. Temperature Comparison

8. Conclusion

Throughout the analysis and the research done on PharmAid, the group agrees that the autonomous medicine dispenser is convenient and reliable. However, the team evaluated statistics on the product that show that the unit can be improved. Under the analysis, the temperature sensor, humidity sensor, vacuum compressor, ESP32, and the X-Y-Z distributor were improved in the project. The two different prototypes were compared to demonstrate better results for the convenience of the user. In conclusion, the results satisfy the project goals. On the other hand, better applications can be added to increase patient benefit.

9. Acknowledgement

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11. Authorization & Disclaimer

Authors authorize Vaughn College to publish the paper in the Vaughn College Journal of Engineering and Technology. The Authors are responsible for both the content and the implications of what is expressed in the paper.

Search and Rescue Rover Delivery System for Multirotor Drones

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ABSTRACT

The purpose of technology is to provide convenient and efficient ways to assist humans in daily life. With the invention of unmanned vehicles and systems, a door to further innovation has been opened. Locations that were once impossible to reach can now be navigated with the help of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs). These vehicles provide endless assistance where man cannot. There are multiple ways these systems can aid in daily life. Among the most impactful uses are search and rescue operations.

The application of both UAVs and UGVs working in tandem to perform search and rescue operations has yet to be fully developed. Search and rescue (SAR) is a field that is always looking for improvements. With the introduction of UAVs, SAR missions to remote locations, where humans have minimal access, have become possible. Certain situations require immediate aid until further help can reach the destination. In these cases, unmanned systems can be utilized in man's stead.

The purpose of this project is to design and develop a UGV and drop mechanism that can be integrated onto a drone. The drop mechanism will deploy the rover, which will then autonomously drive to a specified location delivering supplies to stranded people, who are otherwise unreachable.

1.0 INTRODUCTION

The unmanned vehicles systems industry has greatly developed in recent years. With many industries moving towards autonomy, the need for UAVs and UGVs has grown. However, the integration of UGVs into the industry has not been as popular as that of its aerial counterpart. Systems that incorporate both UAVs and UGVs to perform search and rescue missions are scarce. By adding UGVs to work in tandem with UAVs, areas previously inaccessible can now be accessed. This lack of assimilation between UAVs and UGVs introduces a need for a UGV system that can be easily integrated onto a UAV platform to perform specific tasks.

The main goal of the project is to design and develop an efficient drop mechanism and rover which will can attach to a multirotor drone. The drop mechanism will safely deploy the rover into a designated ground location, where the rover can autonomously drive to a secondary indicated location and deliver the desired payload.

2.0 Background Research

UGV mainly refers to vehicles like rovers, while UAVs can take the form of either fixed wing or multirotor drones. While fixed wing drones can easily scan terrains and perform scouting missions, multirotor drones are preferable in search and rescue. Multirotor drones can be easily manipulated to avoid obstacles as well as to hover over specified locations, making them the ideal choice when considering search and rescue.

According to a study performed on behalf of the National Parks Service, between 1992 and 2007, approximately 78,000 hikers were lost and required a search and rescue (SAR) team to be retrieved. Of the individuals lost, over 24,000 were injured or sick. Using multirotor UAVs in SAR operations has become much more prevalent in recent years.

However, the SAR drone can only locate the missing individual, not offer aid which may be needed. The drone can only relay the coordinates to the emergency personnel. In certain situations, the trek to retrieve the lost hiker can take hours or even days. An injured individual may not have much time to wait for first aid. This is where the Rover payload delivery system comes into play. The Rover can be mounted to any multirotor UAV, so that, in the case where the injured hiker needs immediate first aid or medication, it can be dropped near the hiker and deliver the required goods. Once on the ground, the rover will follow the GPS coordinates given by the UAV and deliver supplies to the injured hiker.

2.1 Requirements and Constraints

The requirements and constraints used for this project are in accordance with the AUVSI-SUAS student competition. The objective of the competition is to deliver a package directly to a specified location via UAV and UGV.

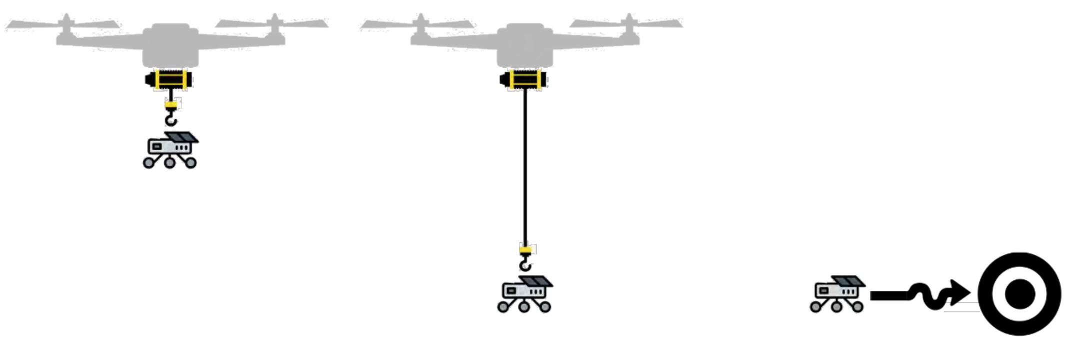

Figure 1: Diagram of rover drop procedure

2.2 Competition Requirements

The AUVSI-SUAS competition has certain requirements and regulations that all teams must follow in order to compete. The competition tests teams on their ability to follow instructions and specific directions. The drone must scan an open, flat terrain to map a grid of the area, while locating unspecified objects on the ground while flying by given waypoints. The UAV receives the GPS coordinates of drop location of the UGV, as well as the secondary location to which the UGV must drive. These coordinates are uploaded to the UAV and transferred to the UGV before takeoff. The rover must be dropped from the drone within five feet of the specified drop location with altitude no lower than 100 ft. The rover must not impact the ground with excessive force. Then the UGV must drive autonomously to the secondary location directed by the GPS coordinates received from the UAV. The rover may not veer out of predetermined boundaries, and if it does exit the boundaries or lose telemetry, it must completely shut down after 30 seconds.

2.3 ENGINEERING REQUIREMENTS

The drop mechanism must release the payload at the specific location and belay the rover at a safe rate. The rover must be able to withstand a one-foot drop onto asphalt while caring an 8 oz water bottle as the payload. The rover must autonomously drive the payload to a secondary location.

2.4 ENGINEERING CONSTRAINTS

The entire UGV and all its components must not exceed 64oz (4lbs) and may only drive up to 10mph. The altitude of rover deployment must be between 100ft and 750ft. The rover must land on the ground within five feet of the designated airdrop location. Additionally, no debris may be left at the airdrop location. The rover must stop driving within 10 ft of the payload drop location. The Unmanned Aerial System (UAS) must be able to withstand 15 knot winds with 20 knot gusts. In addition, the total mission must not exceed 40 minutes.

2.5 CURRENT CIRCUMSTANCES

Due to the wide-spread COVID-19 pandemic, social interactions have been limited and in-person meetings in school have been cancelled to limit further spread. The university has also been closed, and classes have been moved to remote teaching. This situation has a major impact on the degree project, due to limitations imposed by the home environment. A lot of 3D printing will have to be postponed until further notice, or modified to accommodate the equipment available.

The 3D printer available has a print bed of 4 cubic inches. Therefore, all the components must be updated to ensure that the parts are small enough to be printed. All the mechanisms will need to be redesigned into smaller parts which will later be assembled to produce the entire mechanism. Additionally, small scale models of all the components' initial designs will be printed.

Because it is no longer possible to print the initial designs of the components, finite element analysis (FEA) will be used to test the parts. These simulations will replace physical testing and yield the data necessary to enable appropriate modifications. Programs such as SolidWorks and Patran-Nastran will be used to determine the stresses experienced by the mechanisms.

Unfortunately, due to the pandemic, the AUVSI-SUAS competition has been canceled. However, the competition rules will continue to dictate the design as the main requirement and constraint.

The timeline using the Gantt chart needs to be adjusted in consideration of the current situation, therefore postponing any physical implementations and testing. The project's plan and schedule is now modified, and group meetings will continue to be done using virtual software, until further notice.

3.0 ROVER DESIGN

For this year's competition, a larger weight limit for the rover was given. Taking advantage of the increased weight limit, we plan on building a more robust rover that resists bending and cracking. In addition, a stress analysis will be executed, prior to printing, to ensure the rover is strong in all the necessary locations and to shave weight where it is not needed.

The drop line attachment will be in multiple locations to balance the rover in descent, while being held by the UAV. The line will disengage itself from the rover via hooks operated by a servo. This ensures that no part of the drop line stays attached to the rover as it continues to its secondary location.

The continuous metal gear servo drivetrain will be replaced with two DC motors capable of moving the rover at a more substantial pace (while keeping the speed below 10 mph) and overcoming slight discontinuities in the asphalt.

Driving the DC motors is the Omnibus flight controller and Adafruit DC motor breakout board. These two systems, in tandem, will allow the rovers' wheels to spin in opposite directions of each other, facilitating a better turning ability.

The rover will orient itself, upon landing, by the addition of new electrical components which were not previously utilized. By incorporating a quad antenna RFD, combined with the pre-downloaded GPS coordinates from the drone, the issues with the rover processing the directions are irrelevant.

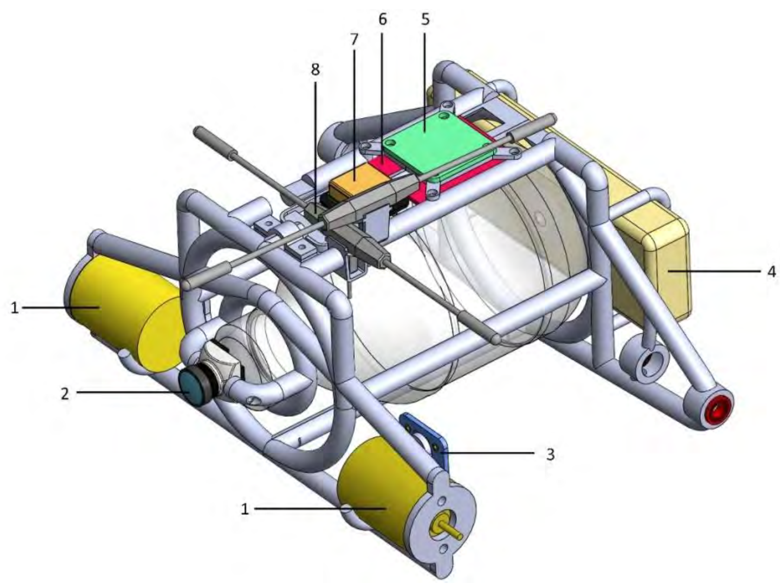

Figure 2: Rover chassis with accompanying components

Table 1: Rover parts list

1	High Torque DC Brushed Motors	Rover front wheel direct drive
2	Runcam nano2 Camera	Provides visual feedback to ground control
3	Adafruit DC Motor Driver Board	Controls the DC motors
4	3000Mah 2s Lipo Battery	Provides power to run systems
5	Omnibus F4 Nano V6 Flight Controller	Takes GPS coordinate input and instructs rover where to travel

6	Matek V3.1 PDB	Power distribution board
7	Matek GPS	External GPS and Compass
8	FrSky 915 Mhz Receiver	Provides telemetry to ground control

The overall chassis structure of the rover was designed in a similar manner to that of a small race car. The chassis is made up of tube components to maximize the strength of the structure, similar to a space frame or exoskeleton. This design limits the amount of excess material and weight.

Towards the front of the frame near the bottle cap, there is a mounting point for the run-cam FPV camera. This mounting point enables the camera to swivel, allowing the rover to better orient itself. To the right and left of the bottle cap, two DC motors will be mounted on either side. These motors determine the maneuverability of the rover. Power will either be sent to one or both motors, or turned off, to provide the direction in which the rover will proceed. In the rear of the UGV, there will be two independent axles, each supported by two ball-bearings to prevent bending in the axle itself. These axels cannot move independently.

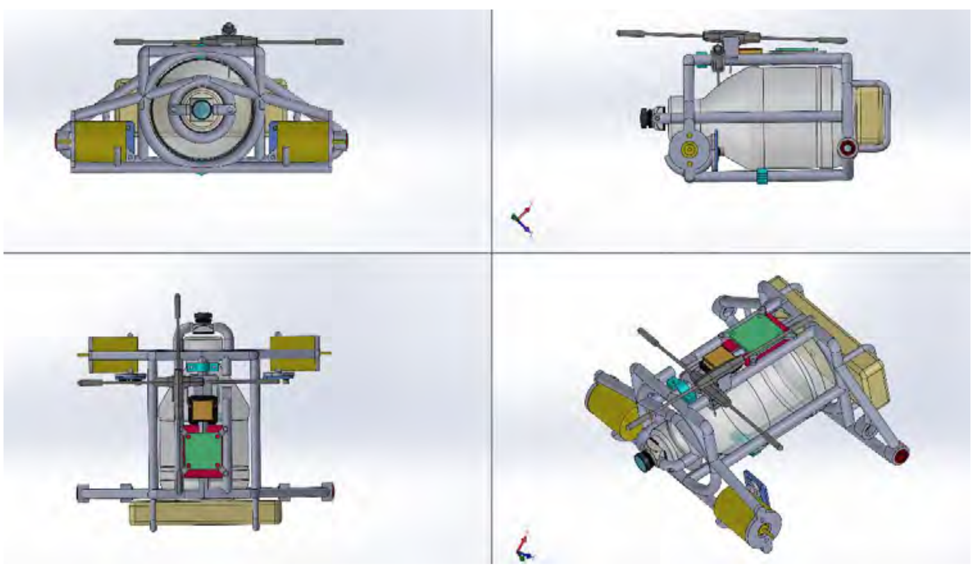

Figure 3: Rover design with attached components

The chassis has a noticeably wider stance than that of the previous designs. This makes the rover less top-heavy by distributing the weight laterally, providing a lower center of gravity. Additionally, rather than designing a chassis and then mounting the hardware, this design incorporates as much of the hardware as possible into the frame itself.

3.1 Rover Modification

With the onset of the Covid-19 pandemic, we no longer have access to much of the equipment for which we had previously designed. A new constraint that arose is the loss of usage of a large format 3D printer, to be used for fitment and physical tests. As we do have possible access to a small format 3D printer, all the various single structure parts of the build now need to be broken down to allow for reproduction on the small printer.

The rover was designed to be a single wireframe part to ensure strength. However, the rover is approximately twice the size of the new allowable build space. Since both sides of the rover are mirror images of one another, it was decided that the rover would be split in half and printed as such.

As most of the load while the rover is hanging and while on the ground would be a lateral strain, it was decided that the attachment method should be a vertical bolt, so that the junction would withstand a much smaller load as a result of shear.

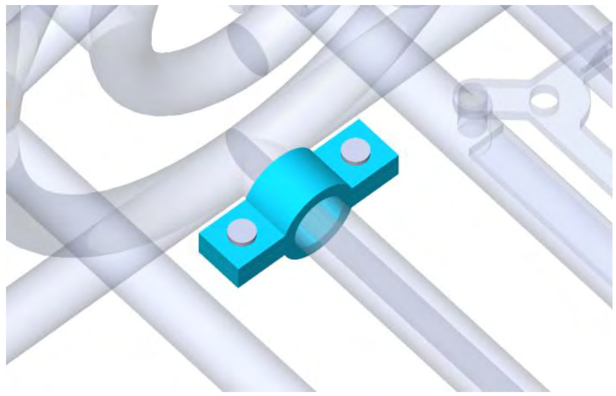

Figure 4: Attachment clamp

4.0 ANALYSIS

4.1 ANALYTICAL ROVER ANALYSIS

The rover was designed to withstand a freefall drop of one foot. In order to ensure that the rover would withstand this drop, the rover stresses were analyzed under two loading conditions.

The first loading condition was a static case, where the rover was subjected to a load of only its own weight. The entire chassis was analyzed under normal conditions with only the weight of the rover acting as force. The heaviest components of the rover were separated and represented by different loading conditions. The battery, motors, and frame were considered concentrated loads acting at the center of gravity of each part. The water bottle was treated as a uniform distributed load, acting across the bottom beam of the chassis. Using these forces, the resultant reactions and moments were calculated. This was done so the rover could be modified if it could not withstand its own weight.

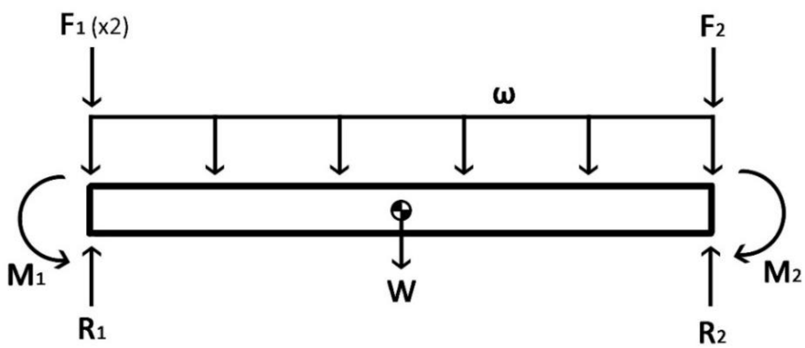

Figure 5: Simplified Free Body Diagram (FBD) of the rover

F_1: Concentrated loads due to weight of the motors
F_2: Concentrated load due to the weight of the battery

ω: Distributed load due to the weight of the water bottle
W: Weight of the rover chassis acting at the centroid of the system
R_1, R_2: Reaction forces
M_1, M_2: Moments

The second condition was an impact load which analyzed the rover's stresses after it was dropped from a height of one foot. This force was calculated using the impact energy equation which states that the work produced is equal to the potential energy of the body in question. Rearranging this formula produced the equation for impact force (1). The impact force of a system is defined as

$$F = \frac{mgh}{d} \tag{1}$$

F: Impact force
m: Mass
g: Gravity
h: Height of drop
d: Distance traveled after impact

The rover was treated as an undamped system, so it could be analyzed at its maximum loading condition. An undamped system would treat the rover as a rigid body. When subjected to an impact load, the rigid body would experience the maximum stress the system could experience. However, because the specimen could not be physically tested, the distance traveled after impact could not be measured. Therefore, it was necessary to calculate the response of the system (2).

$$x(t) = x_0 cos(\omega_n t) + \frac{\dot{x}_0}{\omega_n} sin(\omega_n t) \tag{2}$$

where
x(t): Response of an undamped system
x_0: Initial displacement
$\dot{x}_0$: Impact velocity
ω_n: Natural frequency
t: Time elapsed

The response of the system utilized the impact velocity of the system (3) as well as its natural frequency (4).

$$\dot{x}_0 = \sqrt{2gh} \tag{3}$$

where
$\dot{x}_0$: Impact velocity
g: Gravity
h: Height of drop

$$\omega_n = \sqrt{\frac{K}{m}} \tag{4}$$

and
ω_n: Natural frequency
K: Spring constant
m: Mass of system

Once the impact force was calculated, the stresses acting on the rover could be calculated, and the rover could be redesigned, as necessary.

4.2 Simulated Rover Analysis

When analyzing a system in SolidWorks Simulation, Finite Element Analysis (FEA) is used. Initially, a static simulation was performed. This simulation mimicked the effects of how the chassis of the rover would react under the weight of its own components. The components analyzed included the chassis itself, the two motors, the battery, and the water bottle. These components were chosen, because they were the main elements contributing to the weight of the rover.

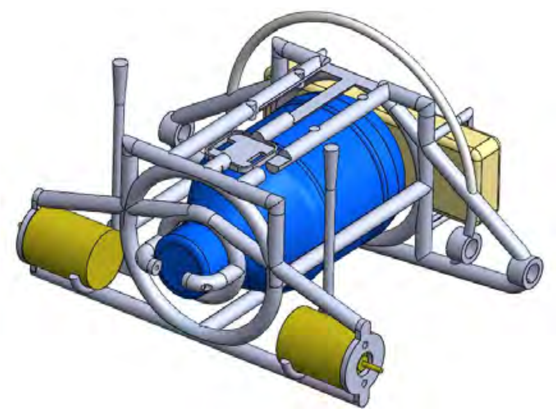

Figure 6: Rover and components to be analyzed

The static test required the specification of the material properties as well as the constraints that would be acting on the rover. We chose to fix the rover from the top crossbeams with upward forces acting at the locations of each of the weighted components. These upward forces simulated the reaction forces that would be felt by the rover if it were loaded under its own weight alone.

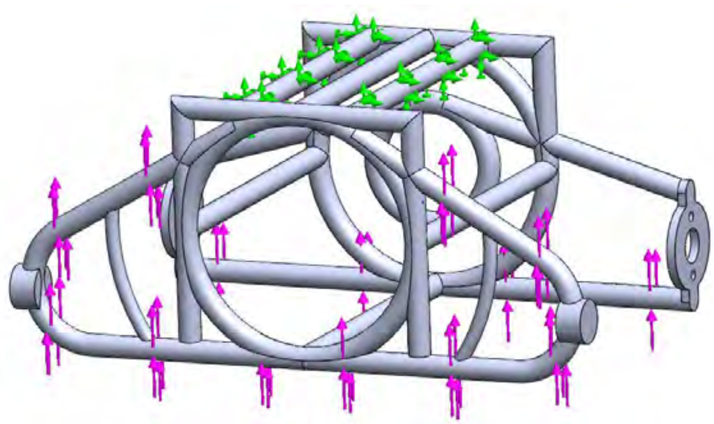

Figure 7: Static simulation loads

The SolidWorks Static simulation studies how a force affects the stresses, strains, and displacements of the bodies in question. The program first calculates the displacement of the structure and then uses these values to calculate the strains, and then stresses, experienced.

The equation that SolidWorks uses to calculate the stresses is yielded from the von-Mises Yield Criterion. The reason the von-Mises Stress, or Equivalent Stress (5), is used is because these stresses are independent of direction. Using these criteria, the stress found expresses itself in the following manner:

$$\sigma_v = \sqrt{\tfrac{1}{2}((\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2)} \tag{5}$$

where

σ_v: von-Mises stress
$\sigma_{1,2,3}$: Principal stresses

When the rover chassis was studied under a static loading of 4lbs, the maximum weight allowed by the AUVSI-SUAS guidelines, the maximum stress experienced was 6.745 MPa. This stress was far below the yield stress of the chassis material.

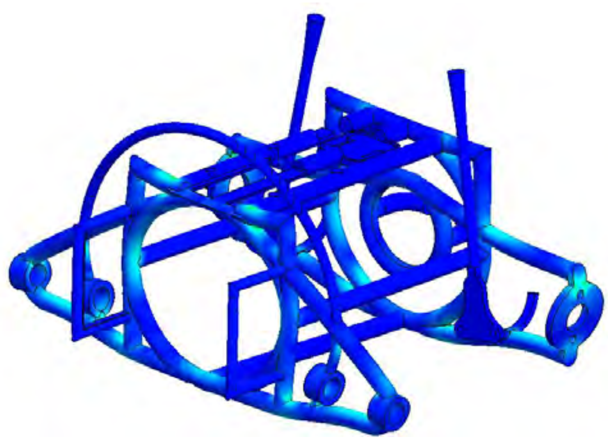

Figure 8: Static simulation stress results

The next simulation performed was an impact test, which would simulate how an object reacts if released from a certain height onto a chosen surface. Two independent FEA programs were used to ensure accurate results: SolidWorks Simulation and SimScale. The rover was tested with the heaviest components attached. The components included the 2s LiPo battery, two DC motors, and the 8 oz water bottle payload. The rubber wheels were removed to simulate the hardest impact possible from one foot. The materials of all the components were defined prior to performing the analyses, so the results would display accurate results.

A Drop Test study was performed in SolidWorks. The simulation requires the value and direction of gravity as well as the desired drop height. Because this is a dynamic problem, the calculated results are a function of time. The equation used to determine the external forces (6) acting on the body in question uses forces that are time dependent.

$$F_I(t) + F_D(t) + F_E(t) = R(t) \tag{6}$$

where

F_I: Inertia forces
F_D: Damping forces
F_E: Elastic forces
R: External forces

The external forces calculated incorporate various forces, including the desired impact force. Once the impact force was found, the program solves for the displacement of the model and the stresses experienced due to the impact. Using the stress and displacement values yielded from the simulation, the rover was reevaluated and modified to withstand the appropriate impact loads.

SimScale performed a Dynamic study. As opposed to SolidWorks, SimScale required the impact velocity (3) to be calculated using the desired drop distance of one-foot. Additionally, the material of the impact surface must be defined. Concrete was chosen because of the constraints of the AUVSI-SUAS competition. The next condition necessary to specify was where the rover would make contact with the ground once dropped. Like SolidWorks, SimScale calculated the von-Mises Stress and the displacement of the rover.

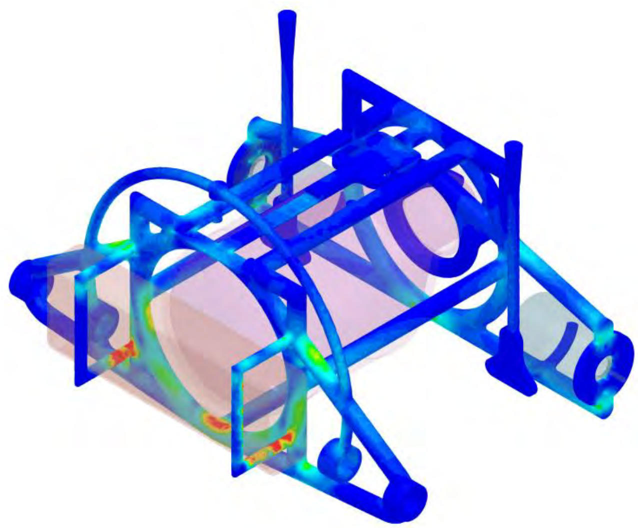

Figure 9: SimScale, von-Mises stress visualization

Both simulation softwares produced similar results. SimScale determined that the portion of the rover frame undergoing the most stress was at the rear bottom of the chassis. The von-Mises stress (5) was calculated to be 29.2 MPa. The SolidWorks Drop Test simulation determined the same location as the most stressed, and a von-Mises stress of 29.4 MPa. However, the non-structural portion of the frame, which cradles the battery, experienced stresses of 41.08 MPa.

According to MatWeb, the yield stress of ABS, the material of the rover chassis, is 22.1 to 59.3 MPa. However, MatWeb determined that the average yield stress is 45.1 MPa, as a result of 153 samples. With our chosen factor of safety of 1.5, the rover frame can withstand a one-foot drop on concrete without failing based on the calculated factor of safety.

$$N_{fs} = {}^{S_{yld}}/_{\sigma_v} \tag{7}$$

where

N_{fs}: Factor of safety

S_{yld}: Yield strength of the material

σ_v: Calculated von-Mises stress from analysis

However, the battery carrying-point requires modifications, including additional supports, to ensure it will not break off from the rest of the rover body on impact.

5.0 Mechanism Design

5.1 Drop Mechanism Design

A winch-pulley mechanism will be used to drop the rover from the UAV. The drop mechanism will use a pre-rolled fishing line. The fishing line will be driven by a motor, which will release the braided string until the rover has landed. Once the rover is within a certain distance from the ground, the motor will begin to slow the spool so the rover can be slowly lowered the final distance to the ground. Once the rover is released, the motor will reverse, bringing the string back up to the drone, allowing the release mechanism to be lifted off the ground and returned to the drone. This is done to address the competition rule that states that no debris may be left at the UGV drop location.

This mechanism utilizes a pulley which allows for two points of contact with the fishing line. If the release mechanism only used the motor as the point of contact, the rover would be subjected to external elements which would affect the stability of the drop. By using two points of contact, the string acts as a stabilization method and prevents the rover and release mechanism from excessively oscillating as it is lowered to the ground.

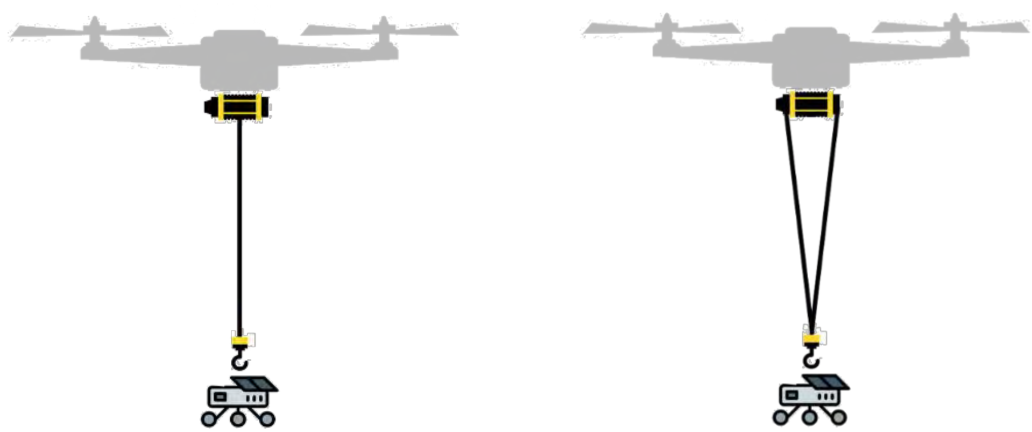

Figure 10: Comparison between one and two points of contact

A high torque DC motor will be used to operate the winch at a quicker rate for most of the descent. Towards the end of the rover's descent, the motor will slow the descent to facilitate a softer landing. This ensures the rover will not be dangling in the air, for an extended period of time, as it approaches the drop location. By releasing the rover at a quicker velocity, the rover will not need to withstand the environmental factors that can create instability. To prevent the rover's own weight from causing its premature descent, a new securing mechanism is being used, as well as a locking system to refuse the motors free-rotation. Finally, on the UGV, there will be a detachment mechanism to jettison the drop line, which will then be rewound, so that no cable is hanging off of the rover or drone.

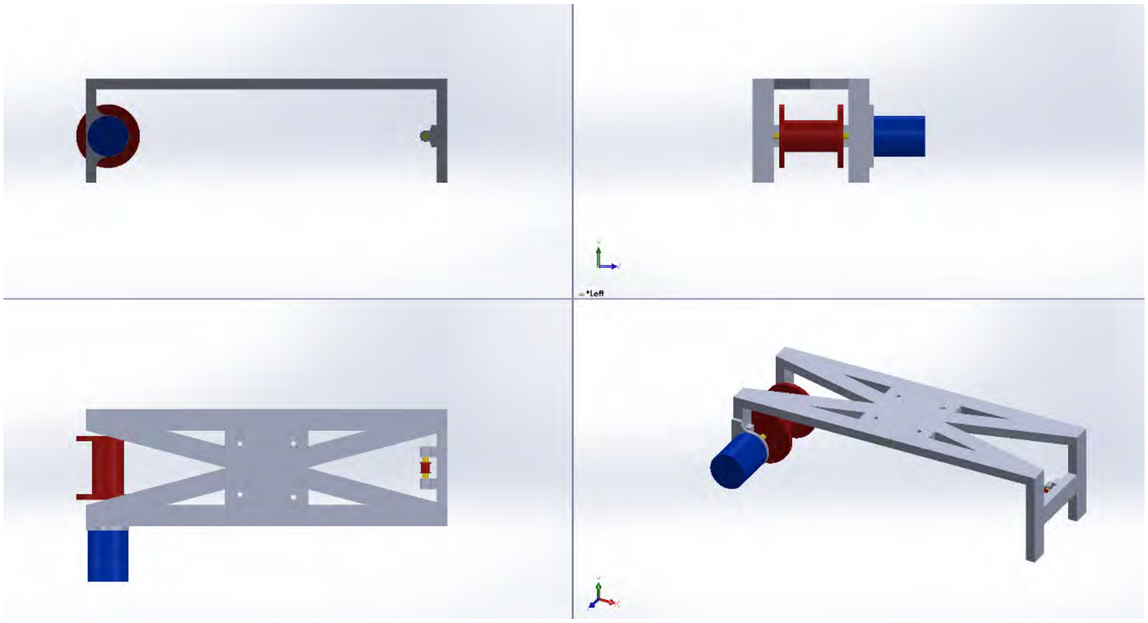

Figure 11: Drop mechanism design

5.2 RELEASE MECHANISM DESIGN

The release mechanism consists of a hook system that utilizes gravity to enable the release. When the rover touches the ground, the release mechanism is activated and unhooks itself from the rover. The remaining parts of the mechanism are then pulled back up to the UAV by the reversed motor on the drop mechanism. This allows for the UAV to continue its mission without components hanging below.

It was important that the part not have any motors or sensors, in order to limit the possibility of failure. The release mechanism consists of a hook and a latch to hold onto the hook. The gravity would be pulling on the mechanism which would be held tight until the rover would hit the ground, and the weight of the rover would contradict the gravity and the mechanism would release itself. The original design had 3 latches to attach the sides of the drop mechanism; the latches and the sides would have to align perfectly in order for the release mechanism to work as intended. A prototype of the release mechanism was 3D printed, and due to its complexity, the initial set-up was redesigned.

The release mechanism now attaches the sides to a hoop, and it is much easier to attach and doesn't need as much precision. The initial set-up of the release mechanism is thus simpler and quicker. It is also important to study the stresses on the mechanism, in order to avoid breakage and failure. The whole point of this mechanism is to release the rover and to detach itself from the drop mechanism.

Shown below is the method in which the release mechanism will work. Figure 7 shows the mechanism in its initial state, held together by the tension produced by the hanging rover. Figure 8 depicts how the mechanism will release once the rover has touched down. Figure 9 shows the mechanism completely released. The top component will be reeled back to the UAV, while the bottom portion will remain attached to the rover for the duration of its mission.

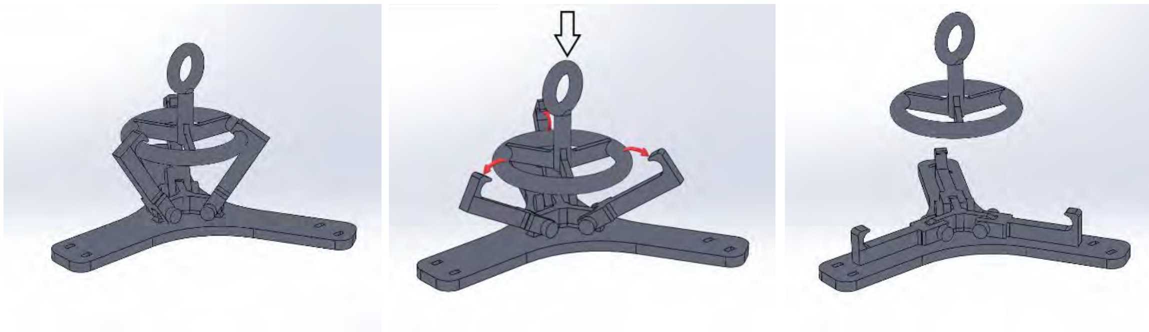

Figure 12: Initial position (left), Opening movement (middle), Separated position (right)

6.0 Economic, Social, and Environmental Impacts

6.1 Economic Impacts

An estimated $5 million dollars is spent annually on search and rescue missions; this cost does not include the thousands of man-hours that go into these searches. A lot of money is spent on training, conferences, meetings and seminars. The UGV and UAV system (designed to function in limited lines of sight environments) greatly decreases the amount of money needed. The rover attachment to a multirotor drone provides first aid, thus shortening the amount of time used to search for the person in need and reducing the number of people needed to perform this task. The Coast Guard is the leader in SAR operations; assisting an average of 114 people per day costs an average of $680 million annually, including the expense of patrol boats. The price increases if a C-130 turboprop plane is used. Most of the time and money is spent searching for the person in need of assistance. Using our design lessens the time and decreases the risk of injury or fatality to the rescuers, since the rover provides necessary aid until further assistance can be safely provided. According to an AUS article on the benefits of UAS (Unmanned Aircraft Systems) the cost of operating one of these is approximately $3.36 per hour as opposed to a manned aircraft, the cost of which ranges from $260 to $600 per hour.

6.2 Social Impacts

With the use of the UGV and UAV system stranded people are located more quickly; according to the AUS article, during Hurricane Katrina, people stranded by floodwaters were found much more quickly by using UAS than by using emergency responders conducting searches by rowboats. Researchers at the University of North Dakota used this system in 2010 to capture images of the flooded Red River in the Midwest, which helped greatly with vital data for flood research, planning and rescue. The use of the rover in search and rescue missions will help save lives. As mentioned previously, approximately 24,000 of 78,000 hikers lost were injured or sick, often needing emergency first-aid or supplies of food and water. Unfortunately, the search and rescue team was not able to access these people in an efficient manner. Using the rover system attached to a multirotor drone will make the provision of crucial aid in such missions more effective. This innovative system would ease the process and minimize the risk involved in search and rescue missions. The elimination of the need for human rescuers to provide first-aid or supplies quickly provides more time for planning and strategy to save the stranded person and ensures the safety of those providing the assistance.

6.3 Environmental Impacts

The project's design eliminates the need for natural gas vehicles which emit carbon dioxide. Using boats to find the stranded person has a negative impact on the environment as well; according to the Environmental Protection article, the presence of vessels seems to increase the algae and kick up sediment, hindering the sunlight essential to the ecosystem. The deposits from the boat change the water chemistry and decrease water quality necessary for wildlife. Boats are harmful to wildlife and water, while the AUS would be able to locate the stranded person in water without harming the environment. It is well known that vehicles have a negative effect on the environment; using the UGV would decrease the greenhouse gases released by vehicles used during search and rescue. In order to locate a person, multiple boats, vehicles and if needed helicopters are sent out; the amount of damage this creates is enormous, due to the large number of people who become stranded, lost and in need of help. Often, the stranded person is surrounded by nature in forests or mountains; using vehicles can harm the soil, wildlife and plants. The UGV is the best alternative due to its size, weight, and lessened impact on soil and plants. The UGV does not use fuel but rather uses cell power, without causing any harm to the environment.

7.0 Conclusion

The objective of this project is to design an efficient drop mechanism and rover system which can attach to a multirotor drone. The drop mechanism would safely deploy the rover onto the ground; the release would detach the rover which can then drive autonomously to a designated secondary location and deliver the desired pay load. In order to accomplish this procedure, the system was broken down into three components: the drop mechanism, the release mechanism and the rover. Each of the parts was designed in SolidWorks and then analyzed for stress and strain to ensure the strength and ability of the system. The three-part system was constantly improved and revised due to requirements and certain constraints. Each component was redesigned and scaled down in order to print the parts without access to full-scale 3D printers. The group used software testing and analysis to minimize deficiencies in the design and to develop a stronger model. One of the main purposes for the development of this project is to compete in the AUVSI-SUAS competition; however, this system is intended to be used in Search and Rescue Missions. This project demonstrated the effective process through which the group reinforced their skills in research, development, design, critical thinking and most importantly, in the employment of engineering judgement.

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Autonomous Customer-Service Robot

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ABSTRACT

The retail industry is one of the largest in the world, where big brand companies generate billions of dollars yearly. The biggest threat faced by retail stores today is competition with the e-commerce industry. Traditional retailers must deliver an efficient and seamless customer service experience as compared to the convenience and simplicity of online shopping. One solution to this discrepancy in customer experience is to make full use of autonomous mobile robots. Robots have been proven to be more cost effective and efficient than humans for many tasks. A robot can perform tasks such as, provide the price and description of a product and even direct a customer to the location of a product within in a large warehouse store. Furthermore, the autonomous mobile robot should be able to conduct self-charging once the battery is almost depleted, given the requirement of high efficiency of most warehouse store management. In this project, a complete customer-serving and self-managing robot is studied, i.e. based on consumer need, the robot can bring the customer to the product location and navigate itself to the solar panel charging station when recharging is needed. The autonomous customer-service robot can significantly impact to our society and economy. Due to high customer satisfaction with the quick and simple shopping experience provided by the autonomous mobile robot, retail companies will substantially increase their sales.

1.0 INTRODUCTION

Millions of customers shop at large consumer goods stores daily. However, most of these stores do not have sufficient workforce to assist all the customers. Sales associates are often engaged with customers for a long period of time, leaving other shoppers to fend for themselves without assistance. This lack of sales support leads to customer frustration and dissatisfaction. Also, employees require training and considerable experience before they can accurately answer all the questions a customer might have. The autonomous customer-service robot would be a viable solution to these issues. The robot would perform all tasks with great accuracy and without the need for breaks or days off. Furthermore, the robot should be able to charge itself when the battery is almost depleted, which largely enhances robot efficiency.

2.0 BACKGROUND RESEARCH

With a 14.9% increase in online sales in 2019 [1], large companies such as Walmart developed new technologies to compete with the e-commerce market. Figure 1 shows the Auto-S, one of the few autonomous robots developed by Walmart, designed to scan shelves to ensure availability, correct shelf location and price accuracy [2].

Figure 1: Walmart Autonomous Robot, Auto-S [3]

While big brand store robots can perform their specific tasks, none provide efficient customer service. Our autonomous robot is designed for direct interaction and customer service. Furthermore, the customer-service robot utilizes green energy, giving it an edge over current robots dependent upon a conventional energy source.

3.0 ENGINEERING REQUIREMENTS AND DESIGN CONSTRAINTS

3.1 3.1 Turtlebot3 Burger

- Dimensions(L x W x H): 138 mm x 178 mm x 192 mm
- Maximum Translational Velocity: 0.22 m/sec
- Expected Operating Time: 2h 30m
- Single Board Computer(SBC): Raspberry Pi 3 Model B+
- Embedded Control Module: OpenCR with a 32-bit ARM Cortex®-M7

3.2 Solar Charge Controller

- Nominal Voltage: 12V/20V
- Wire Gauge Size: 18 ~ 20AWG
- Rated Charge Current: 5A
- Max. PV Input Voltage: 25 VDC
- Enclosure Dimensions(L x W x H): 230 mm x 150 mm x 87 mm

3.3 Solar Panel

- Maximum Power: 25W

- Optimum Operating Current (I_{mp}): 1.4A
- Dimensions: (L x W x H): 522 mm x 367 mm x 17 mm

3.4 Charging Demonstration Station

- Dimensions: 152.4 mm x 73.5 mm x 127.0 mm
- Material: Polylactic acid
- Contact Plate: Aluminum

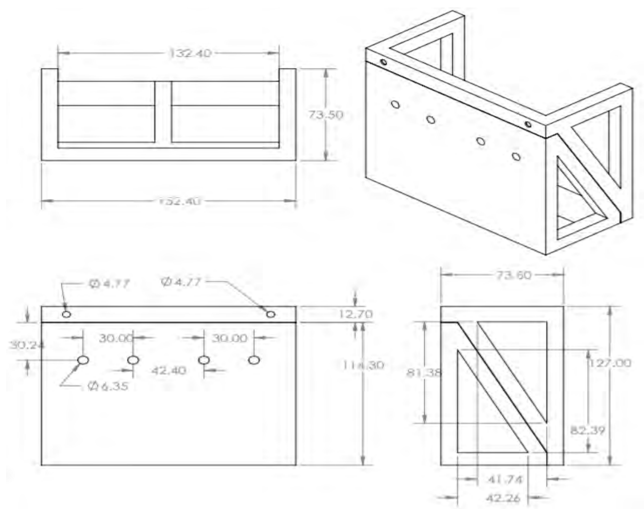

Figure 2: Charging Station Design

4.0 PROJECT DESIGN

4.1 Robot Hardware Design

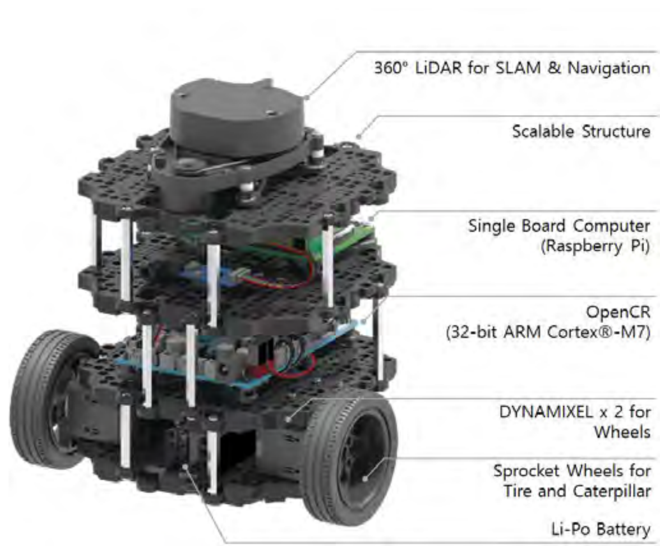

Figure 3: Turtlebot 3 Burger

LDS-01: The LDS-01 LIDAR (Light Detection and Ranging) sensor is capable of scanning a 2D plane at full 360 degrees and has a range of up to 3.5 meters. The LIDAR is essential for the SLAM (Simultaneous localization and mapping) and navigation algorithms.

Raspberry Pi 3 B+: The raspberry Pi 3 B+ is a single board computer which uses a Cortex-A53, 64-bit processor, making it capable of running ubuntu V16.04 and provides enough computing power to run the necessary programs and algorithms.

OpenCR: is an open source control module developed for ROS(Robot Operating System) embedded systems to provide a complete open source experience with both the hardware and the software. On-board, an inertial measurement unit (IMU) and a magnetometer can be found. This board provides the best versatility for the project robot and easy interfaces with the rest of the systems.

Dynamixel-430: actuators are equipped with fully integrated DC motors, reduction gearhead, controller, driver, and DC servo module. The contactless magnetic encoders and hollow back case assembly allow for 360-degree control mode and reduce the amount of debris that can affect the measurements.

4.2 Robot Software Design

ROS and Python: ROS is an open source meta operating system which provides a flexible framework for writing robot software. ROS provides a collection of tools, libraries and conventions to greatly benefit the user in creating robust robotic systems. For this project, most programs are developed in python due to the accessibility of the Rospy module and the great python support on the web.

RVIZ and Gazebo: Simulations provide cost effective solutions to testing the performance for a system and are often used to recreate real-life situations without sacrificing any actual resources. In the project, RVIZ is used, an 3D visualization tool for ROS, to visualize the LIDAR data being recorded by the sensor as shown in Figure 4. The environment was also used to create a map of the supermarket model using the Gmapping SLAM algorithm. A PGM (Portable Gray Map) file of the map is created and its pixel data can then be used within the path planning and navigation algorithms. Gazebo is a robotic simulation tool which is used to test algorithms, design robots, perform regression testing and train AI systems. The navigation and path planning algorithms were all tested within the Gazebo environment before the real-life implementation.

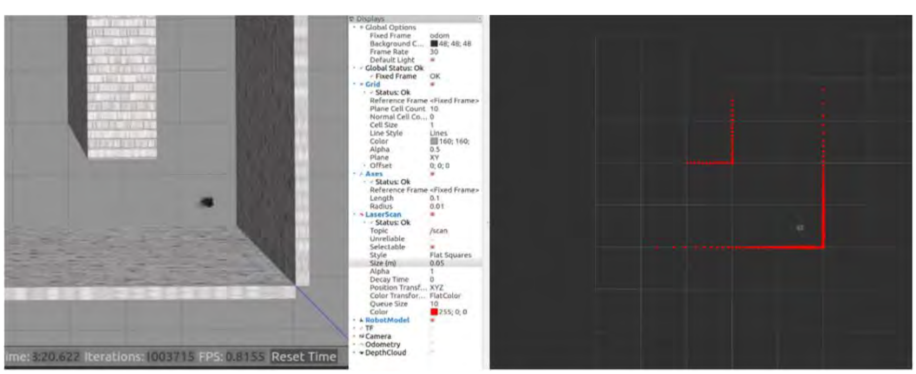

Figure 4: Gazebo(left) and RVIZ(right) Used to Visualize LIDAR Data

SLAM: SLAM (Simultaneous Localization and Mapping) is the concept of creating or updating a map while simultaneously knowing the location of the robot within the map. This is a computational problem which resembles the chicken and egg paradox. Without a known map the location is unknown and without the location the map can't be created. SLAM algorithms are used to handle this issue to accurately map and localize concurrently. To obtain an accurate localization, the robot needs to be equipped with various sensors such as LIDAR and encoders. In our case, the LIDAR is used to measure distances of obstacles around the robot at a full range of 360 degrees. The encoders are used to estimate the distance the robot has moved. With the data from these sensors, the position and orientation of the robot can be estimated.

Localization: Particle filter localization, also known as Monte Carlo localization, is a nonlinear filter that is used for nonlinear systems with non-gaussian noise. Particle filters solve the kidnapped robot problem, where a robot is picked up and moved to another location. Particle filters do not rely on encoders, they use the LIDAR as the main sensor. The LIDAR is used to measure distances around the robot and then compares it to distances of particle samples created within the map. The particles are then assigned a weight depending on how close the distance comparisons were. The particles are then re-sampled and converge towards the particles with the highest weights, and repetition of this process eventually directs the particles to reach one general location for the robot [4].

Mapping: Mapping refers to the process of obtaining a working map of the environment in which the robot is placed. The mapping process consists of using the robot to create an occupancy grid map (OGM) for the program to use when planning and navigating a path. To create the OGM, SLAM methods provided by the ROS framework are used. Although ROS provides many types of SLAM methods (gmapping, cartographer, hector, frontier exploration etc.), the gmapping method is used to map out the supermarket model for this project. As the robot explores the unknown area, the LIDAR sensor was used to pick up distance data from its surroundings. That data was then recorded in respect to the robot's current location and saved within a file. The movement of the robot was tracked by the IMU, magnetometer and the encoders, so there is a reference point from where all the measurements were taken. Simultaneously, as the robot moves around the supermarket model, the map is visualized in RVIZ and is updated via LIDAR data.

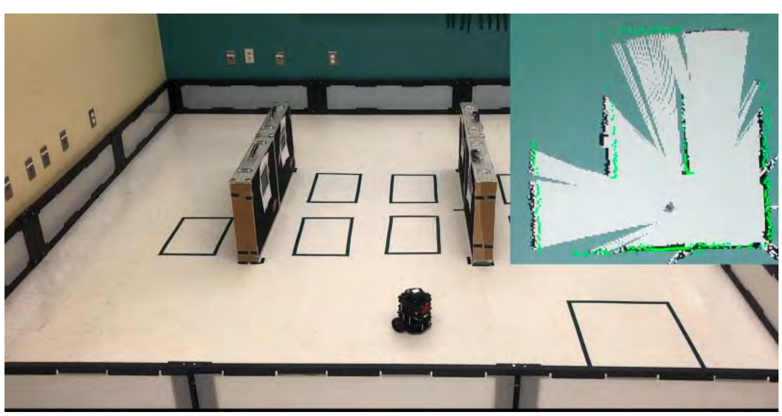

Figure 5: Mapping the Supermarket Model

After the mapping process is completed, a PGM (Portable Gray Map) image is created and saved in memory. This pixel information from this image can then be used to determine the location of free space or obstacles.

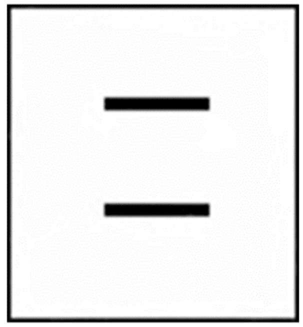

Figure 6: PGM of Supermarket Model

Path Planning

A path planning algorithm (path search algorithm) is a computer algorithm implemented to determine a path to a defined destination, considering any number of additional variables. The A-star search algorithm is one of the more popular path search algorithms due to its characteristics of optimality, completeness and overall flexibility. The A-star algorithm will surely find the most optimal path when a possible path exists. The algorithm's flexible nature, allows its implementation in software systems, machine learning and search optimization in game development [5]. The A-Star search algorithm can be simply defined by the formula $f(n) = g(n) + h(n)$, where $g(n)$ is the total cost of the path from the starting node to any node, $h(n)$ is the heuristic value which represents an estimated cost from any node to the goal node, and $f(n)$ is the total cost of any node. The values of each node are evaluated, and the lowest costing nodes are put into the path. The end result should be a path to the goal with the greatest efficiency, in terms of time or distance. Figure 7 shows an implementation of the A-Star algorithm, where the green node is the starting position and the yellow node is the goal position. The red outline shows the path chosen after cost evaluation for each node and determination of the most efficient route.

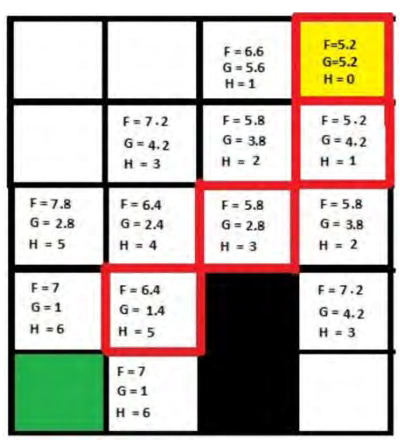

Figure 7: A-Star Algorithm Implementation

Robot Programming

The robot was programmed to take the user's input for either product selection, specific location navigation or return to home. If the user chooses product selection, one is presented a menu of products from which one can select, as shown in Figure 8. Once the product is selected, the robot will plan, from its current location, a path to the product and navigate to this product, as shown in Figure 9. If a specific location is selected, the user can input a location of his or her choice for the robot's navigation. The return home command will return the robot to its home position, where it remains, ready for its next command.

```
Choose a product
1 : fridge
2 : washer/dryer
3 : spraypaint
4 : paint brush
5 : sand paper
6 : interior paint
7 : wood 2x4
8 : plywood

Selection: 5
```

Figure 8: User Menu for Product Selection

In Figure 9, the sandpaper product is selected, and the robot successfully navigates within the designated box for the product. The error within the navigation is minor, caused by a slippage error from the wheels and the floor. The positional error is corrected each time the robot travels to its destination by updating the encoders estimated location with the location provided by the AMCL (Adaptive Monte Carlo Localization) filter. By updating this location at the end of each goal, the error cannot accumulate.

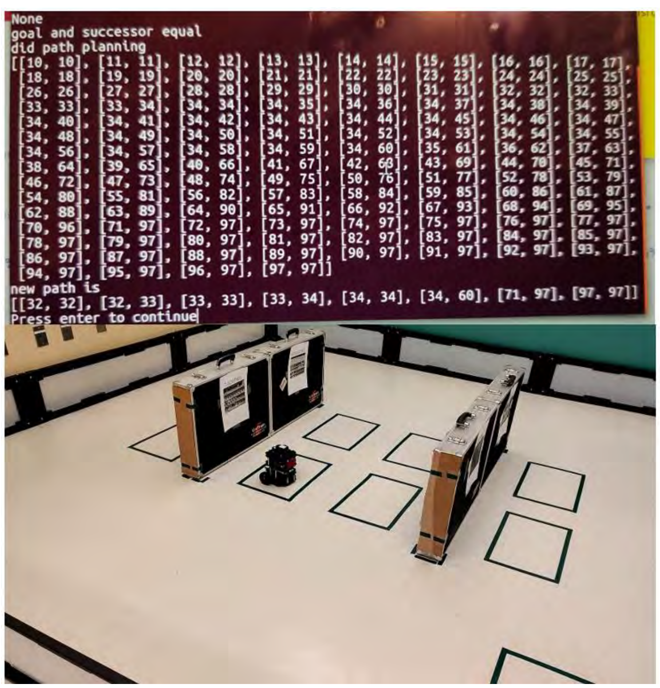

Figure 9: Robot Navigation to Sandpaper Product

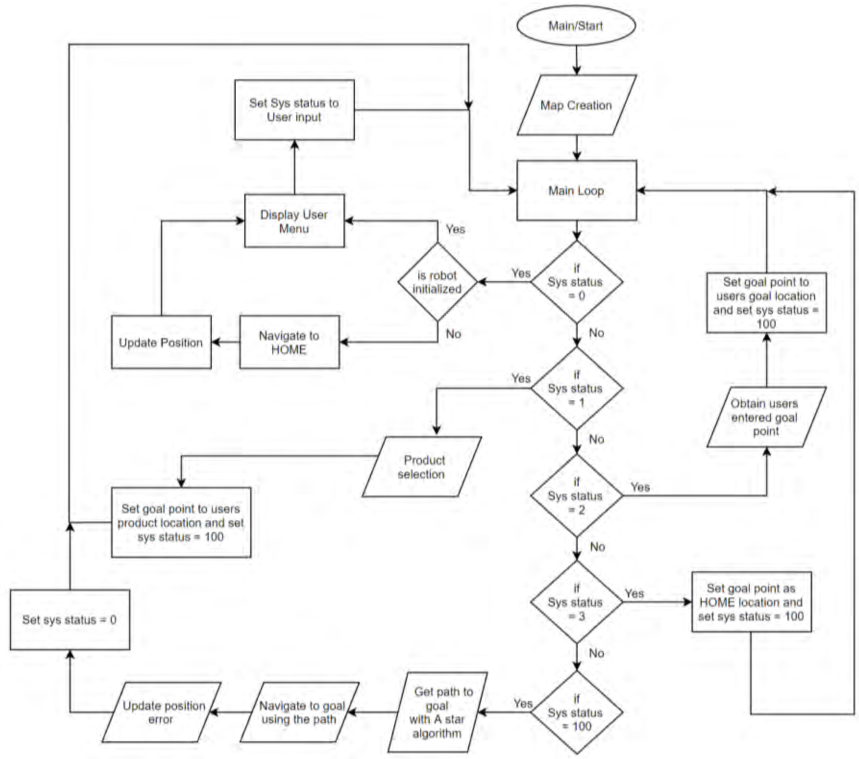

Figure 10: Program Flow Chart

4.3 Charging Station Design

The charging station is comprised of the solar charge controller and the actual solar panel station model. The charge controller takes in voltage from a solar panel and adjusts it to charge the robot's battery at an optimal capability. The charging station implements a PWM charging algorithm. The microcontroller on the Arduino board receives inputs from a temperature sensor and calculates the necessary outputs using algorithms and then sends display information to an LCD module. The control signals are sent to the solar charger circuit to regulate the voltage used to charge the robot battery. For demonstration, the metal contacts on the front face of the station will contact the metal surface on the robot which will complete the circuit, allowing the controller to charge the battery [6].

Arduino Nano

The Arduino Nano microcontroller is the heart of the solar charge controller. To utilize the maximum power point from the solar panel, the controller senses the PV panel voltages as well as the battery for storage and controls it accordingly. Thus, at a dynamic condition of temperature, irradiance and load requirement, the Arduino board controls these conditions in order to utilize the available maximum power.

Current Sensor

The current sensor embedded in the solar charge controller circuit is used to measure the load's current for calculation of the power and energy accordingly. In the project, the ACS712 current sensor module with a range of up to 20 Amps is used. The sensor offers fast response, high linearity, and low temperature drift which makes it immune to electrical noise.

Temperature Sensor

To ensure the longevity and good condition of a battery, it is essential to adjust the charging rate with temperature changes. The LM35 sensor is used to sense room temperature for the adjustments.

Buck Converter

A 12V lead-acid battery is used to charge the robot; however it is also used to power the Arduino Nano Board. The Arduino Nano requires 5V to operates. Thus, the buck converter is used to step down the voltage. A minimum of 10.5V from the battery needs to be lowered to the required voltage of the Arduino Nano, since it has no embedded step-down converter.

MOSFETS & TRANSISTORS

A lead-free P-channel MOSFET is used for the solar charge controller. It has advanced process technology of fast switching and operating at 175°C. Under dynamic conditions of irradiance and temperature, the power MOSFETS can utilize the full MPP from a PV panel. And a general purpose NPN transistor, 2N3094 is used to control the dynamic switching conditions connected to the Arduino Nano.

Charge Controller Program

The program for the charge controller will determine the charging rate of the battery, depending on the battery's current state and solar input. The PWM duty cycle is adjusted accordingly, to ensure the battery gets a constant current in the bulk stages and then drops gradually in the stages of absorption and float. This ensures optimal charging of the battery while maintaining a healthy battery life.

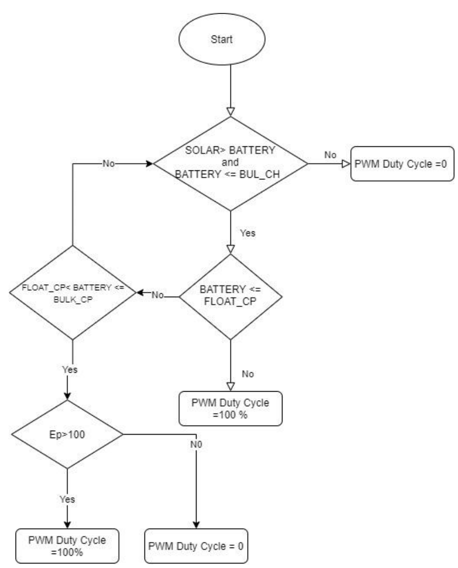

Figure 11: Charging Controller Program Flow Chart

Simulations

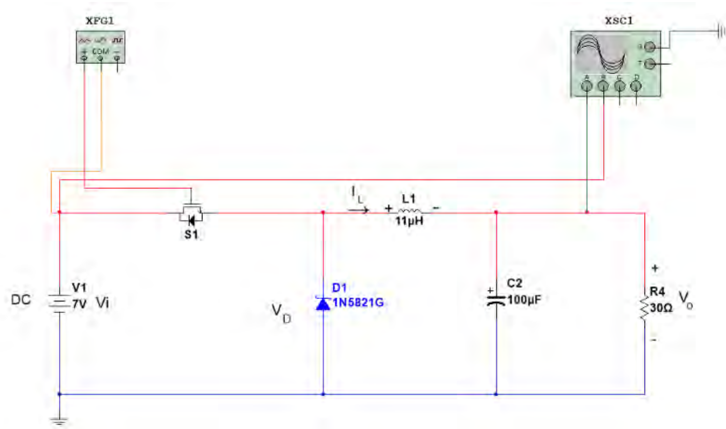

Figure 12: Buck Converter Design

The voltage across the inductor in relation to the rate of current as shown in Eq 1

$$V_L = L\frac{dI_L}{dt} \tag{1}$$

In CCM mode, the change of current for both on-state and off-state is calculated as follows

$$\Delta I_{L_{on}} = \int_0^t on\frac{v_L}{L}dt = \frac{v_i - v_0}{L}t_{on} \tag{2}$$

$$\Delta I_{L_{off}} = \int_{ton}^T \frac{v_L}{L}dt = \frac{-V_o}{L}(T - t_{on}) = -\frac{V_o}{L}t_{off} \tag{3}$$

When the converter is operating in a steady state, the current through the inductor at the beginning of on-state is the same current at the end of the off-state. Thus, the accumulated current during one operational cycle equals zero.

$$\Delta I_{L_{on}} + \Delta I_{L_{off}} = \frac{v_i - v_0}{L}t_{on} - \frac{V_o}{L}t_{off} = 0 \tag{4}$$

Now, assuming D = t_{on}/T as duty cycle in the range of 0 < D <1, Eq 4 becomes

$$\frac{V\mathrm{i} - V_o}{L}DT - \frac{V_o}{L}(1 - D)T = 0 \tag{5}$$

$$\frac{v_0}{v_i} = D \tag{6}$$

Thus, by controlling the duty cycle, the output voltage can be controlled if the duty cycle is below 1. The simulated results shown below validate the converter mode.

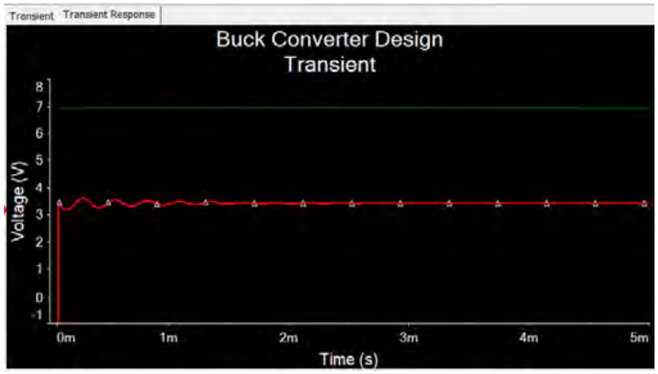

Figure 13: Buck Converter Output with 0.5 Duty Cycle (Green: Input Voltage and Red: Bucked Voltage)

Wiring Schematic

Figure 14 shows the solar charge controller schematic diagram. The entire circuit is protected by a bidirectional Transient Suppression diode (component D1 in circuit) along with 5A fuses to uphold the IEC 60364-4-41 standard. Depending on the voltages, the solar charge controller program determines how to charge the battery and control the load.

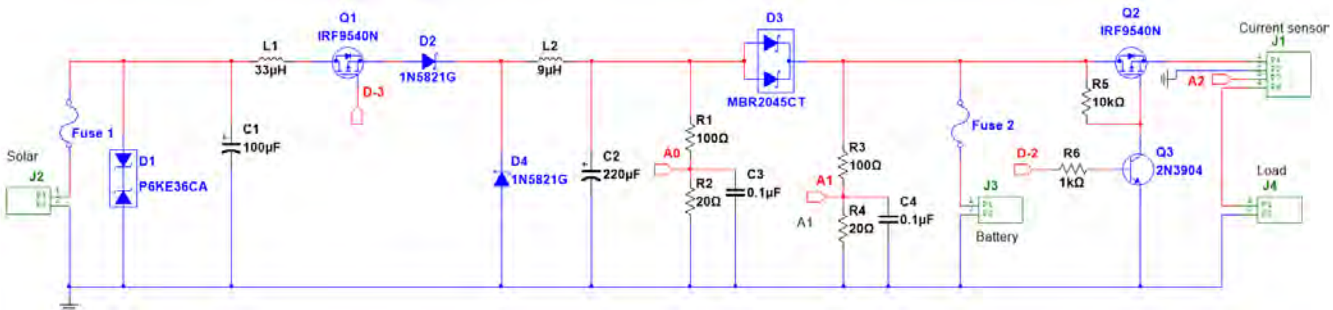

Figure 14: Solar Charge Controller Schematic

Implementation and Testing

Figure 15: Testing the Charge Controller Circuit

Figure 15 shows tests of the inputs from a signal generator (offset= 2.5V, Vpp= 5V, frequency = 5 kHz) to the microcontroller and measures the output load with the solar panel battery in the circuitry. The load voltage was displayed using an oscilloscope. A duty cycle of 50% to 80% was adjusted to verify the output signal.

Final Setup

After both the charging station and charge controller were built, all components as well as the solar panel system were integrated as one unit for testing. The wire was measured so it could connect the station and the controller properly. Everything was connected and a light bulb was used as a load to examine the ability to charge a load battery. The solar panel was placed in an area where the light could be changed from bright to dark. This would represent when the sun is out in the day and set during the nighttime. When the robot contacted the charging stations metal plates, the LED’s lit up as expected and the load, which in this case was the light bulb, was also turned ON. On the charge controller, three LED’s were used to represent the status of the battery, load and solar panel, respectively. When the charging battery voltage is above 10 V, the battery LED is green. Otherwise, the light is off. The load LED is green when there is enough charge to drive a load, and the solar panel LED is green when it can deliver more than 5V.

Figure 16: Complete Charging Station Setup Test

In Figure 16, the whole charging station is set up to be tested. In lieu of sunlight, a bright LED light was used to power the solar panel. The panel was then connected to the solar charge controller. The load and battery were also interfaced to the solar charge controller circuit and worked components of the system.

Figure 17: Solar Charge Controller LCD Display

Figure 17 shows the LCD module which displays the values before and after the robot contacts the charging station. When the robot contacted the charging station, the circuit is completed, which powers the load in this case the light bulb. The LCD then displays that a load is connected, along with the amperage and wattage drawn by that load. In Figure 18, the robot comes in contact with the charging station to bridge the gap between the two conductive plates on the face of the charging station. This completes the circuit, allowing the charge controller to charge the load and to illuminate the green LED’s on top of the station, indicating the circuit has been completed.

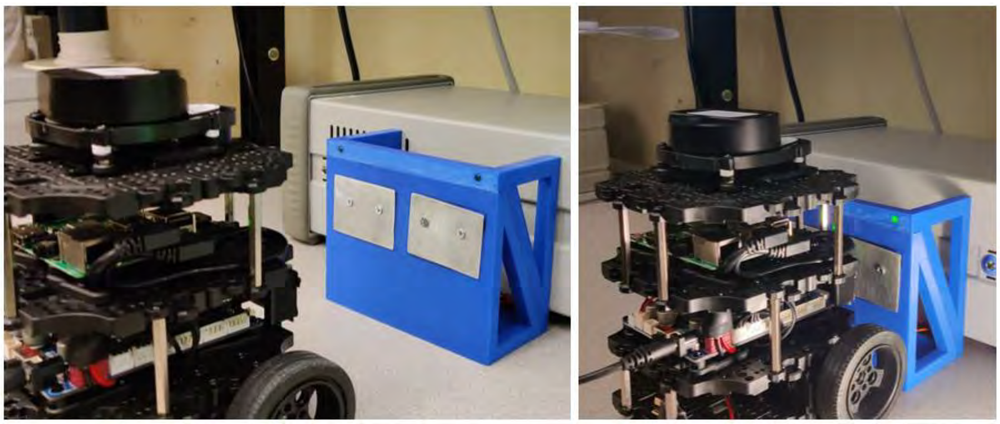

Figure 18: Final Charging Station Design Test

5.0 IMPACTS

5.1 Social Impacts

The introduction of the autonomous customer service robot dramatically improves the customer’s whole shopping experience, by providing quick and easy answers for all shopping queries. This not only increases customer satisfaction, but also the chance of customers wishing to return to the store.

5.2 Economic Impacts

The total price of the robot and charging station is affordable for businesses, costing less than $1500. Also, the robot can increase the revenue for businesses by providing customer service without the need for more workers. The charging station reduces the costs for electricity, by providing a green energy solution for charging the robots.

5.3 Environmental Impacts

Electricity production from fossil-fuel infrastructure is the number one source of greenhouse gases, more than driving and flying combined. These greenhouse gases contribute to climate change and have adverse repercussions on the environment in the long run. Burning of fossil fuels for electricity production also affects the land and water bodies. However, the use of renewable energy in our project contributes to improvement of the environment and sets a great example moving into the future.

6.0 CONCLUSION

With the rapid increase the e-commerce industry, it's imperative for companies to compete by developing new technologies that incentivize shoppers to shop in their stores. The autonomous customer service robot provides the best service for shoppers by providing a quick and seamless shopping experience. The result was an autonomous robot with the capabilities of running SLAM algorithms, to operate functionally and independently, was produced. A solar charge controller which collects solar energy to charge the robot at its own charging station was also designed and implemented. The total cost of the robot and solar charging station is $787, which is less than any other autonomous robots on the market. The robot and solar charging station take up less than a square foot of space. Since it is both cost and space efficient, this robot will appeal to many stores.

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Soil Probing Robot (SPR)

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Abstract

Agriculture is one of the leading industries across the globe and has a significant impact on a country's economy. Farmers are aware that the use of technology can both improve yield and reduce waste. Leading tech companies such as Microsoft and Google are working with farms to increase the effectiveness of technology to improve resource distribution, pest control, and robotic and AI administration. In the future, robots that produce more accurate readings of the soil and crop characteristics minimize the waste of resources and improve the growth of an industry that once generated $1.053 trillion to the US economy.

Keywords: *Autonomous, Robot, Automation, Agriculture, Environment, GPS, Bluetooth, Arduino, MIT App Inventor, CAD, Analysis*

1. Introduction

Modern agricultural techniques require homogenized fields that utilize vast amounts of land with minimal to extremely negative contributions to the health of the ecosystem. These current techniques involve deforestation, displacement of millions of gallons of water from rivers and streams, and utilization of pesticides, herbicides, and fertilizers that leech back into the water table creating danger for humans and the environment. Traditional farming has also mostly been instinctive; a farmer would spend a vast amount of resources on farmland, without an adequate understanding of actual plant requirements. As a result, a huge amount of material resources are expended to regulate farmland. With the help of autonomous robots in the field, farmers can dynamically measure crop requirements at the root level, in order to detect the exact amount of water and nutrients a plant requires for survival. Furthermore, the moisture and temperature levels can also be used to monitor other environmental problems such as mineral and aquifer depletion. Accurate prediction and diagnosis of these problems before they get out of hand, saves the agricultural industry millions of dollars in wasted resources.

2. Background

2.1 Traditional Farming Method and the Toll on the Economy:

According to traditional farming methods, farmers do most of their work based on instinct. In most farming, commercial or personal, farmers supply plant nutrients according to experience and estimation. Even though this farming practice of trial and error has yielded large numbers of crops, waste of water and plant nutrients and overuse of pesticides destroys, through over-nourishment, many seeds and crops at an early stage. The use of autonomous technology is now tackling this problem in farmlands. Unmanned tractors and drones to water crops preserve resources. This use of technology thus provides economic benefits, since less waste allows for greater production of farming goods available in the marketplace.

2.2 The use of Autonomous Robots in Farming:

The use of robots in farming is more common than most people expect. Autonomous farming equipment is being used to plow, plant, and spray large quantities of land, tasks which are challenging for the human workforce. Even though these robots cost more than traditional machinery, farmers save money by hiring fewer workers, and reductions in crop waste and supplies provide further economic improvement.

Figure 19: Autonomous Tractor

Figure 20: Automated Spray Machine

Fig # 1 displays an unmanned autonomous tractor with a planter implement, from the company CNH Industrial that plants seeds in a field using GPS tracking and can be controlled with a tablet. Fig #2 shows a robot of the same category, from the company Blue River Technology, which sprays pesticides on crops.

3. Engineering Requirements and Constraints

3.1 Base: The base of the robot must be strong enough to support the weight of legs, wheels, motors, batteries, and sensors; it must also have sufficient space to wire the microcontrollers and sensors.

3.2 Drivetrain: The drivetrain of the robot will consist of four legs on the four corners of the base to house the wheels and the motors for the wheels. These legs will be 3D-printed using PLA material. The wheels of the robot should support treading in all kinds of fields found on a typical farm. The wheels are kept below 5 inches along with the leg, so that once mounted on the leg, the robot maintains six inches of ground clearance.

3.3 Tower: The tower is one of the most important aspects of the robot, as it holds all the components involved in the mechanism (drilling Auger, motor and Actuator) in place. The support for the tower must be durable enough to withstand a push weight of at least 35lbs, which is the weight of the entire robot without failure, and hold everything connected to it without any sort of jerking.

3.4 3Auger Drill: To take the measurements from the soil, a hole must be made into the soil for the probing sensor to be dropped. To do so an Auger drill is used which makes a 4 inch hole into the soil, with at least a 3 inch diameter, as anything more than that can damage the field and leave unwanted holes in the ground across the crop field. The Auger drill selected must be able to drill in any type of soil typically found in a crop field, and it must withstand friction from the soil.

3.5 Actuator: An actuator will be used to push the auger drill down into the soil. Hence the actuator used for this robot will have to have a pushing force of at least 50lbs, so the drilling mechanism can penetrate the soil.

3.6 Sensor Dropper Mechanism: The soil probing sensor of the robot is placed right across the tower, as it will be dropped into the soil to take the measurements for the temperature and moisture of the soil after the hole in the soil is made. A rack and pinion mechanism controlled by a stepper motor is used to drop the sensor into the soil.

3.7 Motors: The motors used for the different components should have enough stall torque range to work the components without failure. The motors are thus selected after the calculations are conducted to determine the torque required by each of the wheels and the auger drill operation, in the worst-case scenario.

3.8 Sensor Requirements: The sensors utilized in the robot must be compatible with the Arduino platform. This limits us to common communication types such as I^2C and serial communication methods. Furthermore, the communication types for the sensors must work at the same voltage levels to reduce the component count. For example, we must ensure that all I^2C components run on 3.3v communication and not 5v communication, because then it would require a level shifter which is a component that normalizes 5v to 3.3v communication.

3.9 The Microcontroller: The microcontroller should have the ability to manipulate over 12 PWM devices, as well as to accommodate at least 2 I^2C devices. It should be powered through a 5V power source but accommodate 5V and 3.3V logic to control a variety of sensors.

3.10 Specifications for the Components: The specification for the all the components is displayed in Table 1 and Table 2.

Table 1: The Mechanical Components

Component	Dimensions	Material
Base	17.5” L * 17.5” W	Steel
Legs	4” L * 4” W * 5” H	PLA
Wheels	4” Diameter * 1” Thickness	Plastic
Motors (Drivetrain/ Drilling Auger)	0.236” Diameter * 5.087 L	Steel
Auger	3” Diameter * 10” L	Stainless Steel
Auger and Actuator Controller	2.5” Length	Steel
	Holes with 0.376” and 0.236” Diameter	
Actuator	10” Stroke Length	Steel
Tower	2” L * 2” W * 36” H	Stainless Steel
Triangular Support with Arc	5” Vertical Length, 5.90” Horizontal Length	PLA
	1” Thickness	
L-Shape Supports	4” Vertical and Horizontal	Stainless Steel
	1” Thickness	
Battery	5.94” L * 3.86 W * 3.98” H	

Table 2: The Electrical Components

Component	Type
Microcontroller	Arduino Mega 2560
Obstruction Detecting Sensor	HR-S04 Ultrasonic Sensor
Soil Probing Sensor	SHT20 Soil Air Temperature and Humidity Sensor
Drive-motor Controller	Cytron MD10 Dual Motor Controller
Bluetooth Module	HC-05 Bluetooth Module

3.11 Standards

Mechanical: The mechanical standards are those on which the constraints, dimensions and tolerances were measured and presented in the CAD-drafting drawings according to the ASME (American Society of Mechanical Engineers) under the ANSI (American National Standards Institute); the Cad drawings were also exported in SolidWorks using the SolidWorks part and STL file types.

Programming: The robot has all the functions programmed using the Arduino Mega programming window. The Arduino Mega must be used for the robot to function, because the robot requires the control of many components. The programming utilized the TinyGPS++, DFT_Robot, CytronMotorDriver, and standard Arduino libraries

3.12 Safety Measurements

Manufacturing and Testing: To ensure the safety of teammates involved in the project, the robot was designed, manufactured, and tested in a controlled environment. The Robotics club room at Vaughn College of Aeronautics and Technology, with monitoring and safety tools, was thus a suitable location. For the testing phase, no people, other than the teammates, were nearby. As a further safety measure, we insured that each component was working correctly indoors, before testing it outside in open grounds.

User Safety: Remote control of the robot is a safety precaution designed for the user. To ensure the safety of crops and of the robot itself, obstacle avoidance sensors, such as ultrasound, are also used so the robot can stop if it approaches an obstacle it might hit.

4. Construction of the Base and Tower

4.1 The Set-up

The square base of the robot consists of the tower that holds the actuator, auger drill, and the soil sensor dropper. It also acts as a housing unit for all the sensors and the power supply system for the robot. These legs connected to the robot contain the gearboxes and the wheels of the robots. To fix the base together into a place, 8/32" screws with nuts at each of the corners are used, with the holes already printed on the legs. Fig # 3

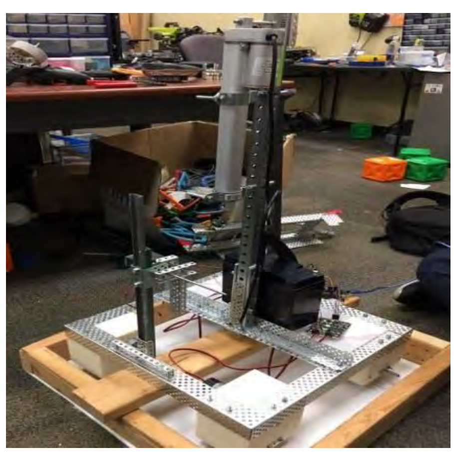

Figure 3: The Drivetrain of the Robot

4.2 Gearbox and Legs

The legs of the robot consist of a motor, two 4-inch wheels, two gears and spacers. The wheels are designed in such a way so they can house all the components for it to run while supporting the base of the robot. This design is displayed in Fig # 4. The leg has a 4 inch length x 4 inch width and a height of 5 inches. The leg is designed with a 1:1 gear ratio for power transference between the motor and the leg, and it utilizes custom 3D-printed gears, which attach to a special flanged coupler, allowing for a set screw to press down on the key cut-out of the motor, for power transmission. The flange of the couple has holes for screws that are driven into holes on the plastic gear to complete the assembly.

Fig # 4 displays the interior view of the design of the robot, which shows the position of the motor, gears, and the wheels to be put in place in the leg. The leg has a cover on it, which is detachable. The detachable layer is added for ease of access to the internal components when they are being put together and if it requires any form of troubleshooting. The Wheels that will be used on the robot are the Vex robot wheel. Vex robot wheels are selected, because they have a suitable hardness to weight ratio, in order to properly tread through farm field soil.

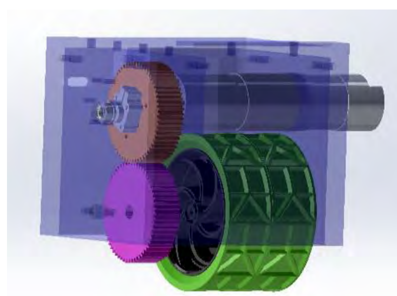

Figure 4: Design of the Leg with the Transparent view of the Interiors

4.3 Drilling

One of the main functions of the robot is being able to drill through any type of soil that a typical farm might have. The auger drill bit used is made of stainless steel so it can survive through friction while drilling in different types of soil. The auger has a length of 10 inches and a diameter of 3 inches, shown in fig # 3, so it can easily make a 4 inch deep hole into the soil, where the soil probing sensor will be dropped to take measurements. Fig # 5.

Figure 5: The Non-Slip Flower Bulb Auger Drill Bit

The reason to choose this auger is that it was the optimal size required for the robot, and the weight was lighter compared to many of the competitor products in the market of a similar price range. The robot is required to drill a 4 inch hole into the ground, which research has shown to be the optimal depth to plant the seed of the crops. At that depth, the temperature and moisture of the roots measured prove the best approximate results. This auger drill will make a hole of 3inches in diameter, which will allows a dropper to place the sensor safely into the hole for the measurements [2].

4.4 Motors

The motors to be selected required a stall torque of at least 1.34 Nm and the auger motor had to sustain a stall torque of 30 Nm. After the calculations, the motor selected for the auger and the motors was the 76-rpm Spur Gear motors with encoders shown in fig # 6. The reason for the selection of this motor is so it can sustain the torque for both the drivetrain and auger drill motors. It is also taken into consideration that the motor allows the robot tread through different soil environments.

4.5 Calculation for the Selection of the Motor for the Drivetrain

To determine the right type of motor necessary for the drivetrain, the total torque required by each of the wheels must be calculated. This is done by using the general force and torque formula. Also, the environmental conditions for the robot are set in a worst-case scenario where the wheels must drive up a 20° incline at an acceleration of 0.2 $\frac{m}{s^2}$, with the entire weight of the robot. After the total torque required by the robot is determined, it is divided by 4 to find the individual torque for each of the wheels [4].

Formula to find the force:

$$\sum \boldsymbol{Fx} = \boldsymbol{M} * \boldsymbol{a} \qquad (1)$$

Fx = Force in the x-direction *[N]*
M = Mass of the Entire Robot [Kg]
a = Acceleration of the Robot $[m/s^2]$
The mass of the robot was measured to be 14.894 kgs
The acceleration at which the robot should be running is set at 0.2 m/s^2.

$$\sum Fx = 14.894\, kg * 0.2\, m/s^2$$

$$\sum Fx = 2.978 \approx 3\, N$$

Formula to find the torque:

$$\boldsymbol{Tall} = \boldsymbol{r} * \boldsymbol{M} * (\boldsymbol{a} + \boldsymbol{g} \sin \boldsymbol{\theta}) \qquad (2)$$

Tall = Total torque required by the entire robot [Nm]
r = Radius of the wheel [m] *a = Acceleration of the Robot* $[m/s^2]$
M = Mass of the entire robot [Kg] *g = Acceleration due to gravity* $[m/s^2]$
θ *= Incline at which the wheel will travel [degree]*
The radius if the wheels are converted from inches to meters

$$Tall = (4\, in * 0.0253 m/in) * 14.894 * (0.2\, m/s^2 + 9.81\ \sin 20°)$$

$$Tall = 5.359\, Nm$$

Torque required by each of the wheels of the robot:

$$\boldsymbol{Tind} = \boldsymbol{Tall} / \boldsymbol{Nw} \qquad (3)$$

Tind = Individual Torque required at each of the wheels [Nm]
Nw = Number of wheels on the drivetrain

$$Tind = 5.359 / 4$$
$$Tind = 1.34\ Nm$$

The Torque required by each of the wheels to move up a hill at an incline of 20° is 1.34 Nm. Hence each motor to be selected has to have the acquired torque. Fig # 7

4.6 Calculation for the Selection of the Motor for the Auger

The average industrial Power drill operates at a drilling Torque of 265 in-lb.
In order to determine the proper motor to support the drilling function of the auger, a motor of a similar torque was selected for the Auger.

Torque calculation of the motor for the Auger

$$T = 265\ inlb * 0.11298\ Nm$$
$$T = 29.9397\ Nm = 30\ \text{Nm}$$

Figure 6: 76-rpm Spur Gear Motor with Encoders

4.7 Power Supply System

For the selection of the battery, it had to be taken into consideration that the battery would have to power the motors on the drivetrain, the actuator, the auger motor, the sensors, microcomputer(s) and the sensors used on the robot. The sensors and motor controllers would not require the amount of power compared to the motors in the drivetrain. The initial idea was to get multiple batteries, but that would not be a sustainable and cost-effective solution. Hence to find a suitable battery, some calculations were done to determine how much power would be required to sustain the torque of motors.

4.8 The Calculations for the Battery

All the calculation is done with an estimated efficiency of 50%-70% of the system
To determine the Power required for the system:
Formula Angular Velocity,

$$\boldsymbol{\omega = v/r = 2/(0.0508 * r) = 12.53189\ rad/s} \qquad (4)$$

Power,

$$\boldsymbol{P = T * \omega = 2.9924\ Nm * 12.531 \frac{rad}{s}} \qquad (5)$$
$$P = 37.500\ W$$

4.9 Conversion from Watts to Watt-hour

The calculation to find the number of watts consumed by the robot to run for an hour is shown below:

$$\boldsymbol{P * t = Wh} \qquad (6)$$

P = Power [W]

T = time in hours [h]
Wh = Watt Hour

$$37.500 * 1 = 37.500\,Wh$$

4.10 Calculating the capacity of the battery in Amp-Hours from the Watt-hours

In order to find the current in amp-hours for the robot number of 12 V batteries were shortlisted, from there each of the batteries were selected to calculate the Amp-hours required by the robot. The calculation to find the amp-hours is shown below:

$$Wh\,/\,Volts = Amp - hour$$
$$37.500\,/\,12 = 3.12\,Amp - hour$$

4.11 The Connectors for the Auger Drill Bit, Motor and Actuator

The dimensions of the motor shaft and auger drill bit shaft are different, so the part in fig # 7 was designed and fabricated using aluminum as the material, so the part is strong enough to hold the components together while in motion. The actuator to auger connector is designed so that a series of set screws can be added to both the top and bottom sections and push down on the sides of the hex power drill adapter on the auger and the screw key on the motor shaft respectively. These connections were tested by hand and by repeatedly plunging the drill into the ground to ensure that the mechanism is secure. The actuator and the auger drill motor must be connected so it can push the running auger drill to the ground to make the hole. Two separate parts were designed for the sole purpose of connecting the auger motor and the actuator shown in fig # 8. The parts were fabricated with aluminum, and they enclose the auger motor with a small slot on the top, so that the wires can escape the enclosure.

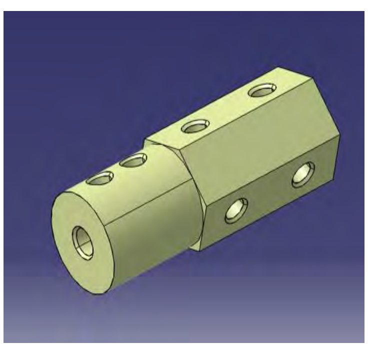

Figure 7: Auger/Motor Connector

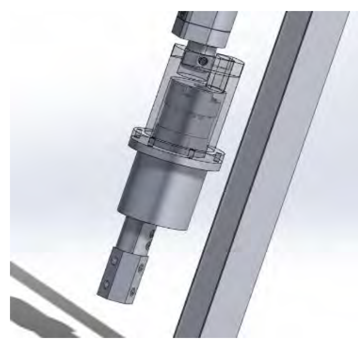

Figure 8: Actuator/Auger Motor Connector

4.12 The Stress Analysis for the Support Bracket with the Arc

Support brackets are used to hold the tower in place. These support brackets help hold the tower in place, so the tower remains rigid and resists the force of plunging the drill into the ground. Three brackets are used to hold the tower in place: two L-Shaped brackets on the sides, and one arc-shaped bracket in the rear. The bracket is designed in SolidWorks, and FEA analysis based on an applied load of 35 lbs on the bracket was conducted to confirm whether or not it could withstand the force exerted on it from the robot. The stress distribution is displayed in fig # 9.

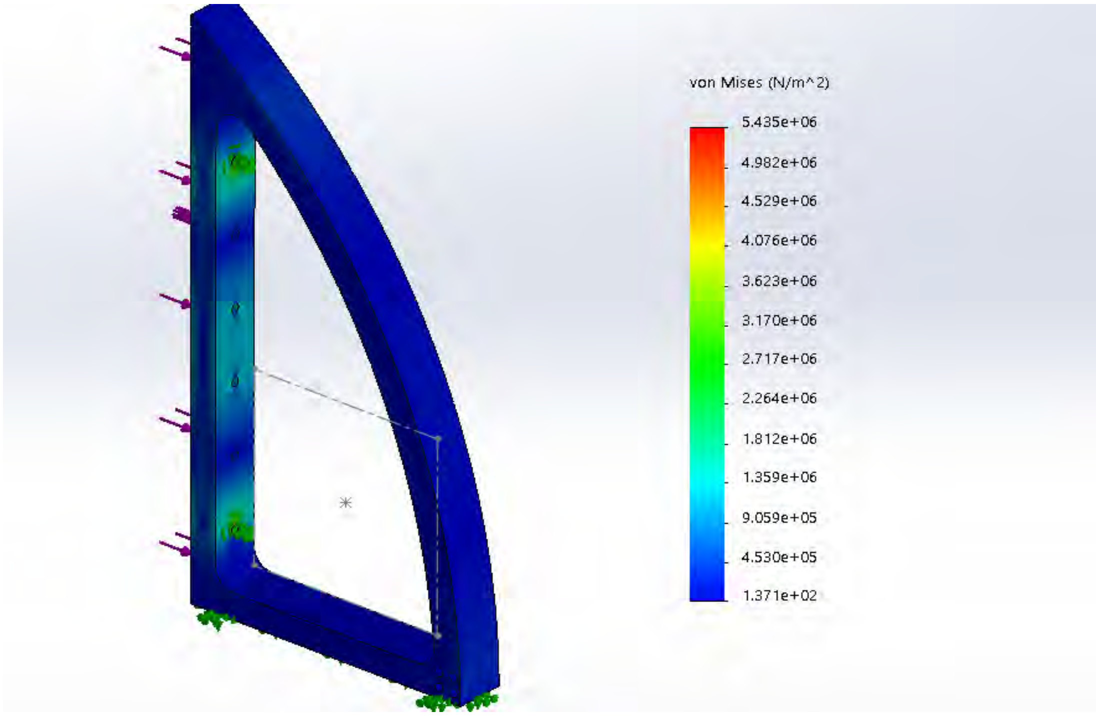

Figure 9: Stress Analysis on the Support Bracket with Arc

The factor of safety of the bracket against material yield strength (4.826e+07 N/m^2) is calculated using equation 7.

$$F.S. = \frac{\sigma_Y}{\sigma_{Max}}. \tag{7}$$

Where:
F.S. is Factor of Safety

$\boldsymbol{\sigma_y}$ is Material Yield Strength = 48.26 MPa

$\boldsymbol{\sigma_{Max}}$ is Maximum Applied Stress = 5.435 MPa

$$F.S = \frac{48.26\ MPa}{5.435\ MPa} = 8.9$$

A high factor of safety, confirm that the bracket safely support the weight of the robot with all attachments.

4.13Sensor

For the measurements of temperature and moisture to be taken, the soil sensor had to be dropped into the hole made by the auger drill. A rack and pinion mechanism fixed to a tower were developed with a stepper motor. It was important to fix the soil dropper mechanism after the tower with the auger was set up, as it had to be parallel to the tower and have some distance between the auger drill and the sensor, so that the auger does not damage the sensor during the operation of the robot. Fig # 3

5. Electrical Components and Design

5.1 Arduino Mega 2560

The Arduino mega board is a specialized board design to be used to accommodate many external components. The Arduino mega board has 54 digital input/output pins, and 15 of these can be used for PWM. The board also has 256KB of flash memory, which is more than enough to hold a large size program to control all the different components on our robot. The Arduino and all the peripheral sensors are powered by a 9v rechargeable battery which provides the robot with enough power to run the peripherals for one hour. Fig # 10

Figure 10: The Arduino Mega

5.2 Ultrasonic Sensors

The main obstacle avoidance sensors are the HC-SR04 ultrasonic sensors. The working principle of these sensors is that when the trigger pin on the sensor receives a high input, it causes the sensor to emit a high-frequency sound, which is then reflected based on the sound. The echo pin then emits the input of that frequency when it is returned. Then the data from the sensor is repeated back to the Arduino, where a special library on the Arduino mega decodes the signal received into a value that represents the time the transmission was sent and received back. Fig # 11

Figure 11: The Ultrasonic Sensor

5.3 Motor-Drive Controller

The Cytron MD10 dual motor controller is ideal for our project, because it can be used to operate 12v motor in range of .2-20A as well up to 30A. It means that the motors will work in a wide variety of conditions and resistance without burning out. On the robot, three of the boards are used to control the left drive motors, right drive motors, auger, and the linear actuator. The boards that are used to control the drive motors utilize a fanout of PWM signals from the main Arduino board, and only two pins control an entire side of the robot. This is done to minimize the number of pins used on the Arduino and to reduce the number of wires coming out of the Arduino. Fig # 12

Figure 12: The Motor Drive Controller

5.4 GPS

The NEO-6m GPS module is a 4800 baud GPS that can receive a satellite NMEA code deciphering to return a user's latitude and longitude within 15 feet of the actual destination. On the robot, GPS is the main navigational sensor. GPS requires certain conditions be met. The weather must be optimal, so that there is little to minimal cloud cover, as the GPS relies on satellites for direction connection. Other types of GPS use cell-phone towers to strengthen the connection to the satellites and allow for a stronger connection. The GPS must also be connected to at least four different satellites, of which three are used to triangulate the current location of the module, and the fourth is used to verify the result from the other three. The GPS is necessary for course-plotting and ensuring correct orientation of the robot. In the program, the GPS and compass are continually consulted to establish the difference between the desired and the actual heading direction of the robot. Those two values are then constantly subtracted from each other to find the actual value. Once the actual value of the heading direction is known, then the robot will either perform a short left or right turn, by giving the appropriate motor side more power. Fig # 13

Figure 13: GPS Module

5.5 Bluetooth Module

The HC-05 Bluetooth module is a 5V compatible IC with a breakout board that interfaces with the TX and RX pins on the Arduino to send and receive serial communication through Serial Port Protocol (SSP). This module can function as either the master or slave when connected to a network of Bluetooth devices, which is why it was selected for application on the robot, as well as for its easy integration into Arduino projects. Fig# 14

Figure 14: HC-05 Bluetooth Module

5.6 Compass/Magnetometer

The compass/magnetometer measures the strength and direction of the local magnetic field with reference to its own orientation. The compass must be properly calibrated, which involves wiring it up to the Arduino and then running a simple code to receive the magnetic field data. The sensor is then spun around in all directions until the results of the X and Y offsets begin to normalize and settle. The process of reading the sensor results and spinning the sensor is then repeated, and the average of the results is taken to minimize the error. Fig # 15

Figure 15: QMC5883L Compass/Magnetometer

6. Arduino Programming Structure

6.1 Arduino IDE

Arduino Programming is done in C++ with a few special functions to make the hardware programming simpler for new users. The IDE that is used to program the Arduino comes with many tools for the reading of sensor data that were utilized for this project. These tools include the serial monitor and serial plotter, which are used to display serial data that the Arduino detects from its TX and RX pins, of which there are three pairs on the Arduino Mega. This information is used to calibrate sensors and troubleshoot the robot.

6.2 Bluetooth Code

Once all connections are established, the HC-05 sensor and the phone begin to share data. Since the phone is primarily sending data, it is considered the master, and the Arduino is primarily receiving data, so it is considered the slave in terms of Bluetooth connection terminology. When the user is ready to send data to the HC-05, they simply press a button that triggers the phone to send a number in ASCII code to the Bluetooth module. The Bluetooth controlling code on the Arduino is written to keep checking certain numbers that trigger functions for specific actions. For example, "5" will cause the robot to stop moving and break out of the go-to-waypoint function, and "17" will cause the actuator to lower 6.3 Compass Direction and Go to Waypoint

The main way that the robot navigates through user input is through GPS waypoints. GPS waypoints are locations to which the user has been and has stored as GPS coordinates using the app. These GPS locations are then stored as an array in the program, and up to five locations can be stored for later navigation. The process for navigation works by first accessing the information on the robot's current orientation and comparing it to the desired orientation to reach the GPS waypoint. The robot will calculate a minimum turn radius by first checking to see if the robot is within 15 degrees of the desired location, in which case it will continue to go straight. If the robot is not within 15 degrees of the GPS course, it will check to see if the heading value is between 0 and 180, in which case it will perform a slow left turn, and if the heading value is anything else, it will perform a slow left turn until it is within the 15 degrees of the GPS waypoint. Once the robot has reached the destination, and it has been confirmed by both the GPS and compass reading, it will begin a drilling routine to drill and implant the sensor

6.3 Steering

The steering code is a collection of simple functions used by other sections of the code to control the robot. For example, the function "Forward" sets both motors equal to the motor speed variable in the main section of the code. The functions mostly involve utilizing the Cytron Motor Controller library to change the PWM and direction values of a motor for a certain period, or until a new command is given by the code. They also include a serial print statement so that the user can see the Arduino is acting on the commands it is given.

7. App Design

7.1 MIT Inventor APP

MIT App inventor is an app development platform developed by Massachusetts Institute of Technology that allows app development beginners to create simple apps for IOS and Android utilizing a programming language similar to Scratch, which allows the user to drag and drop blocks in order to create programs. Through MIT App inventor, creators can create simple apps with powerful effects, such as the ability to interface with databases, automatically store information, and connect to other external devices. The blocks in Fig # 14 use the Bluetooth client hidden object to allow the user to connect to a paired Bluetooth device and then specify what to do after the connection has been established, such as read that the connection has been established using a text to speech tool and change the color of the button, so that the user knows the connection has been made. The rest of the scratch blocks code is used to allow the buttons to send signals from the tap of a button. In the figure below, the blocks are telling the robot that when "BtnStartDrill" is clicked, it will send the number "18" through the Bluetooth client to the module on the robot. If there is no Bluetooth connection established, then it will show a notice as an overlay on the main screen of the app, telling the user that the Bluetooth is not connected. Fig # 14 shows the last component of the app and the first that the user sees is the interface. The interface is a series of buttons that control the movement and actions of the robot. The interface also features a notification window through which the user can see what actions the robot is doing, based on what is printed to the serial monitor.

Figure 14: Bluetooth Connection Blocks

Figure 15: User Interface

8. Future Developments

After successfully making the robot, the next plan is to install a suspension system in the drivetrain, so the robot will be able to tread through rigid surfaces more efficiently. The plan is to install a Rocker-Bogie like suspension system, like the one used for the Rovers at NASA. The idea first came from the Curiosity Rover which has a Rocker-Bogie drivetrain d, so it can tread through different types of terrain with the least possibility of tipping over. Fig # 18. [6]

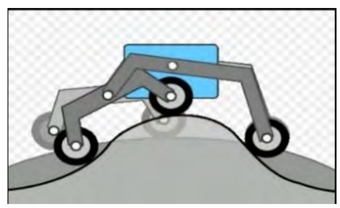

Figure 18: The Rocker-Bogie Design

9. Impacts

9.1 Economic Impacts

The robot will have economic impact in that it will help farmers and agricultural specialist have a better understanding of how their expendable resources such as water, pesticides, and fertilizers are going to use in the field and how to use these resources more effectively to return a greater yield for less material consumed.

9.2 Environmental Impacts

The goal of the robot was to impact the way that farmers view the potentially harmful chemicals they use as part of their agricultural operations. By increasing their mindfulness of where these resources are being expended, the robot promotes tighter control over these dangerous chemicals, as well as limitations on their use. Furthermore, the robot can be used outside the agricultural industry by environmentalists and researchers to conduct analysis of soils.

10. Conclusion

The robot has many unique features. The primary features of the robot include a Bluetooth-based app to give the robot GPS locations to which it will travel and then drill into the soil to implant a temperature and moisture sensor, from which the user can obtain valuable information about soil quality. This design is very beneficial to the farmer and those interested in agriculture automation, as it will help them to gather more data and to apply agricultural resources in a controlled and frugal manner. Fig# 19

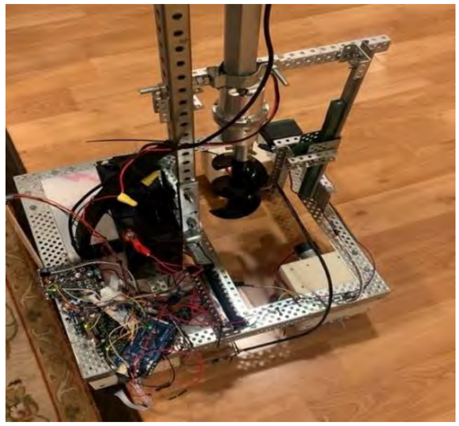

Figure 19: The Final Construction of the Robot

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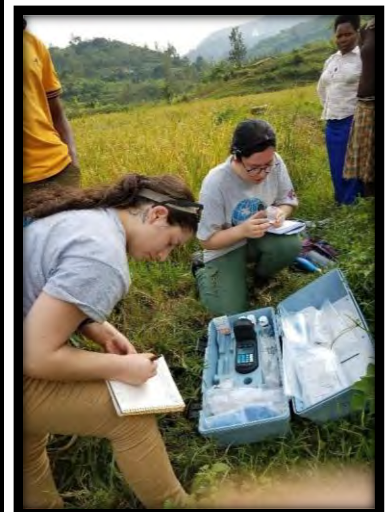

"The only source of knowledge is the experience."
Albert Einstein